LOCAL FLOOD ANALYSIS

TOWN OF MIDDLETOWN – HAMLET OF ARKVILLE

October 2016
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MMI #5197-07

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ABBREVIATIONS/ACRONYMS

BCA	Benefit-Cost Analysis
BCR	Benefit-Cost Ratio
BFE	Base Flood Elevation
CFS	Cubic Feet per Second
CWC	Catskill Watershed Corporation
CY	Cubic Yards
DCSWCD	Delaware County Soil and Water Conservation District
DFIRM	Digital Flood Insurance Rate Map
FEMA	Federal Emergency Management Agency
FHMIP	Flood Hazard Mitigation Implementation Program
FIRM	Flood Insurance Rate Map
FIS	Flood Insurance Study
FTP	File Transfer Protocol
GIS	Geographic Information System
HEC-RAS	Hydrologic Engineering Center – River Analysis System
HMP	Hazard Mitigation Plan
LFA	Local Flood Analysis
LiDAR	Light Detection and Ranging
LOMR	Letter of Map Revision
MMI	Milone & MacBroom, Inc.
NFIP	National Flood Insurance Program
NRCS	Natural Resource Conservation Service
NYCDEP	New York City Department of Environmental Protection
NYSDEC	New York State Department of Environmental Conservation
PMR	Physical Map Revision
SCMP	Stream Corridor Management Plan
SFHA	Special Flood Hazard Area
SMP	Stream Management Program
STA	River Station
USACE	United States Army Corps of Engineers
USGS	United States Geological Survey

EXECUTIVE SUMMARY

The subject Local Flood Analysis (LFA) was undertaken in partnership with the East Branch Flood Commission and the Town of Middletown (the Town) to evaluate potential flood mitigation options along the East Branch Delaware River, Dry Brook, and the Bush Kill in the Hamlet of Arkville. Flooding has long been a problem in the community, evidenced most recently by the devastation during the flood of Tropical Storm Irene. The Town guided this LFA through a number of Town Board and public meetings in 2015 and 2016.

The LFA study area was selected to coincide with the majority of the developed area within the Hamlet of Arkville, extending slightly downstream of the community boundary into the Town of Margaretville. In the Arkville section of Middletown, the Bush Kill joins Dry Brook. Dry Brook then discharges into the East Branch Delaware River only a short distance further downstream. The East Branch discharges into the Pepacton Reservoir, a drinking water supply source to the New York City water system. As such, flooding in Arkville has the potential to directly impact water quality in the Pepacton Reservoir.

Sources of information that have informed this LFA include the effective FEMA Flood Insurance Study (FIS), the Stream Corridor Management Plan (SCMP) for the East Branch Delaware River, the Delaware County Hazard Mitigation Plan (HMP), and accounts of flood events that have impacted Arkville.

Two general types of flood mitigation options were considered in Arkville – those in the river corridor that result in improvements to the river hydraulics and those that are property-specific[1]. Hydraulic options change the water surface elevation and flow velocities during high river flow conditions. The primary objective identified by the East Branch Flood Commission and the Town of Middletown was to develop a set of flood mitigation alternatives that would eliminate, or at least reduce the risk of flood damage to businesses and homes in Arkville.

Over the course of conducting the LFA, initial alternatives were modified and adjusted to maximize the reduction of floodwater elevations. Other alternatives were suggested by the East Branch Flood Commission and the Town, and subsequently evaluated for the LFA. A total of 14 hydraulic alternatives were considered. Many of the alternatives analyzed sought to reduce flooding caused by hydraulic constriction at the numerous bridges in the study area.

Bridges within the project area are shown on Figure 2-1. The following bridge options were initially identified for the LFA study area (with the prefix "BR" denoting a bridge replacement or removal):

- Alternative BR-1: Replacement of Route 38 Bridge over East Branch Delaware River
- Alternative BR-2: Replacement of Route 28 Bridge over Dry Brook with floodplain
- Alternative BR-3: Removal of Erpf Road Bridge over Dry Brook
- Alternative BR-4: Removal of Railroad Bridge over Bush Kill

The following alternatives represent floodplain projects:

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[1] For the purpose of this document, property specific mitigations are those that are accomplished at the building such as elevation, floodproofing, or acquisition.

- Alternative FP-1: South of Route 38 Bridge over East Branch Delaware River
- Alternative FP-2: Field near Route 28 Bridge over Dry Brook
- Alternative FP-3: Opposite Town Hall building
- Alternative FP-4: Upstream of Route 28 Bridge over Dry Brook
- Alternative FP-5: Downstream of Route 28 Bridge over Dry Brook near Pavilion Road

Two levee alternatives and a bypass channel were considered:

- Alternative LV-1: Levee at Lamphere Lane
- Alternative LV-2: Levee at Erpf Maze
- Alternative BC-1: Bypass channel at Route 28 Bridge over Dry Brook

Finally, several combinations of the above alternatives were considered:

- Combination 1: Bypass channel at Route 28 Bridge with floodplain up and downstream of bridge (BC-1 + FP-4 + FP-5)
- Combination 2: Route 28 Bridge replacement with floodplain up and downstream of bridge (BR-2 + FP-4 + FP-5)

Hydraulic analysis of Dry Brook, Bush Kill, and the East Branch Delaware River was conducted using the HEC-RAS program. The HEC-RAS software (*River Analysis System*) was written by the United States Army Corps of Engineers (USACE) Hydrologic Engineering Center (HEC) and is considered to be the industry standard for riverine flood analysis. The model is used to compute water surface profiles for one-dimensional, steady-state, or time-varied flow. The model utilized for this analysis originated with the FIS published in 2016 and its supporting documentation.

By and large, all of the evaluated flood mitigation alternatives will reduce floodwater surface elevations; however, they do predict that water will still reach sections of Pavilion Road, Franks Street, Finnerty Lane, and other roads as well as many properties. The majority of the properties in the study area that are currently in the special flood hazard area (SFHA) associated with Dry Brook, East Branch Delaware River, and Bush Kill *will remain* in the SFHA, and therefore will be subject to continued flood risk and flood insurance coverage requirements. However, a reduction of floodwater surface elevations may lead to reduced time and costs for cleanup and recovery after floods; and may reduce flood insurance premiums for some properties if flood maps are modified.

A Benefit-Cost Analysis (BCA) was conducted to validate the cost-effectiveness of proposed hazard mitigation projects. A BCA is a method by which the future benefits of a project are estimated and compared to its cost. The end result is a benefit-cost ratio (BCR), which is derived from a project's total net benefits divided by its total project cost. The BCR is a numerical expression of the cost effectiveness of a project. A project is considered to be cost effective when the BCR is 1.0 or greater, indicating the long-term benefits of the project are sufficient to justify the upfront and long-term costs. A BCA was conducted for the proposed alternatives BC-1, BR-2, FP-5, Combination 1, and Combination 2. Costs and benefits are compared in Table ES-1.

Based on the BCA conducted for this LFA, one flood mitigation project (FP-5 floodplain near Pavilion Road) has a BCR above 1.0. A "water quality benefit" multiplier is not applicable to any of the projects.

TABLE ES-1
Comparison of Costs and Benefits

Alternative		Cost Estimates	Total Benefits	BCR
BC-1: Bypass Channel by Route 28 Bridge	❑ Create bypass channel under Route 28 Bridge ❑ Replace existing culvert with bridge over bypass channel ❑ Removal of buildings	$2,533,047	$265,109	0.10
BR-2: Route 28 Bridge Replacement	❑ Replace Route 28 Bridge over Dry Brook ❑ Create floodplains FP-4 and FP-5 up and downstream of Route 28 ❑ Removal of buildings	$8,940,999	$2,153,405	0.24
FP-5: Floodplain near Pavilion Road	❑ Floodplain downstream of Route 28 Bridge along Pavilion Road ❑ Removal of buildings	$806,018	$1,046,690	1.29
Combination 1: Bypass Channel with Floodplains	❑ Create bypass channel BC-1 ❑ Create floodplains FP-4 and FP-5 up and downstream of Route 28 ❑ Removal of buildings	$3,387,748	$807,756	0.24
Combination 2: Route 28 Bridge Replacement with Floodplains	❑ Replace Route 28 Bridge ❑ Create floodplains FP-4 and FP-5 up and downstream of Route 28 ❑ Removal of buildings	$9,795,700	$2,631,778	0.27

Creation of extensive floodwalls and levees is not supported by the East Branch Flood Commission due to the issues and risks associated with levee operation. Widespread removal of buildings from the hamlet center is also not supported by the LFA, as the community would suffer from the disruption to its central business district.

Individual property owners will likely need to elevate or floodproof their properties over time as substantial damage or substantial improvement thresholds are triggered. However, optional elevations and floodproofing may be desired in strategic locations where unacceptable flood risk remains after flood mitigation projects are implemented. This will have the dual benefit of reducing flood risks while reducing flood insurance premiums for those properties that are insured.

Finally, key anchor businesses and critical facilities may wish to relocate out of zones of unacceptable flood risk.

In summary, the LFA completed for Arkville has demonstrated that many flood mitigation projects have merit because they will reduce floodwater surface elevations in the hamlet. These projects largely depend on the enhancement of floodplains and creation of lower floodplains coupled with a handful of bridge replacements and strategic building removals and business relocations. The following flood mitigation recommendations are offered:

1. Proceed with further study and apply for funding for the floodplain along Pavilion Road (FP-5).

2. Pursue floodproofing of commercial buildings in Arkville. Floodproofing should include sealing of lower portions of buildings, including doors and other openings, and elevation of building utilities. Ensure that floodproofing is viable under a set of potential future conditions.

3. When opportunities arise for acquisitions where floodplain projects may be effective, support these acquisitions.

4. When opportunities arise for building elevation where floodplain projects are not envisioned, support these elevations. Ensure that elevations are conducted in accordance with the effective BFE at the time of the work.

5. Continue the process of making space for a bypass channel under Route 28 and identify alternate funding sources to pursue the bypass.

6. Ensure that future bridge replacements consider the benefits of enlarging the openings to reduce flooding.

7. Periodically address sediment and gravel buildup with targeted removal projects.

8. Install an automated flood warning system for Arkville and/or the Village of Margaretville, or join forces with the Village of Fleischmanns to install a system that works for both.

Numerous projects described in this report will not likely have BCRs above 1.0. However, many of these remain appropriate flood mitigation projects that could be eligible for funding by other State and Federal Programs such as the Department of Environmental Conservation Water Quality Improvement Project (DEC WQIP) or the U.S. Army Corps of Engineers Water Resources Development Act (USACE WRDA). Table ES-2 summarizes the recommended action for each project.

With the exception of the projects near the Route 28 bridge, most of the projects are not located close enough to each other to affect one another. Because they do not adversely affect one another, projects may be pursued individually.

Several funding sources may be available to the East Branch Flood Commission, the Town, and Delaware County and its departments for the implementation of recommendations. These are listed in Table ES-3; descriptions are provided in Section 6.4.

Table ES-4 lists potential funding sources for property mitigation and relocations.

As this LFA plan is implemented, the East Branch Flood Commission and Town of Middletown will need to work closely with potential funders to ensure that the best combinations of funds are secured for the modeled alternatives and for the property-specific mitigation such as floodproofing, elevations, and relocations. The Town of Middletown should apply for funds through the Catskill Watershed Corporation (CWC) Sustainable Communities Planning Program to plan for relocating businesses and residents within the town.

TABLE ES-2
Recommended Action

Alternative		BCR	Recommended Action
BC-1: Bypass Channel by Route 28 Bridge	❑ Create bypass channel under Route 28 Bridge ❑ Replace existing culvert with bridge over bypass channel ❑ Removal of buildings	0.10	Continue the process of making space for Route 28, and identify alternate funding sources to pursue bypass.
BR-2: Route 28 Bridge Replacement	❑ Replace Route 28 Bridge over Dry Brook ❑ Create floodplains FP-4 and FP-5 up and downstream of Route 28 ❑ Removal of buildings	0.24	Unless washouts at this bridge are a significant concern, do not pursue at this time. Consider when bridge is ready for replacement due to its age.
FP-5: Floodplain near Pavilion Road	❑ Floodplain downstream of Route 28 Bridge along Pavilion Road ❑ Removal of buildings	1.29	BCR is greater than 1, but this is due to acquisitions. Consider if opportunities arise to acquire properties.
Combination 1: Bypass Channel with Floodplains	❑ Create bypass channel BC-1 ❑ Create floodplains FP-4 and FP-5 up and downstream of Route 28 ❑ Removal of buildings	0.24	Too intrusive relative to the benefits; do not pursue unless opportunities arise to acquire properties.
Combination 2: Route 28 Bridge Replacement with Floodplains	❑ Replace Route 28 Bridge ❑ Create floodplains FP-4 and FP-5 up and downstream of Route 28 ❑ Removal of buildings	0.27	Too intrusive relative to the benefits; do not pursue unless bridge is ready for replacement.

TABLE ES-3
Potential Funding Sources for Components of Mitigation Projects

Alternative		Federal	State	Other
BC-1	Acquisition and removal of 65 Pavilion Road	FEMA	NYSDOS	NYCDEP Buyout, CWC
	Create new bridge for bypass channel	None	NYSDOT	DCSWCD SMP, CWC
	Create bypass channel	USACE	NYSDOS	DCSWCD SMP, CWC
BR-2	Acquisition and removal of buildings for floodplain	FEMA	NYSDOS	NYCDEP Buyout, CWC
	Replace Route 28 Bridge over Dry Brook	None	NYSDOT	DCSWCD SMP, CWC
	Create floodplain near Route 28	USACE	NYSDOS	DCSWCD SMP, CWC
FP-5	Acquisition and removal of buildings for floodplain	FEMA	NYSDOS	NYCDEP Buyout, CWC
	Create floodplain near Pavilion Road	USACE	NYSDOS	DCSWCD SMP, CWC
Combo-1	Acquisition and removal of buildings for floodplains	FEMA	NYSDOS	NYCDEP Buyout, CWC
	Create new bridge for bypass channel	None	NYSDOT	DCSWCD SMP, CWC
	Creation of bypass channel	USACE	NYSDOS	DCSWCD SMP, CWC
	Create floodplains FP-4 and FP-5 upstream and downstream of Route 28 Bridge	USACE	NYSDOS	DCSWCD SMP, CWC
	Create new bridge for bypass channel	None	NYSDOT	DCSWCD SMP, CWC
Combo-2	Acquisition and removal of buildings for floodplains	FEMA	NYSDOS	NYCDEP Buyout, CWC
	Replace Route 28 Bridge over Dry Brook	None	NYSDOT	DCSWCD SMP, CWC
	Create floodplains FP-4 and FP-5 up and downstream of Route 28 Bridge	USACE	NYSDOS	DCSWCD SMP, CWC

TABLE ES-4
Potential Funding Sources for Other Mitigation Projects

Option	Federal	State	Other
Floodproofing of individual nonresidential buildings	FEMA	NYSDOS	None
Elevation of individual nonresidential buildings in floodway*	None	None	None
Elevation of individual residential buildings in floodway*	None	None	None
Elevation of individual nonresidential buildings outside of floodway	FEMA	NYSDOS	CWC
Elevation of individual residential buildings outside of floodway	FEMA	None	CWC
Relocation of anchor businesses and critical facilities	FEMA	NYSDOS	NYCDEP Buyout, CWC

* Elevation of buildings within the floodway is not recommended.

1.0 INTRODUCTION

1.1 Project Background

The East Branch Flood Commission and the Town of Middletown, utilizing funding provided by the New York City Department of Environmental Protection (NYCDEP) through the Delaware County Soil and Water Conservation District (DCSWCD), have retained Milone & MacBroom, Inc. (MMI) to complete a Local Flood Analysis (LFA) in the Hamlet of Arkville, Middletown, New York. The LFA builds upon Federal Emergency Management Agency (FEMA) modeling to evaluate flood risks along the East Branch Delaware River, Dry Brook, and the Bush Kill, and assess potential mitigation measures aimed at reducing flood inundation and the associated damages and water quality impairment that may occur due to floods.

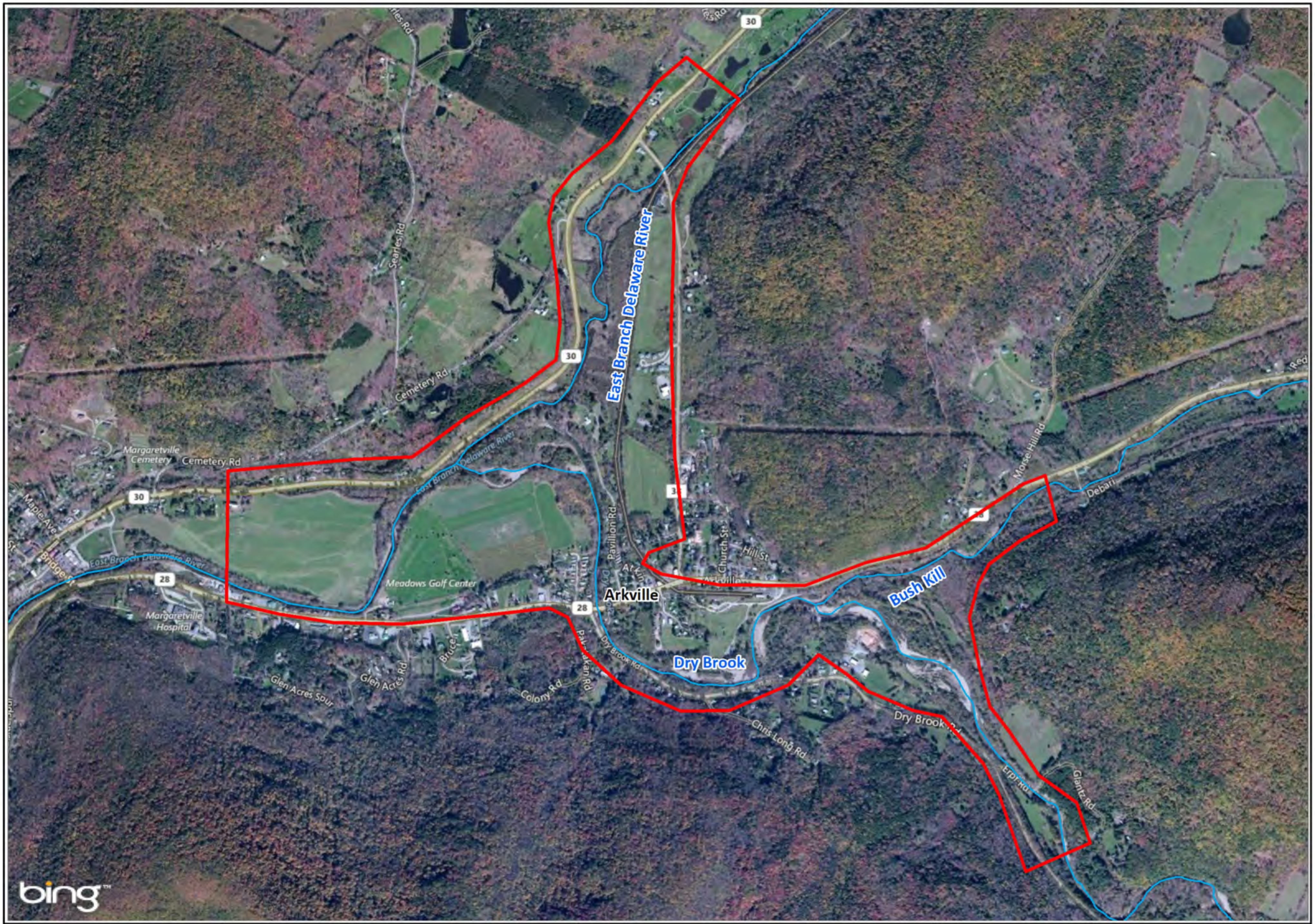
The LFA program is aimed at floodprone areas within in the New York City drinking water supply watershed. The purpose of the LFA program is to help communities identify long-term, cost-effective projects to mitigate flood hazards. The DCSWCD is implementing the LFA program in the watershed communities associated with the West Branch and East Branch Delaware Rivers.

The subject LFA was undertaken separately from the New York Rising Community Reconstruction (NYRCR) program. The NYRCR program was intended to provide rebuilding and resiliency assistance to communities that were severely damaged by Tropical Storms Irene and Lee, Superstorm Sandy, and the summer floods of 2013. The subject LFA is an engineering feasibility analysis that develops a range of flood hazard mitigation alternatives, with the primary focus of identifying options that reduce flood elevations and inundation.

1.2 Study Area

The subject LFA study area largely coincides with the extents of the Hamlet of Arkville. The East Branch Delaware discharges into the Pepacton Reservoir, a drinking water supply source of the New York City public water system. The graphic to the right depicts the West Branch and East Branch Delaware Rivers relative to Delaware County and adjacent counties.

Figure 1-1 is a location plan of the study area, situated along Dry Brook, East Branch Delaware River, and Bush Kill through the Hamlet of Arkville.



SOURCE(S):
Base Map: Image courtesy of USGS
Earthstar Geographics SIO © 2017
Microsoft Corporation © 2017 HERE ©

N

MXD: Y:\5197-07\Maps\Fig 1-1 Study Area.mxd

Figure 1-1: Study Area

Arkville Local Flood Analysis

LOCATION: Arkville, NY

Map By:	JCS
MMI#:	5197-07
Original:	6/15/2016
Revision:	1/26/2017
Scale:	1 in = 1,500 ft

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The Hamlet of Arkville is located in the Town of Middletown in Delaware County, only a mile from the Village of Margaretville. Arkville was one of the first commercial centers within the Town of Middletown. In the late 1800s and early 1900s, a wood acid factory owned by the Treyz and Luzerne Chemical companies was located in Arkville and used the Ulster and Delaware Railroad to transport charcoal, wood alcohol, and wood acid. The Middletown Historical Society website includes a historical profile of the Arkville hamlet. Portions of this profile are reprinted in the box to the right.

Historical Profile of Arkville from Historical Society of Middletown

Arkville, a mile east of the Village of Margaretville on NYS Route 28, is one of the earliest commercial centers in Middletown. It got its name, so the story goes, following the "pumpkin freshet" that occurred soon after the return of the settlers at the close of the Revolution. Coming in the autumn, before the crops had been gathered, the flood floated pumpkins off the fields until the Bush Kill stream was covered by them. The elevated position of Simeon (Hendrick?) Von Waggoner's tavern (now the site of the Erpf House on the knoll next to the Arkville Fire Hall) at the time of this flood suggested the name of Arkville. This property was acquired in 1826 by Colonel Noah Dimmick whose name may also have inspired the story of 'Ark'ville.

Arkville was a bustling business center that grew up on the Esopus and Ithaca turnpike, and later the Arkville and Delhi turnpike which was chartered in 1840 and completed in 1849. It extended from Highmount to Delhi. By 1871, the Ulster & Delaware Railroad had arrived. The first train stopped at the Arkville U&D station October 24, 1871.

Arkville was also the headquarters for a group of prominent Catskill Mountain landscape painters from 1886 to 1921. The Pakatakan Artists Colony, located off NYS Route 28 just west of Dry Brook Road, contained the summer cottages and studios of 13 artists.

The village is primarily situated along Dry Brook, which flows between Dry Brook Road and Route 28 until it passes under the Route 28 bridge. The Bush Kill flows into Dry Brook approximately 3,800 feet upstream of the Route 28 bridge over Dry Brook. Dry Brook then flows into the East Branch Delaware River downstream of the center of Arkville. Dry Brook flows from the southeast, whereas Bush Kill enters Arkville from the northeast. The East Branch Delaware River generally flows towards the southwest in the vicinity of Arkville.

The upstream project boundaries extend 2.25 miles upstream along Dry Brook from the confluence with East Branch Delaware River and 0.64 mile upstream along Bush Kill from its confluence with Dry Brook. Along the East Branch Delaware River, the LFA extends 0.74 mile downstream of the confluence with Dry Brook and 1.24 miles upstream of the confluence with Dry Brook.

Population data is not available for Arkville. In 2007, Delaware County's population loss was -2.2% and the Town of Middletown's population loss was -4.1%. According to the Town of Middletown Comprehensive Plan (2011), the number of housing units in Middletown in 2000 was 3,013. However, the Town of Middletown Comprehensive Plan (2011) speaks of a significant part-time population of second homeowners.

1.3 Community Involvement

The East Branch Flood Commission and Town of Middletown have guided the LFA process and advised MMI regarding which mitigation alternatives to evaluate. Table 1-1 lists the members of the Flood Commission and town that participated in the LFA. Table 1-2 lists Town meeting dates that occurred when this particular LFA was on the agenda for discussion. The LFA process included two public meetings. These were held near the beginning and end of the LFA project as noted in Table 1-3. Appendix A contains copies of the presentation used at meetings listed in Tables 1-2 and 1-3, along with meeting notes.

TABLE 1-1
Flood Commission Members

Committee Member	Affiliation
Marjorie Miller	Former Middletown Town Supervisor
Patrick Davis, CFM	Current Middletown Town Supervisor
John Mathiesen	Catskill Watershed Corporation
Graydon Dutcher, CFM	Delaware County Soil and Water Conservation District
Rick Weidenbach	Delaware County Soil and Water Conservation District
Jessica Rall, CFM	Delaware County Soil and Water Conservation District
Bill Willis	Delaware County Economic Development Department
Steve Hood	Delaware County Department of Emergency Services
Dean Frazier	Delaware County Watershed Affairs Commissioner
Wayne Reynolds	Delaware County Department of Public Works
Molly Oliver	Delaware County Department of Watershed Affairs
Kent Manuel	Delaware County Planning Department
Kristin Schneider, CFM	Delaware County Planning Department
Nate Hendricks, CFM	NYCDEP
Phil Eskeli, CFM	NYCDEP

TABLE 1-2
Meeting Dates

Date	Purpose
June 29, 2015	Introduction and overview of the Arkville LFA
January 26, 2016	Update on flood mitigation hydraulic modeling results
February 29, 2016	Update on flood mitigation and benefit cost analysis results

TABLE 1-3
Public Meeting Dates

Date	Purpose
August 12, 2015	Present LFA background, purpose, types of flood mitigation, and preliminary modeling
April 6, 2016	Findings of Arkville LFA

1.4 Nomenclature

In this report and associated mapping, stream stationing is occasionally used as an address to identify specific points along the East Branch Delaware River, Dry Brook, and Bush Kill. Stationing is typically measured in feet from a downstream point of reference. To simplify the nomenclature, the FEMA cross section stationing was used for the LFA. 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. The datum used throughout this report is NAVD88.

In order to provide a common standard, FEMA's National Flood Insurance Program (NFIP) has adopted a baseline probability called the base flood. The base flood has a one percent (one in 100) chance of occurring in any given year, and the base flood elevation (BFE) is the elevation of this level. For the purpose of this report, the one percent annual chance flood is referred to as the *100-year flood event*. Other reoccurrence probabilities used in this report include the *2-year flood event* (50 percent annual chance flood), the *10-year flood event* (10 percent annual chance flood), the *25-year flood event* (4 percent annual chance flood), the *50-year flood event* (2 percent annual chance flood), and the *500-year flood event* (0.2 percent annual chance flood). The Special Flood Hazard Area (SFHA) is the area inundated by flooding during the 100-year flood event. The floodway is a portion of the SFHA that must be reserved in order to discharge the base flood without increasing the water surface elevation more than a designated height.

2.0 WATERSHED FACTS AND CHARACTERISTICS

2.1 Initial Data Collection

Initial data collected for this analysis included publicly available data as well as input from DCSWCD representatives. Chapter 7.0 includes a full listing of resource material gathered. A brief summary of key documents follows.

Flood Insurance Study

The current Flood Insurance Study (FIS) for Delaware County became effective on June 16, 2016. The FIS covers all jurisdictions in the county, inclusive of the Town of Middletown. The FIS covering Arkville resulted in FIRM panels that were also effective on June 16, 2016. A copy of the effective FIRM is presented on the next page as Figure 2-1.

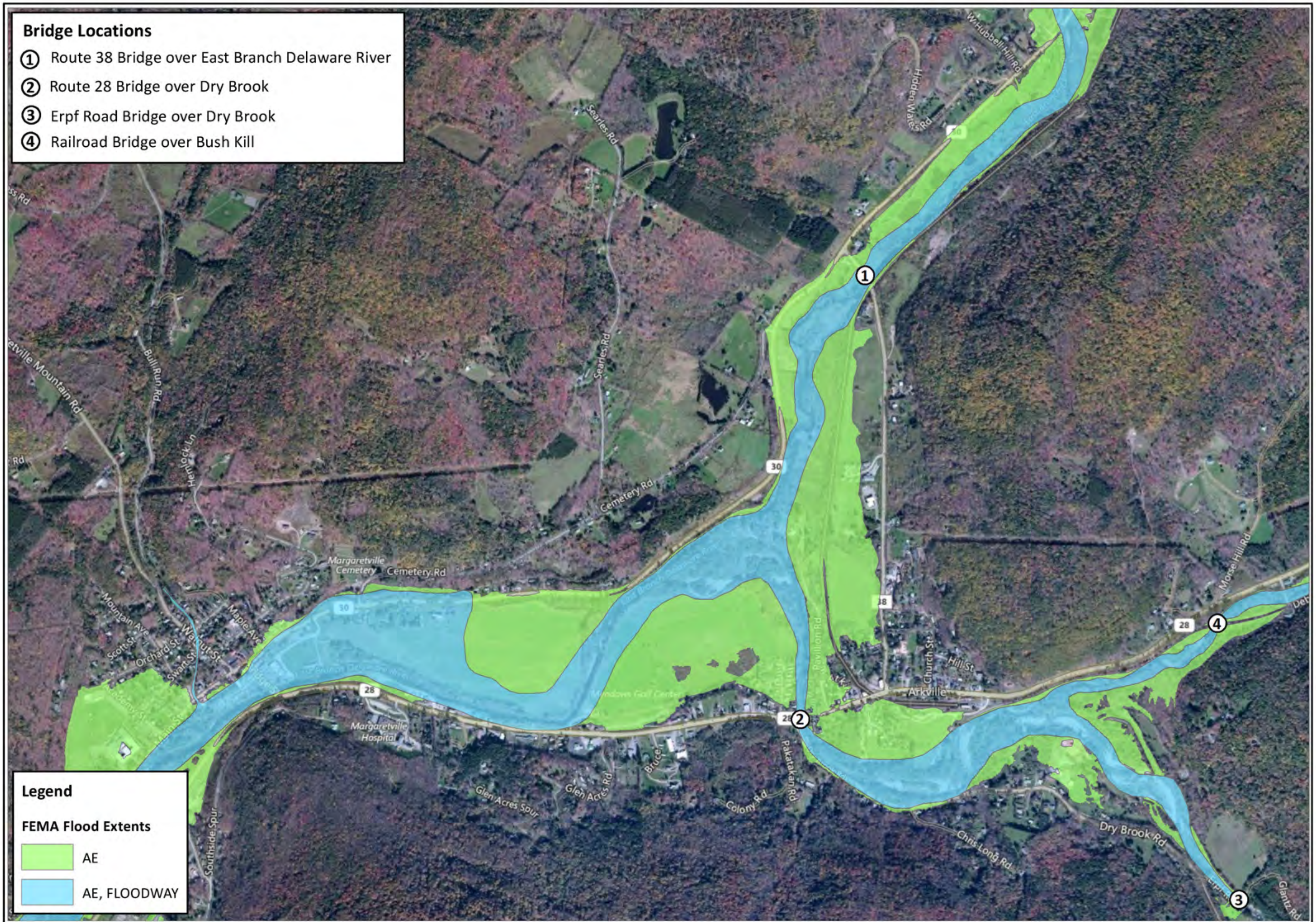
Stream Management Plan

Central to maintaining NYCDEP's Filtration Avoidance Demonstration (FAD) is a series of partnership programs between New York City and the upstate communities, along with a set of rules and regulations administered by NYCDEP. As required in the FAD, Stream Corridor Management Plans (SCMPs) are developed and implemented under the Stream Management Program (SMP). The East Branch Delaware River SCMP was developed by DCSWCD and the Delaware County Planning Department (DCPD) under contract to NYCDEP. One component of the SCMP is the preservation of water quality through effective management of the streams and associated floodplains that feed water supply reservoirs.

The SCMP describes geomorphic types based on the Vermont Agency of Natural Resources Stream Geomorphic Assessment (SGAT) protocol. The East Branch Delaware River and Bush Kill are primarily C type streams. Rosgen classification was used for Dry Brook, which is mostly a Rosgen type C stream.

The SCMP states that the primary problem on Dry Brook is the accumulation of sediment near the confluence of Bush Kill. Historic aerials show that Dry Brook has changed course over time. The plan recommends monitoring of the gravel bars and stream capacity of Dry Brook near the confluence with Bush Kill. Further study is needed to determine the source of the high bed load. On the East Branch Delaware River, the main concerns are streambank erosion and access to the floodplain.

The SCMP provides a framework for general stream management decision making in the watershed. The plan provides documentation of current stream conditions along the East Branch Delaware River and its tributaries as well as a broad assessment of the condition of existing infrastructure.



SOURCE(S): Base Map: Image courtesy of USGS Earthstar Geographics SIO © 2017 Microsoft Corporation © 2016 HERE ©	Figure 2-1: FEMA 100-Year Flood Mapping	Arkville Local Flood Analysis	Map By: JCS MMI#: 5197-07 Original: 6/15/2016 Revision: 1/25/2017 Scale: 1 in = 1,500 ft	MILONE & MACBROOM 99 Realty Drive Cheshire, CT 06410 (203) 271-1773 Fax: (203) 272-9733 www.miloneandmacbroom.com
	N MXD: Y:\5197-07\Maps\Fig 2-1 FIRM.mxd	LOCATION: Arkville, NY		

The current version of the SCMP was published in December 2007, before Tropical Storm Irene. Recommendations of the SCMP include the following (with **bold text** added for emphasis relative to this LFA):

- Scientifically-based post-flood emergency stream intervention
- Technical assistance to local highway departments
- Implement streamside assistance program
- **Education and outreach efforts**
- Annual floodplain development permit training for municipal officials
- Enhance local land use laws and ordinances
- Adopt principles of stream stewardship at the municipal level
- Streamline stream work permitting
- Selective stream gravel management
- Provide assistance to community watershed groups/associations and government entities
- Participation with the Delaware County Action Plan
- Debris management
- Prioritization of identified stream intervention projects
- Enhancement of East Branch Watershed fisheries
- Enhance recreation opportunities
- Invasive species management
- **Flood hazard mitigation**
- Flood response and recovery
- Utilize existing funding sources
- Develop a process for updating the EBDR Stream Corridor Management Plan

Multi-Jurisdiction Hazard Mitigation Plan

The Delaware County Hazard Mitigation Plan (HMP) Update was developed in 2012 by Tetra Tech and became effective March 2013. The plan includes an annex report for the Town of Middletown. The following discussions are taken from the HMP annexes.

It is estimated that in the Town of Middletown, 317 residents live within the 1% annual chance (100-year) and 0.2% chance (500-year) floodplains. Of the town's total land area, 3.9 square miles are located within the 1% annual chance flood boundary and 0.2% annual chance flood boundary.

The computer model HAZUS-MH 2.0 estimates that for a 1% annual chance flood event, 212 people may be displaced, and 86 people may seek short-term sheltering, representing 6.6% and 2.7% of the town's population respectively. For the 0.2% annual chance event, it is estimated that 228 people may be displaced, and 95 people may seek short-term sheltering, representing 7.1% and 3.0% of the town's population respectively.

The Town of Middletown has a total of 492 parcels located within the 1% annual chance flood boundary and 493 parcels located within the 0.2% annual chance flood boundary. There is $113,391,914 of total assessed property (structure and land) exposed to the 1% annual chance flood in the Town of Middletown. For the 0.2% annual chance event, it is estimated that $113,627,614 of total assessed property is exposed in the Town of Middletown.

The HAZUS-MH 2.0 program calculates the estimated potential damage to the general building stock inventory associated with the 1% annual chance and 0.2% annual chance flood events. The program estimates approximately $7,758,000 and $9,558,000 of potential general building stock loss as a result of the 1% and 0.2% annual chance mean return period (MRP) events, respectively.

The HMP notes that the town has zoning, subdivision, and flood damage prevention ordinances as well as a comprehensive plan and a highway management plan. Two feet of freeboard is required for new construction in flood zones per the New York State Building Code. Recommendations of the annex that are consistent with the focus of this LFA include the following:

- "Retrofit structures located in hazard-prone areas to protect structures from future damage."
- "Acquire and demolish or relocate structures located in hazard-prone areas to protect structures from future damage."

Water Quality Reports

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

This inventory of water quality information is the division's Waterbody Inventory/Priority Waterbodies List (WI/PWL). The Delaware River Basin WI/PWL was last published in December 2002. The discussion in the text box to the right is provided in the WI/PWL report. NYSDEC has been working on an update to the WI/PWL, but a formal draft has not been published as of the date of this plan.

Biological (macroinvertebrate) assessments of Bush Kill in Arkville were conducted in 1999 and 2000. Sampling results for both years indicated non-impacted water quality conditions. In 1999 the sample satisfied field screening criteria and was returned to the stream. The 2000 sample was returned to the lab for analysis.

NYSDEC Rotating Intensive Basin Studies (RIBS) Intensive Network monitoring of the Bush Kill in Arkville (at Route 28) was conducted in 2000. Chemical sampling of the river identified no significant parameters of concern. Overall water quality at this site is considered to be fully supporting of uses.

The New York State Section 303(d) List of Impaired Waters (September 2014) identifies those waters that do not support appropriate uses and that may require development of a Total Maximum Daily Load (TMDL). The streams within the project area are not listed in the document.

The NYSDEC Water Quality Standards and Classifications program is responsible for setting New York State ambient water quality standards and guidance values for surface water and groundwaters. The program is also responsible for the classification of surface waters for their best usage. The water quality standards program is a state program with United States Environmental Protection Agency oversight. New York's longstanding water quality standards program predates the federal Clean Water Act and protects both surface waters and groundwaters. All waters in New York State are assigned a letter classification that denotes their best uses. Letter classes such as A, B, C, and D are assigned to fresh surface waters. Within the project area, East Branch Delaware River, Bush Kill, and Dry Brook are assigned a water quality classification of C.

Flood Damage Prevention Codes

The Town of Middletown has adopted a local law for flood damage prevention. Revisions were adopted in 2012 to be consistent with the guidance provided by the state in 2007 for counties where new FEMA studies were being conducted. The Town adopted the recommended revisions, which are identical to the revisions adopted in the village, as described below. The stated purposes of this local law are to:

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

The stated objectives of the local law are:

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

The Town of Middletown Building Inspector/Code Enforcement Officer is empowered as the Local Administrator for administering and implementing the Flood Damage Prevention local law. The primary responsibility of the Local Administrator is the granting or denying of floodplain development permits. The Local Administrator must conduct a thorough permit application review prior to approval and must make periodic inspections during the construction phase of a project after permit approval. Finally, upon completion of a project, the Local Administrator must issue a Certificate of Compliance stating that the project conforms to all requirements of the local law.

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

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

Standards for all structures include provisions for anchoring, construction materials and methods, and utilities. New structures must be anchored so as to prevent flotation, collapse, or lateral movement during the base flood. Construction materials must be resistant to flood damage, and construction methods must minimize flood damage. Enclosed areas below the lowest floor in zones A1 through A30, AE or AH, and in some cases Zone A, must be designed to allow for the entry and exit of floodwaters. Utility equipment such as electrical, HVAC, and plumbing connections must be located at a minimum of 2 feet above the base flood elevation. Water supply and sanitary sewage systems must be designed to minimize or eliminate the infiltration of floodwaters.

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

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

2.2 Watershed and Stream Characteristics

The project watershed area is located within 10 townships: Stamford, Roxbury, Lexington, Halcott, Middletown, Shandaken, Fleischmanns, Margaretville, Hardenburgh, and Denning. The East Branch Delaware River watershed at the downstream project boundary is 160 square miles. Subwatersheds associated with streams that form the project boundaries include: Dry Brook (82.31 square miles) and Bush Kill (47.22 square miles).

The East Branch Delaware River watershed becomes steep in the east near Dry Brook as it borders the Catskill region. Most streams in the East Branch watershed are perennial with a branching form. Within the project area, the East Branch Delaware River has access to floodplains on both sides of the river downstream of the confluence with Dry Brook.

Since the early part of the 20th Century, the East Branch Delaware River drainage basin has experienced a gradual increase in forested land as agricultural lands were abandoned and open fields were encroached upon by woody vegetation (DCSWCD, 2007). Agriculture has also declined over the last 40 years, and farm lands have been subdivided into multiple parcels for residential development: a trend supported by a demand for second homes as well as a decline in the dairy industry. Recreational land use has increased, including fishing, canoeing, kayaking, hiking, and birding. The Delaware and Ulster Railroad, based in Arkville, serves as an excursion train between Arkville and Roxbury.

The underlying bedrock geology of Delaware County is sedimentary. The surficial geology for most of the East Branch Delaware River watershed is till, with areas of recent alluvium and Kame deposits near the stream channels. Sand and gravel soils stretch from Arkville and Margaretville to the Pepacton Reservoir (DCSWCD 2007).

East Branch Delaware River

The East Branch Delaware River is a sixth order stream with a generally broad valley. Most of the land surrounding the river is forested, with some more populated areas. The portion of East Branch Delaware River from the confluence with Dry Brook to a point about 8,750 feet downstream has been straightened. The banks have riparian buffers ranging from zero to 25 feet through this reach. Gravel deposition areas are located immediately downstream of the Dry brook confluence where the channel slope becomes more level (DCSWCD 2007). Within this reach, a portion of the East Branch Delaware River is diverted into the Binnekill, a maintained channel that passes through the Village of Margaretville.

From the Dry Brook confluence to a point 15,500 feet upstream, the East Branch Delaware River flows through a broad valley with well-vegetated banks. The floodplains consist of abandoned fields, brush, and a golf course. Depositional features account for 4% of the reach length and eroding stream banks account for 5% of the total reach length (DCSWCD 2007).

Dry Brook

Dry Brook is a fifth-order stream that flows into the East Branch Delaware River downstream of the Route 28 bridge in Arkville. Dry Brook's valley is generally broad to very broad with very steep side slopes. The soils in this area have a high runoff potential, making the Dry Brook watershed prone to flash flooding. The watershed is mostly wooded with some agricultural fields (DCSWCD 2007).

Dry Brook is considered unstable, with many sediment deposits and eroding stream banks. Historic aerials show that the stream has changed location numerous times. It has cut down to bedrock in some locations, including the section upstream of the Route 28 bridge. The high levels of sediment deposition along Dry Brook may be caused by increased stream length and exposed eroding banks, sediment contributions from tributaries, and a flatter valley gradient in the downstream reaches of the channel (DCSWCD 2007). Through the project area, many structures are located within the 100-year floodplain.

Bush Kill

The Bush Kill flows into Dry Brook upstream of the center of Arkville. The Bush Kill is a fourth-order stream with a channel that is constrained within the project boundaries by a railroad and Route 28 along the right bank. Sinuosity of the Bush Kill ranges from 1.00 to 1.13. About 23% of the channel is bermed and 23% of the channel has revetment protection (DCSWCD 2007). Upstream of Arkville, the Bush Kill has been affected by development, and land uses encroach on the floodplain. Within the project area, the Bush Kill is confined along the right bank by the Ulster and Delaware railroad and Route 28, but has access to a floodplain on the left bank near the confluence of Dry Brook and Bush Kill.

The total length of the Bush Kill from its upstream limit at the confluence of Vly Creek and Emory Brook to its confluence with Dry Brook is 5.3 miles. Along this course, the slope is 0.5%. Within the project area, the Bush Kill generally flows in a southwestern direction. It can be characterized as an alluvial river, meaning its channel is located on sediment previously placed by the river. Alluvial rivers adjust their shape, size, and slope in response to flow rates and sediment loads. The channel bed sediments are primarily gravel and cobble.

2.3 Field Assessment

MMI staff conducted visual inspections of Dry Brook, East Branch Delaware River, and Bush Kill. In general, the inspections were focused on (1) the river channel and its banks (bank and channel conditions, sediment bars, vegetation along the stream corridor); and (2) development in the floodplains.

2.3.1 Visual Assessment of Structures

Visual assessment of the structures within the FEMA flood zone was conducted by MMI on March 12, June 22, June 29, and August 12, 2015. The repeated inspections were necessary to help refine and reality-check the modeling of alternatives and the BCA. Photographs of the buildings within the flood zones were taken along with notes on structures located within the floodplain. Notes regarding accessory structures were also collected. Several of the lots that formerly contained mobile homes were vacant at the time of the site walk.

When observing the stream channel and adjacent floodplains, the following were noted:

- ❑ Does the stream profile match the profile in the FIS and model?
- ❑ Do stream cross sections match the cross sections in the model?
- ❑ Do the Manning n values in the model represent current riverbank and floodplain conditions?
- ❑ Do hydraulic variances in the model make sense relative to the field conditions, such as channel restrictions and bridges?

When observing structures, the following were noted:

- ❑ Do the property and building(s) match the parcel data provided by the Delaware County Planning Department?
- ❑ Is the property in the SFHA or 500-year flood zone? Is the structure in the SFHA or 500-year flood zone?
- ❑ What is the current land use and building use?
- ❑ Does the building have a basement?
- ❑ Is the building vacant or occupied?
- ❑ What is the elevation of the first floor in relation to adjacent grade?
- ❑ For single-family homes, how many feet (vertical) above the adjacent grade is the first floor?
- ❑ Are any unique features present in the building or property that would increase or decrease vulnerability to flooding?
- ❑ Is there any direct evidence of past flooding such as mud in a window sill?

Businesses are located within the 1% annual chance FEMA floodway along Route 28 near the Middletown Town Hall. The majority of the buildings in Arkville within the FEMA 1% annual chance floodplain are residential houses or mobile homes. The total number of buildings excluding accessory structures in the 1% annual chance floodplain in the LFA study area is 112. Approximately 39 of these buildings are trailer homes.

2.3.2 Visual Assessment of River Channel and Floodplain

Visual assessment of the river channel was completed on June 22, June 29, and August 12, 2015. Photographs were taken of the bridges within the study area, low-lying structures, bank failures, and land use surrounding the channels. Low-lying agricultural fields within the floodplain were noted along the East Branch Delaware River, along Dry Brook near the confluence with East Branch Delaware River, and near Erpf Road.

Dry Brook

Dry Brook was observed from the project boundary approximately 850 feet upstream of the Erpf Road bridge to the confluence with East Branch Delaware River. A bank failure was observed immediately upstream of the Erpf Road bridge on the right side of the channel looking downstream. Small tributaries that discharge into Dry Brook near 535 Dry Brook Road and 166 Dry Brook Road were flowing at the time of the site walk.

The channel bed consisted mostly of cobble with some boulders. Cobble bars upstream and downstream of the confluence with the Bush Kill are representative of sediment load concerns along Dry Book.

Near the Route 28 bridge, Dry Brook is confined by stacked rock walls along the right bank and bedrock along the left bank upstream of the bridge and by a stacked rock wall and riprap on the left bank downstream of the Route 28 bridge. The riverbed consists partly of bedrock at the bridge, extending slightly upstream and downstream of the bridge. This bedrock would be expected to provide base level control for Dry Brook, possibly influencing the sediment movement characteristics of the stream system.

A box culvert is located slightly to the east of the main Route 28 bridge over Dry Brook. This opening is limited in horizontal and vertical dimensions, but is likely capable of conveying floodwaters. A retaining wall is located upstream of the culvert and diverts flow toward the culvert entrance.

Bush Kill

MMI walked along the Bush Kill from the project extents about 360 feet downstream of Debari Road to the confluence with Dry Brook. On the day of the June 22, 2015 site walk, the Bush Kill appeared to be flowing at a lower discharge rate than Dry Brook, with a channel bed of cobble mixed with sand. The channel was mostly sand immediately upstream and downstream of the railroad bridge over the Bush Kill. A small rock-lined opening or "culvert" in the railroad embankment was observed east of the railroad bridge. This opening may be partly obstructed based on the inability to see through it to the opposite side. However, it may provide a pathway for floodwaters to leave the left bank of the corridor and bypass the bridge opening.

A small bank failure was noted along the railroad embankment downstream of the railroad bridge. The Bush Kill is confined by steep banks along the right side, with lower wooded land along the left bank between the Bush Kill and Dry Brook.

East Branch Delaware River

East Branch Delaware River was assessed from the project extents 1,700 feet upstream of the Route 38 Bridge to 42235 State Highway 28. Upstream of the Route 38 Bridge, the East Branch Delaware River flows between a railroad track on the left bank and a golf course along the right bank. From the Route 38 Bridge to the confluence with Dry Brook, East Branch Delaware River flows between Route 30 on the right and railroad tracks on the left. Downstream of the confluence with Dry Brook, East Branch Delaware River passes between agricultural fields and Meadows Golf Center.

The confluence of Dry Brook and the East Branch Delaware River was modified after Tropical Storm Irene. A secondary channel that connected Dry Brook and East Branch Delaware River upstream of the main confluence was filled to redirect flow to the main confluence. DCSWCD provided photogrammetry drawings based on photography flown on April 13, 2012 that shows the channel modifications.

The beginning (upstream end) of the Binnekill was observed at the right bank of the East Branch Delaware River. A small metal pipe conveys water out of the river, through a mound of rocks, into the channel of the Binnekill.

2.4 Infrastructure

The three streams included in the project are crossed by four bridges. Flood profiles published in the FEMA FIS indicate that a few of the bridges barely pass the 100-year storm event, while a few are overtopped by the 100-year storm. Table 2-1 lists the bridges in the project area and the streams on which they are located, with predicted 100-year water surface elevations (based on the MMI existing conditions model discussed in Section 4.2). The bridges are listed from upstream to downstream.

TABLE 2-1
Bridges Crossing the Arkville LFA Study Area

Bridge Number on Figure 2-1	Bridge Crossing	Stream	Predicted 100-Year WSEL at Upstream Face (Ft)	Bridge Deck Elevation (Ft)*	Elevation Difference (Ft)
1	Route 38 Bridge	East Branch Delaware River	1344.63	1343.86	0.77
2	Route 28 Bridge	Dry Brook	1353.80	1353.54	0.26
3	Erpf Road Bridge	Dry Brook	1398.76	1401.95	-3.19
4	Railroad Bridge	Bush Kill	1384.42	1384.66	-0.24

*Elevation from HEC-RAS model

2.5 Hydrology

Surface water hydrologic studies are conducted to understand historic and potential future river flow rates using data measured at stream gauging stations and those developed from predictive models. They inform communities of how much water flows in the river at a specific time and place. Hydrologic data on peak flood flow rates for the tributaries of the East Branch of the Delaware River are available from FEMA's contractors and *StreamStats* regional data. *StreamStats* is a United States Geological Survey (USGS) application that uses Geographic Information System (GIS) data and regional regression equations to predict peak flood flow rates (Lumia, et al, 2006 & Mulvihill et al, 2009).

Pertinent data for this LFA was primarily taken from work completed by FEMA contractors including the 10-year, 25-year, 50-year, 100-year, and 500-year flows. The 2-year flow profiles were estimated for use in the hydraulic model. These flows were not published with the FEMA models. Rather, the 2-year flows were calculated using *StreamStats*. Discharges are listed in Tables 2-2 through 2-4.

TABLE 2-2
Discharge Data for Bush Kill

Location	River Station	Discharge (cfs)					
		Irene	2-yr	10-yr	50-yr	100-yr	500-yr
USGS Gauge 1413398	9989.852	13,361	2,900	6,906	11,789	14,206	20,694
At confluence with Dry Brook	3890.339	13,928	2,990	6,955	11,868	14,301	20,828

TABLE 2-3
Discharge Data for Dry Brook

Location	River Station	Discharge (cfs)					
		Irene	2-yr	10-yr	50-yr	100-yr	500-yr
Upstream of confluence of Bush Kill	17,294.40	11,746	2,620	5,611	9,054	10,750	15,077
Downstream of confluence of Bush Kill	69,93.99	24,360	5,510	12,552	20,506	24,404	34,732
USGS Gauge 01413408	63,04.96	24,572	5,510	12,678	20,711	24,644	35,068
At confluence with East Branch Delaware River	33,43.79	24,628	5,520	12,703	20,751	24,691	35,136

TABLE 2-4
Discharge Data for East Branch Delaware River

Location	River Station	Discharge (cfs)					
		Irene	2-yr	10-yr	50-yr	100-yr	500-yr
Downstream of confluence of Batavia Kill	42,492	17,320	3,300	7,047	11,456	13,644	19,325
Approximately 1,375 feet downstream of State Highway 30	41,510	17,590	3,310	7,162	11,640	13,863	19,632
Approximately 2,105 feet upstream of County Highway 38	34,534	18,461	3,500	7,499	12,184	14,512	20,558
Upstream of confluence of Dry Brook	33,506	18,856	3,500	7,610	12,367	14,731	20,877
Downstream of confluence of Dry Brook	26,772	34,746	9,220	15,352	27,440	33,752	50,260
Approximately 795 feet downstream of Bridge Street	26,150	35,022	9,160	15,374	27,543	33,901	50,529
USGS Gauge 1413500	19,944	35,560	9,260	15,443	27,789	34,247	51,138
Approximately 3,880 feet upstream of State Highway 28	18,779	36,317	9,270	15,998	28,600	35,177	52,371

The steady flow data used in the FEMA HEC-RAS models for the East Branch Delaware River and the Bush Kill is consistent with the discharges listed in Table 6 of the effective FEMA FIS for Delaware County dated June 16, 2016. The HEC-RAS discharges for Dry Brook downstream of the confluence with the Bush Kill match the proposed discharges in the East Branch Delaware River Hydrology Methodology Report by Gomez and Sullivan Engineers, P.C. revised July 31, 2012 (Appendix B).

