Flood Mitigation Study

Schoharie Watershed

Contract #C1000449
Tasks 7-1 through 7-4

Schoharie, Albany, Montgomery, Otsego, and Schenectady Counties, New York
April 2017

This study was prepared for the New York State Department of State and Schoharie County SWCD with funds provided under Title 11 of the Environmental Protection Fund Act

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

Flood Mitigation Study

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Schoharie, Albany, Montgomery, Otsego, and Schenectady Counties, New York
April 2017

Prepared for:
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ABBREVIATIONS/ACRONYMS

BIN	Bridge Identification Number
CDBG	Community Development Block Grant
CFS	Cubic Feet per Second
CSSO	Conditional Seasonal Storage Objective
DEC	Department of Environmental Conservation
DPW	Department of Public Works
EWP	Emergency Watershed Protection
FEMA	Federal Emergency Management Agency
FIRM	Flood Insurance Rate Map
FIS	Flood Insurance Study
FMA	Flood Mitigation Assistance
GIS	Geographic Information System
HEC-RAS	Hydrologic Engineering Center – *River Analysis System*
HW/D	Headwater to Culvert Depth Ratio
HWM	High Water Mark
LFA	Local Flood Analysis
LFHMA	Local Flood Hazard Mitigation Analysis
LiDAR	Light Detection and Ranging
LOMR	Letter of Map Revision
MMI	Milone & MacBroom, Inc.
NFIP	National Flood Insurance Program
NOAA	National Oceanic and Atmospheric Administration
NRCS	Natural Resources Conservation Service
NWI	National Wetland Inventory
NYCDEP	New York City Department of Environmental Protection
NYRCRP	New York Rising Community Reconstruction Plan
NYPA	New York Power Authority
NYS	New York State
NYSDEC	New York State Department of Environmental Conservation
NYSDOS	New York State Department of State
NYSDOT	New York State Department of Transportation
PDM	Pre-Disaster Mitigation
RLP	Repetitive Loss Property
SALT	Schoharie Area Long Term, Inc.
SCSWCD	Schoharie County Soil and Water Conservation District
SFHA	Special Flood Hazard Area
Sq. mi.	Square Mile
SRLP	Severe Repetitive Loss Property
T	Trout Waters
TMDL	Total Maximum Daily Load
TS	Trout Spawning
USACE	United States Army Corps of Engineers
USGS	United States Geological Survey
WQC	Water Quality Certification
WTS	Water Treatment System

EXECUTIVE SUMMARY

The Schoharie County Soil and Water Conservation District (SCSWCD) has retained Milone & MacBroom, Inc. (MMI) to complete a Flood Mitigation Study for the Lower Schoharie Creek watershed. Funding for this study has been provided from the New York State Department of State (NYSDOS) under Title 11 of the Environmental Protection Fund for the Local Waterfront Revitalization Program. The study is part of Phase 1 of the Mohawk River Watershed Management Plan Implementation.

With a watershed of approximately 930 square miles, Schoharie Creek drains the northwestern Catskill Mountains. A tributary to the Mohawk River, Schoharie Creek flows through Schoharie County from south to north. The terrain within the watershed is a mix of mountainous landscapes and flat, narrow valleys. Ground elevations range from an average of about 1,200 feet in the northern limestone plateau section of the county to approximately 2,000 feet in the higher plateaus in the southern part of Schoharie County, with the headwaters in Greene County at an elevation of 4,000 feet (Schoharie County All-Hazards Mitigation Plan, 2006).

The Schoharie basin has a long and destructive history of flooding, including most recently as a result of Tropical Storms Irene and Lee.

The Schoharie Creek basin is particularly prone to flooding due to a number of factors, including the location of the headwaters in the Catskill Mountains; the low permeability of the mountainous landscape; the lack of wetland habitats or lakes within the watershed to retain stormwaters; and the prevalent winds, which during coastal storms push storm air masses up and over the mountains, causing cooling and subsequently high amounts of precipitation. As the wettest region in New York State with over 60 inches of precipitation annually, individual rainfall events of 5 inches are common. These and other factors contribute to the flash flood conditions within the basin.

The Schoharie basin has a long and destructive history of flooding, including most recently as a result of Tropical Storms Irene and Lee. By far the largest storm on record occurred on August 28, 2011, as Tropical Storm Irene dumped up to 14 inches of rain within the Schoharie basin, resulting in a peak flow rate in Schoharie Creek of 128,000 cubic feet per second (cfs). This catastrophic flooding was followed by additional precipitation on September 7, 2011, as Tropical Storm Lee dropped a reported 2 to 7 inches of additional rain. Flows in Schoharie Creek exceeded the predicted 500-year flood in some locations, resulting in well over $100 million in estimated damages.

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Public input has been a key element of this study. At the onset of investigations, the public was engaged in an effort to: (1) inform them about the Schoharie flood study, its goals, and intended outcomes; and (2) gather information on floodprone areas and flooding problems. Public meeting attendance and individual participation were excellent. A dialogue was also sought with County Soil and Water District staff in the Schoharie, Otsego, Montgomery, Schenectady, and Albany Counties as well as representatives of various towns, villages, and state agencies.

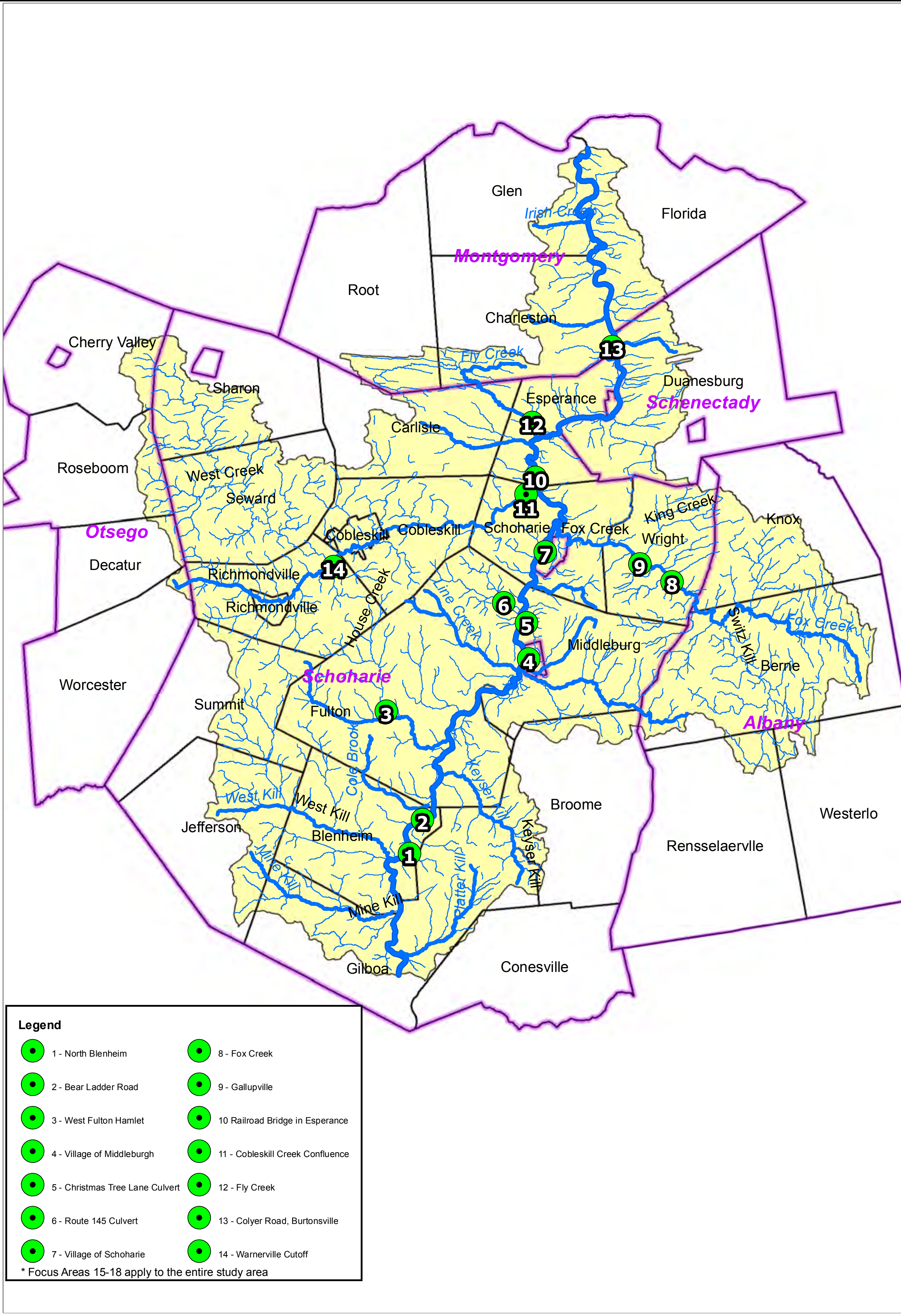
Eighteen flood mitigation focus areas were identified within the Lower Schoharie Creek watershed. Fifteen are location specific; three apply to the entire watershed.

For the purposes of this assessment, 18 focus areas were identified within the Lower Schoharie Creek watershed. Fifteen of the focus areas are specific locations while the remaining three areas can be applied throughout the watershed. A greater level of information was collected for the focus areas in order to assess potential flood mitigation projects. Within each focus area, MMI staff conducted on-the-ground assessments and visual inspections, including identification of land uses and low-lying structures, assessment of bank and channel conditions, measurements of valley confinement, measurements of bridge and culvert openings, and assessment of vegetation along the stream corridors. For each focus area, a range of flood mitigation alternatives was developed and evaluated, and hydraulic modeling was conducted where appropriate. Alternatives were recommended for those alternatives that were found to provide substantial flood mitigation benefit at a cost that would justify their implementation.

The 18 focus areas are listed in Table ES-1 and are graphically depicted in Figure ES-1. A summary discussion follows.

TABLE ES-1
Summary of Floodprone Focus Areas

Focus Area #	***Reference Name***
1	North Blenheim
2	Bear Ladder Road
3	West Fulton Hamlet
4	Village of Middleburgh
5	Christmas Tree Lane Culvert
6	Route 145 Culvert
7	Village of Schoharie
8	Fox Creek
9	Gallupville
10	Railroad Bridge in Esperance
11	Cobleskill Creek Confluence
12	Fly Creek
13	Colyer Road, Burtonsville
14	Warnerville Cutoff
15	Flood Attenuation in Upper Watershed
16	Berms along Farm Fields
17	Flood Attenuation in Reservoirs
18	Protection of Wetlands, Floodplains, and Green Infrastructure



SOURCE(S):

USGS StreamStats Version 3.0 (04/2016)
USGS National Hydrography Dataset (04/2016)
NYS GIS Clearinghouse (04/2016)

Figure ES-1: Focus Areas within Schoharie Creek Project Basin

Location:
Schoharie Creek Watershed, NY

N

Schoharie Creek Flood Study

Map By: EMH
MMI#: 4805-05
MXD: Q:\Projects\4805-05 Schoharie Basin Flood Analysis\GIS\MDX\Focus Area Points 9272106.mxd
1st Version: 04/25/2016
Revision: 9/30/2016
Scale: 1 in = 31,970 ft

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<u>Focus Area #1 – North Blenheim</u>

Focus Area #1 includes an approximately 1.5-mile reach of Schoharie Creek as it flows through the hamlet of North Blenheim. The creek flows across a section of bedrock channel as it approaches the hamlet. As it flows past North Blenheim and under the New York State (NYS) Route 30 bridge, Schoharie Creek is somewhat confined within its river valley, making contact with the right valley wall just downstream of the bridge where the creek runs parallel to NYS Route 30. The hamlet was severely damaged by flooding during Tropical Storm Irene. The following flood mitigation alternatives were evaluated for this focus area:

- Alternative 1-1: Replacement of Historic Covered Bridge
- Alternative 1-2: Floodplain Enhancement
- Alternative 1-3: Sediment Removal

The following recommendations are offered:

1. <u>Alternative 1-2c Floodplain Enhancement</u> – Floodplain enhancement and sediment removal scenario as described in Alternative 1-2c is recommended. This scenario was found to be effective at lowering water surface elevations by up to 2 feet over a distance of two-thirds of a mile upstream, which includes the North Blenheim hamlet. Many structures would be removed from the Federal Emergency Management Agency (FEMA) Special Flood Hazard Area (SFHA) while those that would remain in the SFHA would see reductions in flood elevations. The construction of this enhancement and sediment removal scenario would impact approximately 1,100 linear feet of Schoharie Creek and would require the removal of approximately 20,000 cubic yards of material. Engineering design and permitting are anticipated on the order of $68,000 while construction would be anticipated on the order of $820,000. This estimate does not include the cost of any land acquisition or construction easements that may be required or the relocation of utilities.

2. <u>Alternative 1-1 – Replacement of Covered Bridge</u> – If the Blenheim Covered Bridge is to be replaced, the replacement deck should be set at an elevation that is 10 feet higher than the deck of the former historic bridge. The replacement bridge should be set on the existing abutments or on new abutments that do not occupy more space in the channel than the existing abutments, and no roadway embankment should be constructed on the left side of the bridge to connect the bridge deck to the left bank. Hydraulic modeling should be conducted as part of the engineering design to ensure that the new bridge does not cause an increase in water surface elevations. It is also recommended that a Letter of Map Revision (LOMR) be prepared that reflects the current condition in North Blenheim either with no covered bridge or with a new bridge at a higher elevation.

<u>Focus Area #2 – Bear Ladder Road</u>

Focus Area #2 is located where Bear Ladder Road (County Route 31) parallels Schoharie Creek, just north of the hamlet of North Blenheim. Frequent flooding is reported at a location approximately 2 miles downstream of the NYS Route 30 bridge coincident with a low spot in the road. When the area floods, travel becomes unsafe or impossible, and access is cut off to several residences. The following alternatives were evaluated within this focus area:

- Alternative 2-1: Floodplain Modification
- Alternative 2-2: Raise Roadway
- Alternative 2-3: Roadway Signage and Closure

Neither floodplain modification nor raising the long stretch of Bear Ladder Road through this reach was found to result in significant flood mitigation. Instead, immediate closure of Bear Ladder Road during flooding conditions is recommended, with effective signage and further consideration of alternative routes as described in Alternative 2-3.

Focus Area #3 – West Fulton Hamlet

Focus Area #3 is located in the hamlet of West Fulton and includes House Creek and Panther Creek, both of which are tributaries to Schoharie Creek. Two vehicular bridges located in the hamlet of West Fulton, about 600 feet apart, have been identified as being prone to debris jams and overtopping during flood events: the Patria Road bridge over House Creek and the West Fulton Road (County Route 4) bridge over Panther Creek. The following alternatives were evaluated within this focus area:

- Alternative 3-1: Replace Patria Road Bridge over House Creek
- Alternative 3-2: Replace West Fulton Road Bridge over Panther Creek
- Alternative 3-3: Create Compound Channel with Floodplain along Panther Creek

The following recommendations are offered:

1. Alternatives 3-2 and 3-3 – Bridge Replacement and Compound Channel at West Fulton Road – This bridge is undersized, as is the upstream channel, and thus inadequate for conveyance of flood flows and debris. When the bridge is slated for replacement, the structure should be widened to improve debris movement and conveyance of flood flows.

2. Alternative 3-1 – Bridge Replacement at Patria Road – Near-term bridge replacement is not likely warranted; however, when the Patria Road bridge is slated for replacement, the structure should be widened to improve debris movement and conveyance of flood flows.

Focus Area #4 – Village of Middleburgh

Schoharie Creek flows across a wide, flat-bottomed valley with an extensive floodplain as it approaches and flows past the town of Middleburgh between Route 30 and Route 145. In some locations, the floodplain is over a mile wide. Many buildings along River Street in Middleburgh are located within the 100-year floodplain. The following alternatives were evaluated within this focus area:

- Alternative 4-1: Modify/Replace the NYS Route 30 Bridge
- Alternative 4-2: Floodplain Enhancement
- Alternative 4-3: Right Bank Floodplain Enhancement
- Alternative 4-4: Dredging
- Alternatives 4-5a and 4-5b: Flood Control Levee and Wall
- Alternative 4-6: Individual Building Floodproofing

Replacement of the NYS Route 30 bridge with a wider or taller structure (Alternative 4-1) *would not* reduce flooding at nearby buildings. Given the broad, flat nature of the Schoharie Creek floodplain in this area and the fact that the adjacent floodplain is already quite frequently flooded, little flow capacity is predicted to be gained and little flood reduction benefit as a result of floodplain enhancement (Alternatives 4-2 and 4-3). Hydraulic modeling predicts that channel dredging (Alternative 4-5) would provide only minimal flood reduction benefit, with a cost on the order of $2.3M.

Flood control levees and walls (Alternatives 4-5a and 4-5b) would require a considerable amount of private property acquisition and considerable maintenance, with costs in the $4M to $5M range or greater. A risk associated with these scenarios is the danger of a flood event that exceeds the design storm and overtops or breaches the levee or floodwall and is then trapped. In Middleburgh, peak flows in Schoharie Creek during Tropical Storm Irene exceeded the predicted 100-year storm event. Under such a scenario, it is possible that floodwaters from the creek would have overtopped a levee or floodwall designed to protect structures and properties. Once a levee has been overtopped, floodwaters can become trapped behind it, thus exacerbating flooding problems.

Given the shortfalls of the construction alternatives, individual floodproofing or relocation (Alterative 4-6) is recommended for floodprone areas in Middleburgh. A range of measures is available to protect existing public and private properties from flood damage. On a case-by-case basis where structures are at risk, individual floodproofing should be explored.

Focus Area #5 – Christmas Tree Lane Culvert

Focus Area #5 is located in the town of Middleburgh just south of Christmas Tree Lane. A culvert that traverses NYS Route 30 and conveys a small unnamed tributary to Schoharie Creek is reported to overtop frequently. The following alternatives were evaluated within this focus area:

- Alternative 5-1: Increase Culvert Capacity
- Alternative 5-2: Raise Roadway
- Alternative 5-3: Relocate Roadway
- Alternative 5-4: Roadway Signage and Closure

Replacement of the small culvert under NYS Route 30 (Alternative 5-1) was evaluated and found not to be a large contributor to flooding along the roadway and is not recommended. Due to the high cost of Alternatives 5-2 and 5-3 in relation to the mitigation benefit offered, neither is recommended. Closure of NYS Route 30 during flooding conditions, along with effective signage and further consideration of alternative routes, would provide a low-cost alternative and is recommended for implementation.

Focus Area #6 – Route 145 Culvert in Middleburgh

A concrete box culvert is located at the crossing of NYS Route 145 over an unnamed tributary to Schoharie Creek in the town of Middleburgh. The culvert is reportedly undersized, floods frequently, and is prone to debris jams. The following alternatives were evaluated within this focus area:

- Alternative 6-1: Replace Culvert
- Alternative 6-2: Program of Debris Management

The following recommendations are offered for Focus Area #6 in order of priority:

1. Alternative 6-2 – Debris Management – The development of a debris management program would reduce the volume of upstream debris being mobilized and delivered to the culvert and is recommended for immediate implementation.

2. Alternative 6-1 – Route 145 Culvert Replacement – As a first step, confirmation should be obtained from the New York State Department of Transportation (NYSDOT), Schoharie County Department of Public Works (DPW), or local highway superintendents as to the frequency of flooding associated with this culvert. If the culvert has a history of flooding, scour, and/or clogging, it is recommended that the culvert be replaced with a larger structure that can adequately pass the 50- or 100-year flood event with acceptable headwater to culvert depth (HW/D) ratio requirements.

Focus Area #7 – Village of Schoharie

The village of Schoharie is located in Schoharie County, the county seat. Schoharie Creek flows west of the village and under the Bridge Street bridge. Schoharie Creek flows across a wide, flat-bottomed valley with an extensive floodplain as it flows past the village of Schoharie. According to the FEMA Flood Insurance Rate Maps (FIRMs), the village of Schoharie along Main Street is subject to inundation during the 100-year flood event. The expansive flood zone associated with the 100-year flood event extends into the village of Schoharie, inundating portions of Main Street and affecting neighborhoods to the west of Main Street and portions of the village to the east of Main Street. Four flood mitigation alternatives were evaluated for the Schoharie focus area:

- Alternative 7-1: Floodplain Enhancement
- Alternative 7-2: Dredging
- Alternatives 7-3a and 7-3b: Levee Scenarios
- Alternative 7-4: Individual Building Floodproofing

The floodplain enhancement and dredging scenarios were found to have a minimal benefit toward the reduction of floodwater elevations and at a very high cost. Both levee scenarios while preventing flooding in key areas would be very costly, would be disruptive to the community, would require long-term maintenance, and would not completely remove the community from risk.

The recommended flood mitigation alternative in the village of Schoharie is the relocation and floodproofing of individual structures (Alternative 7-4). A range of measures is available to protect existing public and private properties from flood damage. On a case-by-case basis where structures are at risk, individual floodproofing should be explored.

Focus Area #8 – Fox Creek

Focus Area #8 includes an approximately 3.5-mile-long reach of Fox Creek beginning downstream of the County Route 9 bridge in the hamlet of West Berne, town of Berne, in Albany County and extending downstream to the NYS Route 443 crossing in Schoharie County. This section of Fox Creek runs along or crosses Route 443 for its entire length and passes under a total of six bridges. This section of Fox Creek has been flooding and is prone to sediment aggradation and debris jams, especially at the bridges. The following alternatives were evaluated within this focus area:

- Alternate 8-1: Modification/Replacement of the NYS Route 443 Bridge (Upper)
- Alternate 8-2: Modification/Replacement of the Schell Road Bridge
- Alternate 8-3: Modification/Replacement of Schoonmaker Road Bridge
- Alternate 8-4: Modification/Replacement of Zimmer Road Bridge
- Alternative 8-5: Modification/Replacement of Sholtes Road Bridge
- Alternative 8-6: Modification/Replacement of NYS Route 443 Bridge (Lower)
- Alternative 8-7: Sediment Management
- Alternative 8-8: Bank Erosion Repairs

The following recommendations are offered for this focus area:

1. Sediment Management – The development of a sediment management plan (Alternative 8-7) is recommended for Fox Creek with a focus on stabilization of banks and high bank failures (Alternative 8-8) within and upstream of this focus area.

2. Bridge Replacement – It is recommended that the Zimmer Road bridge (Alternative 8-4) and the Sholtes Road bridge (Alternative 8-5) be replaced with structures that can safely pass the 100-year flood event with adequate freeboard and with a span that is at least 1.25 times the bankfull width of the channel. An approximate cost of replacing the Sholtes Road and Zimmer Road bridges is $1.4M to $1.8M per bridge for construction.

   The two bridges that carry NYS Route 443 over Fox Creek (Alternatives 8-1 and 8-6) span the bankfull width of the channel and are capable of passing the 50-year flood. At the more downstream of the two bridges, floodwaters overtop the roadway adjacent to the bridge in the 50-year flood event. These bridges are not recommended for immediate replacement; however, when the downstream bridge is scheduled for replacement, its replacement should span the floodplain.

   When the Schoonmaker Road bridge is due for replacement, it should be replaced with a structure that can safely pass the 100-year flood event with adequate freeboard and is at least 130 feet in width.

3. Abutment Alteration – The Schell Road bridge is not recommended for immediate replacement; however, it may be feasible to remove the remnants of the center pier and remove or modify the old left abutment, which would increase the hydraulic capacity of the bridge and make it less susceptible to debris jams.

Focus Area #9 – Gallupville

The hamlet of Gallupville, through which Fox Creek runs, was subjected to flooding during Tropical Storm Irene. The flooding was most severe along School Street, Mill Street, and Factory Street, especially in the area of the public works garage and firehouse. The following three alternatives were evaluated within this focus area:

- Alternative 9-1: Modification/Replacement of the School Street Bridge
- Alternative 9-2: Floodplain Enhancement
- Alternative 9-3: Individual Building Relocation, Elevation, or Floodproofing

The School Street bridge (Alternative 9-1) was not found to act as a hydraulic constriction. Floodplain enhancement (Alternative 9-2) did not result in a substantial reduction in flood levels. Given the limited opportunities in this focus area, it is recommended that individual, frequently flooded buildings within the hamlet be assessed for elevation, relocation, or floodproofing, especially in the area of the public works garage and along Factory Street. Structures should be assessed on a case by case basis, depending on owner interest, type of building, and frequency of flood damages.

Focus Area #10 – Railroad Bridge in Esperance

In the town of Esperance, Schoharie Creek flows under an active Canadian Pacific Rail railroad bridge, which crosses the floodplain and spans the creek. In total, the railroad embankment and two bridges cross approximately 2,500 feet, or nearly half a mile of floodplain. FEMA FIRMs indicate that an extensive area upstream of the railroad bridge, including agricultural fields, the neighborhoods along Junction Road and Beechnut Lane, and the Junction Road roadway itself, is subject to inundation during the 100-year flood event. The neighborhood on Beechnut Lane was inundated during Tropical Storm Irene, with damage to properties and structures. Many of the structures in this area were destroyed and have not been rebuilt. The following alternatives were evaluated within this focus area:

- Alternative 10-1: Modification/Replacement of Canadian Pacific Railroad Bridge
- Alternative 10-2: Compliance with and Enforcement of National Flood Insurance Program (NFIP)

In order to eliminate the hydraulic constriction caused by the rail crossing, the bridges and the railroad embankment would need to be removed from the floodplain. Removal of an active Canadian Pacific railroad line over Schoharie Creek is unlikely. If use of the rail line were to be discontinued in the future, the removal of the railroad line from the floodplain should be investigated. In the meantime, individual building floodproofing is recommended, along with stringent requirements on any future development in the floodplain.

Focus Area #11 – Cobleskill Creek Confluence

This study area focuses on the lower reach of Cobleskill Creek just upstream of its confluence with Schoharie Creek in the town of Central Bridge, Schoharie County. NYS Route 30A serves as an important route out of this floodprone area of the Schoharie Valley during large flood events. During Tropical Storm Irene, water overtopped the NYS Route 30A roadway in the area just north of the bridge, making the road impassible. This section of the creek is subject to sediment aggradation and bank erosion. The following alternatives were evaluated:

- Alternative 11-1: Modify/Replace Church Street Bridge
- Alternative 11-2: Modify/Replace NYS Route 30A Bridge and Roadway
- Alternative 11-3: Individual Building Relocation, Elevation, or Floodproofing
- Alternative 11-4: Roadway Signage and Closure

The following recommendations are offered:

1. Alternative 11-3 – Individual Floodproofing – The relocation of structures and greenhouses located just downstream of Church Street is recommended as well as preventing development in the floodway and requiring that any new construction meet NFIP criteria.

2. Alternative 11-4 – Road Closure – Closure of the floodprone section of Route 30A during flooding events is recommended in combination with the installation of effective barriers and clear signage to direct travelers to alternative routes.

Focus Area #12 – Fly Creek

This focus area begins at the Fly Creek and Schoharie Creek confluence adjacent to the Junction Road bridge and extends upstream along Fly Creek for approximately 1.5 miles upstream of the Route 20 bridge in the hamlet of Sloansville, Town of Esperance. The FEMA FIRM indicates locations that experience inundation under different flooding scenarios. Although flooding is a problem along Fly Creek, the larger, related issues are bank erosion, sediment aggradation, and channel instability. The following alternatives were evaluated within this focus area:

- Alternative 12-1: SCSWCD Natural Channel Design Scenario #1
- Alternative 12-2: SCSWCD Natural Channel Design Scenario #2
- Alternative 12-3: Sediment Management Plan

Bank erosion, sediment aggradation, and channel instability are problematic along Fly Creek. The natural setting makes this section of the creek very prone to sediment aggradation and channel instability while repeated dredging has contributed to this channel instability. Restoration actions will be required to stabilize the failing banks, reduce bank erosion, and prevent damage to homes and buildings located close to the eroding stream banks. It is recommended that the SCSWCD plans be developed to a more advanced design stage and that restoration actions be undertaken at Fly Creek. Of the two scenarios, SCSWCD Natural Channel Design Scenario #2 (Alternative 12-2) most closely aligns with the goals for Fly Creek and is recommended.

Because sediment aggradation will continue to occur along Fly Creek, it is recommended that a sediment management plan be developed for Fly Creek (Alternative 12-3).

Focus Area #13 – Colyer Road, Burtonsville

This focus area includes a reach of Schoharie Creek where it runs along the Schoharie County/ Montgomery County line. Colyer Road is located along the left bank of Schoharie Creek in the hamlet of Burtonsville, town of Charleston, in Montgomery County. The reach is just upstream of where Bramans Corner Road (County Route 160) crosses over Schoharie Creek. Extensive flooding of homes occurred along Colyer Road during Tropical Storm Irene. Based on a review of aerial photographs, homes that were once located along the east side of Colyer Road have been removed since the occurrence of Tropical Storm Irene, presumably as a result of damages sustained during the flood. The following alternatives were evaluated within this focus area:

- Alternative 13-1: Modification or Enhancement of Channel or Floodplain
- Alternative 13-2: Survey, Followed by Individual Building Relocation, Elevation, or Floodproofing

Alterations to the channel at this location (Alternative 13-1) would be difficult and costly to undertake due to the presence of bedrock in the channel bed, the high embankment along the right bank, and the close proximity of the homes along Colyer Road to the channel. Survey of first-floor elevations (Alternative 13-2) would allow residents to decide on a case-by-case basis whether building elevation or property acquisition and demolition with relocation to a safe location outside of the floodplain would be most beneficial.

Focus Area #14 – Warnerville Cutoff

Warnerville Cutoff (County Route 23A) is a roadway that crosses over Cobleskill Creek in the hamlet of Warnerville, town of Richmondville, in Schoharie County. Warnerville Cutoff intersects with NYS Route 7/10 in Warnerville center. West Creek flows parallel to Warnerville Cutoff and crosses under it before flowing into Cobleskill Creek approximately 500 feet downstream of the Warnerville Cutoff bridge over Cobleskill Creek. A low area of Warnerville Cutoff, located approximately 400 feet to the northwest of the bridge over Cobleskill Creek, floods on a frequent basis. The following alternatives were evaluated within this focus area:

- Alternative 14-1: Elevation of the Roadway along Warnerville Cutoff
- Alternative 14-2: Elevation of Roadway and Installation of Bypass Culvert under Warnerville Cutoff
- Alternative 14-3: Elevation of Roadway and Installation of Bypass Bridge along Warnerville Cutoff
- Alternative 14-4: Warnerville Cutoff Roadway Signage and Closure

Alternatives 14-1, 14-2, and 14-3 are not recommended because they would not prevent flooding of Warnerville Cutoff and would cause an increase in water surface elevations upstream of the Warnerville Cutoff bridge over Cobleskill Creek and increase flooding risk in the area of the Warnerville Post Office. Immediate closure of Warnerville Cutoff during flooding conditions, effective signage, and further consideration of alternative routes is recommended (Alternative 14-4).

Focus Area #15 – Review of Potential for Flood Attenuation in Upper Watershed

Several comments were received during the public meeting session suggesting that floodwaters could be stored in existing lakes, ponds, or wetlands in order to attenuate downstream flood flows. Two sites within the Schoharie Creek watershed were investigated for their potential to reduce peak flows during storm events by storing a portion of the floodwater. The sites are located at two lakes along tributaries to Fox Creek – Warner Lake and Onderdonk Lake. The following alternatives were evaluated within this focus area:

- Alternative 15-1: Potential for Flood Storage at Warner Lake
- Alternative 15-2: Potential for Flood Storage at Onderdonk Lake
- Alternative 15-3: Potential for Flood Storage at Other Lakes, Ponds, and Wetlands

Stormwater storage at small lakes and ponds in the watershed does benefit downstream property owners by reducing peak flows. However, the potential to further increase storage at these sites is relatively small and is not recommended. Existing wetlands in the watershed provide a vital function by storing stormwater during floods and releasing it gradually downstream, thereby reducing peak flows. Protecting the functions and values of remaining existing wetlands is recommended.

Focus Area #16 – General Review of Berms along Farm Fields

During the data gathering stage for this flood study, interest was expressed in determining what effect, if any, agricultural berms along Schoharie Creek have on downstream flood flows. While a comprehensive inventory of the berms is beyond the scope of the study, an evaluation was made of the berms at two locations:

- Alternative 16-1: Agricultural Berm Site 1
- Alternative 16-2: Agricultural Berm Site 2

These agricultural berms were evaluated for potential removal and were found to have only a minor influence on downstream peak flows. However, berms and levees can influence flow velocities and water depths in cases where they confine the channel and isolate portions of the floodplain. In cases along Schoharie Creek where berms are not protecting important lands or infrastructure, it is recommended that their removal be undertaken.

Focus Area #17 – Review of Potential for Flood Attenuation

During the data gathering process and public input at the onset of this flood study, there was interest in determining the influence that upstream reservoirs may have had on the volume of flood flows experienced along Schoharie Creek during Tropical Storm Irene. Potential for flood storage was evaluated in Schoharie Reservoir and in the Blenheim-Gilboa Reservoir. Additionally, three large flood control dams are maintained in the upper Schoharie Creek Watershed within the Batavia Kill subwatershed. They were constructed by the U.S. Department of Agriculture Natural Resources Conservation Service (NRCS) following a 1960 flood. The pools created by the earthen dams normally contain little water, providing "void" space that is used to temporarily detain floodwater.

Reservoir storage during Tropical Storm Irene mitigated a moderate to substantial amount of downstream flooding. Storage in Schoharie Reservoir resulted in a reduction in peak flows of nearly 20 percent. Measures currently being implemented by the New York City Department of Environmental Protection (NYCDEP) will result in the potential for additional peak flow attenuation. Storage in the Blenheim-Gilboa Reservoir reduced peak flows by 8.1 percent. Neither reservoir is designed to operate in a flood control capacity. Flood control dams located in the upper Schoharie Creek Watershed, on the Batavia Kill, performed as designed and further reduced peak flows.

Focus Area #18 – Protection of Wetlands, Floodplains, and Green Infrastructure

An additional consideration to mitigate flood damages is to maintain the overall health of the watershed since watersheds naturally cycle, filter, and store water. Water enters the watershed as rain, which soaks into the ground, fills ponds and wetlands, and trickles into small intermittent streams that run into larger streams and finally rivers. The watershed stores water, moves it along, or transfers it underground to replenish groundwater. Land development activities change the surface of the land in the watershed by adding impervious surfaces, filling small wetlands, and rerouting streams. These activities change the path of water and ultimately influence where water goes during heavy storms.

Additional recommendations to reduce damages and maintain flood resiliency in the Schoharie Creek watershed are listed below:

Green Infrastructure Recommendations

- Reroute downspout water to rain barrels, cisterns, or permeable areas that allow it to soak into the soil.
- Create rain gardens that collect and absorb stormwater runoff.
- Create and maintain vegetated channels that collect, slow, and filter stormwater and allow it to soak into the soil.
- Install permeable pavements that intercept rainwater, allowing it to infiltrate into the soil.
- Use permeable pavement, trees, rain gardens, and bioswales in and adjacent to parking areas.

Vegetated Buffers Recommendations

- Protect existing buffers from removal, damage, major disturbance, and contamination. Consider local policies, zoning overlays, or buffer protection regulations.
- Prioritize the restoration and maintenance of buffers between the water and adjacent intensive land use areas.
- Keep construction, heavy equipment, and impervious surfaces out of the 100-foot buffer area to retain full benefits from the buffer.
- Establish vegetated buffers where there are none and replenish or replace vegetation to maximize buffer effectiveness. For planting plans, consult with local cooperative extension and regional Department of Environmental Conservation (DEC) offices. Maintain all three layers of vegetation wherever possible: trees, shrubs, herbaceous plants/unmowed grasses.
- Plant trees and shrubs for maximum soil stability and shade over the water.
- Use native plants to maximize sustainability of plantings and reduce cost of maintenance.
- Remove and replace invasive plants with care; contact your regional DEC office for information about management plans that minimize or avoid use of herbicides.
- Avoid mowing to the edge of the water. Mowed lawn does not provide the benefits that we receive from well-vegetated buffers but instead increases the amount of runoff and reduces groundwater recharge.

Recommendations for Protecting Forests and Open Space

- Develop a watershedwide Forest Protection Plan that encourages tree planting, directs development away from forested areas, reduces paved surfaces, and limits clearcutting or tree clearing in sensitive riparian areas.
- Encourage conservation easements that protect forested land from being developed.
- Enhance or restore the health, condition, and function of forest fragments in developed areas, improving conditions for tree growth to ensure long-term sustainability.
- Plant trees and shrubs in buffers along streams wherever feasible, focusing on reaches that are prone to erosion and flooding.
- Develop specific guidelines to limit impervious surfaces.
- Initiatives can be developed for subbasins with less than 10 percent impervious cover to keep this percent low.
- Policies can be developed for subbasins with impervious cover that approaches 10 percent to keep these areas below the threshold.

- Impervious surfaces can be reduced or replaced where possible in subbasins that are 10 percent or more impervious cover, and green infrastructure practices can be employed to mitigate impacts.
- In large subbasins, apply these recommendations to the smaller basins drained by local streams and wetlands.

Recommendations for Floodplains

- Adopt a Floodplain Management Plan for the entire watershed (consistent for all municipalities in the watershed) that may include floodplain ordinances, overlay zones, and guidelines for managing specific sites that are prone to flooding.
- Maintain unimpeded connection between a stream or river and its floodplain to improve floodwater retention and accommodation during floods.
- Use green infrastructure and best management practices within floodplains to improve existing conditions where structures are already present and reduce the extent of impervious surfaces within floodplains.

Recommendations for Streams and Wetlands

- Develop and implement a watershedwide Aquatic Buffer Ordinance or Water Resources Protection Plan that includes specific guidelines for the size and vegetative composition of buffers along all stream, lake, and wetland edges.
- Develop an inventory of "target" riparian areas for restoration to protect water quality, reduce flood damages, and provide habitat.
- Maintain natural stream channels and banks; avoid deepening or straightening channels.
- Use u-shaped rather than v-shaped runoff ditches along roads to decrease erosion and slow the water's flow.
- If there is uncertainty regarding whether a wetland is present in a particular location, have the site evaluated by a professional wetland delineator. Contact the County Soil and Water Districts for assistance.
- Avoid dumping trash and other debris (including organic debris and yard waste) in wetlands and streams.

General and Individual Property Flood Mitigation Recommendations

A number of risk areas within the Lower Schoharie Creek watershed are prone to flooding during severe rain events and associated high discharges in Schoharie Creek and its tributaries. Numerous flood mitigation alternatives have been developed and assessed in areas where flooding is known to have caused extensive damage to homes and properties. Alternatives have been evaluated through the use of hydraulic modeling.

Flood mitigation recommendations are provided that can be applied globally across the Lower Schoharie Creek watershed. In addition, more detailed analysis was conducted within 18 focus areas within the Lower Schoharie Creek watershed. A greater level of information was collected for these focus areas in order to assess potential flood mitigation projects. The following flood mitigation recommendations are provided for the Lower Schoharie Creek watershed:

Flood Preparedness – Home and business owners throughout the watershed can minimize flood damages and ensure personal safety by following the flood preparedness guidelines provided by the NFIP. The NFIP guidelines provide preparedness steps for before, during, and after a flood. Residents throughout the basin should sign up for their county's emergency notification system, which provides notifications to affected residents in the event of an emergency such as a flood. In each of the counties, residents can receive information by way of an emergency notification system.

Sediment Management – Local representatives often report a sentiment that dredging will alleviate flooding within the Lower Schoharie Creek watershed and should be pursued. In fact, in many cases dredging does little or nothing to reduce flooding and under some circumstances can lead to channel instability or overwidening, which can make flooding and sediment aggradation issues worse. The need for dredging can be reduced by reducing the sediment load at its source, by improving bed and bank stability, and by improving sediment transport through reaches that are vulnerable to deposition. In cases where sediment excavation in the stream channel is necessary, a sediment management plan or approach should be developed that would allow for proper channel sizing and slope. A sound sediment management program sets forth standards to delineate how, when, and to what dimensions sediment excavation should be performed. All necessary regulatory approvals must be obtained before sediment removal can take place.

Elevation of Structures – Elevation of a building above the level of flooding can be an effective way to reduce flood damages and is recommended where appropriate. Elevation of a house 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 or installed from basement joists or similar mechanism at an elevation no less than 1 foot above the base flood elevation.

Individual Property Protection – A variety of measures are available to protect existing public and private properties from flood damage, including construction of barriers, floodwalls, and earthen berms; dry or wet floodproofing, and utility modifications within the structure. 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, it is recommended that individual floodproofing be explored.

Acquisition of Floodprone Properties – Undertaking flood mitigation alternatives that reduce the extent and severity of flooding is generally preferable to property acquisition. However, it is recognized that flood mitigation initiatives can be costly and may take years or even decades to implement. Where properties are located within the FEMA-designated flood zone and are repeatedly subject to flooding damages, strategic acquisition, either through a FEMA buyout or other governmental programs, may be a viable alternative. Such properties could be converted to passive, nonintensive land uses.

Individual Property Flood Protection – On a case-by-case basis where homes and businesses are at risk due to flooding, individual floodproofing should be explored. Property owners within FEMA-delineated floodplains should be encouraged to purchase flood insurance under the NFIP and to make claims when damage occurs.

Road Closures – Risks associated with the flooding of roadways can be reduced by temporarily closing roads during flooding events. This requires effective signage, road closure barriers, and consideration of alternative routes. Roadway closure scenarios are investigated for several of the focus areas.

Stream Gauging Improvements – The installation of permanent stream gauging stations along floodprone tributaries to Schoharie Creek is recommended. There are currently no stream gauges on many of the Schoharie Creek tributaries, making early warning systems difficult to implement.

Table ES-2 presents a summary of recommended alternatives.

TABLE ES-2
Summary of Alternatives

Alternative	Recommended for Implementation?
Focus Area #1 – North Blenheim	
Alternative 1-1: Analysis of Historic Covered Bridge	M
Alternative 1-2a: Floodplain Enhancement	N
Alternative 1-2b: Floodplain Enhancement	N
Alternative 1-2c: Floodplain Enhancement	Y
Alternative 1-3: Sediment Removal	N
Focus Area #2 – Bear Ladder Road	
Alternative 2-1: Floodplain Modifications	N
Alternative 2-2: Raise Roadway	N
Alternative 2-3: Roadway Signage and Closure	Y
Focus Area #3 – West Fulton Hamlet	
Alternative 3-1: Replace Patria Road Bridge over House Creek	In future
Alternative 3-2: Replace West Fulton Road Bridge over Panther Creek	In future
Alternative 3-3: Create Compound Channel with Floodplain along Panther Creek	Y
Focus Area #4– Village of Middleburgh	
Alternative 4-1: Modify/Replace NYS Route 30 Bridge	N
Alternative 4-2: Floodplain Enhancement	N
Alternative 4-3: Right Bank Floodplain Enhancement	N
Alternative 4-4: Dredging	N
Alternatives 4-5a and 4-5b: Flood Control Levee and Wall	N
Alternative 4-6: Individual Building Relocation, Elevation, Floodproofing	Y
Focus Area #5 – Christmas Tree Lane Culvert	
Alternative 5-1: Increase Culvert Capacity	N
Alternative 5-2: Raise Roadway	N
Alternative 5-3: Relocate Roadway	N
Alternative 5-4: NYS Route 30 Roadway Signage and Closure	Y
Focus Area #6 – Route 145 Culvert	
Alternative 6-1: Replace Culvert	M
Alternative 6-2: Program of Debris Management	Y
Focus Area #7 – Village of Schoharie	
Alternative 7-1: Floodplain Enhancement	N
Alternative 7-2: Dredging	N
Alternatives 7-3a and 7-3b: Levee Scenarios	N
Alternative 7-4: Individual Building Relocation, Elevation, Floodproofing	Y
Focus Area #8 – Fox Creek	
Alternative 8-1: Modification/Replacement of the NYS Route 443 Bridge (Upper)	N
Alternative 8-2: Modification/Removal of Abutments at Schell Road Bridge	M
Alternative 8-3: Modification/Replacement of Schoonmaker Road	In future
Alternative 8-4: Modification/Replacement of Zimmer Road Bridge	Y
Alternative 8-5: Modification/Replacement of Sholtes Road Bridge	Y

Alternative	Recommended for Implementation?
Alternative 8-6: Modification/Replacement of the NYS Route 443 Bridge (Lower)	In future
Alternative 8-7: Development of Sediment Management Plan	Y
Alternative 8-8: Bank Erosion Repairs	Y
Focus Area #9 – Gallupville	
Alternative 9-1: Modification/Replacement of School Street Bridge	N
Alternative 9-2: Floodplain Enhancement	N
Alternative 9-3: Individual Building Relocation, Elevation, Floodproofing	Y
Focus Area #10 – Railroad Bridge over Schoharie Creek	
Alternative 10-1: Modification/Replacement of Canadian Pacific Railroad Bridge	N
Alternative 10-2: Compliance with and Enforcement of NFIP Criteria	Y
Focus Area #11 – Cobleskill Creek Confluence	
Alternative 11-1: Modify/Replace Church Street Bridge	N
Alternative 11-2: Modify/Replace Route 30A Bridge and Roadway	N
Alternative 11-3: Individual Building Relocation, Elevation, Floodproofing	Y
Alternative 11-4: Roadway Signage and Closure	Y
Focus Area #12 – Fly Creek	
Alternative 12-1: SCSWCD Natural Channel Design Scenario #1	N
Alternative 12-2: SCSWCD Natural Channel Design Scenario #2	Y
Alternative 12-3: Develop a Sediment Management Plan	Y
Focus Area #13 – Colyer Road, Burtonsville	
Alternative 13-1: Modification or Enhancement of Channel or Floodplain	N
Alternative 13-2: Individual Building Relocation, Elevation, Floodproofing	Y
Focus Area #14 - Warnerville Cutoff	
Alternative 14-1: Elevation of the Roadway	N
Alternative 14-2: Elevation of Roadway and Installation of Bypass Culvert	N
Alternative 14-3: Elevation of Roadway and Installation of Bypass Bridge	N
Alternative 14-4: Warnerville Cutoff Roadway Signage and Closure	Y
Focus Area #15 – Potential for Flood Attenuation in Upper Watershed	
Alternative 15-1: Potential for Flood Storage at Warner Lake	N
Alternative 15-2: Potential for Flood Storage at Onderdonk Lake	N
Alternative 15-3: Potential for Flood Storage at Other Lakes, Ponds, and Wetlands	conserve wetlands
Focus Area #16 – Review of Berms along Farm Fields	
Alternative 16-1: Removal of Agricultural Berms	where possible
Focus Area #17 – Review of Potential for Flood Attenuation in Reservoirs	
Focus Area #18 - Recommendations for Protection of Watersheds, Wetlands, Floodplains	
Use Green Infrastructure and Best Management Practices	Y
Establish and Maintain Vegetated Buffers	Y
Protect Forests and Open Space	Y
Protect and Reconnect Floodplains	Y
Develop Guidelines to Limit Impervious Surfaces	Y
Implement Watershedwide Wetland, Stream, and Buffer Protection	Y

1.0 INTRODUCTION

1.1 Project Background

The SCSWCD has retained MMI to complete a Flood Mitigation Study for the Lower Schoharie Creek watershed. Funding for this study has been provided from the NYSDOS under Title 11 of the Environmental Protection Fund for the Local Waterfront Revitalization Program. The study is part of Phase 1 of the Mohawk River Watershed Management Plan implementation.

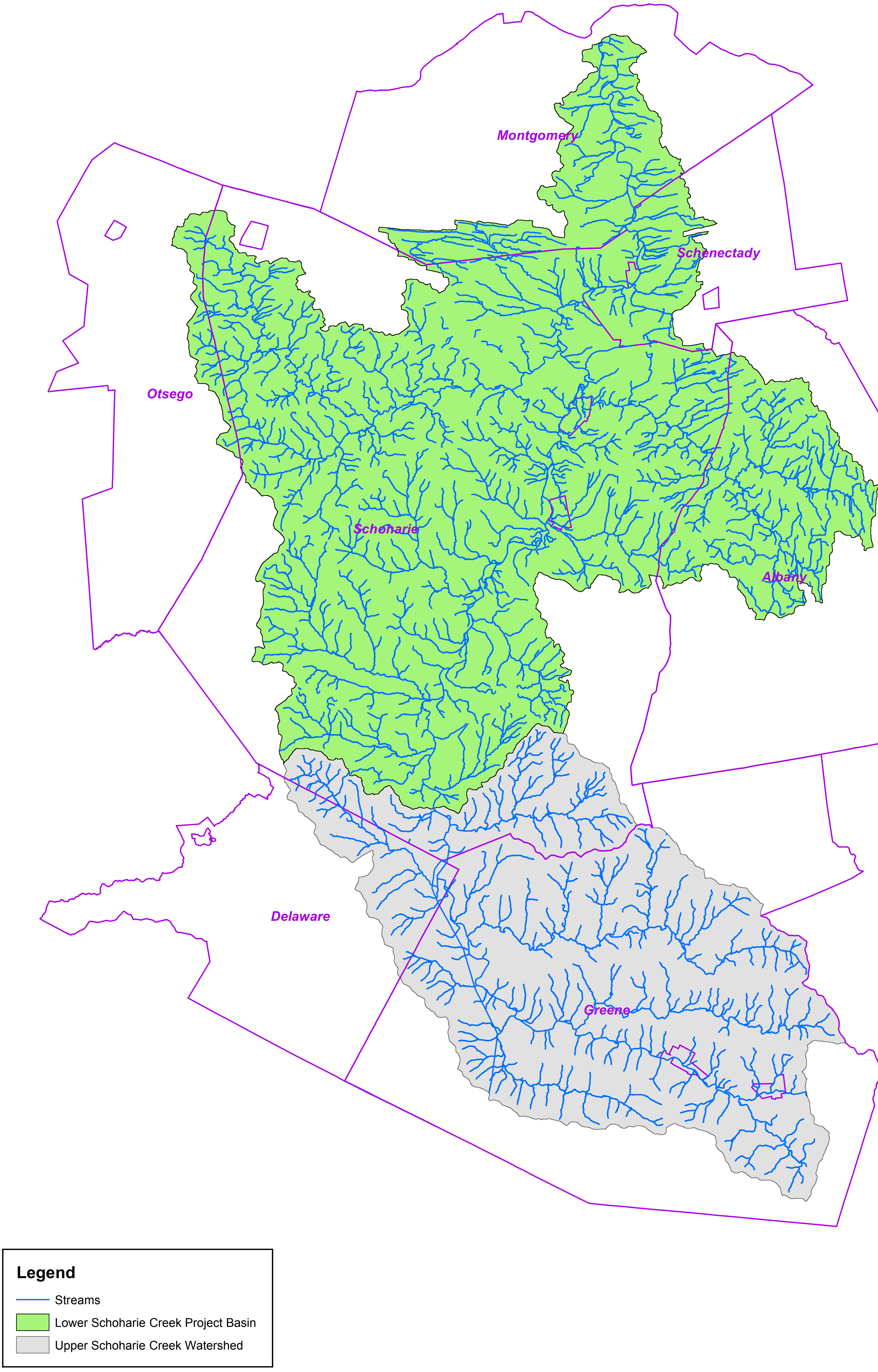
The subject Lower Schoharie Creek Flood Mitigation Study is an engineering feasibility analysis that develops a range of flood hazard mitigation alternatives, with the primary focus of identifying options that reduce flood elevations and inundation. During the completion of this study, MMI worked closely with the SCSWCD, elected officials, and members of the public who own homes or businesses within the watershed. Input from these individuals informed a greater understanding of flood damages and impacts and enabled a process of vetting flood mitigation alternatives.

1.2 Study Area

With a watershed of approximately 930 square miles, Schoharie Creek drains the northwestern Catskill Mountains. A tributary to the Mohawk River, Schoharie Creek flows through Schoharie County from south to north. The terrain within the watershed is a mix of mountainous landscapes and flat, narrow valleys. The elevation ranges from an average of about 1,200 feet in the northern limestone plateau section of the county to approximately 2,000 feet in the higher plateaus in the southern part of Schoharie County, with the headwaters in Greene County at an elevation of 4,000 feet (Schoharie County All-Hazards Mitigation Plan, 2006).

The Lower Schoharie Creek basin, comprising nearly two-thirds of the entire Schoharie Creek watershed, covers an area of 612 square miles and is 61 miles in length. The lower watershed extends into five counties, with the majority of the basin located within Schoharie County and small sections of the basin area located within Otsego County to the west, Montgomery County to the north, and Schenectady and Albany counties to the east. Figure 1-1 depicts the overall Schoharie Creek watershed and the Lower Schoharie Creek basin. Table 1-1 presents a list of the counties and towns that are located within the basin as well as the particular villages, hamlets, and place names that are referenced within this report.

The Schoharie Creek watershed includes numerous major tributaries as well as many smaller unnamed tributaries. The major tributaries are listed in Table 1-2. The course of Schoharie Creek includes two reservoir-dam systems: The Blenheim-Gilboa Dam, which is owned by the New York Power Authority (NYPA) and used to produce hydroelectric power, and the Schoharie Reservoir, a part of the New York City Water Supply System (FEMA, 2012 - Schoharie County Flood Insurance Study [FIS]).



SOURCE(S):

USGS StreamStats Version 3.0 (04/2016)
USGS National Hydrography Dataset (04/2016)
NYS GIS Clearinghouse (04/2016)

Figure 1-1: Schoharie Creek Watershed

Location:
Schoharie Creek Watershed, NY

N

Schoharie Creek Flood Study

Map By: EMH
MMI#: 4805-05
MXD: Q:\Projects\2884-08 Conesville LFA\GIS\Figure 1-1 Overall Schoharie Basin.mxd
1st Version: 04/25/2016
Revision: 8/25/2016
Scale: 1 in = 25,000 ft

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TABLE 1-1
Place Names within the Lower Schoharie Creek Watershed

County	Town	Village/Hamlet/Place Name
Otsego County	Cherry Valley	
	Decatur	
	Roseboom	
	Worcester	
Montgomery County	Charleston	Burtonsville
	Florida	
	Glen	
	Root	
Schenectady County	Duanseburg	
Albany County	Berne	West Berne
	Knox	
Schoharie County	Blenheim	North Blenheim
	Broome	Hauversville, Livingstonville
	Carlisle	
	Cobleskill	
	Esperance	Central Bridge, Sloansville
	Fulton	Breakabeen, Fultonham, West Fulton
	Gilboa	
	Jefferson	
	Middleburgh	Huntersland, East Cobleskill
	Richmondville	Warnerville
	Schoharie	Ecker Hollow
	Seward	
	Sharon	Sharon Springs
	Summit	Charlotteville, Clapper Hollow
	Wright	Galupville, Shutters Corners, Fox Creek, Echo Pond

TABLE 1-2
Major Tributaries within the Lower Schoharie Creek Watershed

Major Tributaries within the Lower Schoharie Creek Watershed		
Cobleskill Creek	Mill Creek	Fly Creek
Fox Creek	Line Creek	Little Schoharie Creek
Stony Creek	House Creek	West Kill
Mill Creek	Keyser Kill	Irish Creek
Wilsey Creek	Stony Brook	Ox Kill
Louse Kill	Switz Kill	House Kill
West Creek	Cole Brook	Betty Brook
Platter Kill	Beaverdam Creek	Panther Creek
Heathen Creek	Wharton Hollow Creek	Cripplebush Creek
King Creek		

The Lower Schoharie Creek basin was selected by the SCSWCD for analysis as a result of the highly floodprone nature of the region that has sustained extensive damage due to flooding, particularly in the recent past. While the entire Schoharie Creek basin is highly floodprone, the upper basin in Greene County has already been the subject of flood analyses funded by the NYCDEP through a number of Local Flood Hazard Mitigation Analyses (LFHMAs) and Local Flood Analyses (LFAs). As a result, there is a greater need to focus on the Lower Schoharie Creek basin. Much of the lower basin is located in Schoharie County, with a population in 2010 of 32,749 people. This area had long been inhabited by the Mohawk Indians, with the British establishing counties in the 1680s. Over time, the area has been sparsely settled, with the primary industry in Schoharie County being agriculture, predominantly dairy farming. More densely populated areas were settled in locations such as Middleburgh, Schoharie, and Cobleskill.

1.3 Nomenclature

All references in this document to right bank and left bank of Schoharie Creek and its tributaries refer to "river right" and "river left." The reference and orientation assumes that the reader is standing in the river looking downstream.

In order to have a common standard, FEMA's NFIP has adopted a baseline probability referred to as the base flood. The base flood has a 1 percent (one in 100) chance of occurring in any given year. In this report, the 1 percent annual chance flood is also 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).

2.0 WATERSHED INFORMATION

2.1 Initial Data Collection

Initial data collected for this study and analysis included publicly available information as well as input from soil and water county district representatives from each county, elected officials, and from the public. A brief discussion of major data sources follows.

FIS

FEMA FISs are available for all five counties within the Lower Schoharie Creek basin: Schoharie County (study dated February 16, 2012), Otsego County (study dated September 30, 2009), Schenectady County (study dated September 30, 2009), Montgomery County (preliminary study dated September 30, 2011), and Albany County (preliminary study dated March, 1, 2012).

For Schoharie County, FEMA's revised hydraulic analysis and floodplain mapping (effective in February 2012) were completed using aerial topographic maps produced from 2001 photographs. An important byproduct of an FIS is the Hydrologic Engineering Center – *River Analysis System* (HEC-RAS) computer model that is available for professional use and a key component of the subject study. The digital FIRM depicts the areas of predicted flooding during the 100-year frequency event, which frequently extend 500 feet to 1,000 feet or more on either side of Schoharie Creek. The area predicted to be flooded during the 100-year frequency event is known as the SFHA.

Stream Gauging Network

The United States Geological Survey (USGS) operates and maintains six active stream flow gauges within the Lower Schoharie Creek watershed. These gauges record daily stream flow, including flood flows. This data is essential to understanding long-term trends and is covered in more detail in the hydrology discussion in this report. Gauge data can be utilized to determine flood magnitudes and frequencies. Additionally, real time data is available at certain gauges to monitor water levels and provide flood alerts. Stream flow data and water levels are available at http://nwis.waterdata.usgs.gov/nwis/peak.

In addition to the USGS gauges, SCSWCD has established stream gauges in the watershed that measure water surface elevation and provide early warning alerts when certain water levels are reached or when water surface elevations undergo a rapid rise. These gauges are located on Schoharie Creek at Middleburgh and Esperance and on Fox Creek in Schoharie. Additional information on the stream gauging network is included in the hydrology section of this report.

Schoharie County Multi-Jurisdiction All-Hazard Mitigation Plan

The 2013 Schoharie County Multi-Jurisdictional All-Hazard Mitigation Plan provides a concise summary of the flood characteristics of the Schoharie Creek watershed with the purpose of giving Schoharie County and its municipalities a plan for implementing hazard mitigation projects that will minimize disaster impacts and losses.

According to the 2013 Schoharie County All-Hazard Mitigation Plan, 29 flood events have occurred since 1996, 13 of which have had major or significant community impacts. The average recurrence is one to two flood events each year in Schoharie County with a 72 percent chance each year of having a flood with significant community impacts. There is a 56 percent chance each year of a flood that will result in federal disaster declaration. In 1996, six separate flood events occurred, and in 2003, four flood events occurred. The villages and hamlets along the course of Schoharie Creek, including Gilboa, Blenheim, Fulton, Middleburgh, Schoharie, and Esperance, are most vulnerable to flood impacts and losses.

The After-Action Report and Improvement Plan prepared after the flooding in 2011 identified Fox Creek-Warner's Lake, West Kill, Cobleskill Creek, Fly Creek, Little Schoharie Creek, and Line Creek as areas where tributary flooding occurred and should be targeted for future monitoring.

The 2006 and the 2013 Schoharie County All-Hazards Mitigation Plans suggest the following recommendations for Schoharie County:

- Where not already completed, local municipalities should consider implementing land use regulations to limit the ability of private property owners to rebuild in high-hazard floodplain areas.

- All municipalities in Schoharie County should participate in the NFIP. Construction standards for structures in the mapped 100-year floodplain or floodway have been regulated through flood damage prevention laws since the 1980s. Each municipality has a designated floodplain administrator for whom proper orientation and training should continue to be a priority.

- Implement stormwater management projects such as improving roadway infrastructure (i.e., culverts and drainageways), extending sanitary sewers, or enacting local laws that limit the percent of impervious cover within a parcel or that require implementation of erosion control techniques during construction.

- Continued encouragement of stream stabilization projects throughout the watershed

- Continued participation and encouragement for funded buyouts of repetitive loss properties (RLPs) as well as land located within the floodplain (for example, approximately 100 floodplain acres have been acquired in the county and the land protected as open space).

- All Schoharie County jurisdictions should participate in the NFIP. The NFIP identifies properties that have been repeatedly flooded and where multiple claims for flood losses have been made through the NFIP fund. There are 265 properties located in high-risk flood zones (Zone A) that carry NFIP coverage. Approximately 38 percent of all NFIP claim costs were the result of damage to RLPs. There are 67 RLPs and one Severe Repetitive Loss Property (SRLP) identified in Schoharie County. The NFIP targets RLPs and sets priorities to use hazard mitigation grant funds to buy out or retrofit RLPs. The NFIP also plans to phase out coverage or begin charging full and actuarially based rates for RLP owners who refuse to accept FEMA's offer to purchase or mitigate the effect of floods on their structures.

