EMERGENCY TRANSPORTATION INFRASTRUCTURE RECOVERY WATER BASIN ASSESSMENT AND FLOOD HAZARD MITIGATION ALTERNATIVES

NOWADAGA CREEK
HERKIMER COUNTY, NEW YORK

April 2014

MMI #5231-01

Photo Source: Milone & MacBroom, Inc. (2013)

This document was prepared for the New York State Department of Transportation, in cooperation with the New York State Department of Environmental Conservation.

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ABBREVIATIONS/ACRONYMS

CFS	Cubic Feet per Second
CME	Creighton Manning Engineering
DPW	Department of Public Works
FEMA	Federal Emergency Management Agency
FIS	Flood Insurance Study
FT	Feet
FTP	File Transfer Protocol
GIS	Geographic Information System
HEC-RAS	Hydrologic Engineering Center – River Analysis System
LiDAR	Light Detection and Ranging
MMI	Milone & MacBroom, Inc.
NYSDEC	New York State Department of Environmental Conservation
NYSDOT	New York State Department of Transportation
STA	River Station
USACE	United States Army Corps of Engineers
USGS	United States Geological Survey
W/O	Without
WSEL	Water Surface Elevation
YR	Year

1.0 INTRODUCTION

1.1 Project Background

A severe precipitation system in June 2013 caused excessive flow rates and flooding in a number of communities in the greater Utica region. As a result, the New York State Department of Transportation (NYSDOT) in consultation with the New York State Department of Environmental Conservation (NYSDEC) retained Milone & MacBroom, Inc. (MMI) through a subconsultant agreement with Creighton Manning Engineering (CME) to undertake an emergency transportation infrastructure recovery water basin assessment of 13 watersheds in Herkimer, Oneida, and Montgomery Counties, including the Nowadaga Creek watershed. Prudent Engineering was also contracted through CME to provide support services, including field survey of stream cross sections.

The Nowadaga Creek basin drains portions of the towns of Danube, Stark, and Little Falls, as well as a small portion of the town of Warren, in southern Herkimer County, east central New York State. The creek drains an area of 31.8 square miles. The drainage basin is approximately 49 percent forested with rural residential and agriculture uses throughout the basin and clusters of residential development in the hamlets of Newville and Smith Corners. The creek has an average slope of 1.7 percent over its entire stream length of 10.0 miles. Figure 1 depicts the contributing watershed of the creek.

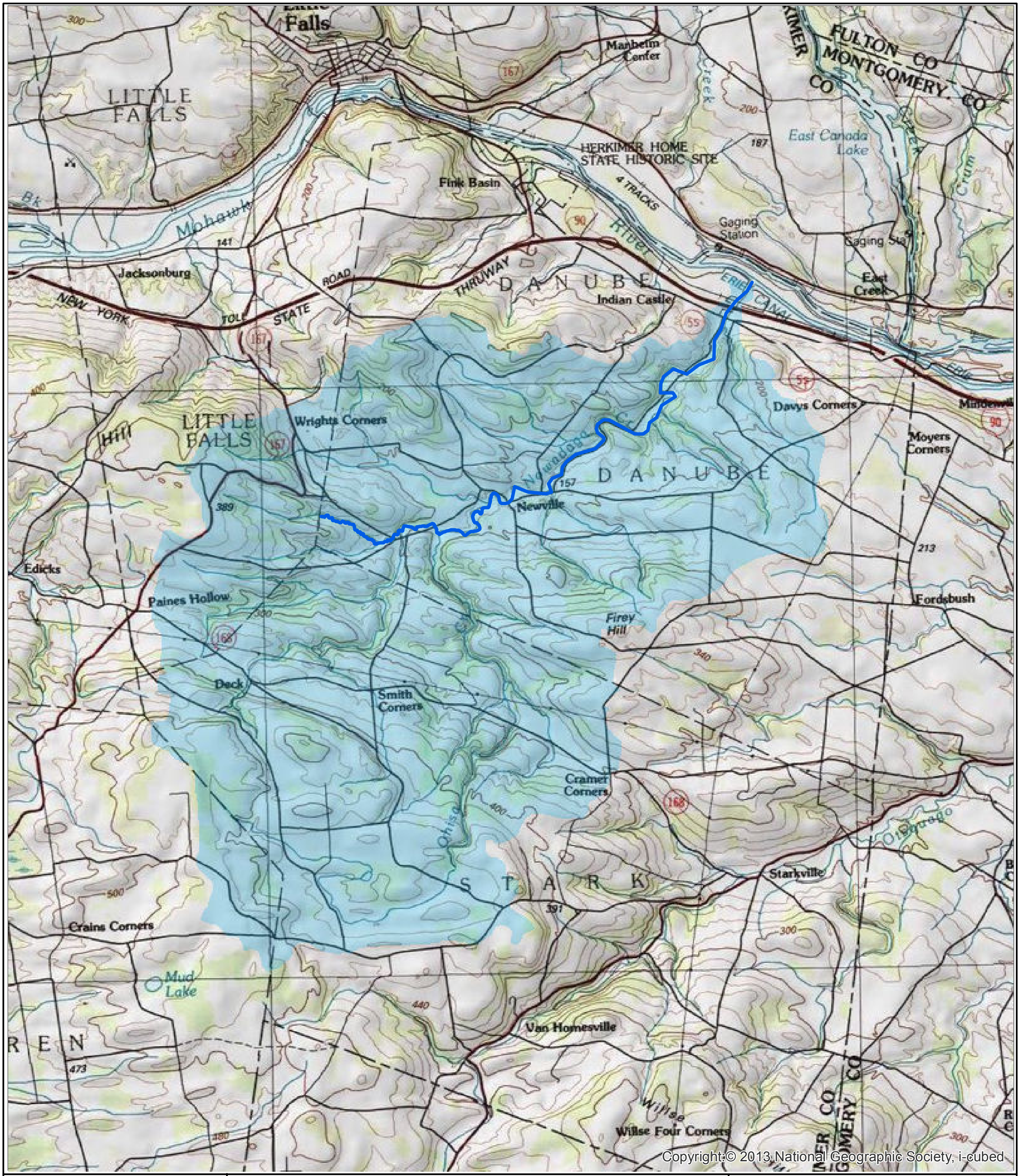
Nowadaga Creek flows over a bedrock bed for much of its length and, therefore, is not subject to alluvial processes as seen in many similarly sized river basins. Despite its natural and relatively undeveloped setting, for much of its length the creek lacks a well-developed natural floodplain. In many areas along the creek, the bedrock channel is disintegrating, and pieces of stone that originate from the channel bed are conveyed downstream and deposited in lower velocity reaches of the channel, contributing to debris jams, avulsions, and flooding.

According to community members, municipal officials, and observations made by MMI staff during field investigations, the most severe flood-related damages and erosion problems along Nowadaga Creek have been in the vicinity of the I-90 bridge; along Creek Road (Route 102); in the vicinity of the Town of Danube Department of Public Works (DPW) garage; at a homeowner-built levee in the vicinity of Tibbitts Road; and at the Newville Road (Route 45) bridge over Nowadaga Creek in the hamlet of Newville.

The goals of the subject water basin assessment were to:

1. Collect and analyze information relative to the June 28, 2013 flood and other historic flooding events.

2. Identify critical areas subject to flood risk.



SOURCE(S):

Figure 1: Nowadaga Creek Drainage Basin Location

LOCATION:
Herkimer County, New York

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Map By: CMP
MMI#: 5231-01
Original: 01/06/2014
Revision: 1/7/2014
Scale: 1 inch = 7,000 feet

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3. Develop and evaluate flood hazard mitigation alternatives for each high risk area within the stream corridor.

1.2 Nomenclature

In this report and associated mapping, stream stationing is used as an address to identify specific points along the watercourse. Stationing is measured in feet and begins at the mouth of Nowadaga Creek at STA 0+00 and continues upstream to STA 410+00. As an example, STA 73+00 indicates a point in the channel located 7,300 linear feet upstream of the mouth. Figure 2 depicts the stream stationing along Nowadaga Creek. All references to right bank and left bank in this report refer to "river right" and "river left," meaning the orientation assumes that the reader is standing in the river looking downstream.

2.0 DATA COLLECTION

2.1 Initial Data Collection

Public information pertaining to Nowadaga Creek was collected from previously published documents as well as through meetings with municipal, county, and state officials. Data collected includes reports, photographs, newspaper articles, Federal Emergency Management Agency (FEMA) Flood Insurance Studies (FIS), aerial photographs, and geographic information system (GIS) mapping. Appendix A is a summary listing of data and reports collected.

2.2 Public Outreach

An initial kickoff meeting was held in early October 2013 with representatives from NYSDOT and NYSDEC, followed by public outreach meetings held in numerous affected communities, including a meeting held at the Stark Community Hall in Fort Plain to discuss flooding issues on Nowadaga Creek. These meetings provided more detailed, firsthand accounts of past flooding events, identified specific areas that flooded in each community as well as the extent and severity of flood damage, and provided information on post-flood efforts such as bridge reconstruction, road repair, channel modification, and dredging. This outreach effort assisted in the identification of target areas for field investigations and future analysis.