Flows for Tropical Storm Irene were calculated using the following USGS stream gauges:

- 01413398 (Bush Kill near Arkville New York)
- 01413408 (Dry Brook at Arkville New York)
- 01413500 (East Branch Delaware River at Margaretville New York).

The exponents from the drainage-area-only equations in the 2006 report entitled *Magnitude and Frequency of Floods in New York* by Lumia et. al. were used to transfer discharge information from the gauged sites to the flow change locations. The drainage area at each flow change location was determined from the East Branch Delaware River Hydrology Methodology Report by Gomez and Sullivan Engineers, P.C. revised July 31, 2012. In order to calculate the Hurricane Irene flows at each ungauged flow change location, the ratio of the ungauged site's drainage area to the gauged site's drainage area raised to the exponent power was multiplied by the Hurricane Irene flow at the gaged site.

The discharges provided in Tables 2-2 through 2-4 provide the baseline data for the flood mitigation alternatives that involve hydrologic assessment, as well as the baseline data for the flood mitigation alternatives that involve hydraulic assessment.

3.0 DESCRIPTION OF FLOOD HAZARDS

3.1 <u>Flood History in the East Branch Delaware River Watershed</u>

Arkville typically experiences mild summers and cold winters, with precipitation occurring year-round. The long-term mean annual precipitation in the watershed is reported to be 46.7 inches per year (DCSWCD, 2007). However, precipitation is not always distributed uniformly throughout the year, and several significant and devastating floods have occurred. The Stream Corridor Management Plan notes that Dry Brook is particularly susceptible to heavy rainfall. A summary of peak discharges and associated stages is provided in Tables 3-1 through 3-3.

TABLE 3-1
Recent Flood Discharges at Gauge #01413400 on
Bush Kill near Arkville New York

Date	Discharge	RI* (years)
January 19-20, 1996	7,600 cfs	>100

*RI as reported by USGS for the period of record available at the date of the flood

TABLE 3-2
Recent Flood Discharges at Gauge #01413398 on
Bush Kill near Arkville New York

Date	Discharge	Stage*	RI** (years)
June 28, 2006	4,520 cfs	10.51	Not Reported
August 28, 2011 (T.S. Irene)	13,800 cfs	16.26	>100 & <200
September 7-11, 2011 (T.S. Lee)	2,830 cfs	9.31	2

* Flood Stage = 9 feet
**RI as reported by USGS for the period of record available at the date of the flood

TABLE 3-3
Recent Flood Discharges at Gauge #01413408 on
Dry Brook at Arkville New York

Date	Discharge (cfs)	Stage*	RI** (years)
January 19, 1996***	12,000	15.5	Not Reported
June 28, 2006	4,520	10.51	Not Reported
August 28, 2011 (T.S. Irene)	24,600	17.1	>100 & <200
September 7-11, 2011 (T.S. Lee)	5,600	Not Reported	2

* Flood Stage Unknown
** RI as reported by USGS for the period of record available at the date of the flood
*** Before period of record, discharge and gauge height estimated by USGS

Beginning with the flood of 1996, major floods are described below.

Flood of 1996 – On January 19 and 20, 1996, Delaware County suffered a devastating flood caused by heavy rain combined with rapid snowmelt. Damages within Delaware County exceeded $20 million. In Arkville, flood discharges on the Bush Kill exceeded the 100-year storm (USGS 1998).

Flood of 2006 – A stalled weather front caused flooding in the Delaware River basin from June 26 to 29, 2006. Rainfall varied from 2 inches to over 13 inches in southern New York (USGS 2009). Arkville received between 6 and 8 inches of rainfall during the storm (USGS 2009). Statewide disaster recovery assistance for individuals and businesses totaled over $227 million. A state of emergency was declared in Delaware County and many others.

Floods of 2011 – In August and September 2011, Tropical Storm Irene and the remnants of Tropical Storm Lee resulted in record flooding in much of the Catskills. In eastern New York, rainfall was the greatest since 1895 (USGS 2014). Total storm runoff for the period of August 27 to September 2 was measured as 5.88 inches on Bush Kill near Arkville and 5.87 inches on Dry Brook in Arkville.

The recurrence intervals listed in the tables were published by USGS at the time of each flood and do not necessarily represent a continuous updating of the hydrologic record with calculation of new recurrence intervals.

3.2 FEMA Mapping

FEMA Flood Insurance Rate Maps (FIRMs) are available for the study area and depict the SFHA. The maps also depict the FEMA designated floodway, which is the stream channel and that portion of the adjacent floodplain that actively conveys flood flows and 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).

Hydrologic and hydraulic modeling for the Town of Middletown was completed in February 1991 for the August 2, 1993 FIS report. For the effective June 16, 2016 FIS, the hydrologic and hydraulic analysis for the East Branch Delaware River watershed was performed by Gomez and Sullivan Engineers, P.C. under subcontract with RAMPP. The task order was HSFE02-11-J0001, and the work was completed in September 2013.

FEMA mapping indicates that during a 100-year frequency event, waters from Dry Brook and East Branch Delaware River inundate much of the Arkville community. This was verified during some of the recent floods such as Tropical Storm Irene in 2011.

4.0 FLOOD MITIGATION ANALYSIS AND ALTERNATIVES

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

Specific areas along Dry Brook, the Bush Kill, and the East Branch Delaware River have been identified as being at risk 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 businesses. Alternatives were assessed with hydrologic evaluation and hydraulic modeling to determine their effectiveness. The sections below describe the analysis and results.

4.1 Analysis Approach

The flood mitigation alternatives for Arkville involve hydraulic evaluation. Hydraulic analysis throughout the study area was conducted using the HEC-RAS program. The HEC-RAS software (*River Analysis System*) was written by the United States Army Corps of Engineers (USACE) Hydrologic Engineering Center (HEC) and is considered to be the industry standard for riverine flood analysis. The model is used to compute water surface profiles for one-dimensional, steady-state, or time-varied flow. The system can accommodate a full network of channels, a dendritic system, or a single river reach. HEC-RAS is capable of modeling water surface profiles under subcritical, supercritical, and mixed-flow conditions.

The most recent FEMA modeling (the effective model) was received from NYCDEP. Separate models were received for Dry Brook, the Bush Kill, and the East Branch Delaware River. The Bushkill and Dry Brook models were completed by Gomez & Sullivan Engineers in June 2013; the East Branch Delaware River model was completed by Gomez & Sullivan Engineers in July 2013. These models were completed after the FIS dated June 19, 2012 and prior to the Revised Effective FIS dated June 16, 2016. The FEMA models were created with NYCDEP 2009 LiDAR mapping. Survey of bridges and hydraulic structures for the East Branch Delaware River detailed and limited detail study reaches occurred between January 17, 2012 and April 29, 2012.

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

4.2 Existing Conditions Analysis

For each of the three streams (Dry Brook, the Bush Kill, and the East Branch Delaware River), a FEMA "Duplicate Effective" model was created by importing the FEMA model into HEC-RAS. The model was run in HEC-RAS v. 4.1.0 with no changes to the FEMA models received. The floodplain and floodway runs were completed in two different plans. The water surface elevations in the duplicate effective model were compared to the Floodway Data Tables in the Effective FIS. The duplicate effective model water surface elevations were within 0.1 foot of the Floodway Data Tables for Dry Brook, the East Branch Delaware River, and the Bush Kill.

The Duplicate Effective models were checked for correct Manning's n values, site conditions, and expansion/contraction coefficients to ensure that the information in the model accurately reflects river and floodplain conditions. A "Corrected Effective Model" was created[2] by combining and truncating the Dry Brook, Bush Kill, and East Branch Delaware River models. A combined flow file was created using flows from the FEMA models. The flow change on Dry Brook at the confluence with Bush Kill was moved from the cross section upstream of the confluence to the cross section downstream of the confluence. An ineffective flow area was added to cross section 362.5992 on the Bush Kill to prevent the model from using cross-sectional area on Dry Brook as active flow area.

Separate reaches represent the previously separate Dry Brook, Bush Kill, and East Branch Delaware River models. The combination of models was necessary to adequately test alternatives in the vicinity of the confluence of Dry Brook and the Bush Kill and in the vicinity of the confluence of Dry Brook and the East Branch Delaware River. The boundary conditions at the confluences were altered to include a junction instead of separate downstream and upstream boundaries.

Gaps were identified between cross section locations in the Corrected Effective model in areas where the East Branch Flood Commission desired evaluation of alternatives for flood mitigation. Additional cross sections were deemed necessary to better represent these possible future mitigation project areas. An "Existing Conditions" model was created by adding cross sections in necessary locations to the Corrected Effective Model. Additionally, where n-values in the overbank areas did not adequately represent site conditions, they were updated. Finally, a flow profile was added for the 2-year recurrence interval.

Cross section 992.175 on Dry Brook was modified to reflect drawings provided by DCSWCD. The drawings included photogrammetry by Axis Geospatial LLC based on photography flown on April 13, 2012. The FEMA model, which is based on 2009 LiDAR, showed a secondary channel at cross section 992.175 that connected Dry Brook and East Branch Delaware River upstream of the main confluence. In the HEC-RAS model, the secondary channel was filled to an elevation of 1336 feet based on the Axis Geospatial drawings.

Five new cross sections were added on Dry Brook. The new cross sections used overbank geometry from the 2009 1-meter resolution LiDAR data collected by NYCDEP. Elevations were sampled from the LiDAR elevation data using HEC-GeoRAS GIS extension software. No new survey was included in the existing conditions model; however, survey was added later for use in the sediment transport modeling. The wet channel sections were taken from the next closest

[2] Changes made to the FEMA model geometry were noted in the plan comments section in HEC-RAS. N-values for some cross sections were updated from the FEMA model in the Existing Conditions model. If a change was made, notes were added to the Cross Section Data Editor Description box where comments can be written for each cross section.

cross section that was included in the FEMA model because the LiDAR data does not penetrate the water surface and therefore underestimates the depth of the channel bottom. The wet section shape was transferred and height adjusted to match the channel slope of the FEMA model in these new cross section locations. Manning's n values were assigned using field observations and aerial photos.

The new Existing Conditions model was the baseline model used to evaluate hydraulic flood mitigation alternatives. For purposes of water surface elevation computations, the model was run in the subcritical flow regime, which tends to predict slower velocities but higher water surface elevations, and also provides a worst-case scenario for flood prediction purposes.

4.3 Channel and Floodplain Mitigation Approaches

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

4.3.1 Sediment Management

A common sentiment in the Catskills region is that dredging, more broadly defined as removal of sediment from river channels, will alleviate flooding and should be pursued. The need for dredging can be minimized by reducing the sediment load at its source and by improving sediment transport through reaches that are vulnerable to deposition. Natural sediment transport is often disrupted by constrictions holding back sediment or channelization causing increased sediment transport, causing abnormal deposition that can be addressed in the long term by removal of constrictions and naturalization of channel and floodplain capacity.

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

East Branch Flood Commission representatives and local officials have reported a need to consider sediment removal in the lower reaches of Dry Brook. This is discussed in the context of Dry Brook in subsequent sections of this chapter.

4.3.2 Levee Construction

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

Risks associated with levees include the potential to increase water surface elevations in the channel by cutting off the floodplain, and the danger of a flood event that exceeds the design storm and overtops or breaches the levee. As an example, peak flood flows on Dry Brook were very close to the 100-year flood flows during Tropical Storm Irene. Under a levee scenario, it is possible 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, thus exacerbating flooding problems.

Finally, levees need to be certified by FEMA and maintained according to FEMA requirements in order for any flood mitigation benefits to be recognized on the Flood Insurance Rate Maps. A lapse in maintenance or certification can lead to sharp flood insurance increases for properties believed protected by the levee system.

East Branch Flood Commission representatives and local officials expressed an interest in creating levees to protect the Erpf maze and the residential buildings on Lamphere Lane. These alternatives are discussed in detail in Section 4.5.

4.3.3 Bridge Replacement or Modifications

In some cases, bridges cause lateral or vertical restrictions that increase flood velocities and/or water surface elevations. The replacement of a bridge with a new structure that has a longer span will often remove the lateral constrictions, while a higher structure will remove vertical restrictions and often reduce water surface elevations on the upstream side. Bridge replacement must be carefully evaluated in combination with other alternatives, because other flood mitigation projects could change the velocity or height of flows approaching and passing under bridges.

Numerous bridges are located in Arkville. Erpf Road bridge over Dry Brook, the railroad bridge over Bush Kill, the Route 28 bridge over Dry Brook, and the Route 38 bridge over East Branch Delaware River were evaluated in this LFA.

4.3.4 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. 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.

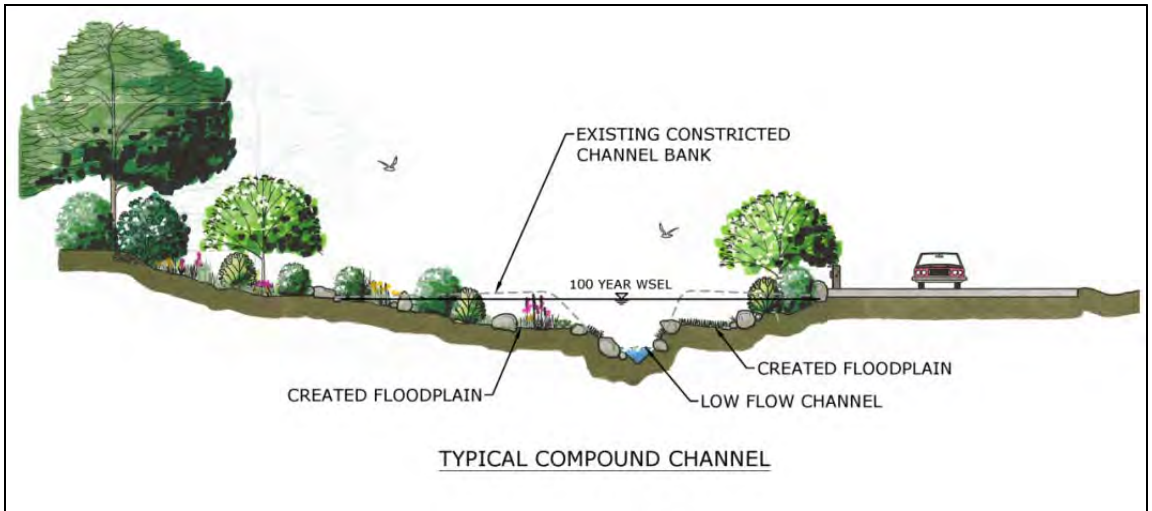
Reducing floodplain capacity also disrupts natural sediment deposition and may cause that sediment to accumulate elsewhere, causing a transfer of problems.

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

The natural floodplain along Dry Brook, the Bush Kill, and the East Branch Delaware River has been built upon in some locations and in other locations has been filled. In certain instances, an existing floodplain can be altered through reclamation, creation, or enhancement, to increase flood conveyance capacity. Floodplain *reclamation* can be accomplished by excavating previously filled areas, removing berms or obstructions from the floodplain, or removal of structures. Floodplain *creation* can be accomplished by excavating land to create new floodplain where there is none today. Finally, floodplain *enhancement* can be accomplished by excavating within the existing floodplain adjacent to the river to increase flood flow conveyance. These excavated areas are sometimes referred to as floodplain benches.

Figure 4-1 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



When considering areas for floodplain reclamation, enhancement, or creation, it may make sense to target areas that were formerly providing better floodplain functions. A review of historical topographic mapping can be beneficial in providing clues about prior floodplain conditions on a macro scale. However, the Margaretville Quadrangle (USGS 1901) depicts the primary roads in

Arkville as they are today, with no obvious signs of large floodplains that existed then but not today. It is likely that floodplain encroachments in Arkville have occurred on a smaller scale in discrete locations.

4.4 Individual Property Flood Mitigation

A variety of measures are available to protect existing public and private properties from flood damage. While broader mitigation efforts are desirable, such as those described above, they often take time and significant funding to implement. On a case-by-case basis, individual floodproofing should be explored where structures are at risk. 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 new elevated first-floor level.

Dry floodproofing of the structure to keep floodwaters from entering. Dry floodproofing refers to the act of making areas below the flood level watertight. Walls may be coated with compound or plastic sheathing. Openings such as windows and vents would be either permanently closed or covered with removable shields. Flood protection should extend only 2 to 3 feet above the top of the concrete foundation because building walls and floors cannot withstand the pressure of deeper water. Dry floodproofing is not appropriate for residential structures but is permissible for nonresidential structures. An Operations and Maintenance Plan is beneficial to ensure that floodproofing is successful.

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. Wet floodproofing is not appropriate for residential structures unless accomplished by elevating the structure as described above, but is permissible for nonresidential structures.

Construction of property improvements such as barriers, floodwalls, and earthen berms. Such structural projects can sometimes be used to prevent flooding. There may be properties within Arkville where implementation of such measures will serve to protect structures.

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.
- ❑ 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.

- 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 a 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.

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

4.5 Overview of Alternatives Analysis

Various alternatives have been evaluated to understand the potential for flood mitigation. These are presented in the sections that follow. The evaluation commenced with several primary types of alternatives identified by the East Branch Flood Commission and the Town:

1. Replacement of bridges that are contributing to flood damage, or elimination of stream crossings where possible.
2. Enhancement of floodplains and creation of floodplain benches where possible.
3. Creation of a bypass channel at the Route 28 bridge over Dry Brook.
4. Creation of levees to protect the Erpf Maze and the buildings on Lamphere Lane.

The primary objective identified by the East Branch Flood Commission and the Town was to develop a set of flood mitigation alternatives that would at least reduce the risk of flood damage to businesses and homes in Arkville if elimination of the risk was not possible. A secondary objective was to keep as much water off Main Street as possible, making the road more resilient to floods.

4.6 Individual Hydraulic Alternatives

Over the course of the LFA, initial alternatives were modified and adjusted to maximize the reduction of floodwater surface elevations. In addition, other alternatives were suggested by the East Branch Flood Commission and the Town and subsequently evaluated for the LFA. A total of 14 hydraulic alternatives were considered.

In particular, the following bridge options were initially identified for the LFA study area (with the prefix "BR" denoting a bridge replacement or removal):

- Alternative BR-1: Replacement of Route 38 Bridge over East Branch Delaware River
- Alternative BR-2: Replacement of Route 28 Bridge over Dry Brook with floodplain
- Alternative BR-3: Removal of Erpf Road Bridge over Dry Brook
- Alternative BR-4: Removal of Railroad Bridge over Bush Kill

The following alternatives represent floodplain projects:

- Alternative FP-1: South of Route 38 Bridge over East Branch Delaware River
- Alternative FP-2: Field near Route 28 Bridge over Dry Brook
- Alternative FP-3: Opposite Town Hall building
- Alternative FP-4: Upstream of Route 28 Bridge over Dry Brook
- Alternative FP-5: Downstream of Route 28 Bridge over Dry Brook near Pavilion Road

Two levee alternatives and a bypass channel were considered:

- Alternative LV-1: Levee at Lamphere Lane
- Alternative LV-2: Levee at Erpf Maze
- Alternative BC-1: Bypass channel at Route 28 Bridge over Dry Brook

Several combinations of the above alternatives were considered:

- Combination 1: Bypass channel at Route 28 Bridge with floodplain up and downstream of bridge (BC-1 + FP-4 + FP-5)
- Combination 2: Route 28 Bridge replacement with floodplain up and downstream of bridge (BR-2 + FP-4 + FP-5)

Because the alternatives are relatively far apart from one another, the individual alternatives do not significantly affect the others, except in the area around the Route 28 Bridge. This modular characteristic of the alternatives allows significant flexibility in their evaluation and the benefit cost analysis presented in Chapter 5.

4.6.1 Alternative BR-1 – Replacement of Route 38 Bridge over East Branch Delaware River (STA 32365 on East Branch Delaware River)

Alternative BR-1 is the replacement of the Route 38 Bridge over East Branch Delaware River with a 440-foot span with four piers. The existing bridge has a 60-foot span and is overtopped in the 100-year storm. Route 38 north of the bridge is low enough to be overtopped by the 10-year flood in existing conditions. This alternative extends the bridge to the intersection of Route 30 and Route 38 so that the roadway remains passable in floods lower than the 500-year. Table 4-1 provides water surface elevations at cross sections upstream and downstream of the Route 38 Bridge over East Branch Delaware River. Figure 4-2 depicts the Route 38 Bridge replacement alternative. Modeling of Alternative BR-1 demonstrated the following:

- The existing bridge raises water surface elevations upstream of the crossing.
- Replacing the bridge with a longer, higher bridge lowers water surface elevations in the 100-year flood by 1.1 feet immediately upstream of the bridge and 0.16 foot near the golf course.
- The existing bridge is overtopped in the 100-year storm. The proposed bridge would be overtopped in the 500-year storm, but not the 100-year storm.

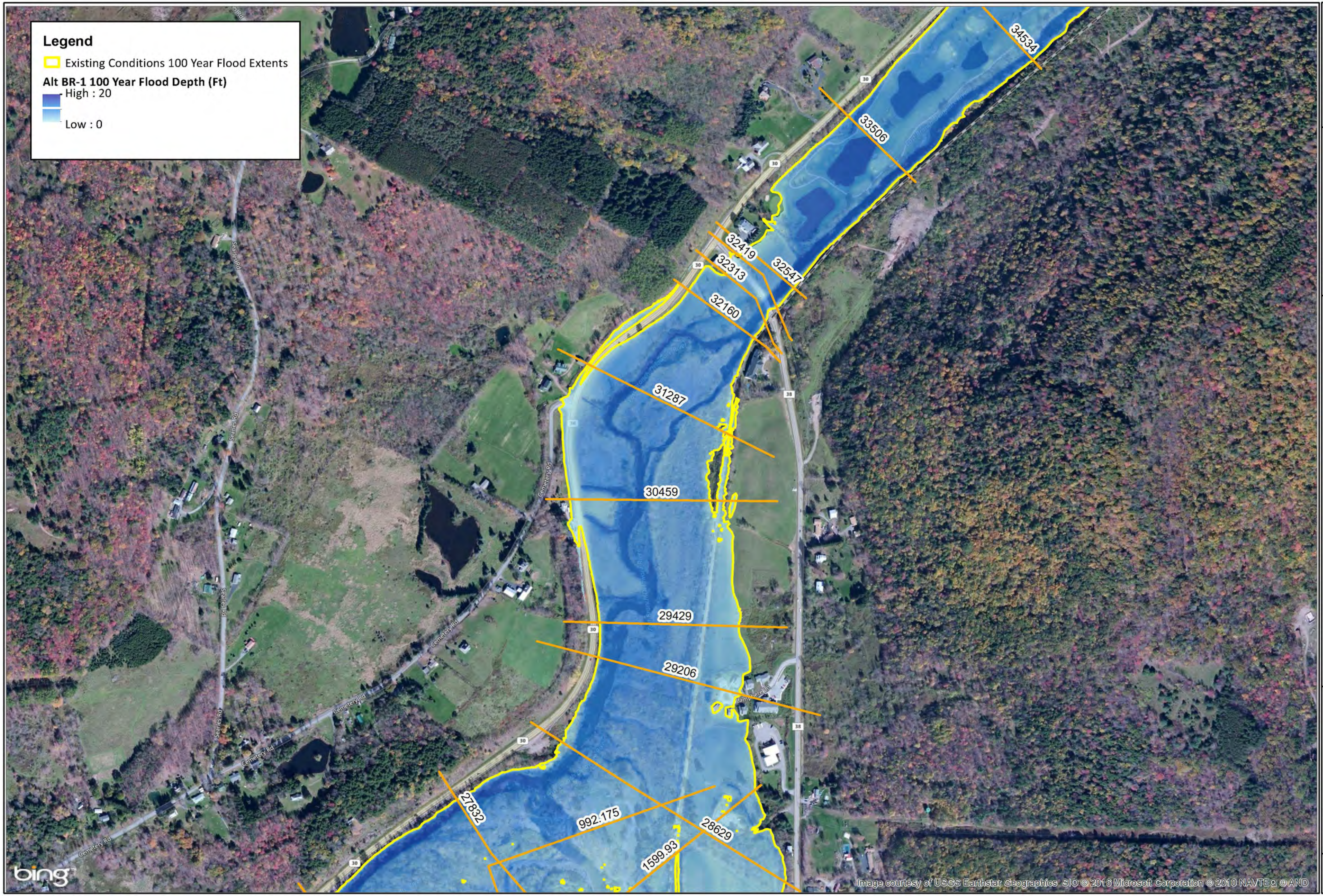


Figure 4-2: Alternative BR-1

Arkville LFA

Middletown

Delaware County, NY

Map By: JCS
MMI#: 5197-07
MXD: Y:\5197-07\Maps\Fig 4-2 BR-1.mxd
1st Version: 5/6/2015
Revision: 10/24/2016
Scale: 1 in = 500 ft

SOURCE(S):
ESRI, Bing, FEMA, NYCDEP WOH 2009 LIDAR

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TABLE 4-1
Water Surface Elevations at
Route 38 Bridge over East Branch Delaware River (100-Year)
[feet NAVD88]

Station on East Branch Delaware River	Existing Conditions	Alternative BR-1
36566 (North of golf course)	1350.39	1350.38
36358 (North of golf course)	1350.26	1350.25
35540 (Near W Hubbell Hill Road)	1347.96	1347.80
34534 (Near Hidden Waters Road)	1347.03	1346.70
33506 (Through golf course)	1346.41	1345.97
32547 (Upstream of Route 38)	1344.82	1343.92
32419 (Immediately upstream of Route 38)	1344.63	1343.52

Overall, the bridge replacement would improve the ability of the bridge to convey frequent floods and raising Route 38 north of the bridge. This alternative was not advanced to the BCA, but should be considered when the bridge is ready for replacement.

4.6.2 Alternative BR-2: Replacement of Route 28 Bridge over Dry Brook and Floodplain (STA 2684.479 to 3797.652 on Dry Brook)

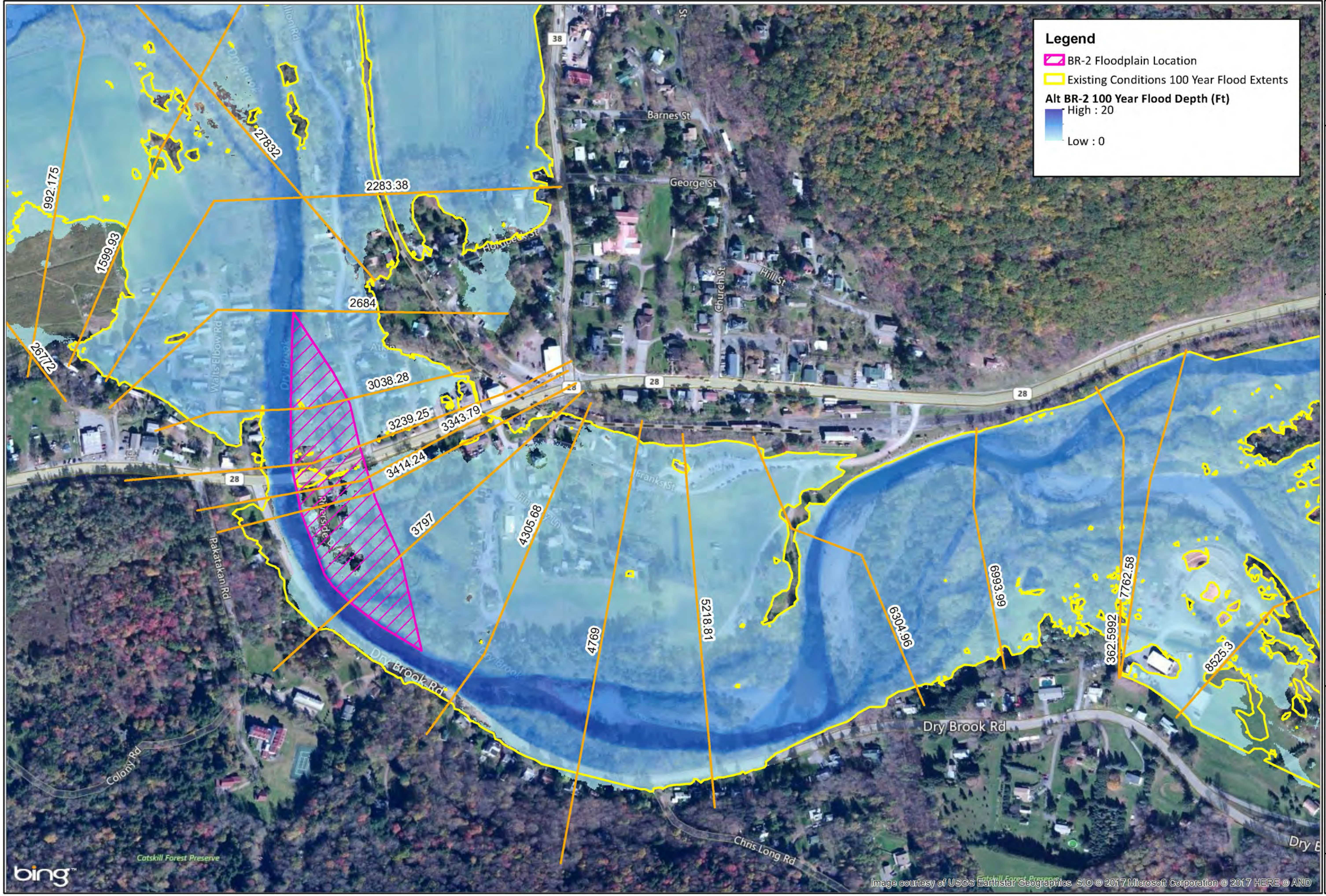
Alternative BR-2 consists of replacement of the Route 28 bridge over Dry Brook with a longer span bridge. The existing bridge has an approximately 90-foot span; the alternative proposed bridge has a 365-foot span with four piers. The proposed bridge would tie in to existing grade near the intersection of Pavilion Road and Route 28. The existing culvert east of the bridge would be removed to make space for the longer bridge. A floodplain below the bridge set at the 2-year flood elevation was also included in the model to further reduce water surface elevations.

Figure 4-3 depicts the location of the floodplain for Alternative BR-2. Table 4-2 provides water surface elevations upstream and downstream of the bridge. Modeling demonstrated the following:

- Alternative BR-2 is predicted to lower water surface elevations by approximately 3.8 feet immediately upstream of the bridge in the 100-year flood. Immediately downstream of the bridge, water surface elevations are predicted to be reduced by 1.8 feet in the 100-year storm.
- This alternative is also predicted to remove water from Route 28 east of the bridge and reduces flooding at buildings in the 100-year storm.
- This alternative is predicted to lower water surface elevations by approximately 2 feet in the 10-year storm.
- Water surface reductions extend from the Route 28 bridge up to Finnerty Lane.

In Alternative BR-2, the 100-year water surface elevation near Finnerty Lane changes from 1355.77 to 1353.47.

Alternative BR-2 provided sufficient benefit to be analyzed further as part of combinations and individually in the BCA.



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SOURCE(S):
ESRI, Bing, FEMA, NYCDEP WOH 2009 LIDAR

N S E W

Figure 4-3: Alternative BR-2

Arkville LFA

Middletown
Delaware County, NY

Map By: JCS
MMI#: 5197-07
MXD: Y:\5197-07\Maps\Fig 4-3 BR-2e 100 Yr.mxd
1st Version: 5/6/2015
Revision: 1/26/2017
Scale: 1 in = 300 ft

TABLE 4-2
Comparison of Water Surface Elevations at
Route 28 Bridge over Dry Brook (100-Year)
[feet NAVD88]

Station on Dry Brook	Existing Conditions	Alternative BR-2
6993.99 (near confluence of Dry Brook and Bush Kill)	1,365.24	1,365.27
6304.96 (Downstream of confluence of Dry Brook and Bush Kill)	1,361.75	1,361.65
5218.81 (Downstream of confluence of Dry Brook and Bush Kill)	1,358.11	1,358.33
4769.675(Downstream of confluence of Dry Brook and Bush Kill)	1,357.43	1,357.77
4305.68 (Near Finnerty Lane)	1,356.30	1,354.78
3797.652 (Near Finnerty Lane)	1,355.77	1,353.47
3414.24 (Upstream of Route 28 Bridge)	1,355.00	1,351.19
3343.79 (Immediately upstream of Route 28 Bridge)	1,353.80	1,350.68
3239.25 (Immediately downstream of Route 28 Bridge)	1,351.53	1,349.71
3038.28 (Downstream of Route 28 Bridge)	1,349.46	1,349.39

4.6.3 Alternative BR-3: Erpf Road Bridge over Dry Brook (STA 11125.03 on Dry Brook)

Alternative BR-3 consists of removing the Erpf Road bridge and abutments. During the site walk, a bank failure was observed on the right bank upstream of the bridge that may contribute to Dry Brook's sediment load. The surrounding area is comprised of wooded land and fields. Few buildings are located near the bridge.

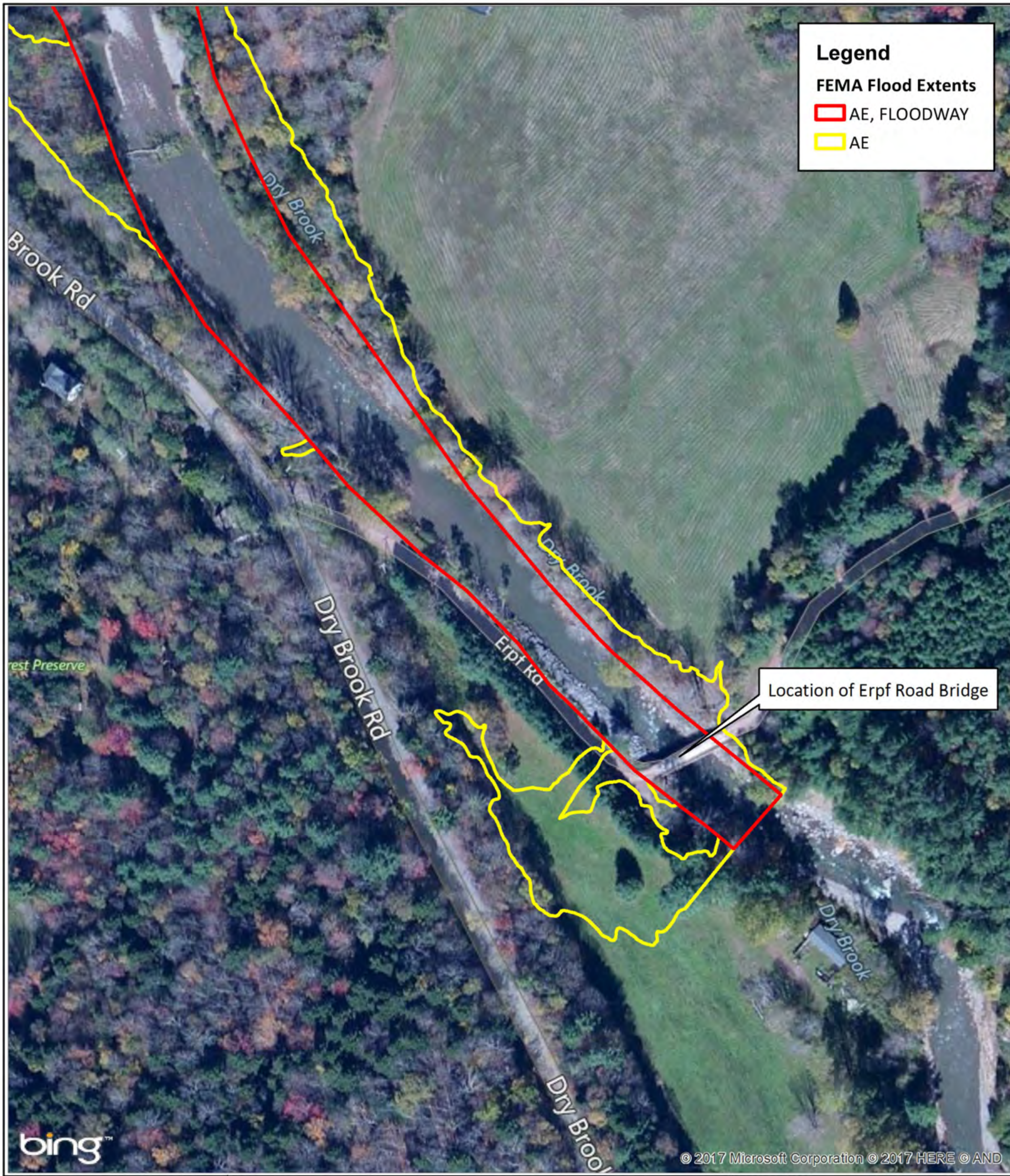
Figure 4-4 shows the location of the Erpf Road bridge. The predicted changes in water surface elevation were too small to be noticeable in depth grid mapping. Table 4-3 provides water surface elevations in the Erpf Road bridge area.

Modeling demonstrated the following:

- Under existing conditions, the 50-year and lower floods are predicted to be conveyed under the bridge, with the 100-year flood mostly conveyed under the bridge.
- Removing the bridge resulted in a predicted a 0.54-foot decrease in water surface elevation in the 100-year storm at the upstream face of the bridge. Downstream of the bridge, the decrease in water surface elevation was only 0.27 foot.

The Erpf Road bridge mostly conveys the 100-year flood, therefore removing or replacing the bridge with a larger structure would not yield significant benefits.

Alternative BR-3 was not advanced to the BCA since the water surface reductions were small and would not benefit any buildings. This alternative could be reevaluated when the bridge needs to be replaced.



SOURCE(S):		LOCATION:
ESRI, Bing, FEMA	**Figure 4-4: Alternative BR-3**	**Middletown, New York**
	N **Arkville LFA** MXD: Y:\5197-07\Maps\Fig 4-4 BR-3 Erpf Road 100 Yr.mxd	Map By: JCS MMI#: 5197-07 Original: 10/24/2016 Revision: 1/26/2017 Scale: 1 inch = 150 feet

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TABLE 4-3
Comparison of Water Surface Elevations at Erpf Road Bridge (100-Year)
[feet NAVD88]

Station on Dry Brook	Existing Conditions	Alternative BR-3
1125.03 (Upstream Face of Erpf Road Bridge)	1398.76	1398.22
11072.5 (Immediately Downstream of Erpf Road Bridge)	1397.98	1397.71

4.6.4 Alternative BR-4: Removal of Railroad Bridge over Bush Kill (STA 2831.419 on Bush Kill)

Alternative BR-4 involves removing the railroad bridge over Bush Kill and the railroad embankment. The railroad bridge is located near Elliott Hills Road. The channel is entrenched near this bridge and passes through a wooded area. Because of the high bank along Route 28, no structures are flooded by the 100-year flood in this area under existing conditions.

Table 4-4 provides water surface elevations in the railroad bridge area. Figure 4-5 depicts Alternative BR-4.

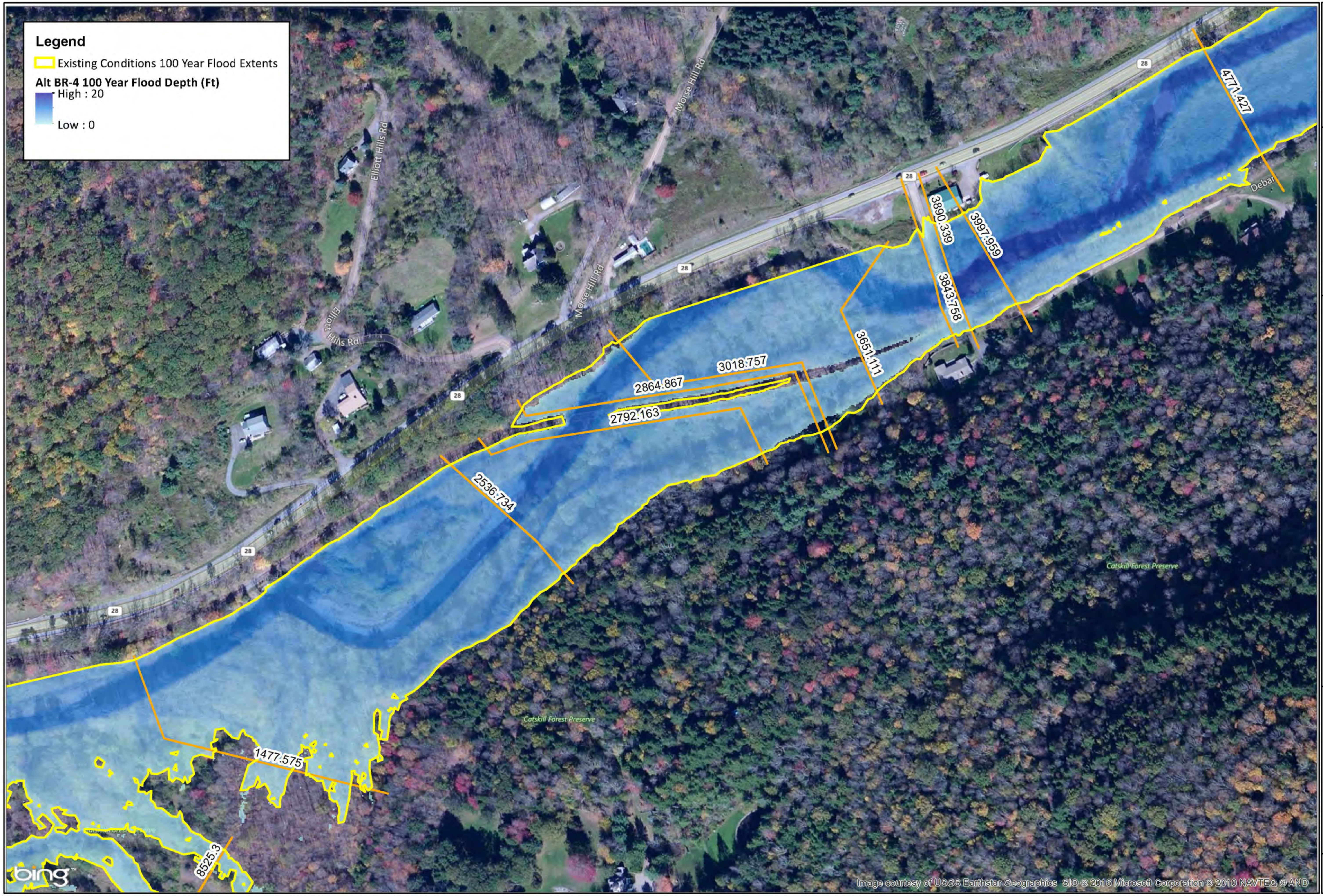
TABLE 4-4
Comparison of Water Surface Elevations at Railroad Bridge over Bush Kill (100-Year)
[feet NAVD88]

Station on Bush Kill	Existing Conditions	Alternative BR-4
3651.111 (760 Feet Upstream of Railroad Bridge)	1384.71	1382.64
3018.757 (150 Feet Upstream of Railroad Bridge)	1384.69	1381.26
2864.867 (Immediately Upstream of Railroad Bridge)	1384.42	1380.17
2792.163 (Immediately Downstream of Railroad Bridge)	1380.26	1380.37

Modeling demonstrated the following:

- The bridge is predicted to overtop in the 100-year flood under existing conditions.
- Alternative BR-4 is predicted to lower water surface elevations by about 4 feet immediately upstream of the railroad bridge. However, there are no benefits upstream of the bridge because the nearby structures are at an elevation that is higher than the 100-year flood.

Alternative BR-4 did not provide enough benefit to be advanced to the BCA.



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SOURCE(S):
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Figure 4-5: Alternative BR-4

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4.6.5 Alternative FP-1: Floodplain South of Route 38 Bridge over East Branch Delaware River (STA 29429 to 32160 on East Branch Delaware River)

Alternative FP-1 consists of a floodplain downstream of the Route 38 bridge between the East Branch Delaware River and Route 30. The floodplain was run at the 1.5-year flood flow, using *StreamStats*. The intention of this alternative was to prevent the overtopping of Route 30 in the 100-year flood.

Figure 4-6 depicts the location of Alternative FP-1. The predicted reductions in water surface elevation were too small to be depicted in depth grid mapping. Table 4-5 provides water surface elevations in the area downstream of the Route 38 bridge on East Branch Delaware River.

TABLE 4-5
Comparison of Water Surface Elevations for
Floodplain Downstream of Route 38 Bridge (100-Year)
[feet NAVD88]

Station on East Branch Delaware River	Existing Conditions	Alternative FP-1
32313 (Immediately d/s of Route 38 bridge over EB Delaware River)	1,341.99	1,341.92
32160 (Approximately 150 feet d/s of Route 38 Bridge)	1,342.02	1,341.95
31287 (Approximately 1,000 feet d/s of Route 38 Bridge)	1,341.88	1,341.81

d/s = downstream

Modeling demonstrated the following:

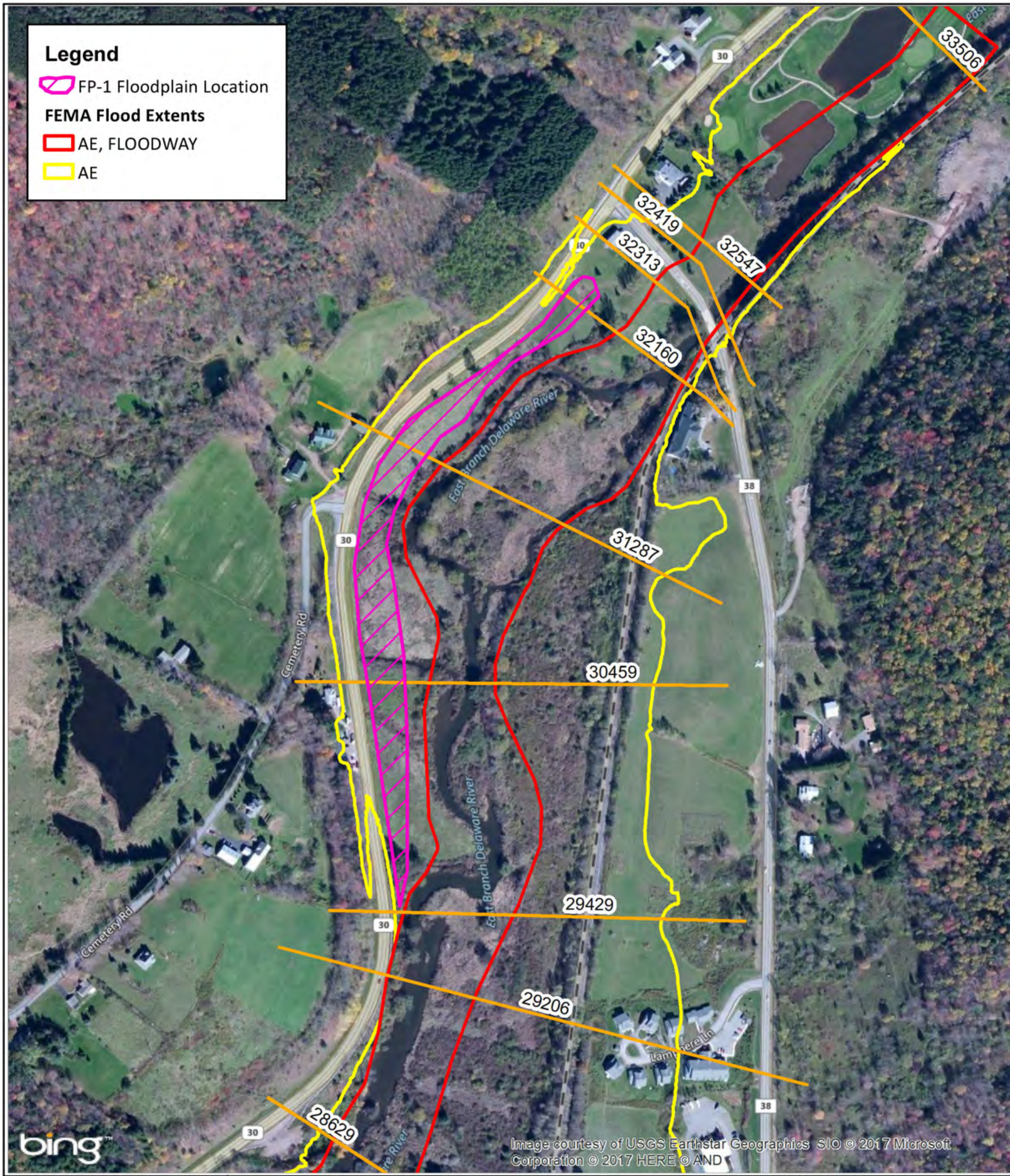
- Alternative FP-1 is predicted to reduce water surface elevations by only 0.07 foot up to the Route 38 bridge.

Alternative FP-1 did not provide significant benefits and was not advanced to the BCA.

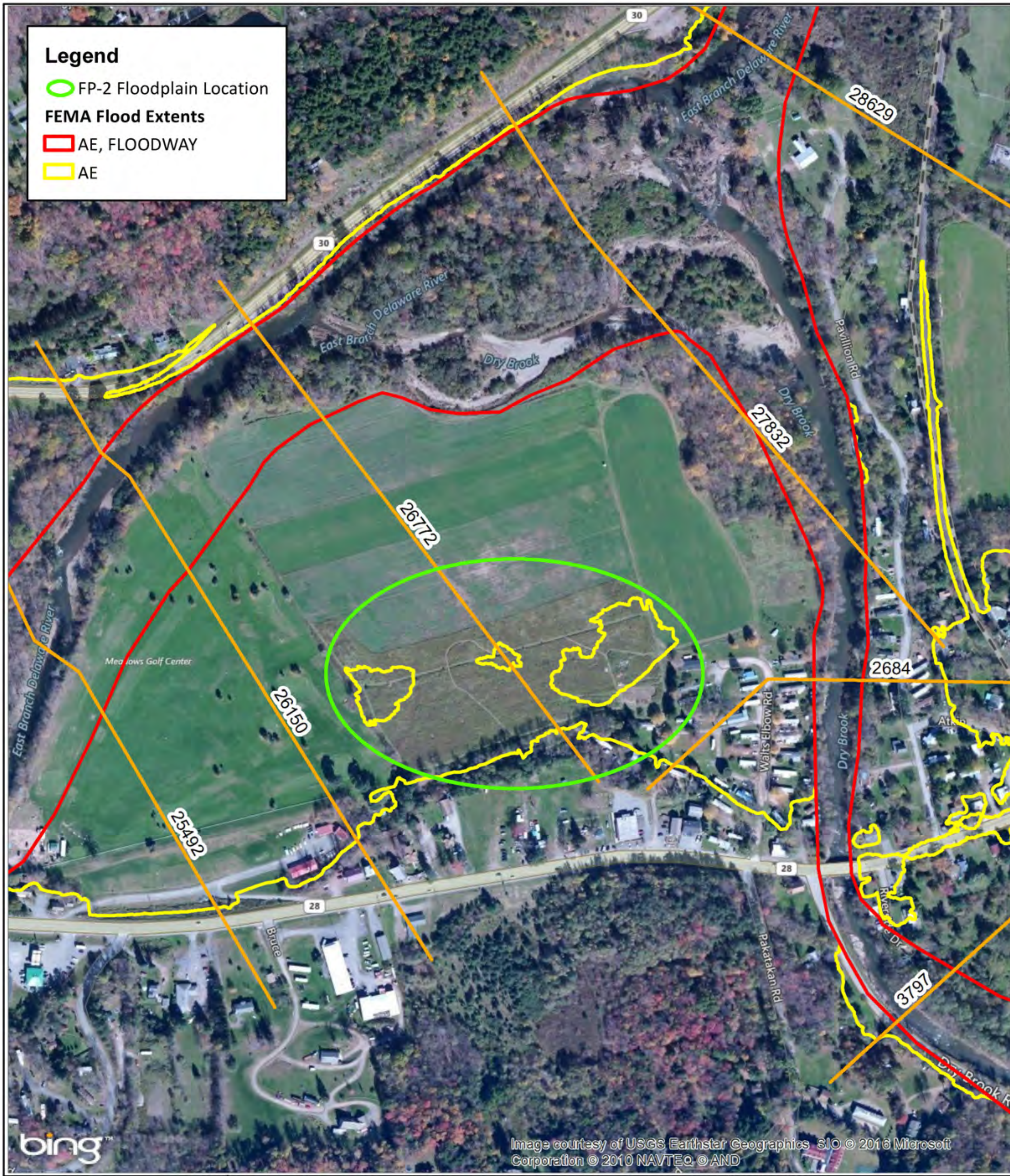
4.6.6 Alternative FP-2 – Floodplain in Field Northwest of Route 28 Bridge over Dry Brook (STA 992.175 to 1599.93 on Dry Brook and STA 26772 on East Branch Delaware River)

Alternative FP-2 involves lowering the floodplain between the East Branch Delaware River and Dry Brook in the field northwest of the Route 28 bridge. A high area in the field was lowered to the 10-year flood elevation.

Figure 4-7 depicts the location of Alternative FP-2. Depth grid mapping was not created due to the low benefits provided by this alternative. Table 4-6 provides water surface elevations near the proposed floodplain.