  The one property in Schoharie County that was identified as a SRLP was located in the town of Middleburgh and received more than $89,000 in payments over the course of four flood events. More than 1,880 property owners, families, and residents from Schoharie County applied for disaster relief due to the flooding in August and September 2011 from Tropical Storms Irene and Lee. This was the greatest number of applicants for any New York county affected by these back-to-back flood events.

Fifty-five properties located in the high-risk A zones that were damaged by the 2011 floods have been approved for buyouts and demolition. Building officials determined that 657 homes in the 15 towns and villages affected by the floods sustained major damage, and repair costs for residential structures are expected to reach $90 million. One hundred floodplain acres have been acquired, and five homes, most having historic significance, have been elevated.

In 2004, Schoharie County received a State Archives and Records Administration grant for equipment, training, and software to better organize the county Geographic Information System (GIS) database. Several of the methods used to estimate potential losses for certain hazards will be modified and improved as the data contained within the Schoharie County GIS is further developed.

In terms of promoting flood awareness, training, and education, Schoharie County produced a 30-minute flood education video to run annually on local cable stations and to distribute to schools and libraries within the county. Additionally, using New York State Department of Environmental Conservation (NYSDEC) funds, the county installed 61 signs at locations where roads intersect SFHAs or at municipal boundaries. The signs state "Flood Zone Regulation in Effect" and have been useful in prompting questions from the general public about flood issues.

Water Quality Reports

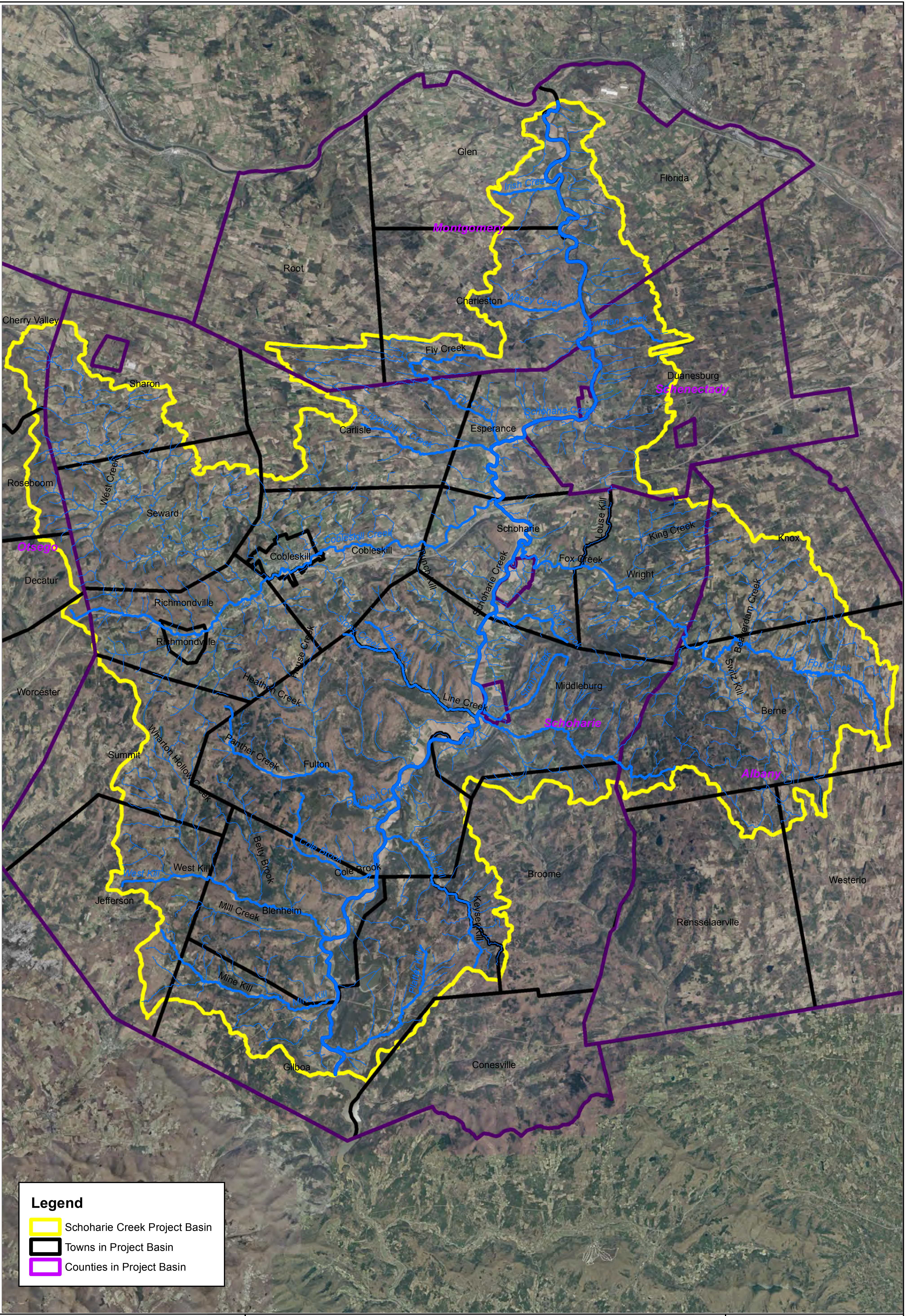
For the entire watershed, NYS's 2014 Section 303(d) inventory only lists Cobleskill Creek and its tributaries as impaired. As such, a Total Maximum Daily Load (TMDL) assessment is required for Cobleskill Creek due to pathogens from an on-site water treatment system (WTS). No other tributaries within the Lower Schoharie Creek watershed have been listed.

2.2 Field Assessment

Initial field investigations were conducted during late 2015 and early 2016. MMI staff conducted on-the-ground assessments and visual inspections throughout the Lower Schoharie Creek basin. The inspections included visual assessment of the riparian corridor, visible infrastructure within the corridor, and existing land use and development patterns. The streambed and banks, riparian cover, and channel structure were noted as were key drainage system outfalls that discharge into the creeks, dams, weirs, bridges, culverts, and other structures in and along the creeks. Photographic documentation was undertaken with select elements being incorporated into subsequent presentations/reports. The emphasis of these inspections was placed on the conveyance of floodwaters, sediment, and debris. Data gathered during field investigations were documented in GIS and Google Earth.

2.3 Watershed Land Use

Figure 2-1 is a watershed map of the Lower Schoharie Creek watershed. Schoharie Creek flows through or borders 10 towns including the towns of Gilboa, Blenheim, Fulton, Middleburgh, Schoharie, Esperance, Duanseburg, Charleston, Florida, and Glen. The Lower Schoharie Creek drains an area of 612 square miles and outlets into the Mohawk River at a point 61 miles downstream of the Gilboa Dam. The Schoharie Creek basin is 76 percent forested (*StreamStats*, 2015) with a mix of agricultural uses located primarily in the river valley, residential and commercial land uses concentrated in and around the hamlets, and rural residential uses outside of the hamlets.



SOURCE(S):	Figure 2-1: Lower Schoharie Creek Watershed Map	Location: Schoharie Creek Watershed, NY
USGS StreamStats Version 3.0 (04/2016) USGS National Hydrography Dataset (04/2016) NYS GIS Clearinghouse (04/2016)	N Schoharie Creek Flood Study Map By: EMH MMI#: 4805-05 MXD: Q:\Projects\4805-05 Schoharie Basin Flood Analysis\GIS\MXD\Figure2-1ProjectBasinMap.mxd 1st Version: 04/25/2016 Revision: 9/22/2016 Scale: 1 in = 17,500 ft	MILONE & MACBROOM 231 Main St, Ste 102 New Paltz, NY 12561 (845) 633-8153 Fax: (845) 633-8162 www.miloneandmacbroom.com

Major population centers within the basin are the town and village of Cobleskill, population of 11,303; the town and village of Esperance, population 2,421; the town and village of Middleburgh, population 5,246; and the town and village of Schoharie, population 4,127 (U.S. Census Bureau, 2010). Other land uses include the SUNY Cobleskill College campus, several limestone quarries, and three natural gas and propane pipelines that traverse the county.

2.4 Watershed and Stream Characteristics

The Schoharie Creek watershed is asymmetrical in shape, with a south-to-north orientation. It has very steep, mountainous slopes that flow into a broad valley. The terrain within the watershed is a mix of mountainous landscapes and flat, narrow valleys while the main channel of Schoharie Creek flows through a broad, flat-bottomed valley. The elevation ranges from an average of about 1,200 feet in the northern limestone plateau section of the county to approximately 2,000 feet in the higher plateaus in the southern part of Schoharie County, with the headwaters in Greene County at an elevation of 4,000 feet (Schoharie County All-Hazards Mitigation Plan, 2006).

The length of the Schoharie Creek from its headwaters on Blackhead Mountain to its outlet at the Mohawk River is 98.5 miles. The portion of the Schoharie Creek that is the focus of this study extends from just downstream of the Gilboa Dam to the confluence with the Mohawk River and is 61 miles. Schoharie Creek can be characterized as an alluvial river, meaning its channel is located on sediment previously placed by the river. Alluvial rivers adjust their shape, size, and slope in response to flow rates and sediment loads. Schoharie Creek and its tributaries flow over exposed bedrock in several locations.

Along the general course of the river, surficial geology is recent alluvium, which consists of oxidized fine sand to gravel and may be overlain with silt in the valley floodplains. The watershed as a whole is predominantly underlain with till of variable texture and usually poorly sorted sand, a result of deposition from glacial ice, with permeability and thickness varying. The underlying bedrock within the watershed consists of shale, limestone, and greywacke (NY State Museum, 2015).

2.5 Hydrology

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 2-1 is a list of active and inactive (historic) USGS water surface stream gauging stations within the lower watershed from north to south. This portion of the Schoharie Creek watershed extends to five counties: Schoharie County, Otsego County, Schenectady County, Albany County, and Montgomery County.

FEMA FISs are available for each county, including Schoharie County in the center, Otsego County to the west, Montgomery County to the north, and Schenectady and Albany counties to the east. The purpose of a FEMA FIS is to determine potential floodwater elevations and delineate floodplains to identify flood hazard areas and establish flood insurance rates.

The hydrologic analysis methods employed by FEMA throughout the study area follow 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 NYS. The Schoharie Creek watershed falls within USGS Regions 4 and 4a for NYS. 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).

TABLE 2-1
USGS Gauging Stations within the Lower Schoharie Creek Watershed

USGS Gauge Number	Location	Drainage Area (sq. mi.)	Period of Record	Active?
01351500	Schoharie Creek at Burtonsville	885	1939-2015	Yes
01350900	Beaverdam Creek near Knox	7	1963-1974	No
01351000	Fox Creek at West Berne	67	1925-1974	No
01350500	Schoharie Creek at Middleburgh	534	1909-1976	No
01350355	Schoharie Creek at Breakabeen	444	1975-2015	Yes
01350200	West Kill at North Blenheim	45	1975-1987	No
01350180	Schoharie Creek at North Blenheim	358	1969-2015	Yes
01350140	Mine Kill near North Blenheim	16	1975-2015	Yes
01350120	Platter Kill at Gilboa	11	1975-2015	Yes
01350101	Schoharie Creek at Gilboa	316	1936-2015	Yes

sq. mi. = square mile

Table 2-2 lists peak discharges for the 10-, 50-, 100-, and 500-year flood events at various points along the Schoharie Creek within the study area as determined by FEMA and reported in the FIS for each county.

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

Location	Nearest USGS Stream Gauge	Drainage Area (sq. mi.)	10-year flood event	50-year flood event	100-year flood event	500- year flood event
At downstream corporate limits of town of Esperance	Burtonsville	886.3	43,200	71,100	85,700	128,000
At the upstream corporate limits of town of Schoharie	Middleburgh	550.42	42,032	69,178	83,383	124,540
At the downstream corporate limits of village of Middleburgh	Middleburgh	546.43	42,018	69,155	83,356	124,499
At downstream corporate limits of town of Fulton	Breakabeen	504.09	41,872	68,915	83,066	124,066

sq. mi. = square mile cfs = cubic feet per second

In addition to the USGS gauges, SCSWCD has established stream gauges in the watershed that measure water surface elevations in 15-minute intervals. These gauges are located on Schoharie Creek at Middleburgh and

Esperance and on Fox Creek in Schoharie. Following Tropical Strom Irene in August 2011, the USGS sent personnel to survey the high water marks (HWMs) in 30 locations throughout the Schoharie basin (USGS, 2014).

Hydrologic data on peak flood flow rates within the Lower Schoharie Creek basin are also available from the USGS *StreamStats* program. *StreamStats* is a web-based GIS that is used to access stream flow statistics, drainage basin characteristics, and other information for selected sites on streams. Basin characteristics include drainage area, stream slope, mean annual precipitation, and percentage of forested area.

For the purpose of the subject study, peak flow rates determined by FEMA are used where available. For analysis within portions of the watershed where no FEMA flows have been determined, *StreamStats* was used to estimate peak flow rates.

3.0 EXISTING FLOODING HAZARDS

3.1 Flooding History in the Schoharie Creek Basin

The Schoharie Creek basin is particularly prone to flooding due to a number of factors, including the location of its headwaters in the Catskill Mountains; the low permeability of the mountainous landscape; the lack of wetland habitats or lakes within the watershed to retain stormwaters; and the prevalent winds, which during coastal storms push the storm air masses up and over the mountains, causing cooling and subsequently high amounts of precipitation. As the wettest region in NYS with over 60 inches of precipitation annually, rainfall events of 5 inches are common. These and other factors contribute to the flash flood conditions within the basin.

A number of documents have been reviewed to assess the flood history within the Schoharie Creek Watershed basin. According to the *History of Schoharie County Floods* (2012), which reviewed historic newspaper articles and personal recollections, 41 major floods have occurred within the Schoharie Creek basin from 1784 to 2011 (Schoharie County Historical Society, 2012). Since that publication, an additional flood occurred in summer 2013. The USGS published a report entitled *Floods of 2001 in New York*, which focuses, in part, on the impact of Tropical Storm Irene within the Schoharie Creek basin (Lumia et al., 2014). Table 3-1 provides a summary of the 42 floods that have occurred since 1784. Beginning in March 1940, a USGS stream gauging station on the Schoharie Creek at Burtonsville (gauge #01351500) was installed to record discharge levels (peak stream flow) and other parameters. Where available, discharge levels are noted in Table 3-1. A time line is presented in Figure 3-1.

TABLE 3-1
Summary of Major Floods within the Schoharie Creek Watershed

Storm #	Date	Comments	Discharge at USGS Gauge Schoharie Creek at Burtonsville NY (cfs)
1	spring 1784	Flooding triggered by ice jams, extensive damage, people petitioned to be exempt from taxation. Waters overtopped banks and damaged farmland and destroyed many buildings.	unknown
2	Jan 31, 1839	Flood on Schoharie Creek and tributaries. Water suddenly rose 26 feet. Records of damage in Esperance include destruction of tannery, sawmill, bridges, gristmill, homes, stores, lumber, and tools.	unknown
3	Nov 15, 1849	Schoharie Creek flooded 4 feet higher than in the past 20 years. Farm animals were lost. In Middleburgh, milldams, bridges, corn crops and fences were damaged. A Mill store (now today's Mill Farm Greenhouses) was destroyed.	unknown
4	May 3-4, 1854	Creek overflowed. Timber and saw logs carried away by creek. Plank Roads in Schoharie, Richmondville, and Middleburgh were damaged. Loss of bridge at North Blenheim.	unknown

Storm #	Date	Comments	Discharge at USGS Gauge Schoharie Creek at Burtonsville NY (cfs)
5	Aug 2, 1856	Very high flows. Fields submerged, bridges washed away, and barns, fences etc. were destroyed. A low estimate of $50,000 in damages was given for the southern parts of Schoharie County. In Blenheim, a bridge was badly damaged.	unknown
6	Feb 12, 1857	Toll bridge across the Schoharie was badly damaged. Bridge at Middleburgh, originally built in 1813, was completely destroyed. Central bridge over the Schoharie and the Richmond Plank Road were badly damaged.	unknown
7	spring 1869	Seventy bridges in the town of Berne were reported destroyed.	unknown
8	Oct 7, 1869	Schoharie Creek flooded 22 inches higher than ever before. In the southern part of the county, nearly all bridges were carried away. The Schoharie railroad line, numerous roads, a kiln, gristmill, barns, and crops were all badly damaged.	unknown
9	1871	Flooding was reported on the Westkill Creek in North Blenheim. Flooding damaged a total of eight bridges and 70 miles of roads in Schoharie County, and the course of the Schoharie Creek was altered.	unknown
10	June 7, 1874	Flooding reported in many locations. Channel was four times its usual width, and much of the best farmland was washed away. Roads and bridges were badly damaged, and crops were badly or entirely destroyed.	unknown
11	Sep 1, 1885	Very high flows from tributaries caused damage to livestock and many bridges. Stores, barns, and a machine shop were damaged. Damage to crops (especially hops) was estimated at $10,000. The railroad line was damaged. In Sharon Springs, many buildings were washed away or destroyed.	unknown
12	Sep 24, 1885	Eight bridges washed away in the town of Summit in Schoharie County.	unknown
13	Dec 15, 1901	Schoharie River reached highest levels in 32 years, and according to historic reports, this flood was 2nd only to the 1869 flood. In Schoharie Village, the flats were flooded, the railroad tracks were covered, and cellars were filled. Bridges and roads were damaged or destroyed throughout the basin. Houses and buildings were flooded.	unknown
14	March 6, 1902	The Schoharie Creek expanded over the flats; ice jams caused damage to one of the piers of Middleburgh Covered Bridge. Bridges were carried away at Shutters Corners and at West Berne on the Fox Creek.	unknown
15	July 24, 1902	There was great damage to crops, highways, and railroads due to heavy rains.	unknown
16	Oct 15, 1903	Flood greater than the 1869 flood resulting from over 10 inches of rain within 24 hours. The flooding destroyed crops, fences, buildings, roads, bridges, dams, and hop poles. Homes and businesses had cellars flooded.	unknown
17	March 21, 1912	Charlotteville reported a large flood with the whole village flooded and many cellars filled with water.	unknown
18	August 1915	There was extensive damage from this flood. In Middleburgh, Huntersland Stream and Little Schoharie flooded homes and property, damaged roads, and destroyed livestock and farm equipment. Every bridge with the exception of the one at Krumm's Falls, on the Keyserkill was swept away, and many roads were swept away. In Broome, 48 bridges were washed away or undermined.	unknown

Storm #	Date	Comments	Discharge at USGS Gauge Schoharie Creek at Burtonsville NY (cfs)
19	Feb 14, 1923	The Town of Jefferson reported a large flood where two bridges washed away, and another bridge, one made of iron, was moved; roads were washed out, and deep gullies were made. Taxes had to be raised "abominably" as a result.	unknown
20	July 12, 1928	In Schoharie, floodwaters rose 10 feet above the low water mark and washed away a temporary bridge at Bridge Street.	unknown
21	March 18-19, 1936	Schoharie County reported the worst flood since 1903. Melting snow and continuous rain caused Schoharie and tributaries to overrun their banks. In the village of Schoharie and town of Middleburgh, great flooding was reported. Main Street in Middleburgh flooded as well as the high school and other roads. Thousands of dollars of damage. Bridges on smaller streams washed out. The Civilian Conservation Corp workers rescued families from flooded homes in Livingstonville.	unknown
22	Sep 22, 1938	This storm was also known as the New England Hurricane or The Long Island Express. Flooding occurred throughout the basin from the Cobleskill Fairground to Schoharie village. Many bridges were destroyed. Telephone service was disrupted due to falling trees severing telephone lines. Rivers changed their courses.	unknown
23	March 31, 1940	In the village of Middleburgh, Main Street flooded with 18 inches of water and ice.	25,200
24	March 30, 1951	In Middleburgh, four men were trapped in four separate automobiles in floodwaters on Route 145 and Route 30. All were rescued.	37,900
25	Aug 19, 1955	Flooding resulting from two hurricanes (Connie and Diane, still the wettest tropical cyclones to hit the Northeast U.S.) in less than a week. Crops and farmland flooded. Schoharie Creek rose 5 feet above normal depth.	13,300
26	Oct 17, 1955	A 100-year flood on the Schoharie and Catskill Creeks caused by 16 to 18 inches of rain over the Tannersville area. Worst flood in county history up to this point. Primarily hit Schoharie and Middleburgh. Water spilled over Gilboa Dam, and the Schoharie Creek grew to a half mile to a mile wide. There was extensive damage to homes, businesses, and farmland including crops and livestock. Electricity was out for 3 days, and telephones were out for 2 weeks. Roads were flooded and badly damaged.	76,500
27	Sep 12, 1960	Flooding due to Hurricane Donna. In the morning, water was 33' below crest of Gilboa Dam. In 18 hours, the reservoir was full and spilling over the dam. Flooding was terrible upstream of the dam and outside of the focus area for this report.	30,500
28	March 11, 1964	Ice jams on Cobleskill Creek and its tributaries lead to flooding. Cobleskill Fire Department had to rescue college students in a row boat.	29,400
29	June 23, 1972	Hurricane Agnes. Water was 2.5 feet over the spillway. This was caused by removal of clog near Harriman Dam in Tannersville (Greene County). Approximately 60 families were evacuated along Route 30 north of Blenheim. Family rescued from home in Blenheim. County estimated, in request to Department of Agriculture aid request, damages totaling $65,000.	28,500

Storm #	Date	Comments	Discharge at USGS Gauge Schoharie Creek at Burtonsville NY (cfs)
30	July 3-4, 1974	Heavy rain caused flooding throughout the basin. Roads in Middleburgh, Cobleskill, and Warnerville flooded. Bridge Street in Schoharie also flooded. There was extensive damage in West Middleburgh and Sharon Springs.	12,900
31	Dec 12, 1974	Three families, totaling eight people, were evacuated from homes along Schoharie Creek between Breakabeen and North Blenheim.	25,200
32	Oct 17, 1977	Four inches of rain fell within 24 hours. Homes evacuated, power outages, and roads coated with "slush."	22,800
33	March 22, 1980	Almost 10 inches of rain fell. Bridges washed out, roads closed, and communities isolated, including Middleburgh.	40,300
34	May 30, 1984	Schoharie, Catskill, and Fox Creeks flooded. Flooding closed roads in northern part of Cobleskill. Gravel supporting Delaware and Hudson Railroad tracks was washed away.	39,400
35	April 3-6, 1987	Coastal storm of 9 inches of rain. Extensive flooding and damage. Ten lives lost when NYS Thruway Bridge over Schoharie Creek collapsed. Middleburgh's Main Street flooded. Schoharie County estimates millions in damage.	64,900
36	Jan 19, 1996	Over 4.5 inches of rain fell, and as much as 45 inches of snow melted resulting in major flooding. Ice jams occurred. Two lives were lost in the village of Schoharie. Several houses were damaged or destroyed. Farmland was damaged and livestock drowned. Roads closed and some badly damaged. Damaged houses were purchased by FEMA and demolished.	81,600
37	Sep 18, 1999	Hurricane Floyd dropped up to a foot of rain in the Catskills.	26,100
38	April 2-3, 2005	There was an excessive rain event, and after a wet March with areas of frozen ground remaining, this led to flooding on all major rivers as well as small streams. Most significant flooding was on Schoharie Creek. Parts of Middleburgh and Schoharie were inundated. Roads were damaged with three to four dozen road closures. Homes were also damaged, and more than 40 families had to evacuate their residences. State of Emergency declared. Shelters set up and populated.	56,100
39	June 28, 2006	Torrential rain. Areas along Schoharie and Cobleskill Creeks experienced the most flooding, affecting the villages of Richmondville and Cobleskill. President Bush signed a major disaster declaration for NYS for cleanup efforts.	18,000
40	Oct 1, 2010	Six to nine inches of rain fell in Prattsville. Discharge was 3rd highest daily average recorded since records kept. Schoharie Reservoir did not overflow, which is attributed to a drought prior to storm.	12,300

Storm #	Date	Comments	Discharge at USGS Gauge Schoharie Creek at Burtonsville NY (cfs)
41	Aug 28, 2011	Hurricane Irene – Up to 14 inches of rain fell causing the Schoharie Creek to flood the entire valley from Gilboa to Esperance, including the villages of Blenheim, Breakabeen, Middleburgh, Schoharie, Gallupville, Old Central Bridge, parts of Sloansville, and Esperance. Largest flood that has been recorded. DEP lost power and was unable to monitor the Gilboa Dam. Sirens at the dam were triggered due to large quantities of rain. All those within the dam's projected flood zones (approximately 7 percent of Schoharie County) were evacuated. The Gilboa Dam held, and no lives were lost. 911 was down due to flooding. State of Emergency declared. Extensive flooding, road closures, and bridges out. The historic Old Blenheim Bridge was swept away. Then Tropical Storm Lee brought additional rain to the region on September 7, 2011.	128,000
42	June 13, 2013	Thunderstorms across Schoharie County produced flash flooding. Three inches of heavy rain in a short time overwhelmed drainage systems, damaged culverts and roads, and a State of Emergency was declared for the villages of Middleburgh and Schoharie and town of Schoharie. Shut down roads, soaked farm fields, flooded some homes and businesses, stranded motorists, and forced dozens of Middleburgh elementary students to remain in school for hours.	22,200

Of the 11 largest events on record, all but three were influenced by snowmelt. Other floods were due to hurricanes in October 1955 and two November rainstorms (FEMA, 2012 – Schoharie County FIS). Below is an expanded discussion of the larger or more significant floods within the basin. For flood events prior to 1940, peak discharge data is not available such that the precise magnitude of the flood is not known; however, personal stories and newspaper articles give a sense of the extent of the flooding damage.

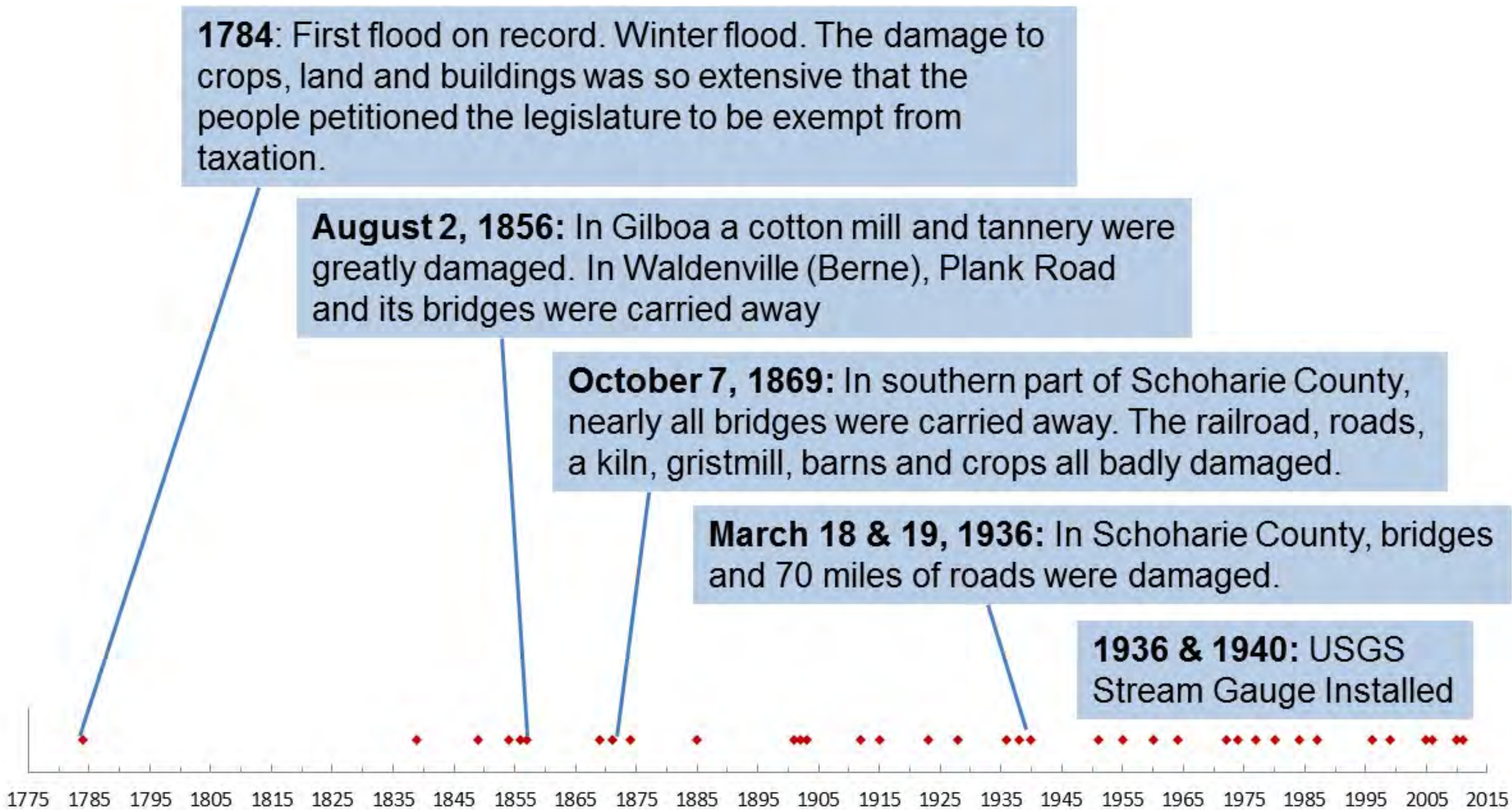
The first flood on record occurred in the **spring 1784**, a year following the end of the American Revolution. The flooding was triggered by ice jams, causing damage to crops, land, and buildings that was so extensive the people petitioned the legislature to be exempt from taxation.

The flood on **August 2, 1856**, was described as, "*the most disastrous freshet ever witnessed in this county*" (Schoharie County Historical Society, 2012). On Fox Creek at Shutters Corners between Schoharie and Gallupville, a farmhouse containing two individuals was swept downstream. Also swept away were a barn, livestock, and grain. In Gilboa, a cotton mill and tannery were greatly damaged. In Waldenville, Plank Road was entirely washed away, and its bridges were destroyed. In Middleburgh, Judge Danforth's bridge was badly damaged. As noted in Table 3-1, damages for the southern portion of Schoharie County were given a low estimate of $50,000.

On **October 7, 1869**, with the Schoharie Creek a reported 22 inches higher than ever before, the Schoharie railroad line was damaged, a brick kiln was destroyed, and a barn near the creek was swept away. In Middleburgh, a gristmill and dam were damaged. In the southern part of the county, nearly all bridges were carried away.

Figure 3-1

Time line created from flood information in *History of Schoharie County Floods,* 2012. Schoharie County Historical Society



On **June 7, 1874**, flooding was reported in many locations within the basin, including in the upper section of Blenheim Village. The Westkill floodwater levels were very high and carried off a mill dam and bridge, a shoe shop, a house and barn, and another house (and 86 beehives). A tributary of the Westkill carried away a saw mill. Also washed away were bridges, mill dams, and roads in many places.

On **December 15, 1901**, the Schoharie River reached its highest levels in 32 years, and according to historic reports, this flood was second only to the 1869 flood. In Schoharie Village, the flats were flooded, the railroad tracks were covered, and cellars were filled. Bridges and roads were damaged or destroyed throughout the basin.

On **October 15, 1903**, according to historic accounts, a flood greater than the 1869 flood resulted from over 10 inches of rain within 24 hours. The flooding destroyed crops, fences, buildings, roads, bridges, dams, and hop poles throughout the basin. Homes and businesses had cellars flooded on Main Street, Foundry Street, and River Street in Middleburgh. The short bridge on the M&S railroad was moved from its foundation, and several washouts of the Schoharie Valley railroad were reported.

From a flood in **August 1915**, there was extensive damage throughout the watershed. In Middleburgh, Huntersland Stream and Little Schoharie flooded homes and property, damaged roads, and destroyed livestock and farm equipment. Similar damage occurred in Middleburgh and Broome, including 48 bridges that were washed away or undermined in Broome, and all bridges and portions of the road bed were washed away along Brooky Hollow Creek in the Huntersland portion of Middleburgh. Every bridge, with the exception of the one at Krumm's Falls, on the Keyserkill was swept away, and many roads were swept away.

On **March 18 and 19, 1936**, Schoharie County reported the worst flood since 1903. Melting snow and continuous rain caused the Schoharie Creek and tributaries to overrun their banks. Flooding damaged a total of eight bridges and 70 miles of roads in Schoharie County. In the village of Schoharie and town of Middleburgh, substantial flooding was reported. In addition, roads in Middleburgh, Breakabeen, Blenheim, Livingstonville, and Cobleskill were closed. Four bridges washed out: two in Livingston, one at Clauverwie Street in Middleburgh, and one in Gallupville. The Catskill Creek bridge was saved using ballast against the piers. Two homes were destroyed in the village of Blenheim. Crops were damaged and livestock killed. The Civilian Conservation Corp workers rescued families from flooded homes in Livingstonville where roads were flooded, and two bridges were washed away. Thousands of dollars of damage were estimated, and the course of the Schoharie Creek was altered.

On **September 22, 1938**, a storm, also known as the New England Hurricane or The Long Island Express, hit the region. The Cobleskill Fairground was covered in a few inches to 6 feet of water during the fair. Livestock was lost, some barns and trailers were washed away, and the grandstand, paddock, and racetrack flooded. Roads were closed including from Ecker Hollow to Middleburgh, and many bridges were destroyed. It was not possible to travel from West Fulton to Cobleskill due to the need for temporary bridges. Telephone service was disrupted due to falling trees severing telephone lines.

As a result of Hurricanes Connie and Diane, a 100-year flood event occurred on **October 17, 1955**, within the Schoharie Creek watershed. It was recorded that 16 to 18 inches of rain fell to the south over the nearby Tannersville area, considered the worst flood in Schoharie County history up to that point with Middleburgh and Schoharie sustaining the worst damage. A peak flow of 76,500 cfs was recorded at Burtonsville. Extensive damage occurred to homes, businesses, and farmland including crops and livestock. Electricity was out for 3 days, and telephones were out for 2 weeks. Roads were flooded and badly damaged.

Over 50 homes in Middleburgh were evacuated, and over 250 people took up shelter in the Schoharie school gymnasium as a result of the October 1955 flood. West Point amphibious duck boats were used to reach towns that were isolated and disconnected by flooding. A State of Emergency was declared in Middleburgh, Schoharie, and Cobleskill. The Red Cross surveyed Schoharie and found that 120 homes were evacuated, 40 had major damage (i.e., water above the first floor), and 6 had major structural damage. Typhoid clinics were set up, and milk pasteurizing plants were tested for contamination. Extensive damage to crops and property were reported, cows drowned, and farm equipment was destroyed. Governor Harriman and President Eisenhower petitioned to have appropriate agencies examine flooding in the Schoharie Valley.

From **April 3 to 6, 1987**, a coastal storm dropped over 9 inches of rain within the basin resulting in a peak discharge of 64,900 cfs. This storm is well remembered as 10 lives were tragically lost when the NYS Thruway bridge over Schoharie Creek collapsed. Extensive flooding and damage resulted throughout the county. Schoharie County estimated millions of dollars in damage.

On **January 19, 1996**, over 4.5 inches of rain and as much as 45 inches of snow pack melted, resulting in a peak flow of 81,600 cfs in Schoharie Creek. Ice jams occurred, exacerbating flooding. Extensive damage occurred to homes, businesses, farms, and roads, including 200 yards of Stryker Road. A large number of cows died due to hypothermia. Middleburgh had over $2.5 million in damage to residential property with 39 homes destroyed, 116 with major damage and 217 with minor damage. Due to recurrent damage from flooding, the cleanup effort for this flood involved purchasing and demolishing 15 homes on Stryker Road as well as moving a church and the Old Town Hall to higher ground.

Between **June 26 and June 28, 2006**, flooding was most severe in areas west of the Schoharie Creek; including the towns of Seward, Richmondville, Cobleskill, Summit, and Gilboa. Through Gilboa and around Cobleskill, 4 to 5 inches of rain fell in a short time, and as much as 6 inches fell in areas of Seward, Richmondville, and Summit. A great deal of damage was sustained, with up to $160,000 in damages reported to municipal roads, bridges, and other infrastructure. Two homes had major flood damage, and 60 others had minor damage. Seventy-three individuals and families applied for FEMA disaster aid. Approximately 35,125 acres, or 43 percent of the farmland in Schoharie County, were damaged, and extensive structural damage was also reported to farm properties.

By far the largest storm on record occurred on **August 28, 2011**, as Tropical Storm Irene dumped up to 14 inches of rain within the Schoharie basin, resulting in a peak flow of 128,000 cfs. This catastrophic flooding was followed by additional precipitation on **September 7, 2011**, as Tropical Storm Lee dropped a reported 2 to 7 inches of additional rain. The emergency 911 system was down due to flooding, and a State of Emergency was declared. For the first time in the Gilboa Dam's history, sirens were triggered. Eight thousand Schoharie County residents were inundated, with extensive damage to homes. According to a USGS report (2014) on the floods of 2011, "*Communities along Schoharie Creek were particularly hard hit. Local officials estimated that about one-third of homes and businesses in the village of Schoharie were destroyed as a result of the flooding. Similar destruction occurred within other villages (Prattsville, Middleburg, Esperance, and many others) along the creek*" (Lumia et al., 2014).

In NYS, over $1 billion in damages occurred, with 600 homes destroyed, six towns inundated, 150 major highways damaged, and 22 state bridges closed. Approximately 140,000 acres of farmland in NYS were destroyed, with damages upwards of $45 million.

In Schoharie County, well over $100 million in damages was estimated to have occurred. Schoharie County was part of President Obama's Disaster Declaration. The Schoharie County Emergency Management Main Street headquarters was evacuated due to flooding. Additional county offices on Main Street were badly damaged, including the Health Department, Department of Public Works, and the county jail. Inmates had to be transferred due to flooding. The estimate for damages to county property alone is in the double-digit millions. In Schoharie County, 908 structures were damaged, and 230 sustained damage equal to 50 percent or more of their value. Approximately 10,000 customers in Schoharie County were without power on September 1, 2011.

According to a December 16, 2015, article in the Watershed Post, the Schoharie County Corrections Office facility had been housed in, "*a dilapidated FEMA trailer with a portable outhouse for a bathroom,*" following Hurricane Irene. The trailer is described as a temporary solution that has far outlived its intended lifespan, with blackened air filters, a leaking roof, and an electrical panel that is hanging by its hinges, among other issues.

In Middleburgh, water rose 6 feet above the 100-year flood level. According to one resident's account, the floods of 1955 and 1996 pale in comparison to 2011 (Major Lamont). The Middleburgh Middle/High School sustained at least $5 million in damage, and it took more than 4 months for the Middleburgh Library to reopen, with 3,000+ books lost.

The Schoharie Town Hall sustained damage, and the firehouse lost most of its gear and equipment. Transformers exploded during flooding, and two large oil storage tanks from a fuel company business overturned, releasing pools of oil. In the village of Schoharie, 275 homes and businesses were significantly damaged. Most people did not have flood insurance. Of the 437 homes in the village of Schoharie, only 91 had policies. As of January 10, 2012, Mayor Borst of the Village of Schoharie estimated that of the 940 people in the village only 20 families have been able to return to their homes. The mayor estimated damages of $27 million. FEMA funded the rebuilding of Schoharie Fire Station with $900,000 in aid.

Towns throughout the basin sustained damage. The Blenheim historic covered bridge, built in 1855, was swept away. In the town of Broome, two houses were demolished, and nine were over 50 percent damaged. The damage to roads totaled $1.2 million within Broome. Due to a log jam and general flooding during Tropical Storm Irene, there was no way to evacuate the hamlet of Gallupville. A 1944 World War II vehicle was used to transport volunteers to haul debris. Several homes on Old Route 30 in Esperance were washed off their foundations, and a mobile home on Route 20 in Esperance was swept downstream by floodwaters.

The cleanup efforts following Tropical Storm Irene were described as immense. People used their own equipment to clear roads and to work within the creeks. Road crews dumped fill into creeks "*for protection*." Emergency operations were set up at the Cobleskill Fairgrounds, and rescues were made by air, boat, and ground. Local, state, and federal personnel responded. FEMA's Urban Search and Rescue teams from Ohio and Pennsylvania reported to the scene. The New York National Guard sent 2,500 soldiers to the region to aid in the cleanup efforts. The Salvation Army, Red Cross, and Niagara Mohawk also responded to aid in the cleanup effort. Fire departments from all over the northeast came to help pump out cellars. Numerous church groups from many different denominations helped people clean their homes as did a number of nonprofit groups. Power companies from as far away as Illinois also sent help.

The Red Cross set up "pods" with food, water, and supplies for people. Numerous recovery centers were set up for an extended period after the flooding to assist people with rebuilding their homes. Food cafes were set up in tents to serve meals to local residents. The food was donated from a number of sources, and volunteers served the food. A mobile laundromat was set up as were power relief stations with computers, satellite phones, Wi-Fi, and recharging stations.

As part of the cleanup efforts, monetary assistance came from numerous sources. The Schoharie County Storm Relief Assistance from NYS totaled $48.2 million. FEMA mobile homes were provided to anyone with more than $10,000 in damage. FEMA had difficulty finding locations outside of the 100-year flood zones to place the mobile homes. FEMA determined that the county jail would remain at its current location and be rebuilt within the floodplain. FEMA also determined that the Emergency Management Office would receive floodgates and other flood mitigation devices, and the E-911 centers would likely be moved. The National Grid provided a $6 million Emergency Economic Development Program following the storm. Five hundred eighty-four small businesses and nonprofits that sustained direct flood damage were awarded a total of $7.9 million in assistance from the Businesses Flood Recovery Grant Program. Hay was donated to farmers from upstate farmers.

According to New York Rising Community Reconstruction Plan (NYRCRP) publications for the towns and villages of Esperance, Schoharie, & Middleburgh (March 2014) and for the towns of Fulton and Blenheim (December 2014), the monetary damages within Schoharie County as a result of Tropical Storm Irene were staggering. Table 3-2 provides estimates of damages within different resource categories.

TABLE 3-2
Schoharie County Damage Estimates
Following Tropical Storm Irene (August 28, 2011)*

Resource	Damage Estimate
Crops and Other Agricultural Resources	$18.8M
Roads, Bridges, and Storm Sewers	$130M
Residences	$92.5M

*NYRCRP (March 2014 and December 2014)

The Gilboa Dam is equipped with 30 emergency sirens to warn of a possible breach to the dam. Several sirens are set up near the base of the dam, and sirens are spaced out for 40 miles upstream to the town of Esperance. Four of the sirens were damaged during Irene. Nearly 8 months later, on May 9, 2012, testing was done for the first time to ensure that the sirens were in working order.

Four USGS gauges on the Schoharie Creek were active during Tropical Storm Irene: USGS gauge #01351500 at Burtonsville, #01350355 at Breakabeen, #01350180 at North Blenheim, and #01350101 at Gilboa. USGS gauges #01350120 Platter Kill at Gilboa, NY, and #01350140 Mine Kill near North Blenheim are also active within the basin. The gauge at Burtonsville is the furthest downstream. Irene peaked at this location at 128,000 cfs. The FEMA FIS for Schoharie County predicts the 100-year flood event at the Burtonsville gauge to be 78,100 cfs and the 500-year event to be 109,000 cfs. Therefore, peak flows at Burtonsville during Tropical Storm Irene far surpassed the projected 100-year flood event and even exceeded the projected 500-year flood event. Table 3-3 presents estimated peak discharges at various locations along Schoharie Creek during Tropical Storm Irene.

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

Location	USGS Gauge No.	Drainage Area (sq. mi.)	Tropical Storm Irene Discharge (cfs)
Schoharie Creek at Burtonsville	01351500	886	128,000
Schoharie Creek at Breakabeen	01350355	444	134,000
Schoharie Creek at North Blenheim	01350180	358	119,000
Schoharie Creek at Gilboa	01350101	316	111,000

sq. mi. = square mile cfs = cubic feet per second

According to a USGS report (2011), the flow on August 28, 2011, was nearly equal or exceeded the 0.2-percent (500-year) flood event for the Schoharie Creek stream gauges at Gilboa, North Blenheim, and Breakabeen. The report noted that FEMA FISs are not available for Burtonsville downstream to the mouth of the Schoharie Creek. In addition, USGS personnel surveyed 184 HWMs at 30 locations within the Schoharie basin following this flood event and found that the HWM elevations in the lower reaches of the basin exceeded published elevations for the 0.2-percent (500-year) flood event (Lumia et al., 2014).

Figure 3-2 presents annual peak flows recorded at USGS gauge #01351500 Schoharie Creek at Burtonsville, NY, between 1996 and 2014. According to a USGS report (2014), the HWM was surveyed in 184 locations along Schoharie Creek (upper and lower basins), and the HWM in the lower reaches of the basin exceeded those published by FEMA for their respective 0.2-percent (500-year) flood events. In addition, the USGS report noted that peak discharges exceeded their 1-percent (100-year) flood discharge at 25 stream gauges and their respective 0.2-percent (500-year) discharges at six sites in the Schoharie Creek basin.

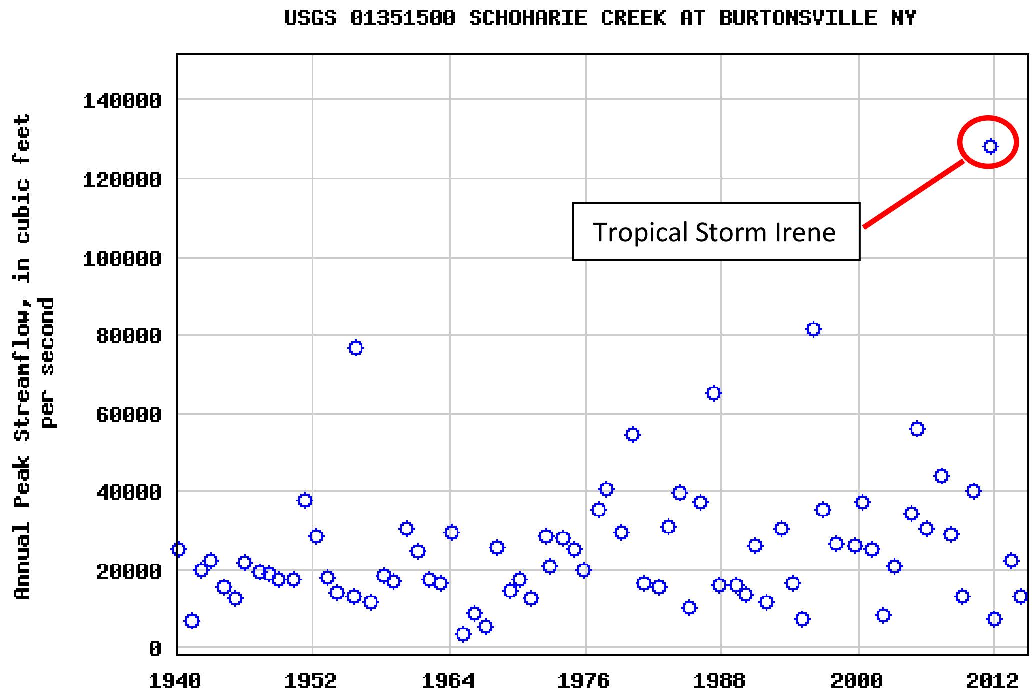


Figure 3-2
Annual Peak Discharge - USGS Gauge #01351500 at Burtonsville, NY

3.2 FEMA Mapping

FEMA FIRMs are available for various reaches of watercourses within the Schoharie watershed and depict the SFHA, 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). Maps showing the FEMA SFHA are included later in this report for the various focus areas.

4.0 FLOOD MITIGATION ANALYSIS AND ALTERNATIVES

A number of risk areas within the Lower Schoharie Creek watershed 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 through the use of hydraulic modeling to determine their effectiveness. The sections below describe these alternatives and their results.

4.1 Analysis Approach

In order to develop hydraulic modeling to assess flood mitigation alternatives, MMI obtained effective FEMA HEC-RAS hydraulic models for areas of the watershed where they were available. Models were obtained from the NYSDEC, Floodplain Management Section, Bureau of Flood Protection and Dam Safety.

In order to develop hydraulic modeling in areas of the watershed where FEMA models were not available or to supplement existing FEMA models, survey was collected by MJ Engineering and Land Survey, P.C. Survey consisted of wet channel cross sections and hydraulic openings of bridges. Elevations of dry overbank areas were derived from LiDAR (Light Detection and Ranging) mapping.

Hydraulic analysis of the Lower Schoharie Creek watershed was conducted using the HEC-RAS computer program. The HEC-RAS software was written by the United States Army Corps of Engineers (USACE) Hydrologic Engineering Center and is considered to be the industry standard for riverine flood analysis. The model is used to compute water surface profiles for one-dimensional, steady-state, or time-varied flow. The system can accommodate a full network of channels, a dendritic system, or a single river reach. HEC-RAS is capable of modeling water surface profiles under subcritical, supercritical, and mixed-flow conditions.

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

4.2 Mitigation Approaches

A number of mitigation approaches have been evaluated for the Lower Schoharie Creek watershed. These are introduced in a more global manner below and are evaluated in specific instances in the subsequent analysis.

4.2.1 Flood Preparedness

There are a number of ways in which home and business owners can minimize flood damages and ensure personal safety. The NFIP provides useful guidance on flood preparedness at www.FloodSmart.gov, or by calling the program at 1-888-379-9531. The following steps are recommended by the NFIP before, during, and after a flood:

Before a Flood:

1. Safeguard Possessions – Create a personal flood file containing information about all your possessions and keep it in a secure place such as a safe deposit box or waterproof container. This file should have the following items:

    - A copy of your insurance policies with your agent's contact information
    - A household inventory – For insurance purposes, be sure to keep a written and visual (i.e., videotaped or photographed) record of all major household items and valuables, even those stored in basements, attics, or garages. Create files that include serial numbers, and store receipts for major appliances and electronics. Have jewelry and artwork appraised.
    - Copies of all other critical documents including finance records or receipts for major purchases

2. Prepare

    - Make sure your sump pump is working, and then install a battery-operated backup in case of a power failure. Installing a water alarm will also let you know if water is accumulating in your basement.
    - Clear debris from gutters and downspouts.
    - Anchor any fuel tanks.
    - Raise your electrical components (switches, sockets, circuit breakers, and wiring) at least 12 inches above your home's projected flood elevation.
    - Place the furnace, water heater, washer, and dryer on cement blocks at least 12 inches above the projected flood elevation.
    - Move furniture, valuables, and important documents to a safe place.

3. Develop a Family Emergency Plan

    - Create a safety kit with drinking water, canned food, first aid, blankets, a radio, and a flashlight.
    - Post emergency telephone numbers by the phone and teach your children how to dial 911.
    - Plan and practice a flood evacuation route with your family. Know safe routes from home, work, and school that are on higher ground.
    - Ask an out-of-state relative or friend to be your emergency family contact.
    - Have a plan to protect your pets.

During a Flood:

- If flooding occurs, go to higher ground and avoid areas subject to flooding.
- Do not attempt to walk across flowing streams or drive through flooded roadways.
- If water rises in your home before you evacuate, go to the top floor, attic, or roof.
- Listen to a battery-operated radio for the latest storm information.
- Turn off all utilities at the main power switch and close the main gas valve if advised to do so.
- If you've come in contact with floodwaters, wash your hands with soap and disinfected water.

After a Flood:

- If your home has suffered damage, call your insurance agent to file a claim.
- Check for structural damage before reentering your home to avoid being trapped in a building collapse.
- Take photos of any floodwater in your home and save any damaged personal property.
- Make a list of damaged or lost items and include their purchase date and value with receipts, and place with the inventory you took prior to the flood. Some damaged items may require disposal, so keep photographs of these items.
- Keep power off until an electrician has inspected your system for safety.
- Boil water for drinking and food preparation until authorities tell you that your water supply is safe.
- Prevent mold by removing wet contents immediately.
- Wear gloves and boots to clean and disinfect. Wet items should be cleaned with a pine-oil cleanser and bleach, completely dried, and monitored for several days for any fungal growth and odors.

4.2.2 Sediment Management

Local representatives often report a sentiment that dredging will alleviate flooding within the Lower Schoharie Creek watershed and should be pursued. Dredging of the stream channel was evaluated as a flood mitigation technique within several of the focus areas. 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 two dam 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, overwidening or overdeepening through dredging can initiate instability (including bed and bank erosion), may foster poor sediment transport, and will 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.

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 the following:

- 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 should be contacted, and appropriate 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 remobilization and redeposition during the next large storm event.

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

4.2.3 Levee and Floodwall Construction

Under certain circumstances, levees and floodwalls can be constructed for the purpose of protecting properties and structures from flood damage. Levees are typically constructed from impervious, compacted soil while floodwalls are made of concrete or other man-made materials. As part of this study, the construction of levees and/or floodwalls to protect populated areas was evaluated in the Middleburgh and Schoharie focus areas.

Levees and floodwalls 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. When subjected to flooding, floodwalls can become structurally unsound if they are not properly designed, as a result of sliding, overturning at the foundation toe, or failure due to excessive soil pressure. Levees can be subject to seepage or scouring (FEMA, 2012). In most instances, residential floodwalls or levees are practical up to a height of only 3 to 4 feet above existing grade although they can be engineered for greater heights.

Risks associated with levees and floodwalls 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 Schoharie, peak flows in Schoharie Creek during Tropical Storm Irene were approximately 33 percent greater than the 100-year storm flows, or 35,000 cfs greater. 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.

Placement of floodwalls in the FEMA floodway is not allowed under NFIP regulations. Additionally, under NFIP regulations, floodwalls and levees cannot be used to bring noncompliant structures into compliance (FEMA, 2012).

4.2.4 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 within the Lower Schoharie Creek basin and particularly along the Schoharie Creek and its larger tributaries. 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 an 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 floodprone corridor is part of the river, and the importance of the floodplain only becomes evident on rare but extreme occasions.

In some locations, the natural floodplain along the Schoharie Creek and its tributaries 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 removing structures. Floodplain *creation* can be accomplished by excavating land to create new floodplain where there is none today. Finally, floodplain *enhancement* can be accomplished by excavating within the existing floodplain adjacent to the river to increase flood flow conveyance. These excavated areas are sometimes referred to as floodplain benches. Figure 4-1 shows a typical cross section of compound channel with excavated floodplain benches on both banks. The graphic shows flood benches on both banks; however, flood benches can occur on either or both banks of a river.

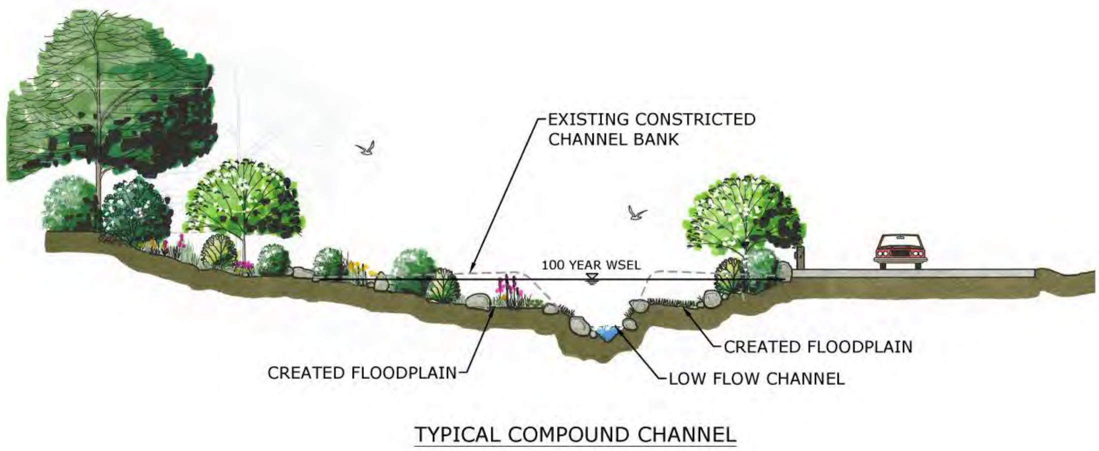


Figure 4-1
Typical Cross Section of a Compound Channel

4.2.5 Individual Property Flood Protection

A variety of measures is 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.

Residents throughout the basin are encouraged to sign up for their county's emergency notification system, which provides notifications to affected residents in the event of an emergency such as a flood. In each of the counties, residents can receive information from some sort of emergency notification system.

- In Montgomery County, residents can sign up for the Code Red program in which you are notified by your local emergency response team via phone message or text message in the event of emergency situations or critical community alerts.

- Schenectady County currently utilizes an emergency call system to notify residents of emergency information. Currently, the call system can only automatically contact residents with listed land line phones. Residents with unlisted phone numbers or who use cell phones as their primary phone can now register with the Rapid Notify system online at: http://www.schenectadycounty.com/reverse911.htm.

- Otsego County maintains a "911 text messaging system" for which residents can sign up at: http://www.otsegocounty.com/depts/911/documents/Textingapplication2015_001.pdf.

- Schoharie County maintains the Schoharie County Emergency Notifications Registration System. This application allows citizens to receive emergency notifications to their cell phone or internet phone numbers. Residents can register at https://www2.schohariecounty-ny.gov/EmergencyNotifications/. Schoharie County also developed a Flood Education video that is aired on a cable network periodically and is available at local libraries for borrowing.

- Albany County maintains a list of radio stations to which residents should listen for emergency notifications. The list can be found at this website: http://www.albanycounty.com/Residents/Radio.aspx.

Towns within the basin should work to identify and remove vacant and abandoned structures to prevent future hazards. 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 or installed from basement joists or similar mechanism at an elevation no less than 1 foot above the base flood elevation.

Figure 4-2
New elevated homes under construction

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 basin 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 can 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 base flood elevation (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 HWM.

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

4.2.6 Road Closures

Approximately 75 percent of all flood fatalities occur in vehicles. Shallow water flowing across a flooded roadway can be deceptively swift and wash a vehicle off the road, an example of which can be seen in Figure 4-3. Water over a roadway can conceal a washed out section of roadway or bridge. When a roadway is flooded, travelers should not take the chance of attempting to cross the flooded area. It is not possible to tell if a flooded road is safe to cross just by looking at it.

One way to reduce the risks associated with the flooding of roadways is their closure during flooding events, which requires effective signage, road closure barriers, and consideration of alternative routes.

Floodprone communities such as Austin, Texas, have implemented on-line warning systems that provide up-to-date flood information on local emergency road closures (Figure 4-4).