2.3 Field Assessment

Following initial data gathering and outreach meetings, field staff from Prudent Engineering and MMI undertook field data collection efforts, with special attention given to areas identified in the outreach meetings. Initial field assessment of all 13 watersheds was conducted in October and November 2013. Selected locations identified in the initial phase were assessed more closely by multiple field teams in late November 2013. Information collected during field investigations included the following:

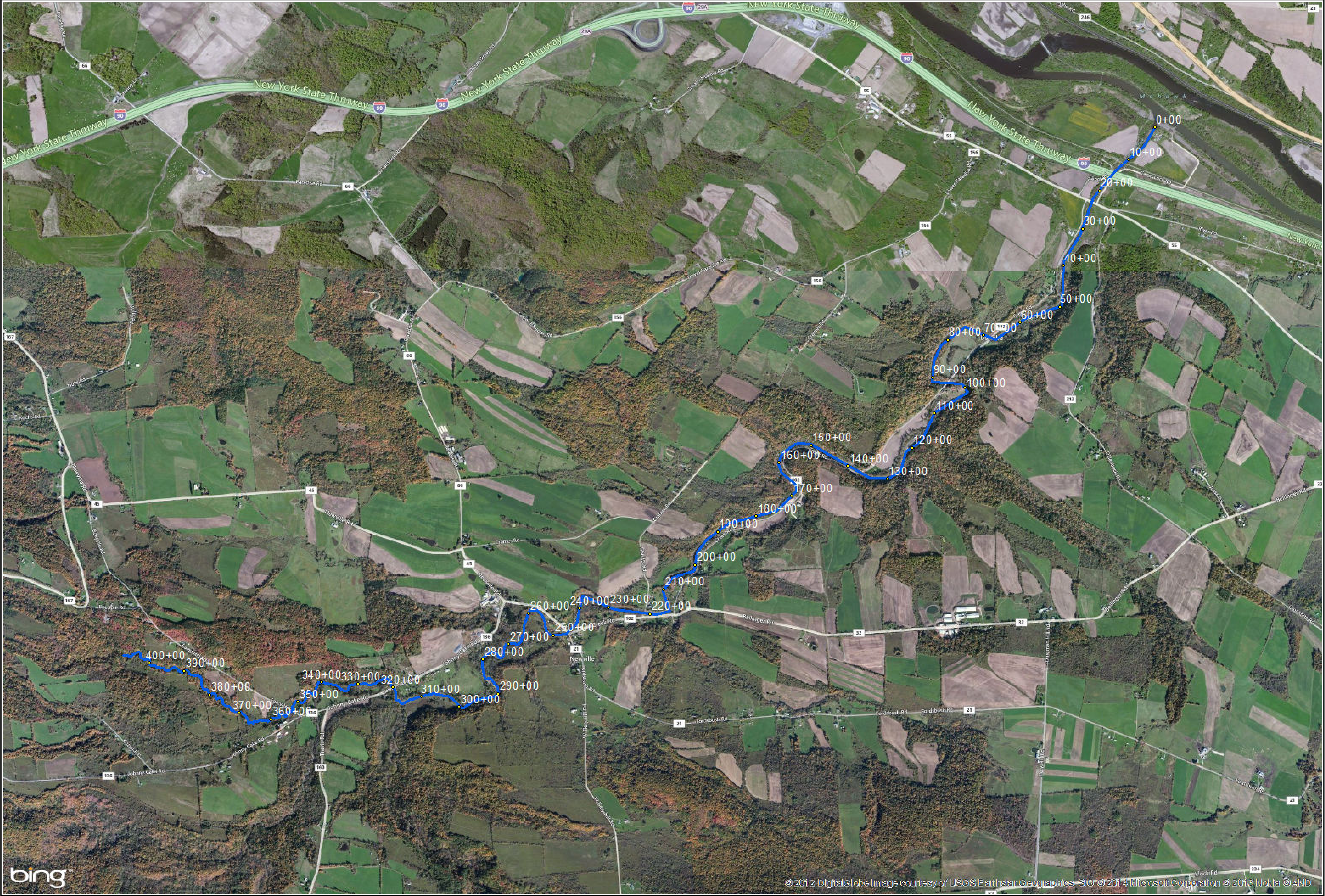

Figure 2: Nowadaga Creek Watercourse Stationing

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Revision: 3/26/2014
Scale: 1 in = 2,000 ft

Figure 2

- Rapid "windshield" river corridor inspection
- Photo documentation of inspected areas
- Measurement and rapid hydraulic assessment of bridges, culverts, and dams
- Geomorphic classification and assessment, including measurement of bankfull channel widths and depths at key cross sections
- Field identification of potential flood storage areas
- Wolman pebble counts
- Cohesive soil shear strength measurements
- Characterization of key bank failures, headcuts, bed erosion, aggradation areas, and other unstable channel features
- Preliminary identification of potential flood hazard mitigation alternatives, including those requiring further analysis

Included in Appendix B is a copy of the River Assessment Reach Data Form, River Condition Assessment Form, Bridge Waterway Inspection Form, and Wolman Pebble Count Form. Appendix C is a photo log of select locations within the river corridor. Field Data Collection Index Summary mapping has been developed to graphically depict the type and location of field data collected. Completed data sheets, field notes, photo documentation, and mapping developed for this project have been uploaded onto the NYSDOT ProjectWise system and the project-specific file transfer protocol (FTP) site at MMI. The data and mapping were also provided electronically to NYSDEC.

2.4 Watershed Land Use

Figure 3 is a watershed map of Nowadaga Creek. The Nowadaga Creek basin drains portions of the towns of Danube, Stark, and Little Falls, as well as a small portion of the town of Warren, in southern Herkimer County. The creek drains an area of 31.8 square miles. The drainage basin is approximately 49.3 percent forested with rural residential and agriculture uses throughout the basin and clusters of residential development in the hamlets of Newville and Smith Corners. Land use along the stream corridor is a mix of agricultural and forested land, with occasional homes located along the creek.

2.5 Geomorphology

Portions of Nowadaga Creek have a fairly steep slope, especially in its upper watershed where slope exceeds 3 percent in some reaches. Along many areas of the creek, the creek bed and creek banks are composed of bedrock. In some areas, the bedrock channel bed is disintegrating. Pieces of stone that break free of the channel bed during high flow events are conveyed downstream and deposited in lower velocity reaches of the channel, contributing to debris jams, avulsions and flooding. A substantial avulsion has formed in the vicinity of STA 122+00, where the channel has relocated through an agricultural field.

A number of eroding banks and slope failures also contribute to the sediment load. A large bank failure has occurred downstream of Creek Road Crossing #3, in the vicinity of STA 136+00.

Figure 3	**Map By:** CMP **MMI#:** 5231-01 **MXD:** Y:\5231-01\GIS\Maps\Figure 3 Maps\Figure 3 Nowadaga Creek.mxd **1st Version:** 01/07/2014 **Revision:** 3/27/2014 **Scale:** 1 in = 6,000 ft	**Figure 3: Nowadaga Creek Drainage Basin Aerial** **NYDOT: Emergency Transportation Infrastructure Recovery** **Herkimer County, New York**	**SOURCE(S):**

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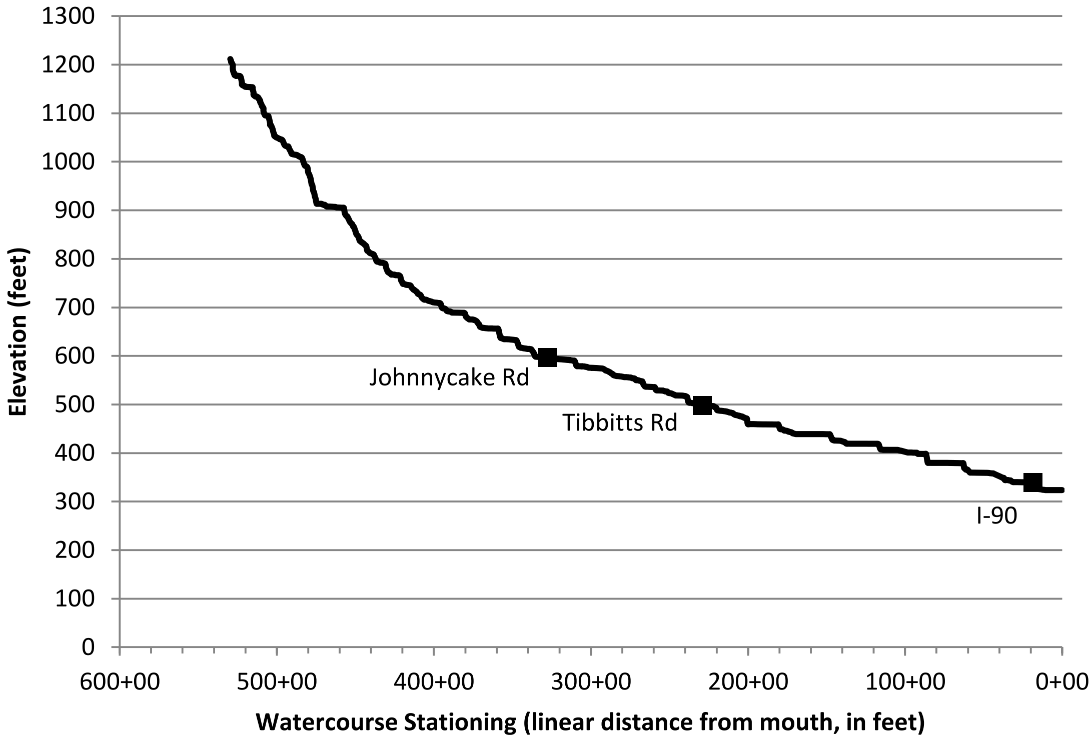
Nowadaga Creek has an average slope of 1.7 percent. The upper reaches of Nowadaga Creek, from its headwaters downstream to where it crosses under Johnnycake Road (Route 136), have a steeper slope of 3 percent, while the lower reaches from Johnnycake Road to the Mohawk River have a mild slope of 0.8 percent.

Figure 4 is a profile of Nowadaga Creek, showing the watercourse elevation versus the linear distance from the mouth of the watercourse.

Figure 4
Nowadaga Creek Profile



In a number of areas, filling has occurred in the floodplain along Nowadaga Creek. For example, just downstream of Tibbitts Road on the left bank, a levee has been constructed (in the vicinity of STA 228+00 to STA 223+00), presumably to protect a private property from flooding. The levee separates the creek from its floodplain. On the right bank adjacent to the DPW garage (STA 180+00 downstream to STA 176+00), it appears that filling of the floodplain has occurred and a salt storage shed that was placed on the fill is now being undermined by erosion.

2.6 Hydrology

There are no United States Geological Survey (USGS) stream gauging stations on Nowadaga Creek. Hydrologic data on peak flood flow rates are available for many New York streams from the FEMA FIS. There is a preliminary draft FIS available for all of Herkimer County, issued September 30, 2011, but it has not yet been formally approved. The FIS does not include flow information or flood mapping for Nowadaga Creek.

Estimated peak discharges for various frequency flood events were calculated using the USGS *StreamStats* program. Table 1 lists estimated peak flows at critical points along Nowadaga Creek. These discharges were input into the hydraulic model.

TABLE 1
Nowadaga Creek Peak Discharges (cfs) from *StreamStats*

Location	Station	10-Yr	50-Yr	100-Yr
Upstream Tibbitts Road bridge	230+70	1,970	2,870	3,320
Upstream Creek Road crossing #1	147+70	2,370	3,470	4,010
At channel avulsion along Creek Road	123+25	2,660	3,900	4,510
Upstream Route 5S bridge	26+35	2,950	4,320	5,000

2.7 Infrastructure

According to municipal officials, observations, and news accounts, much of the flood-related damage along Nowadaga Creek is associated with roads and bridges. Creek Road (Route 102) in the town of Danube parallels Nowadaga Creek along much of its lower reaches. The road floods at various points, especially in the vicinity of the bridge crossings. Several of the bridges are poorly aligned with the creek channel and are prone to becoming clogged with sediment and woody debris, which reduces hydraulic capacity. Ice, sediment, and debris jams have been reported at the rail-to-trail (former railroad) bridge at STA 14+25.