SOURCE(S):		LOCATION:
ESRI, Bing, FEMA	**Figure 4-6 Alternative FP-1**	**Middletown, New York**
	Arkville LFA	**Map By:** JCS **MMI#:** 5197-07 **Original:** 10/24/2016 **Revision:** 1/26/2017 **Scale:** 1 inch = 400 feet
	N MXD: Y:\5197-07\Maps\Fig 4-6 FP-1 Location.mxd	MILONE & MACBROOM 99 Realty Drive Cheshire, CT 06410 (203) 271-1773 Fax: (203) 272-9733 www.miloneandmacbroom.com



SOURCE(S):	Figure 4-7 Alternative FP-2	LOCATION:
ESRI, Bing, FEMA		Middletown, New York
	N Arkville LFA MXD: Y:\5197-07\Maps\Fig 4-7 Alt FP-2 Location.mxd	Map By: JCS MMI#: 5197-07 Original: 10/24/2016 Revision: 10/24/2016 Scale: 1 inch = 400 feet
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TABLE 4-6
Comparison of Water Surface Elevations on East Branch Delaware River near Alternative FP-2 (100-Year)
[feet NAVD88]

Station on East Branch Delaware River	Existing Conditions	Alternative FP-2
32313 (Immediately d/s of Route 38 Bridge over EB Delaware River)	13,41.99	13,41.88
32160 (Approximately 150 feet d/s of Route 38 Bridge)	13,42.02	13,41.91
31287 (Approximately 1,000 feet d/s of Route 38 Bridge)	13,41.88	13,41.76
30459 (Approximately 2,000 feet d/s of Route 38 Bridge)	13,41.46	13,41.33
29429 (U/s of Lamphere Lane)	13,41.06	13,40.89
29206 (At Lamphere Lane)	13,40.86	13,40.68
28629 (1,600 feet u/s of Dry Brook and EB Delaware Confluence)	13,40.41	13,40.17
27832 (U/s of Dry Brook and East Branch Delaware Confluence)	13,39.97	13,39.67
26772 (Immediately d/s of Dry Brook and EB Delaware confluence)	13,36.73	13,36.76

u/s = upstream

Modeling demonstrated the following:

- Most of the field northwest of the Route 28 bridge is already below the 10-year flood elevation.
- Alternative FP-2 was predicted to affect a small reduction in water surface elevations upstream of the confluence of Dry Brook and the East Branch Delaware River.

Lowering the floodplain between the East Branch Delaware River and Dry Brook in the field northwest of the Route 28 bridge provides only negligible benefits.

The benefits of Alternative FP-2 are negligible, and this alternative was not advanced to the BCA.

4.6.7 Alternative FP-3 – Floodplain Opposite Town Hall Building between Binnekill and East Branch Delaware River (STA 25492 to 22539 on East Branch Delaware River)

Alternative FP-3 consists of the creation of a floodplain in the field between Binnekill and East Branch Delaware River, as shown in Figure 4-8. Comparison of the ground elevation to the 2-year flood flows obtained from *StreamStats* showed that the floodplain in this area is already below the 2-year flood. Therefore, this alternative was not modeled in HEC-RAS.

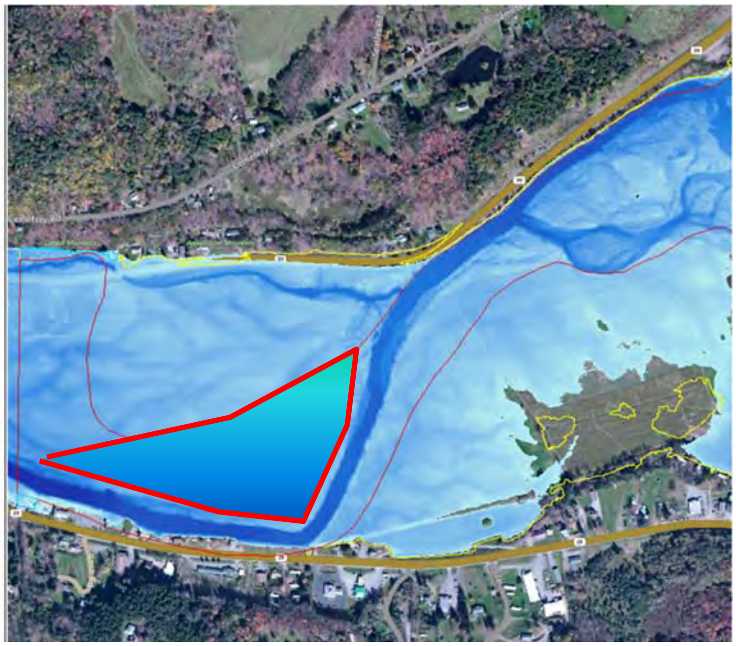

Figure 4-8 – Location of Alternative FP-3

4.6.8 Alternative FP-4 – Floodplain Upstream of Route 28 Bridge over Dry Brook (STA 4305.68 to 5645.89 on Dry Brook)

Alternative FP-4 involves the creation of a floodplain upstream of the Route 28 bridge over Dry Brook and south of Finnerty Lane. The proposed floodplain was set at the 2-year flood elevation. Many residential buildings and some commercial buildings are located in the low-lying Franks Street and Finnerty Lane neighborhood. This floodplain was intended to reduce flooding near the buildings on Finnerty Lane and Franks Street.

Figure 4-9 depicts depth grid mapping for Alternative FP-4. Table 4-7 shows water surface elevations near this alternative.

Modeling demonstrated the following:

- The maximum predicted decrease in the 100-year water surface elevation is 0.38 foot at cross section 5218.81.
- Benefits extended slightly upstream of the confluence of Dry Brook and the Bush Kill.

The floodplain upstream of Route 28 provided sufficient benefits to be considered in combination with other alternatives in the BCA.

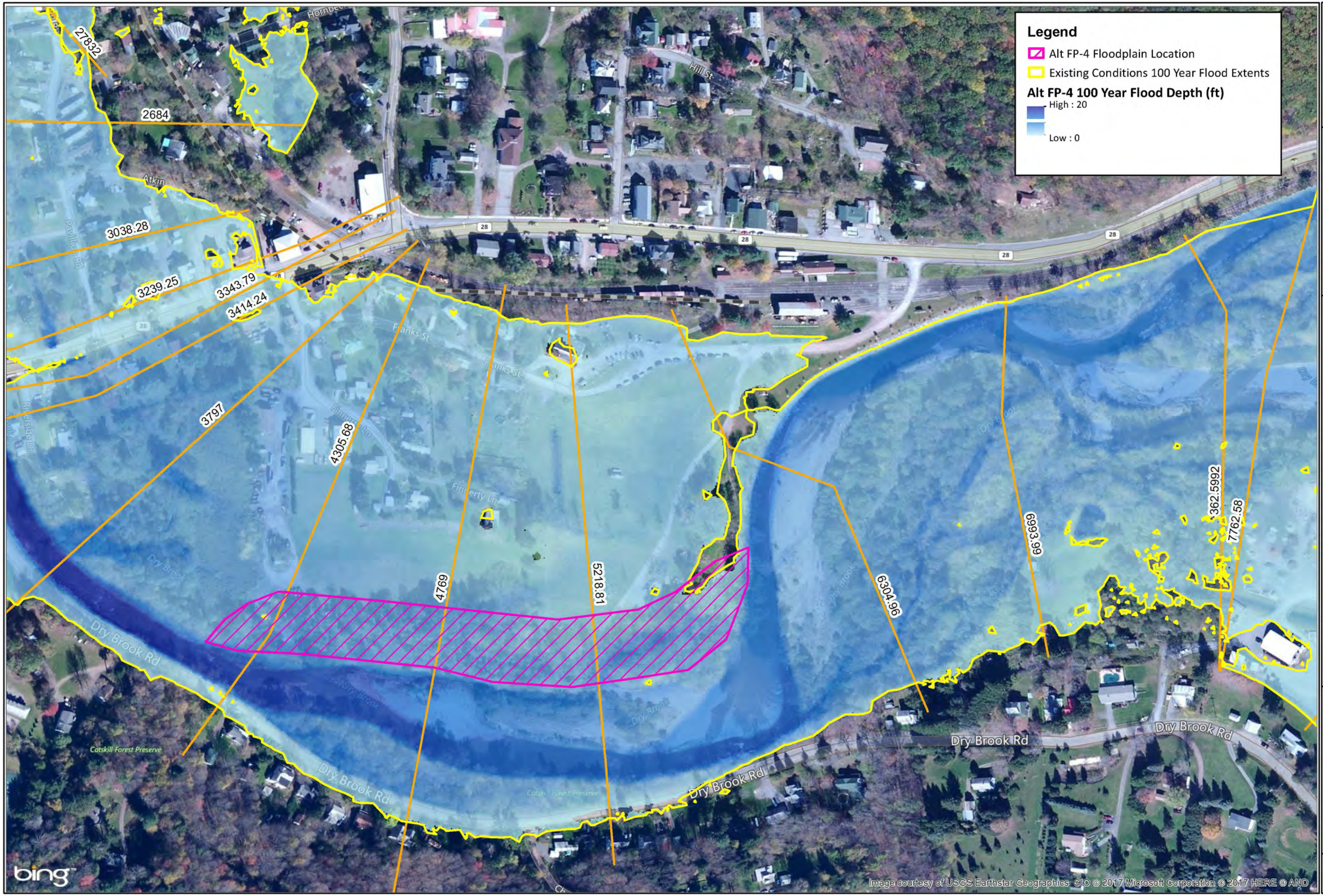

Figure 4-9: Alternative FP-4

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SOURCE(S): ESRI, Bing, FEMA, NYCDEP WOH 2009 LIDAR

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TABLE 4-7
Comparison of Water Surface Elevations for Floodplain
Upstream of Route 28 Bridge (100-Year)
[feet NAVD88]

Station on Dry Brook	Existing Conditions	Alternative FP-4
7762.58 (u/s of Bush Kill and Dry Brook confluence)	1,368.92	1,368.90
6993.99 (Near Bush Kill and Dry Brook confluence)	1,365.24	1,365.32
6304.96 (d/s of Bush Kill and Dry Brook confluence)	1,361.75	1,361.51
5218.81 (Approx. 2,000 feet d/s of the Dry Brook and Bush Kill confluence)	1,358.11	1,357.73
4769.675 (u/s of Finnerty Lane)	1,357.43	1,357.14
4305.68 (At Finnerty Lane)	1,356.30	1,356.41

4.6.9 Alternative FP-5 – Floodplain Downstream of Route 28 Bridge along Pavilion Road (STA 4305.68 to 5645.89 on Dry Brook)

Alternative FP-5 involves the creation of a floodplain between Dry Brook Road and Pavilion Road. The floodplain is set at the 2-year flood elevation along the right bank and requires the relocation of seven buildings.

Figure 4-10 depicts depth grid mapping for Alternative FP-5. Table 4-8 shows water surface elevations near this alternative for both the 10-year and 100-year floods.

Modeling demonstrated the following:

- The maximum predicted decrease in the 10-year water surface elevation is 0.9 foot immediately downstream of the Route 28 bridge. Benefits in the 10-year flood extend from 980 feet downstream of the Route 28 bridge to the confluence of Dry Brook and Bush Kill.
- The maximum predicted decrease in the 100-year water surface elevation is 0.81 foot downstream of the Route 28 bridge. The benefits in the 100-year flood do not extend upstream of the Route 28 bridge.

Lowering the floodplain downstream of the Route 28 bridge provides some benefit, but not sufficient to warrant implementation.

The floodplain along Pavilion Road provided sufficient benefits to be considered in the BCA.

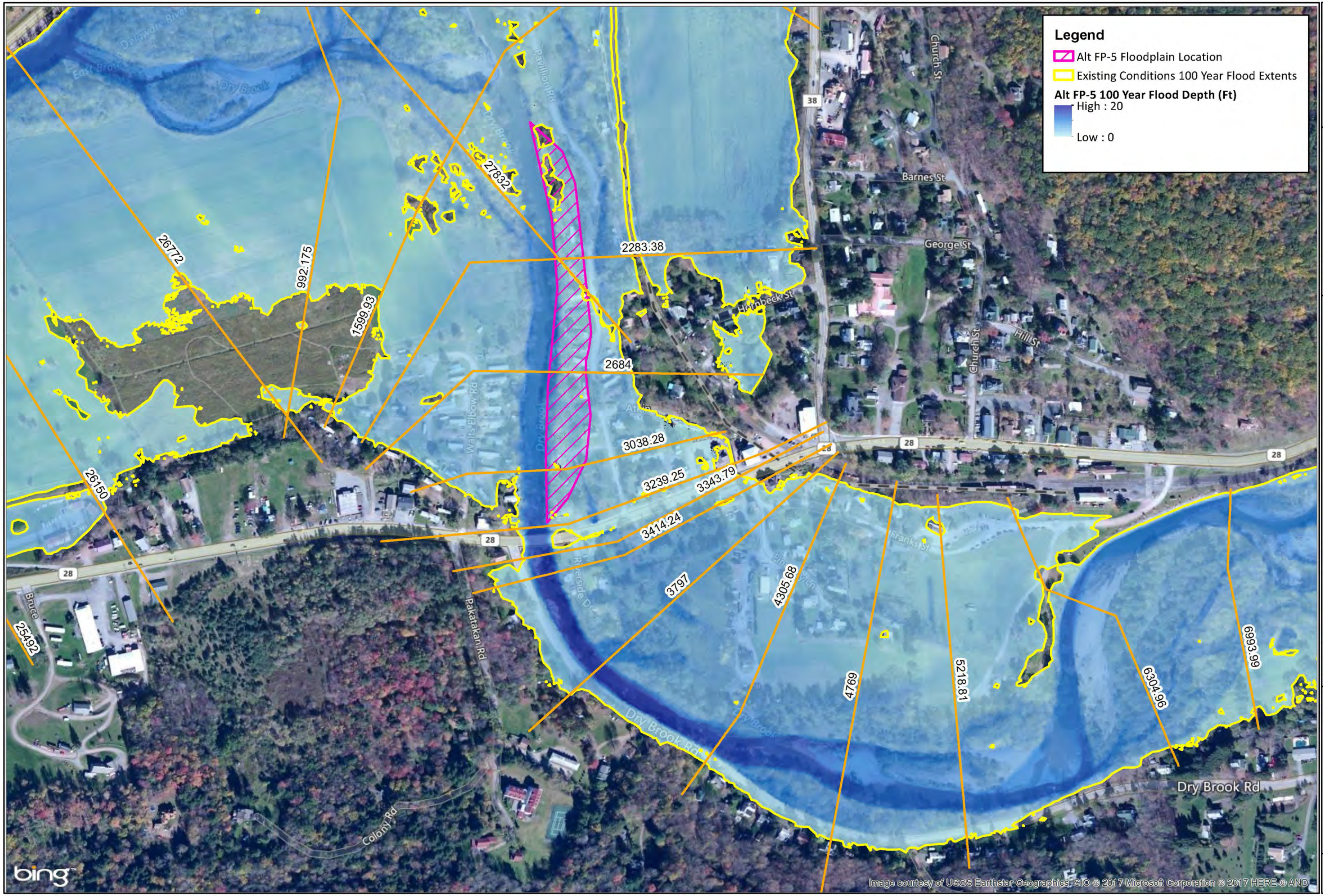

Figure 4-10: Alternative FP-5

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SOURCE(S):
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TABLE 4-8
Comparison of Water Surface Elevations for Floodplain Along Pavilion Road (10-Year and 100-Year)
[feet NAVD88]

Station on Dry Brook	Existing Conditions (10-Year)	Alternative FP-5 (10-Year)	Existing Conditions (100-Year)	Alternative FP-5 (100-Year)
6993.99 (Near Bush Kill and Dry Brook confluence)	1363.11	1363.09	1365.24	1365.24
6304.96 (d/s of Bush Kill and Dry Brook confluence)	1359.81	1359.83	1361.75	1361.75
5218.81 (Approximately 2,000 feet d/s of the Dry Brook and Bush Kill confluence)	1355.8	1355.73	1358.11	1358.11
4769.675 (u/s of Finnerty Lane)	1355.07	1354.95	1357.43	1357.43
4305.68 (At Finnerty Lane)	1353.62	1353.04	1356.3	1356.3
3797.652 (450 feet upstream of Route 28 Bridge)	1352.09	1352.29	1355.77	1355.77
3414.24 (95 feet upstream of Route 28 Bridge)	1348.85	1348.76	1355	1355
3343.79 (Immediately u/s of Route 28 Bridge)	1348.6	1348.5	1353.8	1353.8
3239.25 (Immediately d/s of Route 28 Bridge)	1347.45	1346.55	1351.53	1351.53
3038.28 (240 feet d/s of Route 28 Bridge)	1346.79	1346.22	1349.46	1348.65
2684.479 (550 feet d/s of Route 28 Bridge)	1345.04	1344.94	1347.06	1346.89
2283.38 (950 feet d/s of Route 28 Bridge)	1343.83	1343.8	1346.41	1346.37

4.6.10 Alternative LV-1 – Levee at Lamphere Lane (STA 29206 on East Branch Delaware River)

Alternative LV-1 involves the creation of a levee at cross section 29206 on the East Branch Delaware River to protect the buildings on Lamphere Lane. Under existing conditions, these buildings are within the FEMA 100-year floodplain. The proposed levee was set to protect the buildings from the 100-year flood, but not the 500-year flood.

Figure 4-11 shows the location of Alternative LV-1. The change in water surface elevations was not significant enough to show in depth grid mapping. Table 4-9 shows water surface elevations near Lamphere Lane for the 100-year flood.

TABLE 4-9
Comparison of Water Surface Elevations for Levee at Lamphere Lane (100-Year)
[feet NAVD88]

Station on East Branch Delaware River	Existing Conditions	Alternative LV-1
32160 (Approx. 150 feet d/s of Route 38 Bridge)	1,342.02	1,342.01
31287 (Approx. 1,000 feet d/s of Route 38 Bridge)	1,341.88	1,341.87
30459 (Approx. 2,000 feet d/s of Route 38 Bridge)	1,341.46	1,341.45
29429 (Upstream of Lamphere Lane)	1,341.06	1,341.04

Figure 4-11 – Location of Alternative LV-1

Modeling demonstrated the following:

- A levee or floodwall between the railroad and Lamphere Lane is predicted to protect buildings from the 100-year flood while only raising the water surface elevation by 0.01 or 0.02 foot.
- This alternative would require a stormwater pumping system inside the levee.

The levee at Lamphere Lane is not recommended due to the issues and risks associated with levee operation and was not advanced to the BCA. Refer to section 4.3.2 for additional information on levees. Specific buildings should be addressed as needed.

4.6.11 Alternative LV-2 – Levee at Erpf Maze (STA 9459.109 on Dry Brook)

The public expressed interest in protecting the Erpf Maze on the right bank of Dry Brook by creating a levee. Based on existing conditions, HEC-RAS modeling and the FEMA floodplain, the maze is not located within the 500-year flood zone. Therefore, this alternative was not modeled. If erosion becomes a concern in the future, the riverbank could be stabilized. Figure 4-12 shows the location of Alternative LV-2.

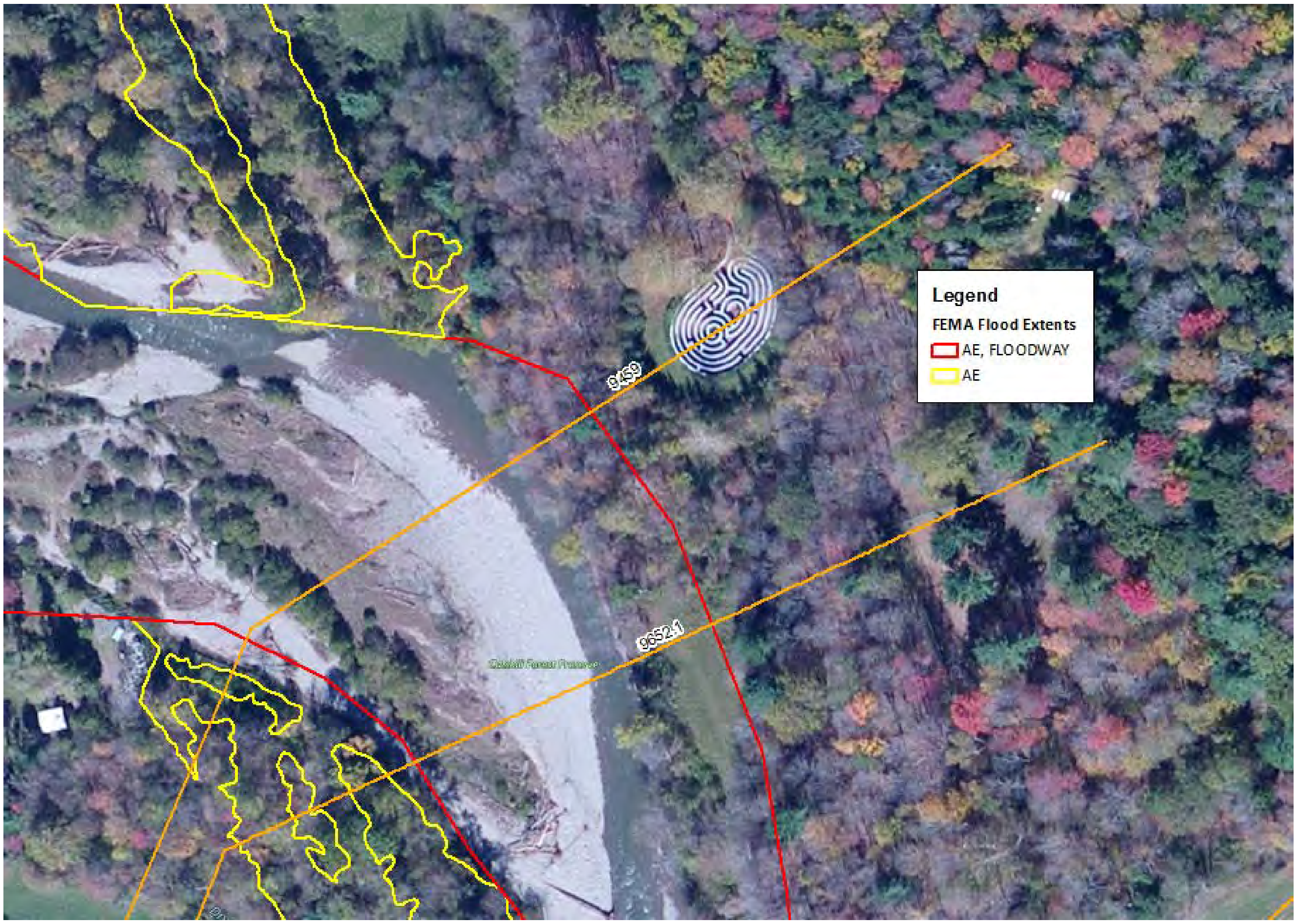

Figure 4-12 – Location of Alternative LV-2

4.6.12 Alternative BC-1 – Bypass Channel at Route 28 Bridge (STA 3038.28 to 3797.652 on Dry Brook)

Alternative BC-1 consists of the creation of a bypass channel next to the Route 28 bridge. The existing Route 28 bridge would remain in place. Under this alternative, the existing culvert east of the bridge would be replaced by a wider 60-foot span bridge and a bypass channel set 1.5 feet below the 2-year flood elevation.

Figure 4-13 shows the depth grid mapping for Alternative BC-1. Table 4-10 shows water surface elevations near the Route 28 bridge for the 100-year flood. Modeling demonstrated the following:

- Slight increases in water surface elevations may be due to decreases in velocity around cross sections 3038.28, 3239.25, 4769.675, 5218.81, and 6993.99.
- This alternative provides a reduction in water surface elevation of up to 1.5 feet in the 100-year storm. The bypass channel provides an even greater reduction of up to 3 feet near Finnerty Lane in the 10-year storm.

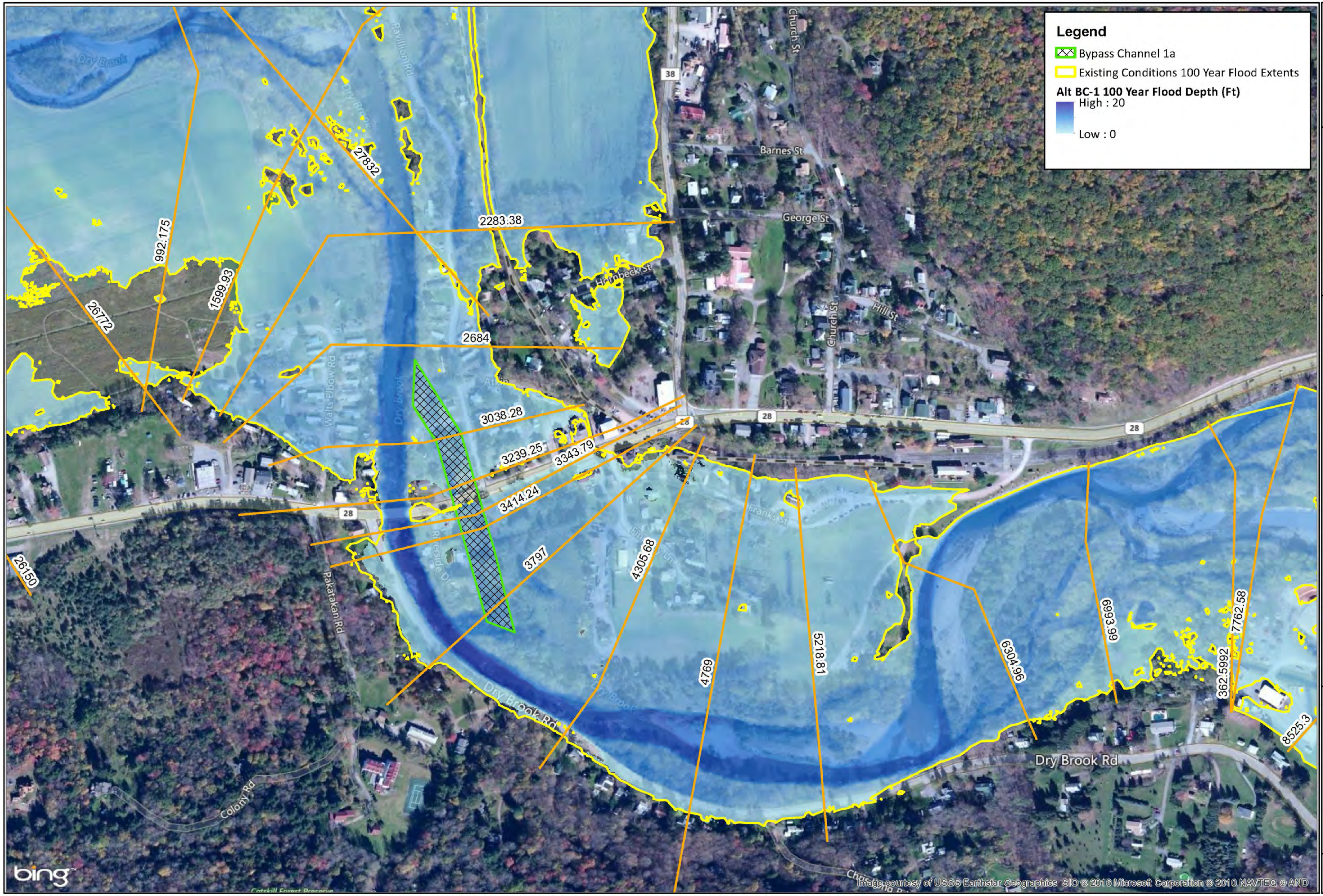

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Figure 4-13: Alternative BC-1

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TABLE 4-10
Comparison of Water Surface Elevations for Bypass Channel at Route 28 Bridge (10-Year and 100-Year) [feet NAVD88]

Station on Dry Brook	Existing Conditions (10-Year)	Alternative BC-1 (10-Year)	Existing Conditions (100-Year)	Alternative BC-1 (100-Year)
7762.58 (u/s of Bush Kill and Dry Brook confluence)	1366.99	1366.97	1,368.92	1,368.91
6993.99 (Immediately d/s of Bush Kill and Dry Brook confluence)	1,363.11	1,363.12	1,365.24	1,365.27
6304.96 (d/s of Bush Kill and Dry Brook confluence)	1,359.81	1,359.77	1,361.75	1,361.65
5218.81 (Approx. 2,000 feet d/s of the Dry Brook/Bush Kill confluence)	1,355.80	1,355.94	1,358.11	1,358.33
4769.675 (u/s of Finnerty Lane)	1,355.07	1,355.27	1,357.43	1,357.77
4305.68 (At Finnerty Lane)	1,353.62	1,350.63	1,356.30	1,354.78
3797.652 (450 feet upstream of Route 28 Bridge)	1,352.09	1,350.64	1,355.77	1,354.70
3414.24 (95 feet upstream of Route 28 Bridge)	1,348.85	1,348.38	1,355.00	1,353.75
3343.79 (Immediately upstream of Route 28 Bridge)	1,348.60	1,348.10	1,353.80	1,353.04
3239.25 (Immediately downstream of Route 28 Bridge)	1,347.45	1,347.53	1,351.53	1,349.53
3038.28 (240 feet downstream of Route 28 Bridge)	1,346.79	1,347.10	1,349.46	1,349.71

The bypass channel under Route 28 was evaluated in the BCA program individually and in combination with other alternatives.

4.7 Combinations of Hydraulic Alternatives

Alternatives were combined to determine the cumulative benefits of multiple actions. The individual alternatives described above were vetted through multiple public meetings including meetings listed in Table 1-2. Combinations were tested to try and create greater benefits than the individual alternatives could provide. The following combinations of alternatives were modeled.

4.7.1 Combination 1 – Bypass Channel at Route 28 Bridge with Floodplains Up and Downstream of Bridge (STA 2283.38 to 5645.89 on Dry Brook)

This alternative includes the bypass channel at the Route 28 bridge (BC-1), the floodplain upstream of the Route 28 bridge (FP-4), and part of the floodplain downstream of the Route 28 bridge (FP-5). Of the three components, Alternative BC-1 was found to cause significant flood reduction. The floodplain alternatives were included to potentially extend benefits from the bypass channel further up and downstream.

Figure 4-14 depicts depth grid mapping for Combination 1. Table 4-11 provides water surface elevations near the Route 28 bridge.

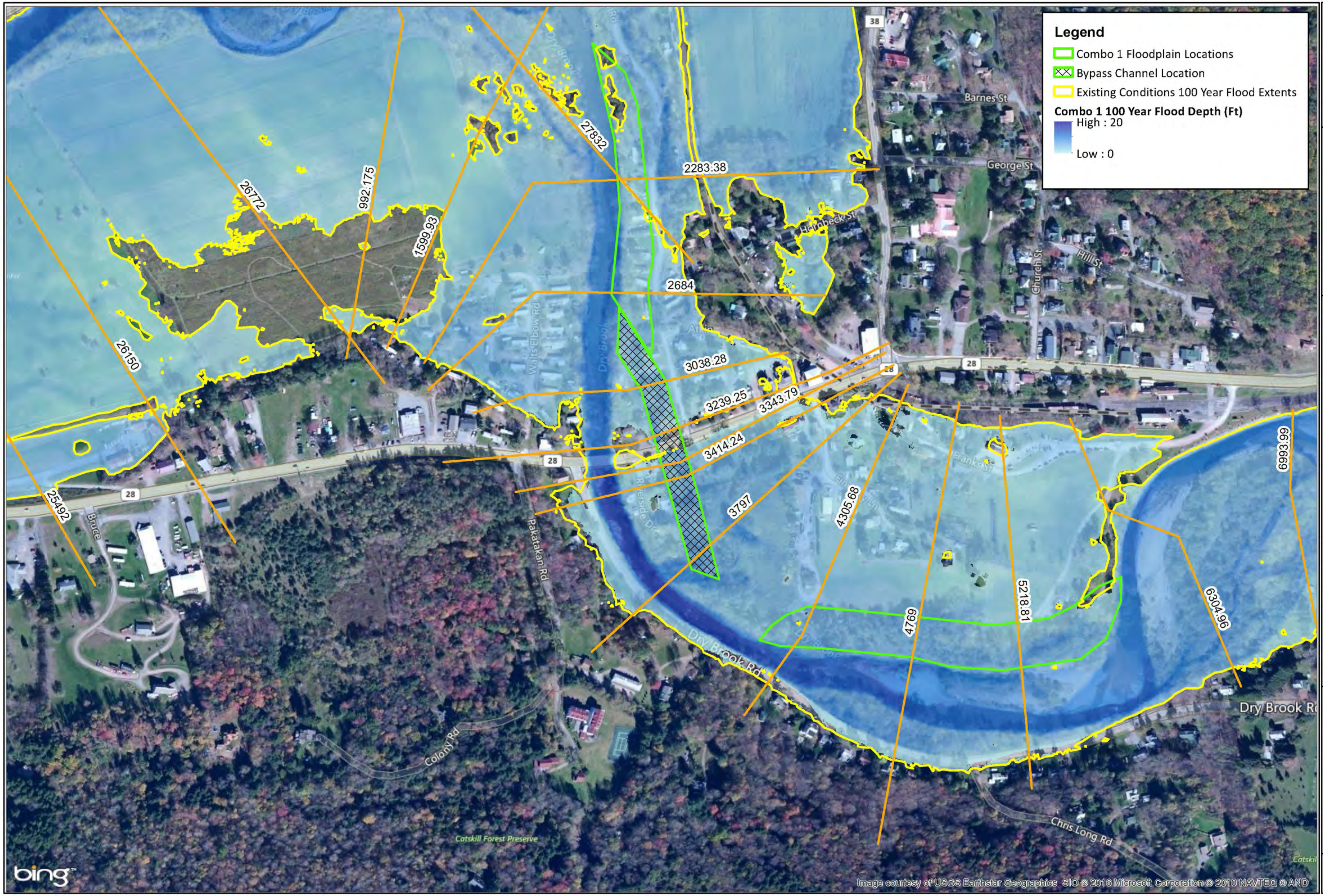

Figure 4-14: Combination 1

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Scale: 1 in = 300 ft

TABLE 4-11
Comparison of Water Surface Elevations for Combination 1 (10-Year and 100-Year)
[feet NAVD88]

Station on Dry Brook	Existing Conditions (10-Year)	Alternative Combo 1 (10-Year)	Existing Conditions (100-Year)	Alternative Combo 1 (100-Year)
7762.58 (u/s of Bush Kill and Dry Brook confluence)	1,366.99	1,366.92	1,368.92	1,368.91
6993.99 (Immediately d/s of Bush Kill and Dry Brook confluence)	1,363.11	1,363.19	1,365.24	1,365.29
6304.96 (d/s of Bush Kill and Dry Brook confluence)	1,359.81	1,359.62	1,361.75	1,361.60
5218.81 (Approx. 2,000 feet d/s of the Dry Brook/Bush Kill confluence)	1,355.80	1,355.17	1,358.11	1,357.56
4769.675 (Upstream of Finnerty Lane)	1,355.07	1,354.31	1,357.43	1,356.84
4305.68 (At Finnerty Lane)	1,353.62	1,351.17	1,356.30	1,354.66
3797.652 (450 feet u/s of Route 28 Bridge)	1,352.09	1,350.60	1,355.77	1,354.69
3414.24 (95 feet u/s of Route 28 Bridge)	1,348.85	1,348.10	1355.00	1,353.73
3343.79 (Immediately u/s of Route 28 Bridge)	1,348.60	1,347.77	1,353.8	1,352.99
3239.25 (Immediately d/s of Route 28 Bridge)	1,347.45	1,347.19	1,351.53	1,349.16
3038.28 (240 feet d/s of Route 28 Bridge)	1,346.79	1,346.59	1,349.46	1,349.20
2684.479 (550 feet d/s of Route 28 Bridge)	1,345.04	1,344.94	1,347.06	1,346.89
2283.38 (950 feet d/s of Route 28 Bridge)	1,343.83	1,343.80	1,346.41	1,346.37

Modeling demonstrated the following:

Combination 1 reduces water surface elevations by approximately 2 feet near the Route 28 bridge in the 100-year flood. In the 10-year flood, Combination 1 removes water from portions of Finnerty Lane and Franks Street.

- Under existing conditions, the section of Route 28 immediately east of the bridge is predicted to overtop in the 50-year flood. With Combination 1, the 50-year flood still overtops Route 28 east of the bridge.
- For the 10-year flood, this combination is predicted to reduce water surface elevations by up to 2.5 feet near Finnerty Lane. In the 100-year flood, Combination 1 reduces water surface elevations by 2.4 feet immediately downstream of the Route 28 bridge and by 1.6 feet near Finnerty Lane.
- The depth grid mapping shows that in the 10-year flood, Combination 1 removes water from some parts of Finnerty Lane and Franks Street. No buildings are removed from the 100-year flood extents under proposed conditions, but there is a reduction in the depth of flooding.

This alternative was advanced to the BCA process for further evaluation.

4.7.2 Combination 2 – Route 28 Bridge Replacement with Floodplains Up and Downstream of Bridge (STA 2283.38 to 5645.89 on Dry Brook)

This alternative consists of replacing the Route 28 bridge with a wider-span structure, removing the existing culvert east of the bridge, and creating a floodplain (BR-2). In addition to the bridge replacement, floodplains would be set downstream of the bridge (FP-5) and upstream of the bridge (FP-4). The floodplain below the proposed bridge would connect to the floodplain downstream along Pavilion Road.

Figure 4-15 depicts depth grid mapping for Combination 2. Table 4-12 provides water surface elevations near the Route 28 bridge.

Modeling demonstrated the following:

Combination 2 reduces water surface elevations by approximately 2 feet immediately downstream of the Route 28 bridge in the 100-year flood. In the 10-year flood, Combination 2 reduces water surface elevations near Finnerty Lane between 1.8 and 2.1 feet.

- Under existing conditions, the section of Route 28 immediately east of the bridge is predicted to overtop in the 50-year flood. With Combination 2, the 100-year and lower floods do not overtop the road east of the Route 28 bridge.
- For the 10-year flood, this combination is predicted to reduce water surface elevations by between 1.8 to 2.1 feet near Finnerty Lane. In the 100-year flood, Combination 1 reduces water surface elevations by 2.2 feet immediately downstream of the Route 28 bridge, 3.8 feet upstream of the Route 28 bridge, and by 1.9 feet near Finnerty Lane.
- Similar to Combination 1, the depth grid mapping shows that in the 10-year flood, Combination 2 removes water from some parts of Finnerty Lane and Franks Street. No buildings are removed from the 100-year flood extents under proposed conditions, but there is a reduction in the depth of flooding.

This alternative was advanced to the BCA for further evaluation.

TABLE 4-12
Comparison of Water Surface Elevations for Combination 2 (10-Year and 100-Year)
[feet NAVD88]

Station on Dry Brook	Existing Conditions (10-Year)	Alternative Combo 2 (10-Year)	Existing Conditions (100-Year)	Alternative Combo 2 (100-Year)
7762.58 (u/s of Bush Kill and Dry Brook confluence)	1,366.99	1,366.87	1,368.92	1,368.87
6993.99 (Immediately d/s of Bush Kill and Dry Brook confluence)	1,363.11	1,363.29	1,365.24	1,365.44
6304.96 (d/s of Bush Kill and Dry Brook confluence)	1,359.81	1,359.42	1,361.75	1,361.20
5218.81 (Approx. 2,000 feet d/s of the Dry Brook and Bush Kill confluence)	1,355.80	1,355.42	1,358.11	1,358.07
4769.675 (u/s of Finnerty Lane)	1,355.07	1,354.59	1,357.43	1,357.42

Station on Dry Brook	Existing Conditions (10-Year)	Alternative Combo 2 (10-Year)	Existing Conditions (100-Year)	Alternative Combo 2 (100-Year)
4305.68 (At Finnerty Lane)	1,353.62	1,351.80	1,356.30	1,354.40
3797.652 (450 feet u/s of Route 28 Bridge)	1,352.09	1,349.98	1,355.77	1,353.48
3414.24 (95 feet u/s of Route 28 Bridge)	1,348.85	1,348.63	1,355.00	1,351.23
3343.79 (Immediately u/s of Route 28 Bridge)	1,348.60	1,348.43	1,353.80	1,350.75
3239.25 (Immediately d/s of Route 28 Bridge)	1,347.45	1,347.04	1,351.53	1,349.34
3038.28 (240 feet d/s of Route 28 Bridge)	1,346.79	1,346.29	1,349.46	1,348.68
2684.479 (550 feet d/s of Route 28 Bridge)	1,345.04	1,344.94	1,347.06	1,346.89
2283.38 (950 feet d/s of Route 28 Bridge)	1,343.83	1,343.80	1,346.41	1,346.37

Evaluation of all of the alternatives demonstrates the following:

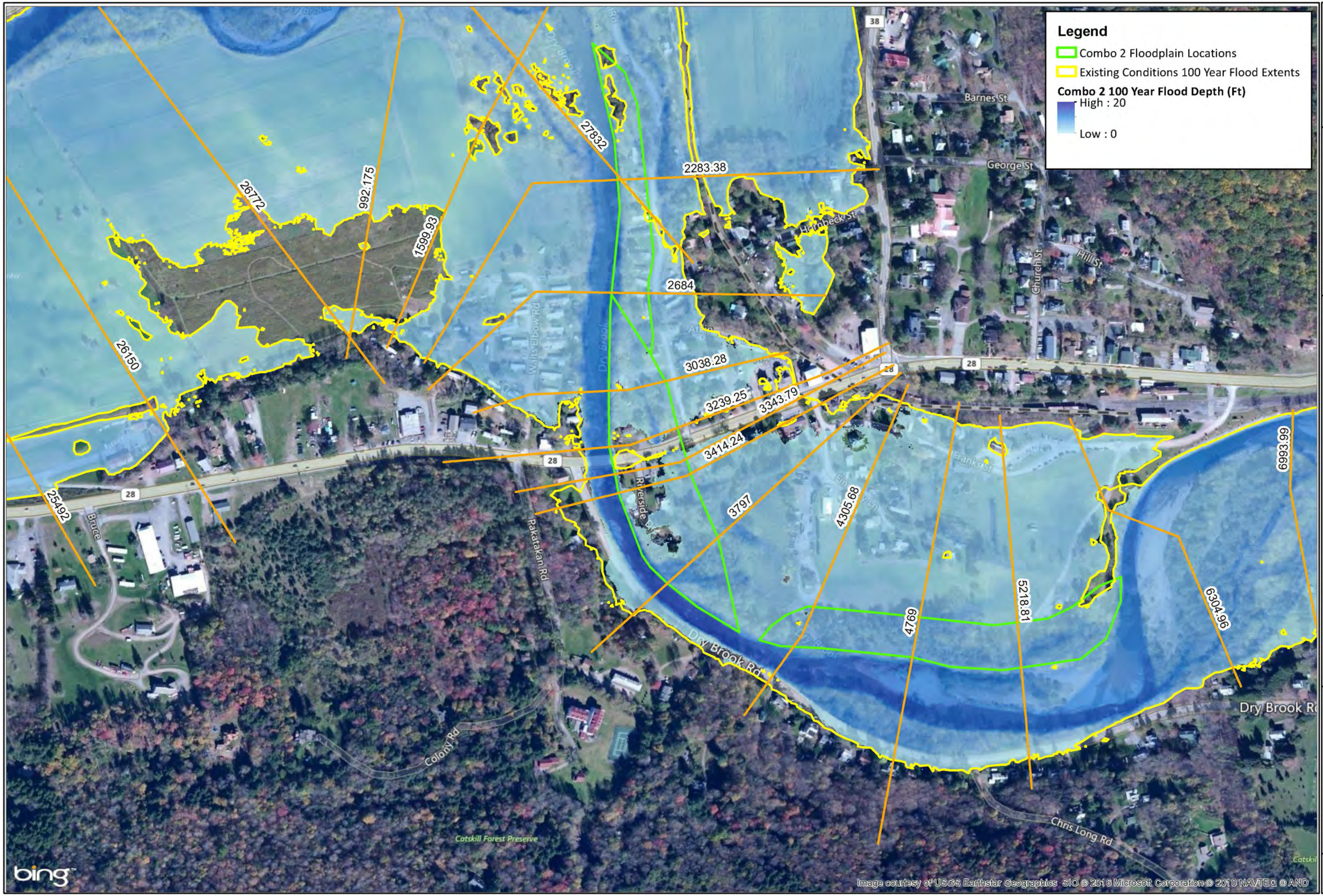
- Combination 1 and Combination 2 provide significant water surface reductions near Finnerty Lane and Franks Street.
- Except for the area around the Route 28 bridge, individual flood mitigation projects such as floodplain benches, when they are combined in series, do not significantly increase benefits throughout Arkville to a degree higher than if they were constructed individually. This gives the Town flexibility to pursue individual projects without being concerned about whether others will be constructed.
- Alternative FP-5 would be disruptive to the same homes along Pavilion Road that need to be protected. Removing the houses would be more economical and make more sense, if there is interest in pursuing a project in that area of the hamlet.
- Some of the alternatives cause very slight local water surface *increases* in locations where the water surface elevation was dipping under existing hydraulic conditions.

Floodplain delineations and water depth mapping (Figures 4-2 through 4-17) have been created for the combinations of alternatives to best represent the changes that are expected in both flood extent and depth. Existing conditions mapping has been provided as a baseline for comparisons of the results of the alternatives. The extents of the existing conditions 10-year and 100-year floodplains are also included on each map to faciliatate comparison of results. Flood depths in the areas where floodplain enhancement and lowering are specified will be deeper than depicted on maps.

4.8 Property-Specific Building Flood Mitigation

Despite the predicted floodwater surface elevation reductions associated with flood mitigation alternatives described in this report, many of the properties in the Arkville LFA study area that are currently in the SFHA associated with the East Branch Delaware River, Dry Brook, and Bush Kill *will remain* in the SFHA. Therefore, they will be subject to continued flood risk and flood insurance coverage requirements[3]. However, the reduction of floodwater surface elevations has two benefits:

[3] Flood insurance requirements are dependent on status of the property relative to loans, mortgages, or other factors that are outside the scope of this plan.



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SOURCE(S):
ESRI, Bing, FEMA, NYCDEP WOH 2009 LIDAR

Figure 4-15: Combination 2

Arkville LFA

Middletown

Delaware County, NY

Map By: JCS
MMI#: 5197-07
MXD: Y:\5197-07\Maps\Fig 4-15 Combo 2.mxd
1st Version: 5/6/2015
Revision: 10/26/2016
Scale: 1 in = 300 ft

1. Depth of actual flooding may decrease in future floods, leading to reduced damages and reduced time and costs for cleanup and recovery.
2. Reduced water surface elevations can be used to support a Letter of Map Revision (LOMR[4]) or physical map revision (PMR[5]), which would formally reduce the BFE and may reduce flood insurance premiums for some properties.

The discussion in this section provides a reasonable description of the options that may be available to property owners under current conditions and potential future conditions if bridge replacement and floodplain enhancement projects are pursued. However, individual property owners should always work with the Town of Middletown code enforcement officer to determine what is legally required when an improvement is planned.

To further reduce risk of flood damage in the future, property owners in Arkville may wish to conduct site-specific mitigation actions to reduce flood risks. The fundamental choice is to determine whether a building should be removed and the parcel converted to open space or mitigated through elevation, floodproofing, elevating utilities, etc. as described in Section 4.4 of this document[6].

If homes are elevated, they will need to be elevated two feet above the BFE. However, this will present an important question to property owners as they work with local authorities – should the current BFE be applied, or should the work be postponed to take advantage of a potential future (and lower) BFE defined by a LOMR or PMR? In many cases a property owner may not have time available to delay a building elevation, floodproofing project, or utility elevation. However, if the property owner can delay a mitigation project until after Arkville has secured a LOMR or PMR, then the design elevation may be lower. Other important considerations include the following:

- FEMA and many other grant funds will allow elevation of buildings in SFHAs but will not in floodways.
- If mitigation is funded by the property owner, then building elevation in a floodway is acceptable as long as the footprint of the structure is not expanded.
- If building elevation or floodproofing is not a substantial improvement or is not the result of substantial damage, then it can be allowed in a floodway; however, the owner will see no benefit on flood insurance premiums.

---

[4] A LOMR is FEMA's modification to a FIRM. LOMRs are generally based on the implementation of measures that affect the hydrologic or hydraulic characteristics of a flooding source and thus result in the modification of the existing regulatory floodway, the effective BFEs, or the SFHA. The LOMR officially revises the FIRM without causing FEMA to republish the FIRM. The LOMR is generally accompanied by an annotated copy of the affected portions of the FIRM.
[5] A PMR is an action whereby one or more FIRM or DFIRM map panels are physically revised and republished. A PMR is used to change flood risk zones, floodplain and/or floodway delineations, flood elevations, and/or planimetric features. A LOMR accomplishes some of the same changes as the PMR, but the FIRM or DFIRM panels are not republished with the LOMR.
[6] Substantial damage or a substantial improvement will trigger elevation of residential buildings and either dry floodproofing or elevation of nonresidential buildings.

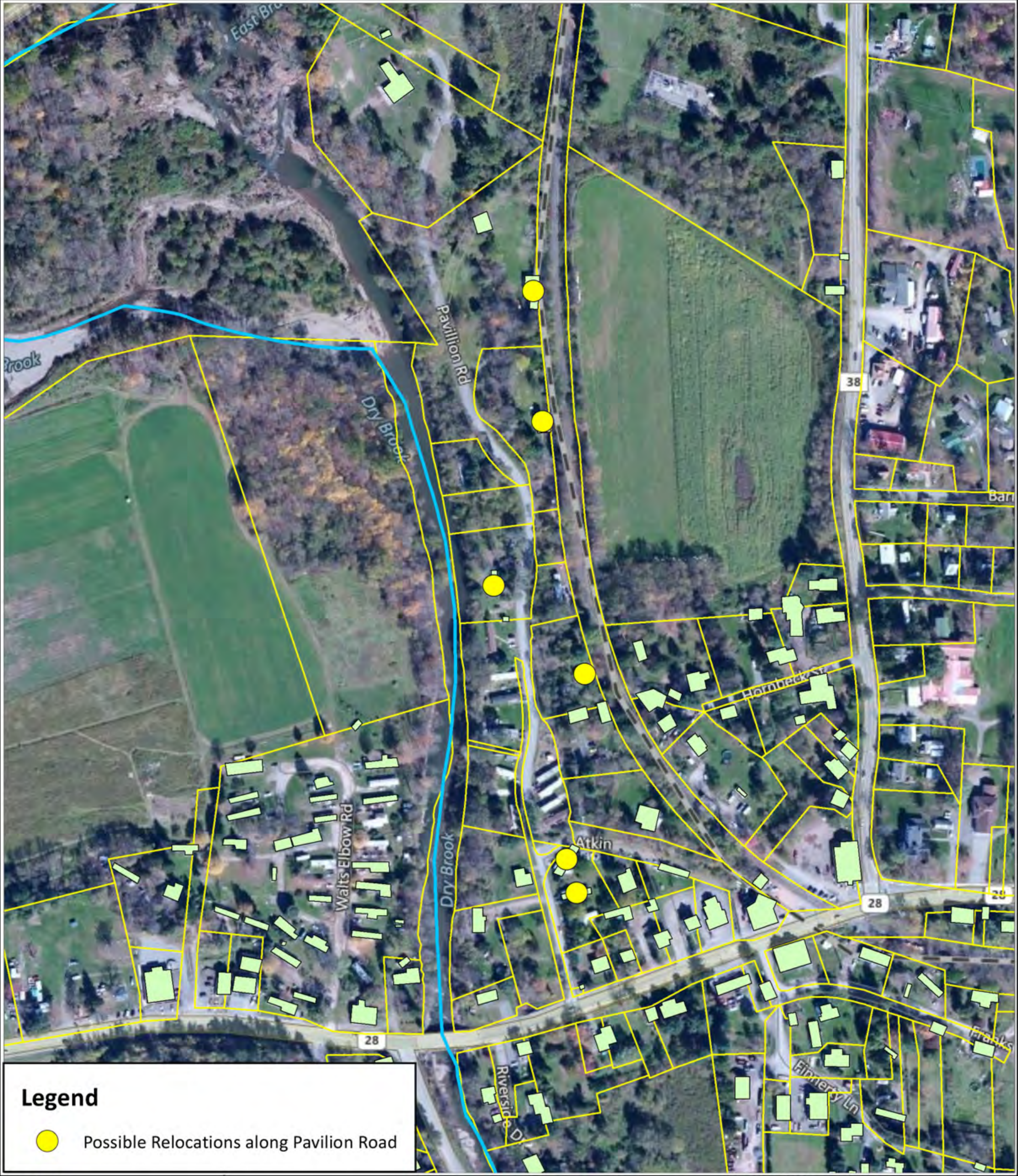
4.9 Relocations

Alternatives BR-2, FP-5, BC-1, Combination 1, and Combination 2 all involve property acquisitions or relocations in order to execute the various floodplain projects. In addition to the relocations necessary for some of the modeled alternatives, the East Branch Flood Commission and the Town of Middletown have expressed interest in acquisition and/or elevation of structures along Pavilion Road (Figure 4-16), in the trailer park northwest of the Route 28 bridge over Dry Brook (Figure 4-17), and in the Finnerty Lane/Franks Street area (Figure 4-18). The relocation costs for each of these three areas are shown in Table 4-13. Relocation costs were estimated using property values and approximate demolition costs. A BCA was not conducted for these acquisitions.

TABLE 4-13
Estimated Building Relocation Costs

Relocation Area	Relocation Costs
Pavilion Road	$600,000
Trailer Park near Route 28 Bridge	$1,200,000
Finnerty Lane/Franks Street	$2,000,000

There may be other key businesses, critical facilities, or residential buildings in Arkville that can be relocated away from zones of flood risk. The subject LFA supports the relocation of any critical facility that is currently at risk of flooding or will continue to be exposed to residual risk after flood mitigation projects are implemented in Arkville. If private property owners are interested in relocating elsewhere within Middletown, the buyout program could be used to facilitate relocations that are not part of the proposed alternatives.