Figure 4-3
Car accident resulting from flooded road

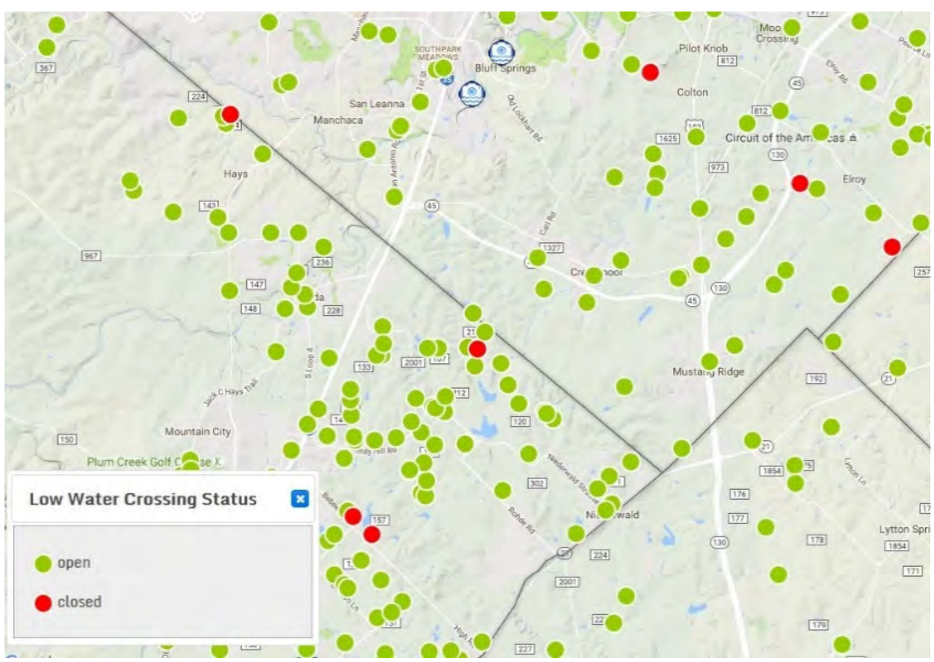


Figure 4-4
Graphic from ATX Floods (Austin, Texas)

4.2.7 Early Warning Systems

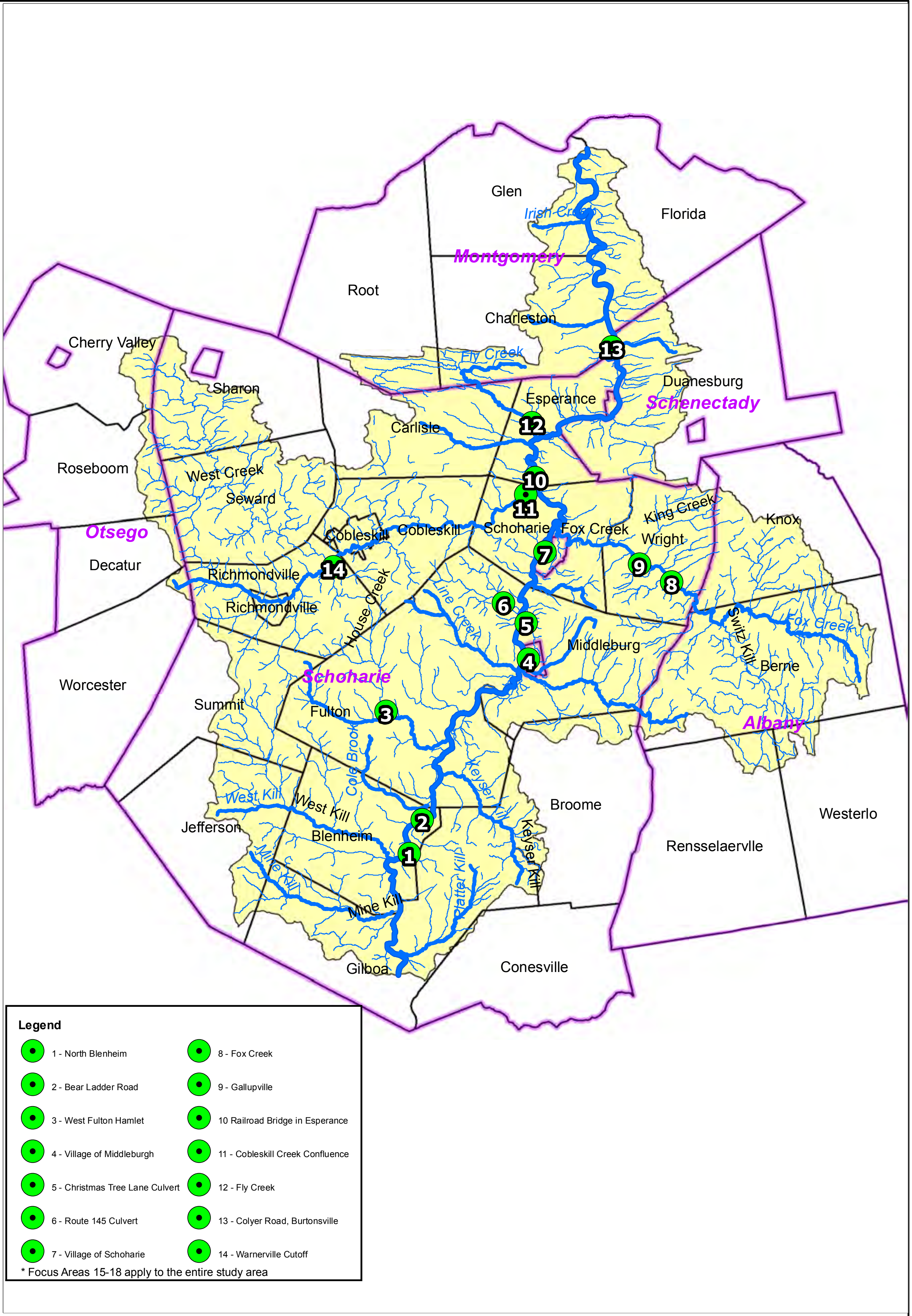
A reliable early warning system would provide community residents and business owners with a warning that flooding is likely while avoiding false alarms. The first and most important step is community flood preparedness. In order for any flood warning system to be successful, community members need to know what to do before, during, and after a flood. Accurate, reliable, and timely information on stream discharge or stage is essential to the success of a flood early warning system. SCSWCD has established devices that measure and record water surface elevations in 15-minute intervals. These devices are located on Schoharie Creek at Middleburgh and Esperance and on Fox Creek in Schoharie. They include radar level recorders, which measure the river stage without contacting the water surface. The devices are battery/solar powered so that they continue to operate during a power failure and are programmed to alert community officials via cell phone when water in Schoharie Creek or Fox Creek reaches a certain stage or when there is a rapid rate of change in river stage.

There are currently no stream gauges on many of the Schoharie Creek tributaries, making early warning systems at the onset of a flood and statistical analysis of flooding after a flood difficult. Installation of permanent stream gauges along floodprone tributaries to Schoharie Creek is recommended.

4.3 Focus Areas

For the purposes of this assessment, 18 focus areas have been identified within the Lower Schoharie Creek watershed. Fifteen of these areas are specific geographic locations while the remaining three areas are common throughout the watershed. A greater level of information was collected for the focus areas in order to assess potential flood mitigation projects. Figure 4-5 is a map showing the locations of the focus areas. They are listed below, and described in greater detail in the sections that follow.

- Focus Area #1 – North Blenheim
- Focus Area #2 – Bear Ladder Road
- Focus Area #3 – West Fulton Hamlet
- Focus Area #4 – Village of Middleburgh
- Focus Area #5 – Christmas Tree Lane Culvert
- Focus Area #6 – Route 145 Culvert
- Focus Area #7 – Village of Schoharie
- Focus Area #8 – Fox Creek
- Focus Area #9 – Gallupville
- Focus Area #10 – Railroad Bridge in Esperance
- Focus Area #11 – Cobleskill Creek Confluence
- Focus Area #12 – Fly Creek
- Focus Area #13 – Colyer Road, Burtonsville
- Focus Area #14 – Warnerville Cutoff
- Focus Area #15 –Potential for flood attenuation in upper watershed
- Focus Area #16 - General review of berms along farm fields
- Focus Area #17 – Potential for flood attenuation in reservoirs
- Focus Area #18 – Protection of wetlands, floodplains, and green infrastructure



SOURCE(S):
USGS StreamStats Version 3.0 (04/2016)
USGS National Hydrography Dataset (04/2016)
NYS GIS Clearinghouse (04/2016)

Figure 4-5: Focus Areas within Schoharie Creek Project Basin

Location: Schoharie Creek Watershed, NY

N

Schoharie Creek Flood Study

Map By: EMH
MMI#: 4805-05
MXD: Q:\Projects\4805-05 Schoharie Basin Flood Analysis\GIS\MDX\Focus Area Points 9272106.mxd
1st Version: 04/25/2016
Revision: 9/30/2016
Scale: 1 in = 31,970 ft

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4.3.1 Focus Area #1 – North Blenheim

Background

This focus area includes an approximately 1.5-mile reach of Schoharie Creek as it flows through the hamlet of North Blenheim and includes the NYS Route 30 Bridge (Bridge Identification Number [BIN] 1020940) as seen in Figure 4-6. The reach also includes the abutments of the historic Blenheim covered bridge, which was damaged during Tropical Storm Irene and is no longer in place. This reach of Schoharie Creek is subject to aggradation of sediments, much of it reportedly originating from West Kill Creek. The hamlet was severely damaged by flooding during Tropical Storm Irene.

Figure 4-6
Photos of NY Route 30

View of NY Route 30 bridge over Schoharie Creek in North Blenheim, with abutments of the former historic Blenheim covered bridge visible (left photo); view along NY Route 30 through hamlet of North Blenheim (right photo)

The North Blenheim focus area has a contributing drainage area of approximately 407 square miles. The creek flows across a section of bedrock channel as it approaches the hamlet. As it flows past North Blenheim and under the NYS Route 30 bridge, Schoharie Creek is somewhat confined within its river valley, making contact with the right valley wall just downstream of the bridge where the creek runs parallel to NYS Route 30.

According to the Schoharie County Region 5 Evacuation Route, residents in the North Blenheim area are directed to proceed to the Jefferson Central School shelter by way of North Road and NYS Route 10. For residents living to the north of North Blenheim, this would require traveling south along NYS Route 30 through North Blenheim.

This reach of Schoharie Creek has been evaluated by FEMA using approximate engineering methods only, meaning that identification of areas subject to flooding has been approximated. An existing conditions HEC-RAS hydraulic model was obtained from FEMA. The resulting FEMA FIRM indicates that the 100-year flood event inundates much of the developed area of the hamlet of North Blenheim along NYS Route 30, including the roadway itself (Figure 4-7). A FEMA floodway has not been designated in this reach.

SOURCE(S):

NYS GIS Clearinghouse Orthoimagery (accessed June 2016)

FEMA Schoharie County Special Flood Hazard Area

Figure 4-7: FEMA Flood Insurance Rate Map - North Blenheim

Location: **Blenheim, NY**

N

Schoharie Basin Flood Analysis

Map By: EMH
MMI#: 4805-05
MXD: Q:\Projects\4805-05 Schoharie Basin Flood Analysis\GIS\MDX
1st Version: 6/6/2016
Revision: 9/22/2016
Scale: 1 in = 540 ft

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New survey was collected through this reach, including channel cross sections and detailed hydraulic survey of the Route 30 bridge. A hydraulic model was developed and run to evaluate potential flood mitigation alternatives. The model utilized a combination of new survey information and published information from FEMA.

The USGS *StreamStats* program was utilized to develop peak flow information at this location, which was compared against peak flows provided in the FEMA FIS. The FEMA flows are consistently higher than those reported by *StreamStats*. The FEMA flows were used for the hydraulic analysis since they are more conservative and represent the jurisdictional standard. *StreamStats* data was used to estimate bankfull characteristics of the creek through this reach. Table 4-1 presents a summary of peak flows as determined by FEMA and *StreamStats*. Table 4-2 presents watershed and stream channel characteristics through this reach.

TABLE 4-1
Summary of Peak Flows from FEMA at Two Flow Locations

Recurrence Interval	2.2 Miles Upstream of NYS Route 30 Bridge (cfs)		1.7 Miles Downstream of NYS Route 30 Bridge (cfs)	
	FEMA	*StreamStats*	FEMA	*StreamStats*
10-Year	39,927	36,100	41,583	39,800
50-Year	65,713	59,000	68,439	65,000
100-Year	79,207	70,800	82,493	77,900
500-Year	118,302	102,000	123,210	112,000

TABLE 4-2
Bankfull Characteristics (Based on USGS *StreamStats*)

	2.2 Miles Upstream of NYS Route 30 Bridge	1.7 Miles Downstream of NYS Route 30 Bridge
Watershed Area (square miles)	357	412
Bankfull Width (feet)	249	264
Bankfull Depth (feet)	6.7	6.9
Bankfull Discharge (cfs)	11,100	12,300

A total of five flood mitigation alternatives were evaluated for the North Blenheim focus area, including an assessment of replacing the historic covered bridge as well as various floodplain enhancement and sediment removal scenarios. These are described in detail below.

Alternative 1-1: Replacement of Historic Covered Bridge

This alternative assesses the impact of the historic Blenheim covered bridge, located just upstream (south) of the NYS Route 30 crossing over Schoharie Creek. Figure 4-8 is an aerial photograph of the bridge site. The timber superstructure of the bridge was destroyed during Tropical Storm Irene and had been damaged during previous flood events. The abutments sustained minor damage during Irene but remained in place after the flood receded. Local interest has been expressed in rebuilding the covered bridge by reusing the existing abutments. As envisioned, the replacement bridge would be a replica of the original bridge, but the deck would be set 10 feet higher than the former deck (Watershed Post, September 18, 2015, and June 23, 2016).

Three alternatives were analyzed to determine the impact of the bridge and its abutments on flooding in the hamlet of North Blenheim. First, an analysis was conducted to determine the impact of the bridge on water surface elevations if the deck were to be replaced at the same elevation as the former bridge deck. Second, an analysis was undertaken to determine whether a replacement bridge with the deck set at an elevation 10 feet higher than the former bridge would cause an increase in water surface elevations that would contribute to flooding in the North Blenheim hamlet. Third, an analysis was conducted to determine whether removal of the existing abutments from the channel would result in a decrease in flood elevations in the hamlet.

Figure 4-8
Aerial Photograph Showing Former Location of Blenheim Covered Bridge

Reconstructing the historic covered bridge at the same elevation as the former bridge would cause a 2.8-foot rise in the 100-year flood elevation at the bridge. The rise in water surface elevation would extend approximately 3,500 feet (three-quarters of a mile) upstream of the bridge and would cause increased flooding of structures in North Blenheim and along NYS Route 30 as it passes through the hamlet. The hydraulic opening of the covered bridge, if reconstructed at the same elevation as the former bridge on the existing abutments, would be substantially undersized for the 100-year flood, and floodwaters would reach the superstructure in all flows greater than or equal to the 10-year event. Under this scenario, the likelihood of the bridge being damaged or destroyed again during a flood would be high.

If the replacement bridge were to be set on the existing abutments and raised 10 feet higher than the elevation of the former covered bridge, hydraulic analysis indicates that the new bridge would safely pass the 100-year flood event with adequate freeboard. There would be no rise in water surface elevations at or upstream of the bridge. However, it is important to note that if larger abutments or piers were to be set in the channel, or if a roadway embankment were to be constructed to connect the replacement bridge to the bank on the left side of the channel, an increase in water surface elevations would result.

A hydraulic analysis was conducted to determine whether removal of the existing abutments from the channel would result in a decrease in flood elevations upstream of the bridge site. The abutments are small relative to the width of the channel, and their removal would result in only a small decrease (approximately 2 inches) in water surface elevations at and upstream of the former structure.

If the Blenheim covered bridge is replaced, the replacement deck should be set at an elevation that is 10 feet higher than the deck of the former historic bridge. The replacement bridge should be set on the existing abutments or on new abutments that do not occupy more space in the channel than the existing abutments. No roadway embankment should be constructed on the left side of the bridge to connect the bridge deck to the left bank. Detailed hydraulic modeling should be conducted as part of the engineering design to ensure that the new bridge does not cause an increase in water surface elevations at or upstream of the bridge.

Because the FEMA FIRMs for North Blenheim were developed when the former covered bridge was in place, preparation of a LOMR that documents the current condition either with no bridge or with a new bridge at a higher elevation is recommended.

Alternative 1-2: Floodplain Enhancement

Three scenarios involving the construction of an enhanced floodplain were assessed. Many factors contribute to whether or not construction of an enhanced floodplain will ultimately result in a meaningful decrease in flooding and flood-related damages in nearby, inhabited areas. For this reason, it is necessary to conduct hydraulic modeling for a range of floodplain enhancement configurations.

Alternative 1-2a – The first floodplain enhancement scenario evaluated involved the construction of a floodplain along the left bank of a meander bend in Schoharie Creek, just upstream of the Route 30 bridge. This alternative is depicted in Figure 4-9. Under this alternative, the floodplain would extend beneath the Route 30 bridge along with the removal of vegetated alluvial deposits that form a point bar on the inside of the meander bend. This alluvial deposit extends beneath the bridge. Excavation beneath the bridge was assumed to be possible for the purpose of this assessment but if pursued would need to be evaluated further relative to the footings of the bridge piers and their susceptibility to scour or undermining if excavation were performed.

Results of the modeling show a drop in the 100-year flood water surface elevations ranging between 2 and 3 feet extending approximately two-thirds of a mile upstream of the bridge. This reduction would lower flood elevations in the hamlet and would result in the elimination of approximately 18 to 20 properties from FEMA's mapped 100-year SFHA.

Figure 4-9
Alternative 1-2a

Scenario involving construction of enhanced floodplain scenario 1-2a, along the left bank in North Blenheim, near the NYS Route 30 bridge (Shaded area outlined in red represents area of enhanced floodplain.)

While the removal of these properties from the floodplain would be beneficial, the cost of such a project would be high. Implementation would involve the removal and off-site disposal of approximately 75,000 cubic yards of material and revegetation of the modified areas. This scenario would also require the removal of the existing abutments of the former covered bridge, which is not feasible if the bridge is to be replaced with a new structure as discussed above.

Alternative 1-2b – The second floodplain enhancement scenario in North Blenheim assessed the construction of a floodplain along the right bank of Schoharie Creek in an existing agricultural field as shown in Figure 4-10. The results of the hydraulic analysis show that this floodplain enhancement configuration would have only a small flood mitigation benefit within the North Blenheim hamlet. The hydraulic constriction driving flood elevations through the hamlet appears to be at or near the NYS Route 30 bridge, and because this alternative does not provide any widening of that area, the resulting reductions in water surface elevation are small.

Similar to the first floodplain enhancement scenario (Alternative 1-2a), the cost of this scenario would be high and is not likely justified due to the minimal reduction in flooding. This alternative would also involve the reconstruction and relocation of East Side Road, which would be impacted by the floodplain bench. For these reasons, this scenario was not pursued further.

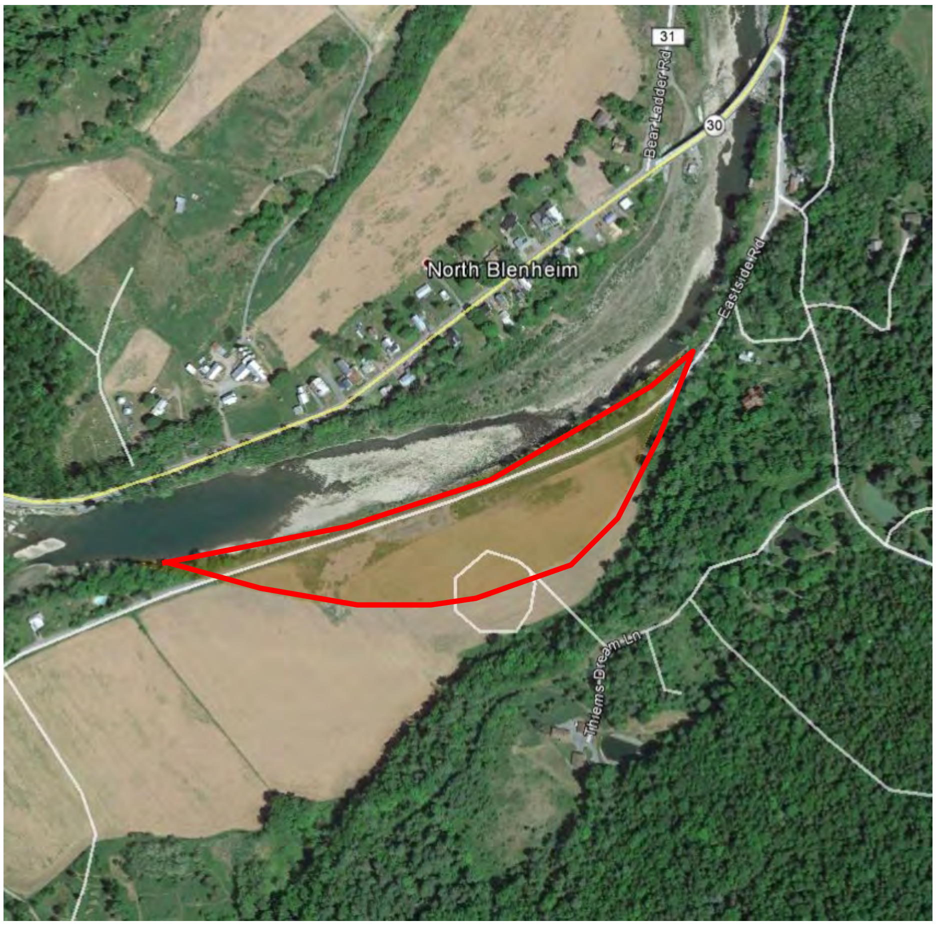


Figure 4-10
Alternative 1-2b

Scenario involving construction of enhanced floodplain scenario 1-2b, along the right bank of Schoharie Creek in North Blenheim (Shading area outlined in red represents area of enhanced floodplain.)

Figure 4-11
East Side Road in North Blenheim, with Schoharie Creek to the right

<u>*Alternative 1-2c*</u> – Based upon an iterative assessment using hydraulic modeling, a reduction in channel of conveyance in the area of the NYS Route 30 bridge was determined to be a hydraulic constriction contributing to a rise in water surface elevations that extend upstream through the North Blenheim hamlet. A floodplain enhancement and sediment removal scenario was assessed in the area of the NYS Route 30 bridge, starting approximately 175 feet upstream of the bridge and extending to 925 feet downstream of the bridge (Figure 4-12). Prior to this scenario being undertaken, further investigation will be necessary to determine whether the removal of the abutments for the former covered bridge would be required or whether they could be left in place (the possible replacement of the historic covered bridge is discussed under Alternative 1-1).

Figure 4-12
Route 30 Bridge

View from NYS Route 30 bridge over Schoharie Creek looking downstream toward location of proposed floodplain enhancement scenario 1-2c

The results of floodplain enhancement and sediment removal scenario 1-2c were found to be effective at lowering water surface elevations by up to 2 feet over a distance of two-thirds of a mile upstream, which includes the North Blenheim hamlet. Figure 4-13 shows the predicted existing (green line) and proposed (blue line) water surface elevations during the 100-year flood event, extending a significant distance upstream of the NYS Route 30 bridge.

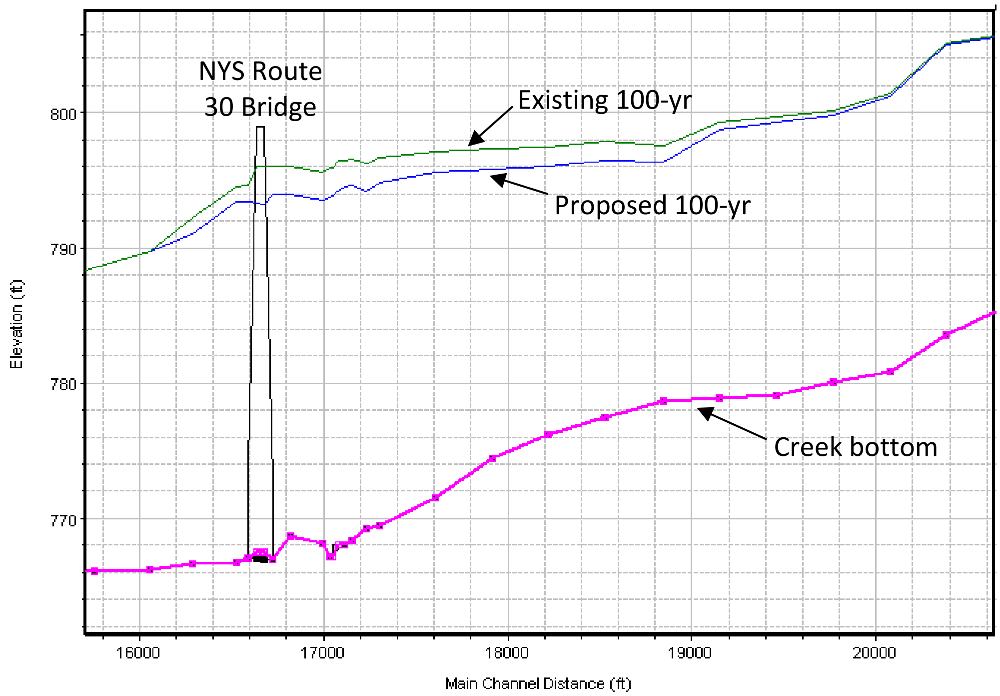


Figure 4-13
Existing and Proposed Water Surface Elevations for Scenario 1-2c

Profile showing existing (green) and proposed (blue) water surface elevations for scenario 1-2c during the 100-year flood event, extending up Schoharie Creek upstream of the NYS Route 30 bridge

Figure 4-14 shows the North Blenheim hamlet overlain with the existing (blue) and approximate proposed (red) FEMA SFHA under this scenario. Many structures would be removed from the FEMA SFHA while others remaining in the SFHA would see reductions in flood elevations. The construction of this scenario would impact 1,100 linear feet of Schoharie Creek and would require the removal of approximately 20,000 cubic yards of material.

The impacts on the channel and the construction costs associated with scenario 1-2c would be lower than the other two floodplain enhancement scenarios (1-2a and 1-2b) while the flood reduction results would be similar or better. Scenario 1-2c is believed to be viable and recommended for further consideration. It should be noted that a gas line is located near the downstream end of the proposed floodplain enhancement area (personal communication with Peter Nichols, Stream Program Manager, Delaware County Soil and Water Conservation District). This and other utilities would need to be identified and, if necessary, relocated.

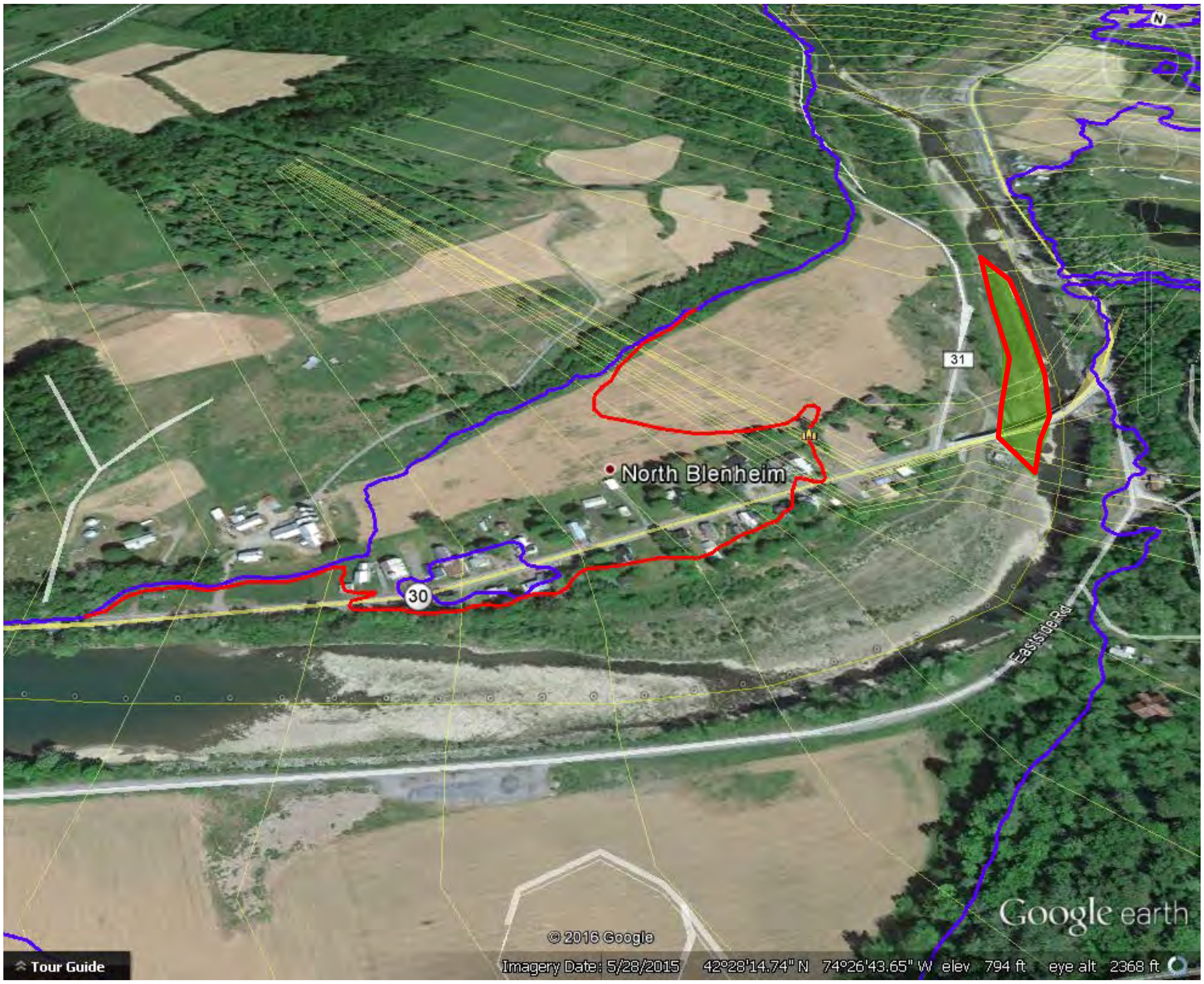


Figure 4-14
Scenario 1-2c

Aerial view of North Blenheim hamlet showing the location of floodplain enhancement scenario 1-2c (shaded area outlined in red), and existing (blue) and approximate proposed (red) FEMA SFHA

Alternative 1-3: Sediment Removal

Field investigations revealed that the Schoharie Creek channel just upstream of North Blenheim contains multiple mid-channel and lateral sediment bars. Removal of accumulated sediment in this area was investigated for its potential to reduce flooding. The hydraulic model was used to assess sediment removal over a half-mile length of Schoharie Creek, up to 4 feet in depth, across the approximately 200-foot width of the channel.

The hydraulic modeling results indicate that sediment removal would have a relatively minor impact on water surface elevations. Reductions in water surface elevations do not provide relief to properties located in the North Blenheim hamlet center. The estimated volume of sediment to be removed under this scenario would be approximately 35,000 cubic yards, requiring off-site material disposal as well as bank restoration and stabilization. Sediment removal is not likely to be sustainable and is likely to continue to aggrade in this area. As such, the sediment removal scenario is not recommended for further study.

Focus Area #1 Recommendations

The following recommendations are offered for Focus Area #1 in order of priority:

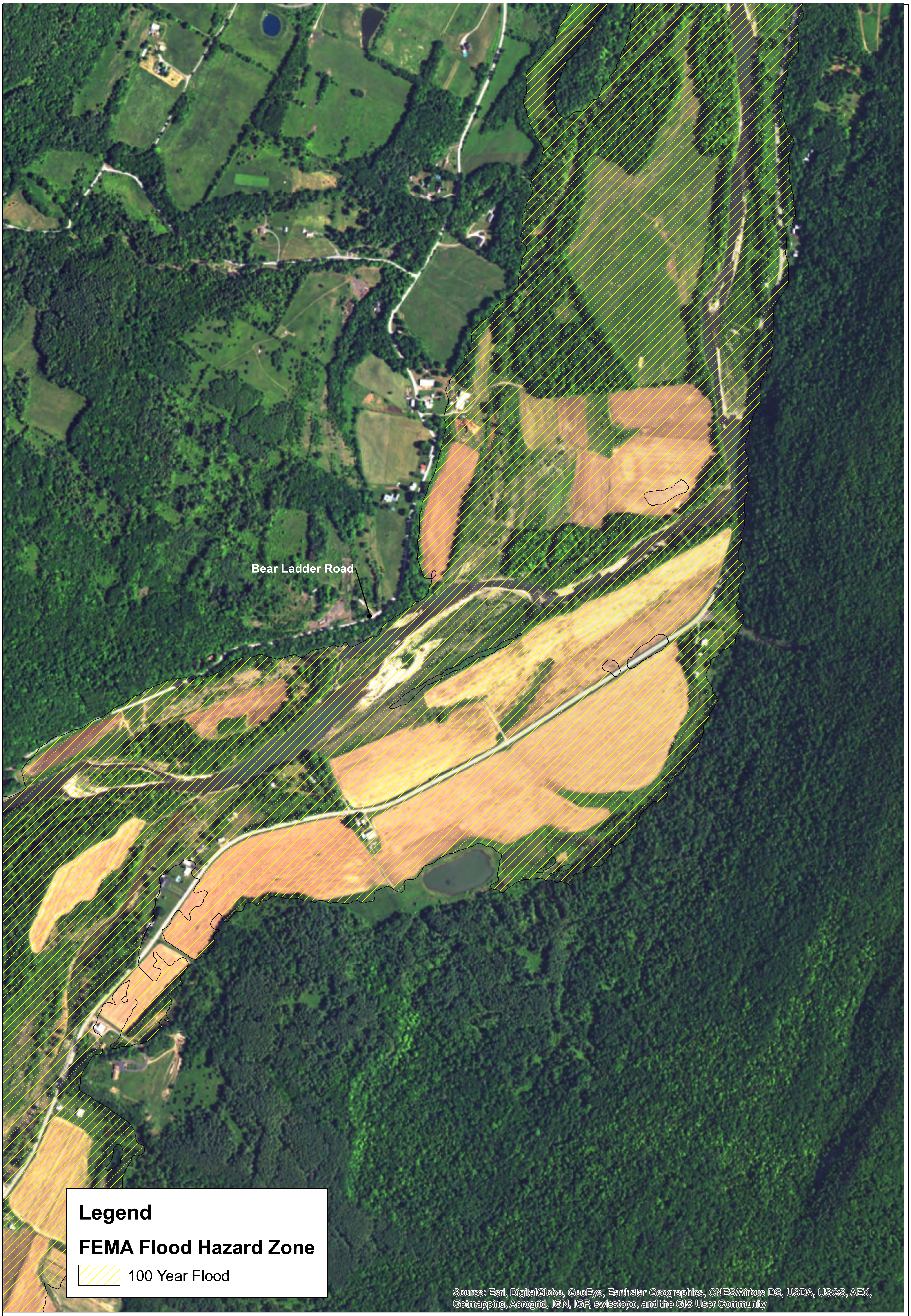
1. Alternative 1-2c Floodplain Enhancement – Floodplain enhancement and sediment removal scenario as described in Alternative 1-2c is recommended. This scenario was found to be effective at lowering water surface elevations by up to 2 feet over a distance of two-thirds of a mile upstream, which includes the North Blenheim hamlet. Many structures would be removed from the FEMA SFHA while those that would remain in the SFHA would see reductions in flood elevations. The construction of this enhancement and sediment removal scenario would impact approximately 1,100 linear feet of Schoharie Creek and would require the removal of approximately 20,000 cubic yards of material. Engineering design and permitting are anticipated on the order of $68,000 while construction would be anticipated on the order of $820,000. This estimate does not include the cost of any land acquisition or construction easements that may be required or the relocation of utilities.

2. Alternative 1-1 – Replacement of Covered Bridge – If the Blenheim Covered Bridge is to be replaced, the replacement deck should be set at an elevation that is 10 feet higher than the deck of the former historic bridge. The replacement bridge should be set on the existing abutments or on new abutments that do not occupy more space in the channel than the existing abutments, and no roadway embankment should be constructed on the left side of the bridge to connect the bridge deck to the left bank. Hydraulic modeling should be conducted as part of the engineering design to ensure that the new bridge does not cause an increase in water surface elevations. It is also recommended that a LOMR be prepared that reflects the current condition in North Blenheim either with no covered bridge or with a new bridge at a higher elevation.

4.3.2 Focus Area #2 – Bear Ladder Road

Background

Focus Area #2 is located where Bear Ladder Road (County Route 31) parallels Schoharie Creek, just north of the hamlet of North Blenheim. Frequent flooding is reported at a location approximately 2 miles downstream of the NYS Route 30 bridge coincident with a low spot in the road. When the area floods, travel becomes unsafe or impossible, and access is cut off to several residences. Reports of flooding are consistent with the FEMA 100-year SFHA mapping, which shows Bear Ladder Road overtopping at two separate locations during the 100-year flood event as depicted in Figure 4-15. The more southern area encompasses approximately 2,250 linear feet of road and the more northern about 1,500 feet.



SOURCE(S):	Figure 4-15: FEMA Flood Insurance Rate Map - Bear Ladder Road		Location: Blenheim, NY
NYS GIS Clearinghouse Orthoimagery (accessed June 2016) FEMA Schoharie County Special Flood Hazard Area	N Schoharie Basin Flood Analysis	Map By: EMH MMI#: 4805-05 MXD: Q:\Projects\4805-05 Schoharie Basin Flood Analysis\GIS\MDX 1st Version: 6/6/2016 Revision: 9/22/2016 Scale: 1 in = 675 ft	MILONE & MACBROOM 231 Main Street, Suite 102 New Paltz, NY 12561 (845) 633-8153 Fax: (845) 633-8162 www.miloneandmacbroom.com

Alternative 2-1 – Floodplain Modification

Hydraulic modeling and an assessment of digital elevation models were used to evaluate the nature and extent of existing flooding conditions along Bear Ladder Road. The roadway elevation varies, but at some of its lowest points, the elevation of the road is only slightly higher than the elevation of bankfull flows in the Schoharie Creek channel. These low areas in the road are predicted to be flooded by as much as 10 feet of floodwater during the modeled 100-year flood. The floodplain along this reach of Schoharie Creek is very broad, in some areas nearly half a mile wide. Given the topography and abundance of an existing floodplain, channel and/or overbank modification would provide little to no flood benefit and would not improve flooding conditions along Bear Ladder Road. No additional modeling was necessary.

Alternative 2-2 – Raise Roadway

Hydraulic modeling was undertaken to assess the scenario of raising Bear Ladder Road up and out of the floodplain with 1 foot of freeboard (a factor of safety usually expressed in feet above a flood level) above the 100-year water surface elevation. Raising the roadway was evaluated, assuming a 30-foot embankment and 3:1 side slopes to avoid expensive structural wall construction. The final elevation of the road would need to be increased by 1 to 7 feet, depending on location, over two sections totaling approximately 4,000 linear foot of roadway to effectively protect the road from flooding during the 100-year storm event (Figure 4-16).

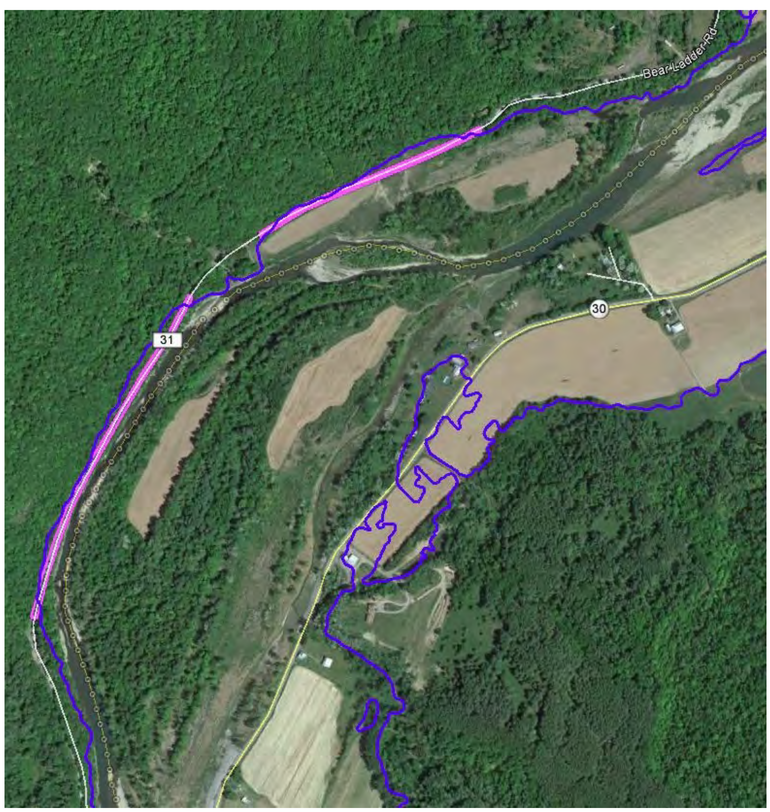


Figure 4-16
Aerial view of Bear Ladder Road (County Route 31) along Schoharie Creek showing limits of 100-year floodplain and proposed elevated areas of Bear Ladder Road (Alternative 2-2)

The cost of elevating Bear Ladder Road to 1 foot above the 100-year water surface elevation would be on the order of $1.9 million. This would involve reconstructing approximately 4,000 linear foot of road, and approximately 28,000 cubic yards of fill material would be required to elevate the road above the elevation of the 100-year flood. The cost of engineering design and permitting would be in the range of $150,000 to $200,000. This estimate does not include the cost of any land acquisition or construction easements that may be required in order to elevate the roadway.

Based on hydraulic analysis, the fill associated with raising the road would have a negligible impact on flood levels. Figure 4-17 is a cross section view of Schoharie Creek showing the proposed elevation of Bear Ladder Road along the left side of the valley and the resulting 0.05-foot rise in water surface elevations during the 100-year flood event.

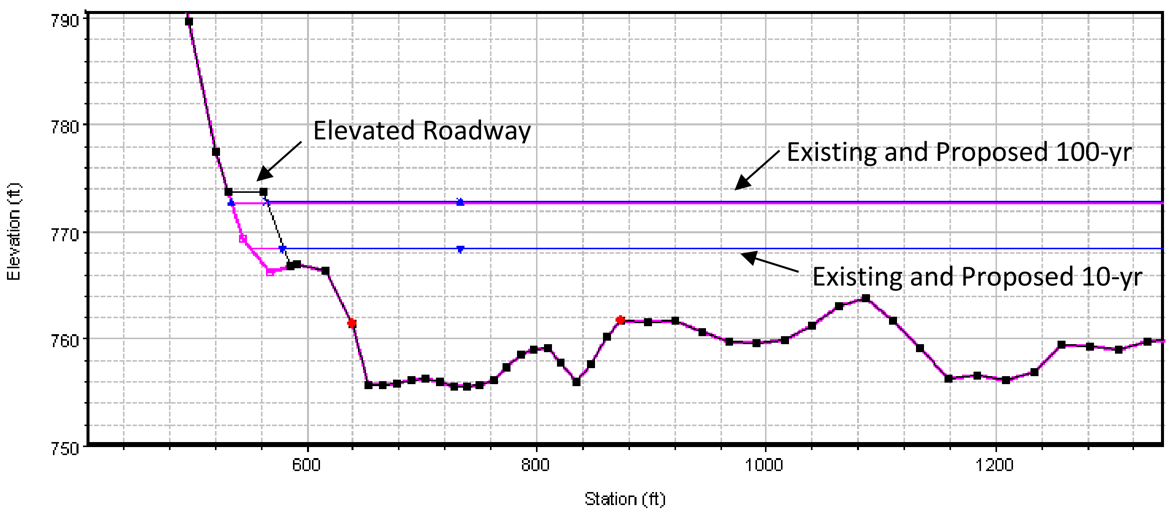


Figure 4-17
Cross Section View of Schoharie Creek

Alternative 2-3 – Roadway Signage and Closure

The most practical and low-cost solution to flooding of the roadway along Bear Ladder Road is its immediate closure during flooding events in combination with effective signage, barriers, and further consideration of alternative routes. Monitoring of the USGS stream gauge at Breakabeen can be accessed (http://waterdata.usgs.gov/nwis/uv?site_no=01350355) to provide highway superintendents and residents with a warning that floodwaters are rising, at which point signs and/or barriers should be put in place, and travel along the floodprone sections of Bear Ladder Road should be avoided.

Focus Area #2 Recommendations

The following recommendations are offered for Focus Area #2 in order of priority:

1. Alternative 2-3 – Roadway Signage and Closure – Immediate closure of Bear Ladder Road during flooding conditions, effective signage, and further consideration of alternative routes are recommended as described in Alternative 2-3.

2. Alternative 2-2 – Raising Bear Rock Road – While this alternative is potentially feasible, the cost of nearly $2.0M should be weighed against the benefit of unimpacted travel during major storm events. No homes or businesses will be removed from the floodplain under this alterative. Given the cost, likely need for land acquisition, and limited flood protection, this is not a high priority recommendation.

4.3.3 Focus Area #3 – West Fulton Hamlet

Background

Focus Area #3 is located in the hamlet of West Fulton and includes House Creek and Panther Creek, both of which are tributaries to Schoharie Creek. Two vehicular bridges located in the hamlet of West Fulton about 600 feet apart have been identified as being prone to debris jams and overtopping during flood events: the Patria Road bridge over House Creek and the West Fulton Road (County Route 4) bridge over Panther Creek. Hydraulic modeling was undertaken to evaluate both bridges and associated stream channels.

The West Fulton Fire Department station is located at 807 West Fulton Road, approximately one quarter of a mile east of the bridge over Panther Creek. The West Fulton Fire Department along with the Middleburgh Fire Department provides fire and rescue services for the town of Fulton. The West Fulton station is also a designated emergency shelter. According to the Schoharie County Region 9 Evacuation Route, residents in the Fultonham area are directed to proceed to the West Fulton Fire Department shelter by way of Pleasant Valley Road, Mallon Road, Patria Road, and West Fulton Road. This route crosses both the Patria Road bridge over House Creek and the West Fulton Road (County Route 4) bridge over Panther Creek. If these bridges were to be flooded or washed out during an emergency, access to and from the West Fulton Fire Department shelter would be impeded. Hydraulic analysis was conducted at both bridges to determine the likelihood that they would overtop or wash out during a flood.

No stream gauges are located on House Creek or Panther Creek near the project area, and a FEMA FIS has not been completed for West Fulton.

Alternative 3-1: Replace Patria Road Bridge over House Creek

Patria Road crosses over House Creek approximately 40 feet upstream of its confluence with Panther Creek (Figure 4-18). The bridge at this location reportedly becomes jammed with debris. According to the Schoharie County Department of Public Works, the dry hydrant pumpout located at Patria bridge was washed out during Tropical Storm Irene and was subsequently reinstalled. The bridge opening is 44 feet wide, with a 6.5-foot vertical distance between the bridge footing and the low chord on both sides. The channel along the left side of the bridge is somewhat scoured, resulting in the channel bed being 1 foot lower than the footing. The right side has a vegetated channel bar that covers the footing by approximately 1 foot, resulting in a distance of 5.5 feet between the top of the bar and the low chord. The bridge deck has a vertical height, or thickness, of 3.5 feet between the low chord and the base of the railing. The railing is open. The deck of the bridge is 24 feet wide. The channel substrate under the bridge is predominantly gravel with an area of sand. Sand is dominant moving downstream approaching the confluence with Panther Creek.

The bankfull width of House Creek measured in the vicinity of the bridge was found to be in the range of 50 to 55 feet. This is in close agreement with the regional regression equations utilized by *StreamStats*, which indicate a bankfull width of 55.8 feet.

Figure 4-18
Photos of Patria Road Bridge

Patria Road bridge over House Creek viewed from downstream (left photo) and looking east along Patria Road (right photo)

Peak flows were calculated for House Creek at this location using *StreamStats* and are reported in Table 4-3.

TABLE 4-3
Peak Flows for House Creek

Peak Flows	Discharge (cfs)
10-year flood	1,420
25-year flood	1,950
50-year flood	2,420
100-year flood	2,930
200-year flood	3,490
500-year flood	4,270

A HEC-RAS model was developed using 2014 Schoharie LiDAR mapping and flows generated from *StreamStats*. The Patria Road profile generated in the HEC-RAS model shows that the 50-year and 100-year floods do not overtop the bridge, but they do touch its low chord. The 200-year and 500-year floods overtop the bridge. The 44-foot span is narrower than the 55.8-foot bankfull width. Based on NYSDEC stream crossing standards, structures should span 1.25 times the channel's bankfull width. Bridges and culverts that do not span the bankfull width of the channel are more prone to debris jams and scour and are more likely to act as a barrier to aquatic organisms due to increased flow velocities through the structure.

The Patria Road bridge reportedly becomes filled with debris during flood events, leading to a reduction in hydraulic capacity and more frequent overtopping. A debris jam was simulated in the hydraulic model, creating a 30-percent blockage of the bridge opening. For the 100-year storm event, the water surface elevation increases by 2.75 feet upstream of the bridge when the bridge opening is blocked by 30 percent. The bridge is overtopped by the 25-year storm and all larger storms when debris blockage is simulated.

HEC-RAS modeling indicates that no buildings located near the Patria Road bridge would flood during the 100-year flood event. The building on Patria Road immediately west of the Patria Road bridge is at a ground elevation of 1,148 feet based on the 2014 LiDAR as shown in Figure 4-19. According to the HEC-RAS model, this building could experience minor flooding at an elevation of 1,148.15 feet in the 500-year flood without debris blockage. The buildings east of the bridge are at a higher elevation and would not experience flooding in the 500-year flood event.

Figure 4-19
Aerial View of Patria Road Bridge

Although predicted flooding associated with the Patria Road bridge devoid of blockage does not directly affect individual homes or businesses, overtopping of the road in the event of debris blockage would cause flooding and potentially dangerous conditions. When the Patria Road bridge is slated for replacement, the structure should be widened to better match the bankfull width of the channel, and detailed hydraulic analysis of the proposed structure should be conducted to ensure that the bridge is adequately sized to pass flows during large flood events.

The approximate cost of bridge replacement at the Patria Road bridge is in the range of $600,000 to $1M. Design and permitting costs would be anticipated on the order of $150,000.

Alternative 3-2: Replace West Fulton Road Bridge over Panther Creek

The West Fulton Road (County Route 4) bridge over Panther Creek was also identified as being prone to debris jams and overtopping during flood events (Figure 4-20). The bridge crosses the creek at a skew and has a hydraulic opening that measures 26 feet in width with a maximum height of 8 feet when measured from channel thalweg to low chord. When measured from the top of a gravel bar along the right bank to the low chord, the opening height is 5 feet. The bridge deck is approximately 2 feet thick. The travel lane on the bridge deck is 25 feet wide from edge to edge with open railings along both sides. A home is located very close to the edge of the creek along the left bank on the upstream side, and buildings are located very close to both banks downstream of the bridge.

Figure 4-20
Photos of West Fulton Road Bridge

West Fulton Road (CR 4) bridge over Panther Creek looking east along West Fulton Road (left photo) and looking downstream from bridge

The West Fulton Road bridge over Panther Creek has a drainage area of 8.8 square miles with a bankfull area of 96.8 square feet, a bankfull depth of 2.12 feet, a bankfull flow of 638 cfs, and a bankfull width of 46.5 feet. Table 4-4 presents peak flows as calculated for this location on Panther Creek. A HEC-RAS model was developed using 2014 Schoharie LiDAR and flows from *StreamStats*.

Elevation mapping indicates that there is a low spot on West Fulton Road located east of the bridge. In the 25-year and higher floods, the model predicts that floodwaters overtop the right bank of Panther Creek and flow over the low spot in the road as shown in Figure 4-21. Flows are predicted to return to Panther Creek at a point further downstream.

TABLE 4-4
Peak Discharges over Panther Creek at the West Fulton Bridge

Peak Flows	Discharge (cfs)
10-year flood	984
25-year flood	1,350
50-year flood	1,670
100-year flood	2,010
200-year flood	2,390
500-year flood	2,900

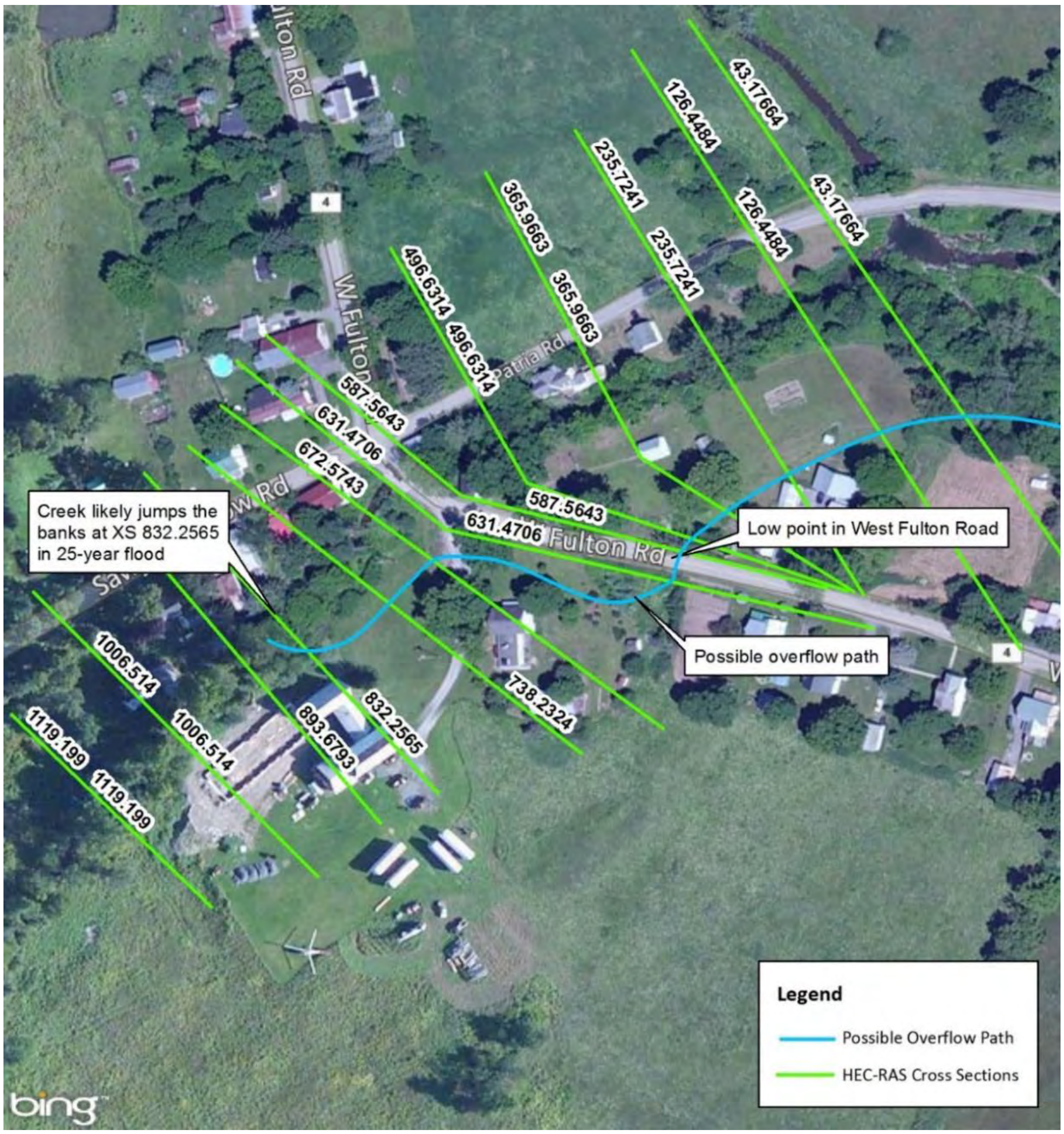


Figure 4-21
West Fulton Road Hydraulic Model

Hydraulic model indicates that flows could pass over the low spot along West Fulton Road during the 25-year flood and larger.

Neighbors have reported that in the recent past, including during the Tropical Storm Irene flood, Panther Creek has flooded the area around the barns to the south of the West Fulton Road bridge but has not overtopped the bridge or the low spot in the road east of the bridge. It is possible that West Fulton Road was not overtopped during Tropical Storm Irene because flooding may not have reached the 25-year storm event at this location. This would explain the discrepancy between individual observations and the hydraulic model predictions.

With a hydraulic opening of just 26 feet, the West Fulton Road bridge over Panther Creek is undersized when compared to the bankfull width of 46.5 feet. When the bridge is slated for replacement, the structure should be widened to better match the bankfull width of the channel, and hydraulic analysis should be conducted to ensure that the bridge is adequately sized to pass large flood events.

The approximate cost of bridge replacement at the West Fulton Road bridge is in the range of $600,000 to $1M. Design and permitting costs would be anticipated on the order of $150,000.

Alternative 3-3: Create Compound Channel with Floodplain along Panther Creek

This alternative evaluated creation of a compound or multistage channel upstream of the West Fulton Road bridge where the channel is overly narrow. A created floodplain along the right bank in combination with a larger bridge structure was modeled. Results indicate that such a modification would add sufficient capacity to convey flood flows without overtopping and would reduce the flooding risk to structures located along the left bank close to the creek.

The cost of engineering design and permitting for the compound channel and floodplain along Panther Creek upstream of the West Fulton Road bridge is anticipated to be on the order of $60,000 to $75,000 while construction is anticipated to be on the order of $150,000 to $200,000. This estimate does not include the cost of any land acquisition or construction easements that may be required.

Focus Area #3 Recommendations

The following recommendations are offered for Focus Area #3 in order of priority:

1. Alternatives 3-2 and 3-3 – Bridge Replacement and Compound Channel at West Fulton Road – This bridge is undersized as is the upstream channel and thus is inadequate for conveyance of flood flows and debris. When the bridge is slated for replacement, the structure should be widened to improve debris movement and conveyance of flood flows.

2. Alternative 3-1 – Bridge Replacement at Patria Road – Near-term bridge replacement is not likely warranted; however, when the Patria Road bridge is slated for replacement, the structure should be widened to improve debris movement and conveyance of flood flows.

4.3.4 Focus Area #4 – Village of Middleburgh

Background

Schoharie Creek flows north through Middleburgh between Route 30 and Route 145. According to *StreamStats*, Schoharie Creek at the Route 30 bridge in Middleburgh has a drainage area of 534 square miles with a bankfull area of 2,280 square feet, a bankfull depth of 7.6 feet, a bankfull flow of 15,400 cfs, and a bankfull width of 301 feet. Schoharie Creek flows across a wide, flat-bottomed valley with an extensive floodplain as it approaches and flows past the town of Middleburgh. In some locations, the floodplain is over a mile wide.

The flows from the FEMA HEC-RAS model with the addition of 2-year flows from *StreamStats* were used to conduct hydraulic modeling analysis and evaluate flood mitigation alternatives. Table 4-5 presents peak flows used in the hydraulic model at this location.

TABLE 4-5
Peak Flow Rates of Schoharie Creek at the Route 30 Bridge in Middleburgh

Peak Flows	Discharge (cfs)
2-year flood	19,800
10-year flood	41,817
50-year flood	68,824
100-year flood	82,957
500-year flood	123,903

Figure 4-22 shows that many buildings along River Street in Middleburgh are located within the 100-year floodplain. River Street is lined with a mix of uses including single-family homes, community services such as churches, and a range of businesses. The businesses include a farm, stores, a mechanics shop, and a karate dojo as well as several abandoned businesses including the former Grand Union on the west side of the road closest to the river. Hydraulic modeling was used to predict flooding depths at various locations in Middleburgh during the 10-year and 100-year flood events. Table 4-6 presents a summary.

TABLE 4-6
Floodwater Depths in Middleburgh during the 10-year and 100-year Floods

Location	10-Year Depth of Flooding (feet)	100-Year Depth of Flooding (feet)
Baseball field behind Middleburgh Junior/Senior High School	0.0	2.9
Intersection of Baker Avenue and Main Street	0.0	2.1
Griebel Lane	0.0	3.8
Intersection of Milk Can Lane and Route 30	0.0	2.4

Alternative 4-1: Modify/Replace the NYS Route 30 Bridge

The area around the NYS Route 30 bridge and approximately 6,000 feet downstream was analyzed with hydraulic modeling. The existing conditions model shows that the NYS Route 30 bridge is overtopped during the 100- and 500-year floods. Modeling predicts that the bridge does not create a significant backwater under the modeled flow conditions and that replacement of the bridge with a wider or taller structure *would not* reduce flooding at nearby buildings.

Figure 4-22: FEMA Flood Insurance Rate Map - Village of Middleburgh

Location: Middleburgh, NY

SOURCE(S):

NYS GIS Clearinghouse Orthoimagery (accessed June 2016)
FEMA Schoharie County Special Flood Hazard Area

N

Schoharie Basin Flood Analysis

Map By: EMH
MMI#: 4805-05
MXD: Q:\Projects\4805-05 Schoharie Basin Flood Analysis\GIS\MDX
1st Version: 6/6/2016
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Alternative 4-2: Floodplain Enhancement

Hydraulic modeling was undertaken to evaluate several different floodplain enhancement configurations along the floodprone section of Schoharie Creek as it flows through Middleburgh. Floodplain enhancement scenarios were modeled within the agricultural fields along the left bank between Schoharie Creek and Route 145 and along the right bank where River Street bends away from Schoharie Creek. Figure 4-23 depicts locations where floodplain enhancement scenarios were evaluated as shown in the red outlines.

Figure 4-23
View showing locations in Middleburgh where floodplain enhancement scenarios were evaluated

Given the broad, flat nature of the Schoharie Creek floodplain in this area and the fact that the fields along the left bank are already quite frequently flooded, little flow capacity is predicted to be gained and little flood reduction benefit as a result of floodplain enhancement.

Alternative 4-3: Right Bank Floodplain Enhancement

Floodplain enhancement was assessed along the right bank of the creek approximately 1 mile downstream of the NYS Route 30 bridge as depicted in Figure 4-24. The proposed floodplain enhancement scenario resulted in predicted water surface elevation decreases of approximately 0.2 feet in the 10-, 50-, 100-, and 500-year floods. Benefits diminish moving upstream toward the NYS Route 30 bridge. This resulting decrease in water surface elevation does not significantly change the extent of flooding in Middleburgh and along River Street and would only moderately decrease flooding depths by as much as 0.27 feet at some structures located along River Street north of Middleburgh. Such improvements may reduce flooding occurrences during smaller events or possibly bring flood elevations below the level of first floors during larger floods; however, large-scale flood mitigation will not be achieved with this alternative.