Bridge spans and heights were measured as part of the field inspection performed for the subject study and are summarized in Table 2.

TABLE 2
Summary of Stream Crossing Data

Roadway Crossing	Station	Width (ft)	Height (ft)
Johnnycake Road	328+00	---	---
Newville Road	254+75	79.0	8.5 – 10.0
Tibbitts Road	229+00	79.0	4.0 – 10.7
Creek Road crossing #3	142+00	45 x 2	10.0 – 12.0
Creek Road crossing #2	99+00	54.0	19.5 – 23.0
Creek Road crossing #1	73+00	97.5	7.8 – 12.0
NY State Route 5S	26+00	106.0	7.5 – 12.0
I-90	18+00	---	---
Old railroad bridge (rail-to-trail)	14+25	3 spans: 28/31/31	7.5 – 8.5

3.0 FLOODING HAZARDS AND MITIGATION ALTERNATIVES

3.1 Flooding History in Nowadaga Creek

According to news reports, a flood event on April 27, 2011 caused extensive damage to creek banks and roads along Nowadaga Creek. The most severe damage occurred along Creek Road (Route 102), which parallels Nowadaga Creek. Portions of the road washed out, and a landslide occurred in the vicinity of the Town of Danube office buildings and DPW garage.

In mid to late June and early July 2013, a severe precipitation system caused excessive flow rates and flooding in a number of communities in the greater Utica region, including in the Nowadaga Creek Basin. Because rainfall across the region was highly varied, it is not possible to determine exact rainfall amounts within the basin.

Some indication of the magnitude of the June 2013 flood can be obtained by looking at the nearby Otsquago Creek Basin, which is located just south and east of the Nowadaga Creek Basin. The USGS New York Water Science Center reports that high water marks have been surveyed along Otsquago Creek in Fort Plain to estimate the peak discharge of the June 28, 2013 event. High water marks obtained at the former stream gauge on July 2 for the June 28, 2013 event provided a preliminary estimate of an associated discharge of 28,000 cubic feet per second (cfs). This far exceeds the 500-year flow projections at that location on Otsquago Creek from FEMA or *StreamStats*.

Community members and municipal officials provided input on locations of the most severe historic flood-related damages and erosion problems along Nowadaga Creek. Flooded homes and roads were reported in the vicinity of I-90 and the rail-to-trail bridge

(STA 24+00 to STA 12+00). Sediment aggradation and debris clogged the rail-to-trail bridge and contributed to the flooding.

Channel aggradation and bank erosion have occurred just downstream of the Tibbitts Road bridge, where Nowadaga Creek makes a hard bend to the left near STA 223+00. Following the June 2013 flood, a homeowner-built levee was constructed along the left bank in this area. Also during this event, the Newville Road (Route 45) bridge over Nowadaga Creek in the hamlet of Newville (STA 254+75) became clogged with debris, resulting in flooding of nearby homes. A barn located close to the creek on the left bank just upstream of the bridge was severely damaged by floodwaters.

Severe bank erosion has occurred in the vicinity of the town of Danube DPW garage (STA 180+00 to STA 176+00). It appears that filling of the floodplain has occurred along the right bank of Nowadaga Creek in this area. The salt storage shed is now in danger of being undermined by erosion of the fill material.

Flooding of homes and the roadway occurred along Creek Road (Route 102) in the town of Danube. The Creek Road bridge over the Nowadaga at STA 142+00 became clogged with sediment and woody debris, causing the creek to overtop its banks at this location and damaging a home on the left bank just downstream of the bridge. Downstream of the bridge, the creek takes a sharp bend to the left, where a high bank failure is occurring near STA 136+00. Highly unstable sections of channel occur between STA 136+00 and STA 103+00, where heavy deposition of sediments and woody debris have caused the channel to overtop its banks and run through a field adjacent to the creek.

3.2 Post-Flood Community Response

Following the heavy flooding in June 2013 along Nowadaga Creek, numerous repairs and flood response were undertaken. Excess sediment that aggraded in the lower portion of Nowadaga Creek appears to have been dredged after the floods, extending from the Interstate 90 crossing to the NY State Route 90 crossing. The channel upstream of the NY State Route 5S bridge crossing was also recently dredged, and both banks were stabilized with riprap. The sediment removed from these reaches appears to have been removed from the area rather than sidecast onto the floodplain.

3.3 Flood Mitigation Analysis

Hydraulic analysis of Nowadaga Creek was conducted using the HEC-RAS program. The HEC-RAS computer program (*River Analysis System*) was written by the United States Army Corps of Engineers (USACE) Hydrologic Engineering Center (HEC), 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.

Hydraulic modeling of Nowadaga Creek has not been completed by FEMA. As such, a new model was developed for the watercourse using surveyed data gathered as part of the subject study. The survey effort included the wetted area (within bankfull elevation) of 20 stream cross sections, plus five bridges/culverts. This data was combined with countywide light detection and ranging (LiDAR) data provided by the NYSDEC to develop sufficient geometry to be input into the model such that existing conditions flooding up to and including the 100-year recurrence interval can be modeled.

The model of existing conditions was then used to hydraulically model certain alternatives, described further in the report sections that follow. Model input and output files have been uploaded onto the NYSDOT ProjectWise site and have been delivered electronically to NYSDEC.

3.4 High-Risk Area #1 – Undersized and Debris-Prone Bridges (STA 142+00 and STA 14+25)

Figure 5 is a location plan of High Risk Area #1. This area includes the Creek Road crossing near STA 142+00 and the rail-to-trail bridge near STA 14+25, both of which are prone to debris jams, ice jams, and clogging by woody debris, which can significantly exacerbate flooding. The bridge at STA 142+00 is poorly aligned with the creek channel, which further reduces hydraulic capacity and contributes to flood problems. This structure also appears to be in poor condition. A single-family residential structure on the left bank, just downstream of this crossing, has been severely damaged by flooding on more than one occasion.

Further downstream, a rail-to-trail bridge crosses the Nowadaga near STA 14+25. Four homes are located in relative close proximity to the bridge although it is not clear whether or how often they are subjected to flooding. Replacement of this bridge could be more costly than acquiring and removing the nearby, floodprone houses.

Alternative 1-1: Bridge Replacement at Creek Road

Hydraulic modeling of Nowadaga Creek at Creek Road near STA 142+00 indicates that the bridge acts as a hydraulic constriction but does not overtop. However, when a moderate debris jam is simulated at the bridge, it does overtop. This is consistent with accounts of actual conditions during recent flood events.

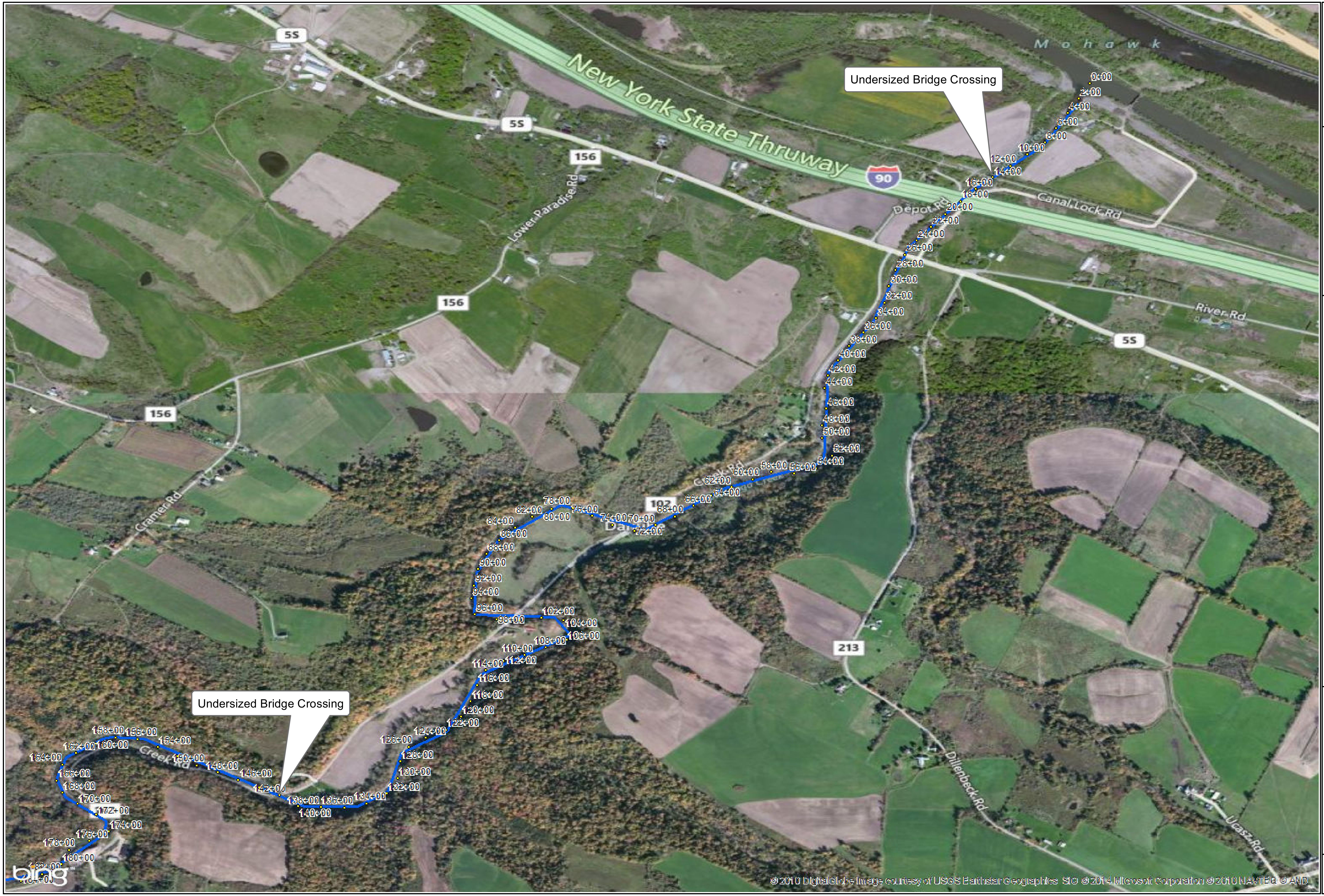


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Figure 5: Nowadaga Creek High Risk Area #1