SOURCE(S):
Base Map Credits: Image courtesy of USGS Earthstar Geographics SIO © 2017 Microsoft Corporation © 2017 HERE © AND

Figure 4-16: Possible Building Relocations on Pavilion Road

LOCATION: **Arkville, NY**

N

Arkville Local Flood Analysis

MXD: Y:\5197-07\Maps\Pavilion Rd Relocations.mxd

Map By: JCS
MMI#: 5197-07
Original: 6/13/2016
Revision: 5/18/2017
Scale: 1 inch = 300 feet

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Figure 4-17: Possible Building Relocations in Trailer Park near Route 28 Bridge

LOCATION: **Arkville, NY**

N

Arkville Local Flood Analysis

MXD: Y:\5197-07\Maps\Trailer Park Relocations.mxd

Map By: JCS
MMI#: 5197-07
Original: 6/13/2016
Revision: 10/26/2016
Scale: 1 inch = 150 feet

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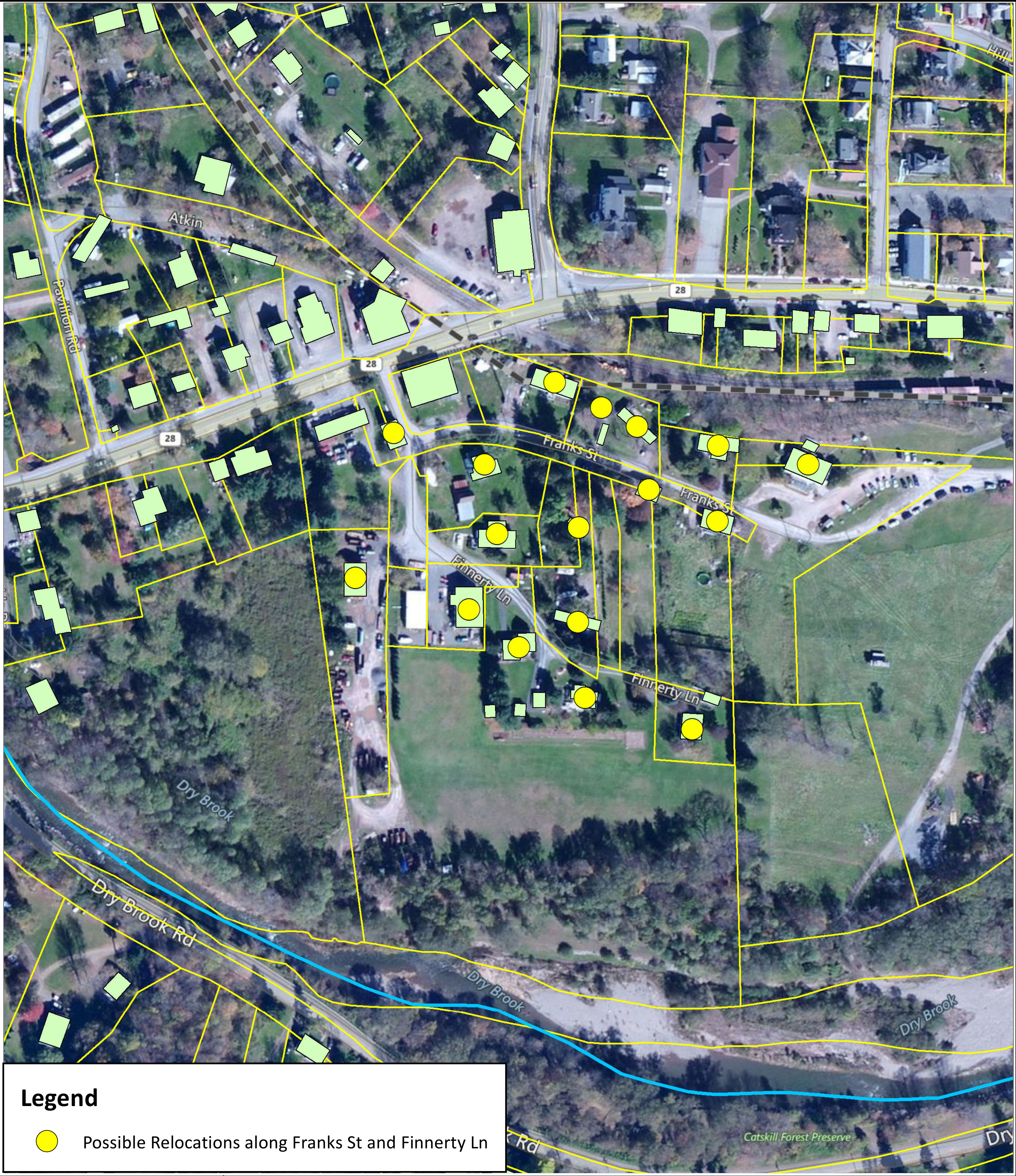

SOURCE(S):	Figure 4-18: Possible Building Relocations on Franks St and Finnerty Ln	LOCATION: Arkville, NY
Base Map Credits: Image courtesy of USGS Earthstar Geographics SIO © 2017 Microsoft Corporation © 2017 HERE © AND	Arkville Local Flood Analysis	

N

MXD: Y:\5197-07\Maps\Franks Finnerty Relocation.mxd

Map By: JCS
MMI#: 5197-07
Original: 6/13/2016
Revision: 5/18/2017
Scale: 1 inch = 200 feet

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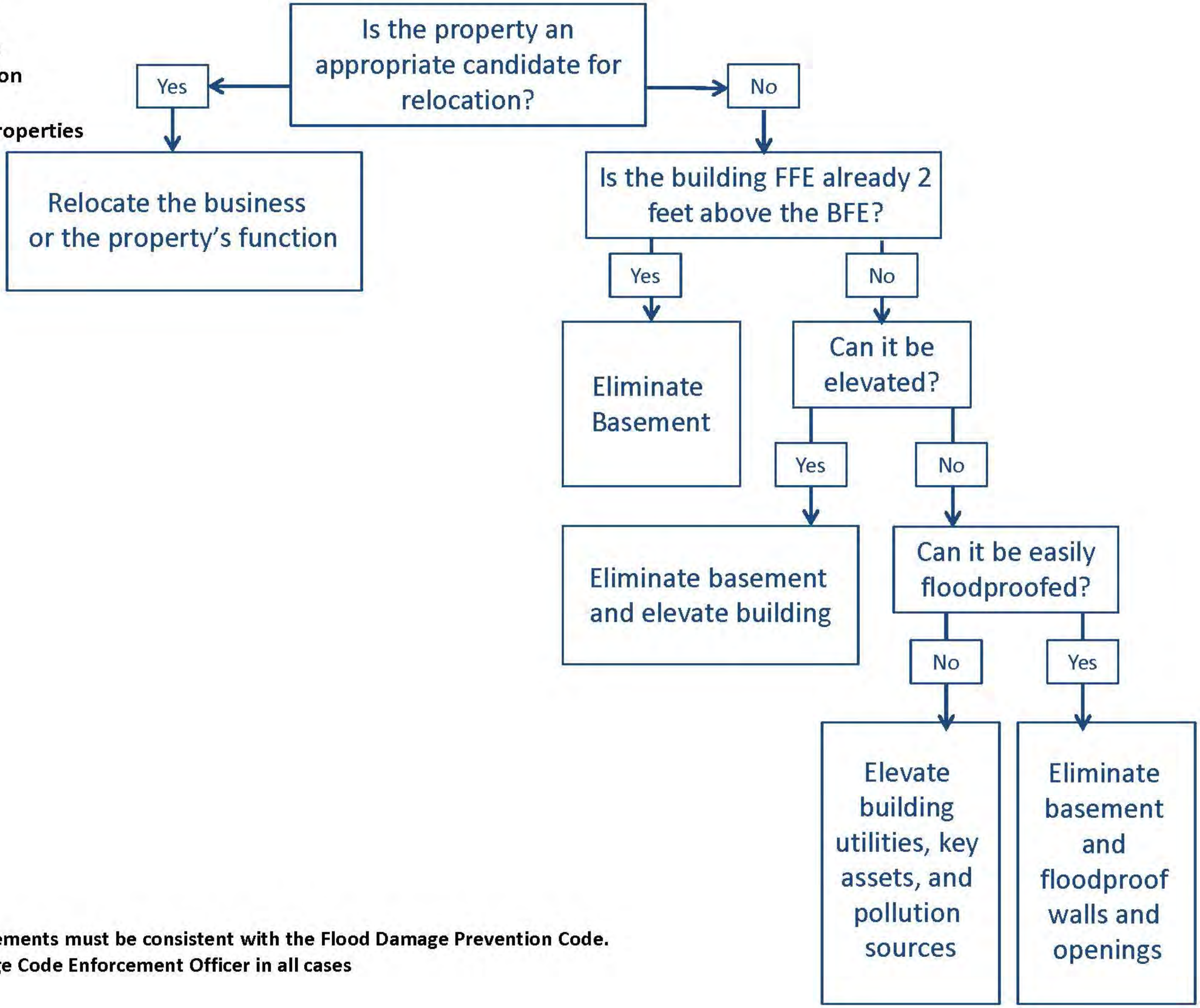
4.10 Decision Support for Property-Specific Building Flood Mitigation and Relocations

To aid the selection of future property-specific mitigation actions such as building elevation and relocation, two decision support flowcharts are offered. The first chart (Figure 4-19) is applicable to nonresidential properties and the second (Figure 4-20) is applicable to residential properties. In both cases, the underlying assumption is that properties are located in the SFHA associated with the Dry Brook, East Branch Delaware River, and Bush Kill. The specific design elevation (for example, the height of floodproofing) should always be determined on a case-by-case basis with reference to the BFE and whether a LOMR or PRM has been obtained in the future.

Figure 4-19

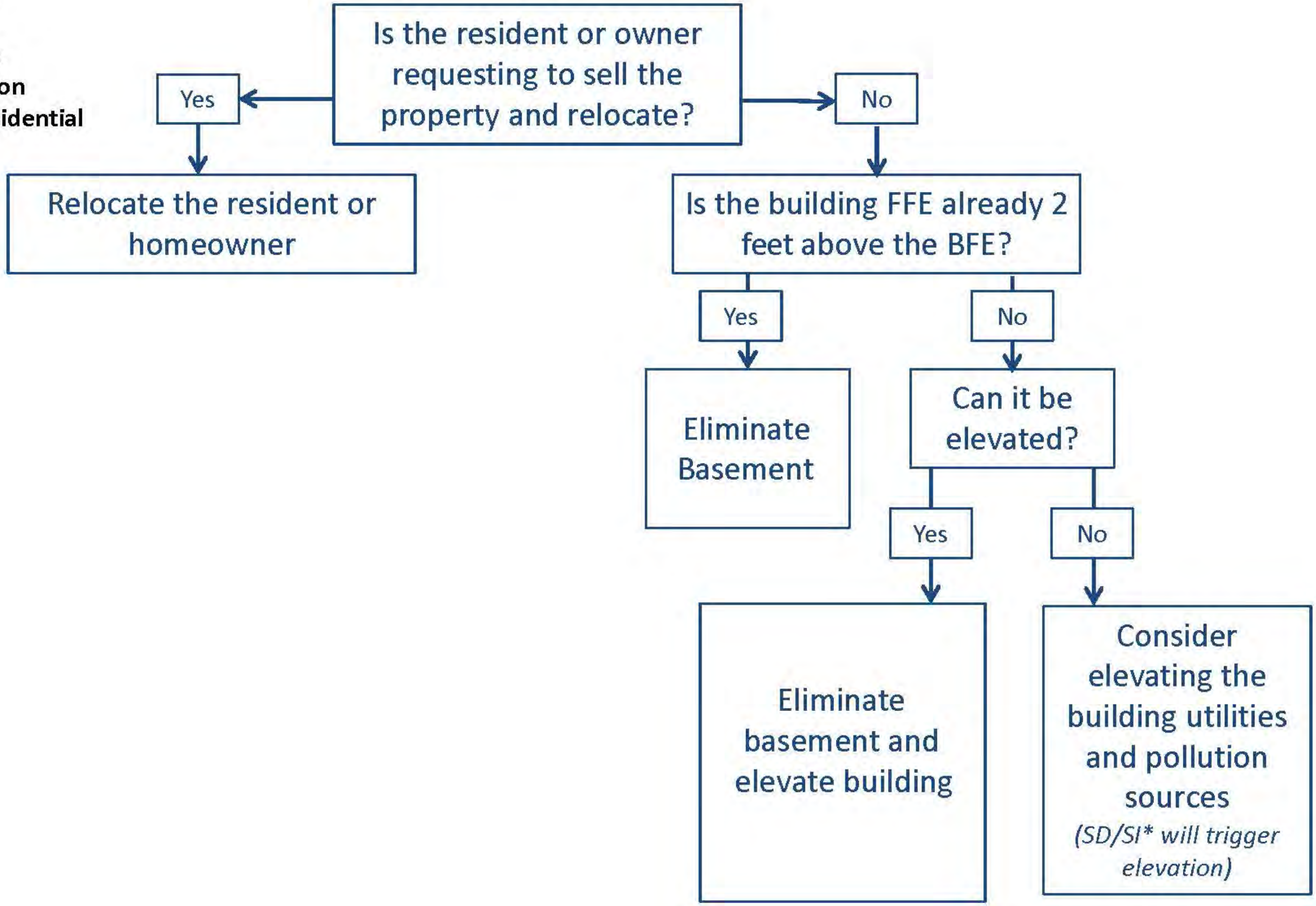
Property-Specific Mitigation Decision Flowchart for Nonresidential Properties



Note: All improvements must be consistent with the Flood Damage Prevention Code. Consult the Village Code Enforcement Officer in all cases

Figure 4-20

Property-Specific Mitigation Decision Flowchart for Residential Properties



*Substantial Damage/Substantial Improvement

Note: All improvements must be consistent with the Flood Damage Prevention Code. Consult the Village Code Enforcement Officer in all cases

5.0 SEDIMENT TRANSPORT MODELING

5.1 Introduction

The East Branch Flood Commission and Arkville community members expressed concern about sediment transport along Dry Brook. Aerial photography and site walks showed numerous gravel bars, particularly between stations 9652.1 and 4305.68 on Dry Brook. In order to evaluate the effects of proposed alternatives on sediment transport, the most promising alternatives (Combination 1, Combination 2, and the bypass channel) were evaluated using the HEC-RAS sediment transport simulation. The USACE cautions that "the data utilized to predict bed change is fundamentally uncertain and the theory employed is empirical and highly sensitive to a wide array of physical variables." Given these limitations, the proposed alternatives were compared to an existing conditions model; however, not enough data was available to create a sediment model capable of predicting sediment load volumes.

DCSWCD provided pebble count data for one location on Dry Brook upstream of the project area. Because the slope of the Bush Kill and Dry Brook are similar within the project area, the Dry Brook pebble count data was used for Bush Kill as well. The existing conditions geometry described in Section 4.2 served as existing conditions data for sediment transport modeling, with the addition of a surveyed cross section at station 5645.89 on Dry Brook. The surveyed section was added to better represent sediment transport at a sharp turn south of the Delaware and Ulster railroad buildings. In order to represent the bedrock in Dry Brook upstream of the Route 28 bridge, no scour was allowed in the model at the three cross sections upstream of the bridge. The 2-year and 100-year flows were used to estimate the alternatives' effects on sediment transport.

Sediment transport model output is presented in a series of figures for the alternatives evaluated. Cool colors (primarily blue and green) and negative values represent scour, whereas warm colors (red, yellow, and orange) with positive values represent deposition.

5.2 Bypass Channel BC-1 Sediment Transport Analysis

The proposed bypass channel next to the Route 28 bridge and the existing conditions model were compared in the sediment transport analysis using a 2-year flow. Figure 5-1 shows areas of scour (cool colors with values less than zero) and areas of deposition (warm colors with values greater than zero). Modeling indicates that the presence of the bypass channel may shrink the area of potential deposition above the bridge and reduce scour downstream.

The bypass channel is not predicted to significantly change relative to sediment transport as shown in Figures 5-2 through 5-4. There is an area of deposition upstream of the Route 28 bridge and an area of scour downstream of the bridge.

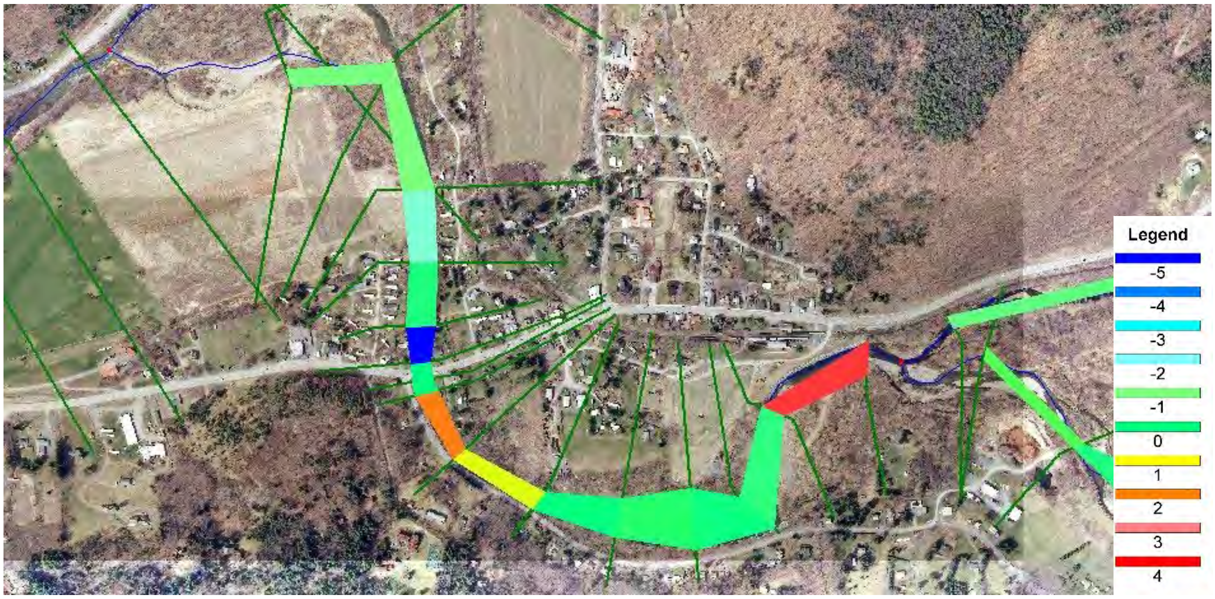


Figure 5-1 – Existing Conditions with 2-Year Flow

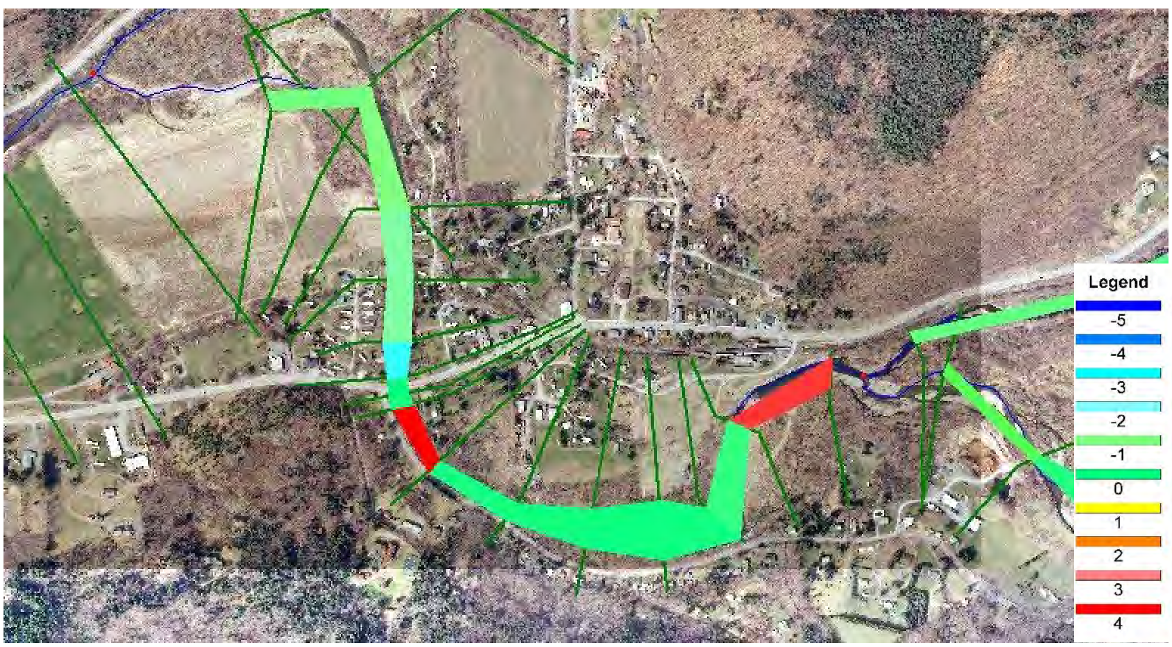


Figure 5-2 – Alternative BC-1 Bypass Channel with 2-Year Flow

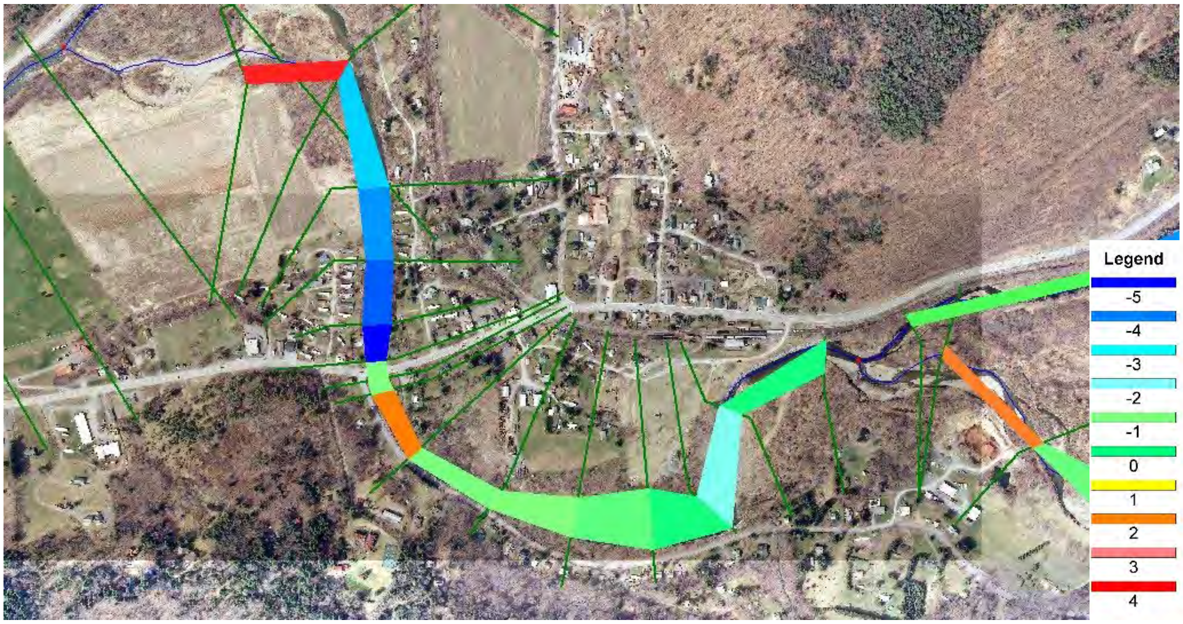


Figure 5-3 – Existing Conditions with 100-Year Flow

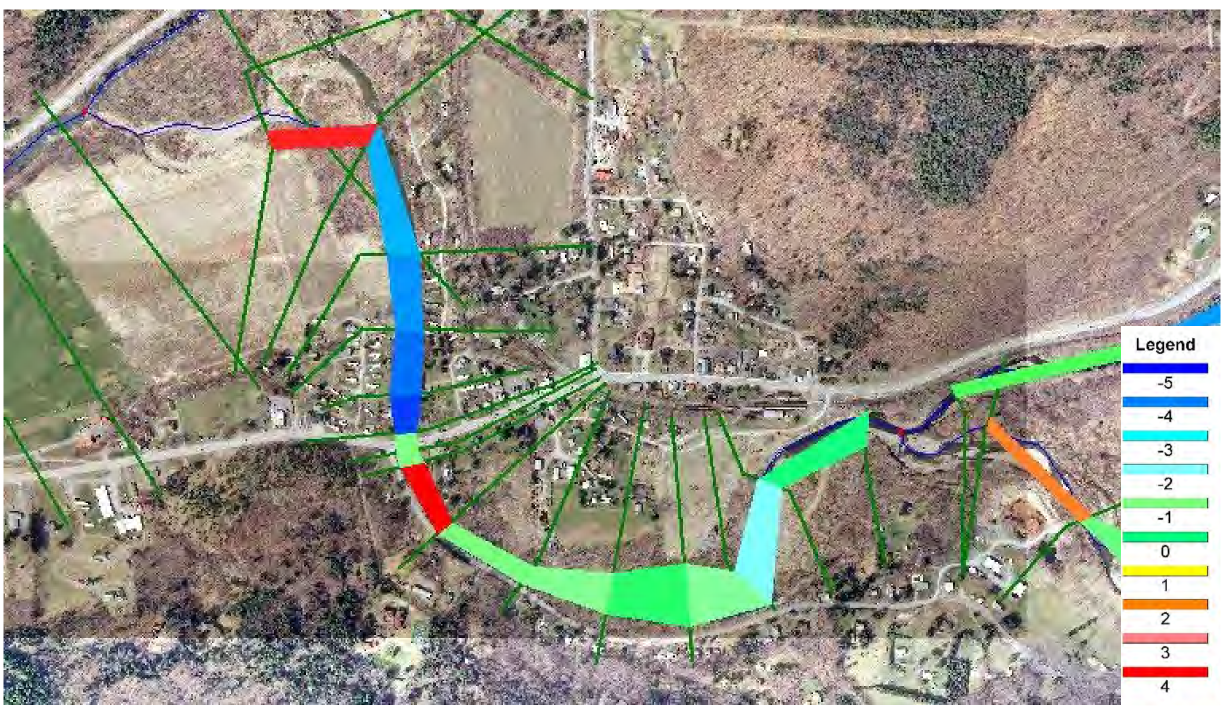


Figure 5-4 – Alternative BC-1 Bypass Channel with 100-Year Flow

5.3 Combination 1 Sediment Analysis

Combination 1 consists of the bypass channel (BC-1) with floodplain benches upstream and downstream of the Route 28 bridge. When the proposed geometry was evaluated in the sediment transport model, the results suggest that this combination may increase the potential for sedimentation above the bridge but decrease scour downstream in the 2-year flood. The results for the 2-year flood are shown in figures 5-5 and 5-6.

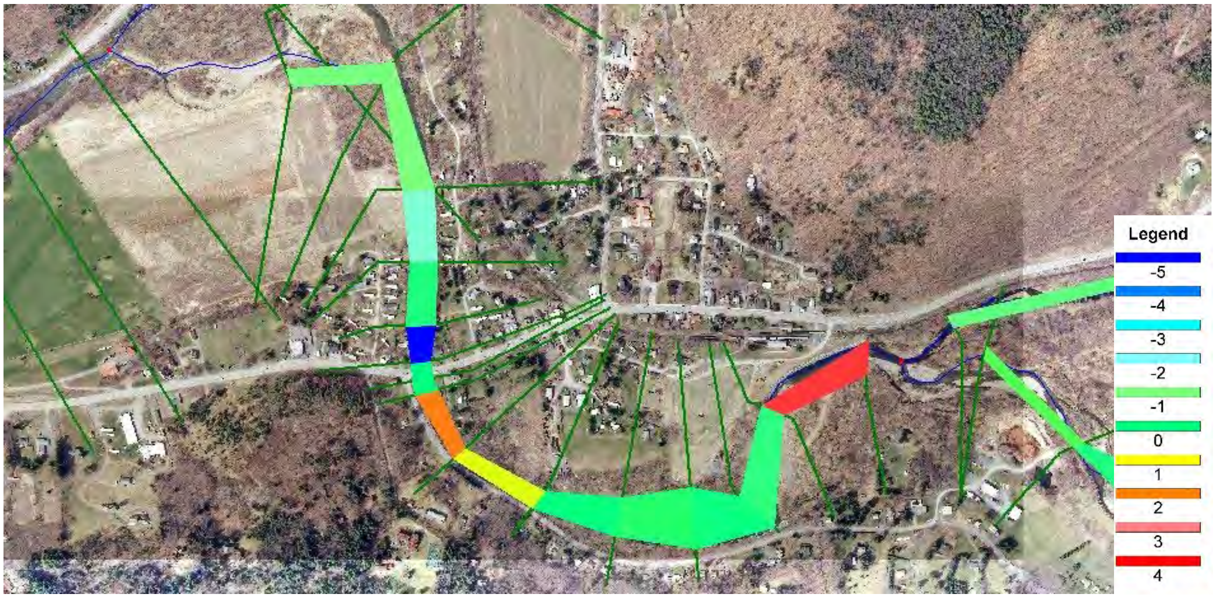


Figure 5-5 – Existing Conditions with 2-Year Flow

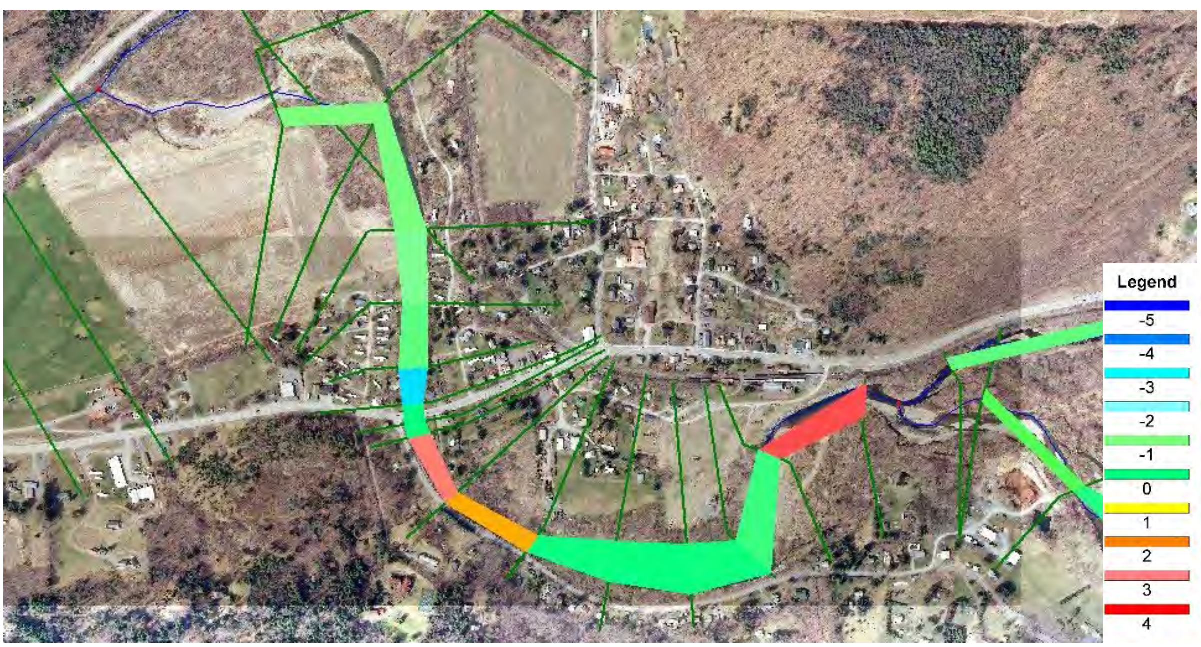


Figure 5-6 – Combination 1 with 2-Year Flow

In the 100-year flood, Combination 1 is not predicted to significantly change sediment transport. As shown in Figures 5-7 and 5-8, the amount of deposition upstream of the Route 28 bridge decreases, but extends further upstream.

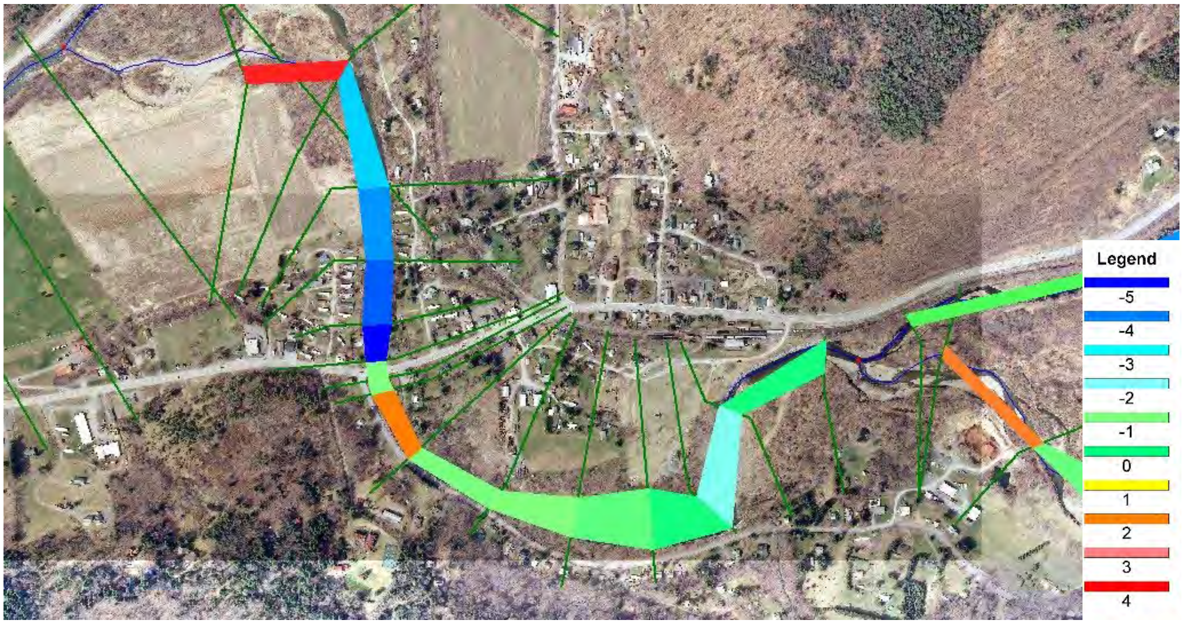


Figure 5-7 – Existing Conditions with 100-Year Flow

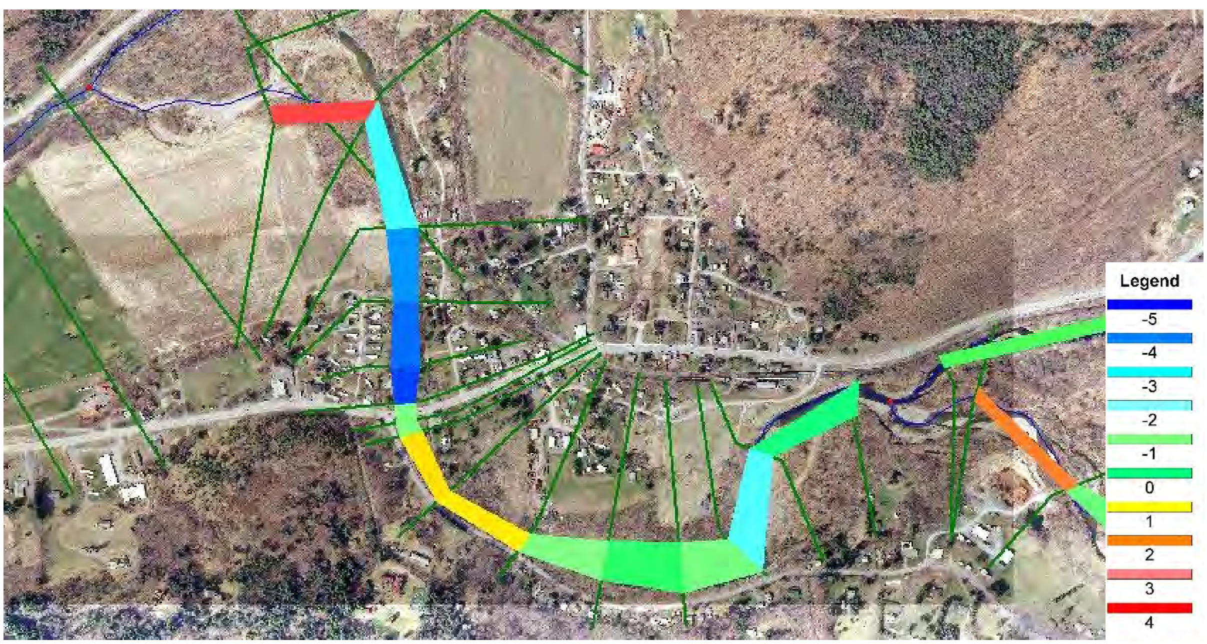


Figure 5-8 – Combination 1 with 100-Year Flow

5.4 Combination 2 Sediment Analysis

Combination 2 includes the Route 28 bridge replacement and floodplains FP-4 and FP-5 up and downstream of the Route 28 bridge. In the 2-year flood, Combination 2 appears to balance scour and deposition. Areas of both scour and deposition under existing conditions become more neutral in proposed conditions, as shown in Figures 5-9 and 5-10.

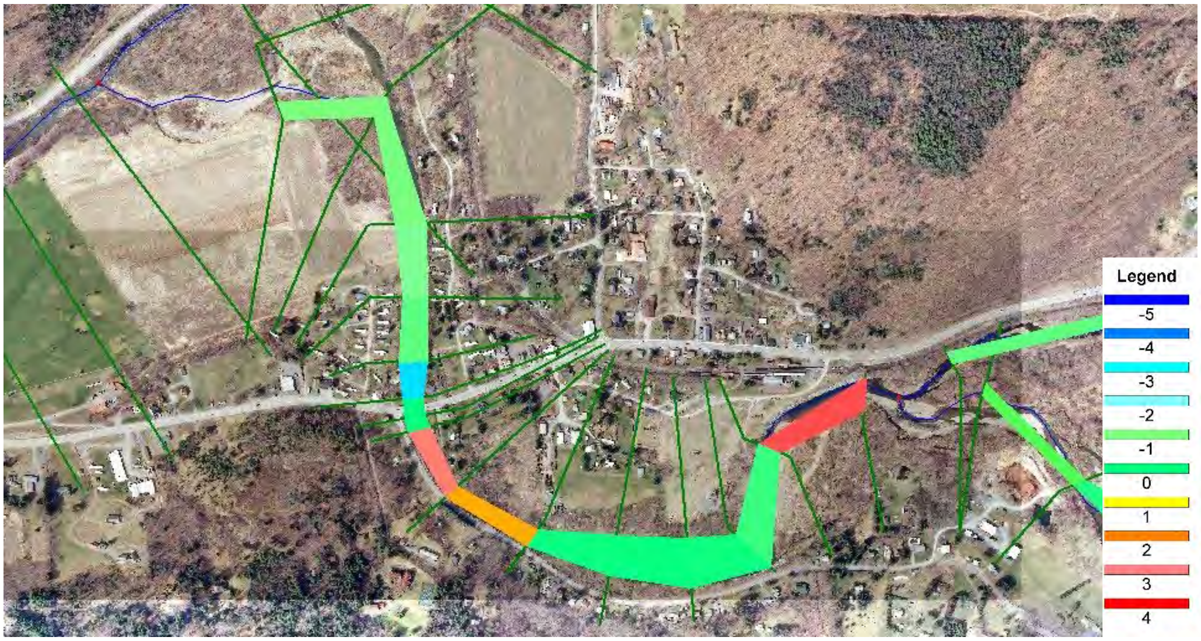


Figure 5-9 – Existing Conditions with 2-Year Flow

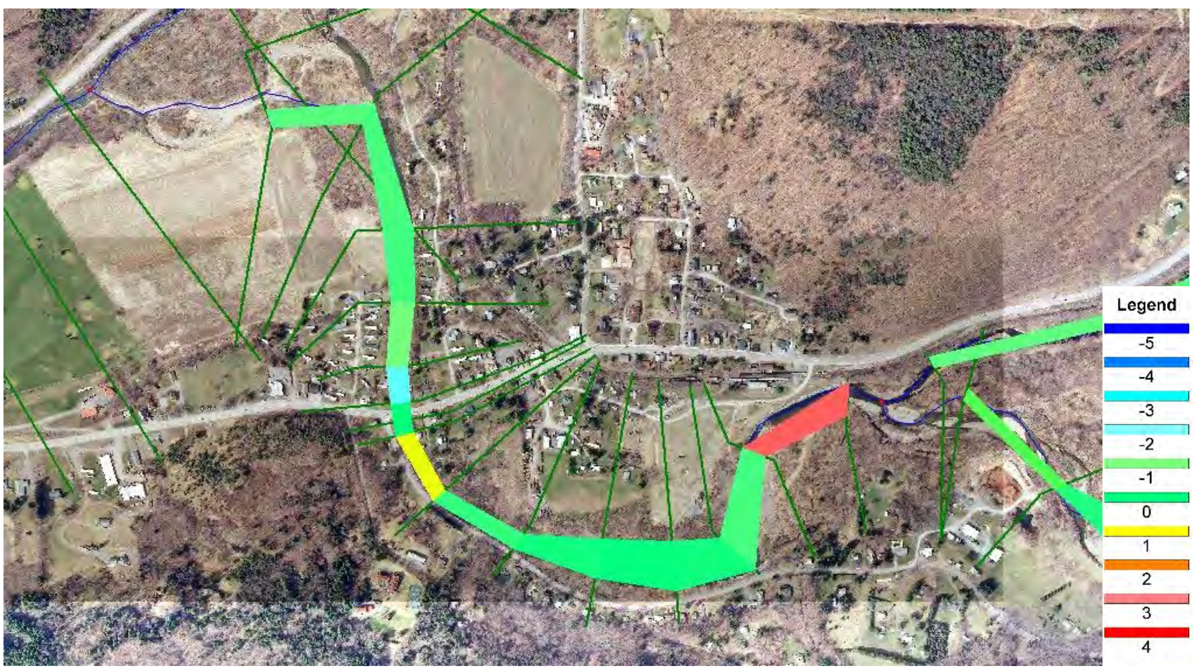


Figure 5-10 – Combination 2 with 2-Year Flow

In the 100-year flood, the proposed bridge replacement and floodplain benches do not significantly change sediment transport, as shown in Figures 5-11 and 5-12. However, deposition is reduced at the downstream end of the channel.

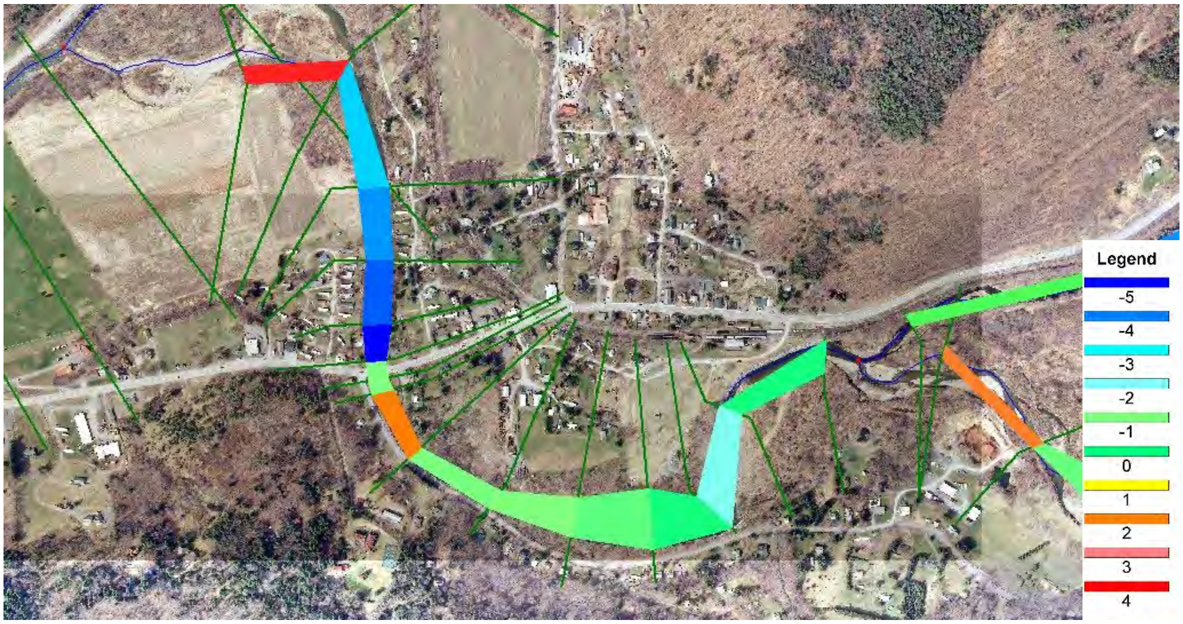


Figure 5-11 – Existing Conditions with 100-Year Flow

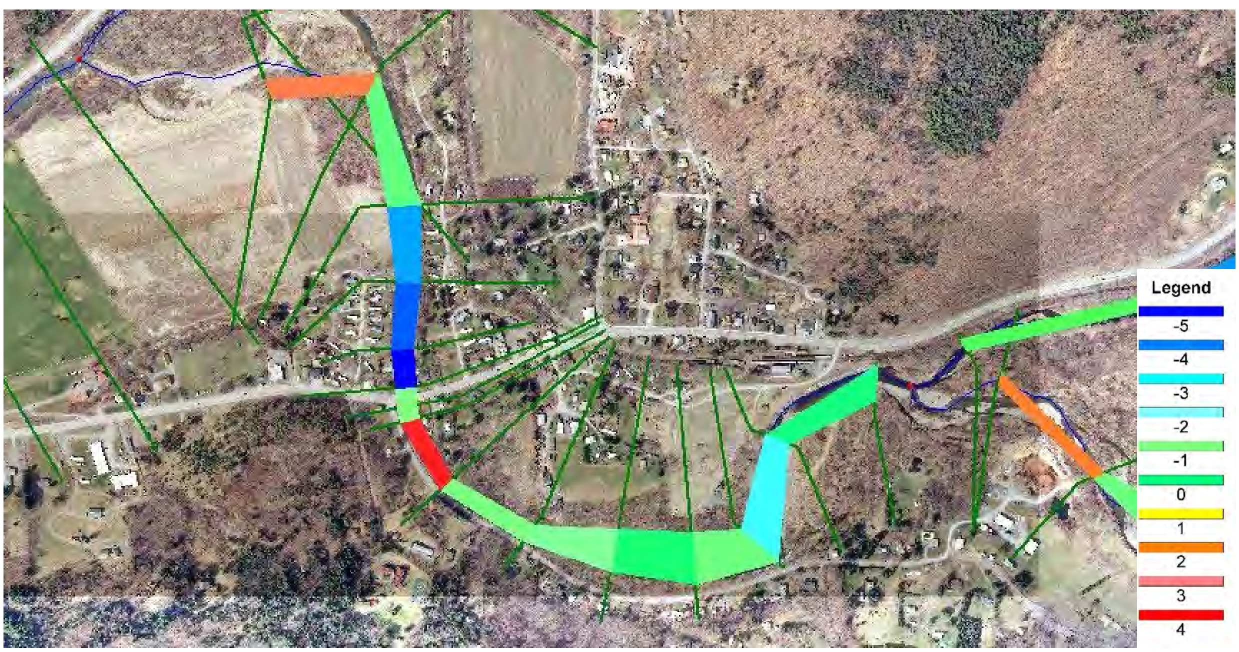


Figure 5-12 – Combination 2 with 100-Year Flow

The sediment transport analysis in general shows that the projects would not dramatically exacerbate the sediment transport issues in the study area. Any future project design should re-model the potential effect of the modified hydraulics on sediment transport.

6.0 BENEFIT COST ANALYSIS

6.1 Overview

Benefit-Cost Analysis is used to validate the cost-effectiveness of a proposed hazard mitigation project. A BCA is a method by which the future benefits of a project are estimated and compared to its cost. The end result is a benefit-cost ratio (BCR), which is derived from a project's total net benefits (value of avoided damages) divided by its total project cost. The BCR is a numerical expression of the cost effectiveness of a project. A project is considered by FEMA to be cost effective when the BCR is 1.0 or greater, indicating the long-term benefits of the project are sufficient to justify the upfront and long-term costs.

A BCA was conducted for five potential flood mitigation alternatives: FP-5, BC-1, BR-2, Combination 1, and Combination 2. The benefits were then summed outside of the BCA program and compared to the costs of the five alternatives. The only weakness to this method is that it neglects the maintenance costs for mitigation projects, which are typically estimated (for example, $500 per year for floodplain bench "maintenance") and assigned a present value by the BCA program. However, the magnitude of the benefits and costs in Arkville (discussed below) are so much greater than the present value of maintenance costs that they can be neglected. Other factors and assumptions for the BCA include the following:

- Benefits for acquired/relocated properties were determined as "acquisitions" in the BCA program. An acquisition benefit is computed by comparing the current condition (flood damage could occur) to a future condition where damage cannot occur because the building has been removed.
- Benefits for all other properties (the majority of those considered) were generated as local flood reduction projects. A local flood reduction benefit is computed by comparing the current condition (flood damage could occur) to a future condition where damage is lower because a mitigation project has been completed.
- Lost revenue data for businesses affected by flooding was not obtained by Village officials and therefore not utilized in the BCA.
- Default depth-damage curves were used in the program.
- Existing and future water surface elevations were determined from the HEC-GeoRAS surfaces created for the proposed alternatives.
- First floor elevations were estimated using the NYCDEP West of Hudson 2009 LiDAR.
- Adjustments to the LiDAR topography were made for these buildings based on observations of first floors relative to adjacent grades.
- Building replacement values were based on the assessed values and square footages provided by the Delaware County Planning Department's GIS database[7].

The BCA does not include benefits that could have been generated for avoiding future street cleanup, avoided detours, avoided emergency response, etc. Also, this report recognizes that the contents of the commercial structures on Finnerty Lane and some other buildings may not be

[7] Property appraisals will be needed for any application developed for FEMA mitigation programs.

well-represented by defaults in the BCA program, but an effort to construct site-specific depth-damage functions was beyond the scope of the LFA and not conducted.

6.2 Property Acquisitions

The first critical piece of the benefits generation was to determine the benefits associated with the act of removing buildings with flood risk. The acquisition and relocation benefits listed in Table 6-1 were generated in conjunction with the floodplain enhancement projects.

TABLE 6-1
Benefits Provided by Acquisitions/Relocations

Alternate	Building Acquisition Benefits
BC-1: Bypass Channel by Route 28 Bridge	$199,023
BR-2: Route 28 Bridge Replacement	$1,986,063
FP-5: Floodplain near Pavilion Road	$910,947
Combination 1: Bypass Channel with Floodplains Upstream and Downstream	$509,162
Combination 2: Route 28 Bridge Replacement with Floodplains Upstream and Downstream	$2,325,949

The benefits are greater for the buildings with the lowest elevations and greatest flood damage potential and lower for the smaller buildings located at higher elevations. The alternatives in Table 6-1 were advanced for use in computing total benefits.

6.3 Benefits Associated with Floodplain Enhancement and Creation Projects

Benefits from water surface reduction were calculated using the drainage improvement option in the BCA Flood module. Benefits from the five alternatives are shown in Table 6-2. For all five alternatives advanced to the BCA, the majority of the benefits come from property acquisitions and not from reductions in water surface elevations.

TABLE 6-2
Summary of Benefits

Alternate	Acquisition Benefits	Benefits from Water Surface Reductions at Buildings that Remain	Total Benefits
BC-1: Bypass Channel by Route 28 Bridge	$199,023	$66,086	$265,109
BR-2: Route 28 Bridge Replacement	$1,986,063	$167,342	$2,153,405
FP-5: Floodplain near Pavilion Road	$910,947	$135,743	$1,046,690
Combination 1: Bypass Channel with Floodplains Upstream and Downstream	$509,162	$298,594	$807,756
Combination 2: Route 28 Bridge Replacement with Floodplains Upstream and Downstream	$2,325,949	$305,829	$2,631,778

6.4 Comparison of Benefits and Costs

The individual cost estimates in Table 6-3 were summed and are listed in the third column of Table 6-4 below. The individual benefits in Table 6-2 were summed and are listed in the fourth column of Table 6-4. When benefits exceed costs, the alternative is considered to have a BCR greater than 1.0.

The BCA does not include consideration of water quality benefits that could be provided by flood mitigation projects. Water quality benefits should be used to increase benefits when the BCR is poorly represented by the flood reduction benefits generated by the BCA program or when stratification or prioritization of mitigation projects is difficult due to a calculation of similar BCRs.

Appendix D includes a memorandum that discusses two potential approaches that can be used to include water quality benefits in future BCA. With reference approach #1 (refer to the bottom of page 3 of the memorandum), no alternatives have BCRs above 0.75 except for Alternative FP-5 which already has a BCR over 1. Therefore, no alternatives are appropriate candidates for assistance from water quality benefits.