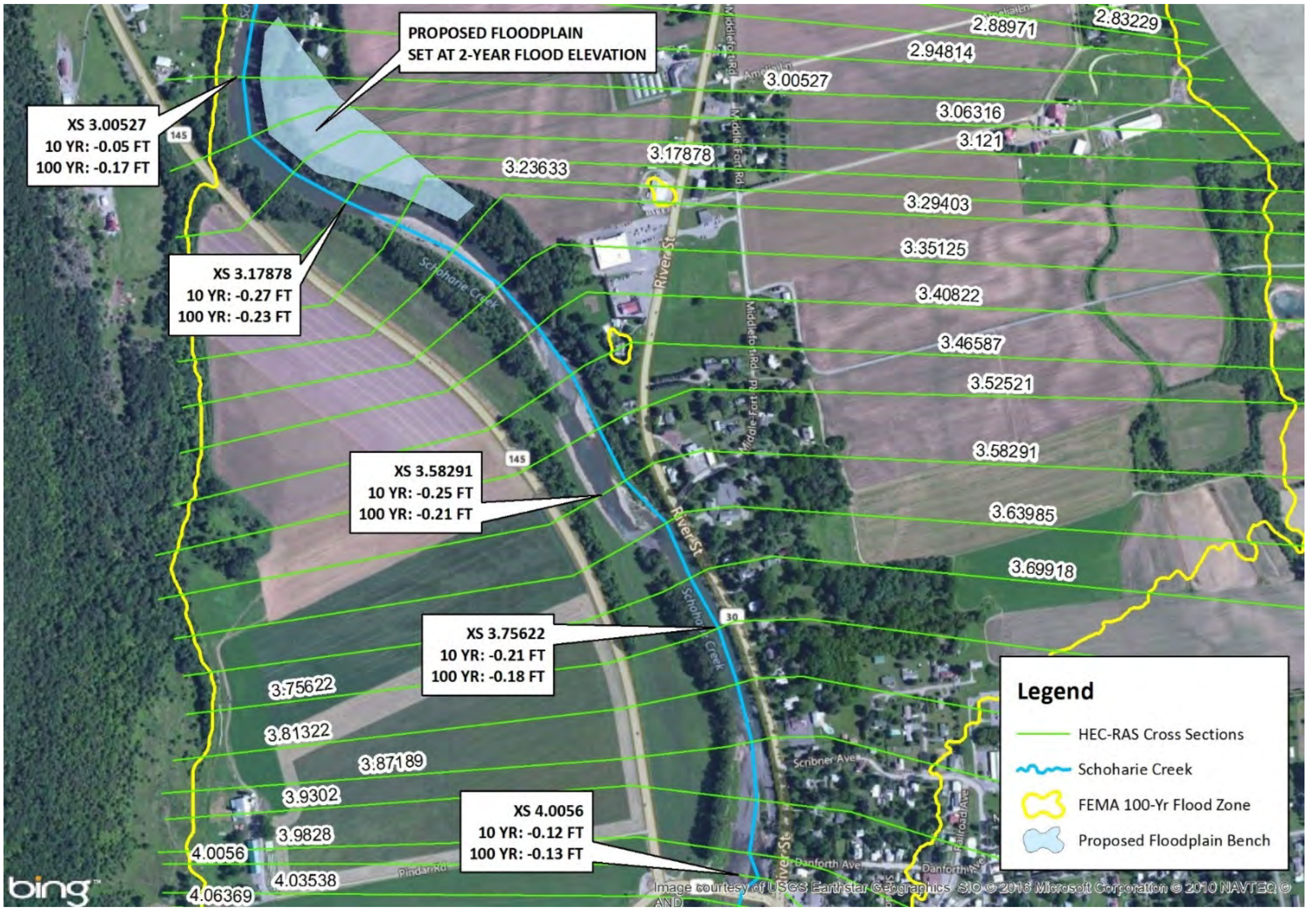

Figure 4-24
Alternative 4-3

Aerial view showing water surface elevation reductions for floodplain enhancement

Construction of the modeled flood bench would require approximately 57,500 cubic yards of excavation and would disturb an area of approximately 9.3 acres along 1,800 linear feet of Schoharie Creek. Due to the large volume of material excavation, construction costs would be anticipated to be on the order of $3M and would not likely justify the minimal reduction in water surface elevations.

Alternative 4-4: Dredging

Hydraulic modeling was conducted to evaluate a dredge scenario in which 2 feet of the Schoharie Creek channel bottom would be dredged from a point located 2,600 feet upstream of the Route 30 bridge to 4,900 feet downstream of the bridge. Hydraulic modeling predicts that dredging would provide only minimal flood reduction benefit with a maximum decrease in water surface elevation of only 0.3 feet during the 10-year event and 0.2 feet during the 100-year event. Approximately 95,500 cubic yards of material (over 5,000 truckloads) would need to be removed with an anticipated cost on the order of $2.3M. Figure 4-25 depicts the extent of the modeled dredging.

Figure 4-25
Aerial view of Middleburgh showing the extent of proposed dredging under Alternative 4-4

Alternatives 4-5a and 4-5b: Flood Control Levee and Wall

Two scenarios were investigated in which a combination of an earthen flood control levee and a flood control wall would be constructed to prevent flooding of portions of Middleburgh. Under the first scenario, a levee would begin behind (south of) the Middleburgh Junior/Senior High School, run north along River Street along Schoharie Creek, then turn east away from the creek north of Scribner Avenue. The proposed levee was evaluated at an average height of 5 feet. Figure 4-26 shows the location of the proposed floodwall and levee.

Because the area between River Street and the creek is too narrow to accommodate the width of an earthen levee, a vertical floodwall would be required. The levee/floodwall would need to be set at least 1 foot above the 100-year water surface elevation, potentially higher. The proposed levee would be approximately 3,200 feet long and would require 13,500 cubic yards of fill. The proposed floodwall would be about 1,500 feet long. Floodgates would be required at locations where roads pass through the floodwall or levee such that the gates would normally be open but then be closed during flood events. Approximately 20 property parcels would be impacted by the construction of the levee/floodwall. Conceptual engineering sketches of the proposed floodwall and levee, including volume calculations, are appended to this report.

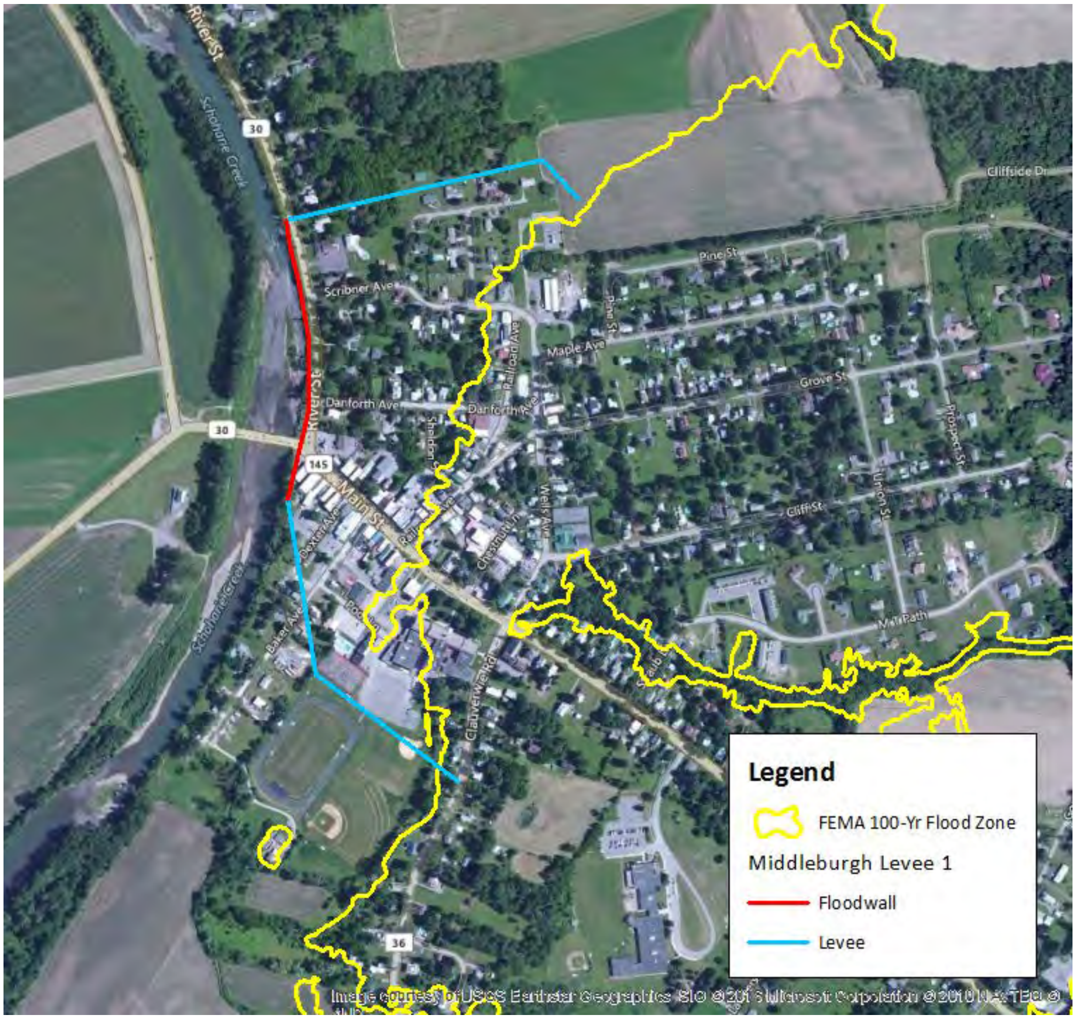

Figure 4-26
Aerial view showing the location of levee 1 in Middleburgh

Under this scenario, a land area of approximately 45 acres that is currently inundated during the 100-year flood would be protected from flooding including areas along Main Street, Railroad Avenue, Danforth Avenue, and Scribner Avenue. Modeling of the levee indicates that increases in water surface elevation in the Schoharie Creek channel adjacent to the levee would be negligible.

Under a second levee/floodwall scenario, the levee would begin behind the Middleburgh Junior/Senior High School, run north along River Street to Milk Can Lane, then turn east. Figure 4-27 shows the location of the proposed levee.

As with the first scenario, a vertical floodwall would be required between River Street and the creek. The levee/floodwall would be set at least 1 foot above the 100-year water surface elevation. Under this scenario, the proposed levee would be approximately 4,900 feet long and would require 21,000 cubic yards of fill. The proposed floodwall would be about 4,700 feet long. As with the first levee scenario above, floodgates would be required at locations where roads pass through the floodwall or levee, which would be closed during flood events. Approximately 35 property parcels would be impacted by the construction of this levee/floodwall. Conceptual engineering sketches of the proposed floodwall and levee, including volume calculations, are appended to this report.

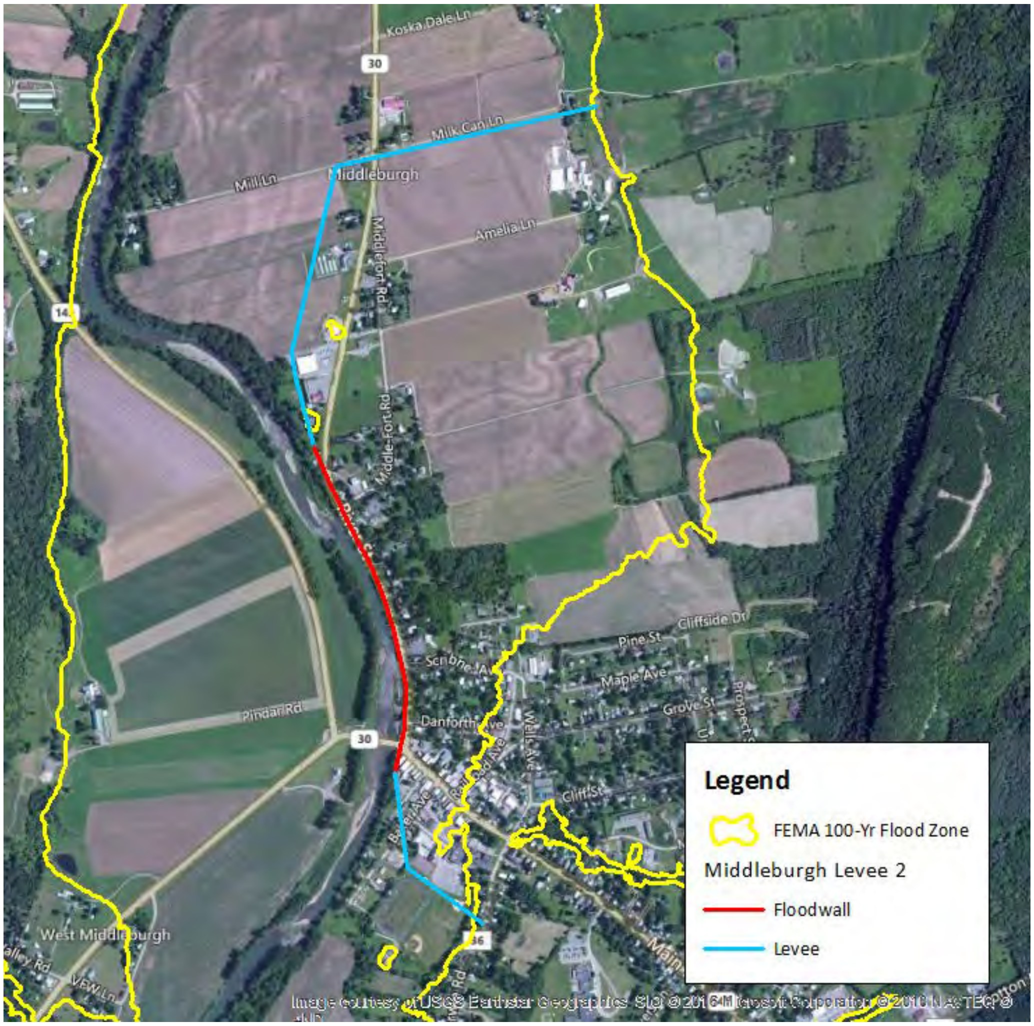

Figure 4-27
Aerial view showing the location of levee scenario 2 in Middleburgh

Under this scenario, a land area of approximately 330 acres that is currently inundated during the 100-year flood would be protected from flooding, including all areas described under the first scenario plus the area extending north of town along River Street and Middle Fort Street. Modeling of this levee/floodwall scenario indicates that increases in water surface elevation in the Schoharie Creek channel adjacent to the levee would be negligible.

The levee and floodwall scenarios described above would require a considerable amount of private property acquisition or construction easements and would require interior drainage pump stations, use of removable panels at road crossings, and considerable maintenance. A risk associated with these scenarios is the danger of a flood event that exceeds the design storm and overtops or breaches the levee or floodwall and is then trapped. In Middleburgh, peak flows in Schoharie Creek during Tropical Storm Irene exceeded the predicted 100-year storm event. Under such a scenario, it is possible that floodwaters from the creek would have overtopped a levee or floodwall designed to protect structures and properties. Once a levee has been overtopped, floodwaters can become trapped behind it, thus exacerbating flooding problems.

The anticipated cost of design and permitting for Alternative 4-5a, the first levee and floodwall scenario, is anticipated to be around $150,000. Construction of the levee and floodwall structure would be on the order of $1.5M. The cost of design and permitting for Alternative 4-5b, the second levee and floodwall scenario, is estimated at $210,000 while construction costs would be anticipated around $2.8M. These figures assume that the floodgates at each of the points where a road would need to pass through the levee would be operated manually. The cost of automated floodgates would substantially increase the cost. Also not included in the estimates is the cost of the required property acquisition, structure demolition, and construction easements to make room for the levee. Approximately 20 property parcels would be impacted by the construction of the first levee/floodwall scenario, and approximately 35 parcels would be impacted by the second levee/floodwall scenario. The cost of a pump operation to remove stormwater from behind the levee has not been included. When all of these cost factors are taken into consideration, it is likely that the cost of the levee/floodwall scenarios would likely be in excess of $5M.

Alternative 4-6: Individual Building Floodproofing

Floodwater depths in Middleburgh during the 100-year flood event range from just under 3 feet at the playing fields behind Middleburgh Junior/Senior High School to nearly 4 feet along Greibel Lane. Water at this depth can be dangerous, capable of knocking an adult off their feet, sweeping away a vehicle, or severely damaging a building.

A variety of measures are available to protect existing public and private properties in floodprone areas from damage. On a case-by-case basis where structures are at risk, individual floodproofing can be explored. This may range from elevation of structures, to construction of barriers, floodwalls, and earthen berms, to dry or wet floodproofing, to other improvements to mitigate damage from flooding. Emphasis should be placed on critical facilities. Costs will vary depending on what measures are implemented. The following approximate costs are provided for individual structures:

- Elevating a residential structure: $175,000
- Protecting homeowner utilities from flooding: $1,500 to $2,000
- Implementing a variety of measures to protect a small business: $6,000 to $50,000

Focus Area #4 Recommendations

The following recommendations are offered for Focus Area #4:

1. Seek to acquire, and relocate where feasible, the most flood-vulnerable properties where there is owner interest and programmatic funding available FEMA or other sources of funding.

2. Move existing structures out of the floodway.

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

4. Some of the homes located toward the periphery of the floodplain may be only rarely flooded. Residents and businesses may benefit from minor individual property improvements. Providing

landowners with information regarding individual property protection is recommended (see Individual Property Flood Protection measures described in Section 4.2 of this report).

4.3.5 Focus Area #5 - Christmas Tree Lane Culvert

Background

Located in the town of Middleburgh just south of Christmas Tree Lane, a culvert traverses NYS Route 30 and conveys a small unnamed tributary to Schoharie Creek. This culvert is reported to overtop frequently, flooding Route 30. According to the Schoharie County Region 13 and 16 Evacuation Routes, residents in the Middleburgh area are directed to proceed to the Rock Road Chapel shelter, which would require travel north on NYS Route 30.

Schoharie Creek flows across a wide, flat-bottomed valley with an extensive floodplain as it flows under NYS Route 30 in the vicinity of Christmas Tree Lane. At this location, the FEMA 100-year floodplain is approximately 1.6 miles wide. According to FEMA's FIRMs, NYS Route 30 in this area is extensively flooded during the 100-year event. As depicted in Figure 4-28, the culvert is a small concrete box 5.0 feet wide by 3.2 feet high and 40 feet long. The watercourse passing through the culvert under NYS Route 30 is a grass swale. Figure 4-29 depicts the FEMA floodplain at the culvert. The USGS *StreamStats* program was utilized to gather hydrologic information at this location. Table 4-7 presents peak flows.

Figure 4-28
Inlet of culvert under NYS Route 30 south of Christmas Tree Lane

Figure 4-29: FEMA Flood Insurance Rate Map - Christmas Tree Lane Culvert

Location: **Middleburgh, NY**

SOURCE(S):

NYS GIS Clearinghouse Orthoimagery (accessed June 2016)

FEMA Schoharie County Special Flood Hazard Area

N

Schoharie Basin Flood Analysis

Map By: EMH
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TABLE 4-7
Peak Flow Rates at Inlet NYS Route 30 South of Christmas Tree Lane

Peak Flows	Discharge (cfs)
10-year flood	125
25-year flood	179
50-year flood	228
100-year flood	282
200-year flood	344
500-year flood	431

Alternative 5-1: Increase Culvert Capacity

The Christmas Tree Lane culvert was analyzed with the use of the HY-8 program and field measurements, hydrologic information derived from *StreamStats* data, and elevations determined from 2014 USGS 3-County LiDAR. NYS Route 30 is predicted to overtop due to excessive flows at the culvert between the 10-year and 25-year storm events. However, based on analysis using the FEMA model for Schoharie Creek, the entire area in the vicinity of the culvert would be inundated by floodwaters from Schoharie Creek during the 10-year flood. Therefore, improvements to this culvert would not provide substantial flood reduction benefits to NYS Route 30.

Alternative 5-2: Raise Roadway

Elevation of Christmas Tree Lane was evaluated as a means to reduce the occurrence of NYS Route 30 being overtopped. Approximately 10,900 feet, or 2.1 miles of roadway would need to be raised. The increase would vary from 0 feet to 8 feet, with an average of about 5 feet.

Due to the broad, flat configuration of the Schoharie Creek floodplain in this area coupled with the predicted depth of flooding during the 100-year flood, sufficiently elevating the roadway to prevent its overtopping during the 100-year flood event would result in the confinement of the available floodplain to nearly 50 percent of its current width. This confinement would cause flood elevations and flow velocities to increase along Schoharie Creek. Additionally, the cost of elevating NYS Route 30 above the 100-year flood elevation would be approximately $4.3M. This would involve reconstructing approximately 10,900 feet, or 2.1 miles, of roadway, and approximately 50,500 cubic yards of fill material would be required. The cost of engineering design and permitting would likely be in the range of $350,000 to $400,000. This estimate does not include the cost of the land acquisition or construction easements that would be required in order to elevate the roadway.

Alternative 5-3: Relocate Roadway

An alternative to raising the roadway as described in Alternative 5-2 would be to construct a new roadway parallel and further east of the current Route 30 outside of the Schoharie Creek floodplain to serve as an evacuation route during periods of flooding. Such an endeavor would cost significantly more than raising the roadway and is not anticipated to be financially feasible, particularly given the associated area of impact. As such, this alternative was not evaluated in any further detail.

Alternative 5-4: Roadway Signage and Closure

A low-cost approach to flooding of the roadway along NYS Route 30 in the vicinity of Christmas Tree Lane would be to close the road during flooding events. This would need to be done in combination with effective signage, barriers, and further consideration of alternative routes. Monitoring of the USGS stream gauge along Schoharie Creek would provide highway superintendents and residents with a warning that floodwaters are rising, at which point signs and/or barriers could be put in place, and travel along the floodprone sections of NYS Route 30 could be avoided.

Focus Area #5 Recommendations

Closure of NYS Route 30 during flooding conditions along with effective signage and further consideration of alternative routes would provide a low-cost alternative.

4.3.6 Focus Area #6 – Route 145 Culvert in Middleburgh

Background

A concrete box culvert is located at the crossing of NYS Route 145 over an unnamed tributary to Schoharie Creek in the town of Middleburgh. The culvert is located along Route 145 northwest of the village of Middleburgh just north of School House Road and Ecker Hollow Road. The unnamed creek parallels Ecker Hollow Road, flows eastward through the culvert under Route 145, then continues east parallel to School House Road toward Schoharie Creek. Based on information collected at the public meeting, the culvert is undersized, floods frequently, and is prone to debris jams. NYS Route 145 serves as an important travelway that is outside of the floodprone Schoharie Valley during large flood events. According to the Schoharie County Region 10, Region 14, and Region 15 evacuation routes, residents in the Middleburgh area are directed to proceed to the Richmondville High School shelter in Cobleskill by traveling north on Route 145.

This focus area was not included in the FEMA study for Schoharie County, and therefore no FEMA hydraulic model or FIRMs are available. The unnamed tributary at the Route 145 culvert has a drainage area of 7.6 square miles with the following hydraulic characteristics: a bankfull area of 86.5 square feet, a bankfull depth of 2.0 feet, a bankfull flow of 570 cfs, and a bankfull width of 43.4 feet (*StreamStats*). Table 4-8 presents peak flows for this location.

TABLE 4-8
Peak Flow Rates at Route 145 Culvert in Middleburgh

Peak Flows	Discharge (cfs)
1.25-year flood	183
1.5-year flood	236
2-year flood	316
5-year flood	560
10-year flood	770
25-year flood	1,090
50-year flood	1,380
100-year flood	1,690
200-year flood	2,050
500-year flood	2,550

Based on observations and field measurements, the Route 145 culvert is a concrete box with a slope of approximately 3.0 to 3.5 percent. Approximately 22 feet of earth is present between the top of the culvert and the Route 145 road surface. The length of the culvert is 220 feet, with a rise of 10 feet and a span of 10 feet. The channel upstream and downstream of the culvert is tightly confined with no natural floodplain. The channel upstream of the culvert consists of cobble with no bedrock. The channel downstream of the culvert consists of exposed bedrock, boulder, and cobble.

Figure 4-30
Downstream face of culvert passing beneath NYS Route 145

The culvert was modeled using the HY-8 program with data from field measurements, *StreamStats*, and the Schoharie 2014 USGS LiDAR. The HY-8 results indicate that a flood between the 200-year and 500-year flows would overtop the roadway. NYSDOT guidelines state that culverts with a height of over 5 feet must have a HW/D ratio of less than 1.0 and be designed for the 50-year flood. Table 4-9 summarizes the HW/D results of the HY-8 analysis.

TABLE 4-9
HW/D for Existing Culvert

Peak Flows	Discharge (cfs)	HW/D
2-year flood	316	0.68
5-year flood	560	0.82
10-year flood	770	0.92
25-year flood	1,090	1.08
50-year flood	1,380	1.24
100-year flood	1,690	1.45
200-year flood	2,050	1.75
500-year flood	2,550	1.96

Alternative 6-1: Replace Route 145 Culvert

The NYSDOT HW/D requirements are exceeded at this culvert during the 25-year flood event. In order to pass the 100-year flow with a HW/D ratio less than 1.0, a replacement culvert could have dimensions of 15-foot rise and 10-foot span, or 10-foot rise and 18-foot span. Since the bankfull width of the channel at this location is 43.4 feet and the span of the culvert is 10 feet, the Route 145 culvert does not come close to spanning the bankfull width of the channel. In order to reduce flooding and debris jams, the culvert would need to be replaced with a larger structure that can adequately pass the 50- or 100-year flood event. A replacement culvert with a size in the range of a 10-foot rise and 18-foot span is recommended. A more detailed hydraulic analysis would be required to determine the appropriate sizing.

The estimated construction cost to replace the existing Route 145 culvert with a four-sided box culvert with a 10-foot rise, an 18-foot span, and a length of 220 feet would be in the range of $1.5M to $1.75M. The cost of engineering design, survey, geotechnical engineering, and regulatory permitting would be on the order of $150,000.

Alternative 6-2: Program of Debris Management

When the Route 145 culvert becomes clogged with debris, its hydraulic capacity is reduced. A program to periodically remove debris from the culvert opening and from the channel upstream of the culvert would reduce the volume of debris and thereby reduce the likelihood of the culvert becoming clogged. However, based on hydraulic analysis, the culvert under Route 145 is fundamentally undersized to pass the required volume of water during large flood events even when it is not clogged with debris. Instituting a program of debris management would help to reduce the frequency of debris jams; however, it would not solve the fundamental problem of the undersized culvert.

Focus Area #6 Recommendations

The following recommendations are offered for Focus Area #6 in order of priority:

1. Alternative 6-2 – Debris Management – The development of a debris management program would reduce the volume of upstream debris being mobilized and delivered to the culvert and is recommended for immediate implementation.

2. Alternative 6-1 – Route 145 Culvert Replacement – As a first step, confirmation should be obtained from NYSDOT, Schoharie County DPW, or local highway superintendents as to the frequency of flooding associated with this culvert. If the culvert has a history of flooding, scour, and/or clogging, it is recommended that the culvert be replaced with a larger structure that can adequately pass the 50- or 100-year flood event with acceptable HW/D ratio requirements.

4.3.7 Focus Area #7 – Village of Schoharie

Background

The village of Schoharie is located in Schoharie County, the county seat. Schoharie Creek flows west of the village and under the Bridge Street bridge. As was the case in Middleburgh, Schoharie Creek flows across a wide, flat-bottomed valley with an extensive floodplain as it flows past the village of Schoharie. In some locations, the floodplain is close to three-quarters of a mile wide. According to the FEMA FIRMs, the village of Schoharie along Main Street is subject to inundation during the 100-year flood event as depicted in Figure 4-31. Figure 4-32 is a photograph taken from the Bridge Street bridge. The expansive flood zone associated with the 100-year flood event extends into the village of Schoharie, inundating portions of Main Street and affecting neighborhoods to the west of Main Street and portions of the village to the east of Main Street.

Under the 500-year flood event, all of Main Street is predicted to flood as well as an area to the west of Main Street. The area inundated during a 500-year flood event includes many structures and facilities that are critical to the function of village, town, and county governance and business. These include the Town Clerk's office, the Village offices, the County Courthouse complex, the County Mental Health facility, and several churches.

Hydraulic modeling was undertaken to determine flooding depths at various locations in Schoharie during the 10-year and 100-year flood events. Table 4-10 reports flooding depths. While many areas remain dry during the 10-year event, they are inundated by floodwaters of up to 2.4 feet deep during the 100-year flood event.

TABLE 4-10
Floodwater Depths in Schoharie during the 10-year and 100-year Floods

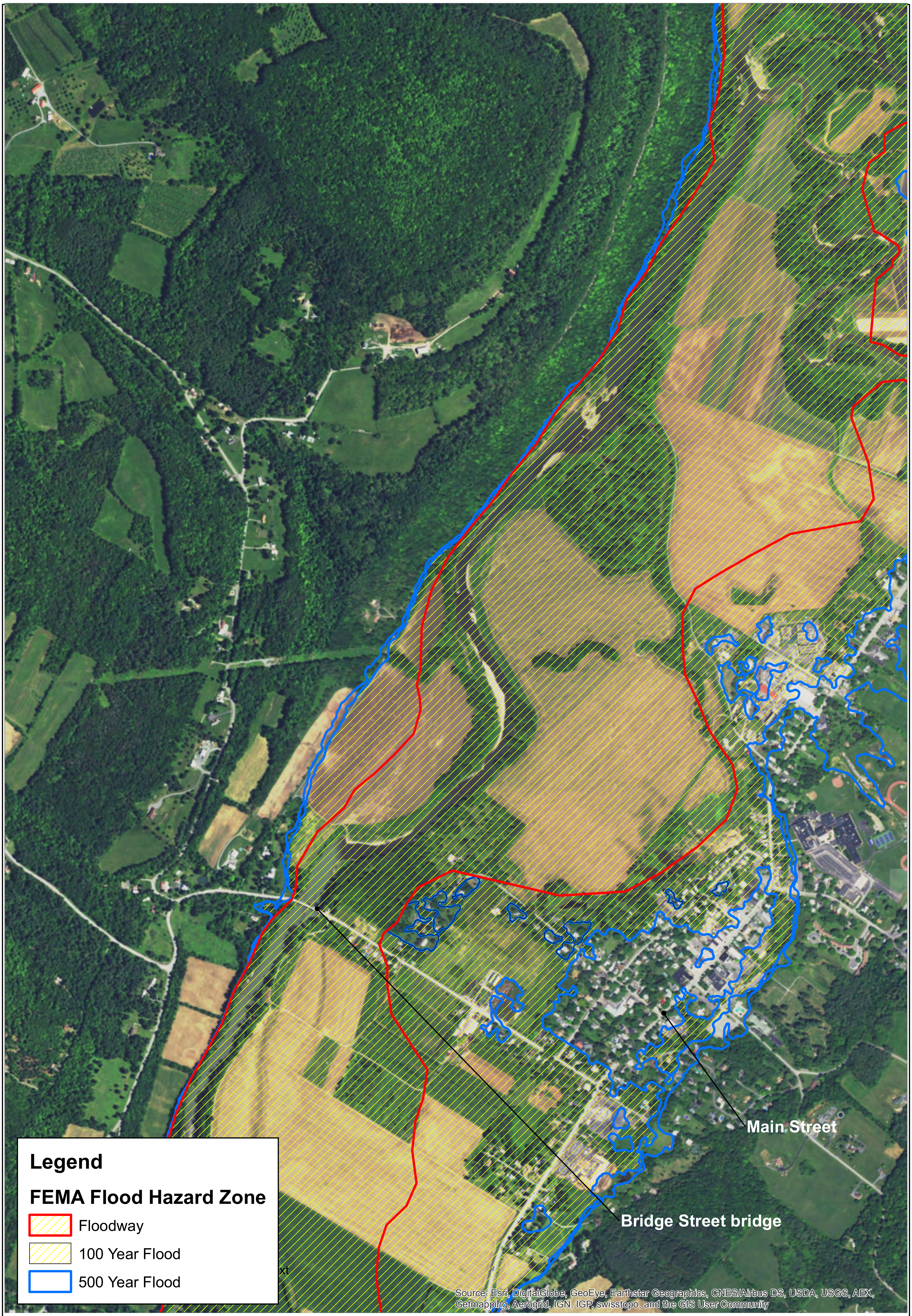
Location	10-Year Depth of Flooding (feet)	100-Year Depth of Flooding (feet)
Intersection of Sunset Drive and Main Street	0.0	1.8
Intersection of Bridge Street and Main Street	0.0	2.4
Intersection of Prospect Street and Main Street near High School	0.0	0.5
Schoharie County Sheriff	0.0	1.4

<u>Alternative 7-1: Floodplain Enhancement</u>

Hydraulic modeling of the study area was undertaken in HEC-RAS using new survey points from field survey combined with information from the FEMA model, *StreamStats* data, and elevations from 2014 USGS 3-County LiDAR. The FEMA HEC-RAS model was updated using surveyed cross sections. Two-year storm flows were added to the model using data from *StreamStats*.

Many factors contribute to whether or not floodplain enhancement will result in a meaningful decrease in flooding and flood-related damages in nearby, inhabited areas. For this reason, it was necessary to conduct hydraulic modeling for a range of floodplain enhancement configurations along Schoharie Creek. One such configuration is illustrated in Figure 4-33, which shows a wide enhanced floodplain along the right bank of Schoharie Creek downstream of the Bridge Street bridge.

The fields along Schoharie Creek downstream of the Bridge Street bridge are frequently flooded under existing conditions. Based on hydraulic modeling, enhancements to the floodplains in this area would provide only minimal flood reduction benefits within the village of Schoharie.



SOURCE(S):
NYS GIS Clearinghouse Orthoimagery (accessed June 2016)

FEMA Schoharie County Special Flood Hazard Area

Figure 4-31: FEMA Flood Insurance Rate Map - Village of Schoharie

Location: Schoharie, NY

N

Schoharie Basin Flood Analysis

Map By: EMH
MMI#: 4805-05
MXD: Q:\Projects\4805-05 Schoharie Basin Flood Analysis\GIS\MDX
1st Version: 6/6/2016
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Figure 4-32
View of Schoharie Creek and its broad floodplain looking downstream from Bridge Street bridge in Schoharie

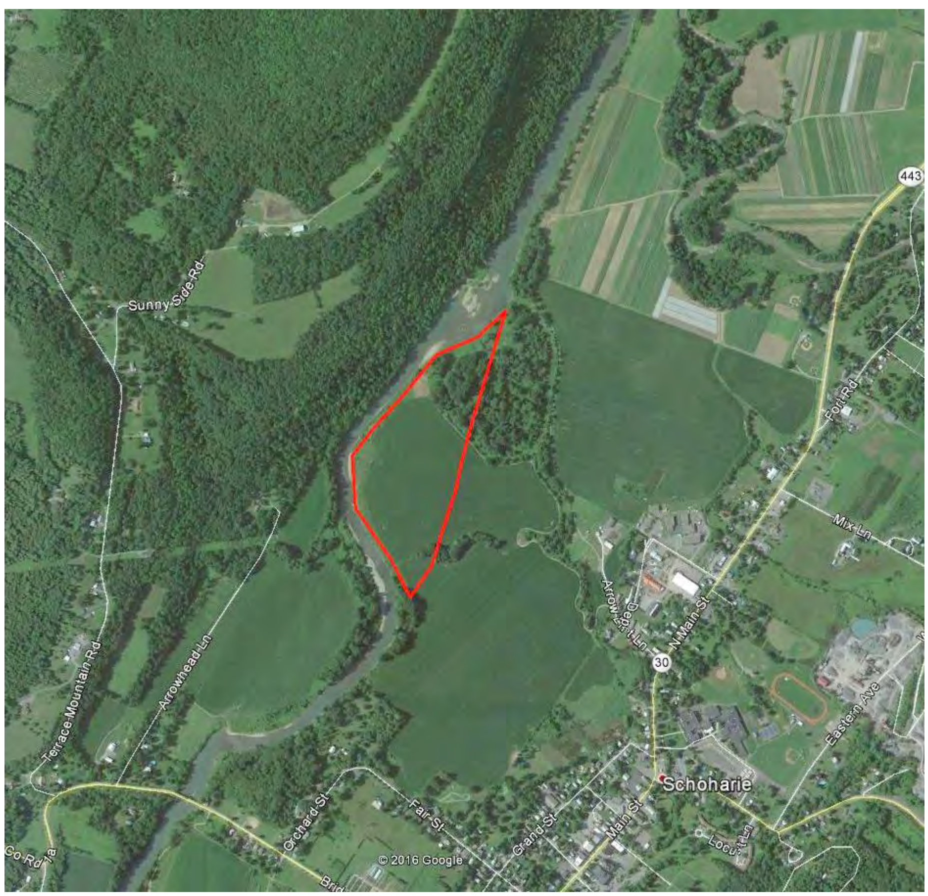

Figure 4-33
Aerial view showing one possible configuration of an enhanced floodplain along the right bank of Schoharie Creek

Alternative 7-2: Dredging

A proposed dredge alternative removes a rise in the channel slope from a point in the channel approximately 2,000 feet downstream of the Bridge Street bridge to immediately downstream of the bridge. Hydraulic modeling predicts that dredging will provide minimal benefit, with a maximum decrease in water surface elevation of 0.4 feet in the 10-year flood and 0.3 feet in the 100-year flood. Approximately 106,500 cubic yards of material would need to be removed from the channel, or nearly 6,000 truckloads. Figure 4-34 depicts the extent of proposed dredging. Under this alternative, approximately 106,500 cubic yards of material would need to be removed, resulting in an estimated cost of $2.8M with little flood mitigation improvement.

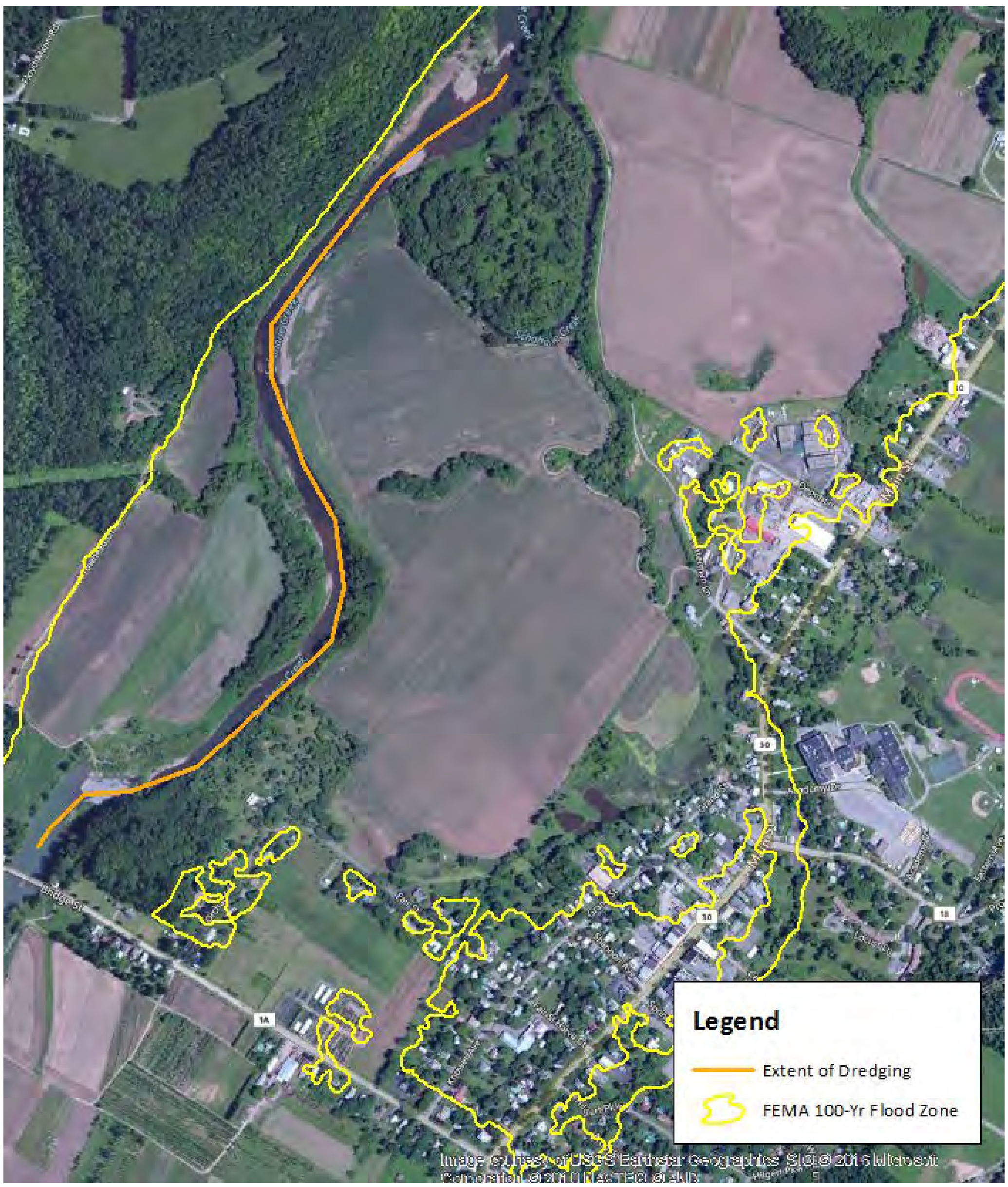

Figure 4-34
Aerial view showing the proposed extent of dredging in Schoharie under Alternative 7-2

Alternatives 7-3a and 7-3b: Levee Scenarios

Alternative 7-3a – The first levee scenario in Schoharie would extend around a substantial portion of the village area. The proposed levee would range in height between 2 feet and 6 feet at an elevation 1 foot above the 100-year water surface elevation. Under this scenario, the levee would be approximately 9,350 feet in length. Automatic or manually operated floodgates would be required at locations where roads pass through the levee, and roads would be closed during flood events.

Under this scenario, a land area of approximately 150 acres that is currently inundated during the 100-year flood would be protected from flooding. Modeling of the levee indicates that increases in water surface elevation in the Schoharie Creek channel adjacent to the levee would be negligible. Figure 4-35 depicts the location of the proposed levee.

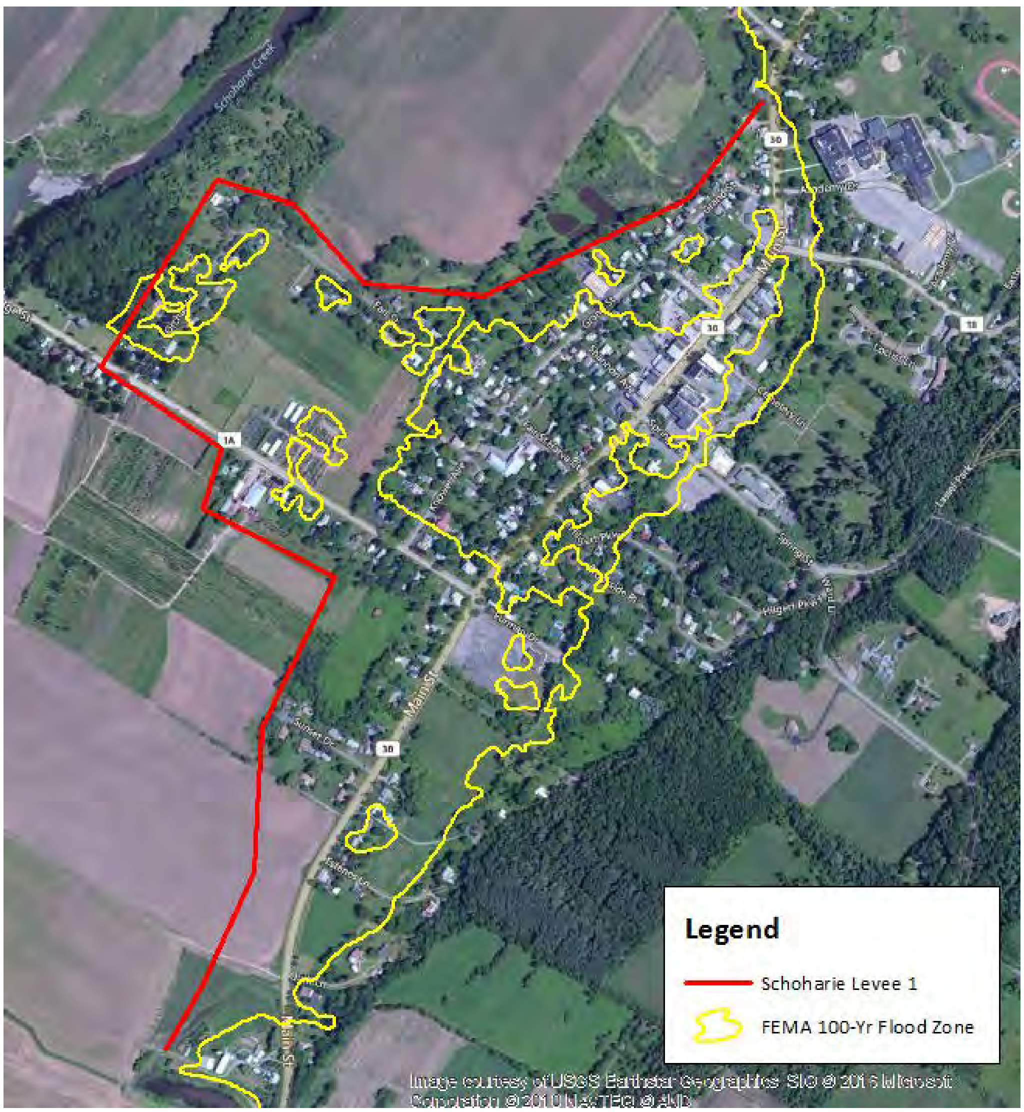

Figure 4-35
Aerial view showing the location of proposed levee scenario 1 in the village of Schoharie

The cost of design and permitting for the Alternative 7-3a levee is approximately $220,000. The construction costs for the levee is estimated at $2.2M.

Alternative 7-3b – A second levee scenario was evaluated in the village of Schoharie that would extend around a smaller area than in Alternative 7-3a and would not protect the area of Bridge Street, Orchard Street, and Fair Street. The proposed levee would range in height between 2 feet and 6 feet at an elevation 1 foot above the 100-year water surface elevation. Under this scenario, the levee would be approximately 6,297 feet in length. Floodgates would be required at locations where roads pass through the levee. Conceptual engineering sketches of the proposed levee and volume calculations are appended. A land area of approximately 100 acres that is currently inundated during the 100-year flood would be protected from flooding. Modeling of the levee indicates that increases in water surface elevation in the Schoharie Creek channel adjacent to the levee would be negligible. Figure 4-36 depicts the location of the proposed levee.

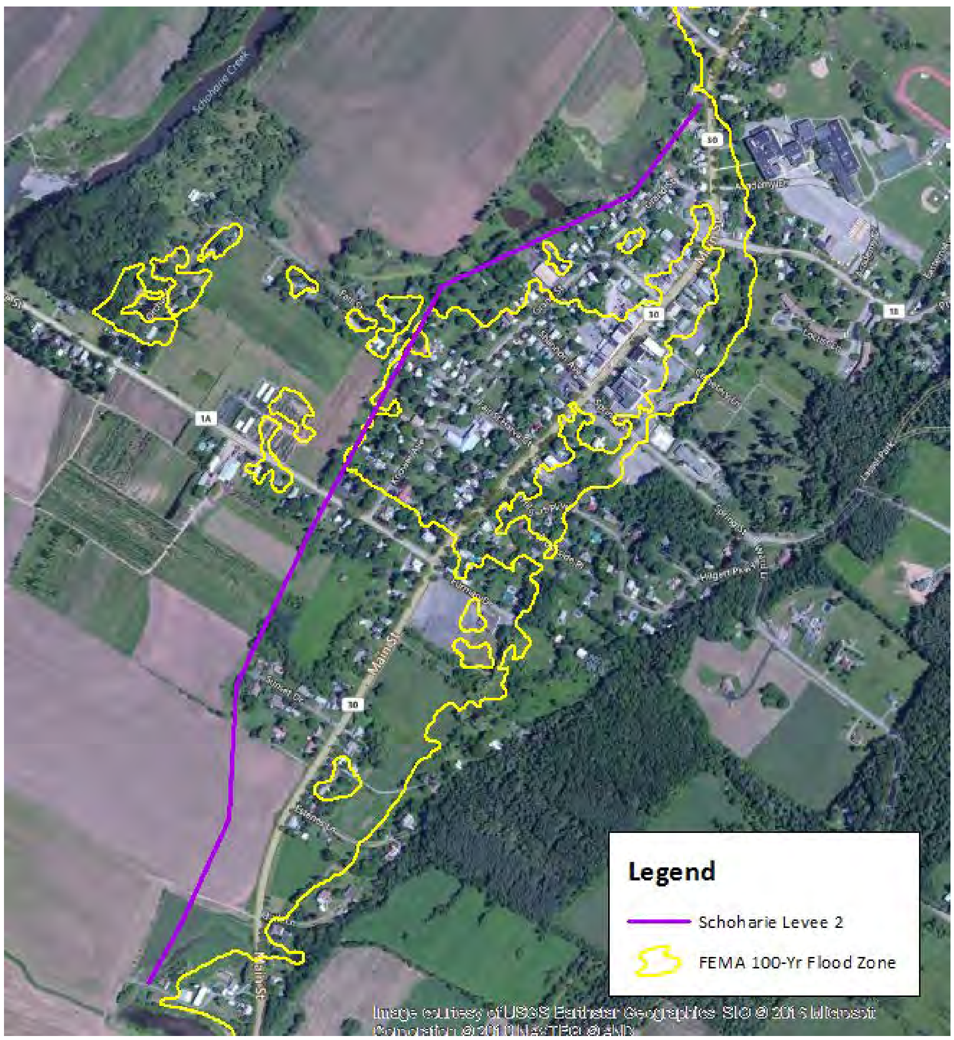

Figure 4-36
Aerial view showing the location of proposed levee scenario 2 in the village of Schoharie

The cost of design and permitting for this alternative is approximately $160,000 while the construction costs would be on the order of $1.6M. As with the cost estimates for a levee in Middleburgh, these figures assume that the floodgates at each of the points where a road would need to pass through the levee would be operated manually. The cost of automated floodgates would substantially increase the cost. Also not included in the estimates is the cost of the required property acquisition, structure demolition, and construction easements to enable construction of the levee. Approximately 25 to 30 property parcels would be impacted by the construction of the levee scenarios. The cost of a pump operation to remove stormwater from behind the levee has not been evaluated. When all of these factors are taken into consideration, it is likely that the cost of the Schoharie levee scenarios would be in excess of $4M.

Alternative 7-4: Individual Building Floodproofing

Floodwater depths in Schoharie during the 100-year flood event range from less than a foot at the intersection of Prospect Street and Main Street near the High School to 2.4 feet at the intersection of Bridge Street and Main Street. Water at this depth can be dangerous, capable of knocking an adult off their feet, sweeping away a vehicle, or severely damaging a building.

A variety of measures are available to protect existing public and private properties in floodprone areas of the village of Schoharie from damage. On a case-by-case basis where structures are at risk, individual floodproofing should be explored. This may range from elevation of structures, to construction of barriers, floodwalls, and earthen berms, to dry or wet floodproofing, to other improvements to mitigate damage from flooding. Emphasis should be placed on critical facilities. Costs will vary depending on what measures are implemented. The following approximate costs are provided:

- Elevating a residential structure: $175,000
- Protecting homeowner utilities from flooding: $1,500 to $2,000
- Implementing a variety of measures to protect a small business: $6,000 to $50,000

Focus Area #7 Recommendations

In the village of Schoharie, the following actions are recommended:

1. Seek to acquire, and relocate where feasible, the most flood-vulnerable properties where there is owner interest and programmatic funding available through FEMA or other sources of funding. Top priority should be placed on critical facilities such as firehouses and schools.

2. Move existing structures out of the floodway. For example, there are several structures along Bridge Street just east of Schoharie Creek that are located within the floodway.

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

4. Some of the homes located toward the periphery of the floodplain may be only rarely flooded. Residents and businesses may benefit from minor individual property improvements. Providing landowners with information regarding individual property protection is recommended (see Individual Property Flood Protection measures described in Section 4.2 of this report).

4.3.8 Focus Area #8 – Fox Creek

Background

Focus Area #8 includes an approximately 3.5-mile-long reach of Fox Creek beginning downstream of the County Route 9 bridge in the hamlet of West Berne, town of Berne, in Albany County and extending downstream to the NYS Route 443 crossing in Schoharie County. This section of Fox Creek runs along or crosses Route 443 for its entire length and passes under a total of six bridges. At a public meeting held on October 26, 2015, numerous members of the public commented on this section of Fox Creek with reports of flooding, sediment aggradation, and debris jams, especially at the bridges. Table 4-11 lists the bridges within this reach from upstream to downstream.

TABLE 4-11
Bridges within Focus Area #8

Bridge Name	Jurisdiction	Bridge Identification Number (BIN)
State Route 443 (upper)	State	1025250
Schell Road	Town	2228690
Schoonmaker Road	Town	3354690
Zimmer Road	Town	3354680
Sholtes Road	Town	3354670
State Route 443 (lower)	State	1025240

In contrast to the broad floodplain along Schoharie Creek, Fox Creek flows through a steep, narrow valley. The creek exhibits flashy behavior as illustrated by the hydrograph in Figure 4-37 from May 29 and 30, 2016, showing an increase in stage of over 6 feet during a period of less than 2 hours and within this period an increase of 5.4 feet in just 30 minutes.

This reach of Fox Creek has been evaluated by FEMA using approximate engineering methods only, meaning that identification of areas subject to flooding has been approximated, and no water surface elevations are provided (see Figure 4-38).

Bankfull width measurements were made in the field at several locations along this reach of Fox Creek and ranged from 90 feet to 120 feet. Hydraulic analysis along this section of Fox Creek focused primarily on determining the adequacy of the six existing bridges.

For the purpose of this study, new survey was collected, including channel cross sections and detailed hydraulic survey of the six bridges. A hydraulic model was developed and run to evaluate potential flood mitigation alternatives. Table 4-12 presents a summary of peak flows at three locations within this reach.

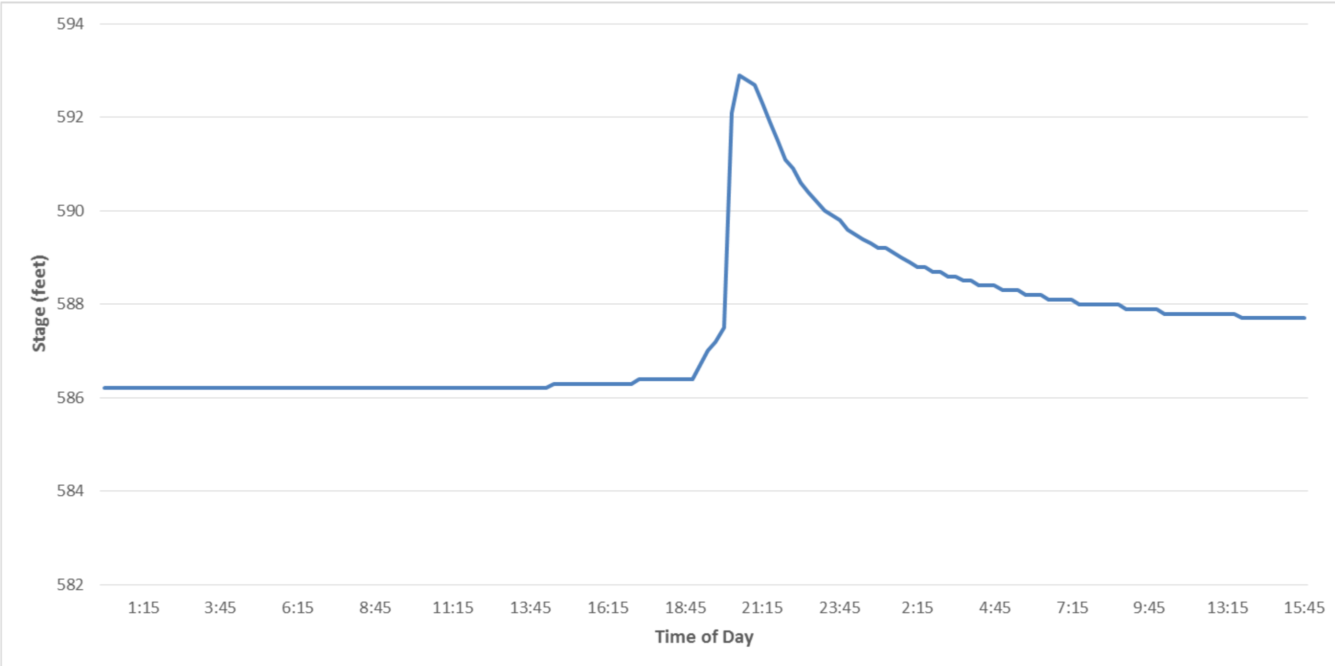

Figure 4-37
Fox Creek Hydrograph – May 29 and 30, 2016

TABLE 4-12
Summary of Peak Flows from USGS *StreamStats* at Three Flow Locations

Recurrence Interval	Fox Creek @ King Creek (cfs)	Fox Creek @ Ox Kill (cfs)	Fox Creek @ Upper 443 Bridge (cfs)
2-Year	3,030	2,680	2,390
10-Year	7,350	6,460	5,750
50-Year	12,800	11,200	9,940
100-Year	15,600	13,700	12,100
500-Year	23,300	20,400	18,000

Alternate 8-1: Modification/Replacement of the State Route 443 Bridge (Upper)

The upper bridge spanning NYS Route 443 is a steel beam bridge with concrete deck (Figure 4-39). Hydraulic assessment determined that this state highway bridge with a span of 115 feet is able to pass the 100-year flood event without overtopping although flows during this magnitude event would touch the low chord of the bridge. A measurement taken at a riffle located just upstream of the bridge determined the bankfull channel width to be 92 feet. This bridge spans approximately 1.25 times the bankfull width of the channel. The bridge is not recommended for replacement.

SOURCE(S):

NYS GIS Clearinghouse Orthoimagery (accessed June 2016)

FEMA Schoharie County Special Flood Hazard Area

Figure 4-38: FEMA Flood Insurance Rate Map - Fox Creek

Location: Berne, NY

Schoharie Basin Flood Analysis

Map By: EMH
MMI#: 4805-05
MXD: Q:\Projects\4805-05 Schoharie Basin Flood Analysis\GIS\MDX
1st Version: 6/6/2016
Revision: 9/22/2016
Scale: 1 in = 1,250 ft

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Figure 4-39
View of NYS Route 443 bridge over Fox Creek (upper of two crossings)

Alternate 8-2: Modification/Replacement of the Schell Road Bridge

The Schell Road bridge (Figure 4-40) provides access to several homes located along Schell Road on the north side of Fox Creek. It is reportedly prone to debris jams and was washed out during Tropical Storm Irene. Although the washout or loss of the bridge would be a major inconvenience for owners of the residences, there is an alternative route to these homes via Brick Schoolhouse Road, and Schell Road does not serve as a critical access route to a shelter or emergency facility. This is a single-span, truss-style bridge that sits on abutments that appear to predate the current bridge. The remnants of a central pier are visible in the center of the channel, and the left abutment juts out into the channel but does not appear to serve a function in supporting the current bridge.

Hydraulic assessment determined that the current bridge with a span of 100 feet between the existing abutments is able to pass the 100-year flood event without overtopping. The bridge does not appear to contribute to flooding of structures located upstream of the bridge. A measurement taken at a riffle located near the bridge determined the bankfull channel width to be approximately 100 feet. The opening between the abutments just barely spans the bankfull width of the channel.

Due to its ability to pass the 100-year flow, this bridge is not recommended for replacement. However, it may be possible to remove the remnants of the center pier and remove or modify the old left abutment. These actions would result in the span being widened to approximately 120 feet, which would increase the hydraulic capacity of the bridge and make it less susceptible to debris jams. A structural investigation of the bridge would be required in order to determine whether removal of the remnants of the center pier and the old left abutment is feasible.

Figure 4-40
Schell Road Bridge over Fox Creek

Alternate 8-3: Modification/Replacement of Schoonmaker Road Bridge

The Schoonmaker Road bridge (Figure 4-41) provides access to a small group of homes located on the north side of Fox Creek and to farm properties located farther north and east of the creek. The bridge is reportedly prone to debris jams and was washed out during Tropical Storm Irene. Although the washout or loss of the bridge would be a major inconvenience for landowners on the north side of the creek, there is an alternative route to these homes from the north via Brick Schoolhouse Road, and Schoonmaker Road does not serve as a critical access route to a shelter or emergency facility.

The Schoonmaker Road bridge is a concrete structure that appears to be of recent construction. The measured width of the span is 63 feet. Hydraulic assessment determined that while the bridge is capable of passing the 50-year flow without overtopping, flows of this magnitude would hit the low chord of the bridge potentially putting the structure in jeopardy. A measurement taken at a riffle located upstream of the bridge determined the bankfull channel width to be 106 feet while the bridge opening is only 63 feet, or only 60 percent of the bankfull width of the channel. Modeling indicates that the hydraulic constriction at the bridge does not contribute to flooding of structures upstream of the bridge, but it does make the bridge vulnerable to debris jams and washouts.

It is recommended that when the Schoonmaker Road bridge is due for replacement, it is replaced with a structure that can safely pass the 100-year flood event with adequate freeboard and is at least 130 feet in width to meet the NYSDEC guideline of 1.25 times the channel's bankfull width.