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Herkimer County, New York

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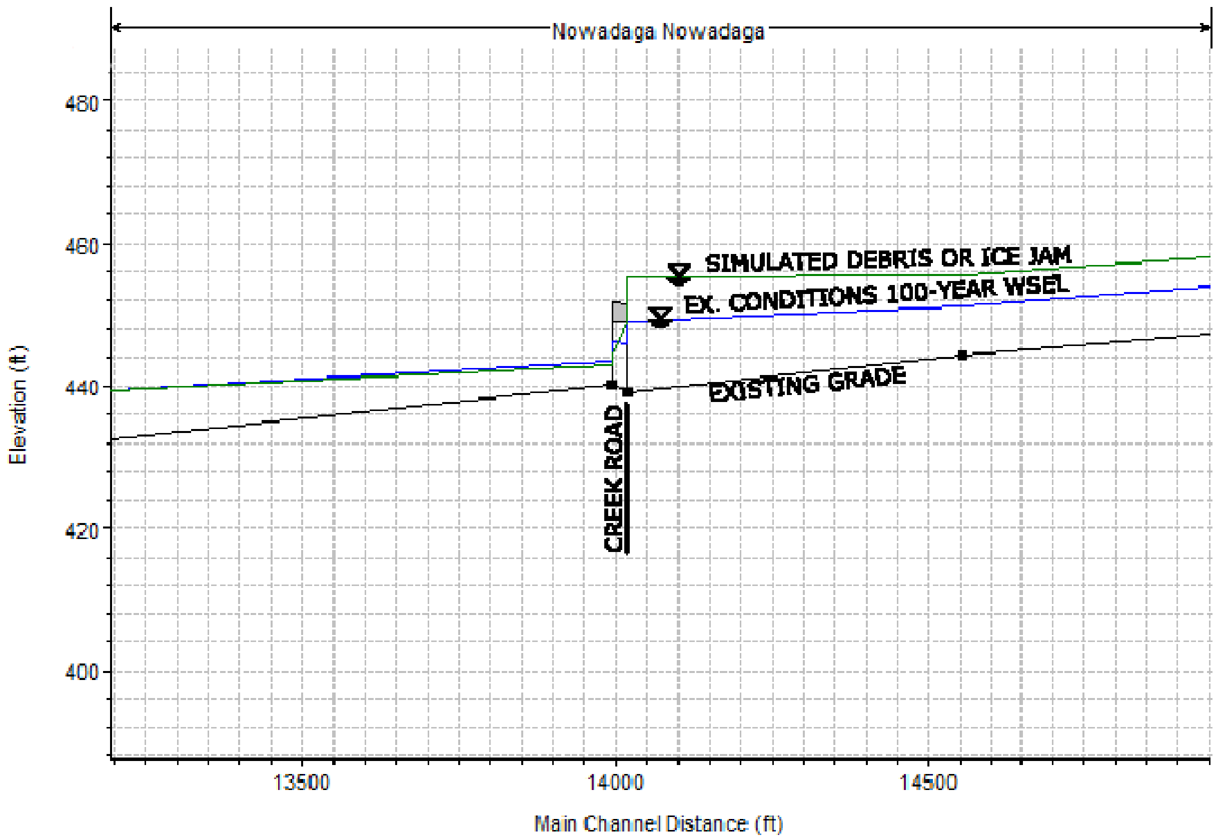
1st Version: 1/4/2014
Revision: 3/28/2014
Scale: 1 in = 1,000 ft

Figure 5

Modeling results showing a water surface elevation profile of the 100-year flood event with and without a simulated debris jam are presented in Figure 6. The blue line shows modeled water surface elevations for existing conditions. The flow of water in this diagram is from right to left. The line jumps up moving from downstream to upstream (left to right across the diagram), indicating the bridge acts as a hydraulic constriction. When a debris jam is simulated, as shown by the green line, the hydraulic constriction is greater, causing water to overtop the bridge.

FIGURE 6
Modeling Results of Debris Jam Near STA 142+00



The bridge is visibly in poor condition and is poorly aligned with the creek. Its large piers make it highly prone to debris jams. Full replacement of this bridge with a new bridge that is better aligned with the creek would reduce debris jams and alleviate the hydraulic constriction. Hydraulic modeling shows that eliminating the center pier from the design will be sufficient to remove the hydraulic constriction. As such, the existing bridge width of 68 feet (measured from skew) or non-skew width of approximately 96 feet appears adequate. Detailed modeling should be conducted during design to confirm the final span dimension.

Alternative 1-2: Remove or Protect Floodprone Structures

Hydraulic modeling indicates that the rail-to-trail bridge at STA 14+25 acts as a moderate hydraulic constriction during the 10-year flood event and larger but does not overtop. The backwater effect from the Erie Canal does not extend upstream as far as the bridge. The hydraulic constriction causes Nowadaga Creek to overtop along the right bank upstream of the bridge. Replacement of this bridge with a larger one would improve the hydraulic constriction and leave it less prone to debris and ice jamming; however, the cost of bridge replacement could potentially exceed the aggregate value of the nearby homes that would be protected. It is unclear how often and how severely these homes are impacted by flooding.

This bride is a three-span structure with two piers, skewe33d 27 degrees. Each pier is eight feet in width. The effective width between piers is 22 feet (66 feet in aggregate for the three openings). Maintaining the 27-degree skew but removing the piers from the bridge and keeping an opening of 95 feet would allow conveyance of the 100-year flood with no pressure flow.

When the rail-to-trail bridge is due for replacement, it should be appropriately sized, with consideration given to high flows, debris accumulation, and ice jamming (approximate single span of 95 feet). Acquisition of nearby properties would remove residential houses from this floodprone area; however, since these structures are not within a FEMA designated floodplain, FEMA funding is not available for such an acquisition.

In areas where properties are vulnerable to flooding and repeatedly flood, 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 1 percent annual chance flood level. The basement area is abandoned and filled to be no higher than the existing grade. All utilities and appliances located within the basement must be relocated to the first-floor level.

Construction of property improvements such as barriers, floodwalls, and earthen berms. Such structural projects can be used to prevent shallow flooding. One or more of the nearby properties may benefit from implementation of such measures to protect structures.

Dry floodproofing of the structure to keep floodwaters from entering. Dry floodproofing refers to the act of making areas below the flood level watertight. Walls may be coated with compound or plastic sheathing. Openings such as windows and vents would be either permanently closed or covered with removable shields. Flood protection should extend only two to three 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 1 percent annual chance flood elevation.

Performing other potential home improvements to mitigate damage from flooding. The following measures can be undertaken to protect home utilities and belongings:

- Relocate valuable belongings above the 1 percent annual chance flood elevation to reduce the amount of damage caused during a flood event.
- Relocate or elevate water heaters, heating systems, washers, and dryers to a higher floor or to at least 12 inches above the high water mark (if the ceiling permits). A wooden platform of pressure-treated wood can serve as the base.
- Anchor the fuel tank to the wall or floor with noncorrosive metal strapping and lag bolts.
- Install a backflow valve to prevent sewer backup into the home.
- Install a floating floor drain plug at the lowest point of the lowest finished floor.
- Elevate the electrical box or relocate it to a higher floor and elevate electric outlets to at least 12 inches above the high water mark.

Recommendations

Replacement of the bridge at Creek Road near STA 142+00 with a single (approximate 96-foot) span structure is recommended. This will reduce flooding of the house located on the left bank. When the rail-to-trail bridge near STA 14+25 is due for replacement, it should be appropriately sized, with consideration given to high flows, debris accumulation, and ice jamming. Similar to the structure at Creek Road, a single span structure of approximately 96-feet is recommended. Until such time as the bridge is replaced, floodproofing of nearby homes on a case-by-case basis is recommended.

3.5 High-Risk Area #2 – Unstable Channel Section (STA 103+00 to STA 142+00)

Figure 7 is a location plan of High Risk Area #2. A highly unstable section of channel occurs between STA 103+00 and STA 142+00, where there is heavy deposition, channel avulsion, and bank erosion. A high bank failure occurs at STA 136+00.

Alternative 2-1: Creation of Floodwater Storage Area

During field investigations, a number of sites within the Nowadaga Creek basin were investigated for their potential use as floodwater detention areas for attenuation of peak flows. One site within an extensive flat area alongside Creek Road upstream of STA 116+00 was identified as having potential.