TABLE 6-3
Summary of Costs for Individual Components

Alternative		Partial Cost Estimates
BC-1	Acquisition and removal of 65 Pavilion Road	$126,900
	Create new bridge for bypass channel	$2,000,000
	Create bypass channel	$406,147
BR-2	Acquisition and removal of buildings for floodplain	$916,900
	Replace Route 28 Bridge over Dry Brook	$7,000,000
	Create floodplain near Route 28	$1,024,099
FP-5	Acquisition and removal of buildings for floodplain	$378,100
	Create floodplain near Pavilion Road	$427,918
Combo-1	Acquisition and removal of buildings for floodplains	$212,300
	Creation of bypass channel and floodplains FP-4 and FP-5 upstream and downstream of Route 28 Bridge	$1,175,448
	Create new bridge for bypass channel	$2,000,000
Combo-2	Acquisition and removal of buildings for floodplains	$1,002,300
	Replace Route 28 Bridge over Dry Brook	$7,000,000
	Create floodplains FP-4 and FP-5 up and downstream of Route 28 Bridge	$1,793,400

TABLE 6-4
Comparison of Costs and Benefits

Alternative		Cost Estimates	Total Benefits	BCR
BC-1: Bypass Channel by Route 28 Bridge	❑ Create bypass channel under Route 28 Bridge ❑ Replace existing culvert with bridge over bypass channel ❑ Removal of buildings	$2,533,047	$265,109	0.10
BR-2: Route 28 Bridge Replacement	❑ Replace Route 28 Bridge over Dry Brook ❑ Create floodplains FP-4 and FP-5 up and downstream of Route 28 ❑ Removal of buildings	$8,940,999	$2,153,405	0.24
FP-5: Floodplain near Pavilion Road	❑ Floodplain downstream of Route 28 Bridge along Pavilion Road ❑ Removal of buildings	$806,018	$1,614,526	1.29
Combination 1: Bypass Channel with Floodplains	❑ Create bypass channel BC-1 ❑ Create floodplains FP-4 and FP-5 up and downstream of Route 28 ❑ Removal of buildings	$3,387,748	$1,375,582	0.24
Combination 2: Route 28 Bridge Replacement with Floodplains	❑ Replace Route 28 Bridge ❑ Create floodplains FP-4 and FP-5 up and downstream of Route 28 ❑ Removal of buildings	$9,795,700	$3,199,614	0.27

The floodplain near Pavilion Road (FP-5) appears to have a BCR greater than 1.0 but the other alternatives do not. However, almost $1 million of the benefits for this alternative are due to acquisitions and relocations, not benefits from the floodplain itself.

6.5 Benefit Cost Analysis for Individual Property Mitigation

Section 4.8 of this document discusses property-specific flood mitigation through elevations and floodproofing. Many of these projects may be eligible for grants, but cost effectiveness is required to secure certain grant funds. The FEMA BCA program can be used in a straightforward manner to evaluate BCRs associated with property-specific elevations and floodproofing. The required information includes pertinent land surface and building elevations, the flood elevations published in the FIS and noted on the FIRM, the stream channel elevation published in the FIS, and project costs for elevating or floodproofing buildings.

Like all projects evaluated through BCA, the highest benefits will be generated for projects that reduce flooding from frequent events *and* infrequent events, as opposed to projects that reduce flooding from only infrequent events. Therefore, higher BCRs will tend to be calculated for buildings at lower elevations.

One potential pathway toward rapid cost effectiveness determination is to utilize the interpretation from FEMA that was effective as of August 15, 2013. Under this interpretation, acquisitions and elevations are considered cost effective if the project costs are less than $276,000 and $175,000, respectively. To be eligible for this automatic determination, structures must be located in SFHAs. The figure of $175,000 for a building elevation is likely sufficient for elevating many of the residential buildings in Arkville.

Costs for floodproofing of individual nonresidential buildings could vary widely in Arkville. Consider the following:

- A low door shield costs approximately $1,500[8]. Dewberry[9] reports a range of $500-$1,500 for door gaskets and seals. Fully floodproofed doors can cost more, up to $4,000 per door, but may be excessive given many of the existing door elevations in the downtown area.

- Dewberry reports a range of $500-$1,500 to elevate an electrical service and meter, a range of $500-$1,500 to floodproof electrical service and meter, a range of $500-$1,500 to elevate HVAC equipment, and a range of $500-$1,500 (and up) to floodproof HVAC equipment. FEMA reports a range of $1,500-$2,000 to include outlets and switches in the elevation of electric service and meter in a house. Given the uncertainty related to actions that business owners may choose, a range of $1,500-$2,000 is reasonable for all utility-related costs.

Total costs to retrofit a single business to make it more flood resilient in the long term are rarely reported in the literature. In the New York Rising Community Reconstruction Plan[10] for the Red Hook section of Brooklyn, New York, total cost estimates per small business in this community ranged from $6,000 to $50,000 for implementing a variety of floodproofing measures. Given the number of doors, openings, and utilities associated with some of the businesses in Arkville, this range may be reasonable for a group of buildings along Route 28 and Finnerty Lane.

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[8] Typical vendor "PS Doors" (http://www.psdoors.com/)
[9] http://www.sbidc.org/documents/RedHookCaseStudyFindingsReportFINAL.pdf
[10] http://stormrecovery.ny.gov/sites/default/files/crp/community/documents/redhook_nyrcr_plan_20mb_0.pdf

7.0 FINDINGS, RECOMMENDATIONS, AND IMPLEMENTATION

7.1 Summary of Findings

The LFA completed for Arkville has demonstrated that many flood mitigation projects have merit in that they will reduce floodwater surface elevations in the village. These projects largely depend on the enhancement of floodplains and creation of lower floodplains coupled with a handful of bridge replacements and strategic building removals and relocations.

Based on the BCA conducted for this LFA (and its underlying assumptions), one flood mitigation project (FP-5 the floodplain bench along Pavilion Road) has a BCR above 1.0. If this project is supported by the Town and there is consensus to pursue its execution, then it may be advanced for further design and funding.

The other projects described in this LFA report are not expected to have BCRs above 1.0. However, many of these are appropriate flood mitigation projects. Table 7-1 summarizes the recommended action for each project.

TABLE 7-1
Recommended Action

Alternative		BCR	Recommended Action
BC-1: Bypass Channel by Route 28 Bridge	❑ Create bypass channel under Route 28 Bridge ❑ Replace existing culvert with bridge over bypass channel ❑ Removal of buildings	0.10	Continue the process of making space for a bypass channel under Route 28, and identify alternate funding sources to pursue bypass.
BR-2: Route 28 Bridge Replacement	❑ Replace Route 28 Bridge over Dry Brook ❑ Create floodplains FP-4 and FP-5 up and downstream of Route 28 ❑ Removal of buildings	0.24	Unless washouts at this bridge are a significant concern, do not pursue at this time. Consider when bridge is ready for replacement due to its age.
FP-5: Floodplain near Pavilion Road	❑ Floodplain downstream of Route 28 Bridge along Pavilion Road ❑ Removal of buildings	1.29	BCR is greater than 1, but this is due to acquisitions. Consider if opportunities arise to acquire properties.
Combination 1: Bypass Channel with Floodplains	❑ Create bypass channel BC-1 ❑ Create floodplains FP-4 and FP-5 up and downstream of Route 28 ❑ Removal of buildings	0.24	Too intrusive relative to the benefits; do not pursue unless opportunities arise to acquire properties.
Combination 2: Route 28 Bridge Replacement with Floodplains	❑ Replace Route 28 Bridge ❑ Create floodplains FP-4 and FP-5 up and downstream of Route 28 ❑ Removal of buildings	0.27	Too intrusive relative to the benefits; do not pursue unless bridge is ready for replacement.

With the exception of the Route 28 bridge over Dry Brook area, most of the proposed alternatives are located a significant distance apart from one another. This makes the individual alternatives relatively independent. Because they do not adversely affect one another, they may be pursued individually.

Creation of extensive floodwalls and levees is not supported by this LFA. The construction of a levee to protect Lamphere Lane was considered; however, it would require a stormwater pumping system inside the levee. This is not recommended, and specific buildings on Lamphere Lane should be addressed as needed. A levee was also considered to protect the Erpf Maze; however, it was found that the maze is already outside the 500-year floodplain. If stream bank erosion becomes a concern near the maze, the bank could be stabilized.

Sediment transport modeling indicates that the proposed flood mitigation projects do not appear to worsen sediment transport and may provide benefits in the 2-year flood event. Periodic removal of sediment and gravel buildup in targeted areas may be necessary on Dry Brook since the proposed alternatives will not reduce the sediment load coming from upstream.

Widespread removal of buildings from the downtown area is not supported by the LFA, as the community would suffer from the disruption to its central business district. Individual property owners will likely need to elevate or floodproof their properties over time as substantial damage or substantial improvement thresholds are triggered. However, optional elevations and floodproofing may be desired in strategic locations where unacceptable flood risk remains after flood mitigation projects are implemented. This will have the dual benefit of reducing flood risks while reducing flood insurance premiums for those properties that are insured.

Finally, key anchor businesses and critical facilities may wish to relocate out of zones of unacceptable flood risk.

7.2 Flood Mitigation Recommendations

The following flood mitigation recommendations are offered:

1. Proceed with further study and apply for funding for the floodplain along Pavilion Road (FP-5).

2. Pursue floodproofing of commercial buildings in Arkville. Floodproofing should include sealing of lower portions of buildings including doors and other openings, and elevation of building utilities. Ensure that floodproofing is viable under a set of potential future conditions.

3. When opportunities arise for acquisitions where floodplain projects may be effective, support these acquisitions.

4. When opportunities arise for building elevations where floodplain projects are not envisioned, support these elevations. Ensure that elevations are conducted in accordance with the effective BFE at the time of the work.

5. Continue the process of making space for a bypass channel under Route 28, and identify alternate funding sources to pursue the bypass.

6. Ensure that future bridge replacements consider the benefits of enlarging the openings to reduce flooding.

7. Periodically address sediment and gravel buildup with targeted removal projects.

8. Install an automated flood warning system for Arkville, or join forces with Fleischmanns to install a system that works for both.

Numerous projects described in this report do not have BCRs above 1.0. However, many of these remain appropriate flood mitigation projects that could be eligible for funding by other State and Federal Programs such as the Department of Environmental Conservation Water Quality Improvement Project (DEC WQIP) or the U.S. Army Corps of Engineers Water Resources Development Act (USACE WRDA).

7.3 Programmatic Recommendations

The Town Board and East Branch Flood Commission have expressed an interest in an automated flood warning system in order to provide ample warning time before floods. Precipitation gauges should be fully automated and able to provide as little advance warning as an hour. Ideally, the early warning system would link directly to Reverse 911 or its equivalent. A flood warning system was installed in the City of Norwich, New York, in 2008 that incorporated stream level monitoring and rain gauges. The monitoring stations provide real-time data monitoring for flood warning systems. The gauges allowed Norwich to warn residents during floods in 2011. This type of system could give Arkville residents valuable time to prepare for flooding.

7.4 Descriptions of Funding Sources

Several funding sources may be available to the East Branch Flood Commission, the Town of Middletown, and Delaware County and its departments for the implementation of recommendations of this plan. These are discussed in detail below.

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

The LFA program that funded the subject study is likely to be the primary funding vehicle for some of the projects described in this report through the SMP. As described in the LFA rules:

> "Stream Management Programs in the NYC water supply watersheds and the Catskill Watershed Corporation are supporting the analysis of flood conditions and the identification of hazard mitigation projects. The process consists of two steps: 1) an engineering analysis of flood conditions and identification of potential flood mitigation projects articulated in a plan and 2) project design and implementation. The engineering analysis and plan are termed 'Local Flood Analysis.' These program rules (Section C) define the process for municipalities to apply for funding to complete a Local Flood Analysis (LFA). These program rules (Section D) also define the process for municipalities to seek funding from the Stream Management

Program [managed by the DCSWCD] to implement projects that involve streams, floodplains and adjacent infrastructure to reduce flood hazards."

NYCDEP Buyout Program

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

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

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

- Septic Repair and Maintenance – Funds residential septic system repairs, replacements, and maintenance.
- Stormwater Planning and Control – Funds planning, assessment, design, and implementation of stormwater and erosion controls for existing conditions, as well as stormwater requirements for new construction.
- Education – Provides grants to schools and organizations.
- Community Wastewater Management – Funds a program to evaluate and build community-specific wastewater solutions, which may include septic maintenance districts, community septic systems, or wastewater treatment plants.
- Local Technical Assistance Program – Provides grants to communities conducting watershed protection and land use planning initiatives.

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

CWC Sustainable Communities Planning Program

The Sustainable Communities Planning Program began in December 2014 and funds revisions to local zoning codes or zoning maps. It also funds upgrades to comprehensive plans in order to identify areas within municipalities where residences and/or businesses could be relocated after purchase through the voluntary NYC Flood Buyout Program. Grants of up to $20,000 are available through the Sustainable Communities Planning Program.

CWC Economic Development Program

The Economic Development program, known as Catskill Fund for the Future (CFF) is a revolving fund intended to support environmentally responsible businesses and to create and retain jobs in the Catskills Region.

Emergency Watershed Protection Program (EWP)

Through the EWP program, the U.S. Department of Agriculture's NRCS can help communities address watershed impairments that pose imminent threats to lives and property. Most EWP work is for the protection of threatened infrastructure from continued stream erosion. NRCS may pay up to 75% of the construction costs of emergency measures. The remaining costs must come from local sources and can be made in cash or in-kind services. EWP projects must reduce threats to lives and property; be economically, environmentally, and socially defensible; be designed and implemented according to sound technical standards; and conserve natural resources.

FEMA Pre-Disaster Mitigation (PDM) Program

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

The PDM program is subject to the availability of appropriation funding, as well as any program-specific directive or restriction made with respect to such funds.

FEMA Hazard Mitigation Grant Program (HMGP)

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

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

FEMA Flood Mitigation Assistance (FMA) Program

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

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

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

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

NYS Department of State

The Department of State may be able to fund some of the projects described in this report. In order to be eligible, a project should link water quality improvement to economic benefits.

U.S. Army Corps of Engineers

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

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

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

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

- Section 206 – Floodplain Management Services: This section of the 1960 Flood Control Act, as amended, authorizes the Corps to provide a full range of technical services and planning guidance necessary to support effective floodplain management. General technical assistance efforts include determining the following: site-specific data on obstructions to flood flows, flood formation, and timing; flood depths, stages, or floodwater velocities; the extent, duration, and frequency of flooding; information on natural and cultural floodplain resources; and flood loss potentials before and after the use of floodplain management measures. Types of studies conducted under FPMS include floodplain delineation, dam failure, hurricane evacuation, flood warning, floodway, flood damage reduction, stormwater management, floodproofing, and inventories of floodprone structures. When funding is available, this work is 100% federally funded.

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

Other Potential Sources of Funding

- Community Development Block Grant (CDBG) – The Office of Community Renewal administers the CDBG program for the State of New York. The NYS CDBG program provides financial assistance to eligible cities, towns, and villages (including the Town of Middletown) in order to develop viable communities by providing affordable housing and suitable living environments, as well as expanding economic opportunities, principally for persons of low and moderate income. It is possible that CDBG funding program could be applicable for floodproofing and elevating residential and nonresidential buildings, depending on the eligibility of those buildings relative to the program requirements.

- Delaware County Industrial Development Agency (IDA) – The IDA works in conjunction with the Delaware County Department of Economic Development to "build a sustainable future for Delaware County" by meeting the needs of new and existing businesses through expertise, financial assistance, and continued support. The IDA offers a variety of programs and performance-based incentives to encourage businesses to expand or locate within Delaware County and create new jobs. The program primarily helps secure low-interest loans and Industrial Revenue Bonds (tax-exempt financing alternatives for large-scale investments in facilities and equipment). 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.

- Empire State Development – The State's Empire State Development program offers loans, grants and tax credits, as well as other financing and technical assistance, to support businesses and encourage their growth. It is possible that the program could be applicable for floodproofing, elevating, or relocating nonresidential buildings, depending on the eligibility of those businesses relative to the program requirements.
- Private Foundations – Private entities such as foundations are potential funding sources in many communities. The East Branch Flood Commission will need to identify the foundations that are potentially appropriate for some of the actions proposed in this report.

7.5 Potential Funding Sources for Mitigation Projects

Table 7-2 lists potential funding sources for the alternatives that were advanced to the BCA. Note that in all cases, federal funds cannot be duplicated for any particular project. Potential funding sources described under the heading "Other Potential Sources of Funding" (above) have not been listed, as additional evaluation may be needed to determine their applicability.

TABLE 7-2
Potential Funding Sources for Components of Mitigation Projects

Alternative		Federal	State	Other
BC-1	Acquisition and removal of 65 Pavilion Road	FEMA	NYSDOS	NYCDEP Buyout, CWC
	Create new bridge for bypass channel	None	NYSDOT	DCSWCD SMP, CWC
	Create bypass channel	USACE	NYSDOS	DCSWCD SMP, CWC
BR-2	Acquisition and removal of buildings for floodplain	FEMA	NYSDOS	NYCDEP Buyout, CWC
	Replace Route 28 Bridge over Dry Brook	None	NYSDOT	DCSWCD SMP, CWC
	Create floodplain near Route 28	USACE	NYSDOS	DCSWCD SMP, CWC
FP-5	Acquisition and removal of buildings for floodplain	FEMA	NYSDOS	NYCDEP Buyout, CWC
	Create floodplain near Pavilion Road	USACE	NYSDOS	DCSWCD SMP, CWC

Alternative		Federal	State	Other
Combo-1	Acquisition and removal of buildings for floodplains	FEMA	NYSDOS	NYCDEP Buyout, CWC
	Create new bridge for bypass channel	None	NYSDOT	DCSWCD SMP, CWC
	Creation of bypass channel	USACE	NYSDOS	DCSWCD SMP, CWC
	Create floodplains FP-4 and FP-5 upstream and downstream of Route 28 Bridge	USACE	NYSDOS	DCSWCD SMP, CWC
	Create new bridge for bypass channel	None	NYSDOT	DCSWCD SMP, CWC
Combo-2	Acquisition and removal of buildings for floodplains	FEMA	NYSDOS	NYCDEP Buyout, CWC
	Replace Route 28 Bridge over Dry Brook	None	NYSDOT	DCSWCD SMP, CWC
	Create floodplains FP-4 and FP-5 up and downstream of Route 28 Bridge	USACE	NYSDOS	DCSWCD SMP, CWC

Table 7-3 lists potential funding sources for property mitigation and relocations.

TABLE 7-3
Potential Funding Sources for Other Mitigation Projects

Option	Federal	State	Other
Floodproofing of individual nonresidential buildings	FEMA	NYSDOS	None
Elevation of individual nonresidential buildings in floodway	None	None	None
Elevation of individual residential buildings in floodway	None	None	None
Elevation of individual nonresidential buildings outside of floodway	FEMA	NYSDOS	None
Elevation of individual residential buildings outside of floodway	FEMA	None	None
Relocation of anchor businesses and critical facilities	FEMA	NYSDOS	NYCDEP Buyout, CWC*

*CWC funding may be available only if off-site flood levels are reduced as a result of the action

As the recommendations of this LFA are implemented, the East Branch Flood Commission and Town of Middletown will need to work closely with potential funders to ensure that the best combinations of funds are secured for the modeled alternatives and for the property-specific mitigation such as floodproofing, elevations, and relocations. The Town of Middletown should apply for funds through the CWC Sustainable Communities Planning Program to plan for relocating businesses and residents within the town. The East Branch Flood Commission and Town of Middletown may also work closely with local lenders and the chamber of commerce to facilitate the provision of loan services for property mitigation and floodproofing.

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APPENDICES

APPENDIX A

MEETING PRESENTATIONS AND NOTES

Milone & MacBroom

Local Flood Analysis

Dry Brook, Bush Kill, and East Branch Delaware River
Arkville, NY

Mark Carabetta, CFM

Arkville Flood Committee Meeting | June 29, 2015

Purpose of Meeting

- Review the study area and flood prone areas
- Introduce existing conditions modeling
- Explain modeling concepts
- Collect information about flooding and flood damage
- Discuss potential flood mitigation strategies

Milone & MacBroom

Confluence of Bush Kill and Dry Brook

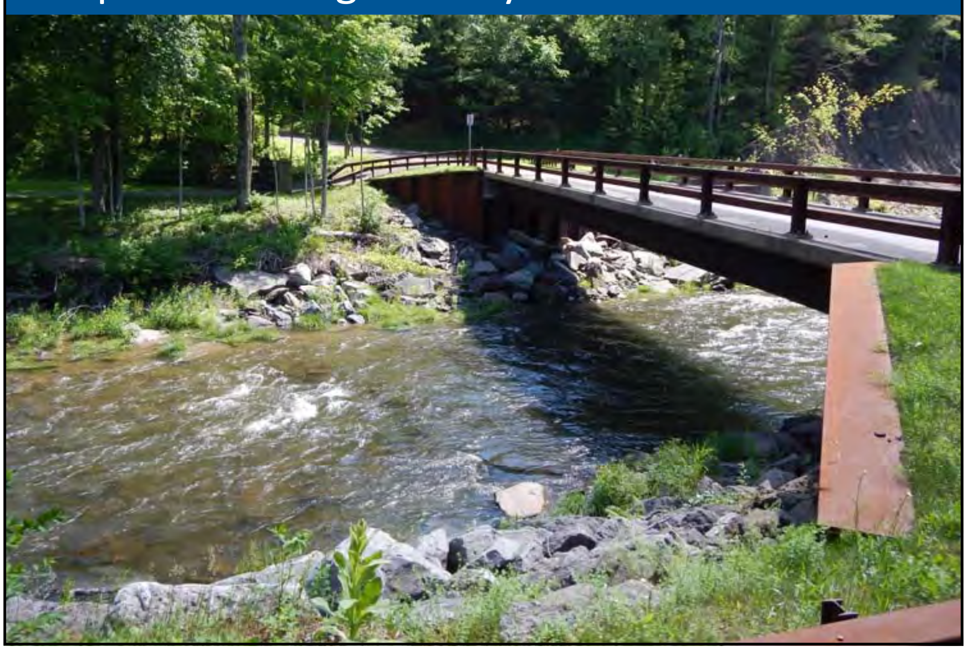
Confluence of Dry Brook and Bush Kill – 10 Year

MILONE & MACBROOM

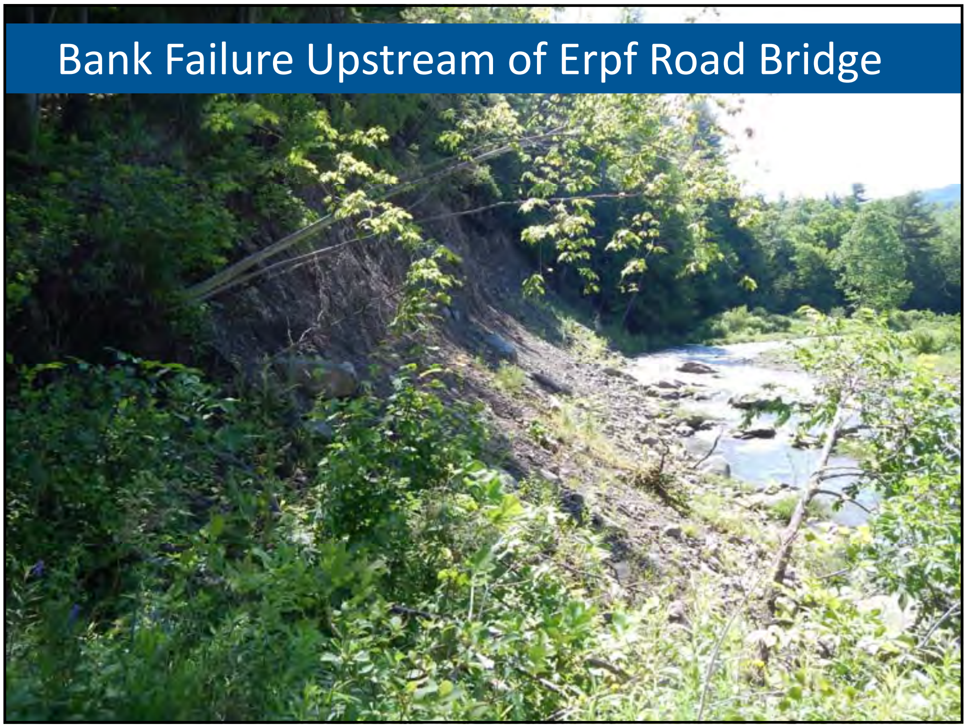
Confluence of Dry Brook and Bush Kill – 100 Year

MILONE & MACBROOM

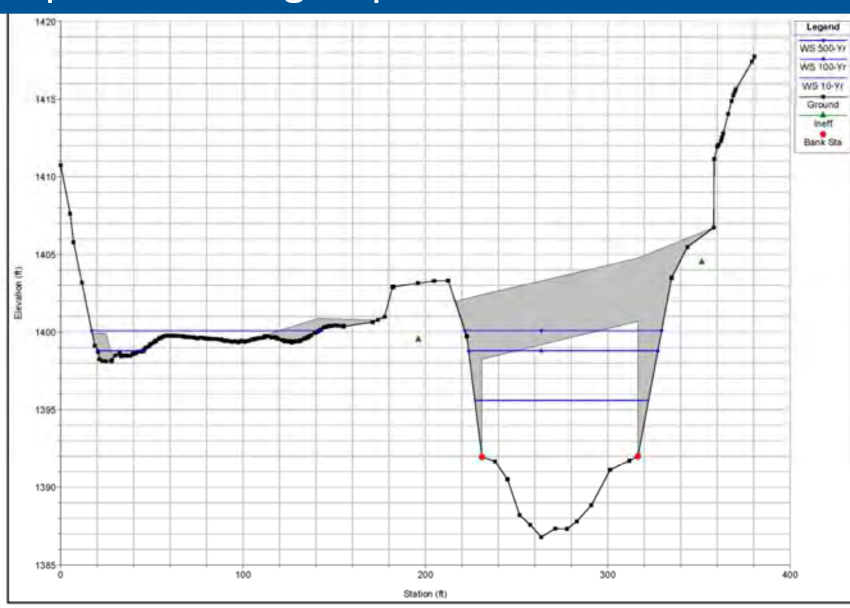
Erpf Road Bridge on Dry Brook



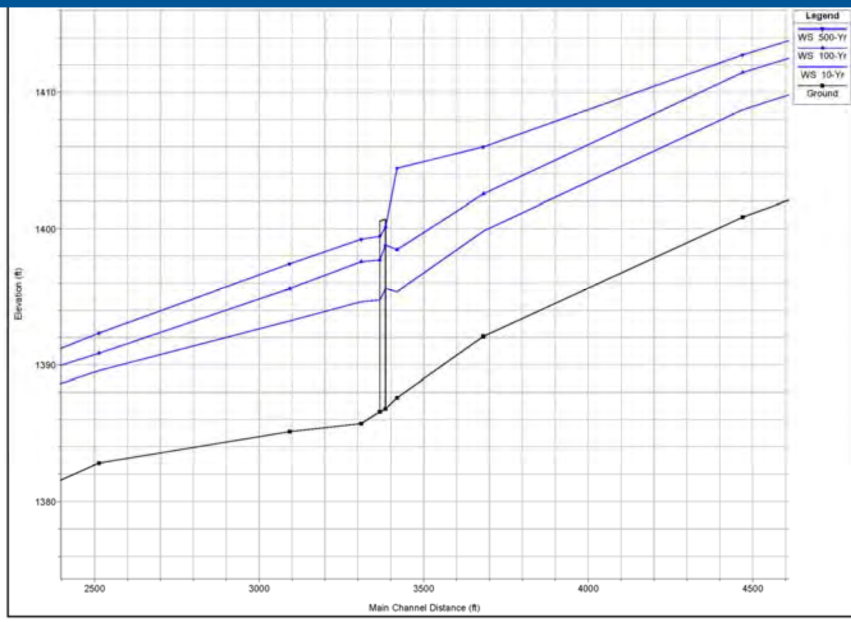
Bank Failure Upstream of Erpf Road Bridge



Erpf Road Bridge Upstream Cross Section



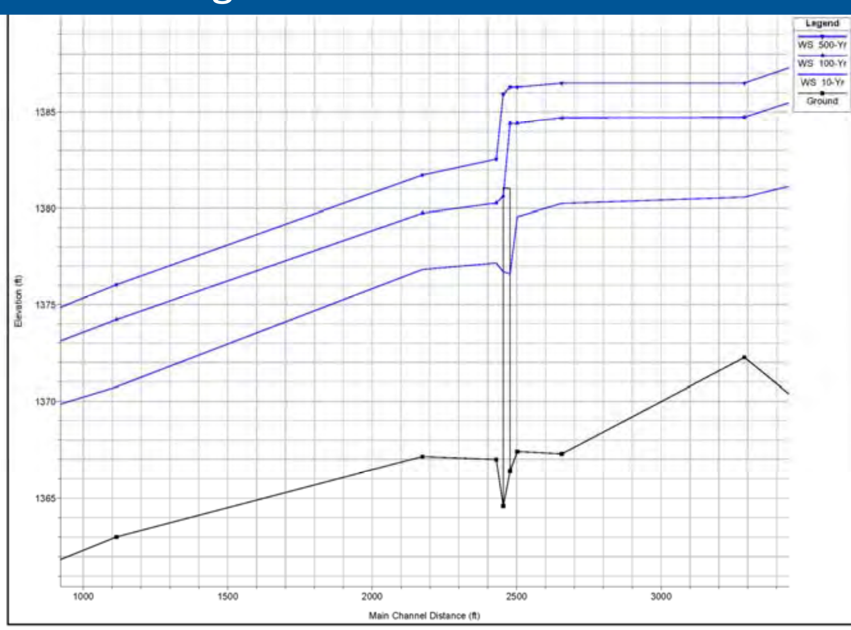
Erpf Road Bridge Profile



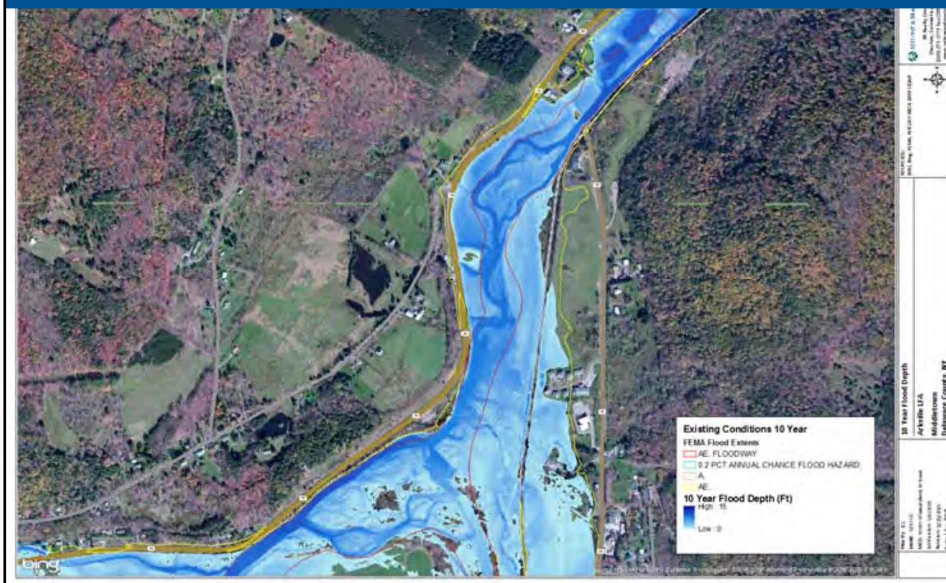
Delaware & Ulster Railroad Bridge on Bush Kill

Railroad Bridge Upstream Cross Section

Railroad Bridge Profile

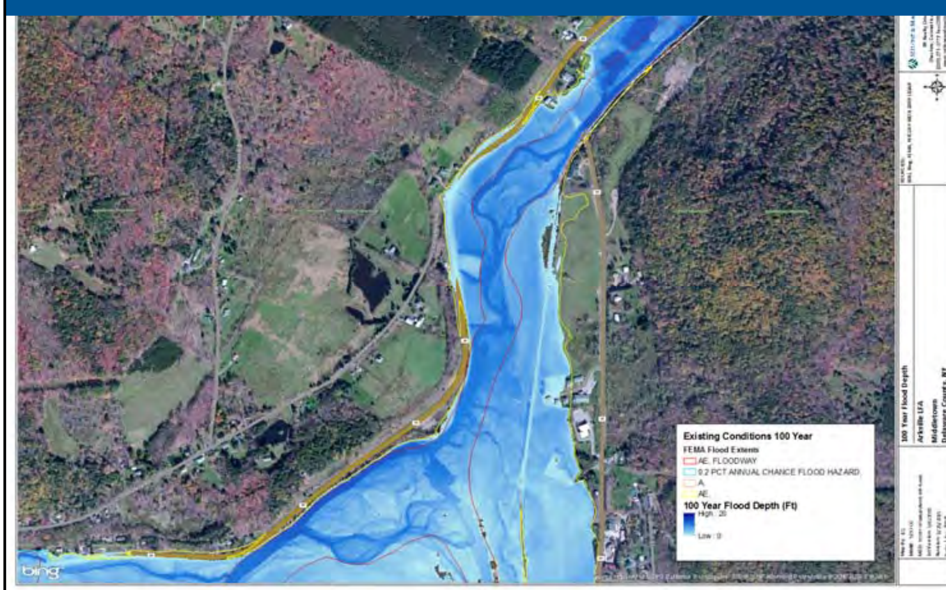


Northern East Branch Delaware River – 10 Year



MILONE & MACBROOM

Northern East Branch Delaware River – 100 Year



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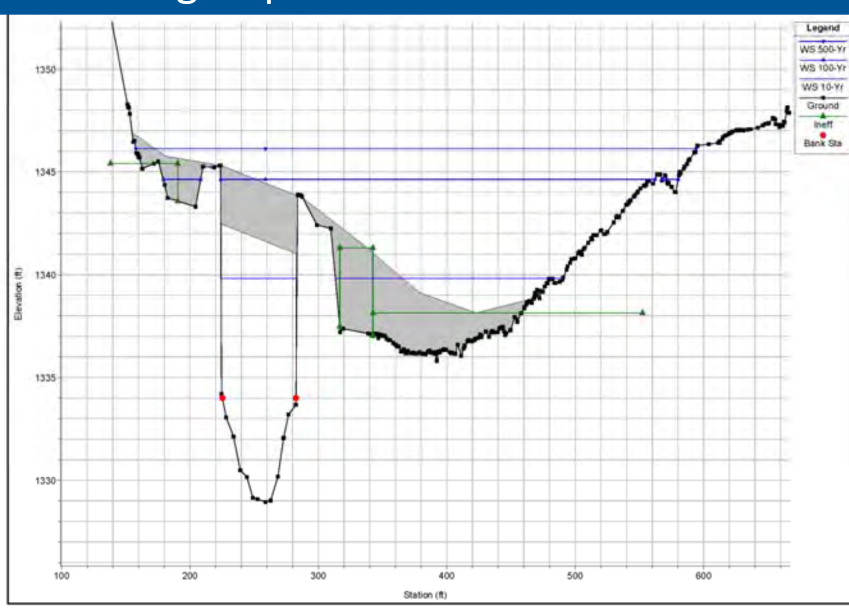
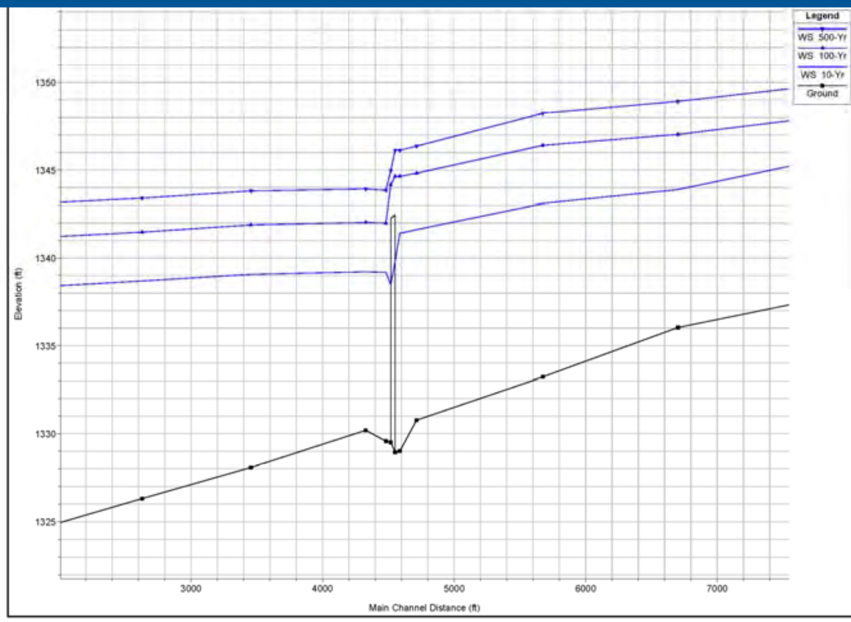
Rte 38 Bridge on East Branch Delaware River

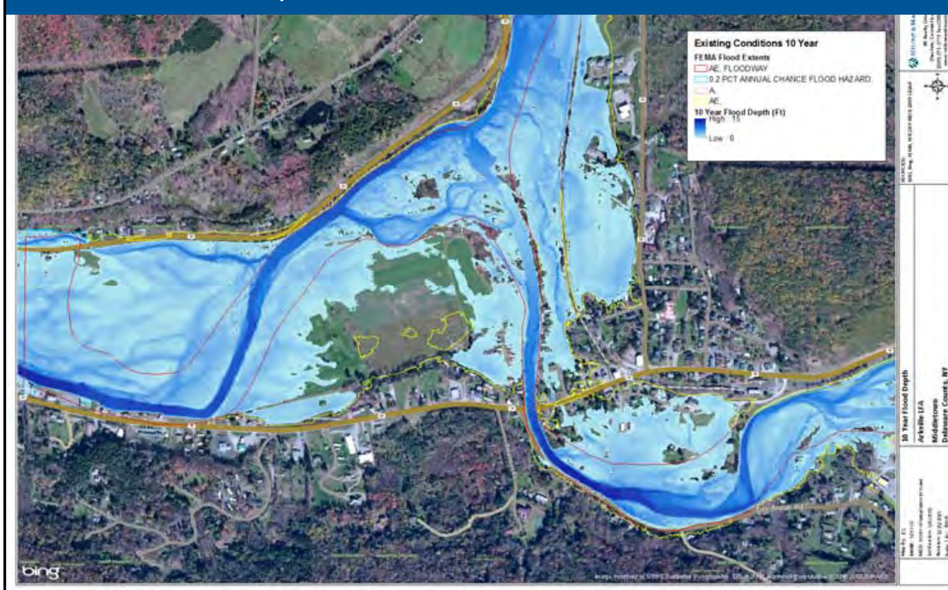
Rte 38 Bridge Upstream Cross Section



Rte 38 Bridge Profile

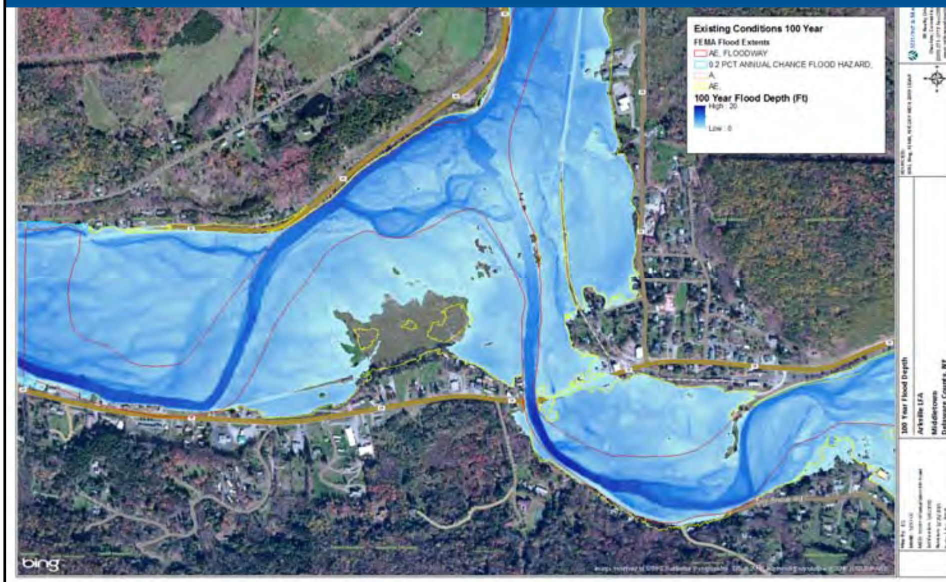


Confluence of Dry Brook and East Branch Delaware River – 10 Year



MILONE & MACBROOM

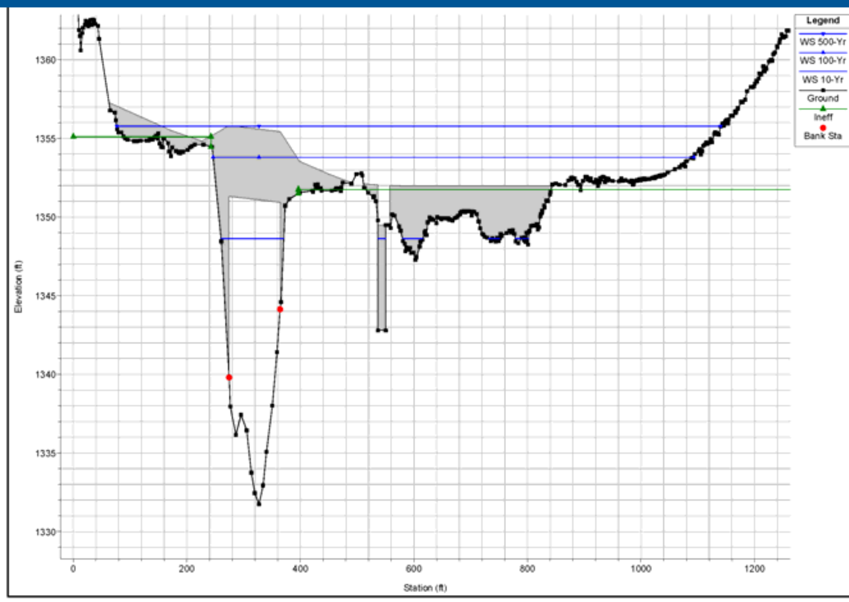
Confluence of Dry Brook and East Branch Delaware River – 100 Year



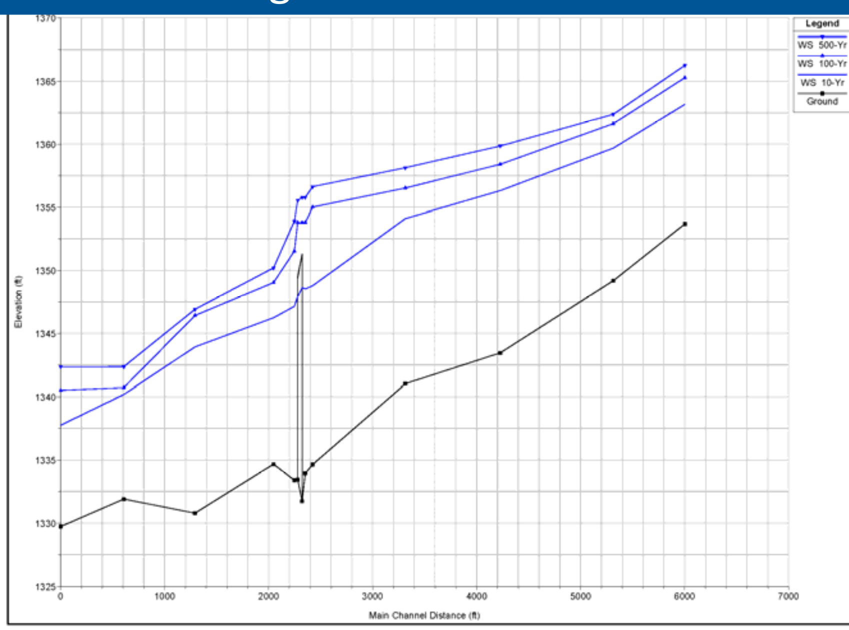
MILONE & MACBROOM

Rte 28 Bridge on Dry Brook

Rte 28 Bridge Upstream Cross Section



Route 28 Bridge Profile



Flood prone areas


Homes along Dry Brook in flood plain

Industrial buildings on Finnerty Road

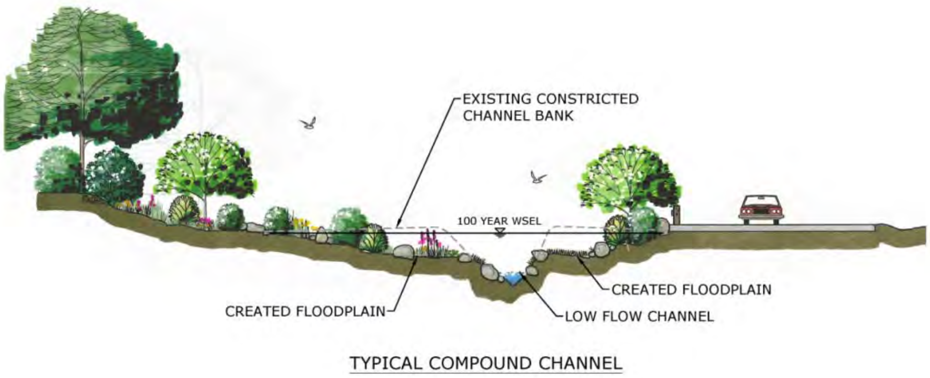
Flooding of businesses along Route 28 – 100 Year Flood

Flood Mitigation Strategies to be Modeled

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

MILONE & MACBROOM

Compound or Multi-Stage Channel

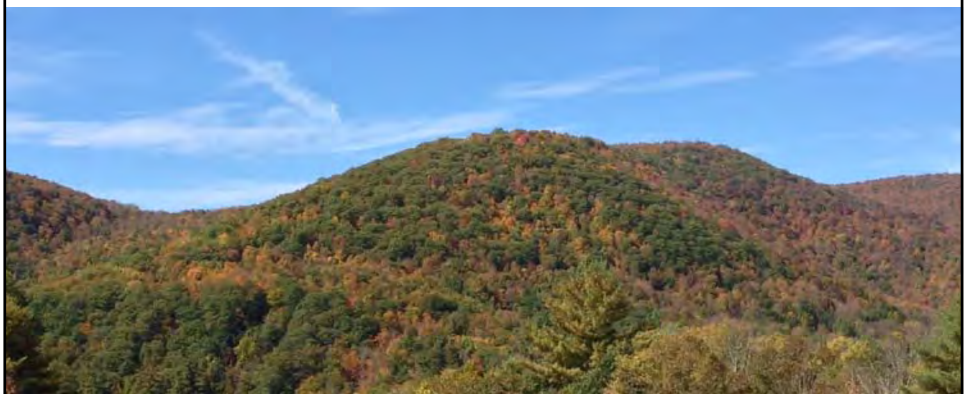


MILONE & MACBROOM

Final Outcomes

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

MILONE & MACBROOM



Questions, Comments, or Thoughts?

DATE: June 29, 2015
MMI #: 5197-07
PROJECT: Arkville LFA

SUBJECT: Notes from Flood Commission Meeting
LOCATION: Middletown Town Hall
42339 State Highway 28, Margaretville, NY

ATTENDEES:

Mark Carabetta, MMI
Marge Miller, Supervisor, Middletown
Diane Cope, Mayor, Margaretville
Don Kearney, Mayor, Fleischmanns
Graydon Dutcher, DCSWCD
Nate Hendricks, CWC
7 other attendees from flood commission

A meeting of the East Branch Flood Commission was held on June 29, 2015 at 10:00 a.m. at the Middletown Town Hall. One agenda item was an introduction and overview of the Arkville LFA. A number of non-Arkville topics were also covered.

Mark Carabetta was present from Milone & MacBroom, Inc. (MMI). Mr. Carabetta presented a PowerPoint presentation showing hydraulic modeling and maps that will be used to evaluate flooding issues in Arkville. He provided an overview of flood prone areas, flooding issues, and potential solutions that have been evaluated in other LFA efforts.

Group discussion followed regarding specific issues, bridges and flood prone areas in and around Arkville.

- The group viewed an aerial image showing the confluence of Bush Kill and Dry Brook. The channel is aggrading in this area, and braiding is visible. Potential solutions may include controlling sediment at its source where banks are failing upstream; improving sediment transport through the reach; or periodic, strategic removal of sediment from the channel. Mr. Dutcher commented that improving transport through the reach may result in sediment deposition issues further downstream. The group also viewed a photo of a failing bank upstream upstream of Erpf Road on Dry Brook, which is a potential source of sediment.
- The group viewed existing conditions depth grid mapping showing the 10-year and 100-year flood event at the confluence of Bush Kill and Dry Brook. Much of the area between Route 28 and Dry Brook Road is flooded in the 100-year event.
- Output from the HEC-RAS hydraulic modeling showing the Erpf Road bridge was viewed in cross section and profile view under existing conditions. The bridge appears to pass the 10- and 100-year flows but acts as a hydraulic constriction during the 500-year event. Mr. Carabetta commented that each bridge within the project area can be "removed" from the HEC-RAS model to determine what sort of reduction in water surface elevation results.
- The Delaware & Ulster Railroad bridge on Bush Kill was viewed in cross section and profile view under existing conditions. The bridge appears to be acting as a hydraulic constriction under a range of flows (10-year, 100-year, 500-year).

- The group viewed existing conditions depth grid mapping along the East Branch of the Delaware River upstream of the confluence with Dry Brook.
- The Route 38 bridge over the East Branch was viewed in cross section and profile view under existing conditions. The bridge appears to be acting as a hydraulic constriction under a range of flows (10-year, 100-year, 500-year), and flows appear to bypass the bridge to the right-hand side (viewed looking downstream), flooding Route 38.
- The group viewed existing conditions depth grid mapping near the confluence of Dry Brook and East Branch Delaware River. Flooding occurs along Pavilion Road and at two trailer parks. Businesses along Route 28 near the town hall are flooded during the 100-year flood.
- The Route 28 bridge over Dry Brook was viewed in cross section and profile view under existing conditions. The bridge appears to be acting as a hydraulic constriction under the 100-year and 500-year flows. The bridge is fitted with a box culvert in the right (east) floodplain, presumably to pass floodflows. Mr. Dutcher asked about the settings used to represent the culvert in HEC-RAS. Mr. Carabetta responded that he would examine whether the settings in HEC-RAS correctly represent existing conditions.

Mr. Carabetta explained a range of flood mitigation options that are being evaluated in other LFA efforts, which include:

- Channel Alteration – Widening or Realignment, Creation of Compound or multi-stage Channel
- Floodplain – Reclamation, Creation, Enhancement
- Bridges - Removal or Replacement
- Sediment Management – Dredging, Sediment Management Plan
- Individual Structure Treatment – Floodproofing, Elevation of Structures, Relocation, Voluntary Buy-Out

Mr. Carabetta described the intended final outcomes of the LFA, which include:

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

Graydon Dutcher had previously convened a public meeting of Arkville residents to introduce the LFA approach and collect information on flooding issues. Mr. Dutcher to provide MMI with marked-up maps from the public meeting.

Supervisor Miller requested that MMI present an introduction of the LFA and provide a progress report at the town board meeting scheduled for August 12 at 6pm at the Middletown Town Hall.

Supervisor Miller also requested that MMI make a copy of today's PowerPoint presentation available for posting on the town's website. Mr. Carabetta said he would either email the presentation or set up a folder on MMI's ftp site to allow easy transfer of large documents.