Figure 4-41
Schoonmaker Road Bridge over Fox Creek

Alternate 8-4: Modification/Replacement of Zimmer Road Bridge

The Zimmer Road bridge (Figure 4-42) provides access to several farm properties located along the road northeast of the creek. The bridge is reportedly prone to debris jams and was washed out during Tropical Storm Irene. Although the washout or loss of the bridge would be a major inconvenience for landowners on the north side of the creek, there is an alternative route to these homes from the northeast via Brick Schoolhouse Road. Zimmer Road does not serve as a critical access route to a shelter or emergency facility.

The Zimmer Road bridge is a concrete structure that appears to be of fairly recent construction. The measured width of the span is 60 feet. Hydraulic assessment determined that the bridge is considerably undersized. The 10-year flow event would touch the low chord of the bridge. The 50-year flood would cause flows to flank the bridge while the 100-year flow would completely overtop the deck. Hydraulic modeling indicates that a bridge width of 125 feet would be required in order to safely pass the 100-year flood event under the bridge but that the hydraulic constriction at the bridge does not contribute to flooding of any structures upstream of the bridge. It does leave the bridge vulnerable to debris jams and washouts.

A measurement taken at a riffle located just downstream of the Zimmer Road bridge determined the bankfull channel width to be 98 feet while the bridge opening is only 60 feet, or 60 percent of the bankfull width of the channel. It is recommended that a bridge in this location be designed with an approximately 125-foot opening to meet NYSDEC's guideline of 1.25 times the channel's bankfull width. It is recommended that the Zimmer Road bridge be replaced with a structure that can safely pass the 100-year flood event with adequate freeboard and is at least 125 feet in width.

Figure 4-42
Zimmer Road Bridge over Fox Creek

Alternative 8-5: Modification/Replacement of Sholtes Road Bridge

The Sholtes Road bridge (Figure 4-43) provides access to a small group of homes on the north side of Fox Creek and to several farm properties located along Sholtes Road to the northeast of the creek. The bridge is reportedly prone to debris jams and was washed out during Tropical Storm Irene. Although the washout or loss of the bridge would be an inconvenience for landowners on the north side of the creek, there is an alternative route to these homes from the northeast via Brick Schoolhouse Road. The road does not serve as a critical access route to a shelter or emergency facility.

The Sholtes Road bridge is a concrete structure that appears to be of new construction. The Fox Creek channel approaching the bridge is confined along the left bank by Route 443 where sheet piling has been used to protect the road embankment. The measured width of the bridge span is 64.5 feet. Hydraulic assessment determined that the bridge is considerably undersized. The 10-year flow event would touch the low chord of the bridge. The 50-year flood would cause flows to flank the bridge along its right embankment while the 100-year flow would completely overtop the deck. Hydraulic modeling indicates that a bridge width of at least 121 feet would be required in order to safely pass the 100-year flood event under the bridge.

A measurement taken at a riffle located near the bridge determined the bankfull channel width to be approximately 100 feet while the bridge opening is only 64.5 feet, or 64.5 percent of the bankfull width of the channel. It is recommended that the Sholtes Road bridge be replaced with a structure that can safely pass the 100-year flood event with adequate freeboard and is at least 125 feet in width in order to meet NYSDEC's guideline for 1.25 times the channel's bankfull width. This size would also pass the 100-year flood event.

Figure 4-43
Sholtes Road Bridge over Fox Creek

Alternative 8-6: Modification/Replacement of State Route 443 Bridge (Lower)

The more downstream bridge spanning NYS Route 443 (Figure 4-44) is a steel beam bridge with concrete deck with a span of 133 feet. The bridge spans Fox Creek at the midpoint of an S-turn in the channel where Fox Creek bends sharply to the left, flows under the bridge, and then bends sharply to the right. A floodplain culvert is located adjacent to the bridge in the floodplain on the right overbank. In contrast to the more confined upstream reaches of Fox Creek, the channel in the vicinity of the Route 443 bridge has a broad, forested floodplain.

Figure 4-44
Photos of Route 443 Bridge and Floodplain Culvert

At Left: View of State Route 443 bridge over Fox Creek (lower of two crossings)
At Right: Floodplain culvert adjacent to State Route 443 Bridge

Hydraulic assessment determined that the Route 443 bridge, with a span of 133 feet, overtops during the 100-year flood event. During the 50-year flood event and larger, floodwaters overflow the channel and are conveyed across a floodplain chute on the right overbank. The floodplain culvert located adjacent to the bridge on the right overbank is not adequately sized to pass flow under the roadway during large flood events. Based on hydraulic analysis, a bridge opening of 253 feet would be required to pass the 100-year flood event under the bridge. A bridge of this size would be close to double the size of the existing bridge and would need to span not only the Fox Creek channel but also the floodplain along the right overbank as shown in Figure 4-45.

Figure 4-45
Aerial view indicating path of flood flows at State Route 443 bridge

<u>Alternative 8-7: Sediment Management</u>

In addition to the undersized bridges along Fox Creek, there are sections along which the creek is unstable with steep, eroding banks. This is likely due to past removal of sediment from the channel, which was evident by the presence of side-cast dredge spoils along the channel (Figure 4-46). A sound sediment management program should be established that 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 developed standards. Conditions under which active sediment management should be considered include the following:

- 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

Figure 4-46
Side-cast dredge spoils along Fox Creek

If it is determined that sediment excavation in the Fox Creek 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. Although regional curves are a useful tool for estimating bankfull geometry, on-site field measurements are always preferred. The measured bankfull width through the subject reach of Fox Creek ranges from approximately 95 to 105 feet. These measured values should be verified using additional field measurements and should be supplemented with measurements of bankfull depth and cross-sectional area.

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. The contributing watershed of Fox Creek at this location is approximately 85 square miles. Therefore, sediment removal volume should not exceed 4,250 cubic yards.

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 should be contacted, and appropriate permitting should be obtained.

5. Disposal of excavated sediments should always occur outside of the floodplain. Along Fox Creek, these materials have been placed on the adjacent bank where they block the creek's access to the floodplain and will be vulnerable to remobilization and redeposition during the next large storm event. This is especially evident in the floodplain just upstream of the Schoonmaker Road bridge. This material should be removed from the floodplain.

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

Alternative 8-8: Bank Erosion Repairs

The need for targeted sediment removal on Fox Creek can be reduced by reducing the sediment load at its sources (i.e., by repairing bank failures and headcuts and reducing erosion). Areas of severely eroding banks were observed along Fox Creek during this study (Figure 4-47) and have been documented in previous reports (Cleveland, Moore and Kusler, 2013). Many of these sites occur on private landowner properties.

Figure 4-47
Steep eroding bank along Fox Creek

Focus Area #8 Recommendations

The following recommendations are offered for Focus Area #8:

1. Alternative 8-7 – Sediment Management – The development of a sediment management plan (Alternative 8-7) is recommended for Fox Creek with a focus on stabilization of banks and high bank failures (Alternative 8-8) within and upstream of this focus area.

2. <u>Alternatives 8-4 and 8-5 – Bridge Replacement</u> – It is recommended that the Zimmer Road bridge (Alternative 8-4) and the Sholtes Road bridge (Alternative 8-5) be replaced with structures that can safely pass the 100-year flood event with adequate freeboard and with a span that is at least 1.25 times the bankfull width of the channel. An approximate cost of replacing the Sholtes Road and Zimmer Road bridges is $1.4M to $1.8M per bridge for construction.

3. <u>Alternatives 8-1 and 8-6 – Bridge Replacement</u> – The two bridges that carry NYS Route 443 over Fox Creek (Alternatives 8-1 and 8-6) span the bankfull width of the channel and are capable of passing the 50-year flood. At the more downstream of the two bridges, floodwaters overtop the roadway adjacent to the bridge in the 50-year flood event. These bridges are not recommended for immediate replacement; however, when the downstream bridge is scheduled for replacement, its replacement should span the floodplain.

4. <u>Alternative 8-2 – Abutment Alteration</u> – The Schell Road bridge is not recommended for immediate replacement; however, it may be feasible to remove the remnants of the center pier and remove or modify the old left abutment, which would increase the hydraulic capacity of the bridge and make it less susceptible to debris jams.

5. <u>Alternative 8-3 – Bridge Replacement</u> – When the Schoonmaker Road bridge is due for replacement, it should be replaced with a structure that can safely pass the 100-year flood event with adequate freeboard and at least 130 feet in width.

4.3.9 <u>Focus Area #9 – Gallupville</u>

<u>Background</u>

The hamlet of Gallupville, through which Fox Creek runs, was subjected to flooding during Tropical Storm Irene. This reach of Fox Creek has been evaluated by FEMA using approximate engineering methods only, meaning that identification of areas subject to flooding has been approximated, and no water surface elevations are provided (Figure 4-48). According to input received at a public meeting, flooding was most severe along School Street, Mill Street, and Factory Street, especially in the area of the public works garage and firehouse (Figure 4-49).

<u>Alternative 9-1: Modification/Replacement of School Street Bridge</u>

The School Street bridge (BIN 3354660) as seen in Figure 4-50 was assessed using hydraulic modeling. The bridge was not found to cause a hydraulic constriction during flood events and therefore is not contributing to flooding within the hamlet. The bridge is adequately sized to pass the 100-year flood event.

<u>Alternative 9-2: Floodplain Enhancement</u>

Floodplain enhancement was evaluated along the right bank of Fox Creek in the area of confined channel just upstream of the School Street bridge. An enhanced floodplain 1,200 linear feet in length with a maximum width of 135 feet was modeled, with results indicating that floodplain enhancement would not cause a substantial reduction in flood levels in Gallupville. Figure 4-51 is a water surface profile showing hydraulic modeling results of an enhanced floodplain scenario along Fox Creek.

SOURCE(S):
NYS GIS Clearinghouse Orthoimagery (accessed June 2016)

FEMA Schoharie County Special Flood Hazard Area

Figure 4-48: FEMA Flood Insurance Rate Map - Gallupville

Location: **Wright, NY**

N

Schoharie Basin Flood Analysis

Map By: EMH
MMI#: 4805-05
MXD: Q:\Projects\4805-05 Schoharie Basin Flood Analysis\GIS\MDX
1st Version: 6/6/2016
Revision: 9/22/2016
Scale: 1 in = 337 ft

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Figure 4-49
View showing floodprone area of the Gallupville Hamlet, including firehouse and public works

Figure 4-50
Fox Creek viewed from the School Street bridge in Gallupville, looking upstream. Under Alternative 9-2, floodplain enhancement was modeled along the right bank.

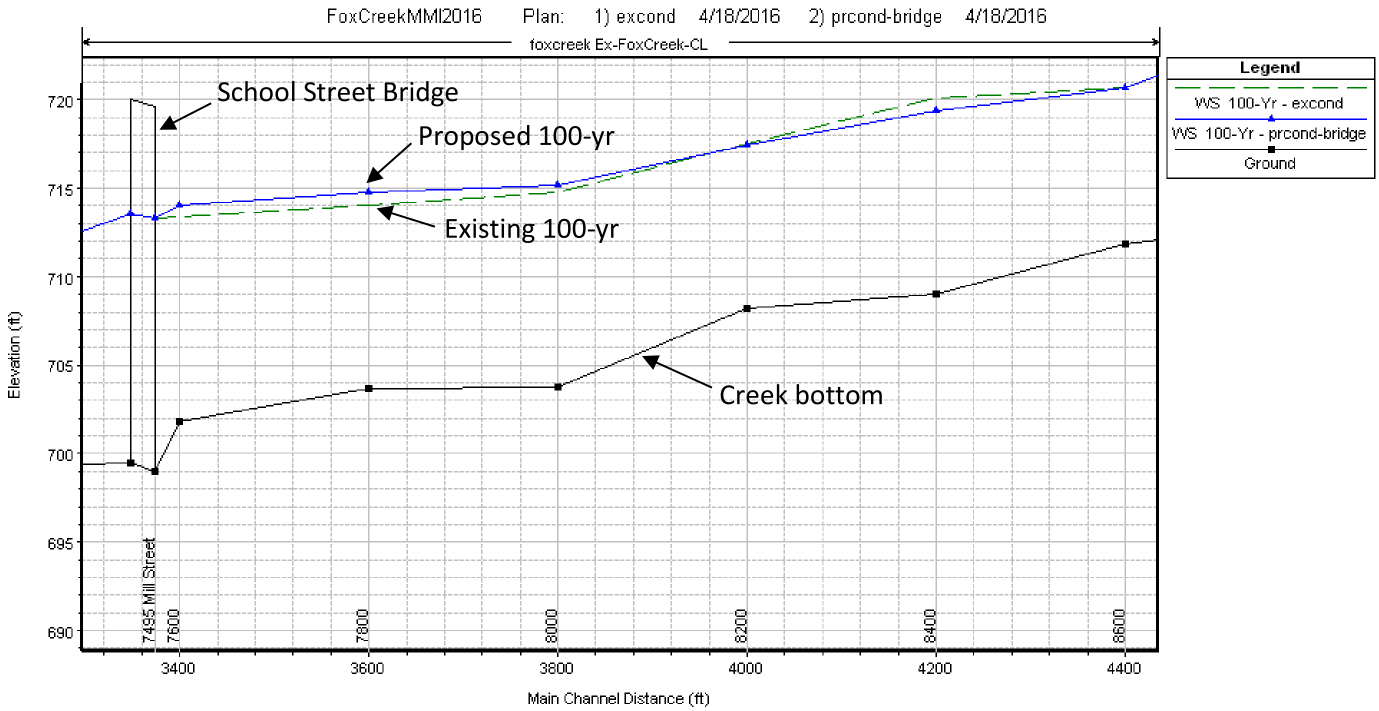


Figure 4-51
Water surface profile showing results of enhanced floodplain along Fox Creek in Gallupville

Alternative 9-3: Individual Building Relocation, Elevation, or Floodproofing

A variety of measures are available to protect existing public and private properties in floodprone areas. On a case-by-case basis where structures are at risk, individual floodproofing should be explored. This may range from elevation of structures, to construction of barriers, floodwalls, and earthen berms, to dry or wet floodproofing, to other improvements to mitigate damage from flooding. In some cases, removal of the structures and relocation of the uses may be appropriate. Emphasis should be placed on town-critical facilities. Costs will vary depending on what measures are implemented. The following approximate costs are provided for individual structures:

- Elevating a residential structure: $175,000
- Protecting homeowner utilities from flooding: $1,500 to $2,000
- Implementing a variety of measures to protect a small business: $6,000 to $50,000

Focus Area #9 Recommendations

In the hamlet of Gallupville, the following actions are recommended:

1. Seek to acquire, and relocate where feasible, the most flood-vulnerable properties where there is owner interest and programmatic funding available through FEMA or other sources of funding. Top priority should be placed on critical facilities such as the firehouse and the DPW garage.

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

3. Some of the homes located toward the periphery of the floodplain may be only rarely flooded. Residents and businesses may benefit from minor individual property improvements. Providing landowners with information regarding individual property protection is recommended (see Individual Property Flood Protection measures described in Section 4.2 of this report).

4.3.10 Focus Area #10 – Railroad Bridge in Esperance

The Town of Esperance is located in Schoharie County. Schoharie Creek flows under an active Canadian Pacific Rail railroad bridge, which crosses the floodplain and spans the creek just downstream of Beechnut Lane at the southern side of town. The main span of the railroad bridge over the Schoharie Creek channel is approximately 275 feet in length. There is also a smaller span, approximately 125 feet in length, over a side channel. Between these spans, the rail line runs across an earthen railroad embankment that cuts across the floodplain. In total, the railroad embankment and the two bridges cross approximately 2,500 feet, or nearly half a mile of floodplain. Schoharie Creek at the railroad bridge has a drainage area of 815 square miles.

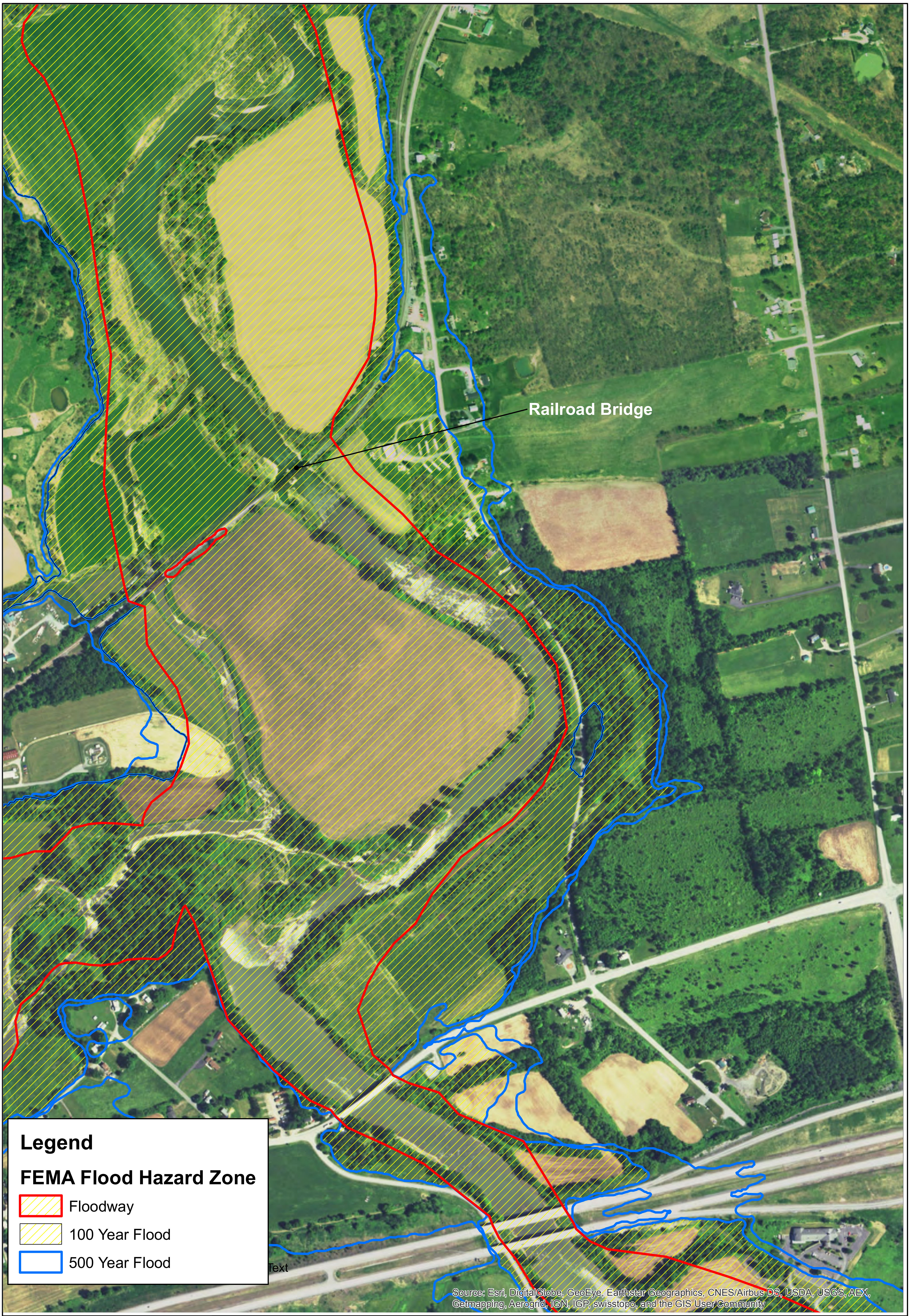
FEMA FIRMs indicate that an extensive area upstream of the railroad bridge including agricultural fields, the neighborhoods along Junction Road and Beechnut Lane, and the Junction Road roadway itself are subject to inundation during the 100-year flood event (Figure 4-52). According to input received at a public meeting, the neighborhood on Beechnut Lane was inundated during Tropical Storm Irene, with damage to properties and structures. Many of the structures in this area were destroyed and have not been rebuilt. A hydraulic analysis was undertaken to determine whether the railroad bridge acts as a hydraulic constriction during flood events and the extent to which the bridge may be contributing to upstream flooding.

Alternative 10-1: Modification/Replacement of Canadian Pacific Railroad Bridge

The study area was analyzed using the FEMA HEC-RAS model to represent existing conditions. The removal of railroad bridges and associated railroad embankment was analyzed and compared to existing conditions. Removing the railroad bridges and embankment is predicted to result in a reduction of water surface elevations upstream of the bridge by 2.2 feet during the 100-year event, 0.8 feet during the 50-year event, and 0.3 feet during the 10-year event. The reduction during the 100-year flood extended over a mile upstream of the railroad bridge crossing, well upstream of the I-88 highway bridge over Schoharie Creek.

The flood extents were mapped using HEC-GeoRAS, with elevations from the 2014 USGS Schoharie LiDAR data. Figure 4-53 shows the extent of the 100-year flood in existing and proposed conditions. Although water surface elevations are reduced by removing the railroad bridge and embankment, buildings along Beechnut Lane and Junction Road are not removed from the 100-year flood zone.

In order to eliminate the hydraulic constriction caused by the rail crossing, the bridges and the railroad embankment would need to be removed from the floodplain. Removal of an active Canadian Pacific railroad line over Schoharie Creek is unlikely. If use of the rail line were to be discontinued in the future, the removal of the railroad line from the floodplain should be investigated.



SOURCE(S):	Figure 4-52: FEMA Flood Insurance Rate Map - Railroad Bridge in Esperance		Location: Esperance, NY
NYS GIS Clearinghouse Orthoimagery (accessed June 2016) FEMA Schoharie County Special Flood Hazard Area	N Schoharie Basin Flood Analysis	Map By: EMH MMI#: 4805-05 MXD: Q:\Projects\4805-05 Schoharie Basin Flood Analysis\GIS\MDX 1st Version: 6/6/2016 Revision: 9/22/2016 Scale: 1 in = 500 ft	MILONE & MACBROOM 231 Main Street, Suite 102 New Paltz, NY 12561 (845) 633-8153 Fax: (845) 633-8162 www.miloneandmacbroom.com

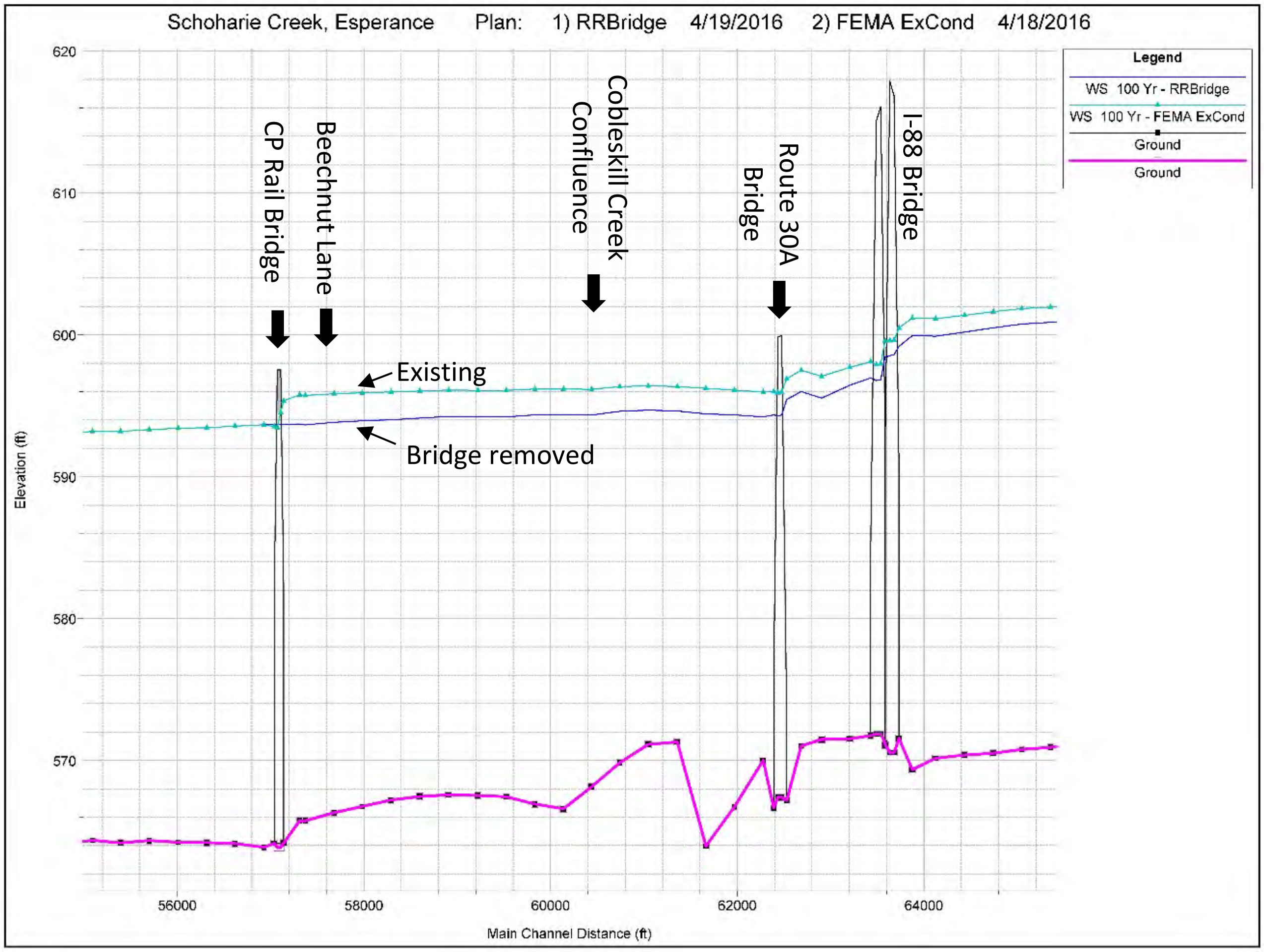


Figure 4-53
Water Surface Elevations with Bridge Removed

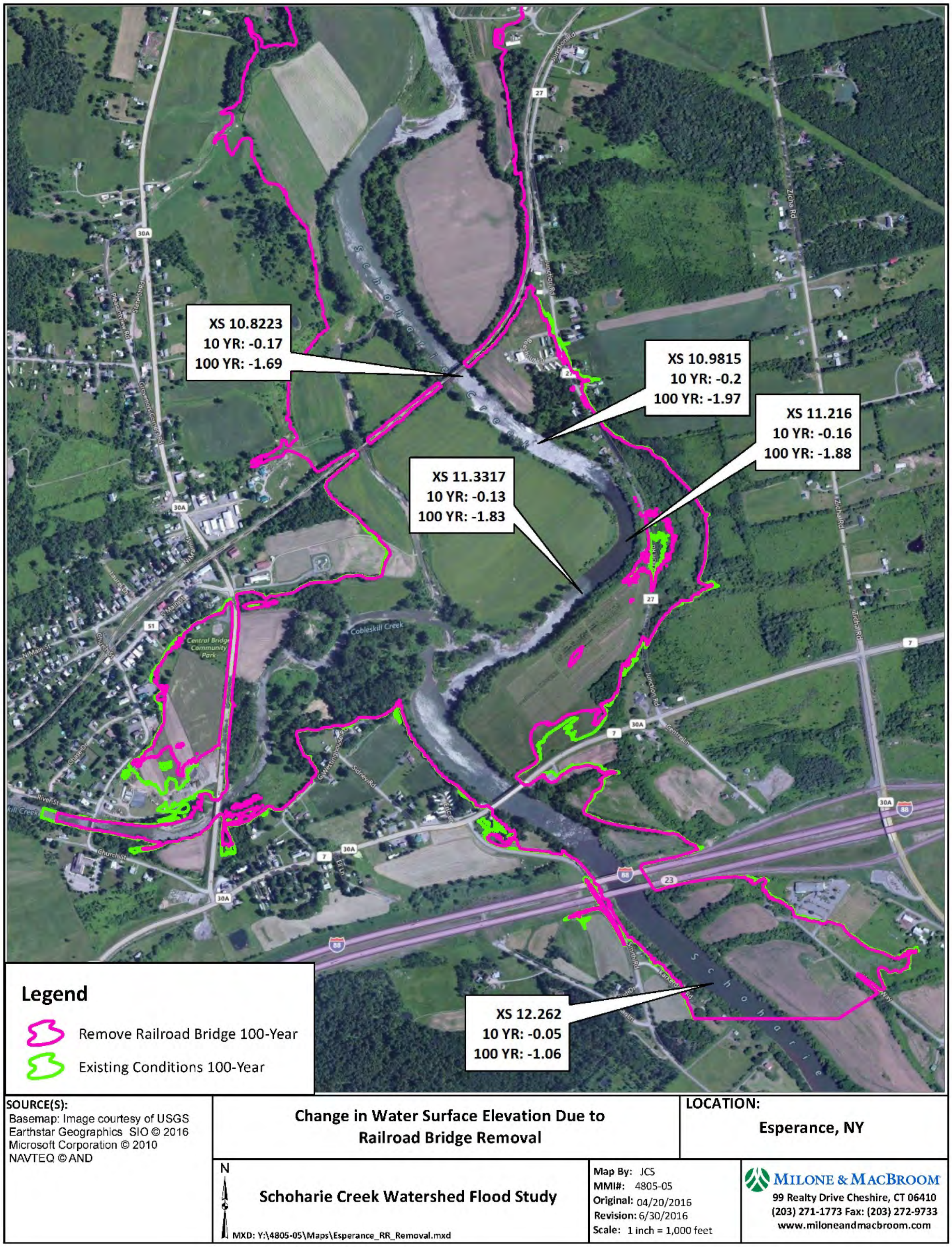


Figure 4-54
Change in water surface elevations if bridge and embankment were to be removed (Alternative 10-1)

Alternative 10-2: Compliance with and Enforcement of NFIP

Any new development in the floodway as well as any new construction or reconstruction of substantially damaged structures should be required to meet NFIP criteria. There are few structures subject to flooding in this area. It is recommended that they be assessed for elevation, relocation, or floodproofing.

Focus Area #10 Recommendations

Given the limited options for structural alterations or floodplain enhancement within this focus area, individual building floodproofing is recommended along with stringent requirements on any future development in the floodplain.

4.3.11 Focus Area #11 – Cobleskill Creek Confluence

Background

This study area focuses on the lower reach of Cobleskill Creek just upstream of its confluence with Schoharie Creek in the town of Central Bridge, Schoharie County. Two bridges cross this reach of Cobleskill Creek: the Church Street (County Route 51) bridge (BIN: 3354630) and the NYS Route 30A bridge (BIN: 1021360). Downstream of the NYS Route 30 bridge, Cobleskill Creek meanders through Central Bridge Community Park before reaching its confluence with Schoharie Creek. This section of the creek is subject to sediment aggradation and bank erosion.

NYS Route 30A serves as an important route out of this floodprone area of the Schoharie Valley during large flood events. According to the Schoharie County Region 27 Evacuation Route, residents in the Central Bridge area are directed to proceed to the Schoharie Valley Gospel Church shelter on Sprakers Road in Esperance by traveling north on NYS Route 30A across the bridge.

Attendees at a public meeting held at the onset of this flood study reported that during Tropical Storm Irene water overtopped the NYS Route 30A roadway in the area just north of the bridge, making the road impassible. These observations are consistent with FEMA flood mapping, which indicates that the 100-year flood event inundates an extensive portion of the area north of Cobleskill Creek between Church Street and Route 30A, including structures and greenhouses located just downstream of Church Street, and that floodwaters overtop Route 30A to the north side of the bridge. The greenhouses and a portion of NYS Route 30A are located within the FEMA floodway. Figure 4-55 shows the bridges over Cobleskill Creek and the floodplain in this area.

Alternative 11-1: Modify/Replace Church Street Bridge

According to the FEMA HEC-RAS model, the Church Street bridge opening is 129 feet wide. The bankfull width of Cobleskill Creek was measured in the field to be 120 feet at this location. Therefore, the bridge spans 1.08 times the bankfull width of the channel.

Cobleskill Creek within Focus Area #11 was analyzed using hydraulic modeling, using flows from the FEMA FIS to represent existing conditions. In order to determine the influence that the Church Street bridge is having on water surface elevations, the bridge was removed from the model. This resulted in a water surface elevation decrease of only 0.1 feet upstream of Church Street bridge during the 100-year event;

flood mitigation in the more frequent floods was negligible. Therefore, it can be concluded that replacing the Church Street bridge with a larger structure would not be expected to provide appreciable benefits. Replacement of the Church Street bridge is not recommended.

Figure 4-55
Photos of Bridges over Cobleskill Creek

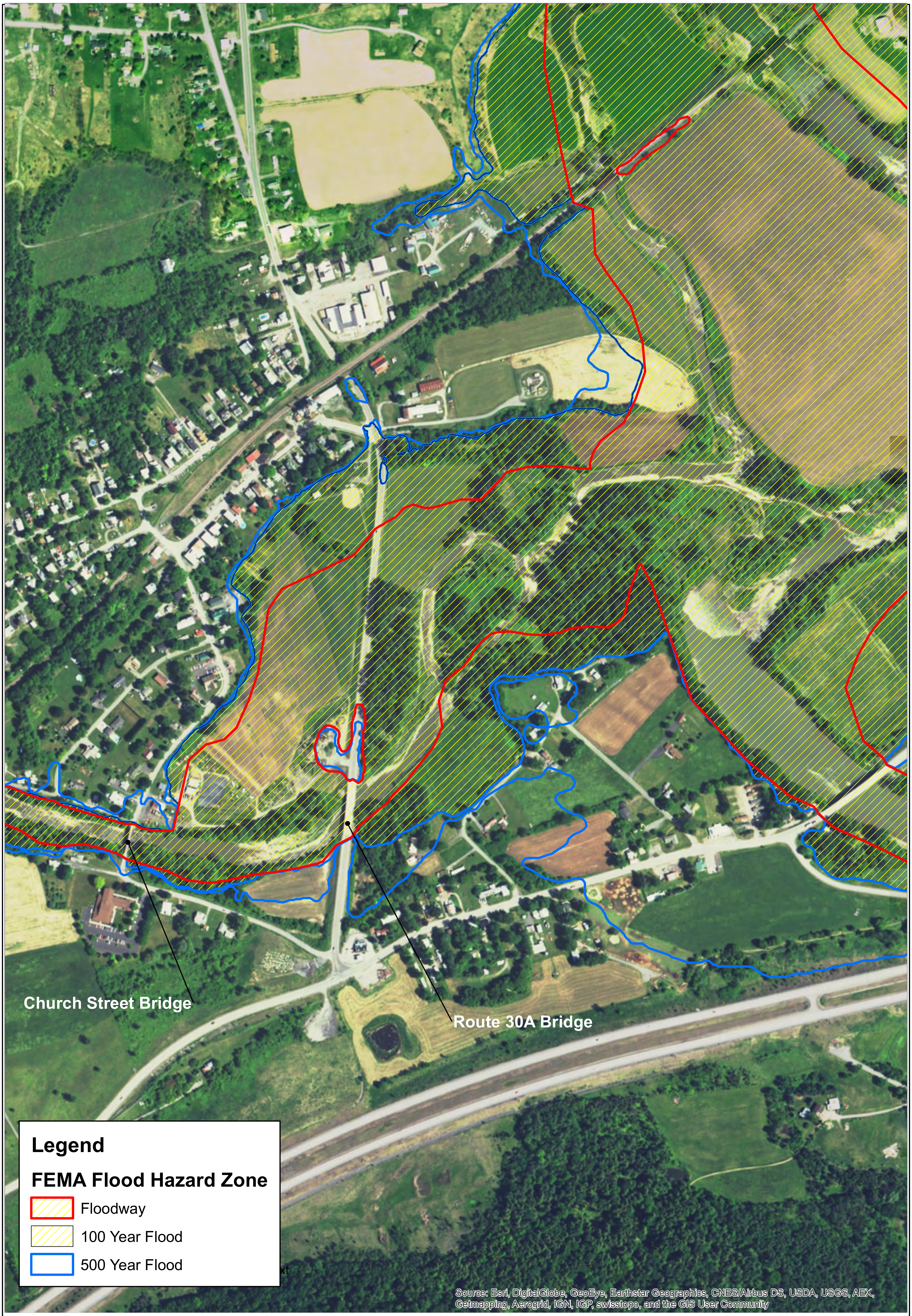
At Top Left: View of Route 30A bridge over Cobleskill Creek
At Bottom Left: View of Church Street bridge over Cobleskill Creek

Alternative 11-2: Modify/Replace State Route 30A Bridge and Roadway

Extensive flooding occurs along the left bank of Cobleskill Creek between the Church Street bridge and the Route 30A bridge with flows overtopping the roadway to the north of the bridge, making it impassable and unsafe. Using hydraulic modeling, the NYS Route 30A Bridge and the roadway embankment for NYS Route 30A were evaluated. Results indicate that the 100-year backwater effects from Schoharie Creek reach the NYS Route 30A bridge and exacerbate flooding in this area during large flows on Schoharie Creek (Figure 4-56). As discussed in Focus Area #10, the hydraulic constriction caused by the active Canadian Pacific railroad bridge over Schoharie Creek extends upstream to beyond the Cobleskill Creek confluence and contributes to the backwater condition at the Route 30A bridge during the 100-year flood event.

The low-lying area that is flooded upstream of the NYS Route 30A bridge on the left side of Cobleskill Creek is approximately 9 feet lower than the elevation of the Route 30A embankment. According to hydraulic modeling results, this low area floods in the 100-year and 50-year flood events. Modeling indicates that the combination of the backwater influence from Schoharie Creek, the low elevation of the floodplain on the left side of Cobleskill Creek, and the higher road embankment acting as an obstruction are the main causes of flooding.

Replacing the Route 30A bridge with a larger structure would not reduce flooding or prevent overtopping of the roadway north of the bridge. Elevation of the roadway north of the bridge above the level of the 100-year flood event would exacerbate flooding in the area along Church Street and possibly along Main Street. Installation of culverts under Route 30A to pass flood flows would not be effective due to the influence of the backwater from Schoharie Creek.



SOURCE(S):	Figure 4-56: FEMA Flood Insurance Rate Map - Cobleskill Creek Confluence		Location: Esperance, NY
NYS GIS Clearinghouse Orthoimagery (accessed June 2016) FEMA Schoharie County Special Flood Hazard Area	N Schoharie Basin Flood Analysis	**Map By:** EMH **MMI#:** 4805-05 **MXD:** Q:\Projects\4805-05 Schoharie Basin Flood Analysis\GIS\MDX **1st Version:** 6/6/2016 **Revision:** 9/22/2016 **Scale:** 1 in = 422 ft	MILONE & MACBROOM 231 Main Street, Suite 102 New Paltz, NY 12561 (845) 633-8153 Fax: (845) 633-8162 www.miloneandmacbroom.com

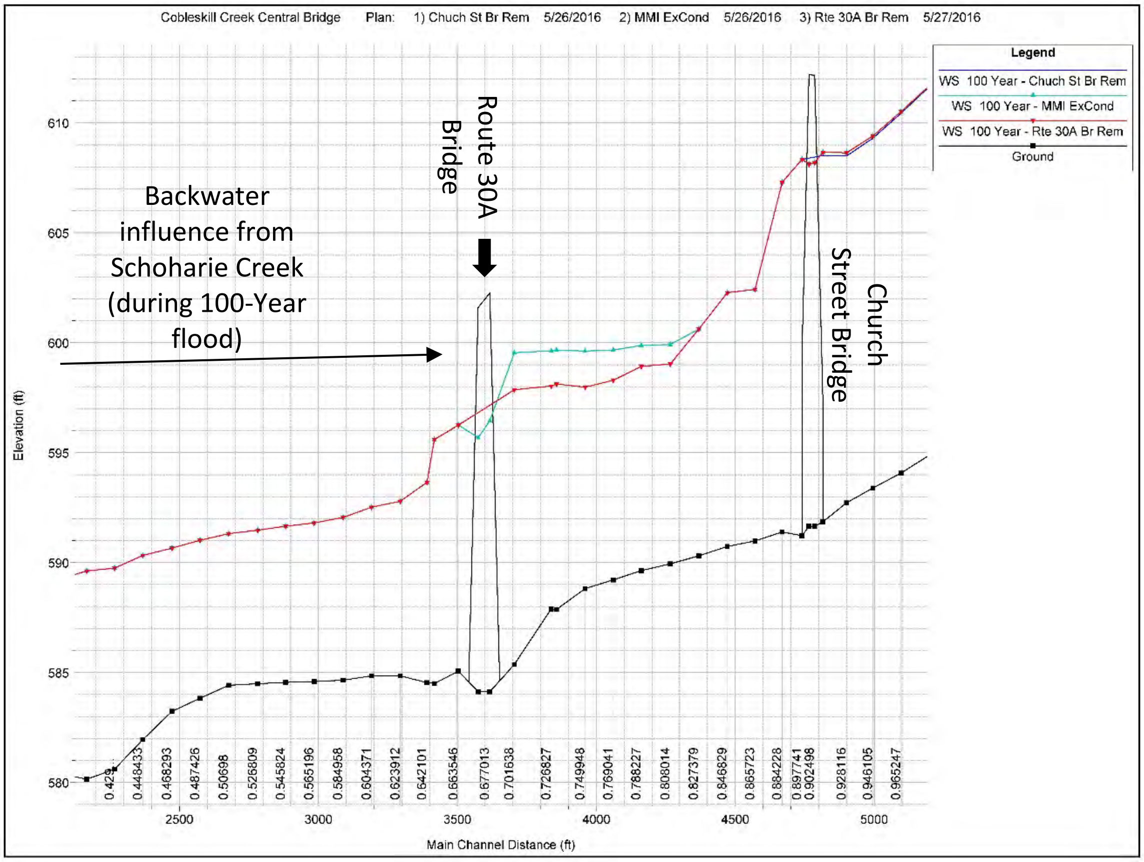


Figure 4-57
Profile of Cobleskill Creek in Central Bridge

Alternative 11-3: Individual Building Relocation, Elevation, or Floodproofing

In the floodprone area along the left bank of Cobleskill Creek between the Church Street bridge and the Route 30A bridge, the following actions are recommended:

1. Seek to acquire, and relocate where feasible, the most flood-vulnerable properties where there is owner interest and programmatic funding available. This includes the structures and greenhouses located just downstream of Church Street. The greenhouses are located within the FEMA floodway.

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

Alternative 11-4: Roadway Signage and Closure

NYS Route 30A serves as an important evacuation route during large flood events. However, travel becomes dangerous in areas where the road is subject to inundation. A low-cost solution to flooding of the roadway along NYS Route 30A in this area is its immediate closure during flooding events in combination with effective barriers and clear signage to direct travelers to alternative routes. One possible alternative to crossing Cobleskill Creek at Route 30A would be Church Street and Main Street.

Focus Area #11 Recommendations

The following recommendations are offered for Focus Area #11:

1. Alternative 11-3 – Individual Floodproofing – The relocation of structures and greenhouses located just downstream of Church Street is recommended as well as preventing development in the floodway and requiring that any new construction meet NFIP criteria.

2. Alternative 11-4 – Road Closure – Closure of the floodprone section of Route 30A during flooding events is recommended in combination with the installation of effective barriers and clear signage to direct travelers to alternative routes.

4.3.12 Focus Area #12 – Fly Creek

Background

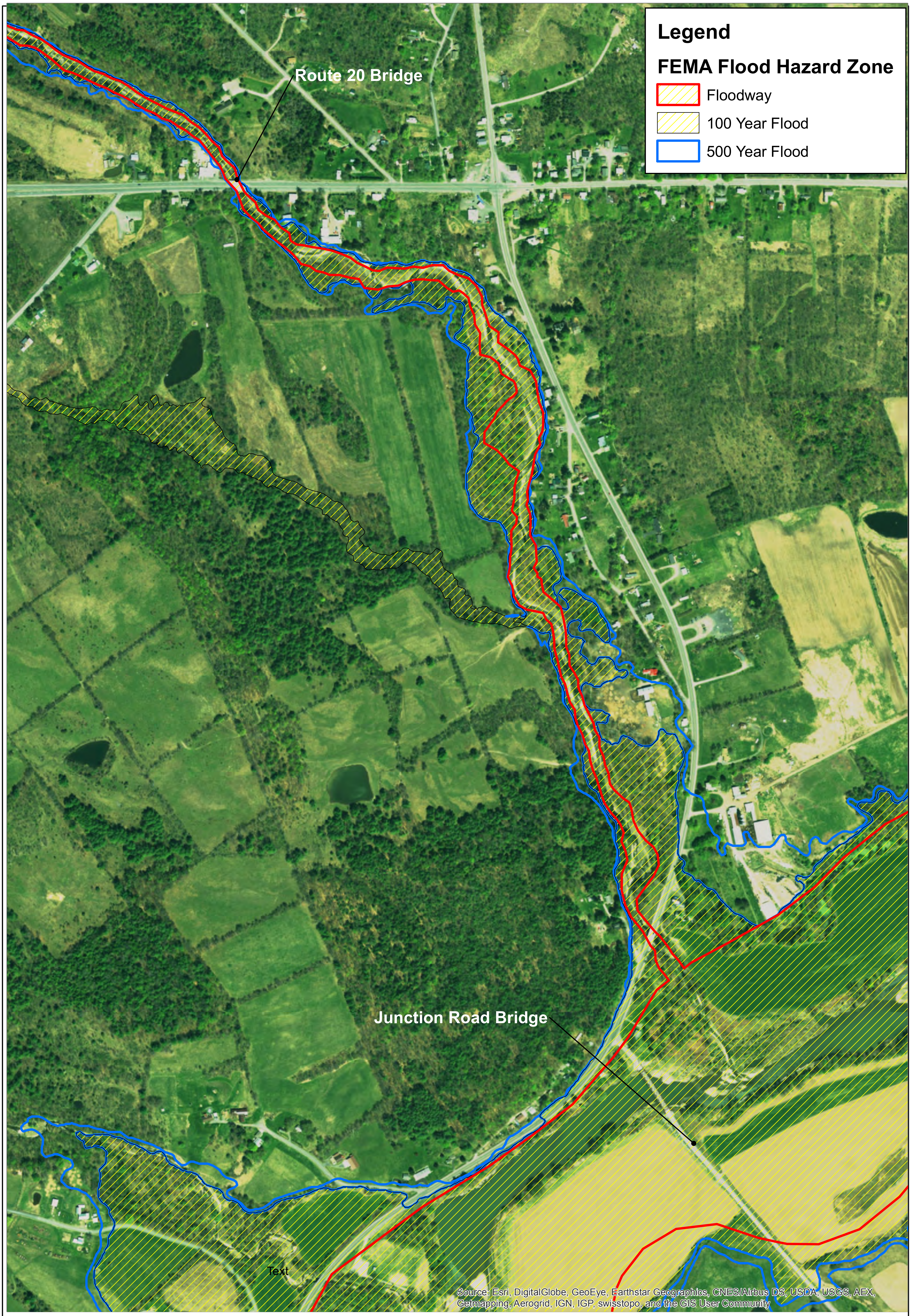
This focus area begins at the Fly Creek and Schoharie Creek confluence adjacent to the Junction Road bridge and extends upstream along Fly Creek for approximately 1.5 miles upstream of the Route 20 bridge in the hamlet of Sloansville, town of Esperance. The FEMA FIRM depicts locations that experience inundation under a range of flooding scenarios (Figure 4-58). Although flooding is a problem along Fly Creek, the larger, related issues are bank erosion, sediment aggradation, and channel instability.

The natural setting and position of this reach of Fly Creek leave it prone to sediment aggradation and channel instability. In addition, the downstream portion of this reach has been the subject of dredging, which is often the first response after flooding. Dredged materials have been side cast onto the adjacent floodplain. The channel is deeply incised, by more than 6 vertical feet in some areas, and is disconnected from the adjacent floodplain. The deepening of the channel along this lower reach has resulted in headcutting, which has migrated upstream, resulting in raw and oversteepened banks and extensive bank erosion.

Overwidening or overdeepening through dredging often initiates instability (including bed and bank erosion), reduces sediment transport, and will not necessarily provide flood mitigation. As seen along Fly Creek, 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. Fly Creek now shows signs of severe instability.

According to files and reports provided by SCSWCD, problems along Fly Creek have progressively worsened over the past 10 years with numerous landowners losing portions of their property due to the eroding stream banks. SCSWCD's review of historic aerial photographs indicates that the Fly Creek channel has undergone significant lateral adjustment over the last 60 years (Findings Report for Fly Creek, provided by SCSWCD).

Goals for this area of Fly Creek include protecting the residences adjacent to the creek and correcting the stream channel instability problems by implementing an effective, long-term restoration/stabilization plan while minimizing the effect proposed channel modifications may have on flood elevations.



SOURCE(S): NYS GIS Clearinghouse Orthoimagery (accessed June 2016) FEMA Schoharie County Special Flood Hazard Area	**Figure 4-58: FEMA Flood Insurance Rate Map - Fly Creek**	**Location:** **Esperance, NY**
	N **Schoharie Basin Flood Analysis**	**Map By:** EMH **MMI#:** 4805-05 **MXD:** Q:\Projects\4805-05 Schoharie Basin Flood Analysis\GIS\MDX **1st Version:** 6/6/2016 **Revision:** 9/26/2016 **Scale:** 1 in = 500 ft

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Figure 4-59
Photos of Fly Creek

Above Left: Severely eroding stream bank threatens to undermine buildings along Fly Creek.
At Right: Vertical incision along Fly Creek exceeds 6 feet in some areas.

SCSWCD has evaluated two natural channel design scenarios along Fly Creek. These are discussed in greater detail below.

Alternative 12-1: SCSWCD Natural Channel Design Scenario #1

This alternative entails reconstructing and stabilizing the channel with an alignment that would generally follow the existing channel but shifting it away from unstable slopes and existing stream banks to allow for stabilization of the banks. A range of natural channel design approaches and techniques could be utilized in order to reduce stress on the stream banks by redirecting flows toward the center of the channel.

If fully implemented, this approach to stabilizing Fly Creek would result in a restored channel over the entire length of the project. However, the reach would still be subject to periodic sediment aggradation and channel instability due to its setting in the watershed, especially following large flood events. Properties and structures located close to the creek would likely remain at risk.

Alternative 12-2: SCSWCD Natural Channel Design Scenario #2

This alternative involves relocating the channel through much of the project reach to follow the alignment of a relic channel in the right floodplain of Fly Creek. The upper and lower limits of the project area would be reconstructed and stabilized in place. Sections of the existing channel would be backfilled to create more gentle slopes along currently unstable hillslopes at the upstream and downstream ends of the project. Sections of the existing channel along the back of properties adjacent to the creek would be backfilled to protect residences, barns, and sheds while maintaining the floodplain.

Alternative 12-3: Sediment Management Plan

Development and implementation of a sediment management plan for Fly Creek is recommended in cooperation with landowners who live on or own property along the creek. A sound sediment management program would set 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 the following:

- Situations where the channel is confined without space in which to laterally migrate
- For the purpose of infrastructure protection

If it is determined that sediment excavation and removal in the Fly Creek channel are 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. Although regional curves are a useful tool for estimating bankfull geometry, on-site field measurements are always preferred. The measured bankfull width through the subject reach of Fly Creek ranges from approximately 64 to 68 feet. These measured values should be verified using additional field measurements and should be supplemented with measurements of bankfull depth and cross-sectional area.

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. The contributing watershed of Fly Creek at this location is 20.3 square miles. Therefore, sediment removal volume should not exceed 1,015 cubic yards.

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 should be contacted, and appropriate permitting should be obtained.

5. Disposal of excavated sediments should always occur outside of the floodplain. Along Fly Creek, these materials have been placed on the adjacent bank where they block the creek's access to the floodplain and will be vulnerable to remobilization and redeposition during the next large storm event.

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

Focus Area #12 Recommendations

The following recommendations are offered for Focus Area #12:

1. Alternative 12-3 – Sediment Management – Because sediment aggradation will continue to occur along Fly Creek, it is recommended that a sediment management plan also be developed for Fly Creek.

2. Alternative 12-2 – Channel Restoration – It is recommended that the SCSWCD plans be developed to a more advanced design stage and that restoration actions be undertaken at Fly Creek. Of the two scenarios, SCSWCD Natural Channel Design Scenario #2 (Alternative 12-2) most closely aligns with the goals for Fly Creek and is recommended.

4.3.13 Focus Area #13 – Colyer Road, Burtonsville

This focus area includes a reach of Schoharie Creek that runs along the Schoharie County/Montgomery County line. Colyer Road is located along the left bank of Schoharie Creek in the hamlet of Burtonsville, town of Charleston, in Montgomery County. The reach is just upstream of where Bramans Corner Road (County Route 160) crosses over Schoharie Creek (Figure 4-60). Participants at a public meeting reported that extensive flooding of homes occurred along Colyer Road during Tropical Storm Irene and that flood-related damages occurred. Based on a review of aerial photographs, homes that were once located along the east side of Colyer Road have been removed since the occurrence of Tropical Storm Irene, presumably as a result of damages sustained during the flood.


Figure 4-60
Photos of Colyer Road Area

At Top Left: Schoharie Creek as it flows along Colyer Road, with bedrock channel bed and high bedrock embankment along the opposite bank
At Top Right: Homes along Colyer Road

The section of Schoharie Creek that flows adjacent to Colyer Road has not been modeled or mapped by FEMA, and no SFHA has been designated for this area. The hydraulic model developed by FEMA for Schoharie Creek ends just upstream at the Schoharie County/Montgomery County line. Elevation data from the 2014 LiDAR were added to the FEMA model by MMI in order to extend the modeling further downstream to include Colyer Road.

Results of the hydraulic modeling indicate that buildings along Colyer Road are susceptible to frequent and dangerous flooding. The area to the east of Colyer Road where homes were located prior to Tropical Storm Irene and the roadway itself are inundated during the 10-year flood event. During the 50-year and 100-year events, all of the buildings located along the west side of the road are inundated and surrounded by water. Based on estimated water surface elevations determined by the hydraulic model, the 100-year flood elevation ranges from 523.2 feet (North American Vertical datum, 1988) near the upstream end of Colyer Road to 518.1 feet near the downstream end. These water surface elevations are well above the measured ground elevations adjacent to homes along Colyer Road. The hydraulic model does not take into account any backwater effect of the bridge spanning Schoharie Creek at Bramans Corner Road just downstream of Colyer Road. Any backwater effect resulting from the bridge would potentially further exacerbate flooding levels along Colyer Road.

Figure 4-61 shows approximate flood extents during the 10-year, 50-year, and 100-year flood events as well as estimated ground elevations near buildings.

Alternative 13-1: Modification or Enhancement of Channel or Floodplain

Schoharie Creek has a bedrock channel bed in this area with a high bedrock embankment along the right bank of the creek opposite Colyer Road. Alterations to the channel were investigated for flood mitigation potential. This included consideration of deepening or widening of the channel to increase its flood conveyance capacity or enhancement of the floodplain along the right or left channel banks. Alterations to the channel at this location would be difficult and costly to undertake due to the presence of bedrock in the channel bed, the high embankment along the right bank, and the close proximity of the homes along Colyer Road to the channel. Therefore, channel and floodplain alterations were not pursued.

Alternative 13-2: Survey, Followed by Individual Building Relocation, Elevation, or Floodproofing

In the absence of a formal FEMA FIS, a survey should be undertaken to determine first-floor elevations of buildings along Colyer Road. Homes with first-floor elevations that are not at least 2.0 feet above the estimated elevation of the 100-year flood event should be considered for building elevation or for property acquisition and demolition with relocation of residents to a safe location outside of the floodplain.

On a case-by-case basis where structures are at risk, individual measures can be explored. For homes along Colyer Road, this may range from elevation of structures to removal of the structures. Costs will vary depending on what measures are implemented. The elevating of a residential structure will cost approximately $175,000. The costs of removing a structure and relocating its residents to another location consist of the purchase price of the property, demolition costs, and moving costs.

Focus Area #13 Recommendations

Survey of first-floor elevations is recommended to allow residents to decide whether elevation or relocation out of the floodprone area would be most beneficial.

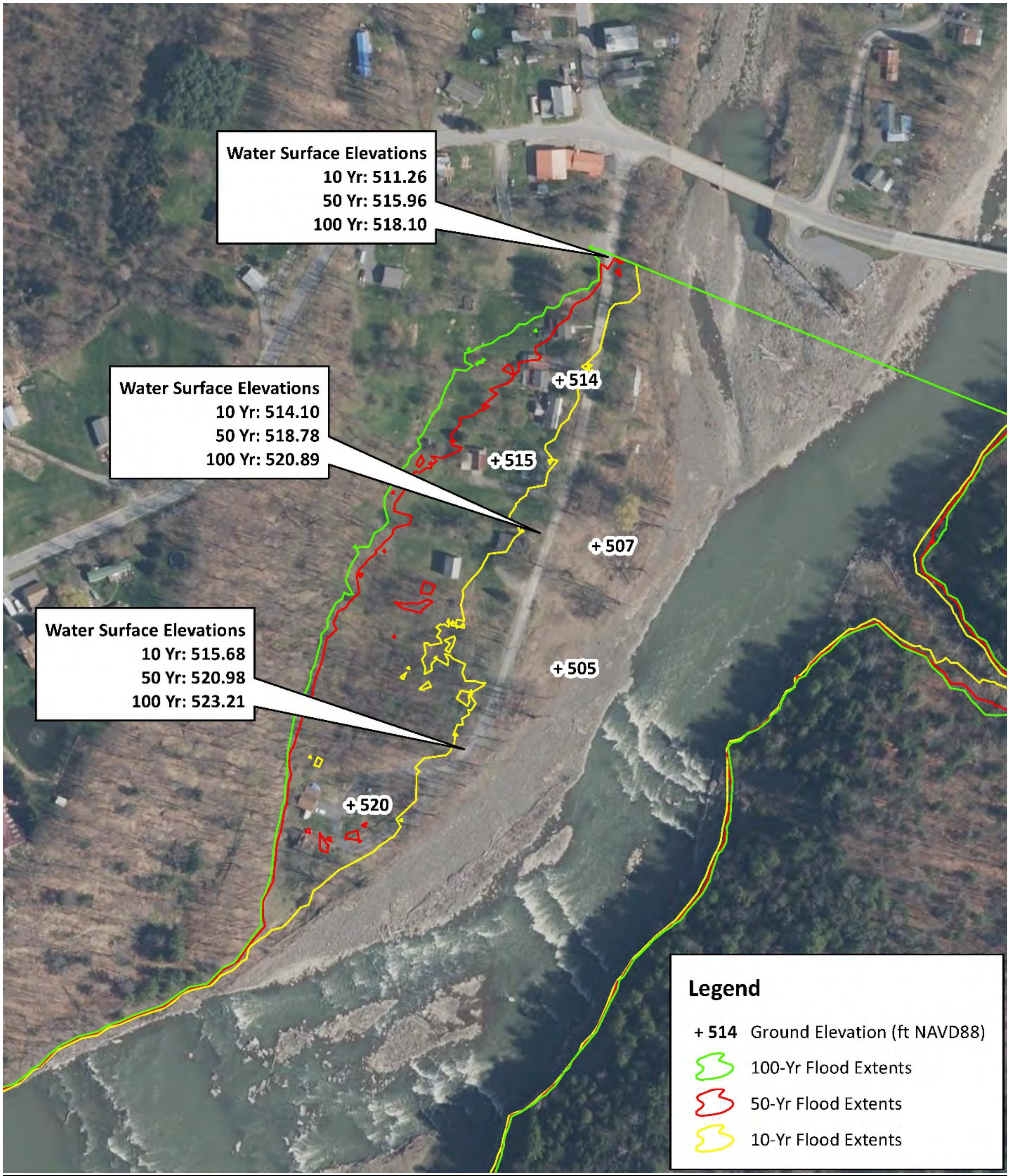


Figure 4-61
Approximate flood extents on Schoharie Creek along Colyer Road during the 10-year, 50-year, and 100-year flood events as well as estimated ground elevations near buildings

4.3.14 Focus Area #14 – Warnerville Cutoff

Warnerville Cutoff (County Route 23A) is a roadway that crosses over Cobleskill Creek in the hamlet of Warnerville, town of Richmondville, in Schoharie County. Warnerville Cutoff intersects with NYS Route 7/10 in Warnerville center. West Creek flows parallel to Warnerville Cutoff and crosses under it before flowing into Cobleskill Creek approximately 500 feet downstream of the Warnerville Cutoff bridge over Cobleskill Creek.

A low area of Warnerville Cutoff located approximately 400 feet to the northwest of the bridge over Cobleskill Creek floods on a frequent basis. Work was recently undertaken along Cobleskill Creek in this area to replace the bridge over Cobleskill Creek, realign the channel in the vicinity of the bridge, and place rock vane structures in the channel. In order to evaluate scenarios for reducing the severity and frequency of flooding of the Warnerville Cutoff roadway northwest of the bridge, the hydraulic model developed by FEMA was obtained and updated to include the recent channel and bridge work that was undertaken in this area. Elevations and cross-section geometry from C&S Plans titled "*Replacement of County Road 23A Bridges over West Creek and Cobleskill Creek*," dated December 2009, were used to update the FEMA HEC-RAS model.

FIRMs (Figure 4-62) indicate that the agricultural fields along the left (north) bank of Cobleskill Creek are subject to inundation during the 100-year flood event as is much of Warnerville Cutoff between the bridge over West Creek and the bridge over Cobleskill Creek. Figures 4-63 and 4-64 show photographs of the area.