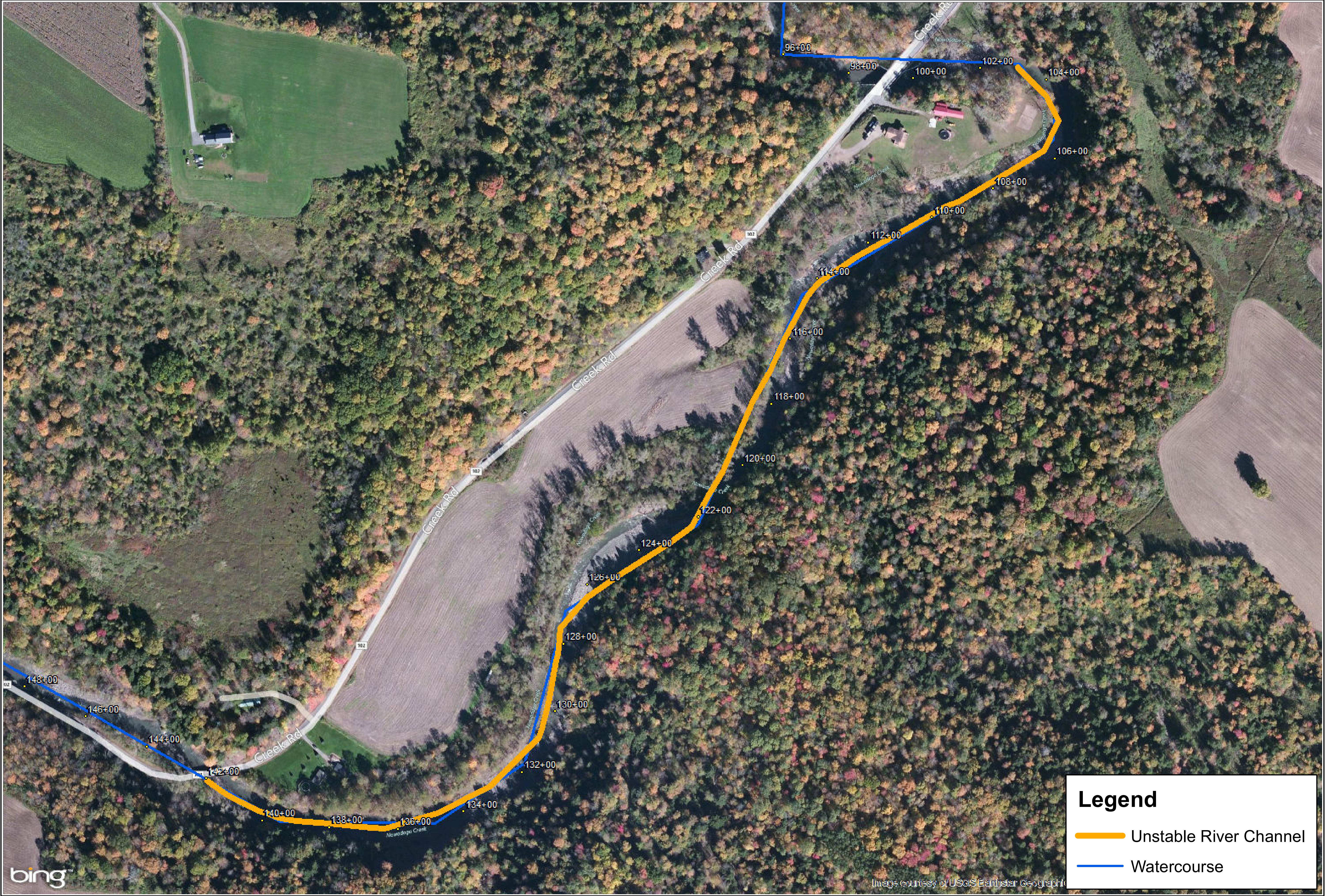


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Figure 7: Nowadaga Creek High Risk Area #2

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Herkimer County, New York

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Scale: 1 in = 250 ft

Figure 7

Excavation of a storage area at this location combined with the construction of a berm to increase storage capacity and protect the road from flooding was evaluated. The total computed storage upstream of STA 116+00 for a 100-year frequency flood event would equal 308,662 cubic yards, or approximately 6 percent of the total storm runoff volume. The "rule of thumb" for a feasible, cost-effective flood detention area is to store at least 10 percent of the runoff generated during the 100-year event. Given the marginal floodwater detention capacity, constructing a detention basin at this location is not recommended. Supporting computations are included in Appendix D.

Alternative 2-2: Stabilize Hill Slope

This alternative involves stabilizing the bank along approximately 200 feet of the channel outside of the bend near STA 136+00 to reduce sediment loading contributing to the downstream channel avulsion. In this particular case, the failure mechanism needs to be studied further, potentially requiring a geotechnical assessment of the adjacent hillslope in order to develop a specific design approach.

Alternative 2-3: Avulsion Repair

A substantial avulsion has formed in the vicinity of STA 122+00, where the channel has relocated through an agricultural field. Clearing sediment and woody debris from the channel would allow it to return to its previous location and would allow the landowner to make use of the agricultural field. The channel should not be extensively dredged.

Recommendations

Alternatives 2-2 and 2-3 are recommended to stabilize this section of Nowadaga Creek.

3.6 High-Risk Area #3 – Danube DPW Garage (STA 176+00 to STA 180+00)

Figure 8 is a location plan of High Risk Area #3. Bank erosion has occurred on the right bank in the vicinity of the town of Danube DPW garage (STA 176+00 to STA 180+00). It appears that substantial filling of the floodplain has occurred along the right bank of Nowadaga Creek in this area. The salt storage shed and other stockpiled materials are now in danger of being undermined by bank erosion.

Alternative 3-1: Move Shed and Stockpiled Materials

The location of the salt storage shed and other stockpiled materials in an area of apparent fill within the natural floodplain of the river leaves the shed, stockpiled material, and filled stream bank prone to undermining. Moving the shed and stockpiled materials to a different location further away from the creek would prevent the loss of these materials. A logical relocation site is across Creek Road in the area of the town garage.

SOURCE(S):	N	Figure 8: Nowadaga Creek High Risk Area #3	NYDOT: Emergency Transportation Infrastructure Recovery	Map By: CMP	MILONE & MACBROOM
		MXD: Y:\5231-01\GIS\Maps\High Risk Areas\Nowadaga High Risk #3.mxd	LOCATION: Herkimer County, NY	MMI#: 5231-01 Original: 4/22/2014 Revision: 4/22/2014 Scale: 1 in = 150 ft	99 Realty Drive Cheshire, CT 06410 (203) 271-1773 Fax: (203) 272-9733 www.miloneandmacbroom.com

Additionally, local stabilization of the toe of bank and re-establishment of a floodplain on the right bank would mitigate the ongoing erosion. Based on stream reference measurements taken in the vicinity, the floodplain bench should be in the range of 100 to 120 feet wide, although it may need to be narrower due to the constraint of Creek Road. The bench should be constructed at an elevation approximately 2.5 feet above the channel bed and should be pitched slightly towards the creek.

Recommendations

Alternative 3-1 is recommended.

3.7 High-Risk Area #4 – Homeowner Levee (STA 223+00 to STA 228+00)

Figure 9 is a location plan of High Risk Area #4. Immediately downstream of Tibbitts Road on the left bank, a levee has been constructed by a local homeowner in the vicinity of STA 223+00 to STA 228+00. The levee isolates the creek from its natural floodplain on the inside of a sharp left bend. Hydraulic modeling indicates that while the levee may protect the home and yard from flooding it also causes an increase in water surface elevation along Creek Road and will contribute to flooding of the road and possibly adjacent homes during significant flood events. The levee also acts to constrict flows and increases flow velocities, contributing to erosion.

Alternative 4-1: Remove or Modify Levee

Removal of the levee would enable the Nowadaga Creek to access its natural floodplain on the inside of the sharp left bend and would reduce water surface elevations and erosion along Creek Road. Alternate means of protecting the left bank property, such as placing a landscaped berm closer to the house and/or undertaking individual floodproofing measures, could be undertaken to offset the risk to this one property that will occur by eliminating the levee.

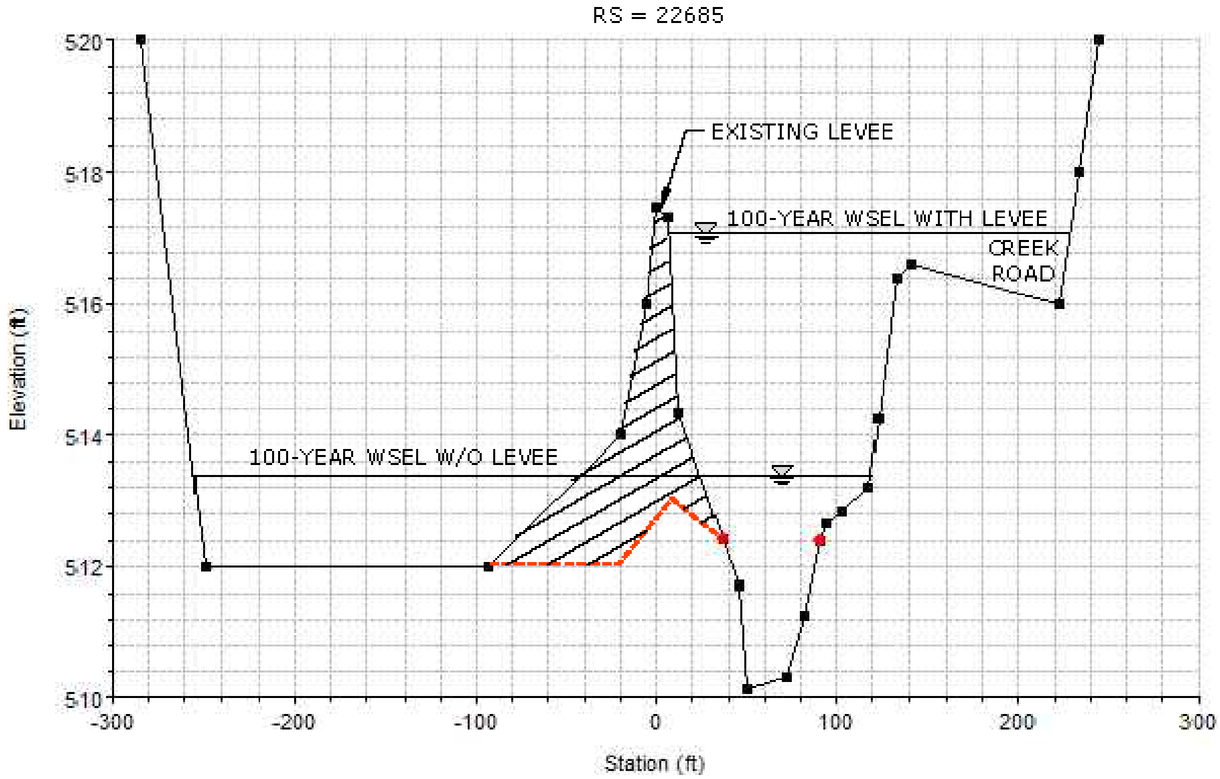
Modeling results showing a water surface elevation profile of the 100-year flood event, with and without the levee in place, are presented in Figure 10.

Recommendation

Alternative 4-1 is recommended to reconnect Nowadaga Creek to its floodplain and reduce flooding along Creek Road.

SOURCE(S):	Figure 9: Nowadaga Creek High Risk Area #4	NYDOT: Emergency Transportation Infrastructure Recovery	Map By: CMP	MILONE & MACBROOM
	MXD: Y:\5231-01\GIS\Maps\High Risk Areas\Nowadaga High Risk #4-1.mxd	LOCATION: Herkimer County, NY	MMI#: 5231-01 Original: 4/22/2014 Revision: 4/22/14 Scale: 1 in = 125 ft	99 Realty Drive Cheshire, CT 06410 (203) 271-1773 Fax: (203) 272-9733 www.miloneandmacbroom.com

FIGURE 10
Modeling Results of Levee in the Vicinity of STA 228+00 to STA 223+00



4.0 RECOMMENDATIONS

1. ***Remove or Modify the Levee in the Vicinity of STA 228+00 to STA 223+00*** – Immediately downstream of Tibbitts Road on the left bank, a levee has been constructed by a local homeowner. The levee isolates the creek from its natural floodplain on the inside of a sharp left bend, will cause an increase in water surface elevation along Creek Road, and will contribute to flooding of the road and possibly adjacent homes during significant flood events. Removal of the levee is recommended along with alternate means of protecting the left bank property, such as placing a landscaped berm closer to the house and/or undertaking individual floodproofing measures.