MILONE & MACBROOM

Local Flood Analysis

Dry Brook, Bush Kill, and East Branch Delaware River

Arkville, NY

David Murphy, P.E., CFM

Middletown Town Board Meeting | August 12, 2015

Agenda

- Review LFA focus area
- Review existing conditions modeling
- Review public input received to date
- Discuss potential flood mitigation strategies
- Present preliminary modeling of these strategies
- Review information obtained for buildings

MILONE & MACBROOM

LFA Focus Area

Bush Kill, Dry Brook, and East Branch Delaware River between:

- Village of Margaretville boundary
- Upstream of Route 36 bridge
- Upstream of Railroad museum
- Upstream of Erpf Road bridge

MILONE & MACBROOM

Review of Existing Conditions Modeling

- 10-Year Depth Maps (10% annual chance flood)
- 100-Year Depth Maps (1% annual chance flood)
- Irene Depth Maps were not produced because the Irene flood discharges are nearly identical to the 100-year flows at this location

MILONE & MACBROOM

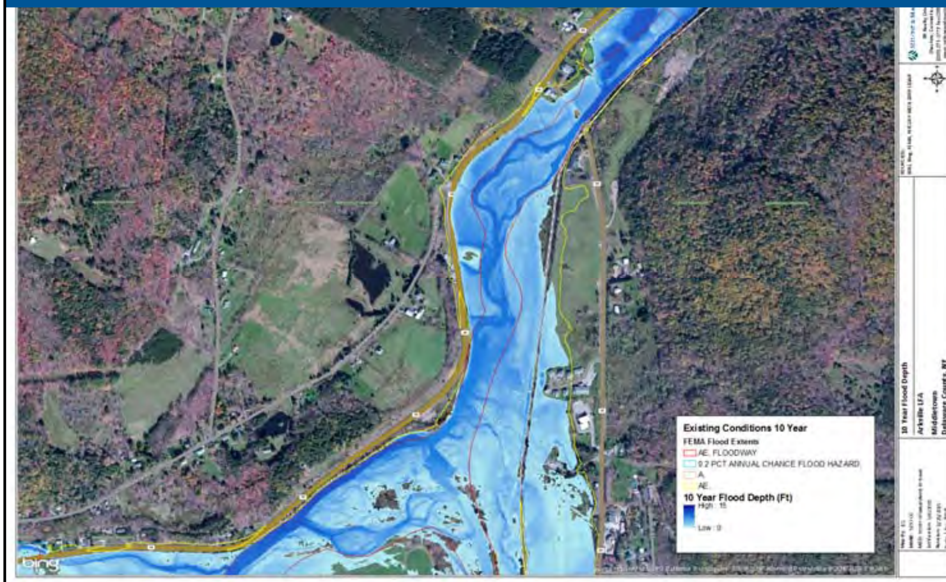
Confluence of Dry Brook and Bush Kill – 10 Year

MILONE & MACBROOM

Confluence of Dry Brook and Bush Kill – 100 Year

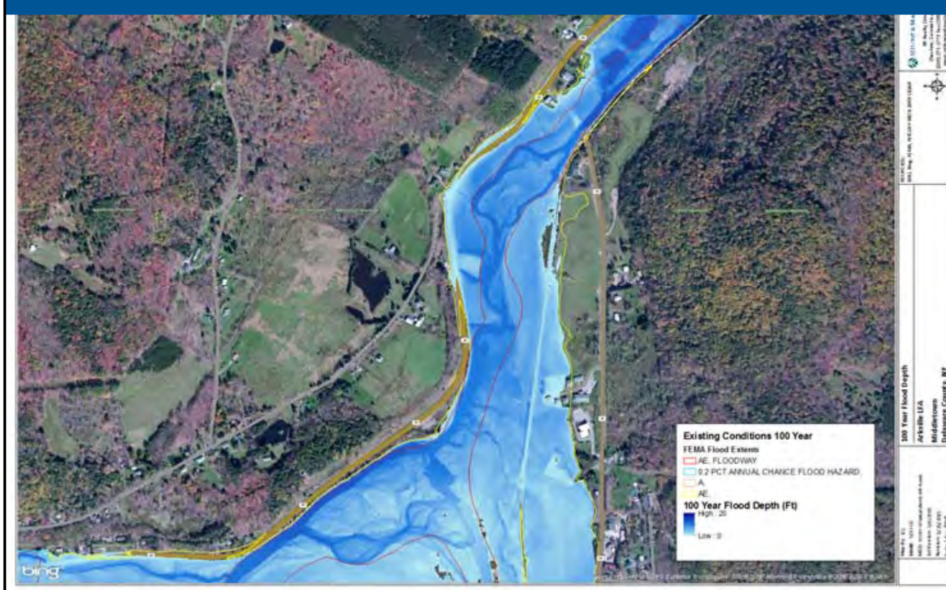
MILONE & MACBROOM

Northern East Branch Delaware River – 10 Year



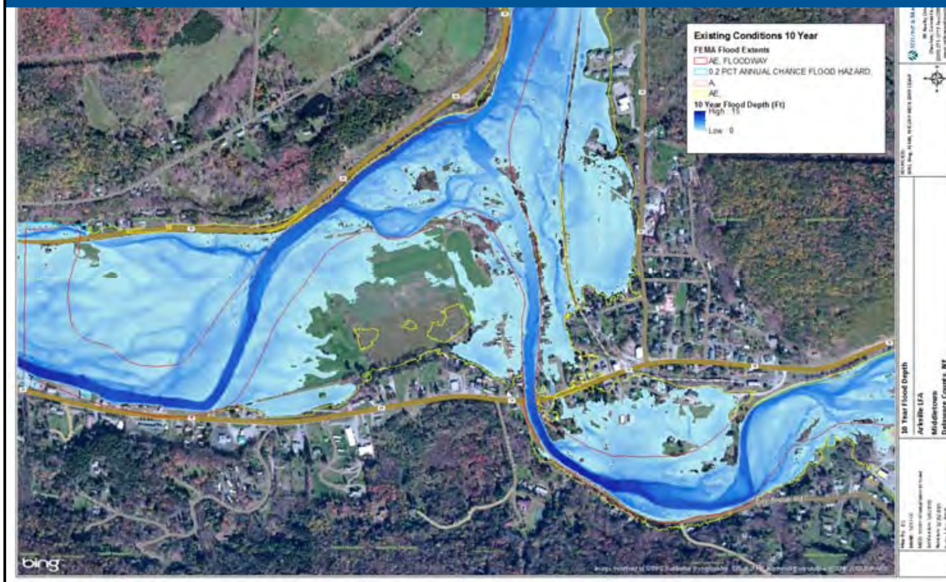
MILONE & MACBROOM

Northern East Branch Delaware River – 100 Year



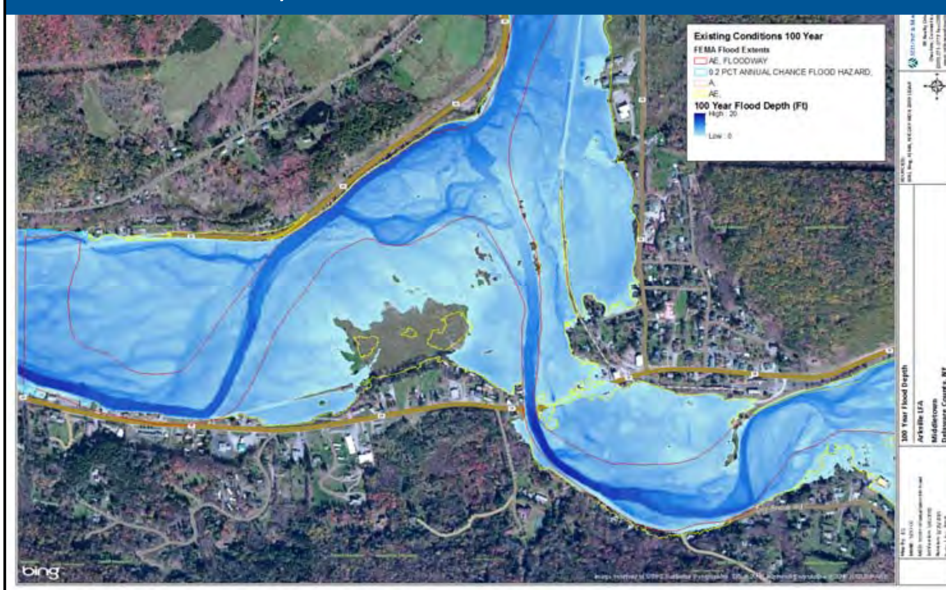
MILONE & MACBROOM

Confluence of Dry Brook and East Branch Delaware River – 10 Year



MILONE & MACBROOM

Confluence of Dry Brook and East Branch Delaware River – 100 Year



MILONE & MACBROOM

Review Public Input Received to Date

- Bridges cause flooding or make it worse
- Bypass channel parallel to Dry Brook under Route 28
- Restore various older channels
- Sediment transport management is needed
- Periodic gravel harvesting needed
- Control discharge into Binnekill
- Protect the maze
- Mitigate bank erosion
- Automated early warning system (similar need raised for Fleischmanns)

MILONE & MACBROOM

Potential Flood Mitigation Strategies

- Bridges – Removal or replacement
- Channel Alteration – Widening, realignment, compound channel
- Floodplain – Reclamation, creation, enhancement
- Sediment Management – Sediment removal, develop sediment management plan
- Individual Structure Treatment – Floodproofing, elevation of structures, relocation, voluntary buy-out

MILONE & MACBROOM

Addition of Five Cross Sections

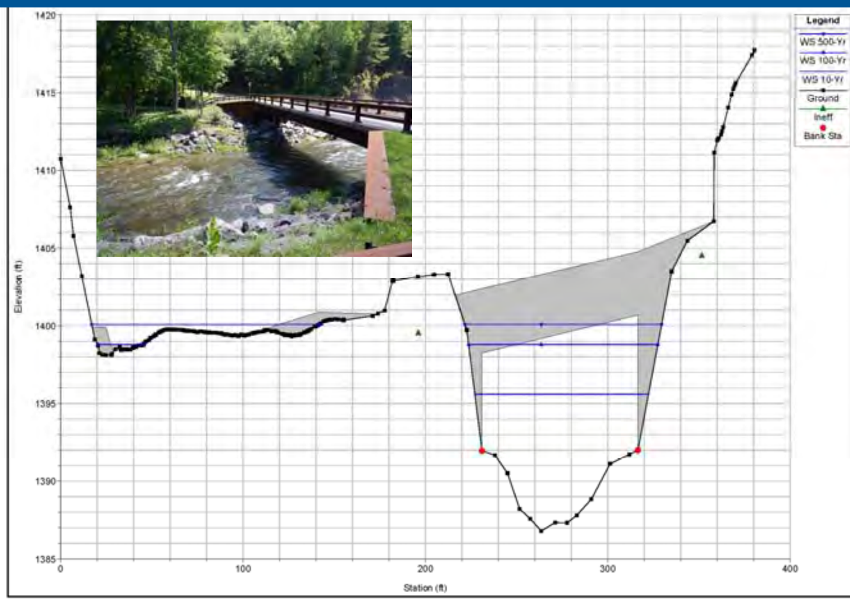
Modeled Flood Mitigation Strategies

Let's review these six tonight

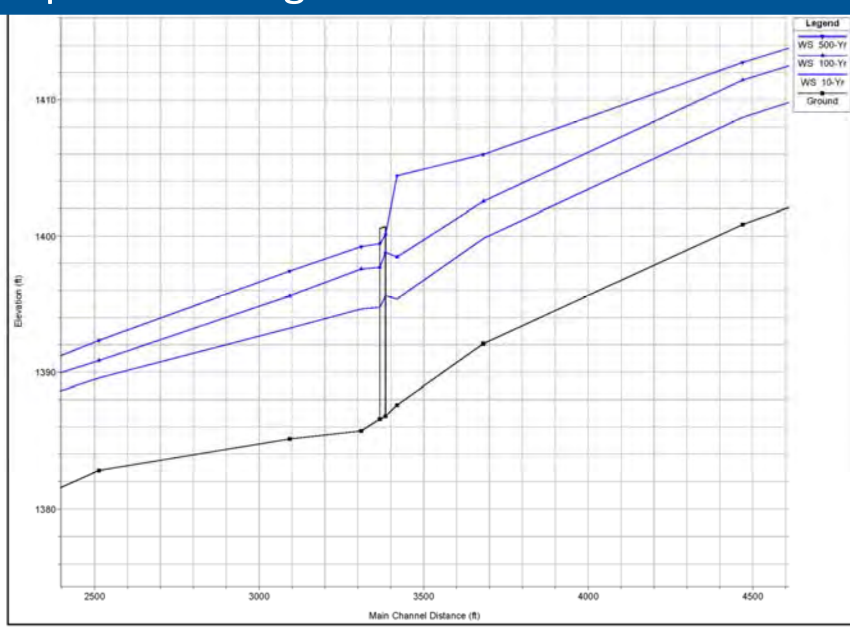
- Erpf Road Bridge
- Delaware & Ulster RR Bridge
- Route 28 Bridge
- Route 38 Bridge
- Lower floodplain along Route 30 downstream of Route 38 bridge
- Lower limited part of the floodplain between East Branch and Dry Brook
- Lower floodplain between Binnekill Creek and East Branch
- Bypass flood channel between Binnekill Creek and East Branch
- Floodplain bench between Dry Brook and Pavillion Road
- Bypass channel under Route 28
- Lower floodplains on north side of Dry Brook Road
- Limited levee or flood wall for maze
- Limited levee or flood wall for housing complex on Lamphere Lane

MILONE & MACBROOM

Erpf Road Bridge Upstream Cross Section



Erpf Road Bridge Profile



Erpf Road 10-Year with and without bridge

10-Year flood is conveyed under the bridge so removing the bridge does not affect WSE

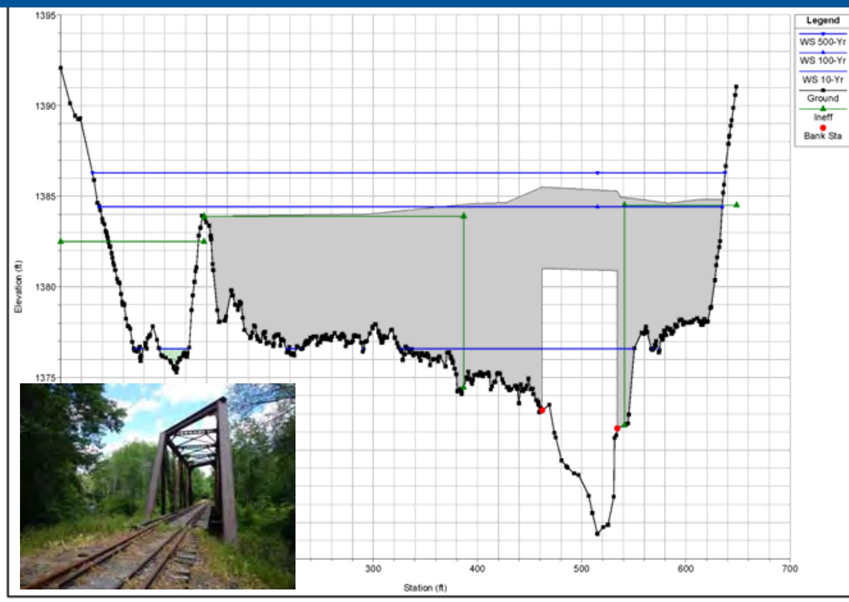
Negligible change in WSE at cross sections

Erpf Road 100-Year with and without bridge

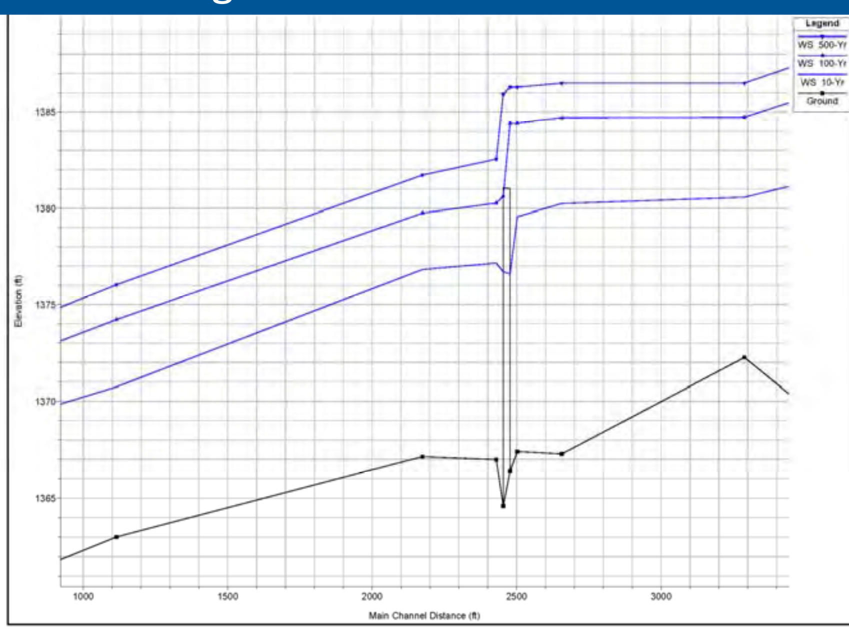
100-Year flood is *mostly* conveyed under the bridge so removing the bridge does not affect WSE

Negligible change in WSE at cross sections

Railroad Bridge Upstream Cross Section



Railroad Bridge Profile



RR Bridge 10-Year with and without bridge

10-Year flood is *mostly* conveyed under the bridge and some bypasses the bridge, so removing the bridge does not affect WSE

Decrease in WSE of 2.7 feet at the bridge, but it does not extend upstream

MILONE & MACBROOM

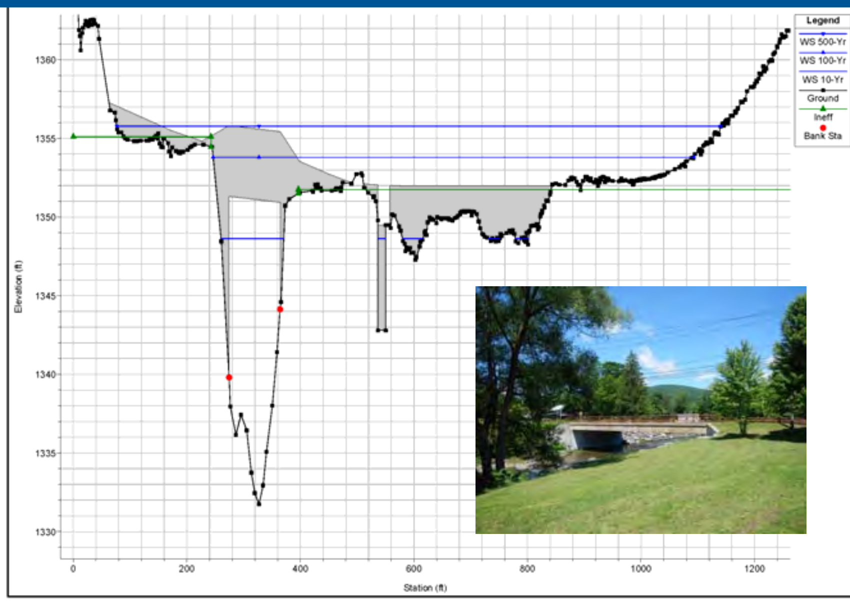
RR Bridge 100-Year with and without bridge

100-Year flood bypasses the bridge, so removing the bridge only partly reduces the WSE

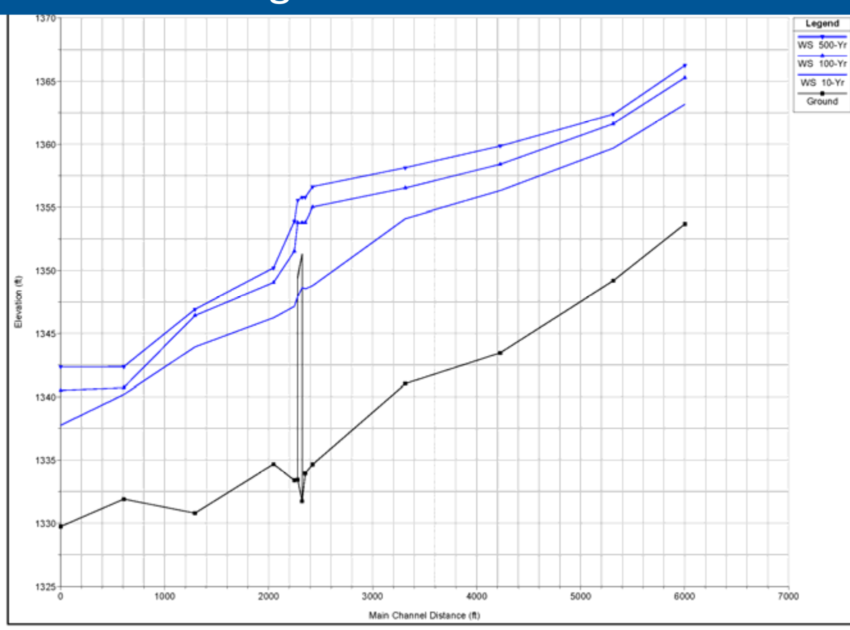
Decrease in WSE of 4.3 feet at the bridge, but it does not extend upstream

MILONE & MACBROOM

Rte 28 Bridge Upstream Cross Section



Route 28 Bridge Profile



Route 28 10-Year with and without bridge

10-Year flood is *mostly* conveyed under the bridge, so removing the bridge does not significantly reduce WSE

Decrease in WSE of 0.9 ft near the bridge, with benefits of 0.6 ft extending upstream to midway along Finnerty Road

MILONE & MACBROOM

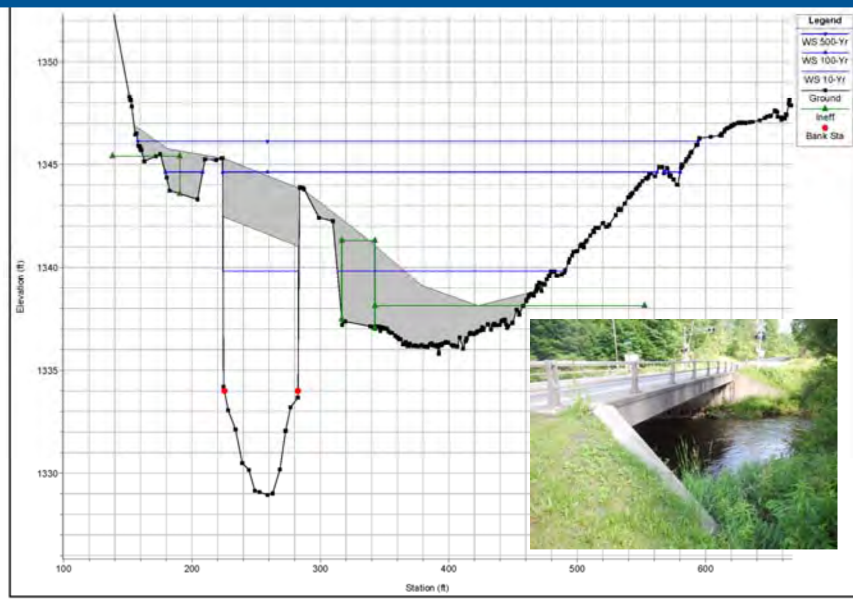
Route 28 100-Year with and without bridge

100-Year flood bypasses the bridge, so removing the bridge does not significantly reduce WSE

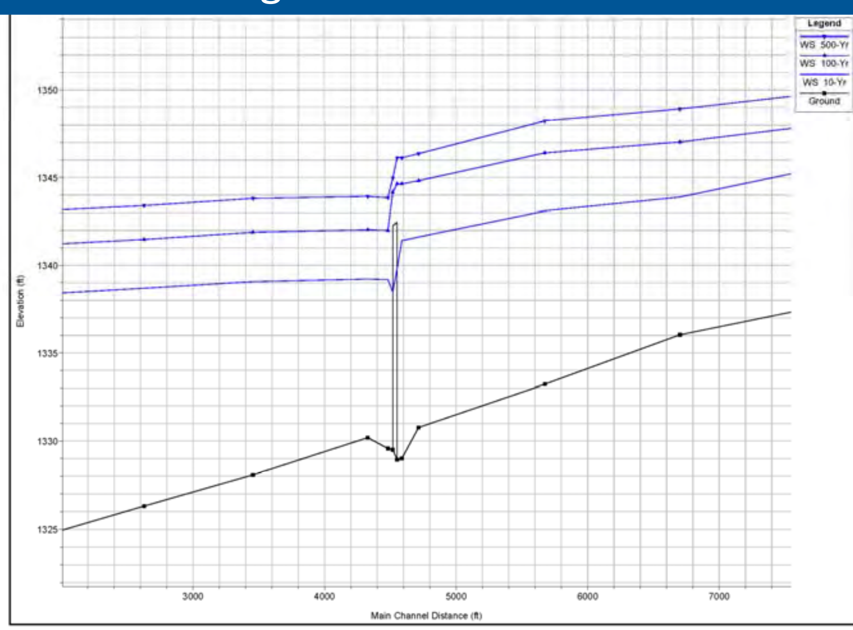
Decrease in WSE of 1.0 ft near the bridge, with benefits of 0.1 ft extending upstream to midway along Finnerty Road

MILONE & MACBROOM

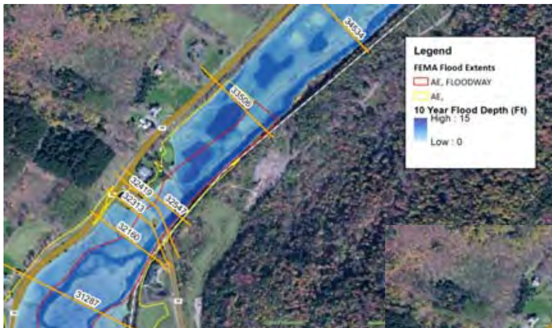
Route 38 Bridge Upstream Cross Section



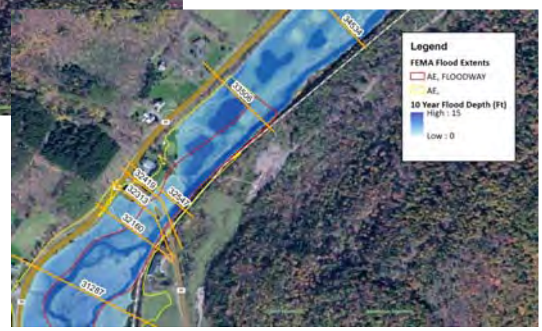
Route 38 Bridge Profile



Route 38 10-Year with and without bridge



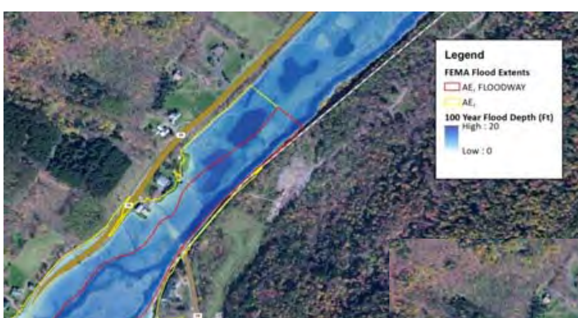
10-Year flood still passes over the low part of the road, but removing the bridge slightly reduces the WSE



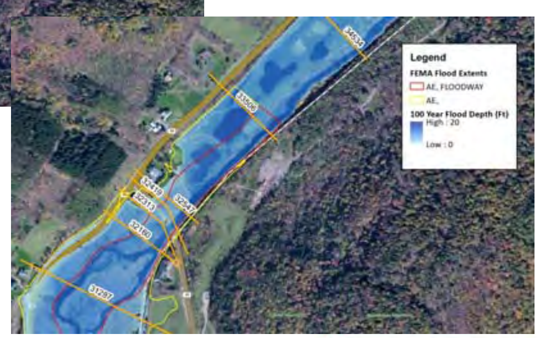
Decrease in WSE of 2.5 ft near the bridge, with moderate benefits extending about 2,000 feet upstream into the golf course

MILONE & MACBROOM

Route 38 100-Year with and without bridge



100-Year flood still passes over the low part of the road, but removing the bridge slightly reduces the WSE



Decrease in WSE of 3.2 ft near the bridge, with moderate benefits extending about 3,000 feet upstream into the golf course

MILONE & MACBROOM

Floodplain bench downstream of Route 38

- Lower floodplain along Route 30 downstream of Route 38 bridge
- Objective is to take the road out of the FEMA floodplain
- WSE decrease is only 0.07 ft at the midpoint of this floodplain enhancement alternative

MILONE & MACBROOM

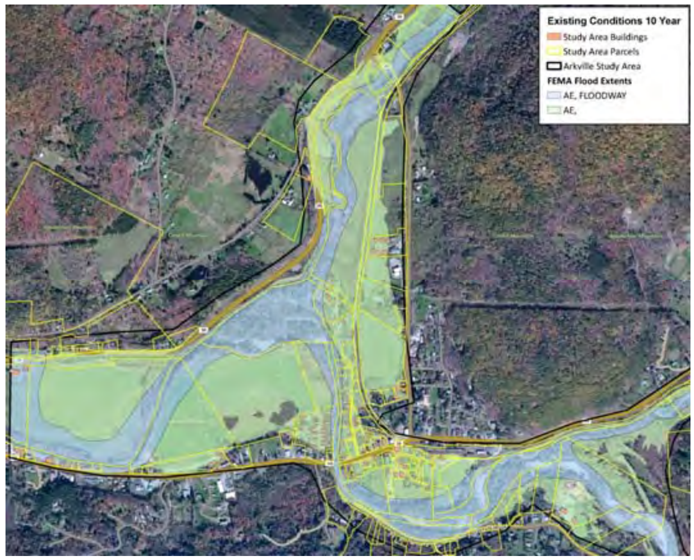
Lower floodplain to 10-year WSE

- Maximum decrease in WSE is only 0.2 ft for the 100-year flood
- We can test lower ground surfaces if there's consensus to do so

MILONE & MACBROOM

Information Obtained for Buildings

- LiDAR topo from NYCDEP
- Parcels and buildings from Delaware County Planning Department
- Visual reconnaissance of buildings
- Field descriptions of building elevations relative to grade
- Elevation certificates



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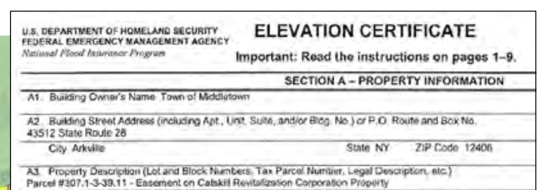
Information Obtained for Buildings



U.S. DEPARTMENT OF HOMELAND SECURITY
FEDERAL EMERGENCY MANAGEMENT AGENCY
National Flood Insurance Program

ELEVATION CERTIFICATE

Important: Read the instructions on pages 1–9.

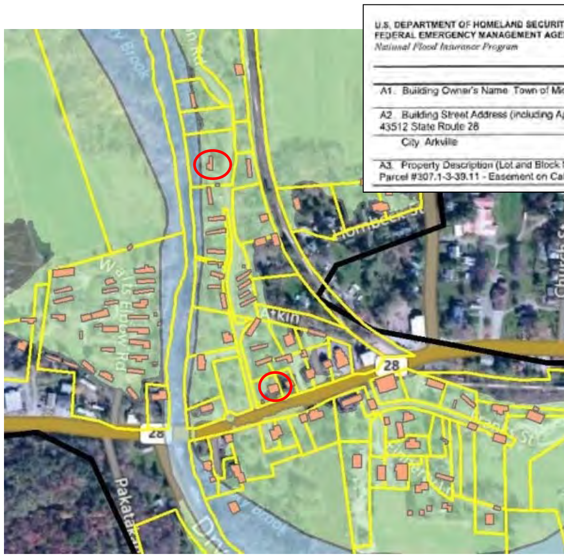
SECTION A – PROPERTY INFORMATION

A1. Building Owner's Name Town of Middletown

A2. Building Street Address (including Apt., Unit, Suite, and/or Bldg. No.) or P.O. Route and Box No.
43512 State Route 28

City Arkville State NY ZIP Code 12406

A3. Property Description (Lot and Block Numbers, Tax Parcel Number, Legal Description, etc.)
Parcel #307.1-3-39.11 - Easement on Catskill Revitalization Corporation Property



Elevation Certificate May be Available

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LFA Outcomes

- Engineering Analysis – Scientifically Based
- Benefit Cost Analysis – To Understand Viability
- Sketches of Mitigation Options
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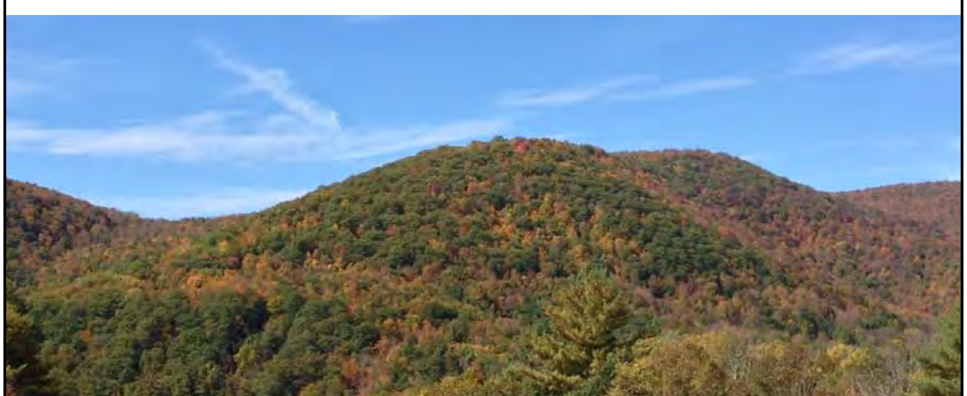


Questions, Comments, or Thoughts?

DATE: August 12, 2015
MMI #: 5197-07
PROJECT: Arkville LFA

SUBJECT: Notes from Town Board Meeting
LOCATION: Middletown Town Hall
42339 State Highway 28, Margaretville, NY

ATTENDEES:

David Murphy, P.E., CFM, MMI
Marge Miller, Supervisor, and the other Town Board Members and the Secretary
Graydon Dutcher, DCSWCD
Dean Frazier, Delaware County Watershed Affairs
Phil Eskeli, NYCDEP
Members of the public (sign-in sheet available from Town Clerk)

The Middletown Town Board held its regular meeting on August 12, 2015 at 6:00 PM at the Middletown Town Hall. Agenda item #6 provided for an update of the Arkville LFA. David Murphy was present from Milone & MacBroom, Inc. (MMI).

Mr. Murphy presented PowerPoint slides showing hydraulic modeling and maps that are being used to evaluate flooding in Arkville as well as the results of preliminary flood mitigation alternatives for four bridge replacements and two floodplain enhancements. He explained that some of the bridge replacement alternatives (for example Erpf Road, the railroad bridge, and the Route 38 bridge) either do not cause flood reduction benefits, or do not cause any benefits at roads or buildings and therefore many not justify further evaluation. However, these types of findings should be "parked" and incorporated into long-term recommendations for re-sizing bridges when they are eventually replaced.

He also explained why building and parcel data was important to the LFA (model verification, laying out alternatives, and as the basis for the benefit cost analysis) and explained how this information was being gathered. He asked individual property owners to provide comments outside the conference room after the presentation.

Group discussion topics (agenda item #7) included:

- Sediment within Dry Brook and transported along Dry Brook continues to be a major concern. The LFA should include modeling of flood levels for various sediment/gravel removal scenarios. Mr. Murphy indicated that this can be done, and reminded attendees that sediment removal typically yields only moderate or negligible reductions in water surface elevations. Mr. Dutcher provided additional commentary about sediment management and the need to consider sources of sediment as well as its transport downstream.

- Sediment sources from the Bush Kill should also be considered. The removal of the Lake Switzerland dam may have altered sediment transport in the Bush Kill.

- Residents near Dry Brook report that the channel has changed considerably over the last 10 years. Bank failures and channel migration near the railroad museum have also been significant.

- Town staff reminded MMI that the end of Dry Brook was re-routed and does not follow the pathway depicted in the aerial photographs used for base mapping. The concern is that the modeling is not accurate without the correct channel configuration in the model. Mr. Murphy explained that HEC-RAS is calculating water surface elevations at cross sections and therefore the focus should be the cross section that passes through this area of channel work. This will be checked in the model. Mr. Dutcher indicated that DCSWCD has additional information that can help in this area such as an as-built drawing.

Following agenda item #7, residents and property owners were joined in the hallway by Mr. Murphy, Mr. Dutcher, and Mr. Eskeli. Feedback included the following:

- The house at 50 Dry Brook Road owned by Mr. Steiglehner) was not flooded by Irene.

- The owner of the Meadows Golf Center (Julie Hernandez) was concerned that the LFA is not focused on the East Branch Delaware River. Mr. Murphy explained that this was indeed a primary topic of the study. Ms. Hernandez has owned the property since 2000 and their structure is currently being elevated. They recently renovated the mini-golf area immediately adjacent to the river. Mr. Murphy and Mr. Eskeli explained that these facilities are in the floodplain and will continue to be flooded in the future, but the LFA could look at ways that the golf center could be more resilient to floods.

- The owner of the home at 3 Finnerty Lane explained that his basement was flooded during Irene but the top of the water remained 4 inches below his first floor. He elevated the home after Irene, but instead of the required 5.5’ he elevated it two feet.

- The owner of the house at 99 Franks Street (Charlene Bode) reported that the flood water surface elevation during Irene was 2 inches below her first floor, and the level was similar in the 1996 flood. Her daughter’s trailer home on the same property was damaged. Her husband’s shop nearby on Finnerty Lane had four feet of water on the first floor (slab on grade).

- The owner of the house 43211 Route 28 (Elsie West) acquired the property just before Irene. It is a cement block home. She rode out the storm on the second floor. Floodwaters were as high as four feet on the first floor. She is thinking about pursuing the buyout program.

Local Flood Analysis
Dry Brook, Bush Kill, and East Branch Delaware River
Arkville, NY

David Murphy, P.E., CFM

East Branch Flood Commission | January 26, 2016

Agenda

- Review LFA focus area
- Review existing conditions modeling
- Present modeling of flood mitigation options
- Present sediment transport modeling

LFA Focus Area

Bush Kill, Dry Brook, and East Branch Delaware River between:

- Village of Margaretville boundary
- Upstream of Route 36 bridge
- Upstream of Railroad museum
- Upstream of Erpf Road bridge

MILONE & MACBROOM

Review of Existing Conditions Modeling

- 10-Year Depth Maps (10% annual chance flood)
- 100-Year Depth Maps (1% annual chance flood)
- Irene Depth Maps were not produced because the Irene flood discharges are nearly identical to the 100-year flows at this location

MILONE & MACBROOM

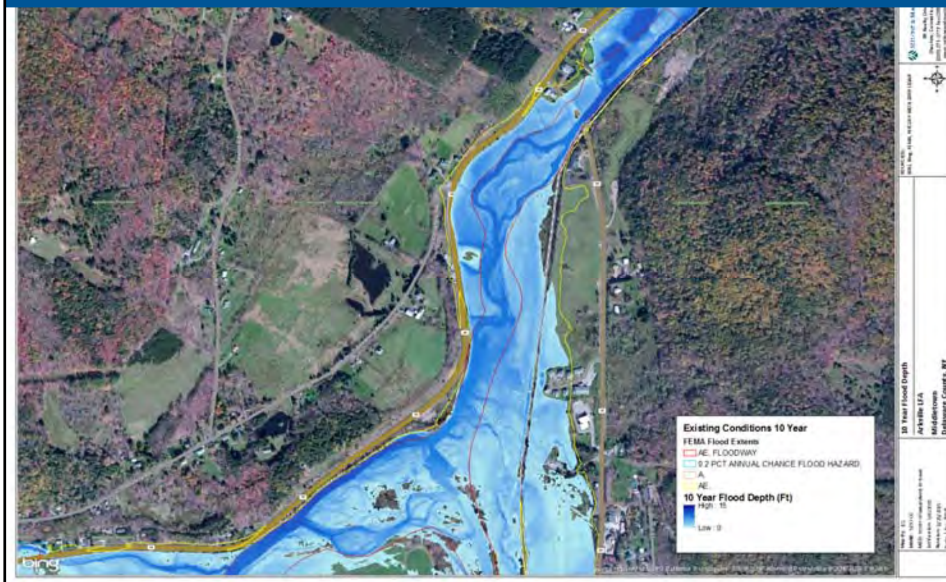
Confluence of Dry Brook and Bush Kill – 10 Year

MILONE & MACBROOM

Confluence of Dry Brook and Bush Kill – 100 Year

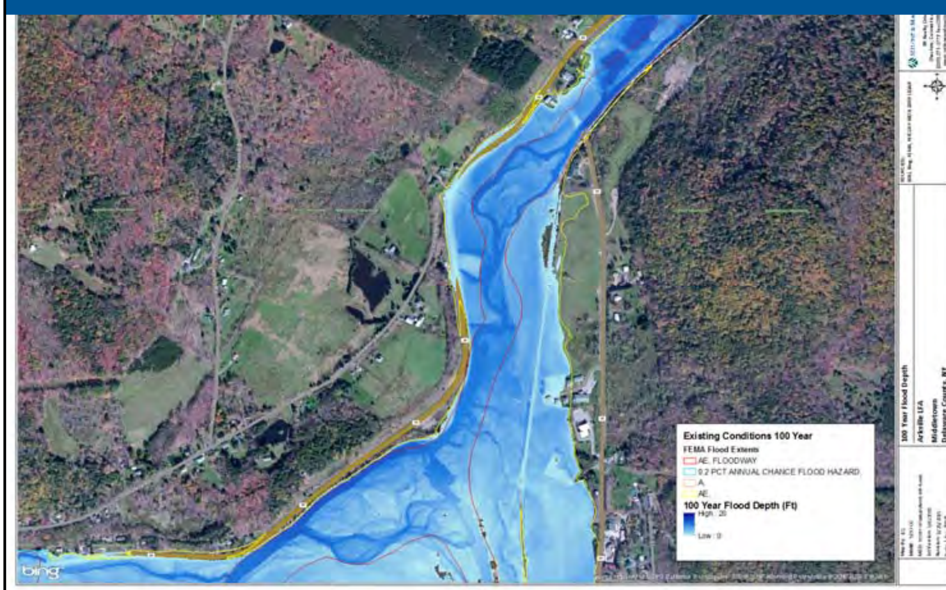
MILONE & MACBROOM

Northern East Branch Delaware River – 10 Year



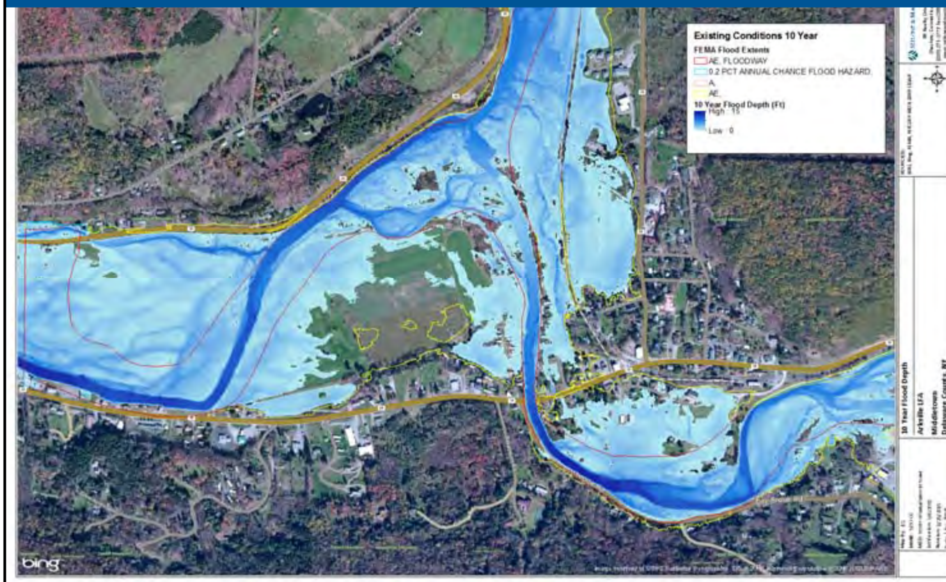
Milone & MacBroom

Northern East Branch Delaware River – 100 Year



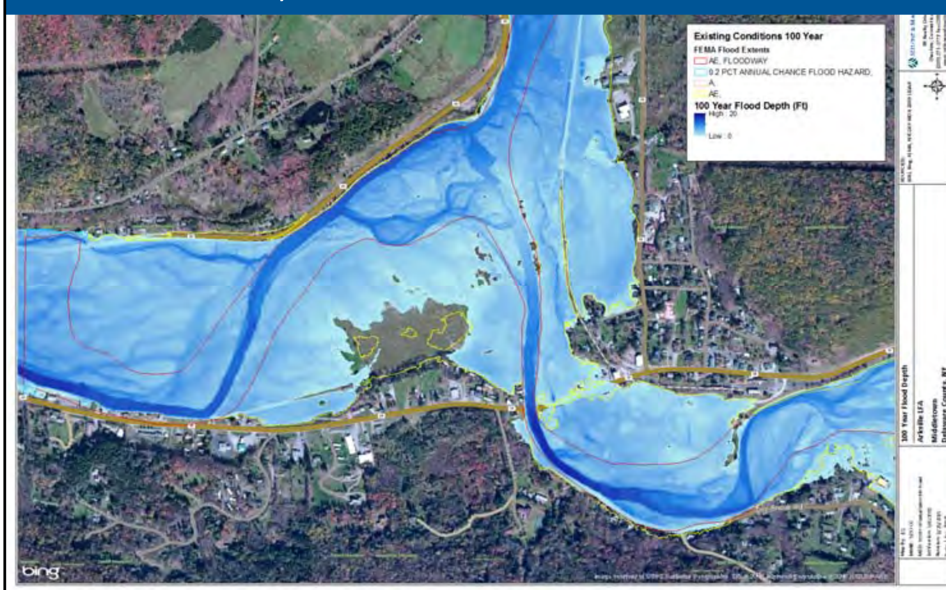
Milone & MacBroom

Confluence of Dry Brook and East Branch Delaware River – 10 Year



MILONE & MACBROOM

Confluence of Dry Brook and East Branch Delaware River – 100 Year



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Flood Mitigation Strategies

- Bridges – Removal or replacement
- Channel Alteration – Widening, realignment, compound channel
- Floodplain – Reclamation, creation, enhancement
- Sediment Management – Sediment removal, develop sediment management plan
- Individual Structure Treatment – Floodproofing, elevation of structures, relocation, voluntary buy-out

MILONE & MACBROOM

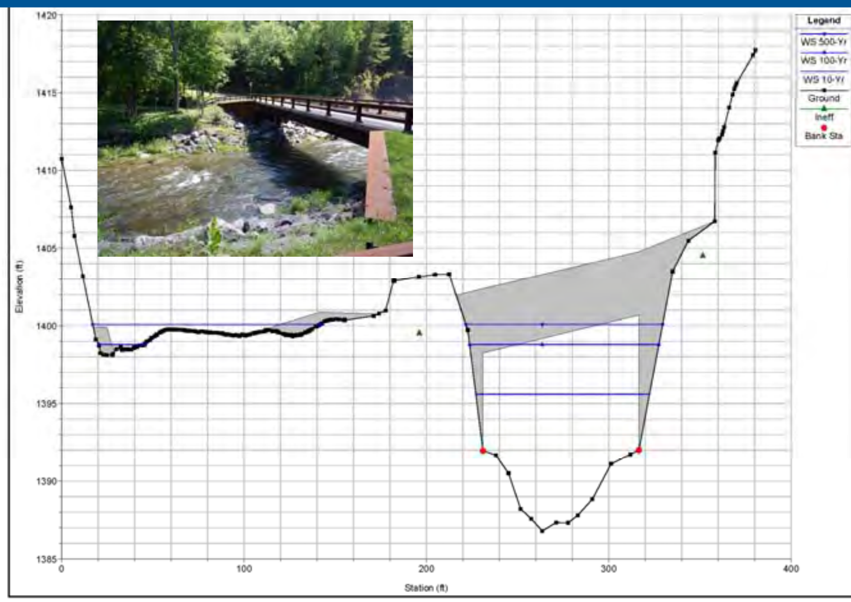
Modeled Flood Mitigation Strategies

Reviewed in Meeting of August 12, 2015

- Erpf Road Bridge
- Delaware & Ulster RR Bridge
- Route 28 Bridge
- Route 38 Bridge
- Lower floodplain along Route 30 downstream of Route 38 bridge
- Lower limited part of the floodplain between East Branch and Dry Brook
- Lower floodplain between Binnekill Creek and East Branch
- Bypass flood channel between Binnekill Creek and East Branch
- Floodplain bench between Dry Brook and Pavillion Road
- Bypass channel under Route 28
- Lower floodplains on north side of Dry Brook Road
- Limited levee or flood wall for maze
- Limited levee or flood wall for housing complex on Lamphere Lane
- Combination of bypass channel and floodplains
- Combination of Rte 28 Bridge replacement and floodplains

MILONE & MACBROOM

Erpf Road Bridge Upstream Cross Section



Erpf Road 10-Year with and without bridge

10-Year flood is conveyed under the bridge so removing the bridge does not affect WSE

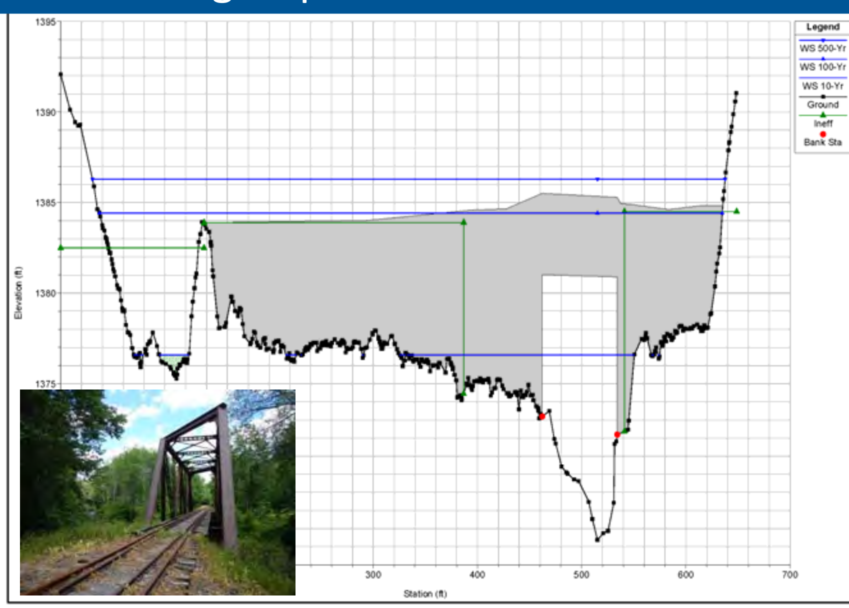
Negligible change in WSE at cross sections

Erpf Road 100-Year with and without bridge

100-Year flood is *mostly* conveyed under the bridge so removing the bridge does not affect WSE

Negligible change in WSE at cross sections

Railroad Bridge Upstream Cross Section



RR Bridge 10-Year with and without bridge

10-Year flood is *mostly* conveyed under the bridge and some bypasses the bridge, so removing the bridge does not affect WSE

Decrease in WSE of 2.7 feet at the bridge, but it does not extend upstream

MILONE & MACBROOM

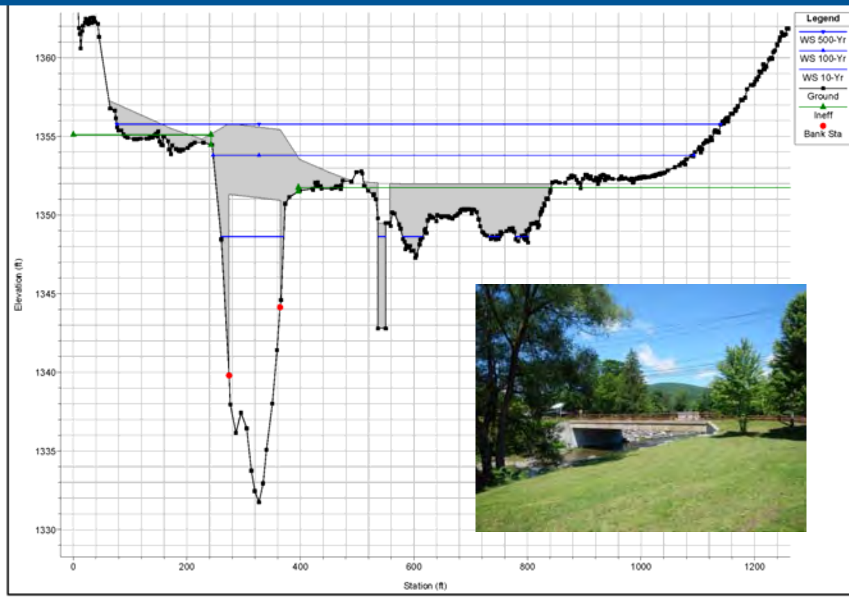
RR Bridge 100-Year with and without bridge

100-Year flood bypasses the bridge, so removing the bridge only partly reduces the WSE

Decrease in WSE of 4.3 feet at the bridge, but it does not extend upstream

MILONE & MACBROOM

Rte 28 Bridge Upstream Cross Section



Route 28 10-Year with and without bridge

10-Year flood is *mostly* conveyed under the bridge, so removing the bridge does not significantly reduce WSE

Decrease in WSE of 0.9 ft near the bridge, with benefits of 0.6 ft extending upstream to midway along Finnerty Road

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Route 28 100-Year with and without bridge

100-Year flood bypasses the bridge, so removing the bridge does not significantly reduce WSE

Decrease in WSE of 1.0 ft near the bridge, with benefits of 0.1 ft extending upstream to midway along Finnerty Road

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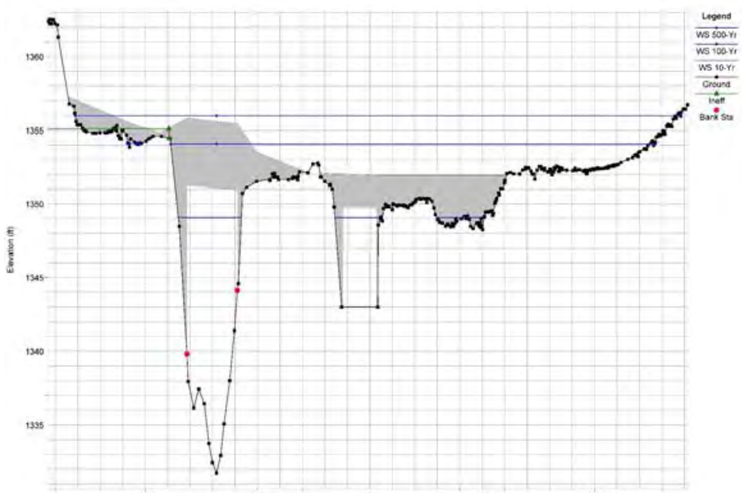
Bypass Channel at Route 28 Bridge

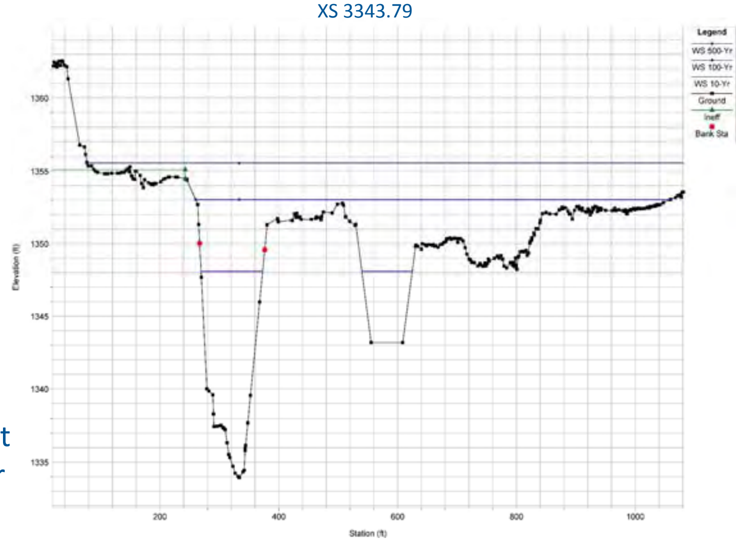
- Existing Rte 28 Bridge remains
- Replaces existing culvert with a wider bridge