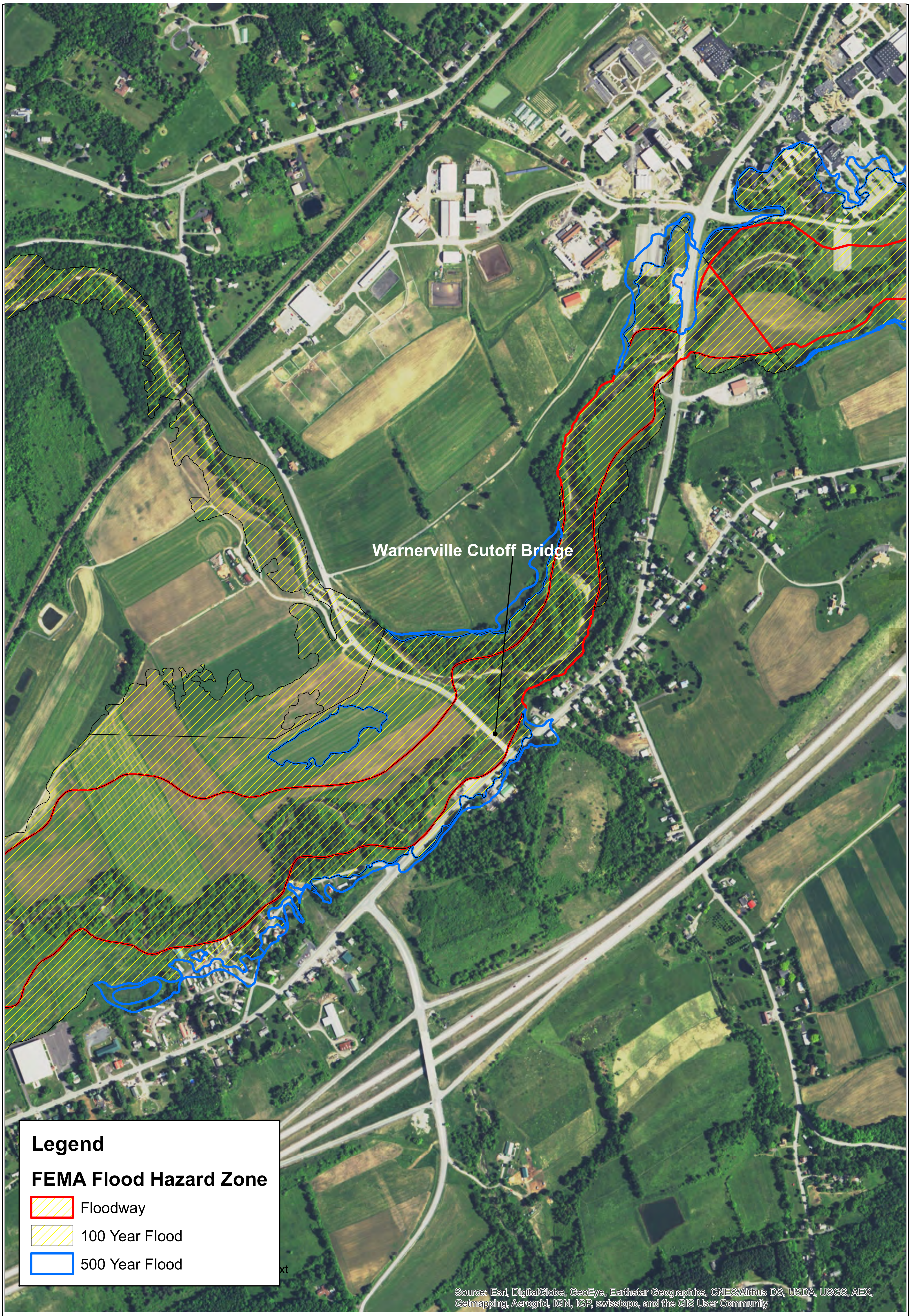
Hydraulic modeling under existing conditions indicates that while the bridge has capacity to pass all but the 100-year flood event and greater the low area in the road is flooded during the 10-year flood event. The road is overtopped by 1.8 feet of water during the 10-year flood event and by 4.0 feet of water in the 50-year event.

Alternative 14-1: Elevation of the Roadway along Warnerville Cutoff

In an attempt to prevent the low-lying area of Warnerville Cutoff from overtopping, hydraulic modeling was undertaken to investigate the scenario of elevating the low-lying portion of the roadway. The road surface elevation was raised by a maximum of 5.6 feet over a 590-foot length. When the roadway is simulated as raised, it no longer overtops during the 10-year flood event and is overtopped by 1.1 feet of water during the 50-year flood. However, raising the road results in an increase in water surface elevations upstream of Warnerville Cutoff in the area of the Warnerville Post Office by 1.8 feet during the 50-year flood event and by 1.4 feet during the 100-year event. Under the raised road scenario, the 50-year flood overtops the bridge as well as the roadway.

Alternative 14-2: Elevation of Roadway and Installation of Bypass Culvert under Warnerville Cutoff

In combination with elevating the roadway (Alternative 14-1), a scenario was investigated in which a series of seven 4-foot-span by 2-foot-rise culverts were placed under the raised road area to pass floodwaters. The addition of culverts under the roadway did not reduce water surface elevations in the 100-year event when compared to raising the road without the addition of culverts. In this alternative, the Warnerville Cutoff bridge and the roadway to the west still overtop in the 50-year and 100-year floods. When compared to existing conditions upstream of the bridge, the hydraulic model indicates an approximate 1.0-foot rise in the 10-year flood, 50-year flood, and 100-year flood events under this scenario.



SOURCE(S):

NYS GIS Clearinghouse Orthoimagery (accessed June 2016)

FEMA Schoharie County Special Flood Hazard Area

Figure 4-62: FEMA Flood Insurance Rate Map - Warnerville Cutoff

Location: Richmondville, NY

N

Schoharie Basin Flood Analysis

Map By: EMH
MMI#: 4805-05
MXD: Q:\Projects\4805-05 Schoharie Basin Flood Analysis\GIS\MDX
1st Version: 6/6/2016
Revision: 9/26/2016
Scale: 1 in = 562 ft

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Figure 4-63
Warnerville Hamlet and floodprone section of Warnerville Cutoff, northeast of bridge over Cobleskill Creek

Figure 4-64
View along Warnerville Cutoff looking toward NYS Route 7/10 and bridge over Cobleskill Creek

Alternative 14-3: Elevation of Roadway and Installation of Bypass Bridge along Warnerville Cutoff

A scenario involving a flood overflow bridge with a 145-foot span and 3.5-foot rise was modeled with the new bridge placed approximately 240 feet northwest of the current Warnerville Cutoff bridge over Cobleskill Creek. Hydraulic modeling indicates that the installation of the flood bypass bridge would lower water surface elevations in the 100-year flood by about 0.4 foot when compared to the raised road alternative; however, the roadway and both bridges would be overtopped in the 50-year and 100-year floods. Compared to existing conditions, water surface elevations upstream of Warnerville Cutoff increase by 1.4 feet in the 10-year flood and by approximately 0.8 feet in the 50-year and 100-year flood events.

Alternative 14-4: Warnerville Cutoff Roadway Signage and Closure

Warnerville Cutoff crosses a broad, low-lying area of floodplain near the confluence of West Creek and Cobleskill Creek. A low point in the roadway located just northeast of the bridge over Cobleskill Creek is overtopped by deep, dangerous waters during the 10-year and larger flood events. The various scenarios discussed above would not alleviate overtopping of the roadway. The most practical and low-cost solution to flooding of the roadway along Warnerville Cutoff is its immediate closure during flooding events in combination with effective signage, barriers, and consideration of alternative routes. For example, routing traffic along Columbia Lane and Schoharie Parkway during times of high water could serve as an alternative access route.

Focus Area #14 Recommendations

Alternatives 14-1, 14-2, and 14-3 are not recommended because they would not prevent flooding of Warnerville Cutoff, would cause an increase in water surface elevations upstream of the Warnerville Cutoff bridge over Cobleskill Creek, and would increase flooding risk in the area of the Warnerville Post Office. Immediate closure of Warnerville Cutoff during flooding conditions, effective signage, and further consideration of alternative routes should be considered as described in Alternative 14-4.

4.3.15 Focus Area #15 – Review of Potential for Flood Attenuation in Upper Watershed

Several comments were received during the public meeting session suggesting that floodwaters could be stored in existing lakes, ponds, or wetlands in order to attenuate downstream flood flows. Two sites within the Schoharie Creek watershed were investigated for their potential to reduce peak flows during storm events by storing a portion of the floodwater. They are located at two lakes along tributaries to Fox Creek – Warner Lake and Onderdonk Lake.

Alternative 15-1: Potential for Flood Storage at Warner Lake

Warner Lake is a 0.18-square-mile lake located on an unnamed tributary to Fox Creek near East Berne. Onderdonk Lake is a 0.12-square-mile lake located on Switz Kill, a tributary to Fox Creek, near Rensselaerville. Both lakes are used for recreational purposes and are surrounded by seasonal homes and cottages. After examining the outlet structures at both lakes, it was estimated that each lake could store up to 2 feet in elevation during a storm event.

The runoff volume to each lake was calculated using the drainage area from USGS *StreamStats*, a precipitation depth of 4.93 inches during a 12-hour period from the National Oceanic and Atmospheric

Administration (NOAA) Precipitation Frequency Data Server 100-year event (Figure 4-65), and an assumed 30-percent runoff coefficient. Runoff volume was calculated for each location.

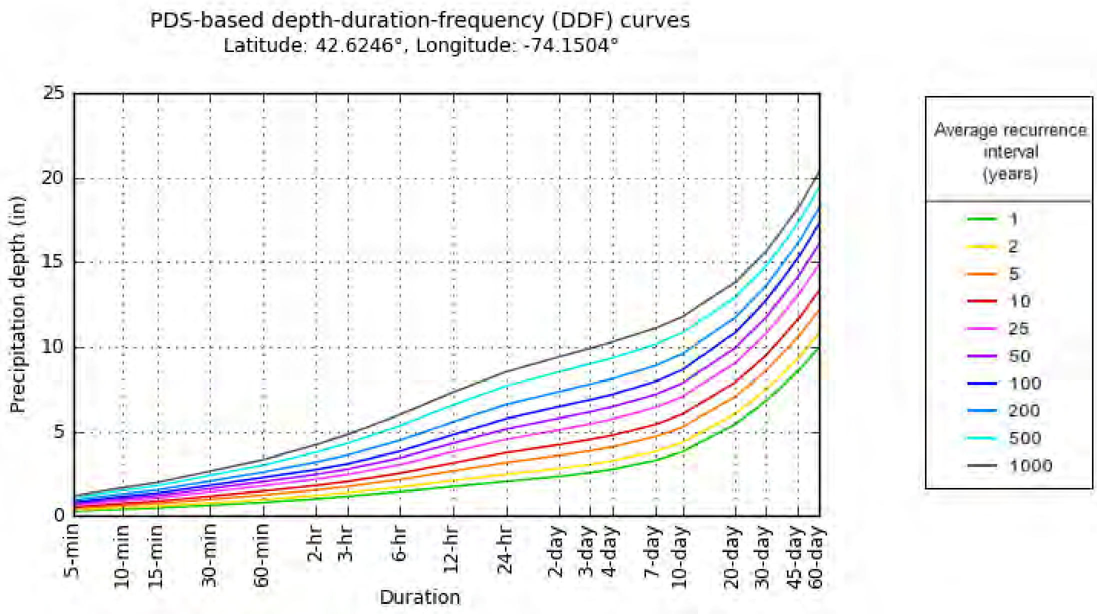


Figure 4-65
Precipitation Depths from NOAA Precipitation Frequency Data Server

Warner Lake has the potential to store 75.8 million gallons if it is assumed that property owners and other users of the lake would be agreeable to the lake being used for this purpose, which would involve fluctuating water levels. The lake's storage potential is limited by its high location in the watershed and small contributing area of only 1.87 square miles. The contributing runoff during a 100-year event was estimated to be less than the potential storage capacity of the lake. While flows just downstream of the lake could be significantly reduced as a result of the storage, it would have little impact on the flow in Fox Creek. The potential storage in Warner Lake would reduce runoff during a 100-year storm event by approximately 0.6 percent downstream along Fox Creek at Gallupville.

Alternative 15-2: Potential for Flood Storage at Onderdonk Lake

Onderdonk Lake (Figure 4-66) has the potential to store 49.3 million gallons. As with Warner Lake, this lake's storage potential is limited by its high location in the watershed and small contributing area of only 0.67 square miles. This alternative also assumes that landowners on the lake would be agreeable to drawdown by 2 feet on a regular basis and then being filled up during a flood event. The contributing runoff during a 100-year event was estimated to be less than half of the potential storage capacity of the lake. While flows just downstream of the lake could be reduced, it would have little impact on the flow in Fox Creek. The potential storage in Onderdonk Lake would reduce runoff during a 100-year storm event by approximately 1.1 percent at the confluence of the Switz Kill with Fox Creek and by 0.2 percent further downstream at Gallupville.

Figure 4-66
Outlet structure at Onderdonk Lake, where potential for floodwater storage was investigated

Alternative 15-3: Potential for Flood Storage at Other Lakes, Ponds, and Wetlands

A mapping review of other lakes, ponds, and wetlands in the watershed was conducted. Based on watershed and impoundment characteristics, increasing storage capacity in existing lakes and ponds in the watershed would likely yield similar results as computed for Warner and Onderdonk Lakes. Therefore, stormwater storage is not recommended for further evaluation.

Focus Area #15 Recommendations

Stormwater storage at small lakes and ponds in the watershed does reduce peak flows. However, the potential to increase storage at these sites is relatively small and is not recommended. Existing wetlands in the watershed provide a vital function by storing stormwater during floods and releasing it gradually downstream, thereby reducing peak flows. Protecting the functions and values of remaining existing wetlands is recommended. This is discussed further in Section 4.3.18.

4.3.16 Focus Area #16 – General Review of Berms along Farm Fields

During the data gathering stage for this study, interest was expressed in determining what effect, if any, agricultural berms along Schoharie Creek have on downstream flood flows (Figure 4-67). While a comprehensive inventory of the berms is beyond the scope of the study, an evaluation was made at two locations.

Figure 4-67
View of one of many agricultural berms situated along Schoharie Creek

Alternative 16-1: Agricultural Berm Site 1

A 1,700-foot berm is located on the east bank of Schoharie Creek south of Breakabeen. The berm is preventing floodwaters from inundating an adjacent agricultural field. An area of the field was evaluated relative to its potential to contain water if the berm were to be removed. To calculate the potential storage capacity, the depth of water during the 100-year storm event was analyzed using HEC-RAS. It was determined that the field could provide an additional 0.9 million gallons of storage area, or 307 cfs when converted to flow over a 12-hour period. During a 100-year storm event, this would reduce the peak flow of 82,493 cfs by approximately 0.4 percent.

Alternative 16-2: Agricultural Berm Site 2

A similar, 2,000-linear-foot earthen berm is located on the east bank of Schoharie Creek north of Breakabeen. The area of the adjacent agricultural field that could contain water if the berm were to be removed was evaluated as potential storage. As with the analysis for Alternative 16-1, the depth of water during the 100-year storm event was analyzed using HEC-RAS. It was determined that the field could provide an additional

0.6 million gallons of storage area, or 2 cfs when converted to flow over a 12-hour period. During a 100-year storm event, this would reduce the peak flow of 82,493 cfs by a negligible amount. Figure 4-68 shows a HEC-RAS cross section of one of the agricultural berms.

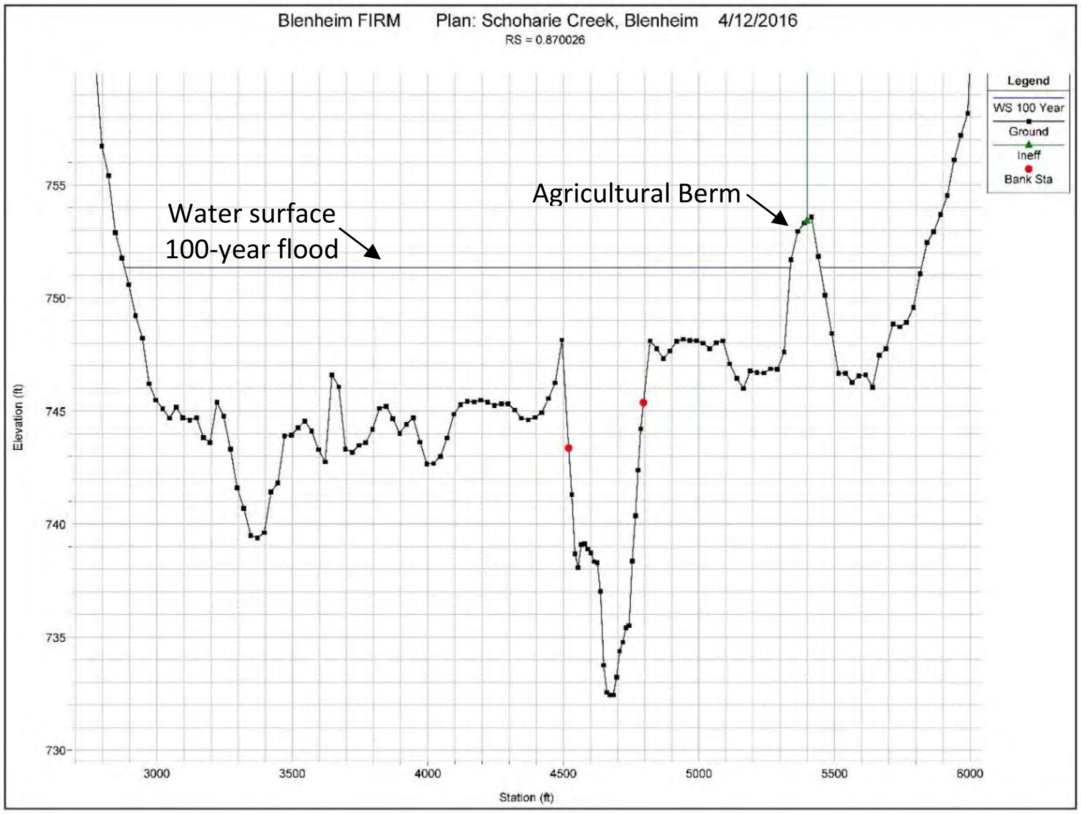


Figure 4-68
HEC-RAS cross section showing an agricultural berm along Schoharie Creek

Focus Area #16 Recommendations

While individual agricultural berms may have only a minor influence on downstream peak flows, berms and levees influence flow velocities and water depths in cases where they confine the channel and isolate portions of the floodplain. Due to the broad, flat configuration of the Schoharie Creek floodplain, confinement of the available floodplain caused by berms along the creek can cause local flood issues and increase flow velocities along Schoharie Creek. In cases where berms are not protecting important lands or infrastructure, their removal should be encouraged. If feasible, the berms should be removed.

4.3.17 Focus Area #17 – Review of Potential for Flood Attenuation

During the data gathering process and public input, interest was expressed in determining the influence that upstream reservoirs may have had on the volume of flood flows experienced along Schoharie Creek during Tropical Storm Irene and on the potential for increasing flood storage at the reservoirs through modifications or operational changes. This topic was evaluated as Focus Area #17.

Potential for Flood Storage in Schoharie Reservoir

Figure 4-69
Dam and Spillway at Schoharie Reservoir

The Schoharie Reservoir, located in the towns of Gilboa and Conesville (Figure 4-69), is owned and operated by the NYCDEP and is used as a diversion reservoir to route water through the Shandaken tunnel into Esopus Creek. The operation of the reservoir is regulated by the State of New York Rules and Regulations under Part 670 – Reservoir Releases and Regulations. The reservoir has a surface area of 1,112 acres, a mean depth of 56 feet, and a total capacity of 19 billion gallons. The reservoir is not designed to be a storage facility and has limited ability to preemptively release water prior to anticipated storm events. A repair was made to the dam's spillway in 2006, resulting in the installation of siphons that allow for limited drawdown of the reservoir. Also installed at that time was a 220-foot-long by 5.5-foot-deep notch, which was used to divert water during dam reconstruction. In 2012, the NYCDEP installed inflatable crest gates that restore the reservoir crest when raised and when lowered create a notch 220 feet long by 4.93 feet deep.

NYCDEP reports that in order to meet water supply and regulatory requirements the water surface elevation in the Schoharie Reservoir is drawn down through the summer and fall storm season. The crest gates are typically opened at the end of the summer and closed near the end of the spring to capture the spring runoff and maximize cold water storage. Under most storm events, when the crest gates are open (fall and winter), they provide additional peak flow attenuation. Since 2006, NYCDEP considers snow pack as part of the dam operations plan. As snow pack builds, water is released approximately equal to 50 percent of the snow pack equivalent either via the siphons to Schoharie Creek or through the Shandaken tunnel to Esopus Creek.

NYCDEP reports that at the start of Hurricane Irene Schoharie Reservoir had an estimated 4 billion gallons of capacity and estimates that a peak flow of 137,000 cfs flowed into the reservoir, with a peak flow discharge of 111,000 cfs. NYCDEP estimated that the reservoir was able to reduce peak flows by 26,000 cfs, or 19 percent of the peak flow.

The USGS report entitled *Floods of 2011 in New York* (Lumia et al., 2014), which focuses, in part, on the impact of Tropical Storm Irene within the Schoharie Creek basin, includes an assessment on the effects of reservoirs. According to this report, the highest water surface elevation of record was documented for Schoharie Reservoir (based on 86 years of record) during the Irene flood. The Schoharie Reservoir stored over 1.3 inches of upstream runoff during 10 hours on August 28, 2011. The maximum computed hourly inflow to Schoharie Reservoir was 137,000 cfs on August 28 while the maximum outflow was 111,000 cfs. This represents a reduction of nearly 20 percent and is consistent with NYCDEP reports.

NYCDEP reports that construction of a low-level outlet is planned for the dam at Schoharie Reservoir that will include a 9-foot-diameter outlet tunnel at the dam that can be regulated between 0 and 2,400 cfs and is designed to meet NYSDEC dam safety release requirements. This improvement is scheduled for completion in 2020. In addition, the new release structure will have the capability to provide a modest, year-round conservation release. NYCDEP has submitted a proposed operating protocol to NYSDEC that seeks to operate Schoharie Reservoir against a conditional seasonal storage objective (CSSO) similar to how NYCDEP operates the Ashokan, Cannonsville, Neversink, and Pepacton reservoirs. The CSSO seeks to maintain the reservoir at 90 percent storage through regular releases during the fall tropical storm and winter rainfall snowmelt seasons while returning the reservoir to 100 percent storage in the late spring to meet water supply needs. The resultant 10 percent storage will provide additional peak flow attenuation.

Potential for Flood Storage in Blenheim-Gilboa Lower Reservoir

Figure 4-70
Blenheim-Gilboa Hydroelectric Facility

The Blenheim-Gilboa Hydroelectric Facility (Figure 4-70) is operated by the NYPA. A lower reservoir is used in conjunction with an upper, offline reservoir as part of a hydroelectric facility. Water is captured in this lower reservoir and pumped to the offline, upper reservoir for storage and subsequent power generation. During storm events, the lower reservoir is operated to reduce outflow as much as possible within operating limits. The dam is designed for a maximum outflow of approximately 178,000 cfs.

In response to MMI's request for information, NYPA provided data on reservoir routing recorded at the Blenheim-Gilboa lower reservoir through Tropical Storm Irene, including total inflow, total outflow, reservoir water surface elevations, and storage volume. These data were received by NYPA from RJ Associates, LLC (NYPA's consultant) on September 6, 2011, 9 days after Irene.

RJ Associates used data recorded at 20-minute intervals for items such as reservoir water level and tainter gate opening. Reservoir water level is measured by pressure transducers located in the powerhouse and the upper reservoir well pit. Established curves were used to determine spillway outflow based on tainter gate position and reservoir level. Tainter gates are used to regulate outflow from the lower reservoir. The inflow was determined based on calculated spillway outflow and changes in reservoir volume at each time interval.

The data from RJ Associates was graphed by MMI and is presented in Figures 4-71 and 4-72.

The peak inflow to the lower reservoir during Tropical Storm Irene was measured at 129,155 cfs. This peak occurred at 1:22 p.m. on Sunday, August 28, 2011. After the inflow peaked, the level in the lower reservoir continued to rise. Peak outflow from the lower reservoir occurred at 3:22 p.m. on August 28, measured at 118,614 cfs. The water surface elevation in the lower reservoir also peaked at 3:22 p.m. on August 28 at an elevation of 898.25 feet. At that elevation, the lower reservoir has a storage volume of 689,324,850 cubic feet. The lower reservoir is considered to be full when it reaches a water surface elevation of 900 feet. The earthen dam overtops at elevation 910 feet.

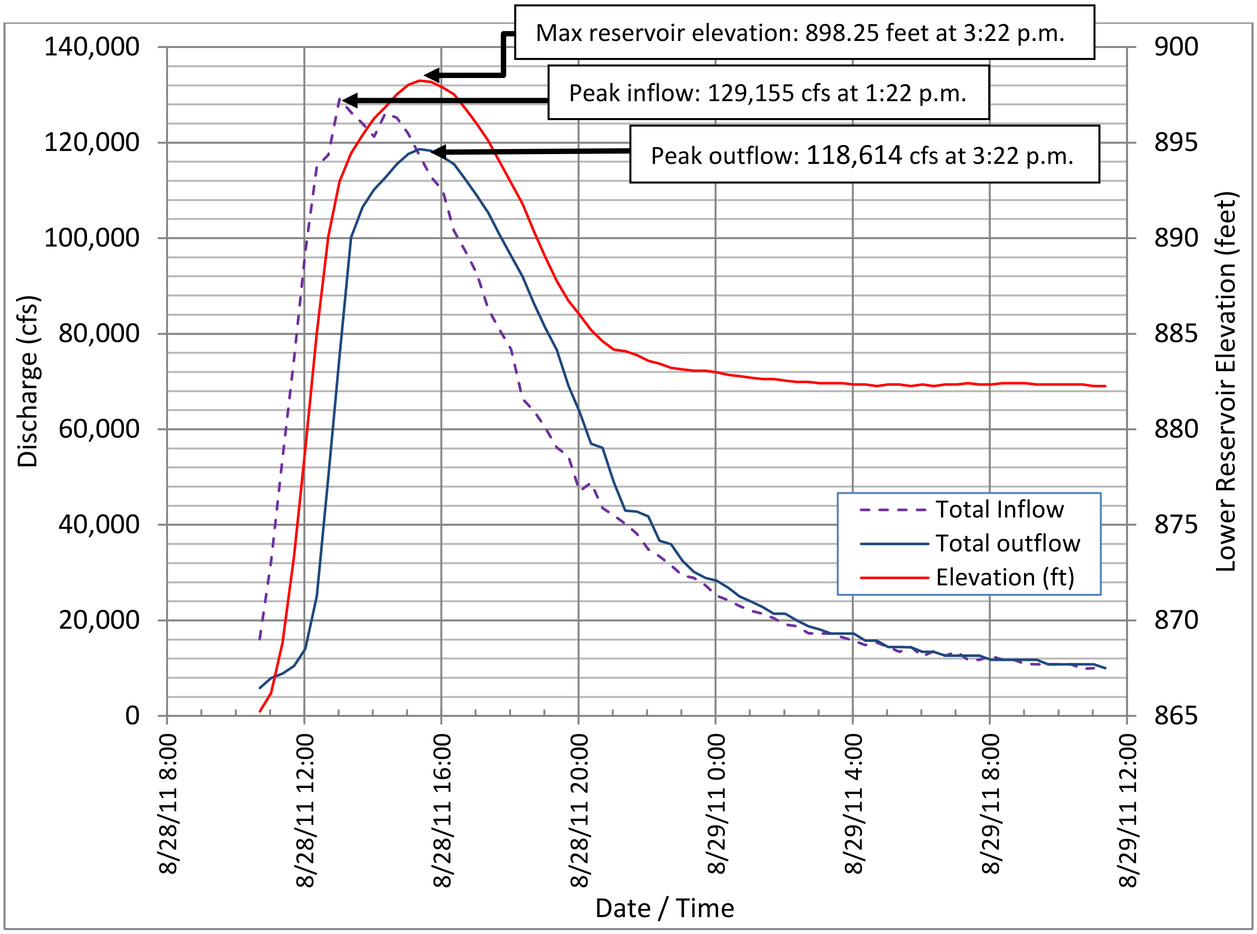


Figure 4-71

NYPA Blenheim-Gilboa Lower Reservoir Inflow, Outflow, and Elevation during Tropical Storm Irene

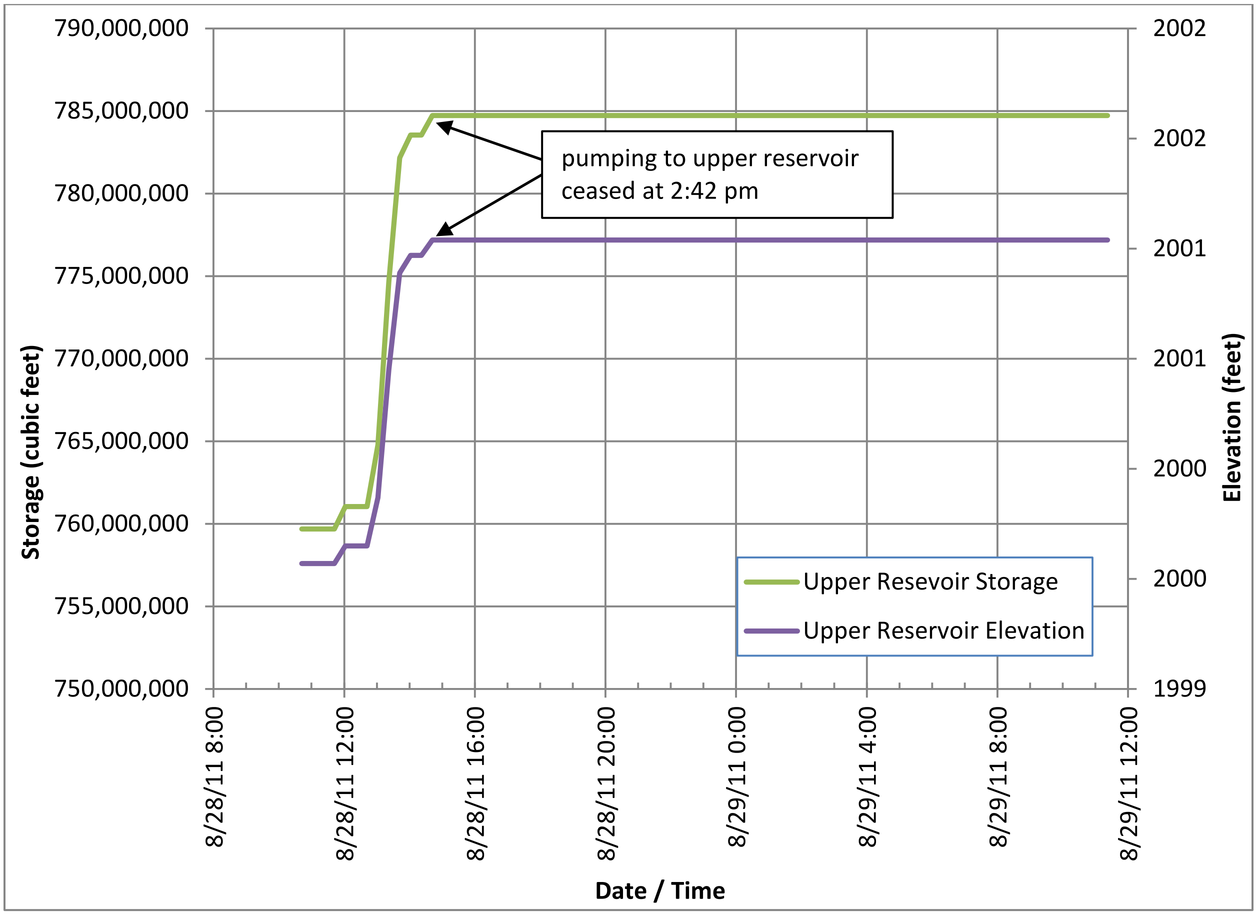


Figure 4-72
NYPA Blenheim-Gilboa Upper Reservoir Storage and Elevation during Tropical Storm Irene

During Tropical Storm Irene, water was being pumped from the lower reservoir to the upper reservoir, but that action ceased at 2:42 p.m. According to NYPA, the pumps were shut down after the three tainter gates that control outflow from the lower reservoir had been raised out of the water. This was done in order to preserve remaining upper reservoir storage for use in the event that Tropical Storm Irene produced flows that continued to increase. The pumps were running during the peak inflow to the lower reservoir. According to NYPA, the normal upper reservoir useable volume between elevation 1965 and 2003 is approximately 555,669,627 cubic feet.

From the input and output flows discussed above, it can be determined that during Tropical Storm Irene the storage within the NYPA lower reservoir reduced peak flows by 10,541 cfs, or 8.2 percent of the peak flow, which otherwise would have been discharged downstream. According to NYPA, peak shaving and pumping during high water events have been utilized in numerous past high water events, including during Tropical Storm Irene. According to NYPA, the storage capacity of the lower and upper reservoirs cannot be increased in any feasible manner.

Flood Control Dams

Three large flood control dams are maintained in the upper Schoharie Creek watershed within the Batavia Kill subwatershed. They were constructed by the U.S. Department of Agriculture's NRCS following a 1960 flood. The pools created by the earthen dams normally contain little water, providing "void" space that is used to temporarily detain floodwater. The dams each consist of an earthen embankment, low-level outlet pipe under the dam, and twin grass-lined emergency spillways to convey flows in excess of a 100-year frequency flood. All emergency spillways were active during Tropical Storm Irene with variable levels of erosion. All three dams were inspected after the flood and found to have been at full capacity with active spillway usage. The dams performed as designed, storing 2.5 billion gallons of flood runoff. If this runoff had proceeded downstream over 12 hours, it would have increased river flow rates by an estimated 7,600 cfs, a 6.3 percent increase at Prattsville.

Conclusions

Reservoir storage during Tropical Storm Irene mitigated a moderate to substantial amount of downstream flooding. Storage in Schoharie Reservoir resulted in a reduction in peak flows of nearly 20 percent. Measures currently being implemented by the NYCDEP will result in the potential for additional peak flow attenuation. Storage in the Blenheim-Gilboa Lower Reservoir reduced peak flows by 8.2 percent. Neither reservoir is designed to operate in a flood-control capacity. Flood-control dams located in the upper Schoharie Creek watershed on the Batavia Kill performed as designed and further reduced peak flows.

4.3.18 Focus Area #18 – Protection of Wetlands, Floodplains, and Green Infrastructure

A wide range of flood mitigation scenarios have been evaluated in the preceding sections. An additional consideration to mitigate flood damages is to maintain the overall health of the watershed since watersheds naturally cycle, filter, and store water. Water enters the watershed as rain, which soaks into the ground, fills ponds and wetlands, and trickles into small intermittent streams that run into larger streams and finally rivers. The watershed stores water, moves it along, or transfers it underground to replenish groundwater. Land development activities change the surface of the land in the watershed by adding impervious surfaces, filling small wetlands, and rerouting streams. These activities change the path of water and ultimately influence where water goes during heavy storms.

Rain that falls on impervious surfaces (rooftops, streets, parking lots) does not soak into the ground but is carried away, often by engineered stormwater infrastructure (such as gutters, piped drainages, storm sewers) and discharged into nearby waters. This runoff can carry contaminants from impervious surfaces and other sources. Higher runoff flows from heavy rain can cause extensive erosion and flooding as water that falls across a large area is concentrated into stormwater collection areas.

Conventional engineered stormwater systems are designed to carry runoff away from developed areas. These systems are often expensive and are not designed to accommodate climate-change-induced severe storms and flooding on a watershedwide basis. "Green infrastructure" is an alternative method designed to reduce and treat stormwater at its source using vegetation and soils to restore natural watershed processes. Local green infrastructure practices include rain gardens, permeable pavement, green roofs, and green parking lots. Green infrastructure also includes the preservation and restoration of natural watershed features that provide critical services like clean water and flood protection.

Many land-based activities within the watershed affect water, and climate change adds unpredictability to these effects in terms of the severity and frequency of storms and floods. While construction and infrastructure changes are sometimes necessary to address heavy flooding at particular problematic sites, reduction of expensive infrastructure and flooding can be achieved by protecting, restoring, and recreating the watershed's natural functions.

Watersheds and Their Benefits

Under natural, undisturbed conditions, watersheds dissipate flood flows by spreading them out, storing them, and allowing for seepage through the soil and into groundwater. As noted above, land development affects the natural functions of watersheds, which include the following:

- Water Supply – Watersheds replenish groundwater, an important source for drinking water, agriculture, and aquatic habitats. Watersheds maintain connections between surface water and groundwater that help supply water in streams, lakes, and wetlands during drought.

- Water Quality – Vegetation and soils filter pollutants from runoff. A network of forested areas, streams, and wetlands improves water quality and can reduce the costs of treating drinking water.

- Flood Protection – Watersheds reduce vulnerability to flooding by collecting and storing water and slowly releasing it to lakes and streams, absorbing flood flows via floodplains, and slowing surface runoff across naturally vegetated areas where it is taken up by plants or seeps into the soil.

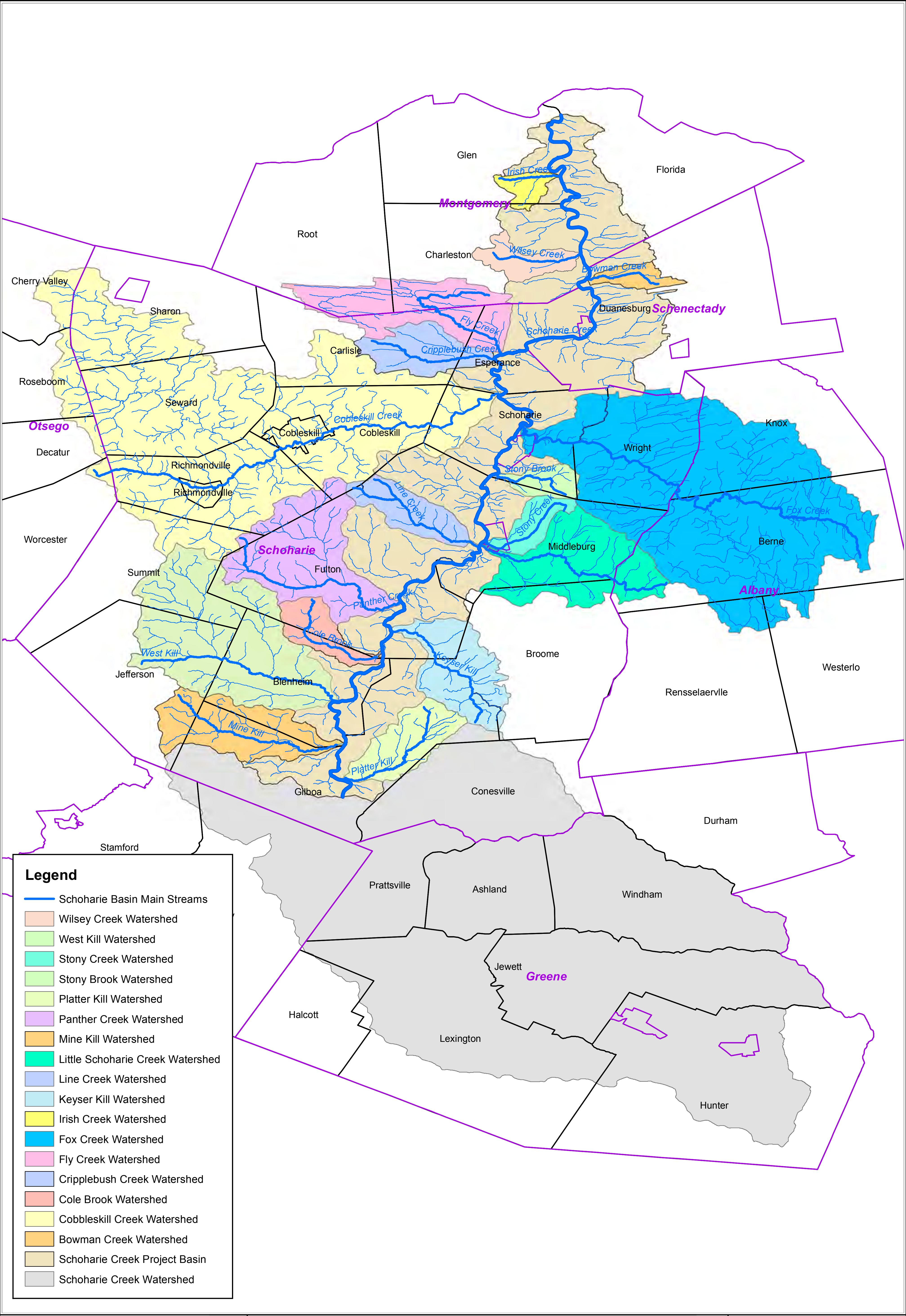
- Moderating the Effects of Climate Change – Watersheds provide natural stormwater management that reduces vulnerability to increased flooding and other damaging effects of more severe and frequent storms.

- Biodiversity – Watersheds support a variety of ecosystems and habitats that together support diverse plant and animal life including rare species, reduce vulnerability to invasive species, and provide habitat connections via stream corridors, wetlands, and vegetated buffers.

- Economic Values – Watershed features that provide aesthetic appeal and flood reduction can improve property values. In addition, streams, wetlands, lakes, and forests provide opportunities for education, research, water-based recreation, and tourism. Many of these services and benefits have measurable economic value that can be calculated on a watershedwide basis.

Subbasins and Watershed Management

The Schoharie is a large watershed with features spread across multiple hamlets, towns, and counties. To better understand and manage watershed issues on a local level, the watershed can be divided into smaller units, or subbasins. By dividing a large watershed into smaller more manageable areas, land use impacts and natural resources can be more easily identified and evaluated. This allows for development of locally effective restoration and flood mitigation plans. The lower Schoharie watershed contains 18 subbasins as depicted in Figure 4-73.



SOURCE(S):

USGS StreamStats Version 3.0 (04/2016)
USGS National Hydrography Dataset (04/2016)
NYS GIS Clearinghouse (04/2016)

Figure 4-73: Sub-Basins of the Lower Schoharie Creek Watershed

Location:
Schoharie Creek Watershed, NY

N

Schoharie Creek Flood Study

Map By: EMH
MMI#: 4805-05
MXD: Q:\Projects\4805-05 Schoharie Basin Flood Analysis\GIS\MDX\Streams and Sub basins Port (2).mxd
1st Version: 04/25/2016
Revision: 9/26/2016
Scale: 1 in = 25,000 ft

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As with the overall watershed, the buffers, forests, floodplains, wetlands, and streams all serve to reduce flood impacts within the subbasins as well. By focusing on preventive measures and bolstering watershed health before large storms occur, the damages and costs of future flooding can be reduced. These measures will also enhance water quality protection, drinking water supply, habitat, and healthy ecosystems throughout the watershed, which brings additional benefits to local communities.

Green Infrastructure Recommendations

Many green infrastructure practices can be used throughout the watershed; the following are designed for developed areas with a higher percentage of impervious surfaces and incorporate features that mimic natural watershed functions with the built environment.

- Downspout Disconnection – Reroutes rooftop drainage that would otherwise go to a storm sewer to rain barrels, cisterns, or permeable areas that allow it to soak into the soil
- Rain Gardens – Shallow vegetated basins that collect and absorb stormwater runoff
- Bioswales – Vegetated channels that collect, slow, and filter stormwater and allow it to soak into the soil
- Permeable Pavements – Intercept rainwater, allowing it to infiltrate into the soil and storing it where it falls
- Green Parking – Use of permeable pavement, trees, rain gardens, and bioswales in and adjacent to parking areas

Vegetated Buffers

Buffers are zones of permanent vegetation along the edges of wetlands, streams, rivers, and lakes. They are the transitional areas between upland and aquatic systems and protect aquatic systems from the effects of adjacent land use changes. Low-lying riparian areas often overlap with floodplains. A healthy wetland, stream, or lake includes a vegetated buffer along its edges. (Riparian areas are ecosystems adjacent to flowing waters; they often overlap with buffers.) Buffers are critical to maintaining the health of wetlands, streams, rivers, and lakes. Their vegetation protects water resources from adjacent land use impacts and provides important habitat. Buffers generally support a high diversity of wildlife and are important corridors between different habitat areas. Benefits are summarized in Table 4-13. Though this study emphasizes flood mitigation and protection, the table illustrates additional benefits derived from buffer protection.

Not all buffers provide all benefits. The characteristics of a buffer affect the level of protection provided for the adjacent water resource. These characteristics include size (width), linear extent (length of protected shoreline), type of vegetation, slope, and soil. To be effective, a buffer design must match its purpose(s) such as habitat, flood reduction, bank stabilization or erosion control, and/or water quality protection (Bentrup, 2008).

TABLE 4-13
Benefits of Vegetated Buffers

Benefit	How It Works
Flood Control	Buffers intercept, slow, and absorb stormwater runoff and floodwaters; enhance wetland flood control; protect floodplains; and facilitate gradual release of flood flows within watersheds.
Bank Stabilization and Erosion Control	Buffers intercept the erosive force of runoff, stabilize banks and stream channels, and control or prevent soil erosion.
Clean Water	Buffer vegetation intercepts and filters stormwater runoff; reduces or removes pollutants (including road salt, fertilizers, herbicides, pesticides, and heavy metals) before they reach wetlands, lakes, and streams; and reduces sediment load in streams.
Habitat	Buffers are important wildlife travel corridors and wetland-to-upland transitional habitats vital to the survival of wetland and stream-dependent species.
Cool Water	Buffer vegetation provides shade to maintain cool, well-oxygenated water for growth and reproduction of aquatic life.
Food for Aquatic Life	Leaves and stems from buffer plants supply organic matter to streams that are important sources of food and energy for microorganisms, aquatic invertebrates, and fish.
Visual/Noise Barrier	Buffers shield wetland, lake, and stream wildlife from human disturbances.
Cultural Value	Buffers are natural open space areas for education, research, and passive recreation.

Buffer Size:

Properly sized, vegetated buffers are critical to reducing flood flows and to reducing sediment load in streams, which can contribute to stream channel scouring. The size of a buffer affects how well it can slow floodwaters and protect water quality. Size includes the width as well as the extent of the buffer, e.g., whether is it patchy or continuous along the edge of a stream or wetland. The ideal size of a buffer depends on its purpose; buffers that are too small will not provide the same level of protection as buffers that are adequately sized.

No single buffer size fits all circumstances; some flexibility is required when assessing appropriate buffer size for water resources throughout the watershed. That being said, a 100-foot buffer is a widely accepted size recommended for basic water quality protection and some habitat protection. The NYSDEC uses this as a standard for protected wetlands. Research by the Environmental Law Institute (Kennedy et al., 2003) supports this as a minimum and recommends larger buffers (over 300 feet) along rivers. Streamside buffers need to be wide enough to support trees that can replace those closest to the bank if they are washed out during floods.

At a minimum, a riparian buffer should include the stream channel and the stream edge from the HWM toward adjacent uplands where plants are affected by high water tables or flooding and the ability of the soil to hold water. Often riparian buffers include all or part of the floodplain. Recommended buffer widths for bank stabilization are described in a variety of studies: 30 to 65 feet to more than 170 feet for bank stabilization (depending on location); 65 to 100 feet for stream channel stabilization; more than 125 feet (stream stabilization and sediment control); and 65 to 500 feet for floodplain storage depending on the size of floodplain (Kennedy et al., 2003).

Buffers need to be wider to effectively slow and intercept runoff and floodwaters where the following conditions exist:

- Stream bank slopes are steep. (Approximately 45 percent of the Schoharie watershed is classified as moderately to very steep, with slopes greater than 15 percent.)
- Banks or water edges are rocky or contain impervious soils, surfaces, or structures.
- Adjacent land use is intensive, for example, agricultural fields or developed areas with a high percentage of impervious surfaces.

Buffers that are adjacent to a source of contamination need to be wider to filter and absorb contaminants carried by stormwater runoff.

Buffer Extent:

Buffers that are continuous along a shoreline generally provide better protection for the stream, river, or wetland than do fragmented buffer segments. For example, remote sensing studies in Montgomery County, Maryland, measured tree cover, impervious surfaces, and riparian buffers. Stream health was rated as "excellent" when at least 65 percent of the length of the stream network in the watershed is forested (within 100 feet of the stream's edge).

To be effective on a watershedwide basis, buffers should be maintained at the edges of all streams (intermittent and perennial), wetlands, ponds, and lakes. In developed areas, buffers may be limited by existing development, but they can still provide some benefits though they cannot be ideally sized.

Type of Vegetation:

The most effective buffers contain a mix of native plants that includes trees and shrubs to slow floodwaters and keep the soil in place. The roots of woody vegetation are most effective in holding soil in place to stabilize banks and edges. Grasses, herbaceous plants, ground cover, and even low shrubs slow water so that it drops some of its sediment load, causes less erosion, filters contaminants, and allows runoff to seep into the soil replenishing groundwater supply. Mowed lawn, however, does not provide this level of bank protection and slowing of stormwater flows. Plants with shallow roots may easily be washed out during floods.

Recommendations for Vegetated Buffers:

One of the most effective practices to reduce flooding and protect banks is maintaining effective vegetated buffers along the edges of all streams, wetlands, lakes, and rivers. The following actions will help to increase the watershed's capacity to reduce flooding and as an added bonus will improve water quality and habitat as well.

- Protect existing buffers from removal, damage, major disturbance, and contamination. Consider local policies, zoning overlays, or buffer protection regulations.

- Prioritize the restoration and maintenance of buffers between the water and adjacent intensive land use areas.

- Keep construction, heavy equipment, and impervious surfaces out of the 100-foot buffer area to retain full benefits from the buffer.

- Establish vegetated buffers where there are none and replenish or replace vegetation to maximize buffer effectiveness. For planting plans, consult with local cooperative extension and regional DEC offices. Maintain all three layers of vegetation wherever possible: trees, shrubs, and herbaceous plants/unmowed grasses. The right mix of plants will also protect water quality by filtering contaminants from stormwater runoff. Try to match native vegetation found in local undisturbed buffers.

- Plant trees and shrubs for maximum soil stability and shade over the water. A single row of trees along the edge is not adequate to provide sustained protection and is at risk from flood damage.

- Use native plants to maximize sustainability of plantings and reduce cost of maintenance.

- Remove and replace invasive plants with care; contact the regional DEC office for information about management plans that minimize or avoid use of herbicides.

- Avoid mowing to the edge of the water. Mowed lawn does not provide the benefits that we receive from well-vegetated buffers but instead increases the amount of runoff and reduces groundwater recharge.

<u>Forests, Open Space, and Impervious Surfaces</u>

When rain falls on a watershed, the land cover determines how much water is captured, stored, and available to replenish groundwater. Forests are particularly effective at reducing stormwater runoff and flooding. Trees absorb rain and snowmelt, slow runoff, and take up water from the soil. Because of this, forested areas produce little runoff. They recharge aquifers and help to sustain stream flows. Tree roots stabilize soil and shorelines. In addition, trees filter sediment and some pollutants from stormwater runoff, take up nitrogen, and in some cases break down pollutants in soil and runoff. Trees also provide habitat and supply organic matter (e.g., leaves) for aquatic ecosystems.

Forest cover both within buffers and throughout the watershed is one measure of watershed health. It can be measured as a percent of total watershed area or as linear riparian buffer. Though there is no one ideal value, research provides some information about the importance of size. For example, a Maryland study using remote sensing measured tree cover, impervious surfaces, and riparian buffers (width=100 feet) and rated stream health as "excellent" when at least 65 percent of the length of the streams in the watershed are forested and "good" with at least 45 percent forested cover (Goetz et al., 2003).

As a bonus, forested cover in a watershed can lower the treatment costs for drinking water. According to a Trust for Public Land and American Water Works Association study, forest cover up to about 60 percent resulted in lower water treatment costs, and for every 10 percent increase in forest cover, treatment costs decreased by about 20 percent leveling out at 70 to 100 percent cover (Ernst et al., 2004).

Tree cover is a marked contrast to impervious surfaces, which prevent water from sinking into the soil and increase runoff. When the amount of impervious surface cover in a watershed is greater than 10 percent, water quality in streams decreases. According to the NRCS (2010), 67.6 percent of the Schoharie watershed is forested; this includes deciduous, evergreen, and mixed forest.

As a whole, the Schoharie watershed has very low impervious cover, with 4.5 percent of the land in low-density development and only 0.2 percent in urban land (medium to high intensity development); however, this varies by subbasin. In small subbasins drained by small streams, concentrations of high intensity development can have significant local effects on water quality and flooding.

Recommendations for Protecting Forests and Open Space:

- Develop a watershedwide Forest Protection Plan that encourages tree planting, directs development away from forested areas, reduces paved surfaces, and limits clearcutting or tree clearing in sensitive riparian areas (especially in subbasins or along streams that already have a low percentage of forested cover).

- Encourage conservation easements that protect forested land from being developed.

- Enhance or restore the health, condition, and function of forest fragments in developed areas, improving conditions for tree growth to ensure long-term sustainability.

- Plant trees and shrubs in buffers along streams wherever feasible, focusing on reaches that are prone to erosion and flooding.

- Develop specific guidelines to limit impervious surfaces. Subbasins with less than 10 percent impervious cover can develop actions to keep this percent low. Subbasins with impervious cover that approaches 10 percent can develop policy to keep these areas below the threshold. Subbasins that are 10 percent or more impervious cover can reduce or replace existing impervious surfaces where possible and employ green infrastructure practices to mitigate impacts.

- In large subbasins, apply these recommendations to the smaller basins drained by local streams and wetlands.

<u>*Floodplains*</u>

Floodplains are a watershed's natural flood-control systems. When a stream overflows its banks, floodplains slow floodwaters and spread them across the land. Standing water soaks into the ground, and its load of sediment is deposited in the floodplain. Nutrients from the land may be carried back into the stream system when floodwaters recede. Floodplains are part of the normal pattern of stream dynamics. Over time, stream channels and meander patterns change within the floodplain.

Floodplains must be connected to the stream channel to work properly. Connectivity with the stream helps reduce flooding downstream by providing water with an easy path away from the stream as it spreads outward across the floodplain. When water cannot escape the channel, the stream velocity and flow increase, resulting in downstream flood damage. If the stream is cut off from its floodplain on one side (e.g., if there is a barrier between the stream and the floodplain), floodwater shifts to the opposite side of the stream channel with greater potential for causing more flood damage. Buildings in the floodplain similarly obstruct floodwaters; impervious surfaces increase surface water flow, and this often results in greater flood damage.

The shape and depth of the stream channel as it flows through a floodplain also affect the location and extent of flooding. Meandering stream channels and braided channels slow stream flow; straight channels concentrate flows into a shorter distance and increase water velocity (and the potential for downstream flood damage). Similarly, deeper channels allow floodwaters to build up and increase their flow and scour potential, increasing erosion. The greater the volume of water the more potential for greater bank damage, erosion, and flood damage when that water finally overflows the stream channel.

By protecting floodplains along all tributaries and small streams, the potentially damaging effects of floodwaters can be reduced as they are dispersed over a larger area. The benefits provided by floodplains are cumulative throughout the watershed, and even floodplains along small tributaries play a role in reducing downstream flooding.

Recommendations for Floodplains:

- Adopt a Floodplain Management Plan for the entire watershed (consistent for all municipalities in the watershed) that may include floodplain ordinances, overlay zones, and guidelines for managing specific sites that are prone to flooding. It is the nature of rivers and streams to periodically flood, and it is the purpose of floodplains to accommodate that flooding. While it is necessary to protect and assist property owners who already live in floodplains, it is equally necessary to limit the potential for future damage by regulating or restricting new development (and construction of impervious surfaces) within the floodway and floodplain. The management plan may also include expanding the width of a "no build" zone in the floodway to include areas of potential channel migration or meanders.

- Maintain unimpeded connection between a stream or river and its floodplain to improve floodwater retention and accommodation during floods.

- Use green infrastructure and best management practices within floodplains to improve existing conditions where structures are already present and reduce the extent of impervious surfaces within floodplains.

<u>*Wetlands and Streams*</u>

Wetlands and small streams throughout the watershed are collectively important for providing stormwater storage, slowing and spreading floodwaters, recharging groundwater, and moving water through the watershed. Numerous wetland and stream ecosystems can contribute significantly to the watershed's ability to reduce floodwaters, erosion, and subsequent property damage (Cappiella and Fraley McNeal, 2007).

Streams:

A network of small streams distributes floodwaters from heavy rainfall across the landscape and channels some of it to larger streams and rivers, lakes, ponds, and wetlands. Nutrients washed from the land (e.g., soil, leaf litter) by stormwater are carried downstream where they support aquatic food chains. Small tributary streams, especially those with cool and relatively clean water, may provide refuges and breeding areas for fish and other aquatic life during hot weather or periods of low flow in river channels.

Headwaters are the sources and upper reaches of river systems. They often include small intermittent streams, rivulets, wetlands, seeps, or springs. Headwater streams collect floodwater or runoff, support a high diversity of species, and sustain downstream waters. They comprise just over 50 percent of total stream miles in the continental United States and provide the foundation for all of our large river systems (Environmental Protection Agency website, accessed May 2016).

Wetlands:

In wetlands, soils are saturated with water long enough to produce conditions favoring plants that are adapted to grow in wet conditions. The U.S. Fish and Wildlife Service defines wetlands as follows:

> *Wetlands are lands transitional between terrestrial and aquatic systems where the water table is usually at or near the surface or the land is covered by shallow water… wetlands must have one or more of the following three attributes: (1) at least periodically, the land supports predominantly hydrophytes (plants specifically adapted to live in wetlands); (2) the substrate is predominantly undrained hydric (wetland) soil; and (3) the substrate is nonsoil and is saturated with water or covered by shallow water at some time during the growing season of each year (Cowardin et al., 1979).*

Wetlands occur throughout the Schoharie watershed. They are usually found in low-lying areas, depressions, or other places that collect water or are connected to the water table, but they can also be found on hilltops and slopes; along the edges of streams, rivers, floodplains, lakes, and ponds; in fields and meadows; and in forests. As transitional areas between land and water, some wetlands protect shorelines of lakes and streams and provide habitat for a variety of plants and animals. There are many different types of wetlands; some contain standing water year-round while others are seasonally dry. Wetland types include marsh, fen, wet meadow, prairie pothole, vernal pools, and forested swamp.

Maps generally show the approximate size and location of wetlands because an exact description requires an on-site wetland boundary delineation. The three types of maps described below provide a good idea of wetland location:

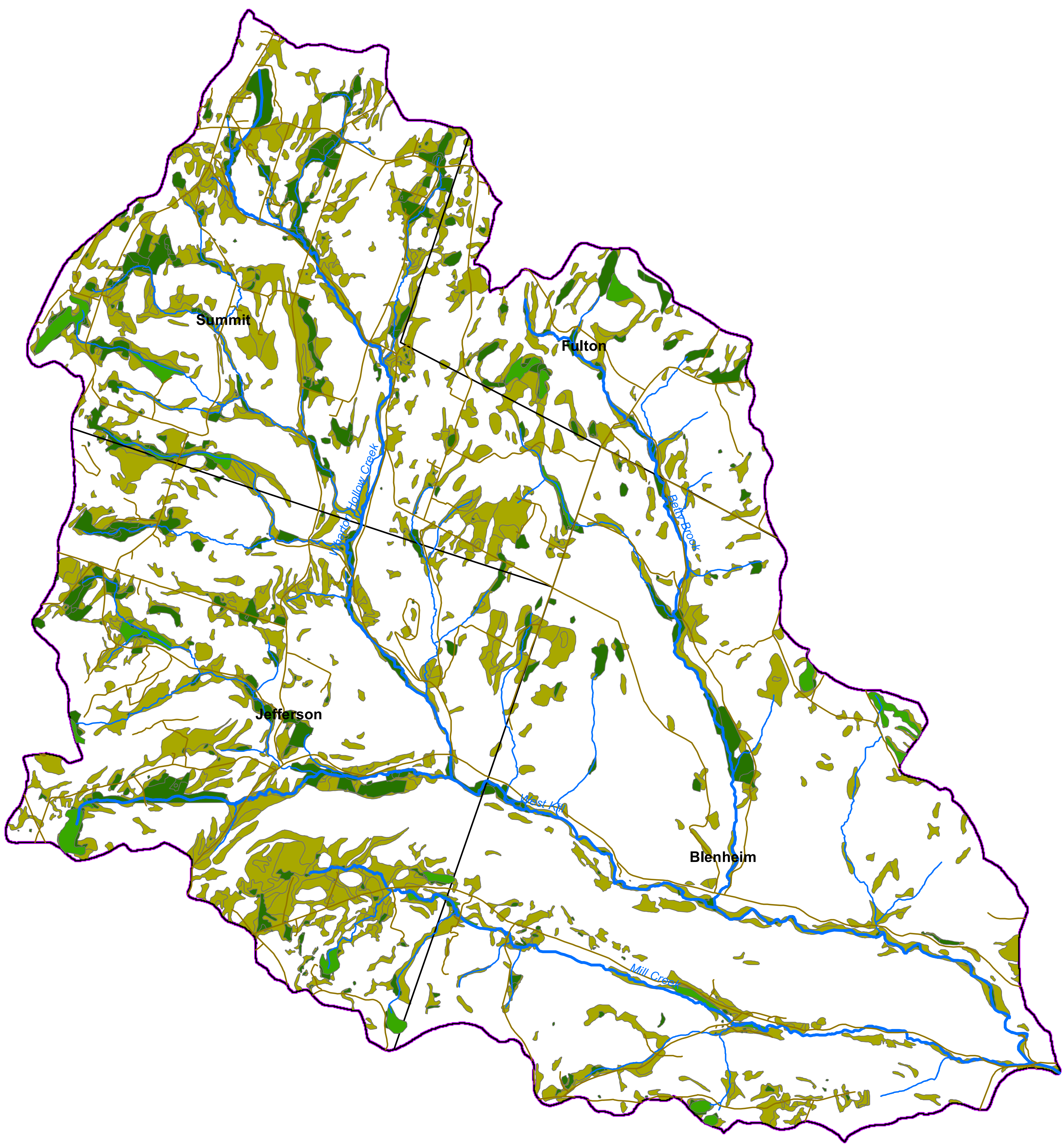
NYS Department of Environmental Conservation Regulatory Wetland Maps – Based on aerial photos (they are not ground verified unless a particular project calls for an accurate depiction of wetlands at a specific site), these maps show only the wetlands that are larger than 12.4 acres. DEC wetland maps do not necessarily include all wetlands of 12.4 acres or more; some of the mapped wetlands may be larger or a different shape from those on the official DEC maps (which is why they must be verified per site). DEC includes a "check zone" around all of these wetlands to underscore the fact that their boundaries as mapped are approximate. The lower Schoharie watershed contains 309 of these wetlands for an approximate total size of 17, 030 acres.