2. *Remove Salt Storage Shed and Other Stockpiled Materials Near STA 180+00 to STA 176+00* – The location of a salt storage shed and other stockpiled materials in an area of apparent fill within the natural floodplain of the Nowadaga leaves the shed, stockpiled material, and filled stream bank prone to undermining. Moving the shed and stockpiled materials to a different location further away from the creek is recommended. Additionally, local stabilization of the toe of bank and re-

establishment of a floodplain on the right bank are recommended to mitigate ongoing erosion.

3. *Replace the Bridge at Creek Road Crossing Near STA 142+00* – Replacement of the bridge at Creek Road near STA 142+00 is recommended. This will reduce flooding of the house located on the left bank. The bridge is visibly in poor condition and is poorly aligned with the creek. Its large piers make it highly prone to debris jams. Full replacement of this bridge with a new single span bridge of similar span (approximately 96 feet) but without piers and that is better aligned with the creek will reduce debris jams and alleviate the hydraulic constriction. If piers are required to support the new structure, additional hydraulic analysis should be undertaken to develop a solution that is not prone to ice and debris jams and that does not create a hydraulic constriction.

4. *Stabilize High Bank Failure at STA 136+00* – A high bank failure occurs at STA 136+00. Stabilizing the bank along approximately 200 feet of the channel is recommended to reduce sediment loading contributing to the downstream channel avulsion. In this particular case, the failure mechanism needs to be studied further, potentially requiring a geotechnical assessment of the adjacent hillslope in order to develop a specific design approach.

5. *Repair of Channel Avulsion in the Vicinity of STA 122+00* – A substantial avulsion has formed in the vicinity of STA 122+00, where the channel has relocated through an agricultural field. Clearing sediment and woody debris from the channel would allow it to return to its previous location and would allow the landowner to make use of the agricultural field. The channel should not be extensively dredged.

6. *Floodproofing Floodprone Structures Near STA 14+25* – Hydraulic modeling indicates that the rail-to-trail bridge at STA 14+25 acts as a moderate hydraulic constriction during the 10-year flood event and larger. The hydraulic constriction causes Nowadaga Creek to overtop along the right bank upstream of the bridge. When this bridge is due for replacement, it should be appropriately sized, with consideration given to high flows, debris accumulation, and ice jamming. Replacement with a single (approximate 96-foot) span bridge would eliminate the constriction. Similar to the bridge at STA 142+00, if piers are required to support the new structure, additional hydraulic analysis should be undertaken to develop a solution that is not prone to ice and debris jams and that does not create a hydraulic constriction. Until such time as the bridge is replaced, floodproofing of nearby homes on a case-by-case basis is recommended.

7. *Evaluate Floodplain Regulations* – A critical evaluation of existing floodplain law and policies should be undertaken to evaluate the effectiveness of current practices and requirements. Identification of a floodplain coordinator and development of a detailed site plan review process for all proposed development within the floodplain

would provide a mechanism to quantify floodplain impacts and ascertain appropriate mitigation measures.

8. *Install and Monitor a Stream Gauge* – There is currently no stream gauge on Nowadaga Creek, making statistical analysis difficult. Installation of a permanent stream gauge is recommended.

9. *Develop Design Standards* – There is currently no requirement to design stream crossings to certain capacity standards. For critical crossings such as major roadways or crossings that provide sole ingress/egress, design to the 50- or 100-year storm event may be appropriate. Less critical crossings in flat areas may be sufficient to pass only the 10-year event. Crossings should always be designed in a manner that does not cause flooding. When a structure that is damaged or destroyed is replaced with a structure of the same size, type, and design, it is reasonable to expect that the new structure will be at risk for future damage as well. Development of design standards is recommended for all new and replacement structures.

The above recommendations are graphically depicted on the following pages. Table 3 provides an estimated cost range for key recommendations.

TABLE 3
Cost Range of Recommended Actions

	Approximate Cost Range				
Nowadaga Creek Recommendations	< $100k	$100k-$500k	$500k-$1M	$1M-$5M	>$5M
Replace the Bridge at Creek Road Crossing				X	
Stabilize High Bank Failure at STA 136+00		X			
Repair of Channel Avulsion	X				
Remove Salt Storage Shed	X				
Remove or Modify Homeowner Levee	X				
Install and Monitor a Stream Gauge	X				

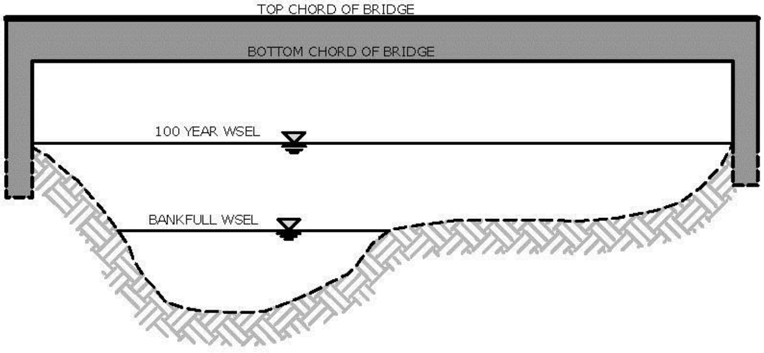
WATER BASIN ASSESSMENT AND FLOOD HAZARD MITIGATION ALTERNATIVES NOWADAGA CREEK, ONEIDA COUNTY, NEW YORK

High-Risk Area #1: Undersized and Debris-Prone Bridges

Site Description: Several bridge crossings along Nowadaga Creek are undersized and cause hydraulic restriction during low frequency flooding events. At the upstream end is the Creek Road Crossing (STA 142+00, Left Picture) and downstream is the rail-to-trail bridge at (STA 14+25, Right Picture).

Recommendations:

- Replace the Creek Road Crossing with a new bridge that is better aligned with the creek and sized to reduce debris jams and alleviate the hydraulic constriction.
- When the rail-to-trail bridge is due for replacement, it should be appropriately sized, with consideration given to high flows, debris accumulation, and ice jamming. Until such time as the bridge is replaced, flood-proofing of nearby homes on a case-by-case basis is recommended.



TYPICAL UNCONSTRAINED BRIDGE CROSSING

	BENEFITS
✓	Reduction in debris jams
✓	Improved hydraulic capacity
✓	Reduced flood hazard

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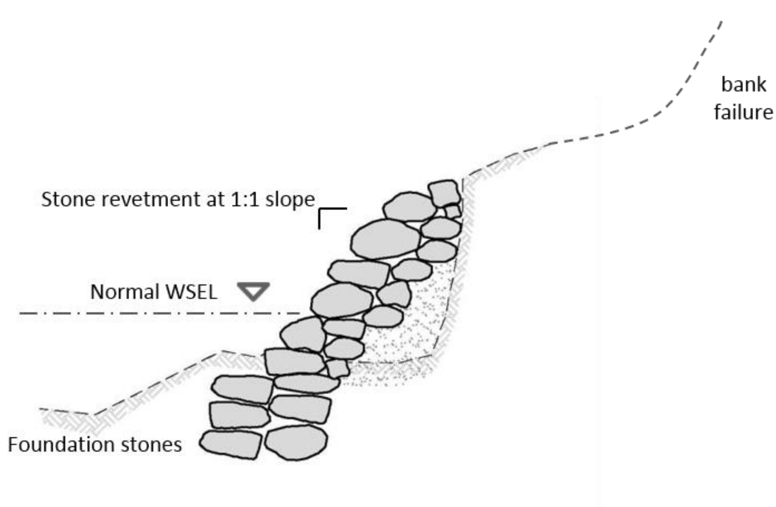
WATER BASIN ASSESSMENT AND FLOOD HAZARD MITIGATION ALTERNATIVES NOWADAGA CREEK, ONEIDA COUNTY, NEW YORK

High-Risk Area #2: Highly Unstable Section of Channel

Site Description: Between STA 142+00 and 103+00, the channel within this reach is highly unstable and present is heavy deposition, channel avulsion and bank erosion.

Recommendations:

- Stabilize the bank along approximately 200 feet of the channel to reduce sediment loading that is contributing to the downstream channel avulsion.
- Clear the sediment and woody debris from the channel to allow it to return to its previous location and allow the landowner to make use of the agricultural field. The channel should not be extensively dredged.



	BENEFITS
✓	Reduction in debris jams
✓	Improved hydraulic capacity
✓	Reduced flood hazard
✓	Improved ecological connectivity

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WATER BASIN ASSESSMENT AND FLOOD HAZARD MITIGATION ALTERNATIVES NOWADAGA CREEK, ONEIDA COUNTY, NEW YORK

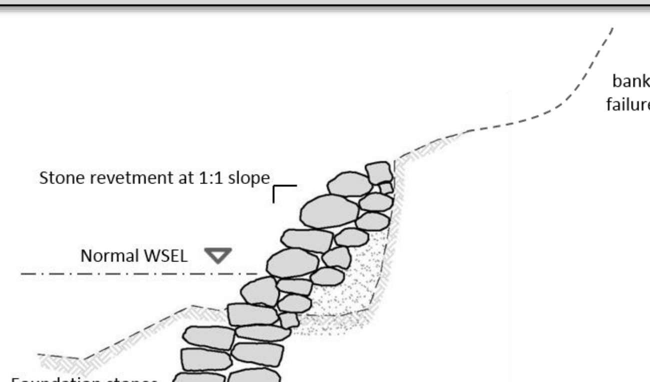
High-Risk Area #3: Danube DPW Garage

Site Description: Bank erosion is occurring the vicinity of the Danube Department of Public Works Garage, from STA 180+00 to STA 176+00, threatening the salt storage shed and other stockpiled materials.

Recommendations:

- Move the shed and stockpiled materials to a different location further away from the creek.
- Stabilize the toe of bank and re-establishment a floodplain on the right bank to mitigate ongoing erosion.