Bypass Channel at Route 28 Bridge

- Creates bypass channel 1.5 feet below existing 2-year flow
- Bypass channel contains 10-year flow but not 100-year flow

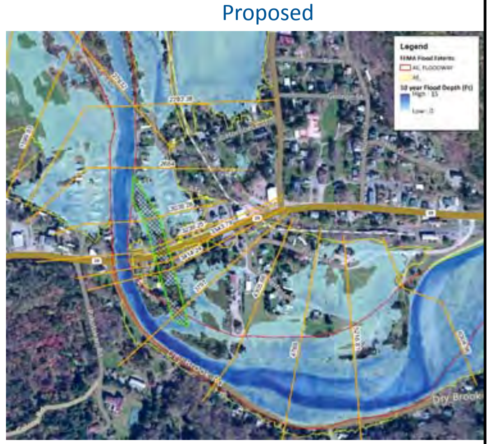
XS 3343.79



Bypass Channel at Route 28 Bridge 10 Year

Existing

Proposed



Decrease in WSE of 2.9 ft at XS 4305
Decrease in WSE of 1.4 at XS 3797

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Bypass Channel at Route 28 Bridge 100 Year

Existing | Proposed

Decrease in WSE of 1.5 ft at XS 4305
Decrease in WSE of 1.0 at XS 3797

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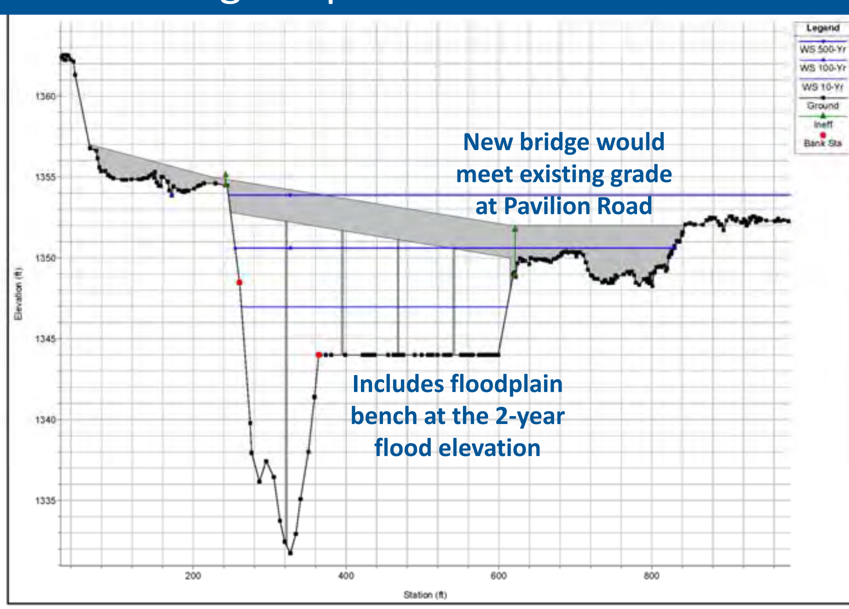
Rte 28 Bridge Replacement



Route 28 10-Year with and without Bridge Replacement

Existing

Proposed

Includes floodplain bench at the 2-year flood elevation (shown in green)

Decrease in WSE of 2.1 ft upstream of the bridge at XS 3797, with benefits of 1.9 ft at XS 4305

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Route 28 100-Year with and without Bridge Replacement

Existing

Proposed

Includes floodplain bench at the 2-year flood elevation (shown in green)

Decrease in WSE of 3.8 ft upstream of the bridge at XS 3414, with benefits of 1.5 ft at XS 4305

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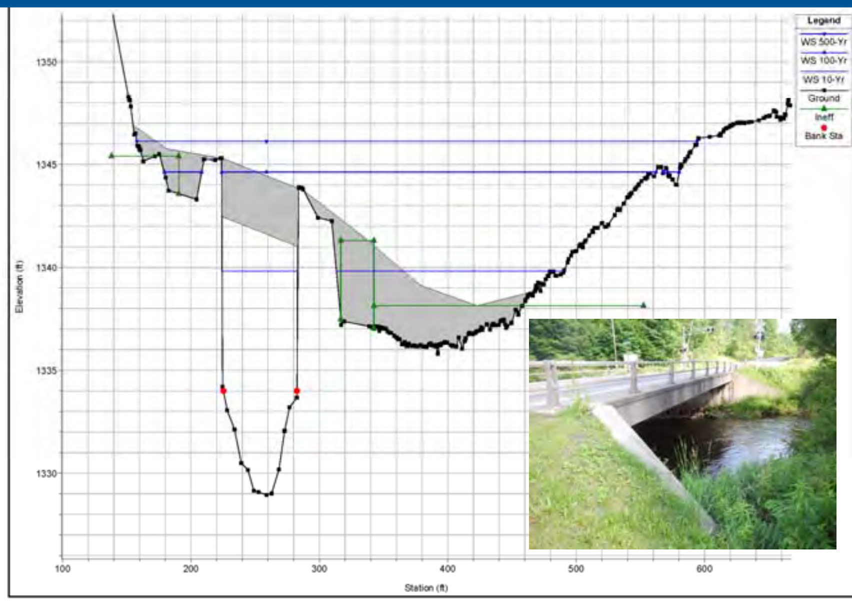
Route 38 Bridge Upstream Cross Section



Route 38 10-Year with and without bridge

Existing

10-Year flood still passes over the low part of the road, but removing the bridge slightly reduces the WSE

Proposed

Decrease in WSE of 2.5 ft near the bridge, with moderate benefits extending about 2,000 feet upstream into the golf course

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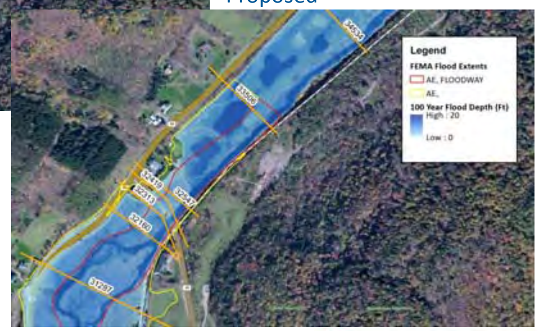
Route 38 100-Year with and without bridge

Existing

100-Year flood still passes over the low part of the road, but removing the bridge slightly reduces the WSE

Proposed



Decrease in WSE of 3.2 ft near the bridge, with moderate benefits extending about 3,000 feet upstream into the golf course

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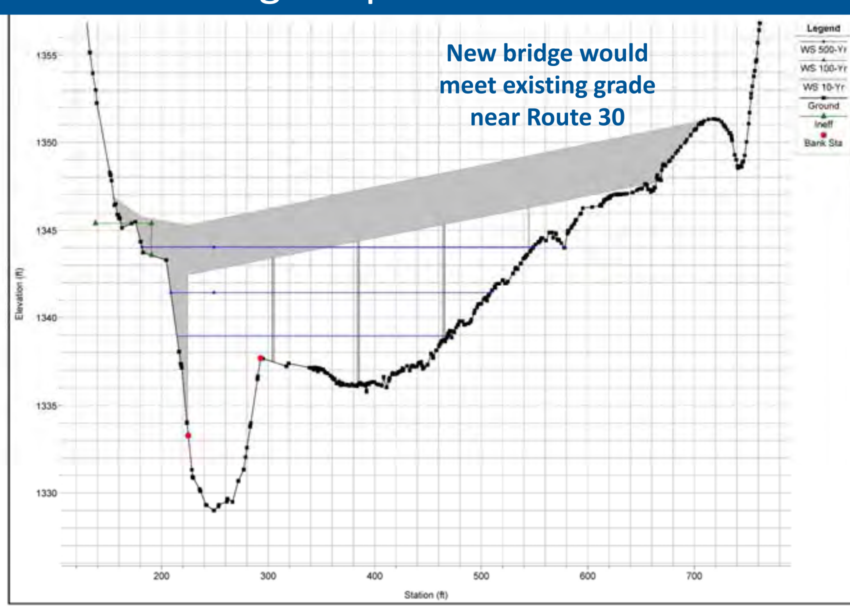
Route 38 Bridge Replacement



New bridge would meet existing grade near Route 30

Route 38 10-Year with and without Bridge Replacement

Existing

10-Year flood does not pass over the road under the proposed condition, but this is not reflected in the depth grid

Proposed

Decrease in WSE of 0.8 ft near the bridge, with moderate benefits extending about 2,000 feet upstream into the golf course

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Route 38 100-Year with and without Bridge Replacement

Existing

100-Year flood does not pass over the road under the proposed condition, but this is not reflected in the depth grid

Proposed

Decrease in WSE of 3.2 ft at upstream bridge face, decrease of 1.1 ft at XS 32419 moderate benefits extending about 3,000 feet upstream into the golf course

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Floodplain bench downstream of Route 38

- Lower floodplain along Route 30 downstream of Route 38 bridge
- Objective is to take the road out of the FEMA floodplain
- WSE decrease is only 0.07 ft at the midpoint of this floodplain enhancement alternative

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Floodplain between Dry Brook and Pavillion Road 10 year

Existing

Proposed

Lower floodplain along Pavillion Road downstream of Route 28 bridge

Decrease in WSE of 0.9 ft at XS 3239,
with benefits of 0.6 ft at XS 3038

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Floodplain between Dry Brook and Pavillion Road 100 year

Existing

Proposed

Lower floodplain along Pavillion Road downstream of Route 28 bridge

Decrease in WSE of 0.8 ft at XS 3038

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Floodplain Bench North of Dry Brook Road

- Lower floodplain along Dry Brook north of Dry Brook Road
- WSE decrease is only 0.4 ft at XS 6304.96

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Lower floodplain to 10-year WSE

- Maximum decrease in WSE is only 0.2 ft for the 100-year flood
- We can test lower ground surfaces if there's consensus to do so

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Levee on Lamphere Lane

- Created levee between railroad and buildings at Lamphere Lane
- Protects buildings from 100 year flood
- Change in WSE is negligible

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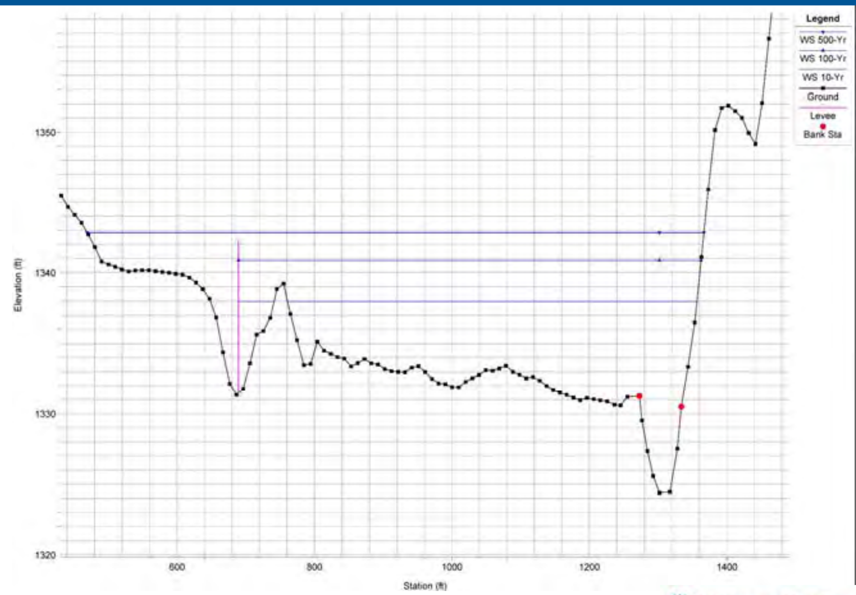
Levee on Lamphere Lane



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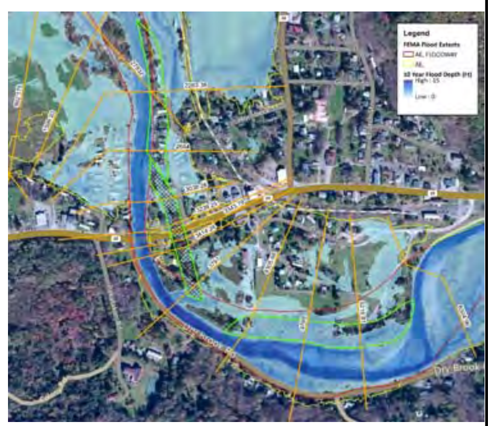
Combination 1: Bypass Channel with Floodplains 10 Year

Existing

Proposed



Decrease in WSE of 1.4 ft at XS 3797
Decrease in WSE of 2.4 ft at XS 4305

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Combination 1: Bypass Channel with Floodplains 100 Year

Existing | Proposed

Decrease in WSE of 1.0 ft at XS 3797
Decrease in WSE of 1.6 ft at XS 4305

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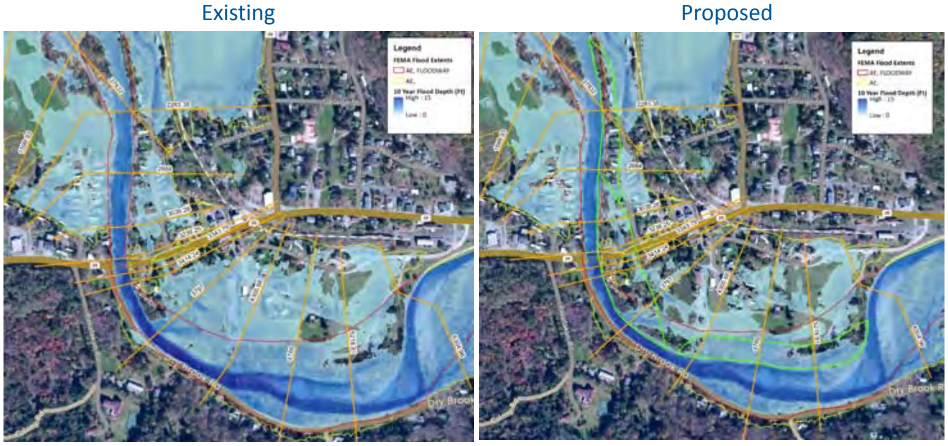
Combination 2: Rte 28 Bridge Replacement with Floodplains 10 Year

Existing | Proposed



Decrease in WSE of 2.1 ft at XS 3797
Decrease in WSE of 1.8 ft at XS 4305

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Combination 2: Rte 28 Bridge Replacement with Floodplains 100 Year

Existing

Proposed

Decrease in WSE of 3.7 ft at XS 3414
Decrease in WSE of 2.2 ft at XS 3797
Decrease in WSE of 1.9 ft at XS 4305

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Summary of 100-Yr Flood Reductions near Route 28

Alternative	WSE Decrease near Bridge (3414)	WSE Decrease Slightly Upstream (3797)	WSE Decrease Midway along Finnerty Road (4305)
Remove Rt 28 Bridge	0.3	0.2	0.1
Bypass Channel	1.3	1.0	1.5
New Bridge	3.8	2.3	1.5
Combination 1 (bypass channel + floodplains)	1.3	1.0	1.6
Combination 2 (new bridge + floodplains)	3.7	2.2	1.9

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Sediment Analysis Assumptions

- Only allowed scour and deposition within main channels since we do not know sediment size on floodplains
- Set maximum scour depth of 5 feet below existing
- Only had sediment size data for Dry Brook, so used the same sediment data for Bush Kill
- Did not allow scour near and above Route 28 Bridge where there is bedrock

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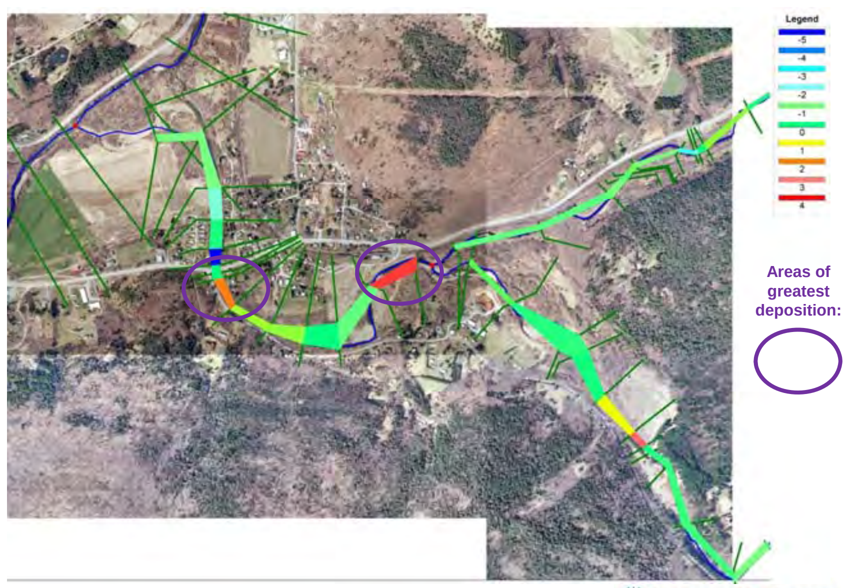
Existing Conditions Sediment Analysis – 2 Year Flow



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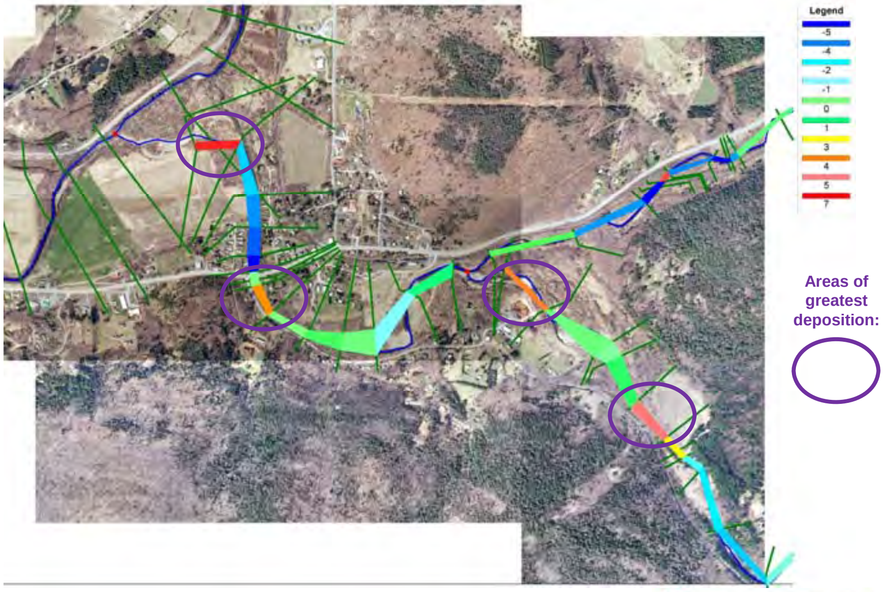
Existing Conditions Sediment Analysis – 100 Year Flow



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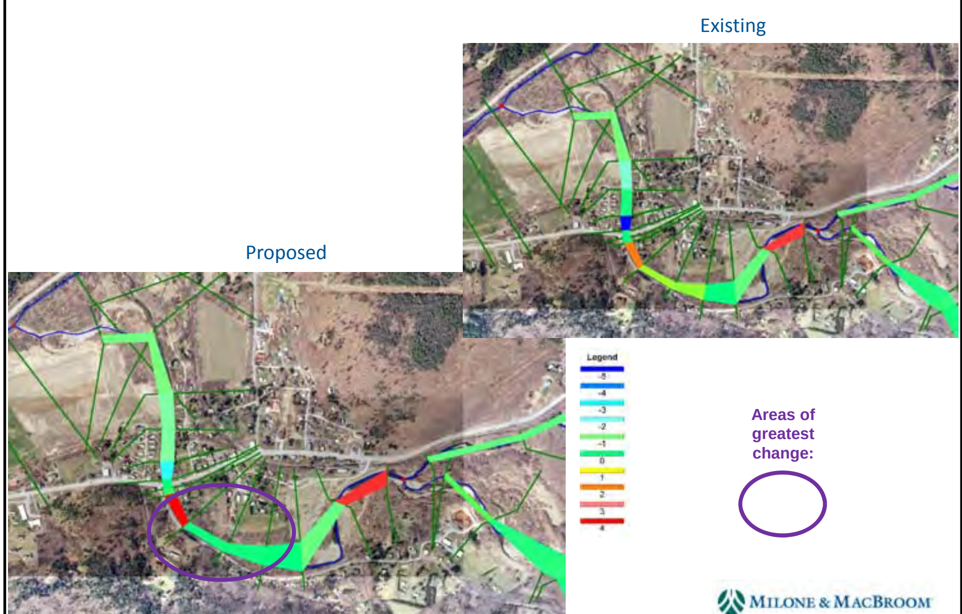
Bypass Channel Sediment Analysis – 2 Year Flow



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Bypass Channel Sediment Analysis – 100 Year Flow

Existing

Proposed

Areas of greatest change:

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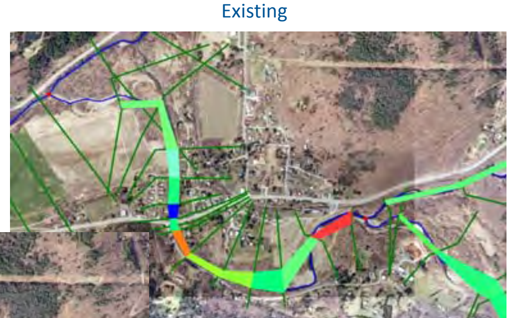
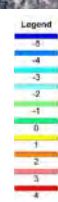
Combination 1 Sediment Analysis – 2 Year Flow

- Includes bypass channel with floodplains upstream and downstream

Existing



Proposed



Areas of greatest change:

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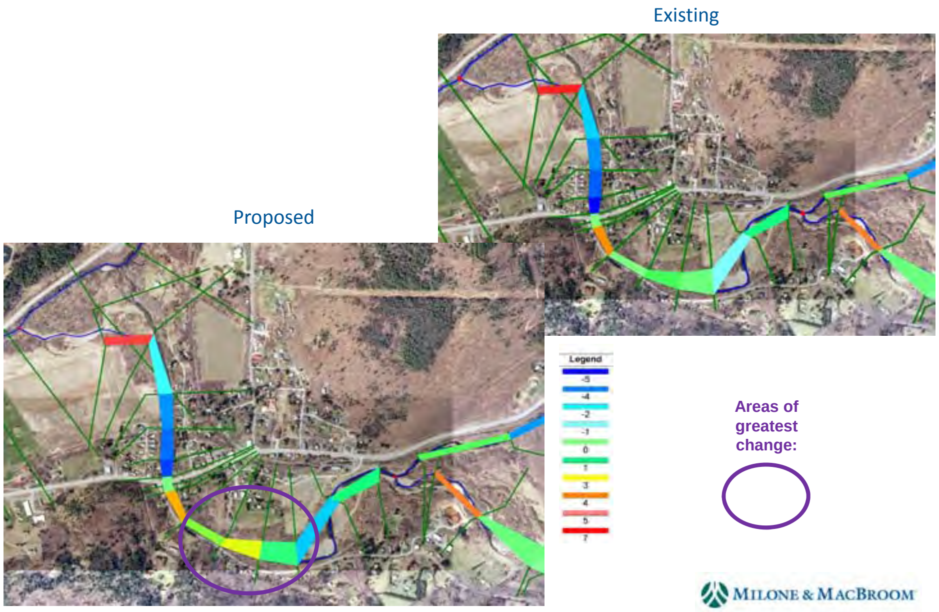
Combination 1 Sediment Analysis – 100 Year Flow



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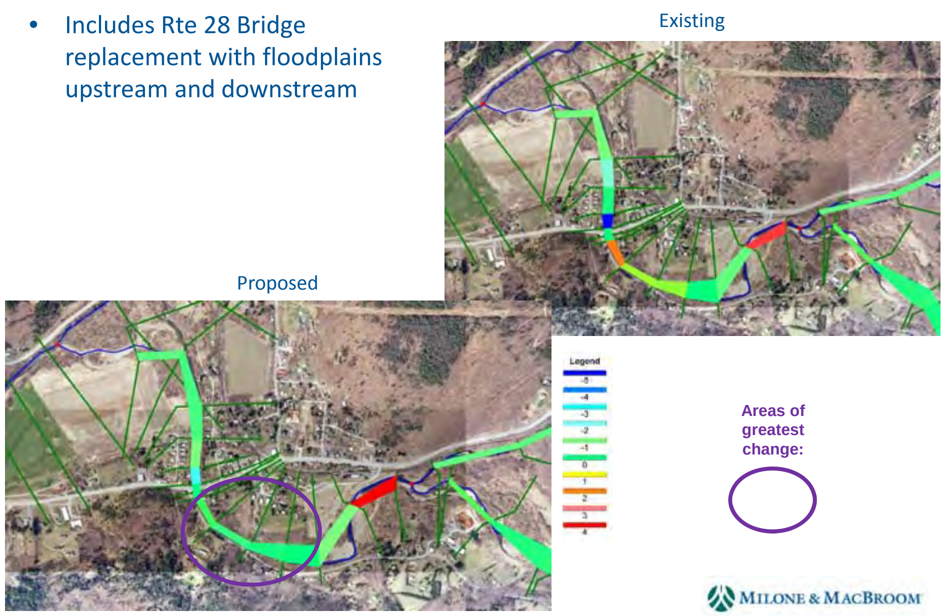
Combination 2 Sediment Analysis – 2 Year Flow

- Includes Rte 28 Bridge replacement with floodplains upstream and downstream



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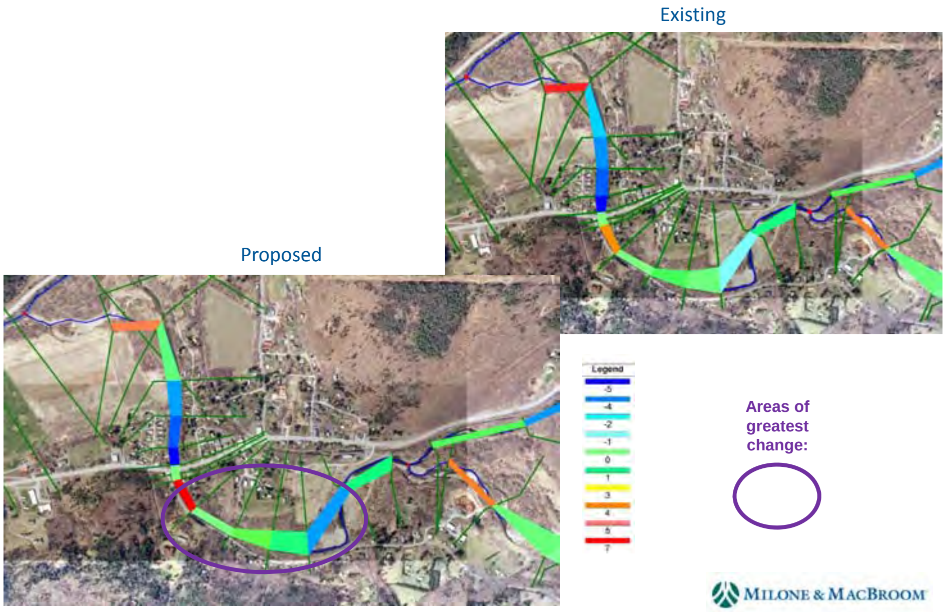
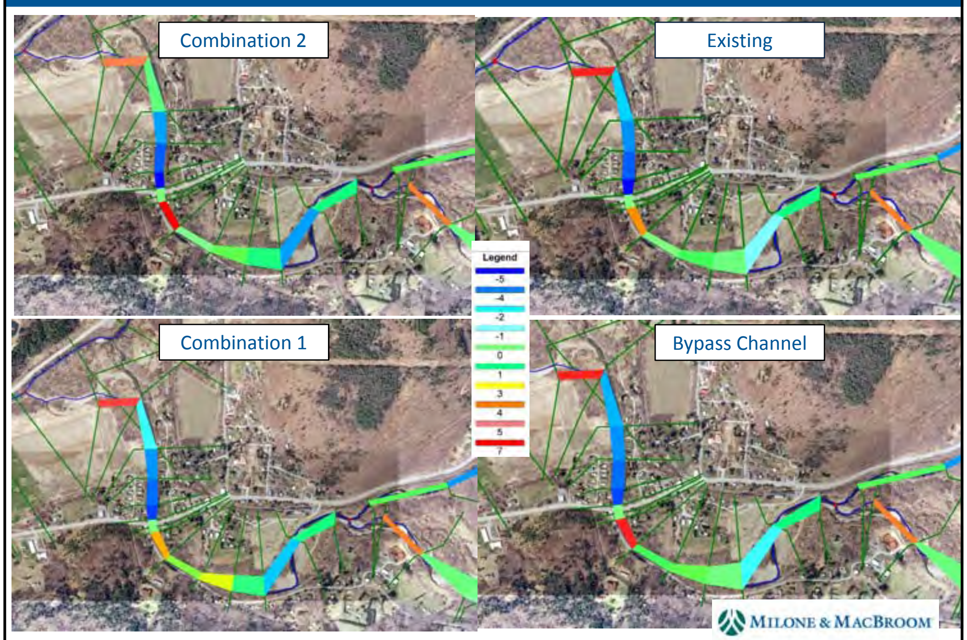
Combination 2 Sediment Analysis – 100 Year Flow



Comparison of Sediment Analysis – 100 Year Flow



Comparison of Sediment Analysis – 100 Year Flow

- What does all this mean?
  - ✓ Sediment transport changes are probably not severe enough to rule out any particular flood mitigation alternative
  - ✓ Flood mitigation alternatives should be paired with sediment management recommendations

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Next Steps

- Benefit Cost Analysis
- Draft LFA Report
- Present Draft Report

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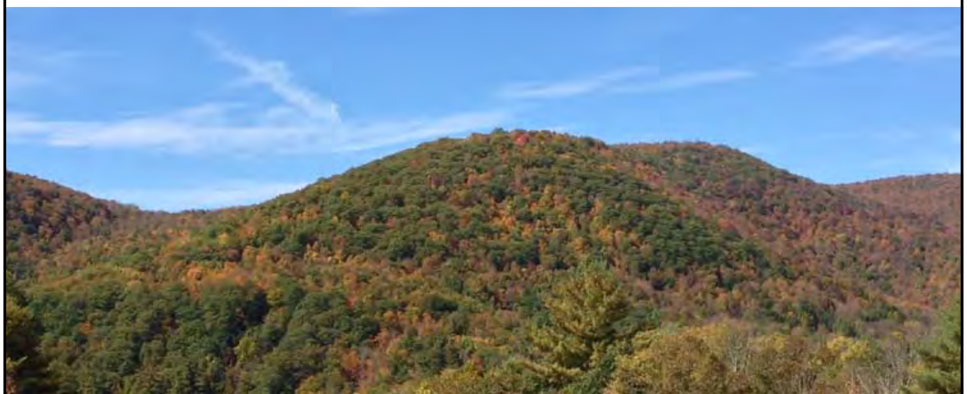

Questions, Comments, or Thoughts?

Minutes of Meeting

DATE: January 26, 2016
MMI #: 5197-07
PROJECT: Arkville LFA

SUBJECT: Notes from East Branch Flood Commission
LOCATION: Middletown Town Hall
42339 State Highway 28, Margaretville, NY

ATTENDEES:

David Murphy, P.E., CFM, MMI
Patrick Davis, Town Supervisor
Graydon Dutcher, DCSWCD
Rick Weidenbach, DCSWCD
Dean Frazier, Delaware County Watershed Affairs
Phil Eskeli, NYCDEP
Nate Hendrix, NYCDEP

The East Branch Flood Commission held a meeting on January 26, 2016 at 10:00 AM at the Middletown Town Hall. Agenda item #1 provided for an update of the Arkville LFA. David Murphy was present from Milone & MacBroom, Inc. (MMI).

Mr. Murphy presented PowerPoint slides showing the results of modeling flood mitigation alternatives for bridge replacements, floodplain enhancements, and a small levee. Following the presentation of hydraulic modeling results, sediment transport modeling was presented and discussed.

Group discussion topics included:

- Attendees asked how stormwater was being handled in the model with the levee around the Lamphere Road housing units. David explained that the model includes a simple barrier in the cross section. The implications of pursing a levee here were discussed, and David explained that elevating the housing units would be the most straightforward method to reduce the flood risk in this area. The Flood Commission directed MMI to avoid developing cost estimates for the levee and stormwater management that would be needed; this alternative may be considered no further.

- Graydon noted that the bypass channel is less costly than other alternatives, can happen in the short term, and has benefits for the 10-year flood. This is an alternative that the attendees are interested in taking a closer look at, including a careful BCA.

- Sediment transport model precision is believed lacking southeast of Finnerty Road. Attendees asked MMI to add a new cross section through this bend. There is a possibility that DCSWCD staff could field survey the topography along a new section. David reminded attendees that one of the nearby sections was already added when the LFA commenced.

- The section of Dry Brook upstream of the Route 28 bridge simulates as depositional through most of the model runs. However, this same section of the river has bedrock in the channel. Attendees asked MMI to prevent changes in the riverbed in this location. Phil asked that parameters be double-checked in this area as well, such as roughness.

- A resident spoke about the deteriorating Binnekill bulkhead and stated that this was an important factor missing from the LFA. David explained that several alternatives were evaluated in this area, including a lowered floodplain and a bypass channel starting near the Binnekill bulkhead and running diagonally to the river, but none of these alternatives had any effects in the hamlet center. David also explained that the 100-year WSE inundates everything in the vicinity of the Binnekill bulkhead. This demonstrates that there aren't any viable alternatives in this area that can provide benefits upstream in the hamlet center. Graydon explained that Margaretville should be evaluating the Binnekill in its NYR/LTR flood mitigation assessment.

- A current list of buyouts is needed. David should contact Planning Department staff. It is possible that the mobile home parcel along Pavilion Road is in the program. However, some private properties are located within this larger parcel.

The next meeting of the East Branch Flood Commission will be on February 29, 2016. BCA results will be presented. If time permits, revised sediment transport modeling will be included in the discussion.

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Local Flood Analysis

Dry Brook, Bush Kill, and East Branch Delaware River
Arkville, NY

David Murphy, P.E., CFM

East Branch Flood Commission | February 29, 2016

Agenda

- Review the modeled flood mitigation options that were selected for further consideration
- Overview of benefit cost analysis (BCA)
- Present preliminary BCA

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Modeled Flood Mitigation Strategies

- Erpf Road Bridge
- Delaware & Ulster RR Bridge
- Route 28 Bridge
- Route 38 Bridge
- Lower floodplain along Route 30 downstream of Route 38 bridge
- Lower limited part of the floodplain between East Branch and Dry Brook
- Lower floodplain between Binnekill Creek and East Branch
- Bypass flood channel between Binnekill Creek and East Branch
- Floodplain bench between Dry Brook and Pavillion Road
- Bypass channel under Route 28
- Lower floodplains on north side of Dry Brook Road
- Limited levee or flood wall for maze
- Limited levee or flood wall for housing complex on Lamphere Lane
- Combination #1 (bypass channel and floodplain benches)
- Combination #2 (Rte 28 Bridge replacement and floodplain benches)

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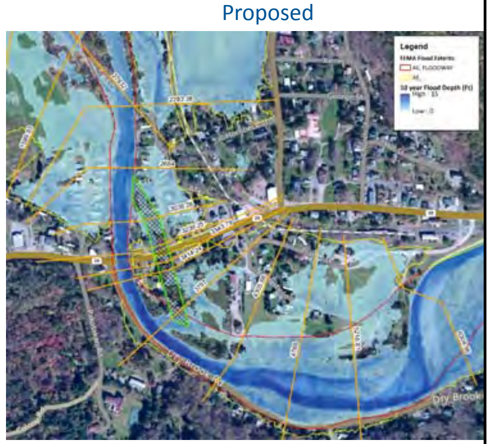
Bypass Channel at Route 28 Bridge 10 Year

Existing

Proposed



Decrease in WSE of 2.9 ft at XS 4305
Decrease in WSE of 1.4 at XS 3797

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Bypass Channel at Route 28 Bridge 100 Year

Existing | Proposed

Decrease in WSE of 1.5 ft at XS 4305
Decrease in WSE of 1.0 at XS 3797

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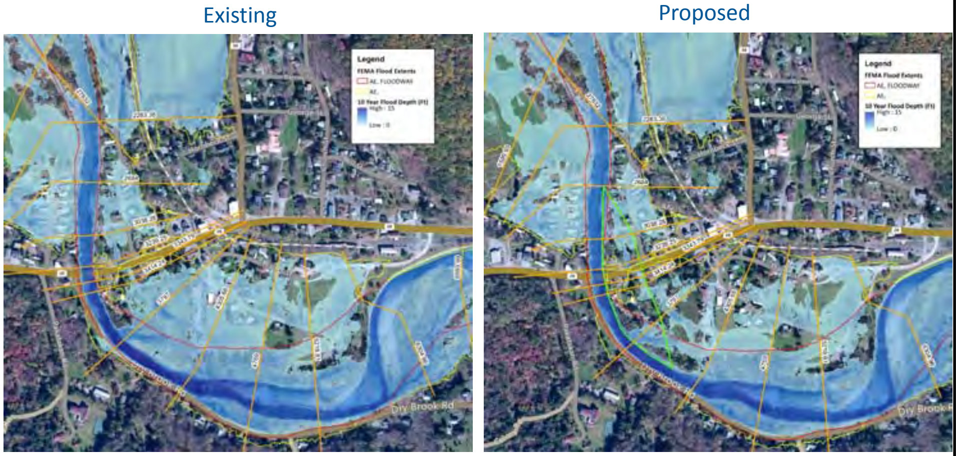
Route 28 10-Year with and without Bridge Replacement

Existing | Proposed



Includes floodplain bench at the 2-year flood elevation (shown in green)

Decrease in WSE of 2.1 ft upstream of the bridge at XS 3797,
with benefits of 1.9 ft at XS 4305

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Route 28 100-Year with and without Bridge Replacement

Existing

Proposed

Includes floodplain bench at the 2-year flood elevation (shown in green)

Decrease in WSE of 3.8 ft upstream of the bridge at XS 3414,
with benefits of 1.5 ft at XS 4305

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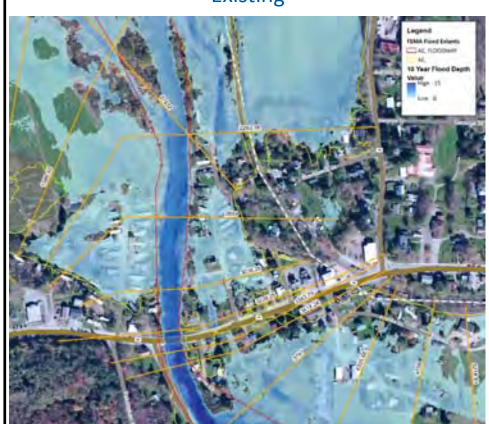
Floodplain between Dry Brook and Pavillion Road 10 year

Existing



Proposed

Lower floodplain along Pavillion Road downstream of Route 28 bridge

Decrease in WSE of 0.9 ft at XS 3239,
with benefits of 0.6 ft at XS 3038

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Floodplain between Dry Brook and Pavillion Road 100 year

Existing

Proposed

Lower floodplain along Pavillion Road downstream of Route 28 bridge

Decrease in WSE of 0.8 ft at XS 3038

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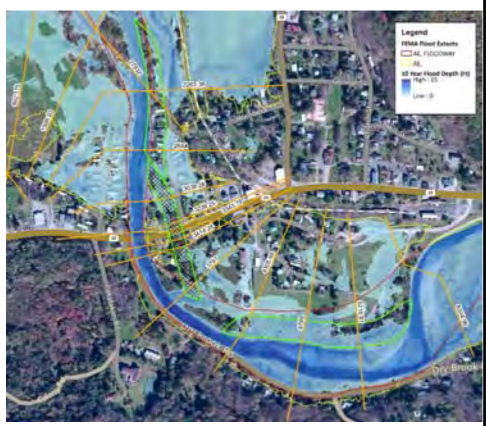
Combination 1: Bypass Channel with Floodplains 10 Year

Existing

Proposed



Decrease in WSE of 1.4 ft at XS 3797
Decrease in WSE of 2.4 ft at XS 4305

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Combination 1: Bypass Channel with Floodplains 100 Year

Existing | Proposed

Decrease in WSE of 1.0 ft at XS 3797
Decrease in WSE of 1.6 ft at XS 4305

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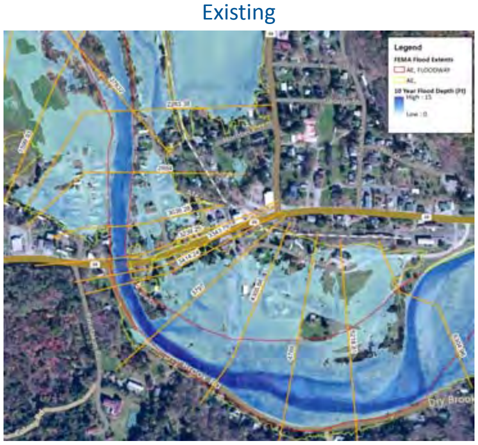
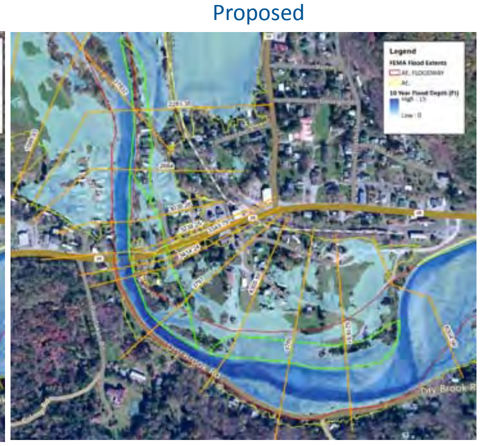
Combination 2: Rte 28 Bridge Replacement with Floodplains 10 Year

Existing | Proposed





Decrease in WSE of 2.1 ft at XS 3797
Decrease in WSE of 1.8 ft at XS 4305

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Combination 2: Rte 28 Bridge Replacement with Floodplains 100 Year

Existing

Proposed

Decrease in WSE of 3.7 ft at XS 3414
Decrease in WSE of 2.2 ft at XS 3797
Decrease in WSE of 1.9 ft at XS 4305

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Summary of 100-Yr Flood Reductions near Route 28

Alternative	WSE Decrease near Bridge (3414)	WSE Decrease Slightly Upstream (3797)	WSE Decrease Midway along Finnerty Road (4305)
Bypass Channel	1.3	1.0	1.5
New Route 28 Bridge	3.8	2.3	1.5
Combination 1 (bypass channel + floodplains)	1.3	1.0	1.6
Combination 2 (new bridge + floodplains)	3.7	2.2	1.9

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BCA

- What is BCA?
  - ✓ Process of determining the Benefit Cost Ratio (BCR)
  - ✓ A mitigation project cannot be funded by FEMA unless it has a BCR greater than 1.0
    - Benefits = Damages Avoided, in units of $
    - Benefits over the life span must exceed project cost
  - ✓ FEMA's BCA tool must be used

BCA

- ✓ Many good projects that reduce flood damage and protect water quality do not have BCR >1.0
  - These projects cannot be funded by FEMA
- ✓ We can use BCA to evaluate projects that may not be appropriate for FEMA funding due to timing, logistics, project cost vs. congressional allocations, programmatic restrictions, or other factors
  - The LFA projects are good examples
  - We can try to apply "water quality benefits" for LFA-assessed projects

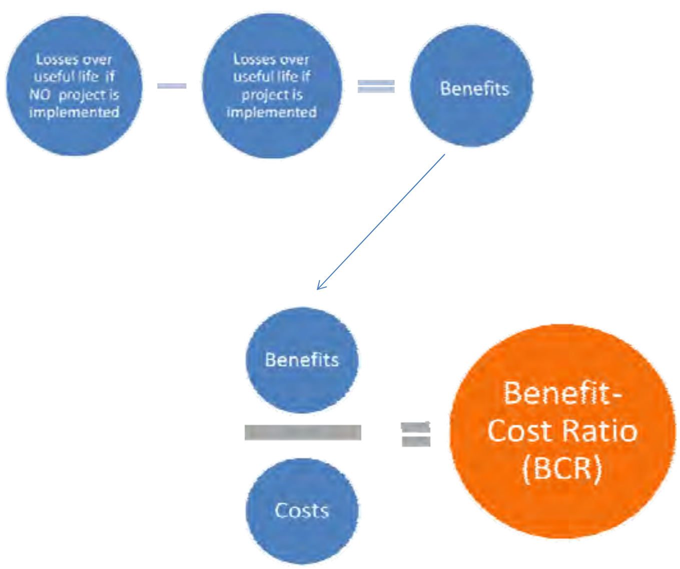
BCA

- The FEMA BCA tool includes six modules:

  - ✓ Flood
  - ✓ Hurricane Winds
  - ✓ Wildfire
  - ✓ Tornado
  - ✓ Earthquake
  - ✓ Damage Frequency

Two can evaluate flood benefits

BCA



BCA

Generating Benefits from Acquisitions/Removals

- Buildings that may be removed are handled as acquisitions/ relocations
- Project life span = 100 years (standard for acquisitions)
- Only the FIS and FIRM are needed, as there is no comparison to future flood levels
- Include annual revenue of property if applicable
- Let the program generate benefits; these will be summed outside the program
- Key assumptions for LFAs:
  - Building elevations based on LiDAR or best available
  - Property values = market values in the Planning Dept. database
  - Demolition costs range from $15,000 to $50,000
  - Default depth/damage curves used

BCA

Generating Benefits from Water Surface Reductions

- Handled as flood reductions with a project life span of 50 years for floodplain benches and floodplain enhancements
- Include annual revenue per building if applicable
- Let the program generate benefits; these will be summed outside the program
- Key assumptions for LFAs:
  - Building elevations based on LiDAR or best available
  - Building values = total market values minus land values in the Planning Dept. database
  - Default depth/damage curves used

Floodplain Bench Downstream of Route 28

- Creation of Floodplain FP-5
- Building Acquisitions: 49, 65, 147, 149, 163, 183, and 261 Pavilion Road

Benefit Cost Summary	FP-5
Benefits: Acquisitions and Relocations	$1,478,783
Benefits: Water Surface Reductions at Buildings that Remain	$136,579
Total Benefits	$1,615,362
Total Costs	$1,034,000
Benefit Cost Ratio	1.56

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Bypass Channel

- Bypass Channel
- Building Acquisition: 65 Pavilion Road

Benefit Cost Summary	BC-1b
Benefits: Acquisitions and Relocations	$199,023
Benefits: Water Surface Reductions at Buildings that Remain	$66,698
Total Benefits	$265,721
Total Costs	$2,533,000
Benefit Cost Ratio	0.10

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Replace Route 28 Bridge

- Replace Route 28 Bridge
- Building Acquisitions: 49 and 65 Pavilion Road; 43141 State Highway 28; 13, 41, and 60 Riverside Drive

Benefit Cost Summary	BR-2e
Benefits: Acquisitions and Relocations	$1,986,063
Benefits: Water Surface Reductions at Buildings that Remain	$159,545
Total Benefits	$2,145,608
Total Costs	$8,941,000
Benefit Cost Ratio	0.24

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Combination 1 (bypass channel + floodplains)

- Bypass Channel, FP-4, and FP-5
- Building Acquisitions: 65, 147, 149, 163, 183, 261 Pavilion Road

Benefit Cost Summary	Combo-1
Benefits: Acquisitions and Relocations	$1,076,988
Benefits: Water Surface Reductions at Buildings that Remain	$286,410
Total Benefits	$1,363,408
Total Costs	$3,615,000
Benefit Cost Ratio	0.38

Milone & MacBroom

Combination 2 (new bridge + floodplains)

- Route 28 Bridge Replacement, FP-4, and FP-5
- Building Acquisitions: 13, 41, 60 Riverside Drive; 49, 65, 147, 149, 163, 183, 261 Pavilion Road and 43141 State Highway 28

Benefit Cost Summary	Combo-2
Benefits: Acquisitions and Relocations	$2,893,785
Benefits: Water Surface Reductions at Buildings that Remain	$292,677
Total Benefits	$3,186,462
Total Costs	$10,023,000
Benefit Cost Ratio	0.32

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Next Steps

- Refine the Benefit Cost Analysis
- Compare the overall costs of bridge/bypass/floodplain projects with relocation of groups of buildings
- Draft LFA Report
- Present Draft Report

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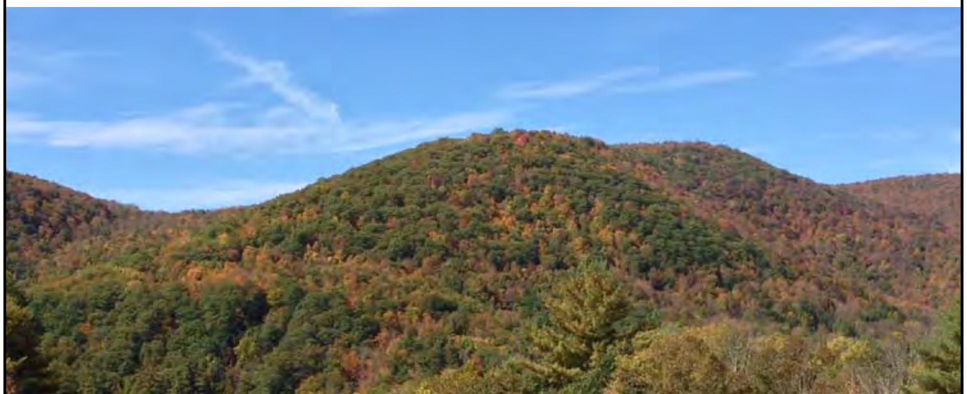

Questions, Comments, or Thoughts?

Minutes of Meeting

DATE: February 29, 2016
MMI #: 5197-07
PROJECT: Arkville LFA

SUBJECT: Notes from East Branch Flood Commission
LOCATION: Middletown Town Hall
42339 State Highway 28, Margaretville, NY

ATTENDEES:

David Murphy, P.E., CFM, MMI
Patrick Davis, Town Supervisor
Graydon Dutcher, DCSWCD
Rick Weidenbach, DCSWCD
Dean Frazier, Delaware County Watershed Affairs
Phil Eskeli, NYCDEP
Nate Hendrix, NYCDEP

The East Branch Flood Commission held a meeting on February 29, 2016 at 10:00 AM at the Middletown Town Hall. Agenda item #1 provided for an update of the Arkville LFA. David Murphy was present from Milone & MacBroom, Inc. (MMI).

Group discussion topics included:

- Timeframes/schedules are important considerations when it comes to bridge replacements. When bridges are replaced, what flood levels must be considered?

- Graydon reminded attendees that the alternatives that have been evaluated must be compared to other types of alternatives such as relocation of groups of buildings. The costs of relocating many residents should be compared to the costs of alternatives. However, relocating people can be costly and it impacts the community character.

- David described the challenges associated with the generation of flood reduction benefits at buildings with uncertain BRVs (building replacement values). The most problematic BRVs appear to be located in the area of Franks Road and Finnerty Road. Patrick committed to working with MMI to review the BRVs.

Attendees generally agreed that flood mitigation alternatives have been sufficiently modeled and evaluated, and understood that the benefit cost analysis (BCA) was not likely to change much after BRVs are adjusted. The next step will be to present the findings to the public.

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Presentation of Local Flood Analysis
Dry Brook, Bush Kill, and East Branch Delaware River
Arkville, NY

David Murphy, P.E., CFM

Public Meeting | April 6, 2016

Agenda

- LFA goals, outcomes, and advisory structure
- Existing conditions
- Potential flood mitigation strategies
- Public input received to date
- Results of evaluation of each alternative
- Sediment transport
- Benefit cost analysis
- Conclusions

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LFA Goals for Arkville

- Reduce flood risk to homes and businesses
- Reduce flood risk to roads
- Become more resilient over the long-term
- Maintain sense of community
- Obtain appropriate funding for flood mitigation projects
- Make sure flood mitigation projects do not make sediment problems worse

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LFA Outcomes

- Scientifically Based Analysis
- Sketches of Mitigation Options
- Planning-Level Cost Estimates
- Benefit Cost Analysis to Understand Project 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 the Citizens of Middletown

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Project Advisory Committee

- East Branch Flood Commission
- Town of Middletown
- Delaware County Soil and Water Conservation District
- Delaware County Planning Department
- Delaware County Public Works
- Delaware County Watershed Affairs
- New York City Department of Environmental Protection
- Catskill Watershed Corporation

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What About Fleischmanns and Margaretville?