U.S. National Wetland Inventory (NWI) Wetland Habitat Maps – The U.S. Fish and Wildlife Service classifies wetland types in terms of their shared physical, chemical, and biological characteristics (Cowardin et al., 1979). These maps, based on aerial photos, show wetlands according to their habitat (NWI website, accessed May 2016). There is no minimum size limit, and sometimes these wetlands overlap with DEC regulatory wetlands. Like the "DEC wetlands," they are an approximation of size and shape and require ground verification. The maps do not necessarily include all wetlands actually present in a given area. The lower Schoharie watershed contains 3,229 of these wetlands for an approximate total size of 10,425 acres. The total area of the wetlands shown on these maps in the lower Schoharie watershed basin is approximately 13, 360 acres.

Hydric Soils (from County Soil Maps) – Hydric soils form under conditions of saturation, flooding, or ponding long enough during the growing season to develop anaerobic conditions. Hydric soils along with hydrophytic vegetation and wetland hydrology are used to define wetlands. The NRCS maps soils by county; soil boundaries on these maps need to be field verified. Map units that are mostly hydric soils may include small areas of nonhydric soils, and map units that are mostly nonhydric soils may include small areas of hydric soils. The United States Department of Agriculture NRCS lists hydric soils by county; most areas with hydric soils are wetlands. The total area of the hydric soils shown on these maps in the lower Schoharie watershed basin is approximately 138,150 acres.

By combining wetland information from these three types of maps, it is possible to get a comprehensive look at the overall likely location of wetlands within a watershed. Because the Schoharie watershed is so large, many wetlands cannot be seen on one map at a small scale. A much clearer view of these areas is possible when the watershed is assessed at a subbasin scale. Figure 4-74 shows the West Kill subbasin and its wetlands based on DEC, NWI, and hydric soils maps. A total of 1,751 acres of wetlands are shown on DEC and NWI maps, and the soil maps show 6,348 aces of hydric soils in this subbasin.

Wetlands are scattered throughout the subbasin, often associated with headwaters and intermittent streams. Where they lie adjacent to streams, they are likely to absorb and slow floodwaters. Between streams, they are sponges across the land that capture and store water and keep it from flowing downstream and adding to flood flows. Some wetlands are particularly valuable because of their specific location in the watershed. For example, wetlands within and downstream of developed areas are important for counteracting the increased volume and flow of stormwater runoff from impervious surfaces. In agricultural areas, wetlands can store water to help prevent flooding of crops.



Legend

- NYSDEC Freshwater Wetlands
- NWI Wetlands
- Hydric Soils

SOURCE(S):
NYS GIS Clearinghouse, April 2016:
NYSDEC, Regulatory Freshwater Wetlands
NRCS SSURGO database, April 2016
USFWS National Wetland Inventory, Data by State, April 2016.

Footnote:
The "Checkzone" is defined as an area around a NYSDEC mapped wetland in which the actual wetland may occur. It is an approximate location and not a precise boundary.

Figure 4-74: West Kill Watershed: Wetlands

Location: West Kill Watershed, NY

N

Schoharie Basin Flood Analysis

Map By: EMH
MMI#: 4805-05
MXD: Q: Schoharie Basin Flood Analysis/Wetlands and Hydric Portrait
1st Version: 4/26/2016
Revision: 5/6/2016
Scale: 1 in = 4,634 ft

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The presence of wetlands throughout a watershed is one indicator of watershed health. Wetlands work as "sponges" on the landscape; they collect water until they become saturated and then release it slowly. The amount of water a wetland can store depends on local conditions, wetland type, and soil permeability. Storage capacity, or the space available for water storage, generally increases during the growing season when evaporation and transpiration from plants is high, and water tables drop. The ability of wetlands to absorb and store water also depends on an intact wetland buffer and the wetland's contributing drainage area, which is similar to a small watershed. The following studies provide examples of wetland storage capacity:

- Grant County, Minnesota – Wetlands have the potential to store up to 20 percent of the basin's total precipitation; restoring 25 percent of the farmed and drained wetlands within one drainage basin would increase watershed storage capacity by 27 to 32 percent. A 50-percent restoration would increase storage by 53 to 63 percent (Gleason et al., 2007).

- South Carolina – A subset of wetlands (wetland types without a surface connection to downstream waters) stores an estimated 45.8 billion gallons of water (enough to fill 70,000 Olympic-size swimming pools) (South Carolina Department of Health & Environmental Control, 2003).

- Indiana – A 1-acre wetland 1-foot deep can hold approximately 330,000 gallons of water. Networks of many small wetlands dispersed throughout the watershed can collectively store a significant amount of water (Purdue University Cooperative Extension website, accessed May 2016).

  The USGS documents a strong correlation between the percentage of the watershed area that is lakes and wetlands and the size of flood peaks. The research documents that subbasins with 30 percent coverage by lakes and wetlands have flood peaks that are 60 to 80 percent lower than the peaks in basins with no lakes or wetlands (USGS website, accessed May 2016).

  Wetlands can provide cost-effective flood control. When wetlands are removed, stormwater runs directly into streams or waterways, increasing flooding. Thus, wetland loss can result in costly flood damage in some areas. For example, the USACE calculated that loss of all wetlands in Massachusetts' Charles River watershed would cause an average annual flood damage cost of $17M. The USACE concluded that conserving wetlands was a natural solution to controlling flooding, and because it was less expensive than the construction of dikes and dams alone, the USACE acquired 8,103 acres of wetlands in the Charles River basin for flood protection (U.S. Environmental Protection Agency, 2006).

Recommendations for Streams and Wetlands:

- Develop a watershedwide Aquatic Buffer Ordinance or Water Resources Protection Plan that includes specific guidelines for the size and vegetative composition of buffers along all stream, lake, and wetland edges. This should cover the entire watershed so that protective measures are consistent in all watershed municipalities. A water resources protection plan should include all headwaters, intermittent and perennial streams, lakes, ponds, and all types of wetlands regardless of regulatory or jurisdictional status.

- Develop a plan to implement watershedwide wetland, stream, and buffer protection as described above.

- Develop an inventory of "target" riparian areas for restoration to protect water quality, reduce flood damages, and provide habitat.

- Maintain natural stream channels and banks; avoid deepening or straightening channels.

- Use u-shaped rather than v-shaped runoff ditches along roads to decrease erosion and slow the water's flow.

- If there is uncertainty regarding whether a wetland is present in a particular location, have the site evaluated by a professional wetland delineator.

- Avoid dumping trash and other debris (including organic debris and yard waste) in wetlands and streams.

5.0 SUMMARY OF RECOMMENDATIONS

5.1 Focus Area Recommendations

A number of recommendations have been provided throughout this analysis. A summary of recommendations by specific focus area is presented in Table 5-1. Table 5-2 is a summary of cost opinions for implementation of the recommended flood mitigation alternatives. It should be noted that some types of mitigation alternatives such as the replacement of a bridge or culvert or the construction of an enhanced floodplain will have a quantifiable cost for design, permitting, and construction. For certain alternatives such as the relocation of a home or the floodproofing of a business, the cost of implementation will vary widely depending on which and how many measures are being implemented and on the size and value of the home or business. Alternatives that emphasize the protection of watersheds, wetlands, and floodplains or that rely on changing local floodplain zoning codes or enforcing NFIP regulations are programmatic in nature, and the cost of implementation can be difficult to quantify.

5.2 Funding Sources

The following funding sources may be available to towns within the Schoharie watershed for the implementation of recommended activities described in this report.

NYSDOS – The DOS 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.

NYS Grants – All NYS grants are now announced on the NYS Grants Gateway (a direct link is in the "Links Leaving DEC's Website" section of the right-hand column of this page). The Grants Gateway is designed to allow grant applicants to browse all NYS agency anticipated and available grant opportunities, providing a one-stop location that streamlines the way grants are administered by the State of New York.

Community Development Block Grant (CDBG) – The Office of Community Renewal administers the CDBG program for NYS. 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 the CDBG funding program could be applicable for floodproofing and elevating residential and nonresidential buildings depending on the eligibility of those buildings relative to the program requirements.

Empire State Development – The state's Empire State Development program offers loans, grants, and tax credits as well as other financing and technical assistance to support businesses and encourage their growth. It is possible that the program could be applicable for floodproofing, elevating, or relocating nonresidential buildings depending on the eligibility of those businesses relative to the program requirements.

TABLE 5-1
Summary of Alternatives

Alternative	Recommended for Implementation?
Focus Area #1 – North Blenheim	
Alternative 1-1: Analysis of Historic Covered Bridge	M
Alternative 1-2a: Floodplain Enhancement	N
Alternative 1-2b: Floodplain Enhancement	N
Alternative 1-2c: Floodplain Enhancement	Y
Alternative 1-3: Sediment Removal	N
Focus Area #2 – Bear Ladder Road	
Alternative 2-1: Floodplain Modifications	N
Alternative 2-2: Raise Roadway	N
Alternative 2-3: Roadway Signage and Closure	Y
Focus Area #3 – West Fulton Hamlet	
Alternative 3-1: Replace Patria Road Bridge over House Creek	In future
Alternative 3-2: Replace West Fulton Road Bridge over Panther Creek	In future
Alternative 3-3: Create Compound Channel with Floodplain along Panther Creek	Y
Focus Area #4– Village of Middleburgh	
Alternative 4-1: Modify/Replace NYS Route 30 Bridge	N
Alternative 4-2: Floodplain Enhancement	N
Alternative 4-3: Right Bank Floodplain Enhancement	N
Alternative 4-4: Dredging	N
Alternatives 4-5a and 4-5b: Flood Control Levee and Wall	N
Alternative 4-6: Individual Building Relocation, Elevation, Floodproofing	Y
Focus Area #5 – Christmas Tree Lane Culvert	
Alternative 5-1: Increase Culvert Capacity	N
Alternative 5-2: Raise Roadway	N
Alternative 5-3: Relocate Roadway	N
Alternative 5-4: NYS Route 30 Roadway Signage and Closure	Y
Focus Area #6 – Route 145 Culvert	
Alternative 6-1: Replace Culvert	M
Alternative 6-2: Program of Debris Management	Y
Focus Area #7 – Village of Schoharie	
Alternative 7-1: Floodplain Enhancement	N
Alternative 7-2: Dredging	N
Alternatives 7-3a and 7-3b: Levee Scenarios	N
Alternative 7-4: Individual Building Relocation, Elevation, Floodproofing	Y
Focus Area #8 – Fox Creek	
Alternative 8-1: Modification/Replacement of the State Route 443 Bridge (Upper)	N
Alternative 8-2: Modification/Removal of Abutments at Schell Road Bridge	M
Alternative 8-3: Modification/Replacement of Schoonmaker Road	In future
Alternative 8-4: Modification/Replacement of Zimmer Road Bridge	Y
Alternative 8-5: Modification/Replacement of Sholtes Road Bridge	Y
Alternative 8-6: Modification/Replacement of the State Route 443 Bridge (Lower)	In future
Alternative 8-7: Development of Sediment Management Plan	Y
Alternative 8-8: Bank Erosion Repairs	Y
Focus Area #9 – Gallupville	
Alternative 9-1: Modification/Replacement of School Street Bridge	N
Alternative 9-2: Floodplain Enhancement	N
Alternative 9-3: Individual Building Relocation, Elevation, Floodproofing	Y

TABLE 5-1 (continued)
Summary of Alternatives

Alternative	Recommended for Implementation?
Focus Area #10 – Railroad Bridge over Schoharie Creek	
Alternative 10-1: Modification/Replacement of Canadian Pacific Railroad Bridge	N
Alternative 10-2: Compliance with and Enforcement of NFIP Criteria	Y
Focus Area #11 – Cobleskill Creek Confluence	
Alternative 11-1: Modify/Replace Church Street Bridge	N
Alternative 11-2: Modify/Replace Route 30A Bridge and Roadway	N
Alternative 11-3: Individual Building Relocation, Elevation, Floodproofing	Y
Alternative 11-4: Roadway Signage and Closure	Y
Focus Area #12 – Fly Creek	
Alternative 12-1: SCSWCD Natural Channel Design Scenario #1	N
Alternative 12-2: SCSWCD Natural Channel Design Scenario #2	Y
Alternative 12-3: Develop a Sediment Management Plan	Y
Focus Area #13 – Colyer Road, Burtonsville	
Alternative 13-1: Modification or Enhancement of Channel or Floodplain	N
Alternative 13-2: Individual Building Relocation, Elevation, Floodproofing	Y
Focus Area #14 - Warnerville Cutoff	
Alternative 14-1: Elevation of the Roadway	N
Alternative 14-2: Elevation of Roadway and Installation of Bypass Culvert	N
Alternative 14-3: Elevation of Roadway and Installation of Bypass Bridge	N
Alternative 14-4: Warnerville Cutoff Roadway Signage and Closure	Y
Focus Area #15 – Potential for Flood Attenuation in Upper Watershed	
Alternative 15-1: Potential for Flood Storage at Warner Lake	N
Alternative 15-2: Potential for Flood Storage at Onderdonk Lake	N
Alternative 15-3: Potential for Flood Storage at Other Lakes, Ponds, and Wetlands	Conserve wetlands
Focus Area #16 – Review of Berms along Farm Fields	
Alternative 16-1: Removal of Agricultural Berms	Where possible
Focus Area #17 – Review of Potential for Flood Attenuation in Reservoirs	
Focus Area #18 - Recommendations for Protection of Watersheds, Wetlands, Floodplains	
Use green infrastructure and best management practices.	Y
Establish and maintain vegetated buffers.	Y
Protect forests and open space.	Y
Protect and reconnect floodplains.	Y
Develop guidelines to limit impervious surfaces.	Y
Implement watershedwide wetland, stream, and buffer protection.	Y

TABLE 5-2
Cost Opinions for Recommended Alternatives

Alternative	Recommended for Implementation?	Cost Opinion Design/Study/ Permitting	Cost Opinion Construction
Focus Area #1 – North Blenheim			
Alternative 1-2c: Floodplain Enhancement	Y	$68,000	$800,000 - $1M
Focus Area #2 – Bear Ladder Road			
Alternative 2-3: Roadway Signage and Closure	Y	see note 1	Costs will vary depending on what measures are implemented.
Focus Area #3 – West Fulton Hamlet			
Alternative 3-1: Replace Patria Road Bridge over House Creek	In future	$150,000	$600,000 - $1M
Alternative 3-2: Replace West Fulton Road Bridge over Panther Creek	In future	$150,000	$600,000 - $1M
Alternative 3-3: Create Compound Channel with Floodplain along Panther Creek	Y	$60,000-$75,000	$150,000 -$ 200,000
Focus Area #4– Village of Middleburgh			
Alternative 4-6: Individual Building Relocation, Elevation, Floodproofing	Y	see note 2	Costs will vary depending on what measures are implemented.
Focus Area #5 – Christmas Tree Lane Culvert			
Alternative 5-4: NYS Route 30 Roadway Signage and Closure	Y	see note 1	Costs will vary depending on what measures are implemented.
Focus Area #6 – Route 145 Culvert			
Alternative 6-1: Replace Culvert	M	$150,000	$1M - $1.5M
Alternative 6-2: Program of Debris Management	Y		
Focus Area #7 – Village of Schoharie			
Alternative 7-4: Individual Building Relocation, Elevation, Floodproofing	Y	see note 2	Costs will vary depending on what measures are implemented.
Focus Area #8 – Fox Creek			
Alternate 8-2: Modification/Removal of Abutments at Schell Road Bridge	M	$5,000	Costs will vary depending on results of structural assessment.
Alternate 8-3: Modification/Replacement of Schoonmaker Road	In future	$150,000	$1.5M - $2M
Alternative 8-4: Modification/Replacement of Zimmer Road Bridge	Y	$150,000	$1.4M - $1.8M
Alternative 8-5: Modification/Replacement of Sholtes Road Bridge	Y	$150,000	$1.4M - $1.8M
Alternative 8-7: Development of Sediment Management Plan	Y		
Alternative 8-8: Bank Erosion Repairs	Y		
Focus Area #9 – Gallupville			
Alternative 9-3: Individual Building Relocation, Elevation, Floodproofing	Y	see note 2	Costs will vary depending on what measures are implemented.

TABLE 5-2 (continued)
Cost Opinions for Recommended Alternatives

Alternative	Recommended for Implementation?	Cost Opinion Design/Study/ Permitting	Cost Opinion Construction
Focus Area #10 – Railroad Bridge over Schoharie Creek			
Alternative 10-2: Compliance with and Enforcement of NFIP Criteria	Y		
Focus Area #11 – Cobleskill Creek Confluence			
Alternative 11-3: Individual Building Relocation, Elevation, Floodproofing	Y	see note 2	Costs will vary depending on what measures are implemented.
Alternative 11-4: Roadway Signage and Closure	Y	see note 1	Costs will vary depending on what measures are implemented.
Focus Area #12 – Fly Creek			
Alternative 12-2: SCSWCD Natural Channel Design Scenario #2	Y	$40k - $50k	$400k - $500k
Alternative 12-3: Develop a Sediment Management Plan	Y		
Focus Area #13 – Colyer Road, Burtonsville			
Alternative 13-2: Individual Building Relocation, Elevation, Floodproofing	Y	see note 2	Costs will vary depending on what measures are implemented.
Focus Area #14 - Warnerville Cutoff			
Alternative 14-4: Warnerville Cutoff Roadway Signage and Closure	Y	see note 1	Costs will vary depending on what measures are implemented.
Focus Area #15 – Potential for Flood Attenuation in Upper Watershed			
Focus Area #16 – Review of Berms along Farm Fields			
Alternative 16-1: Removal of Agricultural Berms	M		
Focus Area #17 – Review of Potential for Flood Attenuation in Reservoirs			
Focus Area #18 - Recommendations for Protection of Watersheds, Wetlands, Floodplains			
Use green infrastructure and best management practices.	Y		
Establish and maintain vegetated buffers.	Y		
Protect forests and open space.	Y		
Protect and reconnect floodplains.	Y		
Develop guidelines to limit impervious surfaces.	Y		
Implement watershedwide wetland, stream, and buffer protection.	Y		

Note 1: Cost of road closures will vary depending on the length of the detour, the volume of traffic, and the mechanisms used to close the road.

Note 2: Costs of individual building relocation, elevation, floodproofing will vary depending on the size and number of structures in the floodprone area and on what measures are implemented. The following approximate costs are provided as examples:

- Elevating a residential structure: $175,000
- Low door shield: $1,500
- Door gaskets and seals: $500 - $1,500

- Fully floodproofed doors: up to $4,000 per door
- Elevate electric service and meter: $500 - $1,500
- Floodproof HVAC equipment: $500 - $1,500 (and up)
- Implementing a variety of measures to protect a small business: $6,000 to $50,000

Mohawk River Watershed Grants – The Environmental Protection Fund provides grant awards aimed at promoting economic revitalization and environmental sustainability in the Mohawk River watershed. Municipalities and not-for-profit corporations are eligible to apply. Periodically, funding for environmental protection or improvement projects throughout the Mohawk River Basin is available through Requests for Proposals. Eligible projects include those that conserve, protect, and restore fish, wildlife, and their habitats; protect and improve water quality; and promote flood hazard mitigation and enhanced flood resiliency. Examples include installation of green infrastructure projects to reduce stormwater runoff, right-sizing of culverts, restoration of natural stream conditions, restoration of riparian buffers, farmland protection, elevating or floodproofing critical structures, and environmental education activities.

Private Foundations – Private entities such as foundations are potential funding sources in many communities.

FEMA Flood Mitigation Assistance (FMA) Program – The FMA program was created as part of the National Flood Insurance Reform Act of 1994 (42 U.S.C. 4101). 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 former Repetitive Flood Claims and Severe Repetitive Loss programs have been replaced by the following recent (2012) changes to the FMA Program:

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

The FMA program focuses on mitigation for structures that are insured or located in significant flood hazard areas.

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. The NRCS may pay up to 75 percent of the construction costs of emergency measures. The remaining costs must come from local sources and can be made in cash or in-kind services. EWP projects must reduce threats to lives and property; be economically, environmentally, and socially defensible; be designed and implemented according to sound technical standards; and conserve natural resources.

FEMA Pre-Disaster Mitigation (PDM) Program – The PDM Program was authorized by the Robert T. Stafford Disaster Assistance and Emergency Relief Act (Stafford Act), 42 U.S.C. 5133. The program provides funds to states, territories, tribal governments, communities, and universities for hazard mitigation planning and implementation of feasible, effective, and cost-efficient mitigation measures. The purpose of funding pre-disaster plans and projects is to reduce overall risks to populations and facilities. The PDM Program is subject to the availability of appropriation funding.

USACE Floodplain Management Planning – The USACE provides 100 percent funding for floodplain management planning and technical assistance to states and local governments under several flood control acts and the Floodplain Management Services Program. Specific programs include the following:

- Small Flood Damage Reduction Projects: Section 205 of the 1948 Flood Control Act authorizes the USACE to study, design, and construct small flood control projects in partnership with nonfederal government agencies. Feasibility studies are 100 percent federally funded up to $100,000 with additional costs shared equally. Costs for preparation of plans and construction are funded 65 percent with a 35 percent nonfederal match. Maximum federal expenditure for any project is $7M.

- Emergency Stream Bank and Shoreline Protection: Section 14 of the 1946 Flood Control Act authorizes the USACE to construct emergency shoreline and stream bank protection works to protect public facilities such as bridges, roads, public buildings, sewage treatment plants, and water wells and nonprofit public facilities such as churches, hospitals, and schools. Cost sharing is similar to Section 205 projects above. Maximum federal expenditure for any project is $1.5M.

- Clearing and Snagging Projects: Section 208 of the 1954 Flood Control Act authorizes the USACE to perform channel clearing and excavation with limited embankment construction to reduce nuisance flood damages caused by debris and minor shoaling of rivers. Cost sharing is similar to Section 205 projects above. The maximum federal expenditure for any project is $500,000.

- Floodplain Management Services: Section 206 of the 1960 Flood Control Act authorizes the USACE to provide technical services and planning guidance for floodplain management. Technical assistance includes 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; natural and cultural floodplain resources; and flood loss potentials before and after the use of floodplain management measures. Studies include floodplain delineation, dam failure, hurricane evacuation, flood warning, flood damage reduction, stormwater management, floodproofing, and inventories of floodprone structures. When funding is available, this work is 100 percent federally funded.

5.3 Additional Resources

In addition to the funding sources listed in Section 5.3, other resources are available for technical assistance, planning, and information. While the following sources do not provide direct funding, they offer other services that may be useful for proposed flood mitigation projects listed in the table.

TABLE 5-3
Potential Funding Sources

Type of project	US Dept. of State	FEMA Flood Mitigation Assistance Program	FEMA Pre-Disaster Mitigation Program	Emergency Watershed Protection Program	Community Development Block Grant	Empire State Development	Mohawk River Watershed Grants	USACE
Floodplain Enhancement	X	X	X	X		X	X	X
Bridge Replacement or Modifications	X	X	X				X	
Roadway Signage and Closure								
Create Compound Channel with Floodplain	X	X	X	X			X	X
Individual Building Relocation, Elevation, Floodproofing				X	X	X	X	
Replace Culvert		X	X	X			X	X
Program of Debris Management		X	X	X			X	X
Development of Sediment Management Plan		X	X	X			X	X
Bank Erosion Repairs	X	X	X	X			X	X
Compliance with and Enforcement of NFIP Criteria								

TABLE 5-3
Potential Funding Sources

Type of project	US Dept. of State	FEMA Flood Mitigation Assistance Program	FEMA Pre-Disaster Mitigation Program	Emergency Watershed Protection Program	Community Development Block Grant	Empire State Development	Mohawk River Watershed Grants	USACE
SCSWCD Natural Channel Design	X	X	X	X			X	X
Removal of Agricultural Berms		X	X				X	X
Use green infrastructure and best management practices.							X	
Establish and maintain vegetated buffers.			X	X			X	X
Protect forests and open space.							X	
Protect and reconnect floodplains.				X			X	X
Develop guidelines to limit impervious surfaces.							X	X
Implement watershedwide wetland, stream, and buffer protection plan.							X	

Project eligibility for grants and other funding opportunities depends on project details.

Schoharie Area Long Term, Inc. (SALT) – SALT has a mission of rebuilding resilient and sustainable communities and a vision that the Schoharie Creek Basin and surrounding communities will be vibrant, thriving, resilient, and sustainable. While not a source of direct funding, SALT is dedicated to flood recovery in the Schoharie Creek watershed and is a potential partner in flood mitigation implementation and long-term recovery. Areas of interest include rebuilding infrastructure to meet future community needs; implementing mitigation strategies; control of flow and height of the water carried by the river, floodplain, and watershed; land-use practices to protect structures against flooding; and floodproofing.

Land Trust and Conservation Groups – These groups play an important role in the protection of watersheds, including forests, open space, and water resources.

Cornell Cooperative Extension: Schoharie and Otsego Counties – This nonprofit educational organization is part of the Cooperative Extension land grant system, a partnership between county, state, and federal governments that is administered in NYS by Cornell University. Extension serves the needs of local communities; staff work with residents to identify community issues and needs and create strategies and programs to address those needs. They deliver educational programs, encourage collaboration, and connect people with information. For example, Extension provides stream restoration information including guidance for stream buffer planting and woody debris removal.

NYSDEC "Trees for Tribs" Program – DEC's Trees for Tribs offers low-cost to no-cost native trees and shrubs for streamside restoration. The program also offers free technical assistance that includes plant selection and designing a site planting plan. Native bare root trees and shrubs are provided by the Saratoga State Tree Nursery. The goal of the program is to plant young trees and shrubs along stream corridors to prevent erosion, increase flood water retention, improve wildlife and stream habitat, and protect water quality. The program emphasizes comprehensive watershed restoration designed to protect "green infrastructure" and serves as the first line of defense against storm and flooding events, protecting property, water quality, and fish and wildlife habitat. The program also promotes best management practices and encourages tributary protection.

5.4 Regulatory Permitting Requirements

The following regulatory permits may be required for projects listed in Table 5-4.

USACE Individual Permit – Section 404 of the Clean Water Act establishes a program to regulate the discharge of dredged or fill material into waters of the United States, which includes wetlands. Proposed activities are regulated through review of individual permits, which are required for potentially significant impacts. Discharged or fill material includes earth moving or placement of fill to build any structure; causeway/road fills; levees, shore protection devices like riprap, breakwaters, and seawalls; most mechanical land clearing; and temporary stockpiling of soil from construction of a drainage ditch. Waters of the US include interstate waters such as wetlands; waters currently, formerly, or susceptible to use in interstate commerce; intrastate waters including lakes, streams, wetlands, sloughs, prairie potholes, etc. the use, degradation, or destruction of which could affect interstate commerce; all impoundments of waters otherwise defined as Waters of the United States; tributaries of waters of the U.S.; and wetlands "adjacent" to waters of the U.S.

TABLE 5-4 Potential Permitting Requirements									
Alternative	**Recommend for Implementation**	**USACE Individual Permit**	**USACE Nationwide Permit**	**401 Water Quality Certification**	**NYSDEC Article 15 Protection of Waters Permit**	**NYSDEC Wetlands Permit**	**Local Building Permit**	**Local FEMA Permits**	**Comments**
Focus Area #1 – North Blenheim									
Alternative 1-2c: Floodplain Enhancement	Y	X		X	X			X	
Focus Area #2 – Bear Ladder Road									
Alternative 2-3: Roadway Signage and Closure	Y								
Focus Area #3 – West Fulton Hamlet									
Alternative 3-1: Replace Patria Road Bridge over House Creek	In future		X	X	X			X	
Alternative 3-2: Replace West Fulton Road Bridge over Panther Creek	In future		X	X	X			X	
Alternative 3-3: Create Compound Channel with Floodplain along Panther Creek	Y	X		X	X			X	
Focus Area #4 – Village of Middleburgh									
Alternative 4-6: Individual Building Relocation, Elevation, Floodproofing	Y						X	X	Additional permits may be required depending on construction details.
Focus Area #5 – Christmas Tree Land Culvert									
Alternative 5-3 – NYS Route 30 Roadway Signage and Closure	Y								
Focus Area #6 – Route 145 Culvert									
Alternative 6-1: Replace Culvert	M		X	X				X	

Table 5-4 (continued)									
Alternative	**Recommend for Implementation**	**USACE Individual Permit**	**USACE Nationwide Permit**	**401 Water Quality Certification**	**NYSDEC Article 15 Protection of Waters Permit**	**NYSDEC Wetlands Permit**	**Local Building Permit**	**Local FEMA Permits**	**Comments**
Alternative 6-2: Program of Debris Management	Y							X	No permits are needed until the plan is implemented. Permits are required if work occurs below the HWM or involves heavy equipment in the channel.
Focus Area #7 – Village of Schoharie									
Alternative 7-4: Individual Building Relocation, Elevation, Floodproofing	Y						X	X	Additional permits may be required depending on construction details.
Focus Area #8 – Fox Creek									
Alternate 8-2: Modification/Removal of Abutments at Schell Road Bridge	M		X	X				X	
Alternate 8-3: Modification/Replacement of Schoonmaker Road Bridge	In future		X	X				X	
Alternate 8-4: Modification/Replacement of Zimmer Road Bridge	Y		X	X				X	
Alternative 8-5: Modification/Replacement of Sholtes Road Bridge	Y		X	X				X	
Alternative 8-7: Development of Sediment Management Plan for Fox Creek	Y							X	No permits are needed until the plan is implemented. Permits are required if work occurs below the HWM or involves heavy equipment in the channel.
Alternative 8-8: Bank Erosion Repairs	Y		X	X				X	

TABLE 5-4 (continued)									
Alternative	**Recommend for Implementation**	**USACE Individual Permit**	**USACE Nationwide Permit**	**401 Water Quality Certification**	**NYSDEC Article 15 Protection of Waters Permit**	**NYSDEC Wetlands Permit**	**Local Building Permit**	**Local FEMA Permits**	**Comments**
Focus Area #9 – Gallupville									
Alternative 9-3: Individual Building Relocation, Elevation, Floodproofing	Y						X	X	Additional permits may be required depending on construction details.
Focus Area #10 – Railroad Bridge over Schoharie Creek									
Alternative 10-2: Compliance with and Enforcement of NFIP Criteria	Y							X	
Focus Area #11 – Cobleskill Creek Confluence									
Alternative 11-3: Individual Building Relocation, Elevation, Floodproofing	Y						X	X	Additional permits may be required depending on construction details.
Alternative 11-4: Roadway Signage and Closure	Y								
Focus Area #12 – Fly Creek									
Alternative 12-2: SCSWCD Natural Channel Design Scenario #2	Y	X		X	X			X	
Alternative 12-3: Develop a Sediment Management Plan	Y							X	No permits needed until the plan is implemented. Permits are required if work occurs below the HWM or involves heavy equipment in the channel.
Focus Area #13 – Colyer Road, Burtonsville									
Alternative 13-2: Individual Building Relocation, Elevation, Floodproofing	Y						X	X	Additional permits may be required depending on construction details.

TABLE 5-4 (continued)									
Alternative	**Recommend for Implementation**	**USACE Individual Permit**	**USACE Nationwide Permit**	**401 Water Quality Certification**	**NYSDEC Article 15 Protection of Waters Permit**	**NYSDEC Wetlands Permit**	**Local Building Permit**	**Local FEMA Permits**	**Comments**
Focus Area #14 – Warnerville Cutoff									
Alternative 14-1: Roadway Signage and Closure	Y								
Focus Area #16 – Review of Berms along Farm Fields									
Alternative 16-1: Removal of Agricultural Berms	M		X	X	X			X	Required permits will depend on final project design.
Focus Area #18 – Recommendations for Protection of Watersheds, Wetlands, Floodplains									As these plans are developed and implemented, some actions may require permits on a case-by-case basis.
Use green infrastructure and best management practices.	Y							X	
Establish and maintain vegetated buffers.	Y							X	
Protect forests and open space.	Y								
Protect and reconnect floodplains.	Y							X	
Develop guidelines to limit impervious surfaces.	Y							X	
Implement watershedwide wetland, stream, and buffer protection plan.	Y							X	

USACE Nationwide Permit – Under Section 404 of the Clean Water Act, the USACE is authorized to issue general or "Nationwide" permits for categories of activities that are minor in scope with minimal adverse environmental impacts. Definitions of waters of the United States are the same as those described for individual permits. General permits are valid only if the conditions applicable to the permits are met (otherwise, an individual permit is required). Currently, there are 52 categories of nationwide permits authorizing a wide variety of project activities including utility lines, maintenance of previously authorized structures, bank stabilization, linear transportation projects, minor dredging or discharges, aquatic habitat restoration, residential developments, reshaping existing drainage ditches, and stormwater management facilities. These activities require compliance with specific conditions and scope-of-project limitations. Some of them require preconstruction notification.

401 Water Quality Certification (WQC) – Under Section 401 of the Clean Water Act, the NYSDEC is authorized to issue or deny WQC for USACE Nationwide permits. The Nationwide permits are divided into three categories for review:

- Twenty-four of the Nationwide permits are covered by WQC as long as the project meets the general regional conditions listed in the WQC (if not, an individual section 401 WQC from the NYSDEC is required). General conditions include this stipulation: "*This authorization does not allow the stacking of nationwide permits, so that in combination they exceed 1/4 of an acre of fill or 300 linear feet of stream disturbance. When used in combination, the most restrictive conditions apply*."

- Nine of the Nationwide permits are covered by WQC as long as they meet the general conditions as well as the listed special conditions.

- Eight Nationwide permits are not eligible for a blanket WQC and require an individual WQC from the NYSDEC.

NYSDEC Article 15 Protection of Waters Permit – For projects that require both federal and state permits, a joint application form is available from NYSDEC to streamline the paperwork for obtaining the necessary permits. The Protection of Waters Permit Program regulates the (permanent or temporary) disturbance of the bed or banks of a protected stream, which includes water bodies in the course of a stream of 10 acres or less, with a classification of AA, A, or B, or with a classification of C with a standard of (T) or (TS). Some examples of activities requiring this permit are placement of structures in or across a stream (i.e., bridges, culverts or pipelines); fill placement for bank stabilization or to isolate a work area (i.e., riprap or coffer dams); excavations for gravel removal or as part of a construction activity; lowering stream banks to establish a stream crossing; utilization of equipment in a stream to remove debris or to assist in-stream construction; excavation or placing of fill in navigable waters of the state, below the mean high water level, including adjacent and contiguous marshes and wetlands; construction, reconstruction, or repair of dams and other impounding structures; and construction, reconstruction, or expansion of docking and mooring facilities.

NYSDEC Wetlands Permit – The intent of the NYS Freshwater Wetlands Act administered by the NYSDEC is to preserve, protect, and conserve freshwater wetlands and their adjacent areas. Adjacent areas extend 100 feet from the wetland boundary. Protected wetlands must be 12.4 acres or larger; in rare cases, the DEC may determine that smaller wetlands may be protected if they have unusual local importance. The act requires DEC to map all state-regulated wetlands. Activities that could have negative impacts on wetlands are regulated. A permit is required to conduct any regulated activity in a protected wetland or its adjacent area. Activities that require a wetland permit from the DEC include construction of buildings, roadways, septic systems, bulkheads, dikes, or dams; placement of fill, excavation, or grading; modification, expansion, or extensive restoration of existing structures; drainage, except for agriculture; and application of pesticides in wetlands.

Town Building Permits – Work on structures that have been damaged by flooding or will be floodproofed may require a building permit from the local township or village. The permit is required prior to construction or other improvements; removal, relocation, or occupation of a business; demolition of any building or structure; and before the installation of equipment (such as oil and gas heaters) that is not portable. Other stipulations may apply depending on the municipality.

Local FEMA Permits – All development within SFHAs is subject to floodplain development regulations. The SFHA is the area that would be inundated by the100-year flood. Local communities that participate in the NFIP have a local law or ordinance that regulates development within mapped floodplains and SFHAs. Schoharie County participates in the NFIP, which makes flood insurance available to residents in the community both within and outside the 100-year floodplain. Any project located within either the floodway or floodplain as designated by FEMA and represented on the most recent FEMA maps may require a permit from the municipality in which it is located. Each municipality has a Building Inspector and/or Floodplain Administrator authorized to determine which local permits are required.

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4805-05-5-a1017-rpt

APPENDIX A

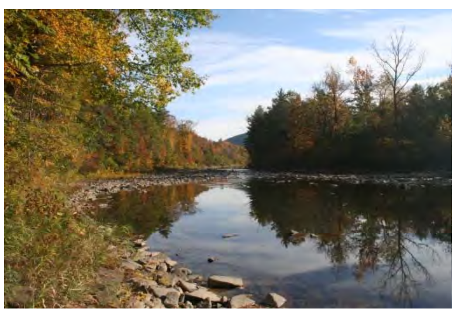
PUBLIC PRESENTATION - OCTOBER 26, 2015

Flood Mitigation Study

Schoharie Creek Watershed

Mark Carabetta, CFM — Milone & MacBroom

Karen Schneller-McDonald — Hickory Creek




Public Meeting #1 | Schoharie Central School Auditorium | October 26, 2015

Project Funding

- New York Department of State, with funds provided under Title 11 of the Environmental Protection Fund - Local Waterfront Revitalization Program
- The Study is part of Phase 1 of the Mohawk River Watershed Management Plan Implementation

NEW YORK STATE OF OPPORTUNITY™ | Department of State

Purpose of Tonight's Meeting

- Introduce the project team
- Explain goals of the study
- Explain public meeting process
- Review the study area
- Schoharie flood history
- Discuss potential flood mitigation strategies
- Collect information about flooding and flood damage

Schoharie Creek

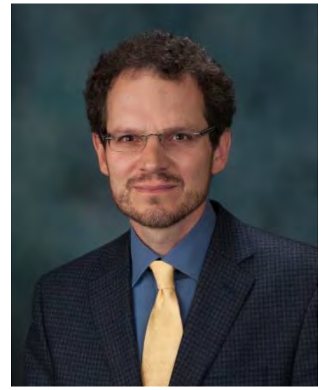
MILONE & MACBROOM

Milone & MacBroom's Project Team

Jim MacBroom, P.E.

Jeanine Gouin, P.E.

David Murphy, PE, CFM



Mark Carabetta, CFM

Andie Greene, P.E.

Jessica Louisos, P.E.

Jenabay Sezen, E.I.T.

Vernon Bevan, E.I.T.

Hickory Creek Consulting LLC
Natural resources for the future

MJ Engineering and Land Surveying, P.C.

MILONE & MACBROOM

Project Steps and Goals

Goals:

- Evaluate the causes of flooding
- Recommend options for flood hazard mitigation

Steps:

- Collect input from property owners, municipal officials and other stakeholders
- Build upon FEMA flood modeling, previous studies, and County hazard mitigation plans
- Through field investigations and hydraulic modeling, assess the potential magnitude of flood relief alternatives
- Refine alternatives for approximately 15 sites, through vetting of cost, feasibility, and public input
- Develop Drainage Master Plan Report

Fox Creek

MILONE & MACBROOM

Public Meeting Process

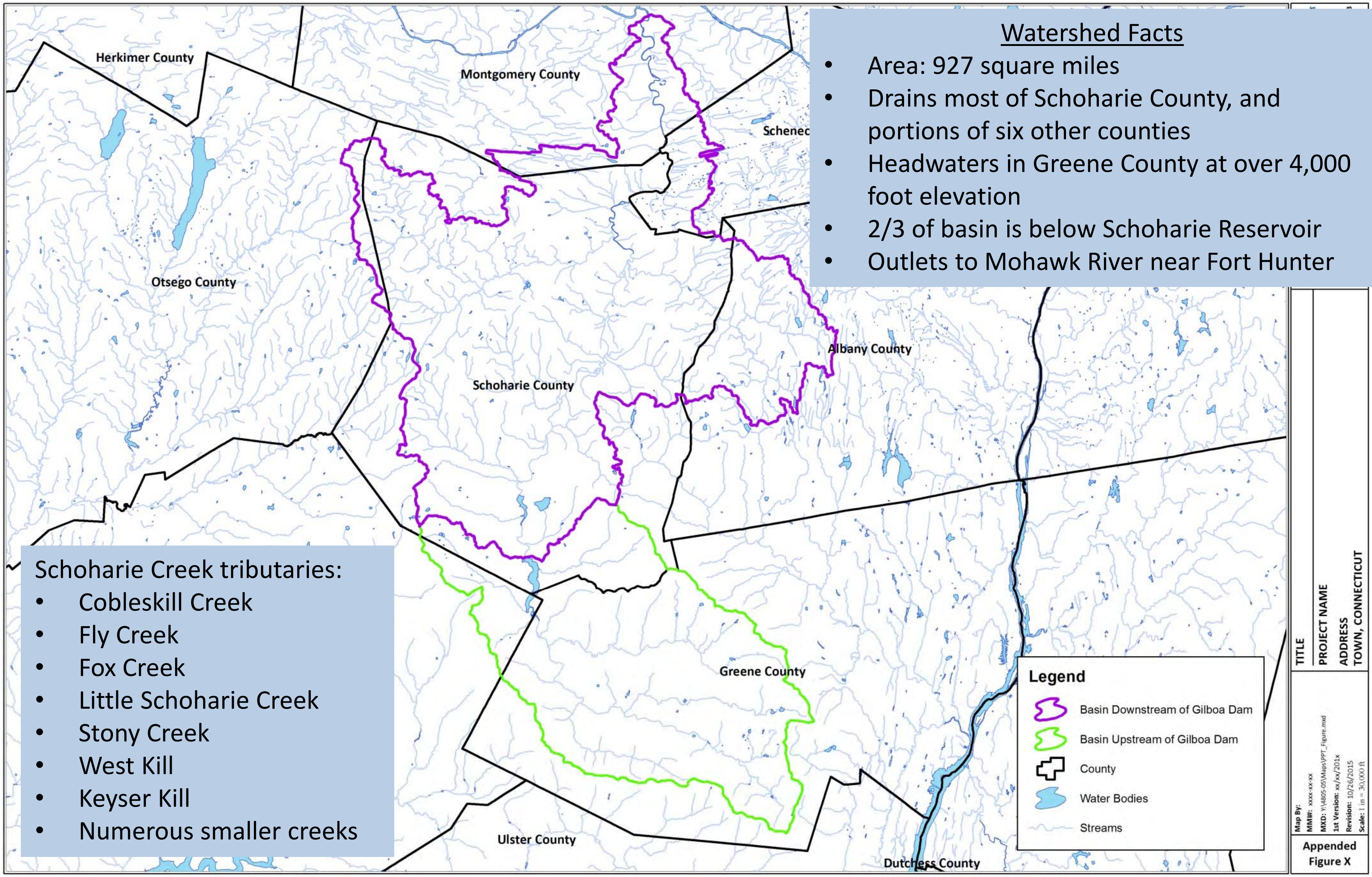
PUBLIC MEETING #1
gather information about flooding and flood damages
(10/26/15)

PUBLIC MEETING #2
present preliminary results and gather feedback
(anticipated spring 2016)

PUBLIC MEETING #3
present final project analysis and results
(anticipated summer 2016)

MILONE & MACBROOM

Schoharie Creek Watershed



Watershed Facts

- Area: 927 square miles
- Drains most of Schoharie County, and portions of six other counties
- Headwaters in Greene County at over 4,000 foot elevation
- 2/3 of basin is below Schoharie Reservoir
- Outlets to Mohawk River near Fort Hunter

Schoharie Creek tributaries:

- Cobleskill Creek
- Fly Creek
- Fox Creek
- Little Schoharie Creek
- Stony Creek
- West Kill
- Keyser Kill
- Numerous smaller creeks

Flood History in the Schoharie Basin

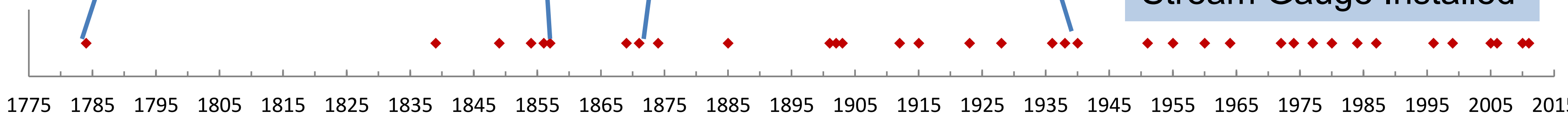
1784: First flood on record. Winter flood. The damage to crops, land and buildings was so extensive that the people petitioned the legislature to be exempt from taxation.

August 2, 1856: In Gilboa a cotton mill and tannery were greatly damaged. In Waldenville (Berne), Plank Road and its bridges were carried away

October 7, 1869: In southern part of Schoharie County, nearly all bridges were carried away. The railroad, roads, a kiln, gristmill, barns and crops all badly damaged.

March 18 & 19, 1936: In Schoharie County, bridges and 70 miles of roads were damaged.

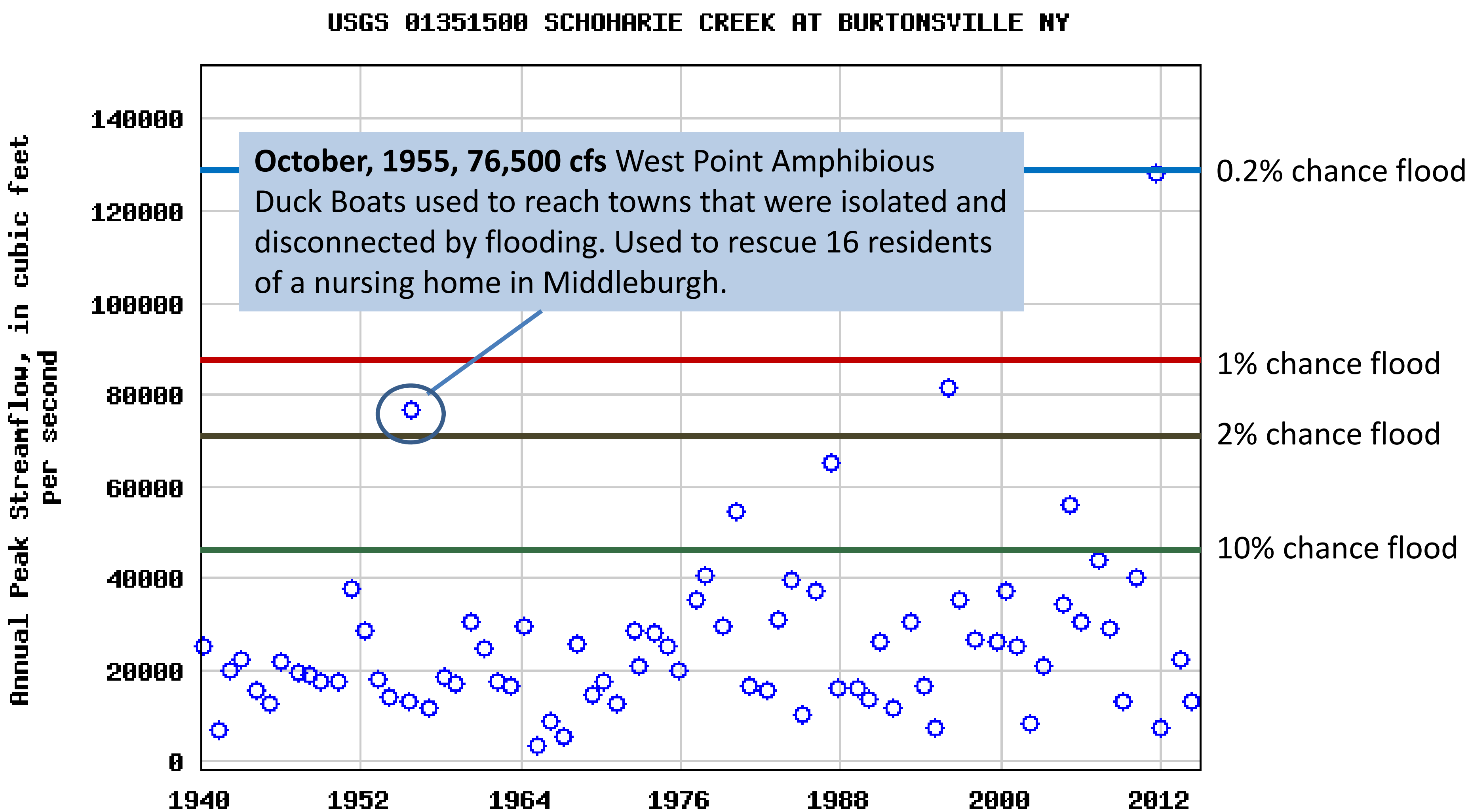
1936 & 1940: USGS Stream Gauge Installed



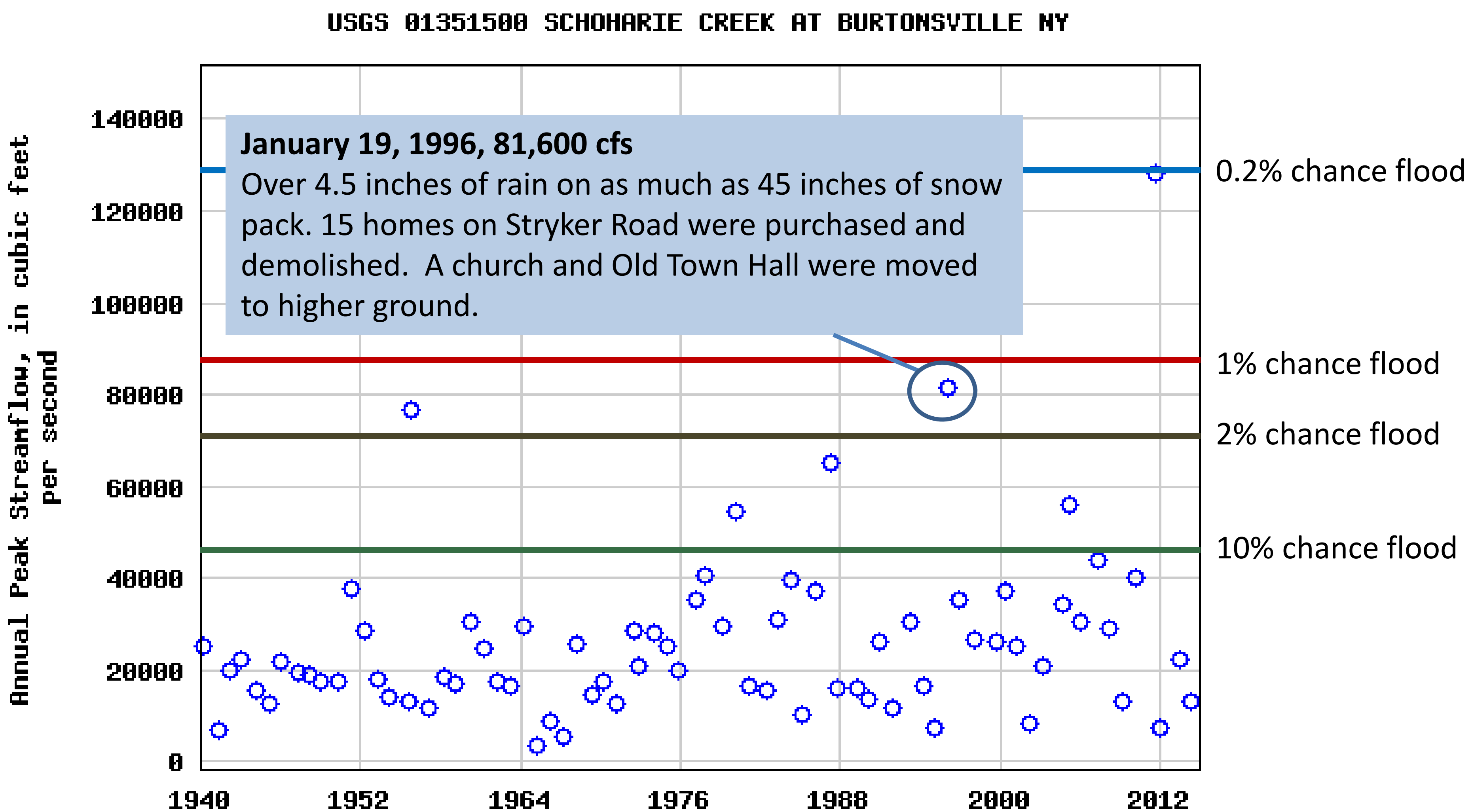
From *History of Schoharie County Floods,* 2012. Schoharie County Historical Society

MILONE & MACBROOM

Flood History in the Schoharie Basin

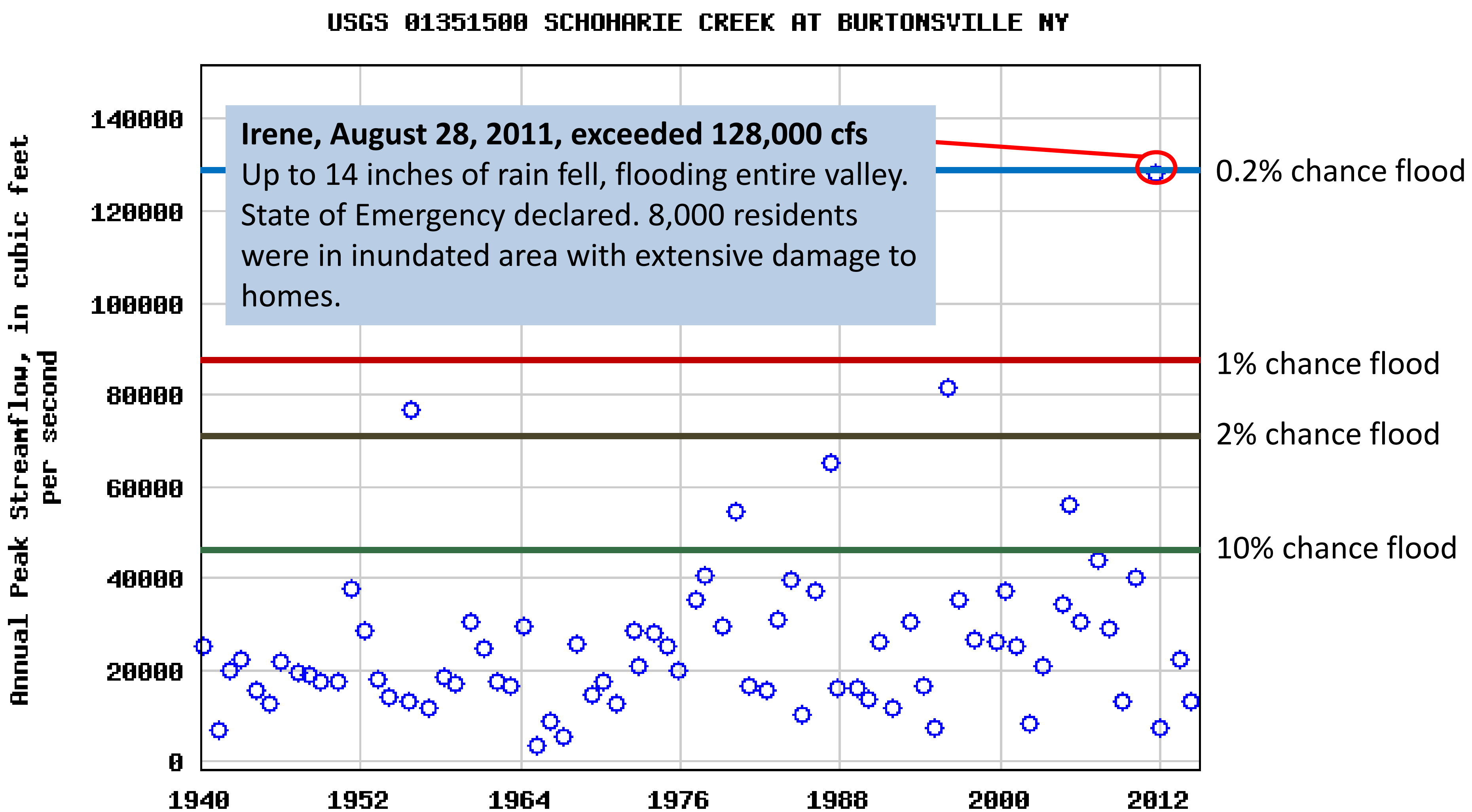


Flood History in the Schoharie Basin

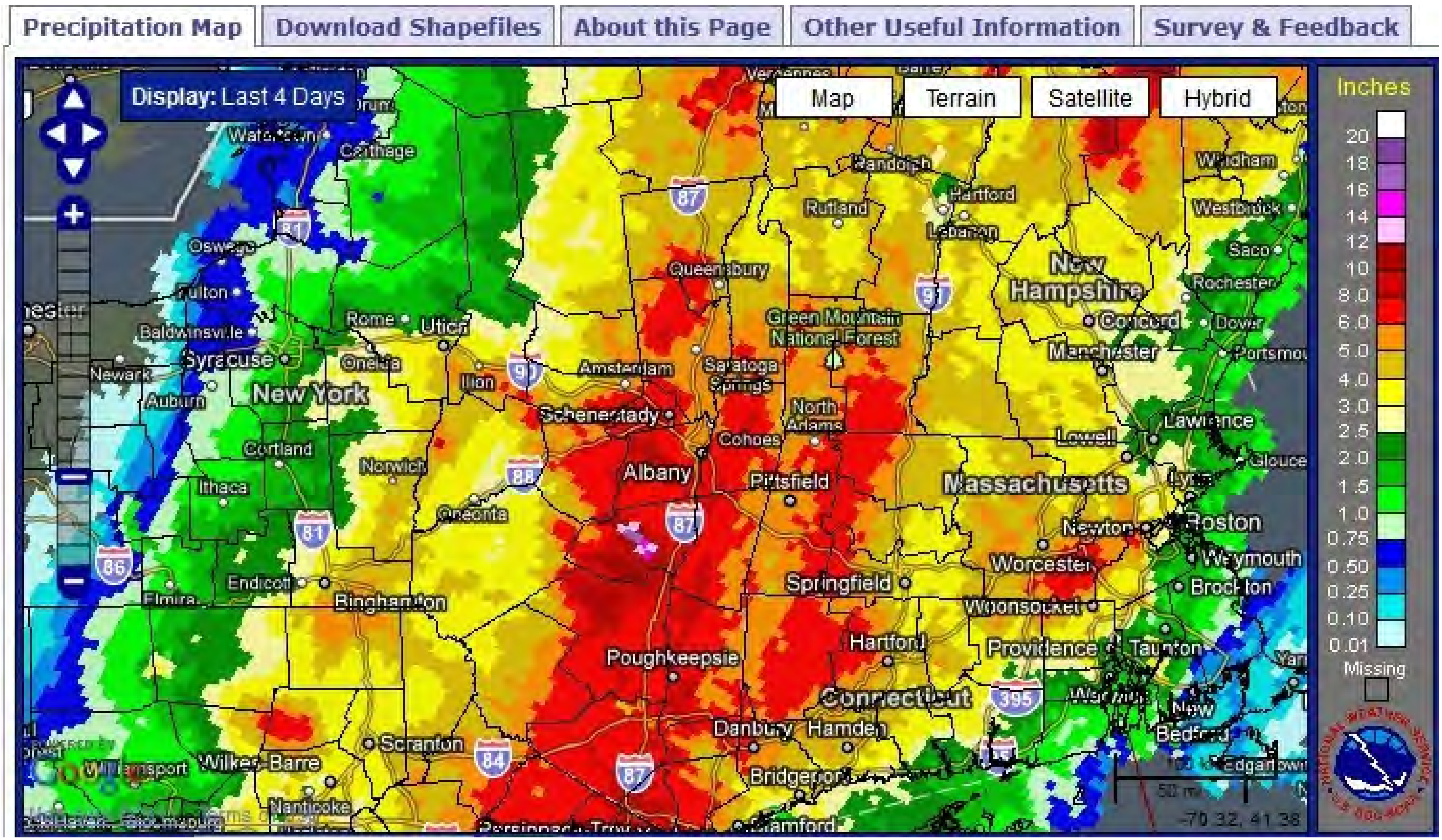


MILONE & MACBROOM

Flood History in the Schoharie Basin



Tropical Storm Irene, August 2011



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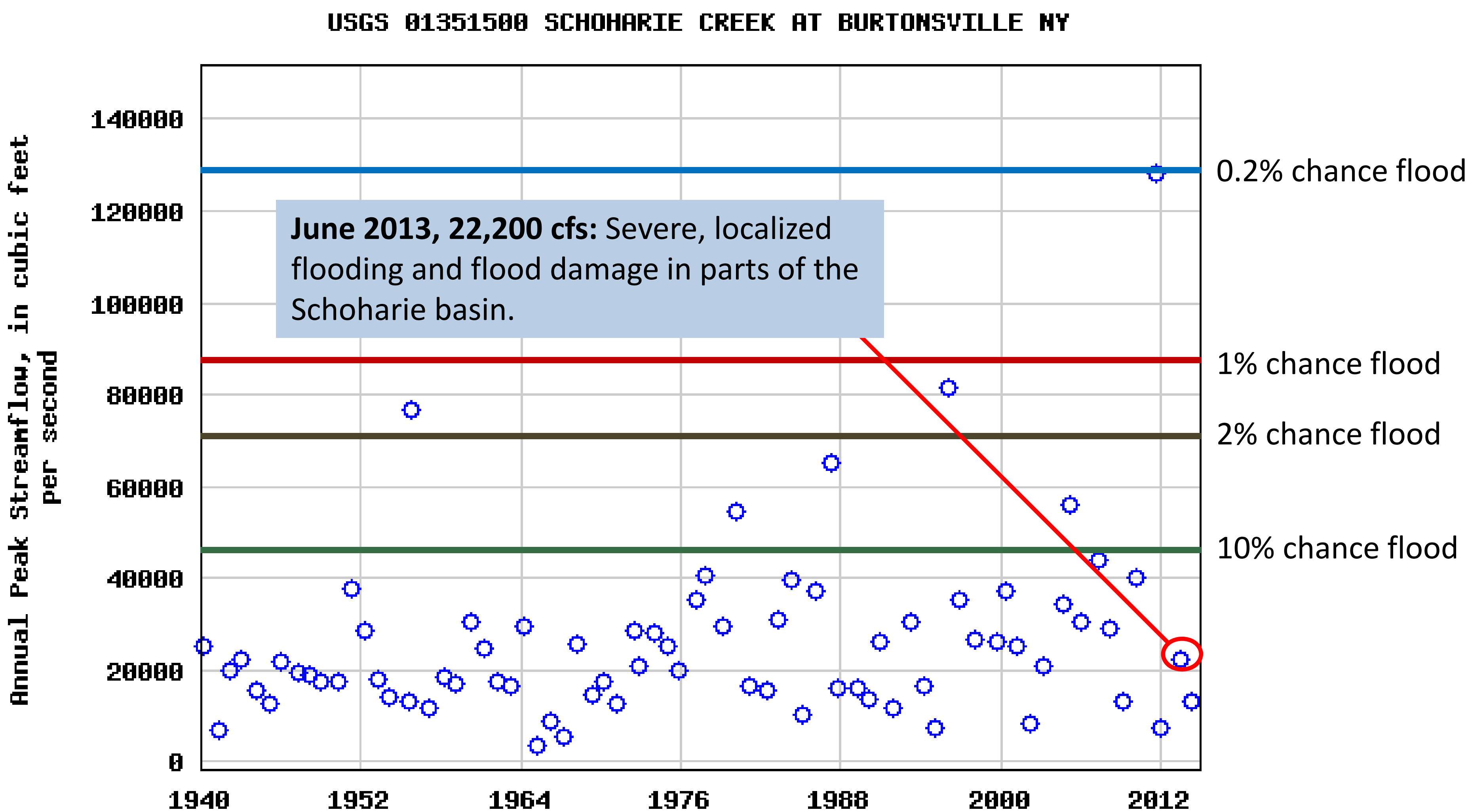
Flood History in the Schoharie Basin