	BENEFITS
✓	Improved safety
✓	Improved hydraulic capacity
✓	Reduced flood hazard



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APPENDIX A

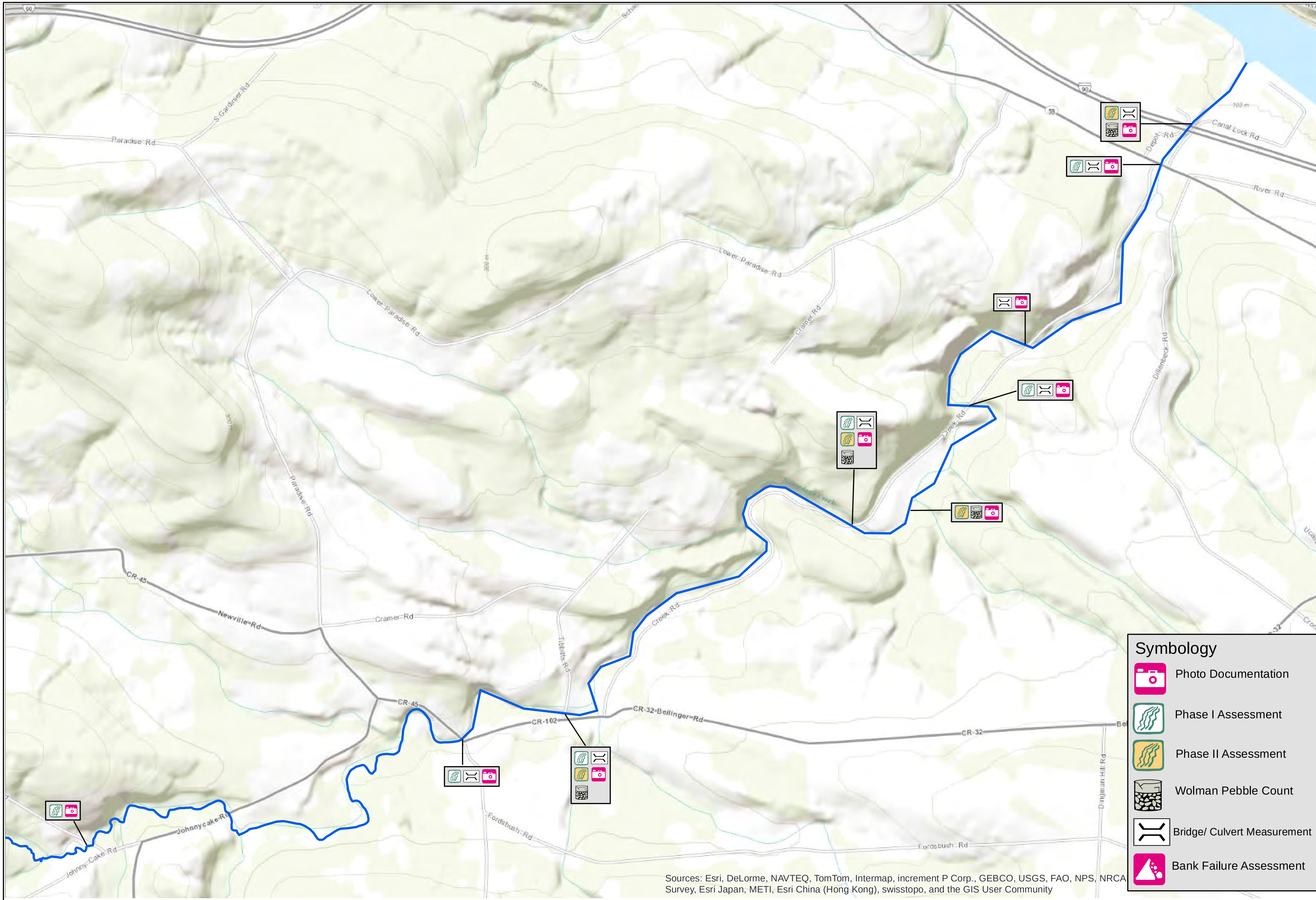
Summary of Data and Reports Collected

ATTACHMENT A: DATA INVENTORY

Year	Data Type	Document Title	Author
2013	Presentation	Flood Control Study for Fulmer Creek	Schnabel Engineering
2012	Map	Sauquoit Creek Watershed/Floodplain Map	Herkimer-Oneida Counties Comprehensive Planning Program
2011	Report	Oriskany Creek Conceptual Plan and Feasibility Study for Watershed Project	Oneida County SWCD
2009	Presentation	Ice Jam History and Mitigation Efforts	National Weather Service, Albay NY
2007	Report	Cultural Resources Investigations of Fulmer, Moyer, and Steele Flood Control Projects	United States Army Corps of Engineers (USACE)
2006	Report	Riverine High Water Mark Collection, Unnamed Storm	Federal Emergency Management Agency (FEMA)
2005	Report	Fulmer Creek Flood Damage Control Feasibility Study	United States Army Corps of Engineers (USACE)
2005	Report	Steele Creek Flood Damage Control Feasibility Study	United States Army Corps of Engineers (USACE)
2004	Report	Fulmer Creek Basin Flood Hazard Mitigation Plan	Herkimer-Oneida Counties Comprehensive Planning Program
2004	Report	Moyer Creek Basin Flood Hazard Mitigation Plan	Herkimer-Oneida Counties Comprehensive Planning Program
2004	Report	Steele Creek Basin Flood Hazard Mitigation Plan	Herkimer-Oneida Counties Comprehensive Planning Program
2003	Report	Fulmer, Moyer, Steele Creek - Stream Bank Erosion Inventory	Herkimer-Oneida Counties Comprehensive Planning Program
1997	Report	Sauquoit Creek Watershed Management Strategy	Herkimer-Oneida Counties Comprehensive Planning Program
2011	Report	Flood Insurance Study (FIS), Herkimer County	Federal Emergency Management Agency (FEMA)
2011	Report	Flood Insurance Study (FIS), Montgomery County	Federal Emergency Management Agency (FEMA)
2013	Report	Flood Insurance Study (FIS), Oneida County	Federal Emergency Management Agency (FEMA)
2010	Report	Bridge Inspection Summaries, Multiple Bridges	National Bridge Inventory (NBI)
2002	Hydraulic Models	Flood Study Data Description and Assembly - Rain CDROM	New York Department of Enviromental Conservation (NYDEC)
2013	Data	June/July 2013 - Post-Flood Stream Assessment	New York State Department of Transportation (NYSDOT)
2013	GIS Data	LiDAR Topography, Street Mapping, Parcel Data, Utility Info, Watersheds	Herkimer-Oneida Counties Comprehensive Planning Program
2013	GIS Data	Aerial Orthographic Imagery, Basemaps	Microsoft Bing, Google Maps, ESRI
2011	GIS Data	FEMA DFIRM Layers	Federal Emergency Management Agency (FEMA)
2013	Data	Watershed Delineation and Regression Calculation	US Geological Survey (USGS) - Streamstats Program

APPENDIX B

Field Data Collection Forms



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SOURCE(S):

Nowadaga Creek Data Collection Points

NYDOT: Emergency Transportation Infrastructure Recovery

Herkimer County, New York

Map By: CMP
MMI#: 5231-01
MXD: Y:\5231-01\GIS\Maps\Phase II Icon Maps\Nowadaga 6-1.mxd
1st Version: 12/11/2013
Revision: 12/11/2013
Scale: 1 in = 1,500 ft

App. B

MMI Project #5231-01 Phase I River Assessment Reach Data

River ________________ Reach _____________ U/S Station _______________ D/S Station ___________

Inspectors __________________ Date ______________ Weather ____________________________________

Photo Log ____

A) Channel Dimensions: Bankfull
Width (ft) __________
Depth (ft) __________

Watershed area at D/S end of reach (mi^2) ___________

B) Bed Material: Bedrock Boulders Cobble
Gravel Sand Clay
Concrete Debris Riprap

Notes: ____

C) Bed Stability: Aggradation Degradation Stable Note: ___________________

D) Gradient: Flat Medium Steep Note: ___________________

E) Banks: Natural Channelized Note: _________________

F) Channel Type: Incised Colluvial Alluvial Bedrock Note: __________

G) Structures: Dam Levee Retaining Wall Note: ________________

H) Sediment Sources: ____

I) Storm Damage Observations: ____
____

J) Vulnerabilities: Riverbank Development Floodplain Development Road Trail Railroad
Utility Bridge Culvert Retaining Wall Ball field Notes: _________________

K) Bridges: Structure # _____________ Inspection Report? Y N Date _________________

Notes: ____

Record span measurements if not in inspection report: ____

Damage, scour, debris: ____

L) Culverts: complete culvert inspection where necessary. Size: ____

Type: _________________ Notes: ____

____

Phase II River Assessment
Reach Data

River ____________________ Reach ____________ Road _____________ Station ______________

Inspector _________________ Date _____________ Town ____________ County _____________

Identification Number _____________________ GPS # ________________ Photo # ________________

A) River Reach ID _________________________ Drainage Area, sm ________________________
D/S Boundary ______________________________, U/S Boundary ____________________________
D/S STA ________________________________, U/S STA ________________________________
D/S Coordinates __________________________, U/S Coordinates __________________________

B) Valley Bottom Data:

Valley Type (Circle one)	Confined >80% L	Semiconfined 20-80%	Unconfined <20%
Valley Relief	<20'	20-100'	>100
Floodplain Width	<2 W_b	2-10 W_b	>10 W_b

	Left Side	Right Side
Natural floodplain	_______%	_______%
Developed floodplain	_______%	_______%
Terrace	_______%	_______%

Floodplain Land Use ____________ ____________

C) Pattern: Straight S=1-1.05 Sinuous S=1.05 – 1.25 Meanders S=1.25 – 2.0 Highly Meandering S>2.0 Braided Wandering Irregular

D) Channel Profile Form: (Percent by Class in Reach)

Cascades	__________	Alluvial	__________	Channel Transport
Steep Step/Pool	__________	Semi Alluvial	__________	Sed. Source Area
Fast Rapids	__________	Non Alluvial	__________	Eroding
Tranquil Run	__________	Channelized	__________	Neutral
Pool & Riffle	__________	Incised	__________	Depositional
Slow Run	__________	Headcuts	__________	

E) Channel Dimensions (FT):

	Bankfull	Actual Top of Bank	Regional HGR
Width	__________	__________	__________
Depth	__________	__________	__________
Inner Channel Base Width	__________		
W/D Ratio	__________		

F) Hydraulic Regime:
Mean Bed Profile Slope _______________ Ft/Ft
Observed Mean Velocity ______________________ FPS

G) Bed Controls:

Bedrock	Weathered Bedrock	Dam
Static Armor	Cohesive Substrate	Bridge
Boulders	Dynamic Armor	Culvert
Debris	Riprap	Utility Pipe/Casing

Overall Stability _______________________

H) Bed Material:

D50 __________

Bedrock	__________	Sand	__________	Riprap	__________
Boulders	__________	Silt and Clay	__________	Concrete	__________
Cobble and Boulder	__________	Glacial Till	__________		
Gravel and Cobble	__________	Organic	__________		
Sand and Gravel	__________				

I) Flood Hazards:

Developed Floodplains	Bank Erosion
Buildings	Aggradation
Utilities	Sediment Sources
Hyd. Structures	Widening

Bridge Waterway Inspection Summary

River ____________________ Reach ____________ Road _____________ Station ______________

Inspector _________________ Date _____________ NBIS Bridge Number ____________________

NBIS Structure Rating _____________________ Year Built ___________________________________

Bridge Size & Type _______________________ Skew Angle ________________________________

Waterway Width (ft) ______________________ Waterway Height (ft) _________________________

Abutment Type (circle) Vertical Spill through Wingwalls

Abutment Location (circle) In channel At bank Set back

Bridge Piers _____________________________ Pier Shape __________________________________

Abutment Material ________________________ Pier Material ________________________________

Spans % Bankfull Width ____________________ Allowance Head (ft) __________________________

Approach Floodplain Width _________________ Approach Channel Bankfull Width _______________

Tailwater Flood Depth or Elevation ___________ Flood Headloss, ft ____________________________

	Left Abutment	Piers	Right Abutment
Bed Materials, D_{50}			
Footing Exposure			
Pile Exposure			
Local Scour Depth			
Skew Angle			
Bank Erosion			
Countermeasures			
Condition			
High Water Marks			
Debris			

Bed Slope	Low	Medium	Steep
Vertical Channel Stability	Stable	Aggrading	Degrading
Observed Flow Condition	Ponded	Flow Rapid	Turbulent

Lateral Channel Stability ____

Fish Passage ____

Upstream Headwater Control ____

Project Information

Project Name	
Project Number	
Stream / Station	
Town, State	
Sample Date	
Sampled By	
Sample Method	Wolman Pebble Count

Particle Distribution (%)

silt/clay	
sand	
gravel	
cobble	
boulder	
bedrock	

Sample Site Descriptions by Observations

Channel type	
Misc. Notes	

Particle Sizes (mm)

D16	
D35	
D50	
D84	
D95	

(Bunte and Abt, 2001)

Particle Name	Size Limits (mm) lower	upper	Tally	Count	Percent Passing	Cumulative % Finer
silt/clay	0	**0.063**			0.0	0.0
very fine sand	0.063	**0.125**			0.0	0.0
fine sand	0.125	**0.250**			0.0	0.0
medium sand	0.250	**0.500**			0.0	0.0
coarse sand	0.500	**1**			0.0	0.0
very coarse sand	1	**2**			0.0	0.0
very fine gravel	2	**4**			0.0	0.0
fine gravel	4	**5.7**			0.0	0.0
fine gravel	5.7	**8**			0.0	0.0
medium gravel	8	**11.3**			0.0	0.0
medium gravel	11.3	**16**			0.0	0.0
coarse gravel	16	**22.6**			0.0	0.0
coarse gravel	22.6	**32**			0.0	0.0
very coarse gravel	32	**45**			0.0	0.0
very coarse gravel	45	**60**			0.0	0.0
small cobble	60	**90**			0.0	0.0
medium cobble	90	**128**			0.0	0.0
large cobble	128	**180**			0.0	0.0
very large cobble	180	**256**			0.0	0.0
small boulder	256	**362**			0.0	0.0
small boulder	362	**512**			0.0	0.0
medium boulder	512	**1024**			0.0	0.0
large boulder	1024	**2048**			0.0	0.0
very large boulder	2048	**4096**			0.0	0.0
bedrock	4096	**-**			0.0	0.0
			Total	0	0.0	-

(Wenthworth, 1922)

F-T Particle Sizes (mm)

F-T n-value	0.5
D16	
D5	

(Fuller and Thompson, 1907)

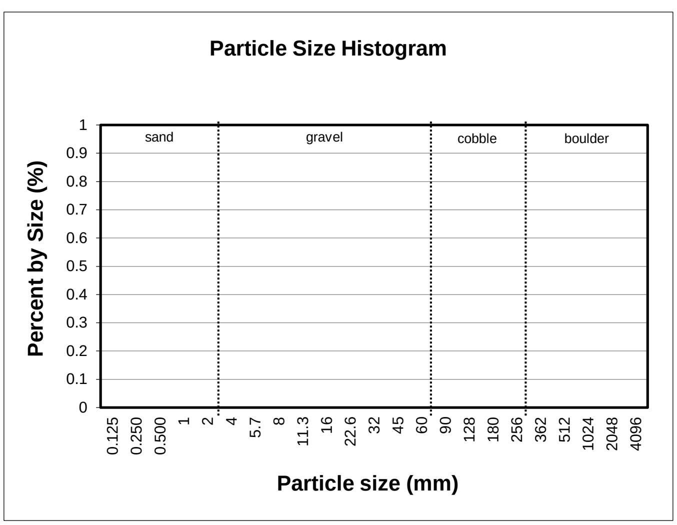
D (mm) of the largest mobile particles on bar

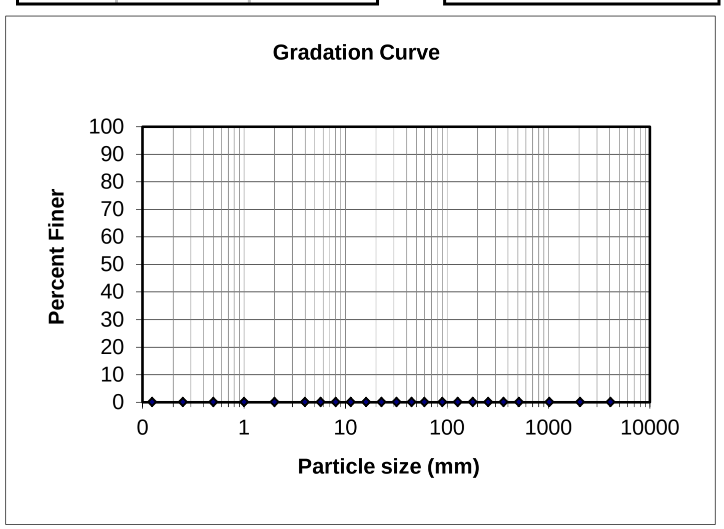
Mean	

Riffle Stability Index (%)

(Kappesser, 2002)

Notes





APPENDIX C

Nowadaga Creek Photo Log

Engineering, Landscape Architecture and Environmental Science
MILONE & MACBROOM®
99 Realty Drive
Cheshire, Connecticut 06410
(203 271-1773

Nowadaga Creek
Photo Log

MMI# 5231-01
NYDOT
January 2014

PROJECT PHOTOS

PHOTO NO.:

1

DESCRIPTION:

Located at approximate STA 224+00 is a constructed berm along the banks of the creek aimed at confining flow to the main channel.

PHOTO NO.:

2

DESCRIPTION:

Looking from the opposide bank of the river as above, this depicts the higher elevation of the berm relative to the height of the road.

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(203 271-1773

Nowadaga Creek
Photo Log

MMI# 5231-01
NYDOT
January 2014

PHOTO NO.:

3

DESCRIPTION:

The Creek Road Bridge crossing at STA 142+00 has a history of ice and debris jamming that restrict floodwaters and causes water to overtop the road.

PHOTO NO.:

4

DESCRIPTION:

The channel has become unstable between STA 126+00 and 112+00, where the channel is braiding and impacting adjacent agricultural land.

Engineering, Landscape Architecture and Environmental Science
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Cheshire, Connecticut 06410
(203 271-1773

PHOTO NO.: **5** DESCRIPTION: Looking downstream from the Creek Road crossing at STA 99+00, a sediment bar has aggradated mid-channel and a small bank failure can be seen downstream.	
PHOTO NO.: **6** DESCRIPTION: In the lower stretch of Nowadaga Creek, the river channel significantly widens, inducing heavy deposition of sediments.	

APPENDIX D

Flood Storage Computations

Engineering, Planning,
Landscape Architecture
and Environmental Science

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99 Realty Drive
Cheshire, Connecticut 06410
(203) 271-1773 Fax (203) 272-9733

JOB 5231-01

SHEET NO. ____ OF ____

CALCULATED BY JCS DATE 1/31/14

CHECKED BY ____ DATE ____

SCALE ____

Nowadaga Creek Sta. 116+00

Total Watershed contributing to Potential Storage Area:

$A = 29.4\ mi^2 = 819,624,960\ ft^2$

Assume 7 in rainfall & 30% runoff over entire watershed:

$V = 819,624,960\ ft^2 \times 7in \times \frac{1\ ft}{12\ in} \times 0.3$

$= 143,434,368\ CF$

$= 5,312,384\ CY$

Available Storage at Site

Alt. 1 Grade & Berm @ 116+00 - including 1 ft freeboard

Storage	Storage (% of V)
308,662 CY	6%

6% < 10% therefore not feasible

Computed By: JCS 1/31/14
Checked By:________________
MMI# 5231-01

Existing Conditions
Stage vs. Storage

Existing conditions calculations could not be completed due to lack of existing berm.

Alt. 1 - Berm and Grading
Stage vs. Storage

Distance Below Spillway (ft)	Elevation (ft.)	Area (s.f.)	Incremental Volume (c.f.)	Incremental Volume (c.y.)	Incremental Volume with 1 ft Freeboard (c.y.)
0	440	987,531	976,891	36,181	0
1	439	966,250	955,336	35,383	35,383
2	438	944,422	932,530	34,538	34,538
3	437	920,638	902,284	33,418	33,418
4	436	883,930	860,213	31,860	31,860
5	435	836,496	811,638	30,061	30,061
6	434	786,780	748,837	27,735	27,735
7	433	710,893	667,980	24,740	24,740
8	432	625,066	593,932	21,997	21,997
9	431	562,797	505,831	18,734	18,734
10	430	448,864	399,757	14,806	14,806
11	429	350,649	299,293	11,085	11,085
12	428	247937	204,859	7,587	7,587
13	427	161,780	146,616	5,430	5,430
14	426	131,451	110,039	4,076	4,076
15	425	88,627	77,029	2,853	2,853
16	424	65,430	55,748	2,065	2,065
17	423	46,066	39,012	1,445	1,445
18	422	31,958	22,955	850	850
19	421	13,952	0	0	0
		Total:	**9,310,776**	**344,844**	**308,662**