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Potential Flood Mitigation Strategies

Structural Solutions

Bridge and culvert removal or replacement

Dam removal or modification

Sediment management

Channel modification

Floodwater attenuation/storage

Wetland creation

Floodplain restoration, creation or enhancement

Individual Property Solutions

Elevation of individual structures

Floodproofing of individual structures

Relocation of floodprone structures

Programmatic Solutions

Establishment or enhancement of floodplain zoning policy

Development of programs such as the Community Rating System

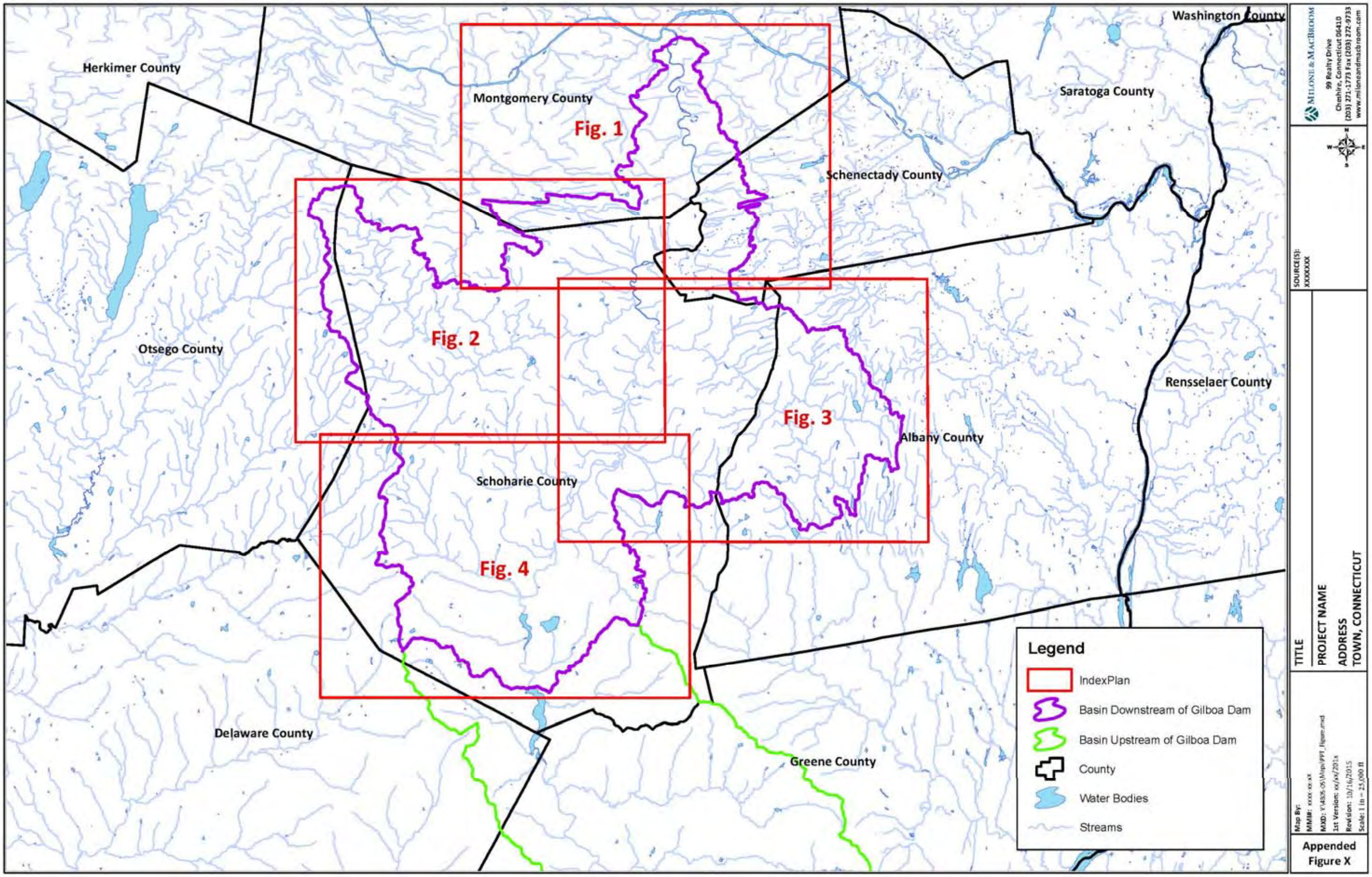
Public education programs

MILONE & MACBROOM

Final Outcomes

- Engineering Analysis – Scientifically Based
- Descriptions and Sketches of Flood Mitigation Options
- Cost Opinions – To Understand Viability
- Identification of Potential Funding Sources
- A Blueprint for Near-Term and Long-Term Flood Mitigation
- A Better Understanding of What is Feasible, What is Cost Effective, and What is Desired by Citizens of Schoharie Creek watershed

Maps



Herkimer County
Montgomery County
Washington County
Saratoga County
Schenectady County
Otsego County
Rensselaer County
Albany County
Schoharie County
Delaware County
Greene County
Fig. 1
Fig. 2
Fig. 3
Fig. 4
Legend
IndexPlan
Basin Downstream of Gilboa Dam
Basin Upstream of Gilboa Dam
County
Water Bodies
Streams
MILONE & MACBROOM
99 Realty Drive
Cheshire, Connecticut 06410
(203) 271-1773 Fax (203) 272-9733
www.miloneandmacbroom.com
SOURCE(S):
XXXXXXX
TITLE
PROJECT NAME
ADDRESS
TOWN, CONNECTICUT
Revision: 10/16/2015
Scale: 1 in = 25,000 ft
Appended Figure X

Ground Rules

- Your input is very important
- Join breakout group for your area of the watershed
- Discuss observations/concerns with station leader, and mark locations on map
- Complete Stakeholder Questionnaire
- Upload photos or video at link below
  - Label with name, date and location taken

https://clients.miloneandmacbroom.com

User Name: Schohariepublic
Password: Floodstudy

MILONE & MACBROOM

Fox Creek

Questions, Comments, or Thoughts?

APPENDIX B

MONTHLY PROJECT UPDATES

DATE: September 30, 2015
MMI #: 4805-05
PROJECT: Schoharie Creek Watershed Flood Study
SUBJECT: Project Status Report

Following is a brief report on the status of the Schoharie Watershed Flood Mitigation Study. The project officially got underway when the contract between Milone & MacBroom (MMI) and Schoharie County Soil & Water Conservation District (SCSWCD) was executed on August 21, 2015.

Subconsultants

Two subconsultants have been retained to assist MMI in the completion of the project. MJ Engineering and Land Surveying is a minority business enterprise (MBE), which has been retained to conduct survey. Hickory Creek Consulting is a women business enterprise (WBE), and will assist with field investigations, public outreach, identification of funding sources and permitting requirements, and drafting of the final engineering report. Agreements between MMI and the two subconsultants are in place or pending. MMI's invoicing will include subconsultant invoices as documentation of M/WBE involvement.

Data Gathering

Following is a summary of project-related information collected to date:

- FEMA HEC-RAS models for watercourses within study area
- Supplementary LiDAR and data associated with HEC-RAS models
- GIS mapping layers
- History of Schoharie County Floods
- FEMA Flood Insurance Rate Maps
- FEMA Flood Insurance Studies
- Schoharie County Multi-Jurisdiction Hazard Mitigation Plan (other counties pending)
- 1996 Russel Wege review of flood problems

Project Meeting

A project meeting was held on September 30, 2015, via conference call. Meeting minutes and a list of participants will be distributed separately.

Plan for Public Meeting

Date, location and format of initial public meeting were discussed on the project meeting call. Goals of meeting are to 1) inform members of the public about the Schoharie flood study, its goals, and intended outcomes; and 2) gather information on flood-prone areas and flooding problems. Meeting date will be the evening of Monday, October 26th. Location will likely be within the town of Schoharie or Middleburgh, although location may change if a system can be used that will allow for participation from remote locations in the project area, such as WebEx. A smaller group led by Pete Nichols will investigate possible venues for meeting, including the use of WebEx-type format. A call will be held on October 7th to finalize plans.

DATE: November 2, 2015
MMI #: 4805-05
PROJECT: Schoharie Creek Watershed Flood Study
SUBJECT: Project Status Report

Following is a monthly update on the status of the Schoharie Watershed Flood Mitigation Study. The contract between Milone & MacBroom (MMI) and Schoharie County Soil & Water Conservation District (SCSWCD) was executed on August 21, 2015.

Data Collection and Field Investigations

MMI has collected and reviewed available data and resource information from a variety of sources including:

- FEMA HEC-RAS models for watercourses within study area
- Supplementary LiDAR and data associated with HEC-RAS models
- County LiDAR for Schoharie and Montgomery Counties
- GIS mapping layers
- History of Schoharie County Floods
- FEMA Flood Insurance Rate Maps and Flood Insurance Studies
- Schoharie County Multi-Jurisdiction Hazard Mitigation Plan (other counties pending)
- 1996 Russel Wege review of flood problems
- Meeting with NYPA at Gilboa-Blenheim Facility on October 23
- Phone conversation with John Vickers of NYCDEP on October 26 regarding Gilboa Dam
- Input from SCSWCD on problem focus areas

Initial field investigations were conducted on October 13 and October 23.

A history of flooding in the Schoharie Creek watershed was compiled.

Public Meeting

Public Meeting #1 was held at 7pm on October 26, 2015, at the Schoharie Central School Auditorium, 136 Academy Drive, Schoharie. Goals of meeting were to 1) inform members of the public about the Schoharie flood study, its goals, and intended outcomes; and 2) gather information on flood-prone areas and flooding problems. Pete Nichols of SCSWCD opened the meeting and introduced the topic. Mark Carabetta of MMI and Karen Schneller-McDonald of Hickory Creek Consulting provided an overview of the study, and collected information from members of the public on flooding problems.

Next Steps

- Compile input from public meeting
- Identify focus areas for further investigation
- Conduct additional field investigations
- Prepare a technical memorandum summarizing above information

- Coordinate with MJ Engineering and Land Surveying to conduct survey
- Initiate hydraulic modeling and assessment

DATE: December 1, 2015
MMI #: 4805-05
PROJECT: Schoharie Creek Watershed Flood Study
SUBJECT: Project Status Report

Following is a monthly update on the status of the Schoharie Creek Watershed Flood Mitigation Study. MMI's work over the last month has focused on the selection of focus areas, and the coordination with MJ Engineering and Land Surveying (MMI's MBE subconsultant) to conduct survey.

Selection of Focus Areas

A total of 16 preliminary 'focus areas' within the Schoharie Creek watershed were identified. These focus areas were selected based on input collected at the October 26 public meeting at the Schoharie Central School Auditorium, from Conservation District staff, and based on MMI's review of technical documents, maps, and flood history reports. As field investigations continue, these focus areas will be refined, and some may be dropped or added.

The 16 preliminary focus areas are as follows:

Focus Area #1 – Bear Ladder Road: This area is located where Bear Ladder Road parallels Schoharie Creek, just north of the hamlet of Blenheim. The road reportedly floods frequently at a location about 2 miles downstream of the Route 30 Bridge, where there is a low spot in the road. When the road floods, access is cut off to several residences.

Focus Area #2 – Burtonsville: An approximately 0.75 mile reach of Schoharie Creek, located within the hamlet of Burtonsville, Town of Charleston, in Montgomery County along the county line. The reach extends to the north and south of the Route 160 Bridge. Participants at the public meeting reported flooding of roads and homes in this area.

Focus Area #3 – Central Bridge Area: This area through Central Bridge includes the downstream-most reach of Cobleskill Creek as it passes under the Church Street and Route 30A bridges, its confluence with Schoharie Creek, and extending along Schoharie Creek to downstream of the Canadian Pacific railroad bridge. Flooding and channel instability has been reported here.

Focus Area #4 – Cripplebush Creek confluence: Includes the lower portion of Cripplebush Creek, including the Route 30A bridge, the confluence with Schoharie Creek, and a section of Schoharie Creek including the Junction Road bridge. Flooding and channel instability is reported to occur in this area.

Focus Area #5 - Christmas Tree Lane Culvert: Located in the Town of Middleburgh just south of Christmas Tree Lane, this culvert traverses Route 30 and conveys an unnamed tributary to Schoharie Creek. This culvert is reported to overtop and flood Route 30.

Focus Area #6 – Fly Creek: Beginning at the Fly Creek and Schoharie Creek confluence adjacent to the Junction Bridge and extending upstream along the Fly Creek for approximately 1.5 miles to upstream of the Route 20 Bridge in the hamlet of Sloansville, Town of Esperance.

Focus Area #7: Fox Creek: Beginning in the hamlet of West Berne, Town of Berne in Albany County, and extending downstream to and including the hamlet of Gallupville in the Town of Wright, Schoharie County. This section of Fox Creek runs along or crosses Route 443 for its entire length and passes under several bridges. There have been numerous reports of flooding, sediment aggradation and debris jams in this area.

Focus Area #8 – Heathen Creek and House Creek Confluence: Located 1.5 miles north of the hamlet of West Fulton, in the Town of Fulton, the confluence of Heathen Creek and House Creek is to the south of the intersection of Nicolai Road and West Fulton Road (Route 4). The bridge at Nicolai Road is reportedly prone to debris jams and flooding.

Focus Area #9 – Village of Middleburgh: Schoharie Creek as it flows adjacent to the Village of Middleburgh, this reach extends from upstream of the Main Street (Route 145) bridge, along River Street, and downstream to include floodprone areas below the Village.

Focus Area #10 – North Blenheim: An approximately 1.5 mile reach of Schoharie Creek as it flows through the hamlet of North Blenheim, including the Route 30 bridge and the remains of the historic covered bridge. The hamlet was severely damaged by flooding during tropical storm Irene, and is subject to sedimentation, much of it reportedly originating from West Kill Creek. This reach passes and includes the confluence with the West Kill.

Focus Area #11 –Route 145 Culvert: This culvert is located at the crossing of Route 145 over an unnamed tributary to Schoharie Creek, in the Town of Schoharie. The culvert is reportedly undersized, floods frequently, and is prone to debris jams.

Focus Area #12 – Village of Schoharie: A floodprone reach of Schoharie Creek as it flows past the Village of Schoharie. The reach begins upstream of Bridge Street and extends approximately 1.5 miles downstream. Flooding problems have been reported to the west of Main Street, and Main Street reportedly flooded during Irene.

Focus Area #13 – West Fulton Hamlet: Patria Road, in the hamlet of West Fulton, crosses over House Creek just upstream of its confluence with Panther Creek. The bridge at this location reportedly becomes jammed with debris. Panther Creek contains debris jams which flood the hamlet of West Fulton.

Focus Area #14 – Village of Cobleskill: Floodprone areas of Cobleskill Creek as it flows through the Village of Cobleskill.

Focus Area #15 – General Review of berms along farm fields along Schoharie Creek.

Focus Area #16 – Review of potential for flood attenuation: This will include a review of potential flood storage at Gilboa Dam and the NYPA Gilboa-Blenheim pump-storage facility. It will also include an examination of potential for flood storage in ponds and wetlands located at various points throughout the watershed.

Coordination with MJ Engineering and Land Surveying to conduct survey

Survey is underway, and coordination with MJ Engineering to complete the survey is ongoing. There are not enough resources available to conduct survey at all of the Focus Areas, nor is new survey necessary at all sites. Emphasis is being placed on collecting new survey where it is needed most. MMI has prioritized the sites, and MJ will collect new survey at as many as they can with the available resources.

Next Steps

- Conduct additional field investigations
- Finalize list of focus areas
- MJ Engineering and Land Surveying to complete survey work
- Initiate hydraulic modeling and assessment

DATE: January 12, 2016
MMI #: 4805-05
PROJECT: Schoharie Creek Watershed Flood Study
SUBJECT: Project Status Report

Following is a monthly update on the status of the Schoharie Creek Watershed Flood Mitigation Study. Over the past month, the following work was accomplished:

Staff from MMI and Hickory Creek conducted site visits and investigations at several of the focus areas. The primary purpose of the visits was to develop preliminary flood mitigation alternatives at each of the focus areas, which will be further evaluated and refined through the use of hydraulic modeling and other engineering methods. The site investigations entailed inspection of the riparian corridor, streambed and banks, and included documentation of riparian cover, flood prone areas, and channel structure. Photographic documentation was collected, and will be used for model calibration, as well as in presentations and reports. Visually inspections and field measurements of several bridges were also conducted.

MMI continued to collect and review available data and resource information relating to hydrology, hydraulics and flood history in the Schoharie Creek watershed.

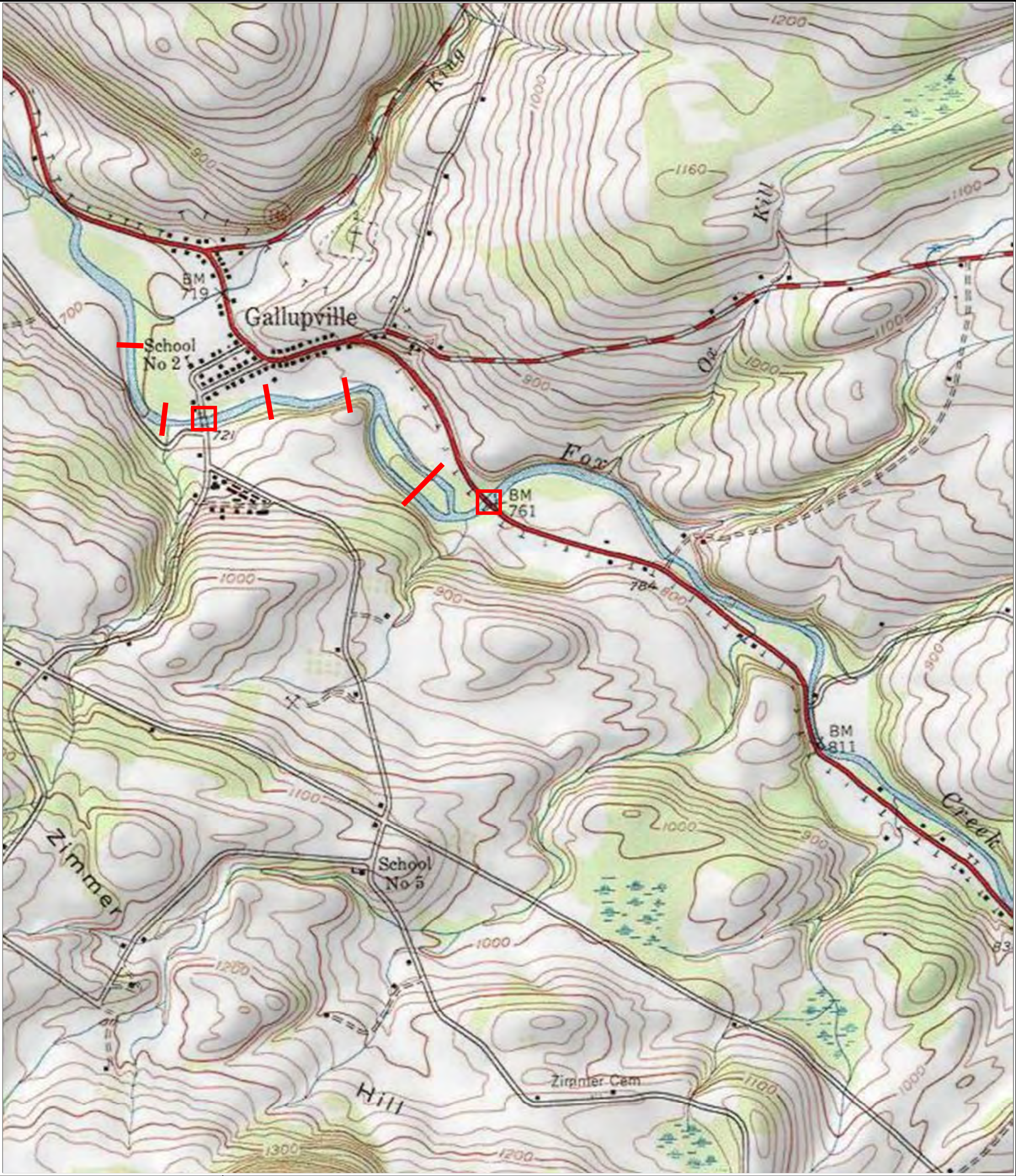
MJ Engineering and Land Surveying conducted channel survey and measurements of bridges within the focus areas. Field survey has been completed and processed for the sites listed below, and will be ready for delivery to MMI shortly. Maps showing the locations of survey cross sections and bridges are appended to this status report.

- Fox Creek
- Schoharie Creek in Middleburgh
- Schoharie Creek in North Blenheim
- Schoharie Creek in Schoharie

Survey in additional focus areas is underway, and coordination with MJ Engineering to complete the survey is ongoing. MMI has prioritized the focus areas, and MJ will collect survey at as many as possible with the available resources.

<u>Next Steps</u>

- MJ Engineering and Land Surveying to complete survey work
- MMI to continue to develop flood mitigation alternatives
- Initiate hydraulic modeling and assessment in focus areas



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USGS The National Map: National Boundaries Dataset, National Elevation Dataset, Geographic Names Information System, National Hydrography Dataset, National Land Cover Database, National Structures Dataset, and National Transportation Dataset; U.S. Census Bureau - TIGER/Line; HERE Road Data

Fox Creek Area 1 - Survey Request
USGS Quad Map "Gallupville"

LOCATION:
New York

N

Schoharie Flood Mitigation Studies

MXD: Y:\4805-05\Maps\SurveyFoxCreek.mxd

Map By: JCS
MMI#: 4805-05
Original: 11/16/2015
Revision: 11/16/2015
Scale: 1 inch = 1,500 feet

MILONE & MACBROOM
99 Realty Drive Cheshire, CT 06410
(203) 271-1773 Fax: (203) 272-9733
www.miloneandmacbroom.com

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USGS The National Map: National Boundaries Dataset, National Elevation Dataset, Geographic Names Information System, National Hydrography Dataset, National Land Cover Database, National Structures Dataset, and National Transportation Dataset; U.S. Census Bureau - TIGER/Line; HERE Road Data

Fox Creek Area 2 - Survey Request
USGS Quad Map "Gallupville"

LOCATION:

New York

N

Schoharie Flood Mitigation Studies

MXD: Y:\4805-05\Maps\SurveyFoxCreek.mxd

Map By: JCS
MMI#: 4805-05
Original: 11/16/2015
Revision: 11/16/2015
Scale: 1 inch = 1,500 feet

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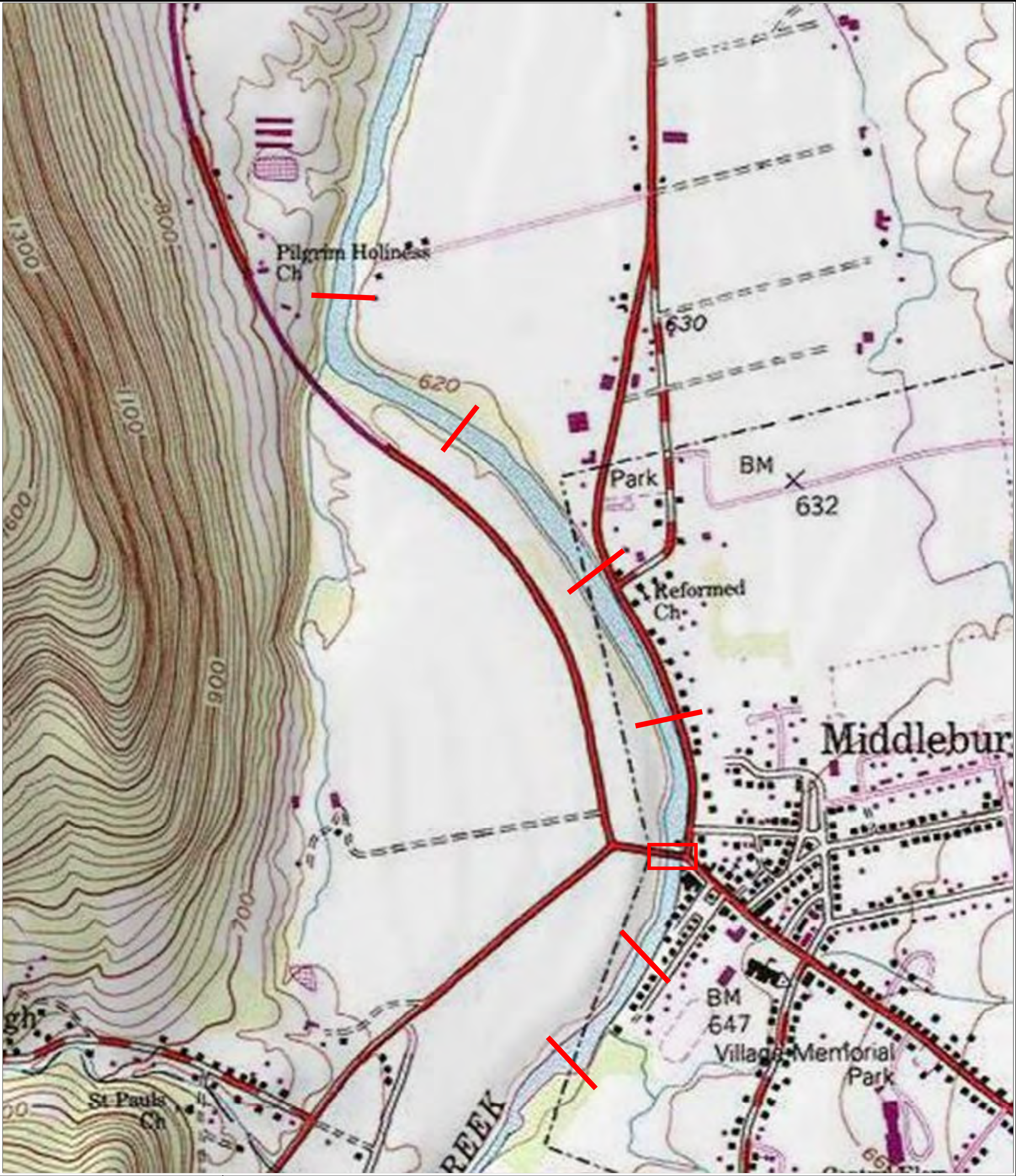

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USGS The National Map: National Boundaries Dataset, National Elevation Dataset, Geographic Names Information System, National Hydrography Dataset, National Land Cover Database, National Structures Dataset, and National Transportation Dataset; U.S. Census Bureau - TIGER/Line; HERE Road Data

Middleburgh Area - Survey Request
USGS Quad Map "Middleburgh"

LOCATION:
New York

N

Schoharie Flood Mitigation Studies

MXD: Y:\4805-05\Maps\SurveyMiddleburgh.mxd

Map By: JCS
MMI#: 4805-05
Original: 11/16/2015
Revision: 11/16/2015
Scale: 1 inch = 1,000 feet

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North Blenheim Area - Survey Request
USGS Quad Map "Gilboa"

LOCATION:
New York

N

Schoharie Flood Mitigation Studies

MXD: Y:\4805-05\Maps\SurveyNorthBlenheim.mxd

Map By: JCS
MMI#: 4805-05
Original: 11/16/2015
Revision: 11/16/2015
Scale: 1 inch = 1,000 feet

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Schoharie Area - Survey Request
USGS Quad Map "Schoharie"

LOCATION:
New York

N

Schoharie Flood Mitigation Studies

MXD: Y:\4805-05\Maps\SurveySchoharie.mxd

Map By: JCS
MMI#: 4805-05
Original: 11/16/2015
Revision: 11/16/2015
Scale: 1 inch = 1,500 feet

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DATE: February 2, 2016
MMI #: 4805-05
PROJECT: Schoharie Creek Watershed Flood Study
SUBJECT: Project Status Report

Following is a monthly update on the status of the Schoharie Creek Watershed Flood Mitigation Study. During the month of January the following work has been accomplished:

MJ Engineering and Land Surveying continued channel survey and measurements of bridges within the focus areas. Survey data from Fox Creek has been delivered to MMI (see appended maps from MJ showing bridge and cross section locations).

The Fox Creek focus area includes an approximately 4.8-mile long reach of Fox Creek beginning downstream of the County Route 9 bridge in the hamlet of West Berne in Albany County, and extending downstream to below the School Street bridge in the hamlet of Gallupville, Schoharie County. This section of Fox Creek runs along or crosses Route 443 for its entire length and passes under a total of seven bridges. There have been numerous reports of flooding, sediment aggradation and debris jams in this area, especially at the bridges. Survey files from additional focus areas are anticipated from MJ this week.

MMI continued to collect and review available data and resource information relating to hydrology, hydraulics and flood history in the Schoharie Creek watershed. Bridge and channel measurements were made in the Village of Cobleskill, and design drawings were obtained for the replacement County Route 23A bridge at Warnerville Cutoff.

MMI has now obtained all available FEMA HEC-RAS hydraulic models, and hydraulic modeling work has begun. Hydraulic analysis is currently underway along the section of Fox Creek described above; at the Patria Road bridge over House Creek and the West Fulton Road (County Route 4) bridge over Panther Creek in the hamlet of West Fulton; and at an unnamed culvert crossing under NY Route 30 in Middleburgh, just south of Christmas Tree Lane.

Next Steps

- MJ Engineering and Land Surveying to complete survey work and deliver all files to MMI
- MMI to continue to develop flood mitigation alternatives
- MMI to progress with hydraulic modeling

Hydraulic Cross Sections
Schoharie County
Fox Creek Area 1 and Area 2
"Gallupville Quad"
Town of Wright, Schoharie County

M.J. Engineering and Land Surveying, P.C. was requested by *Milone & MacBroom* to perform hydraulic cross sections along a portion of the Fox Creek from the Schoharie County/ Albany County Line to the Village of Gallupville in the Town of Wright, Schoharie County. Hydraulic cross sections are located on sketches provided designated as Fox Creek –Area 1 & Area 2. The "wet section" and overbank survey along the stream channels are to augment FEMA cross sections in developing new modeling for flood-prone streams in current FEMA modeling.

M.J. Engineering and Land Surveying, P.C. performed the hydraulic cross sections utilizing a Trimble GPS base station and Rover receiver. The horizontal values are reported in English units on the New York State Plane Coordinate System, Eastern Zone, referenced to the North American Datum of 1983/2011.

The vertical datum for this project is based upon North American Vertical Datum of 1988 (NAVD88). All elevations are in English units.

NOTES:

HORIZONTAL DATUM NEW YORK STATE PLANE EAST ZONE NAD 83/(2011) IN U.S. SURVEY FEET DERIVED FROM STATIC GPS AND BASE STATION GPS RTK OBSERVATIONS.

VERTICAL DATUM IS REFERENCED TO THE NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD 88) IN FEET.

SUBMITTAL / REVISIONS

No.	DATE	DESCRIPTION	BY	REVIEWED BY:	DATE

PROJ. MANAGER:
CHIEF DESIGNER:
DESIGNED BY:
DRAWN BY:
CHECKED BY:

Engineering and Land Surveying, P.C.
1533 Crescent Road - Clifton Park, NY 12065

HYDRAULIC CROSS SECTION SKETCH
USGS QUAD MAP "GALLUPVILLE"
FOX CREEK AREA 1
TOWN OF WRIGHT, SCHOHARIE COUNTY

SCALE: N.T.S.
CONTRACT No.: -
MJ PROJ. No.: 1121.03
DATE: JANUARY 15, 2016

NOTES:

HORIZONTAL DATUM NEW YORK STATE PLANE EAST ZONE NAD 83/(2011) IN U.S. SURVEY FEET DERIVED FROM STATIC GPS AND BASE STATION GPS RTK OBSERVATIONS.

VERTICAL DATUM IS REFERENCED TO THE NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD 88) IN FEET.

MATCHLINE SHEET 2

SUBMITTAL / REVISIONS

No.	DATE	DESCRIPTION	BY	REVIEWED BY:	DATE

PROJ. MANAGER:
CHIEF DESIGNER:
DESIGNED BY:
DRAWN BY:
CHECKED BY:

Engineering and Land Surveying, P.C.
1533 Crescent Road - Clifton Park, NY 12065

HYDRAULIC CROSS SECTION SKETCH
USGS QUAD MAP "GALLUPVILLE"
FOX CREEK AREA 2
TOWN OF WRIGHT, SCHOHARIE COUNTY
SHEET 1 OF 4

SCALE: N.T.S.
CONTRACT No.: -
MJ PROJ. No.: 1121.03
DATE: JANUARY 15, 2016

SUBMITTAL / REVISIONS

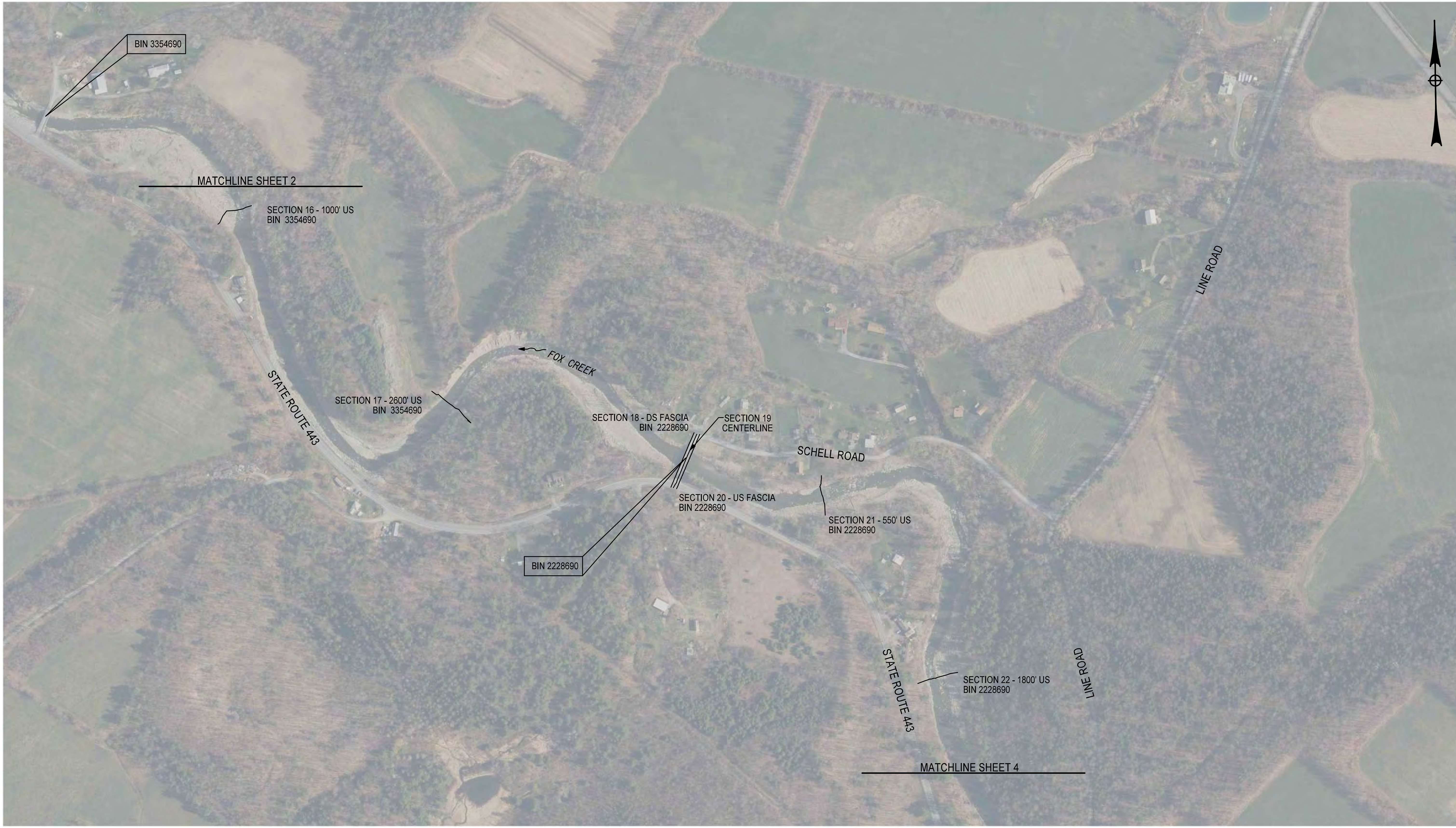
No.	DATE	DESCRIPTION	BY	REVIEWED BY:	DATE

PROJ. MANAGER:
CHIEF DESIGNER:
DESIGNED BY:
DRAWN BY:
CHECKED BY:

Engineering and Land Surveying, P.C.
1533 Crescent Road - Clifton Park, NY 12065

HYDRAULIC CROSS SECTION SKETCH
USGS QUAD MAP "GALLUPVILLE"
FOX CREEK AREA 2
TOWN OF WRIGHT, SCHOHARIE COUNTY
SHEET 2 OF 4

SCALE: N.T.S.
CONTRACT No.:
MJ PROJ. No.: 1121.03
DATE: JANUARY 15, 2016



SUBMITTAL / REVISIONS

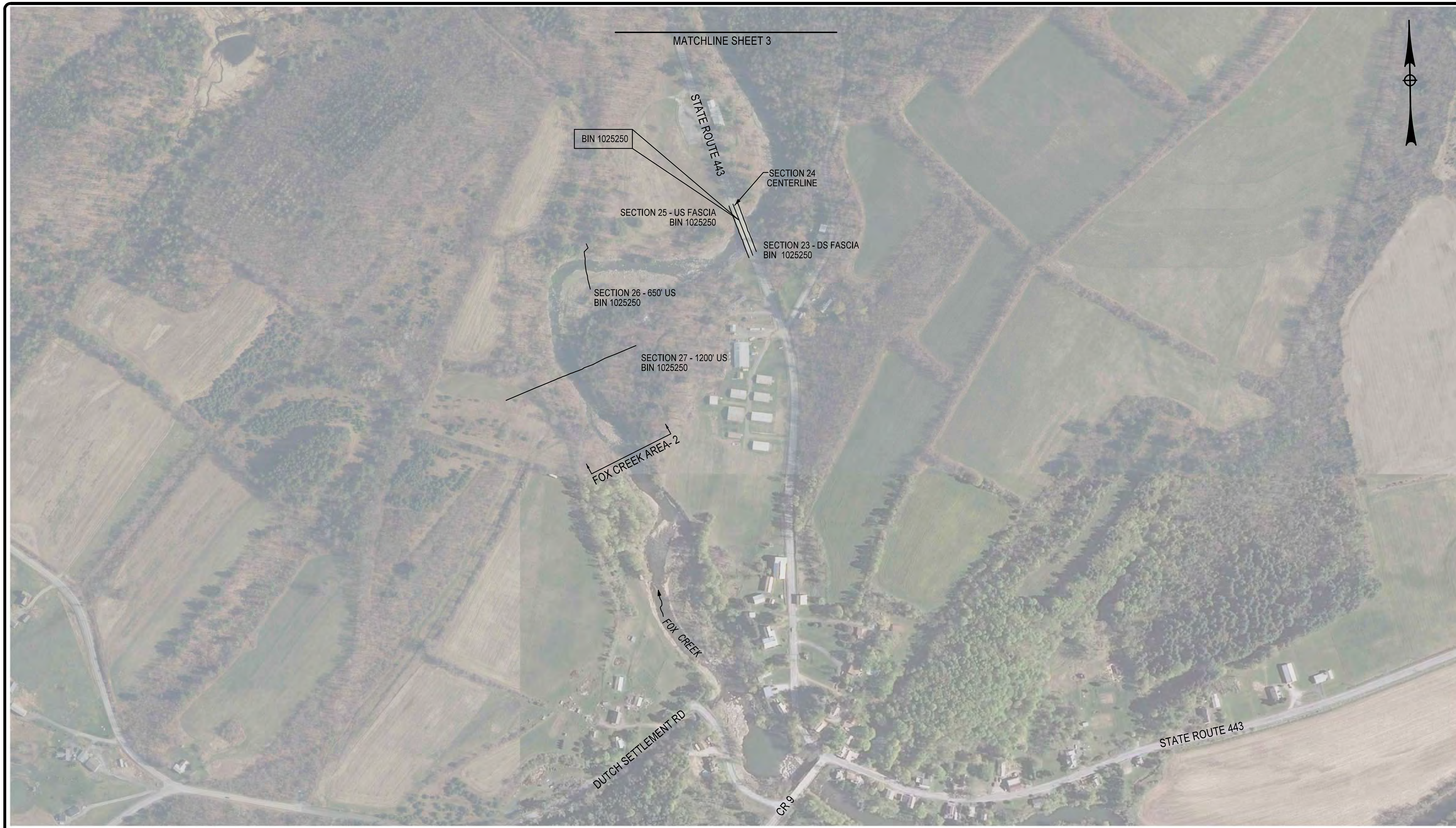
No.	DATE	DESCRIPTION	BY	REVIEWED BY:	DATE

PROJ. MANAGER:
CHIEF DESIGNER:
DESIGNED BY:
DRAWN BY:
CHECKED BY:

MJ Engineering and Land Surveying, P.C.
1533 Crescent Road - Clifton Park, NY 12065

HYDRAULIC CROSS SECTION SKETCH
USGS QUAD MAP "GALLUPVILLE"
FOX CREEK AREA 2
TOWN OF WRIGHT, SCHOHARIE COUNTY
SHEET 3 OF 4

SCALE: N.T.S.
CONTRACT No.: -
MJ PROJ. No.: 1121.03
DATE: JANUARY 15, 2016



SUBMITTAL / REVISIONS

No.	DATE	DESCRIPTION	BY	REVIEWED BY:	DATE

PROJ. MANAGER:
CHIEF DESIGNER:
DESIGNED BY:
DRAWN BY:
CHECKED BY:

MJ Engineering and Land Surveying, P.C.
1533 Crescent Road - Clifton Park, NY 12065

HYDRAULIC CROSS SECTION SKETCH
USGS QUAD MAP "GALLUPVILLE"
FOX CREEK AREA 2
TOWN OF WRIGHT, SCHOHARIE COUNTY
SHEET 4 OF 4

SCALE: N.T.S.
CONTRACT No.: -
MJ PROJ. No.: 1121.03
DATE: JANUARY 15, 2016

DATE: March 7, 2016
MMI #: 4805-05
PROJECT: Schoharie Creek Watershed Flood Study
SUBJECT: Project Status Report

Following is a monthly update on the status of the Schoharie Creek Watershed Flood Mitigation Study. During the month of February the following work has been accomplished:

MJ Engineering and Land Surveying continued their processing of channel survey and measurements of bridges within the focus areas, delivering survey data to MMI for Schoharie Creek through North Blenheim and Middleburgh. Maps showing survey locations within both areas are appended.

The North Blenheim focus area includes an approximately 1.5 mile reach of Schoharie Creek as it flows through the hamlet of North Blenheim, which was severely damaged by flooding during Tropical Storm Irene. The reach includes the NY State Route 30 bridge and the abutments of the historic Blenheim covered bridge, which is no longer in place. This reach of Schoharie Creek has been evaluated by FEMA using approximate engineering methods only, meaning that identification of areas subject to flooding has been approximated, and no water surface elevations are provided. The FEMA Flood Insurance Rate Map indicates that the 100-year flood event inundates much of the developed area of the hamlet of North Blenheim along Route 30.

The Middleburgh focus area includes approximately 1.8 mile reach of Schoharie Creek as it flows through Middleburgh, including the NY State Route 30 bridge. Flooding has occurred along River Street and, less frequently, on Main Street.

Hydraulic modeling work continues. Hydraulic analysis is continuing at the Patria Road bridge over House Creek and the West Fulton Road (County Route 4) bridge over Panther Creek in the hamlet of West Fulton, and at an unnamed culvert crossing under NY Route 30 in Middleburgh, just south of Christmas Tree Lane.

Next Steps

- MJ Engineering and Land Surveying to complete survey work and deliver all files to MMI
- MMI to continue to develop flood mitigation alternatives
- MMI to progress with hydraulic modeling

NOTES:

HORIZONTAL DATUM NEW YORK STATE PLANE EAST ZONE NAD 83/(2011) IN U.S. SURVEY FEET DERIVED FROM STATIC GPS AND BASE STATION GPS RTK OBSERVATIONS.

VERTICAL DATUM IS REFERENCED TO THE NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD 88) IN FEET.

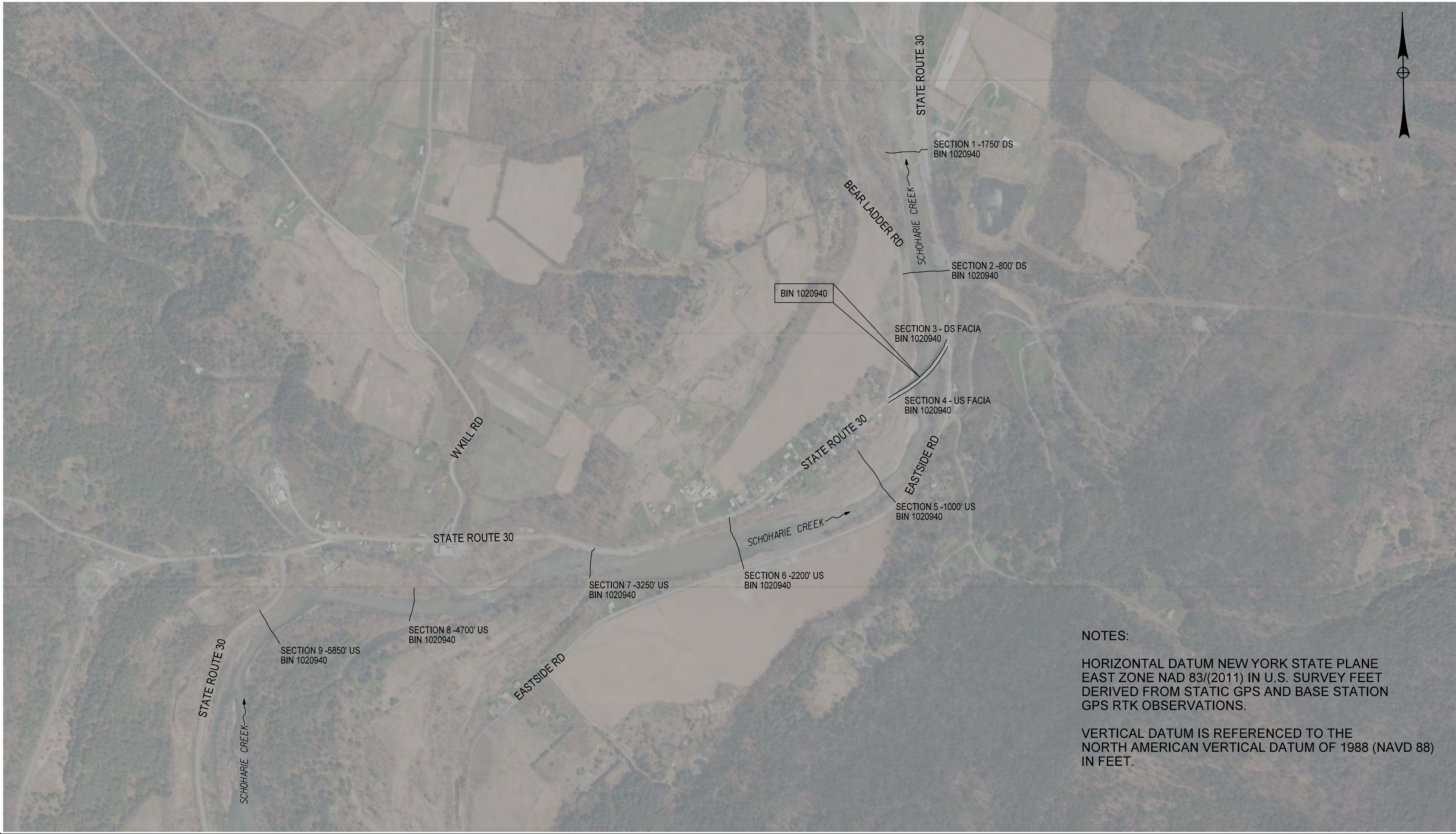
SUBMITTAL / REVISIONS					
No.	DATE	DESCRIPTION	BY	REVIEWED BY:	DATE

PROJ. MANAGER:	JGM
CHIEF DESIGNER:	
DESIGNED BY:	
DRAWN BY:	KS
CHECKED BY:	MJF

Engineering and Land Surveying, P.C.
1533 Crescent Road - Clifton Park, NY 12065

HYDRAULIC CROSS SECTION SKETCH
USGS QUAD MAP "MIDDLEBURGH"
SCHOHARIE CREEK
TOWN OF MIDDLEBURGH,
SCHOHARIE COUNTY

SCALE:	N.T.S.
CONTRACT No.:	-
MJ PROJ. No.:	1121.03
DATE:	FEBRUARY 17, 2016



NOTES:

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VERTICAL DATUM IS REFERENCED TO THE NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD 88) IN FEET.

SUBMITTAL / REVISIONS

No.	DATE	DESCRIPTION	BY	REVIEWED BY:	DATE

PROJ. MANAGER:	JGM
CHIEF DESIGNER:	
DESIGNED BY:	
DRAWN BY:	KS
CHECKED BY:	MJF

Engineering and Land Surveying, P.C.
1533 Crescent Road - Clifton Park, NY 12065

HYDRAULIC CROSS SECTION SKETCH
USGS QUAD MAP "GILBOA"
SCHOHARIE CREEK
TOWN OF GILBOA, SCHOHARIE COUNTY

SCALE: N.T.S.
CONTRACT No.: -
MJ PROJ. No.: 1121.03
DATE: FEBRUARY 17, 2016

Progress Report

DATE: April 11, 2016
MMI #: 4805-05
PROJECT: Schoharie Creek Watershed Flood Study
SUBJECT: Project Status Report

Following is a monthly update on the status of the Schoharie Creek Watershed Flood Mitigation Study.

MJ Engineering and Land Surveying delivered additional survey data to MMI. Survey was provided for Schoharie Creek where it flows through the Town and Village of Schoharie, including the Bridge Street (County Route 1a) bridge. MJ also provided survey for the lower reaches of Cobleskill Creek near Central Bridge.

The Schoharie focus area includes an approximately 1.5 mile reach of Schoharie Creek, extending downstream from Bridge Street. Flooding problems have been reported to the west of Main Street, and Main Street reportedly flooded during Irene. The FEMA Flood Insurance Rate Maps indicate that the 100-year flood event inundates portions of the commercial area.

The Central Bridge focus area includes the downstream-most reach of Cobleskill Creek as it passes under the Church Street and Route 30A bridges, near its confluence with Schoharie Creek. Flooding and channel instability has been reported in this area.

Hydraulic modeling work continues. During the past month we have done extensive modeling along the focus area on Fox Creek upstream of and including Gallopville, which includes analysis of seven bridges, and along Schoharie Creek in North Blenheim. We have also been conducting calculations at potential floodwater storage locations.

<u>Next Steps</u>

- MMI to continue with H&H, hydraulic modeling and development of flood mitigation alternatives
- Hickory Creek is assembling recommendations relating to riparian buffers, wetland protection, green infrastructure
- MMI to conduct field visits to verify modeling results and conduct spot checks at focus areas

DATE: May 10, 2016
MMI #: 4805-05
PROJECT: Schoharie Creek Watershed Flood Study
SUBJECT: Project Status Report

Following is a monthly update on the status of the Schoharie Creek Watershed Flood Mitigation Study.

Hydraulic modeling work and the evaluation of flood mitigation alternatives is coming to a close. We are also wrapping up calculations at potential floodwater storage locations. MMI's subconsultant, Hickory Creek, is providing recommendations relating to riparian buffers, wetland protection, and green infrastructure.

At the end of May, MMI will be producing a technical memorandum summarizing the results of our hydraulic modeling and alternatives analysis, and providing preliminary flood mitigation recommendations. This will allow SCSWCD and its partners to review the recommendations with the appropriate stakeholders in the watershed, and begin to prepare materials for upcoming funding opportunities.

Next Steps

- Finalize hydraulic modeling
- Finalize floodwater storage calculations
- Integrate Hickory Creek's recommendations on riparian buffers, wetland protection, and green infrastructure
- Produce technical memorandum providing preliminary flood mitigation recommendations
- Begin cost assessments, identification of funding sources, and permitting assessment
- Continue development of draft engineering report

DATE: June 9, 2016
MMI #: 4805-05
PROJECT: Schoharie Creek Watershed Flood Study
SUBJECT: Project Status Report

Following is a monthly update on the status of the Schoharie Creek Watershed Flood Mitigation Study.

At the end of May, MMI produced a technical memorandum that summarized the results of our hydraulic modeling and alternatives analysis to date, and provided preliminary flood mitigation recommendations within a total of 17 focus areas. The intention of the memo was to allow SCSWCD and its partners to review the recommendations with the appropriate stakeholders in the watershed, and begin to prepare materials for upcoming funding opportunities. On June 8 a call was convened with the project stakeholders, which provided an opportunity for MMI to gather feedback on the recommendations, and to collect additional information on flooding and potential flood mitigation alternatives within the focus areas.

Next Steps

In June we will be further refining our analysis and recommendations, evaluating additional flood mitigation measures in several of the focus areas, developing more detailed cost opinions, and continuing with production of the engineering report. We will also begin the identification of funding sources, and the assessment of permitting requirements.

DATE: July 12, 2016
MMI #: 4805-05
PROJECT: Schoharie Creek Watershed Flood Study
SUBJECT: Project Status Report

Following is a monthly update on the status of the Schoharie Creek Watershed Flood Mitigation Study.

The team at Milone & MacBroom has been continuing to develop and refine the flood mitigation analysis and recommendations in the draft engineering report. This has included the evaluation of additional flood mitigation measures in several of the focus areas, including sediment removal from the channel, flood walls, and levees. We are developing more detailed cost opinions for several alternatives, and have been creating graphics for inclusion in the report. We have also begun the process of identifying funding sources, and the assessment of permitting requirements.

DATE: August 11, 2016
MMI #: 4805-05
PROJECT: Schoharie Creek Watershed Flood Study
SUBJECT: Project Status Report

Following is a monthly update on the Schoharie Creek Watershed Flood Mitigation Study.

We have been continuing to develop and refine the flood mitigation analysis and recommendations in the draft engineering report. The majority of the report has now been drafted. Our partner at Hickory Creek is working on identifying funding sources and assessing permitting requirements for the recommended alternatives.

We have set a target date of September 30 for completion and delivery of the draft engineering report. After delivery of the draft report we will be looking for feedback from SCSWCD and the other conservation districts and stakeholders. For the public meeting to present the report findings, we have set a tentative timeline of mid-October. We will work with SCSWCD and the other partners to set a specific date, and to identify the location and format for the meeting.

DATE: September 15, 2016
MMI #: 4805-05
PROJECT: Schoharie Creek Watershed Flood Study
SUBJECT: Project Status Report

Following is a monthly update on the Schoharie Creek Watershed Flood Mitigation Study.

Hydraulic modeling and analysis has been completed at two final focus areas: at Warnerville Cutoff over Cobleskill Creek, and at Coyler Road along Schoharie Creek.

We have now completed the data collection, hydraulic modeling, alternatives analysis, and flood mitigation recommendation components of the Schoharie Creek Watershed flood study. We are finishing up, reviewing and formatting the draft engineering report, and producing graphics to accompany the report. Our partner at Hickory Creek has provided the sections of the report on funding sources and regulatory permitting requirements, which will be reviewed and included in the report.

We are targeting September 30 for completion and delivery of the draft engineering report to SCSWCD. After delivery, we will be looking for feedback from SCSWCD and the other conservation districts and stakeholders. The final report will address comments received on the draft report.

Working with SCSWCD, we have set a tentative timeline of mid-October for a public meeting to present the results. We will work with SCSWCD and the other partners to set a specific date, and to identify the location and format for the meeting.

DATE: October 12, 2016
MMI #: 4805-05
PROJECT: Schoharie Creek Watershed Flood Study
SUBJECT: Project Status Report

Following is a monthly update on the Schoharie Creek Watershed Flood Mitigation Study.

The draft engineering report was delivered to SCSWCD on September 30, and was subsequently made available to the other conservation districts and stakeholders.

You can access the report on Milone & MacBroom's FTP site by going to this link:
https://clients.miloneandmacbroom.com/

Username: Schoharie
Password: Flood

Peter Nichols at SCSWCD has asked that conservation district personnel respond to him with comments by October 14. He will compile comments and provide them to Milone & MacBroom. The final report will address comments received on the draft report.

We will continue to work with SCSWCD and other stakeholders to set a date for a public meeting to present the results, and to identify a location and format for the meeting.

Next Steps

- Compile and address comments and issue final engineering report
- Coordinate public meeting to present the results of the flood mitigation study