- Fleischmanns LFA report is under review
- Margaretville LFA has not yet been conducted
- Arkville's LFA can proceed independently of the other LFAs. Why?
  - *The Fleischmanns LFA does not propose changes to flood volumes along the Bush Kill above Arkville*
  - *The Arkville LFA does propose changes to flood volumes along Bush Kill or Dry Brook above Margaretville*
  - *The flood profiles between each population center are sufficiently steep to not create backwater to one another*

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Review of Existing Conditions Modeling

- 10-Year Depth Maps (10% annual chance flood)
- 100-Year Depth Maps (1% annual chance flood)
- Irene Depth Maps were not produced because the Irene flood discharges are nearly identical to the 100-year flows *at this location*

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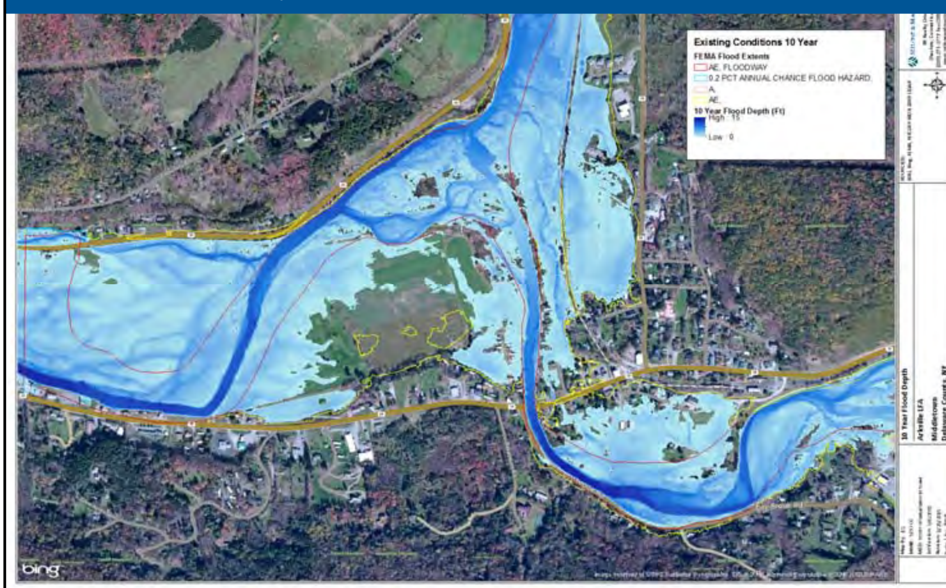
Confluence of Dry Brook and East Branch Delaware River – 10 Year



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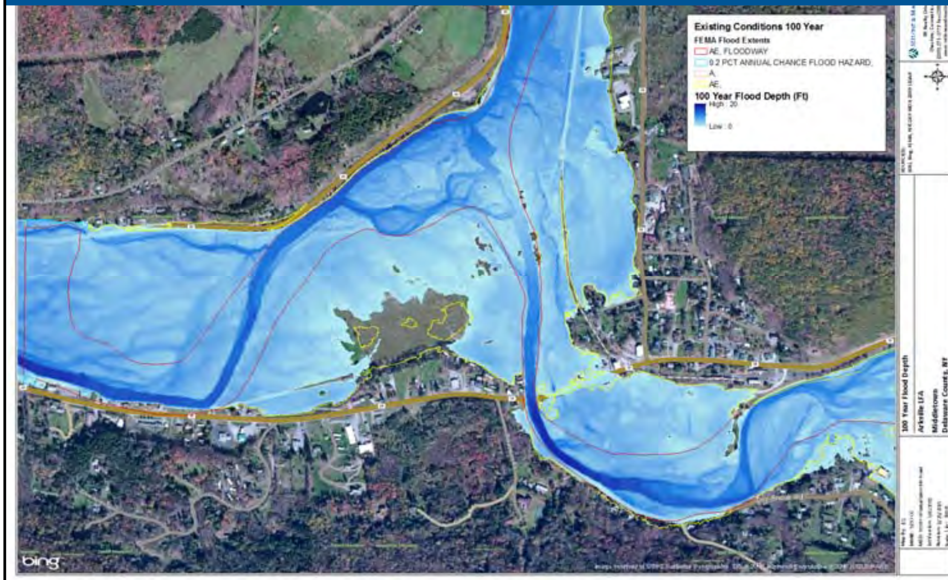
Confluence of Dry Brook and East Branch Delaware River – 100 Year



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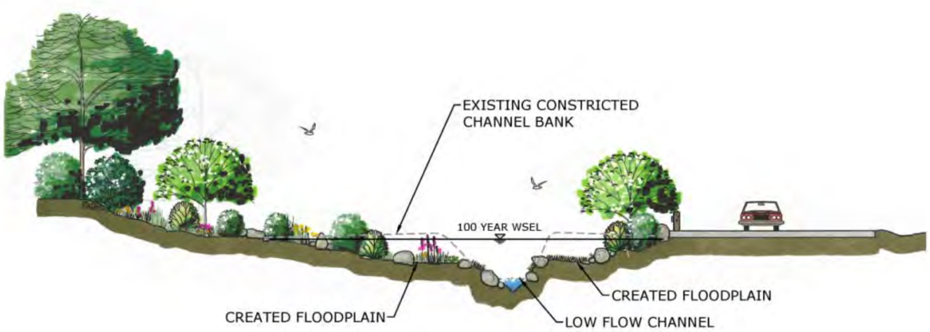
Flood Mitigation Strategies

- Channel Alteration – Widening or realignment, creation of compound channel or bypass channel
- Floodplain – Reclamation, creation, enhancement
- Bridges – Removal or replacement



TYPICAL COMPOUND CHANNEL

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Flood Mitigation Strategies

- Sediment Management
  Sediment removal, stabilization of sources
- Individual Structures
  Floodproofing, elevation of structures, voluntary buy-outs, relocations

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Review Public Input Received to Date

- Bridges cause flooding or make it worse
- Consider a bypass channel parallel to Dry Brook under Route 28
- Restore various older channels
- Sediment transport management needed
- Periodic gravel harvesting needed
- Control discharge from East Branch into Binnekill
- Protect the maze
- Mitigate bank erosion
- Automated early warning system (similar need raised for Fleischmanns)

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Flood Mitigation Strategies for Arkville

East Branch Delaware River
- Route 38 Bridge replacement
- Lower the floodplain along Route 30 downstream of Route 38 bridge
- Levee or flood wall for housing complex on Lamphere Lane
- Lower part of the floodplain between East Branch and Dry Brook
- Lower the floodplain between Binnekill Creek and East Branch
- Create a bypass flood channel between Binnekill Creek and East Branch

Bush Kill
- Railroad Bridge replacement

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Flood Mitigation Strategies for Arkville

Dry Brook
- Erpf Road Bridge replacement
- Limited levee or flood wall for maze
- Floodplain bench on right bank of Dry Brook near Finnerty Road
- Convert culvert to a bypass channel under Route 28
- Route 28 Bridge replacement
- Floodplain bench on right bank of Dry Brook along Pavilion Road
- Combination #1 (bypass channel and floodplain benches)
- Combination #2 (Route 28 Bridge replacement and floodplain benches)

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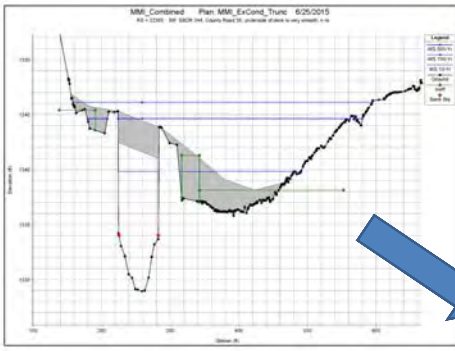
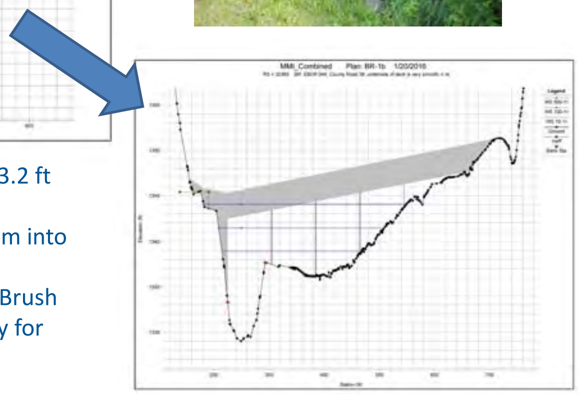
Route 38 Bridge Replacement





- Result: Decrease in WSE of 3.2 ft at the bridge with 0.5-1.0 ft decrease extending upstream into the golf course
- Recommendation: ***Park it.*** Brush this off when bridge is ready for replacement.

Lower Floodplain downstream of Route 38

- Objective is to take the road out of the FEMA floodplain
- Lower floodplain along Route 30 downstream of Route 38 bridge
- Result: WSE decrease is only 0.07 ft at the midpoint of this floodplain alternative
- Recommendation: ***Do not pursue***; benefit is negligible.

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Levee or Floodwall for Lamphere Lane

- Consider levee or flood wall between railroad and buildings at Lamphere Lane
- Result: Would protect buildings from 100 year flood while change outside is negligible
- Would require stormwater pumping system inside the levee

- Recommendation: ***Do not pursue***; address specific buildings as needed

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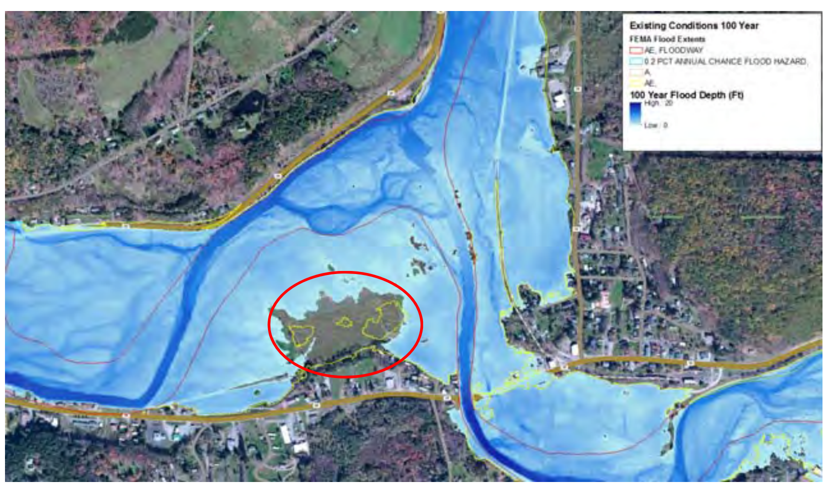
Lower Floodplain between EBDR and Dry Brook



- Result: Maximum decrease in WSE is only 0.2 ft for the 100-year flood
- Recommendation: ***Do not pursue***; benefit is negligible

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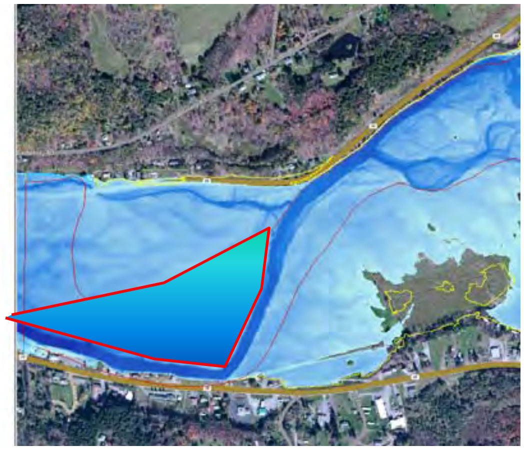
Lower floodplain between Binnekill and EBDR

- Result: Negligible decrease in WSE because this area is already about as low as it can be while remaining a floodplain
- Recommendation: ***Do not pursue***; benefit is negligible



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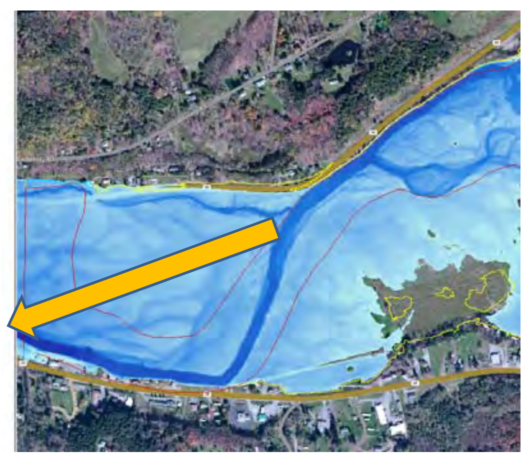
Create Bypass Channel in this Area

- Result: Negligible decrease in WSE because this area is already about as low as it can be while remaining a floodplain
- In other words, this "bypass" already happens during floods
- Recommendation: ***Do not pursue***; benefit is negligible



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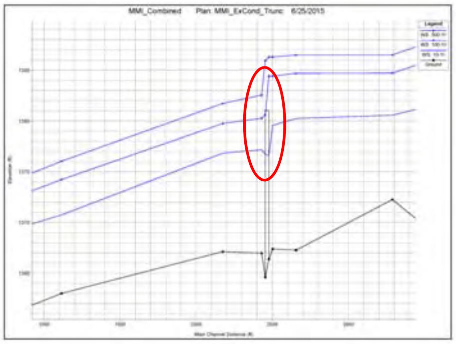
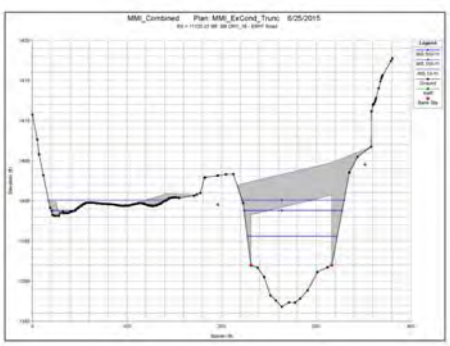
Railroad Bridge Replacement



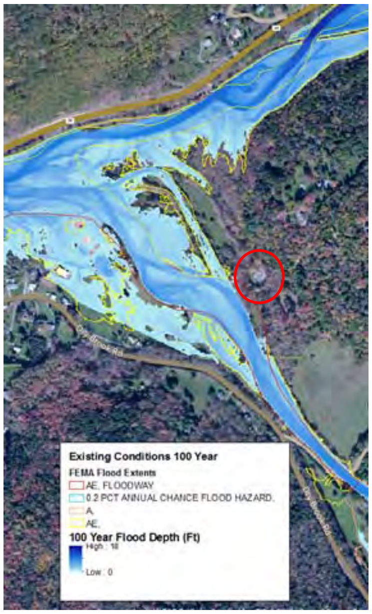
- Result: 10-Year flood is mostly conveyed under the bridge while some bypasses the bridge; the 100-Year flood bypasses the bridge
- In other words, the bridge is simply a "speedbump" during a flood
- Recommendation: ***Park it.*** Brush this off when bridge is ready for replacement.

Erpf Road Bridge Replacement



- Result: 10-Year flood is conveyed under the bridge; the 100-Year flood is mostly conveyed under the bridge
- In other words, the bridge is another "speedbump" during a flood
- Recommendation: ***Park it.*** Brush this off when bridge is ready for replacement.

Limited Levee or Flood Wall for Maze



- Result: The maze is not at risk of inundation.
- Recommendation: ***Do nothing.*** If erosion becomes a concern in the future, address the riverbank.

Photo from Pinterest.com

Floodplain Bench on Right Bank of Dry Brook

- Result: Maximum decrease in 100-Year WSE is 0.4 ft at upstream end.
- Recommendation: ***Not bad. Consider in combination with others?***

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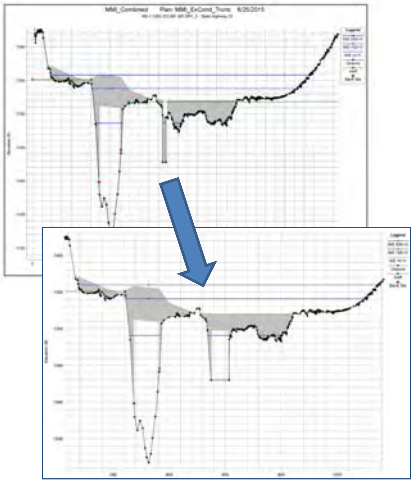
Convert Culvert to Bypass Channel under Rt 28



- Result: For the 100-Year flood, the WSE decrease is only 1 ft to 1.5 ft
- However….

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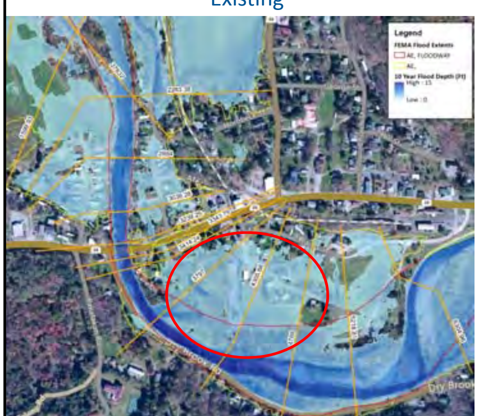
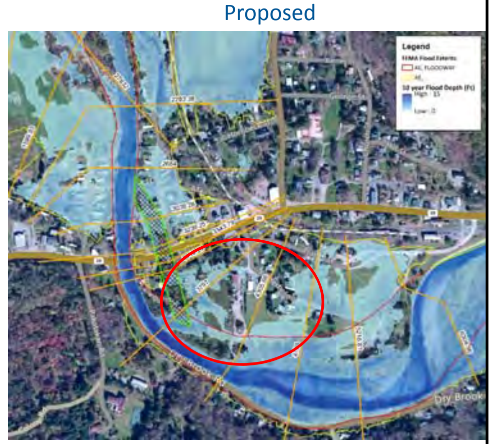
Convert Culvert to Bypass Channel under Rt 28

Existing



Proposed



- Result: For the 10-Year flood, WSE decreases 1.4 ft to 2.9 ft in the circle
- Recommendation: ***Consider alone or in combination with other alternatives.***

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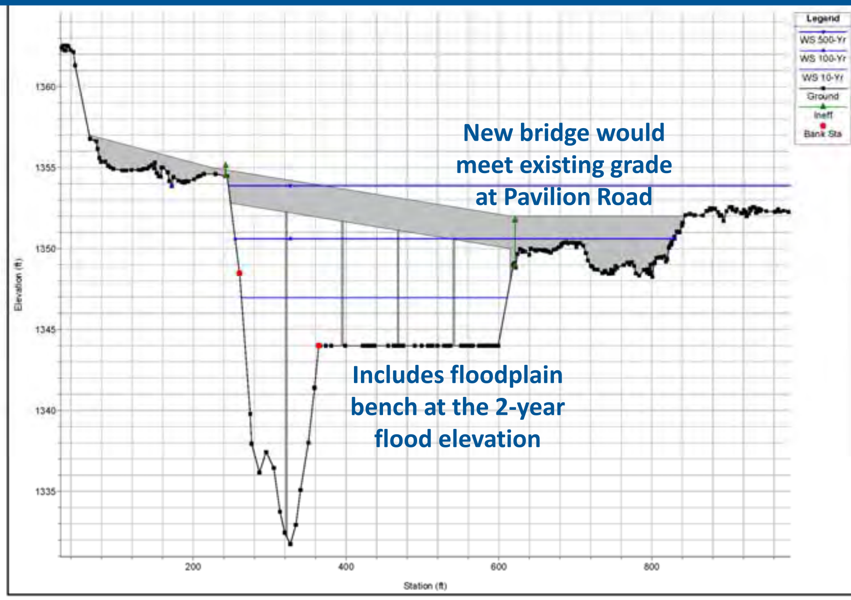
Route 28 Bridge Replacement



Route 28 Bridge Replacement

Existing

Proposed

- Result: For the 10-Year flood, WSE decreases about 2 feet

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Route 28 Bridge Replacement

Existing

Proposed

- Result: For the 100-Year flood, WSE decreases 1.5 ft to 3.8 ft
- Recommendation: ***Consider alone or in combination with other alternatives.***

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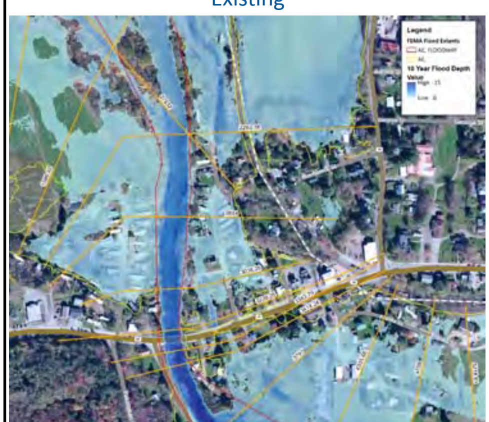
Floodplain Bench along Pavilion Road

Existing



Proposed

- Result: For the 10-Year flood, WSE decreases 0.6 to 0.9 feet

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Floodplain Bench along Pavilion Road

Existing Proposed

- Result: Maximum decrease in 100-Year WSE is 0.8 ft.
- Recommendation: ***Not bad. Consider in combination with others?***

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What Next?

Let's combine our best alternatives

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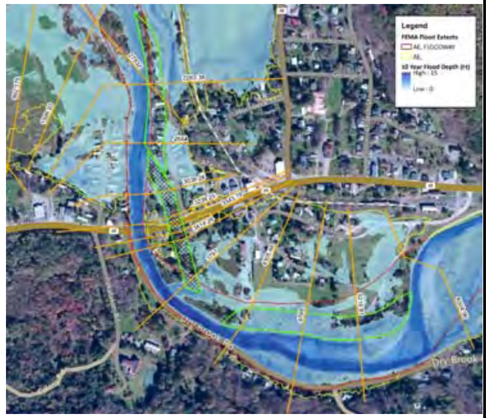
Combination 1: Bypass Channel with Floodplains

Existing

Proposed



- Result: For the 10-Year flood, WSE decreases 1.4 to 2.4 feet

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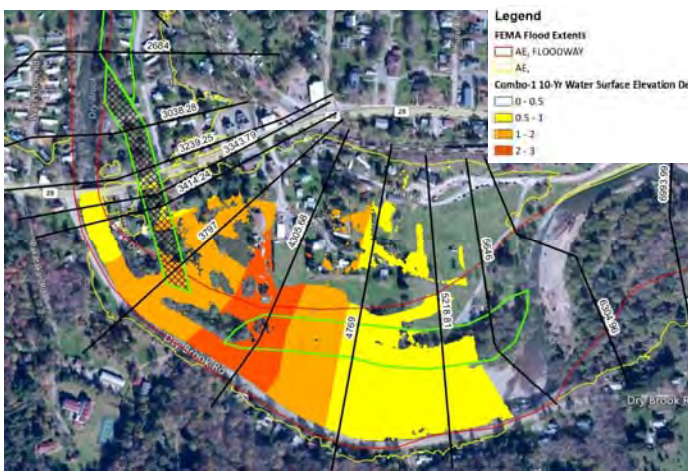
Combination 1: Bypass Channel with Floodplains

Difference Between Existing and Proposed 10-Year Flood (Feet)



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Combination 1: Bypass Channel with Floodplains

Existing | Proposed

- Result: For the 100-Year flood, WSE decreases 1.0 to 1.6 feet

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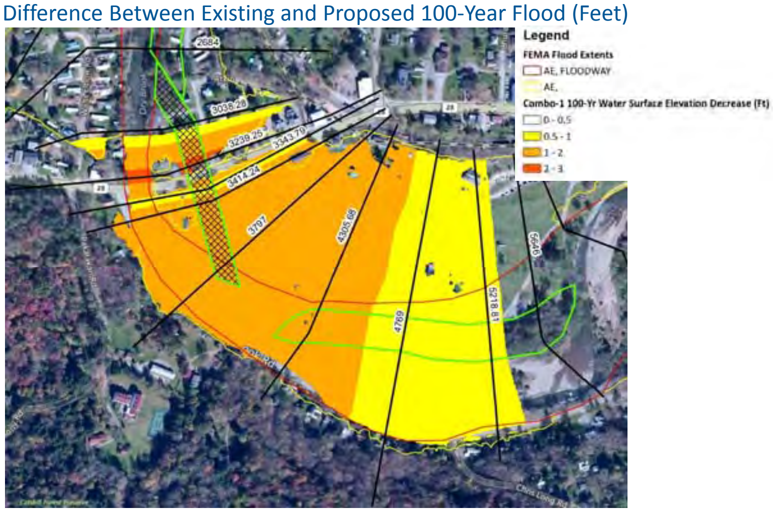
Combination 1: Bypass Channel with Floodplains

Difference Between Existing and Proposed 100-Year Flood (Feet)



- Recommendation: ***Advance to the benefit cost analysis.***

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Combination 2: Rt 28 Bridge Replacement with Floodplains

Existing

Proposed

- Result: For the 10-Year flood, WSE decreases 1.8 to 2.1 feet

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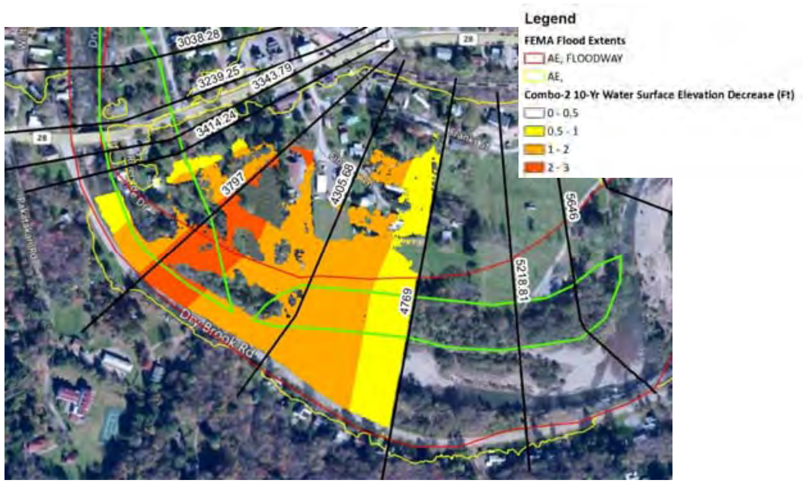
Combination 2: Rt 28 Bridge Replacement with Floodplains

Difference Between Existing and Proposed 10-Year Flood (Feet)



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Combination 2: Rt 28 Bridge Replacement with Floodplains

Existing | Proposed

- Result: For the 100-Year flood, WSE decreases 1.9 to 3.7 feet

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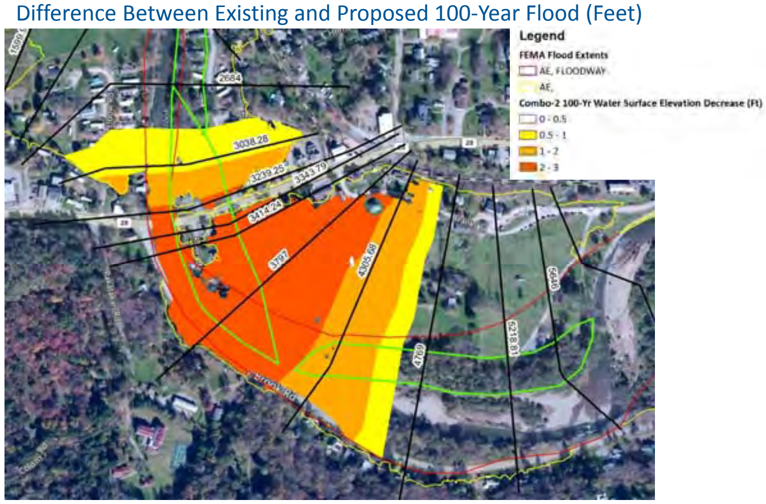
Combination 2: Rt 28 Bridge Replacement with Floodplains

Difference Between Existing and Proposed 100-Year Flood (Feet)



- Recommendation: ***Advance to the benefit cost analysis.***

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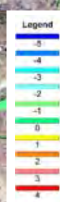
What About Sediment Management?

Bypass Channel Sediment Analysis – 2 Year Flow

- Includes bypass channel near Route 28 Bridge
- The presence of the bypass may shrink the area of potential deposition above the bridge and reduce scour downstream

Existing

Proposed



- Cool colors represent scour.
- Warm colors represent deposition.

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Bypass Channel Sediment Analysis – 100 Year Flow

- However, for the 100-year flood, the bypass channel does not significantly change sediment transport

Existing

Proposed

- Cool colors represent scour.
- Warm colors represent deposition.

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Combination 1 Sediment Analysis – 2 Year Flow

- Includes bypass channel with floodplain banches upstream and downstream
- This combination may increase the potential for sedimentation above the bridge but decrease scour downstream

Existing

Proposed

- Cool colors represent scour.
- Warm colors represent deposition.

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Combination 1 Sediment Analysis – 100 Year Flow

- However, for the 100-year flood, the bypass channel and floodplain benches do not significantly change sediment transport

Existing

Proposed

- Cool colors represent scour.
- Warm colors represent deposition.

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Combination 2 Sediment Analysis – 2 Year Flow

- Includes Rt 28 Bridge replacement with floodplain benches upstream and downstream
- The project may help balance scour and deposition areas

Existing

Proposed

- Cool colors represent scour.
- Warm colors represent deposition.

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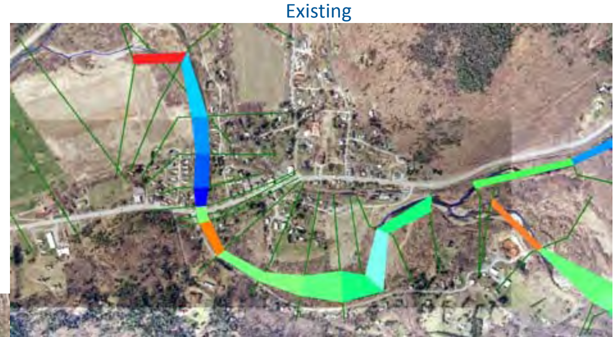
Combination 2 Sediment Analysis – 100 Year Flow

- However, for the 100-year flood, the bridge replacement and floodplain benches do not significantly change sediment transport

Existing



Proposed

- Cool colors represent scour.
- Warm colors represent deposition.

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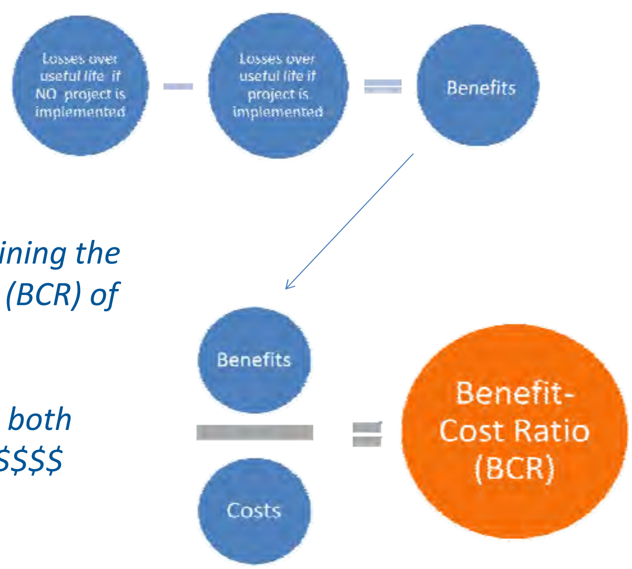
Benefit Cost Analysis (BCA)

What is BCA?

Process of determining the Benefit Cost Ratio (BCR) of a project

Benefits and costs both have the unit of $$$$$



BCA

We can generate benefits in two primary ways:

1. "Acquisitions and Removals" (buildings that are removed)
   - Only the current flood levels are needed; no comparison to future flood levels
   - Benefits are equal to the damages that will no longer occur
2. "Water Surface Reductions" (for buildings that remain)
   - Projects may include floodplain enhancements, bridge replacements, etc.
   - Pre-project and post-project flood levels are needed
   - Benefits are equal to the damages that will still occur, but they will be lower over time

Flood Mitigation Strategies for BCA

East Branch Delaware River – none tested
Bush Kill – none tested
Dry Brook – five tested with BCA:

- Convert culvert to a bypass channel under Route 28
- Route 28 Bridge replacement
- Floodplain bench on right bank of Dry Brook along Pavilion Road
- Combination #1 (bypass channel and floodplain benches)
- Combination #2 (Route 28 Bridge replacement and floodplain benches)

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Floodplain Bench along Pavilion Road

- Creation of Floodplain
- Building Acquisitions: 49, 65, 147, 149, 163, 183, and 261 Pavilion Road

Benefit Cost Summary	FP-5
Benefits: Acquisitions and Relocations	$1,478,783
Benefits: Water Surface Reductions at Buildings that Remain	$135,743
Total Benefits	$1,614,526
Total Costs	$1,034,000
Benefit Cost Ratio	1.56

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Convert Culvert to Bypass Channel under Rt 28

- Bypass Channel
- Building Acquisition: 65 Pavilion Road

Benefit Cost Summary	BC-1b
Benefits: Acquisitions and Relocations	$199,023
Benefits: Water Surface Reductions at Buildings that Remain	$66,086
Total Benefits	$265,109
Total Costs	$2,533,000
Benefit Cost Ratio	0.10

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Route 28 Bridge Replacement

- Replace Route 28 Bridge
- Building Acquisitions: 49 and 65 Pavilion Road; 43141 State Highway 28; 13, 41, and 60 Riverside Drive

Benefit Cost Summary	BR-2e
Benefits: Acquisitions and Relocations	$1,986,063
Benefits: Water Surface Reductions at Buildings that Remain	$167,342
Total Benefits	$2,153,405
Total Costs	$8,941,000
Benefit Cost Ratio	0.24

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Combination 1: Bypass Channel with Floodplains

- Bypass Channel, floodplain along Pavilion Road, floodplain south of Finnerty Road
- Building Acquisitions: 65, 147, 149, 163, 183, 261 Pavilion Road

Benefit Cost Summary	Combo-1
Benefits: Acquisitions and Relocations	$1,076,988
Benefits: Water Surface Reductions at Buildings that Remain	$298,594
Total Benefits	$1,375,582
Total Costs	$3,615,000
Benefit Cost Ratio	0.38

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Combination 2: Rt 28 Bridge Replacement with Floodplains

- Route 28 Bridge Replacement, floodplain along Pavilion Road, floodplain south of Finnerty Road
- Building Acquisitions: 13, 41, 60 Riverside Drive; 49, 65, 147, 149, 163, 183, 261 Pavilion Road and 43141 State Highway 28

Benefit Cost Summary	Combo-2
Benefits: Acquisitions and Relocations	$2,893,785
Benefits: Water Surface Reductions at Buildings that Remain	$305,829
Total Benefits	$3,199,614
Total Costs	$10,023,000
Benefit Cost Ratio	0.32

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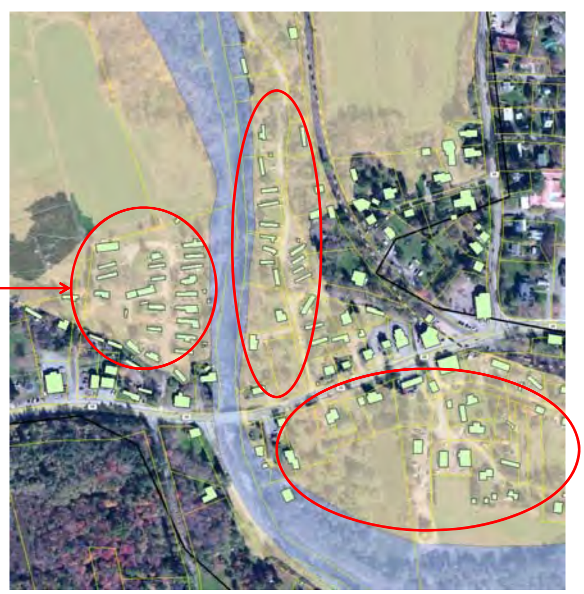
What About Other Options?

Where could we consider acquisitions and elevations of individual structures?

- Structures outside of floodways can be elevated
- Structures in floodways cannot be elevated; but this would only affect a handful of buildings



Conclusions

- Flood risk in Arkville cannot be eliminated but it can be reduced
- Flood mitigation projects do not appear to worsen sediment transport (and they may provide benefits for the 2-yr flow)
- Flood mitigation projects will be costly and some will be disruptive
- The dollar figures for the benefits do not yet justify the costs
- Where they do justify the cost, it's due to acquisitions
- Property owners may wish to reduce risk immediately
  - *Elevate houses*
  - *Relocate within Arkville*

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A Path Forward

1. When opportunities arise for acquisitions where floodplain projects may be effective, support these acquisitions
2. When opportunities arise for building elevations where floodplain projects are not envisioned, support these elevations
3. Continue the process of making space for a bypass channel under Route 28, and identify alternate funding sources to pursue the bypass
4. Ensure that future bridge replacements consider the benefits of enlarging the openings to reduce flooding
5. Periodically address sediment and gravel buildup with targeted removal projects
6. Install an automated flood warning system for Arkville, or join forced with Fleischmanns to install a system that works for both

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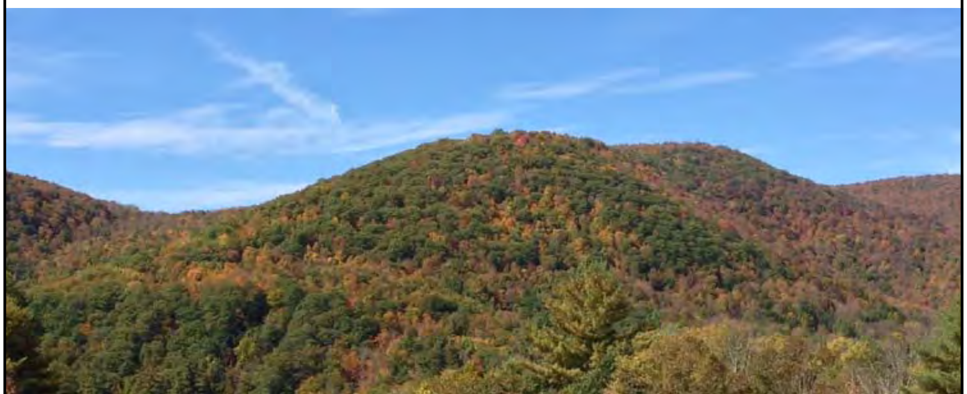
Questions, Comments, or Thoughts?



Milone & MacBroom

Minutes of Meeting

DATE: April 6, 2016
MMI #: 5197-07
PROJECT: Arkville LFA

SUBJECT: Notes from Public Meeting
LOCATION: Middletown Town Hall
42339 State Highway 28, Margaretville, NY

ATTENDEES:

David Murphy, P.E., CFM, MMI
Patrick Davis, Town Supervisor
Members of the Town Board
Jessica Rall, DCSWCD
Dean Frazier, Delaware County Watershed Affairs
Phil Eskeli, NYCDEP
Members of the Public

Findings of the Arkville LFA were presented to the public during the Town Board meeting of April 6, 2016. Comments from the public and Town Board members included the following:

- One Board member stated that relocations must be *within* Middletown.
- A member of the public asked about the bypass channel sizing for clarification. Was the optimal size used for study?
- The same Board member stated that sediment management did not receive sufficient discussion in the presentation. The LFA report must address periodic sediment removal and other management techniques.
- A member of the public asked whether the early warning system would include Reverse 911. David Murphy explained that ideally, the early warning system would link directly to Reverse 911 or its equivalent. Patrick Davis described the efforts to get precipitation gage network throughout the watershed. These gages will provide for better data to develop an early warning system which will work with the reverse 911-type system.
- A member of the public asked if damage to Route 28 shoulder had been considered in the benefit cost analysis (BCA). Someone else explained that the damage was largely because temporary measures were in place after a construction project.
- One member of the public stated that Routes 30 and 38 are critical ways to move around (and leave Margaretville) during floods. He believes that the backwater condition that floods the intersection is due to poor floodplain management and excessive debris and vegetation in the floodplain.
- Another member of the public stated that he also sees improved floodplain management as critical. He believes that debris and vegetation management is needed everywhere.
- County staff asked that the buyouts be double-checked and not included in the BCA if they are already vacant.
- A resident explained that relocations within Middletown are not sufficiently constrained, and that relocations should be within Arkville because a loss of Arkville residents will result in increased tax burden on those who remain. David Murphy explained that this is one area where the community needs to help identify locations where people could go. Many of those in attendance feel that there isn't sufficient space to develop new housing in Arkville.

- A member of the public explained that they need advice about what can or cannot be done. For example, the school was recently renovated or expanded in an area that used to be a swamp. She would like to community to know whether or not actions are appropriate or allowed. Patrick Davis explained some of the challenges of school projects when the State is involved.

APPENDIX B

EAST BRANCH DELAWARE RIVER WATERSHED, NY
DETAILED HYDRAULICS TECHNICAL SUPPORT DATA NOTEBOOK

East Branch Delaware River
Hydrology Methodology Report

Digital Flood Insurance Rate Map Production and Development of Updated Flood Data

Submitted to:
RAMPP - Dewberry

Submitted by:
Gomez and Sullivan Engineers, P.C.
288 Genesee Street
Utica, NY 13502

GS Project No. 1512

Revised July 31, 2012

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1. OVERVIEW

Hydrologic analyses performed within the East Branch Delaware River watershed consists of nominating discharges for the detailed (D), limited detailed (LD), lake (L), backwater (B) and approximate (A) study segments specified in RAMPP Task Order # HSFE02-11-J-001, Work Order #001. Discharge locations were chosen according to the guidelines provided in Attachments B, C and D to that Task Order and FEMA's "Guidelines and Specifications for Flood Hazard Mapping Partners, Appendix C; Guidance for Riverine Flooding Analyses and Mapping" (November 2009). Nominated discharges were compared with existing published flood discharges for the streams studied to determine if any new analysis has a statistically significant difference from prior analyses.

Hydrologic analyses were conducted for 35.47 detailed stream miles in 9 studies, 11.82 miles of limited detailed streams in 2 studies, 0.47 miles of lake in 1 study, 0.18 miles of backwater reaches in 1 study and 9.25 miles of approximate streams in 6 studies. Methods used for the hydrologic analysis of detailed studies, backwater reaches and lakes without significant flood storage capacity consist of gage analyses, the full New York State USGS Regional Regression equations, or a combination of these methods. The Rational Method was used to nominate discharges where the drainage area to the point is smaller than the limits of the regression equation. Peak flood discharges for the 50-, 10-, 4-, 2-, 1-, and 0.2-percent-annual-chance storm events were calculated for detailed, backwater and lake studies. Hydrologic analysis of limited detailed and approximate study reaches consist of the use of the "area-only" New York State USGS Regional Regression equations and the Rational Method (where the drainage area is smaller than the limits of the regression equation). Peak flood discharges for the 50-, and 1-percent-annual-chance storm events were calculated for limited detailed and approximate study reaches.

Figure 1 contains a location map depicting the location of the drainage basin within New York State. The drainage basin encompasses portions of Delaware County, to the west; and Greene and Ulster Counties to the east.

Figure 1: Drainage Basin Location Map

Figure 1: Drainage Basin Location Map

2. NOMINATION METHODS FOR DETAILED STREAMS, AND DETAILED BACKWATER REACHES

Methods for nominating discharges for the detailed study streams include gage analysis, use of the full USGS 2006 New York State Regional Regression equations, the Rational Method, or a combination of these methods. The computed flood discharges were be compared along the stream to ensure internal consistency with regard to the variation of discharge with drainage area. This consistency check is especially important for streams where multiple nomination methods were employed.

Newly-calculated discharges were compared to the effective FIS discharges where they exist. The decision to revise a discharge value or reuse the effective value was based on standard practices described in Appendix C of FEMA "Guidelines and Specifications for Flood Hazard Mapping Partners" (November 2009) (Section C.2.2.2 under the heading "Determining Statistical Significance of Flood Discharges"). Differences between the new and effective discharges are discussed below, as appropriate.

The proposed discharge nomination methods are discussed in Sections 2.1 through 2.3, and more specifically addressed for each of the detailed study streams in Section 3.

In order to compare the various methods utilized in computing flows for detailed streams and backwater reaches, flows computed using the various methods were plotted versus drainage area.

Figure 2 contains a plot of the discharges computed for East Branch Delaware River using the various methods, a comparison of the effective FIS discharges is also included in the plot.

2.1 Nominate Discharges Using Gage Analysis

For the detailed study streams having a gage record of sufficient length (minimum 10 years of record [USGS, 1982]), a discharge-frequency gage analysis methodology was be used to nominate discharges. This methodology utilizes a log-Pearson Type III analysis (LP III) for the available records in accordance with United States Geological Survey (USGS) Bulletin 17B (USGS, 1982). The log-Pearson Type III analysis was be performed using the USGS Peak FQ computer program.

In rural and unregulated flow situations, the gage analysis was weighted with the 2006 New York State Regional Regression equations in accordance with the USGS Scientific Investigations Report (SIR) 2006-5112 "Magnitude and Frequency of Floods in New York" (Lumia, 2006). Within the area of influence of each stream gage (50% to 150% of the drainage area of the stream gage) the gage analysis was transferred to other flow nomination locations according to the method prescribed in "Magnitude and Frequency of Floods in New York".

Table 1 provides a summary of the years of available record by stream for the USGS gages in the East Branch Delaware River Watershed.

Table 1: Summary of USGS Gage Data for East Branch Delaware River Watershed

Gage Name	Gage No.	Period of Record	Comments
East Branch Delaware River at Roxbury, NY	01413088	2001 - Present	
East Branch Delaware River at Margaretville, NY	01413500	1937 - Present	
Bush Kill near Arkville	01413398	1998 - Present	January 1996 Historic Peak Not Used in Analysis
Dry Brook at Arkville	01413408	1996 - Present	January 1996 Historic Peak Not Used in Analysis

2.2 Nominate Discharges Using Regional Regression Equation

For streams where gage data IS lacking, discharges were nominated using the full Regional Regression equation method in accordance with the USGS Scientific Investigations Report 2006-5112 "Magnitude and Frequency of Floods in New York" (Lumia, 2006). For this method, the USGS Stream Stats online program was used to compute the regression equation parameters.

The entire portion of the East Branch Delaware River Watershed which is being studied is within Region 3 as defined for the Regional Regression equations. The Region 3 regression equation parameters include drainage area, basin lag factor, mean annual runoff, and seasonal maximum snow depth. The regression equations were used for nominating flows in basins as small as 0.41 mi^2, the lower limit for the Region 3 regression equations (maximum area is 3480 mi^2) (Lumia, 2006). For the other Region 3 parameters, the valid basin lag factor range is from 0.002 to 20.582; the valid mean annual runoff range is from 16.86 to 40.73 inches; and the valid maximum seasonal snow depth range is from 13.02 to 20.42 inches.

The 2006 New York Region 3 regression equations are provided in Appendix A.

2.3 Rational Method

The Rational Method was employed at discharge points where the drainage area is less than the 0.41 mi^2 lower limit of applicability of the Regional Regression equations. Time of concentration was computed for each basin using the NRCS Curve Number method as described in the “National Engineering Handbook” Chapter 15 (Kent 1972). Rainfall intensity was estimated using the data available from the “Extreme Precipitation in New York & New England Interactive Web Tool” from the Northeast Regional Climate Center (NRCC). Peak stream flows were computed using rainfall intensity for a storm with a duration equal to the time of concentration.

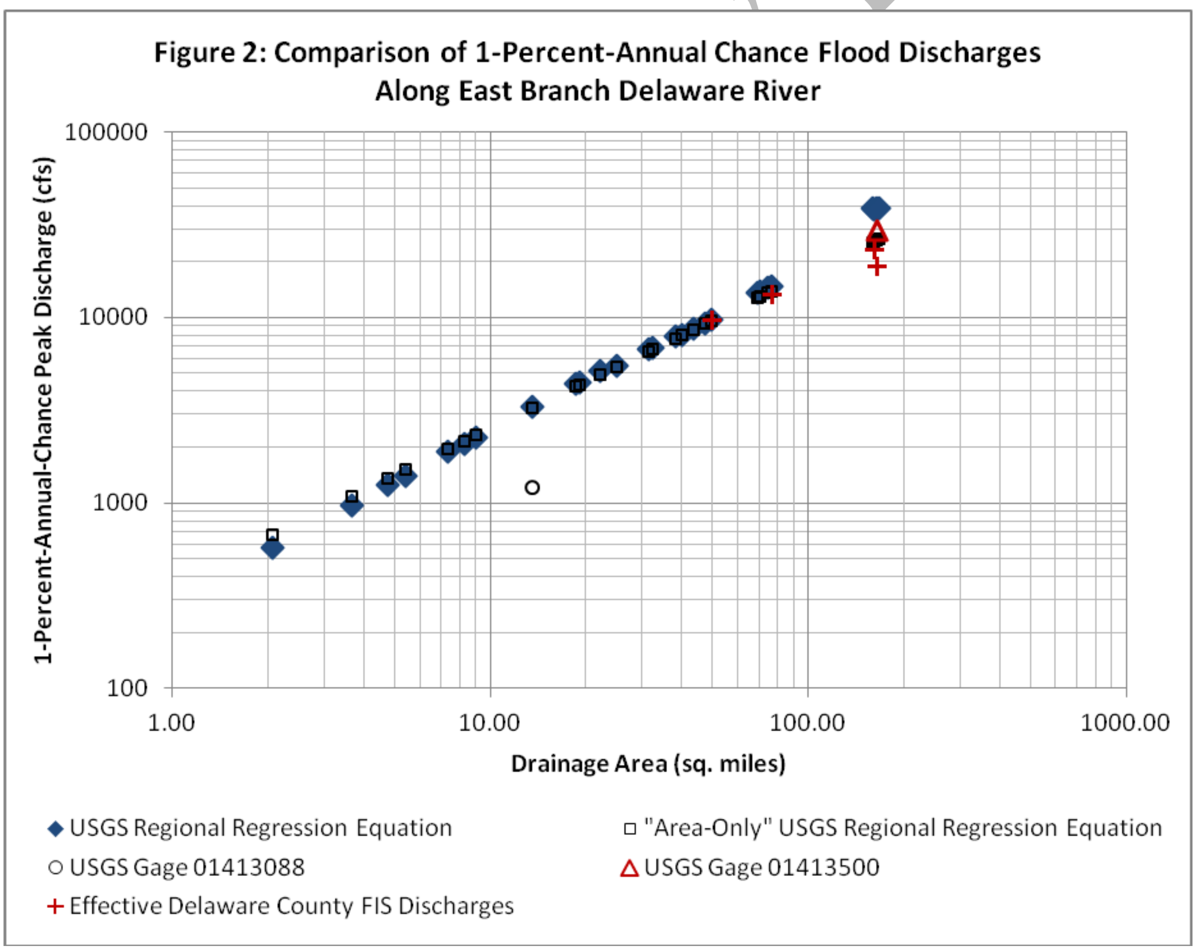

Figure 2: Comparison of 1-Percent-Annual Chance Flood Discharges Along East Branch Delaware River

3. DISCHARGE NOMINATION FOR DETAILED STUDY STREAMS

The detailed study streams, as provided in the Task Order from RAMPP, are listed in Table 2, followed by the proposed discharge nomination method for each stream.

Table 2: Detailed Study Reaches

Stream	Length (mi)	Study Limits
Bush Kill	4.80	From Its Confluence with Dry Brook to the Confluence of Vly Creek and Emory Brook
Tributary 3 to Bush Kill	1.71	From Its Confluence with Bush Kill to Hog Mountain Circle Road
Dry Brook	4.74	From Its Confluence with East Branch Delaware River to Approximately 450 Feet Downstream of Dry Brook Road
East Branch Delaware River	19.56	From Approximately 3,880 Feet Upstream of State Highway 28 to the Dam at Wawaka Lake and From Approximately 2,400 Feet Upstream of the Dam at Wawaka Lake to Approximately 6,225 Feet Upstream of Schuman Road
Emory Brook	0.82	From Its Confluence with Vly Creek to Approximately 400 Feet Upstream of Main Street
Lake Switzerland	0.15	From the Breached Dam at Lake Switzerland for Approximately 2,250 Feet
Little Red Kill	0.21	From its Confluence with Bush Kill to Approximately 240 Feet Upstream of Schneider Ave
Red Kill	0.59	From its Confluence with Bush Kill to Approximately 2,580 Feet Upstream of Old Route 28
Vly Creek	2.89	From Its Confluence with Emory Brook to the Breached Dam at Lake Switzerland and From Approximately 2,260 Feet Upstream of the Breached Dam at Lake Switzerland to Approximately 2,800 Feet Downstream of Ursum Way
Bragg Hollow	0.18	From Its Confluence with East Branch Delaware River to Approximately 210 Feet Upstream of Old River Road

Bush Kill

Based on the Delaware County, New York Flood Insurance Study (FIS) (FEMA, 2012), Bush Kill was previously analyzed using three regional analysis methods; the USGS Regional Regression Equations, the Stankowski Method and a USACE method based on gage data throughout the upper Delaware and Hudson River basins. The prior Flood Insurance Study only provided a discharge nomination at the downstream end of the stream.

A Log-Pearson Type III distribution was computed for USGS gage 01413398 and the gage analysis was weighted with the full Regional Regression Equations to compute the flood flows at the gage. The gage analysis was then transferred to the other discharge locations using the area transfer method given in “Magnitude and Frequency of Floods in New York”.

Tributary 3 to Bush Kill

No flood discharge nominations are given for Tributary 3 to Bush Kill in the Delaware County FIS (FEMA, 2012).

The Rational Method was used to compute flows in the upper portion of the Tributary 3 to Bush Kill drainage basin. The full Regional Regression Equations were used to compute flows for drainage areas larger than 0.41 mi^2.

Dry Brook

Based on the Delaware County, New York FIS (FEMA, 2012), Dry Brook was previously analyzed using three regional analysis methods; the USGS Regional Regression Equations, the Stankowski Method and a USACE method based on gage data throughout the upper Delaware and Hudson River basins. The prior Flood Insurance Study only provided discharge nominations for the 1-percent-annual-chance event.

A log-Pearson Type III distribution was computed for USGS gage 01413408 and the gage analysis was weighted with the full Regional Regression Equations to compute the flood flows at the gage. The gage analysis was then transferred to the discharge locations downstream of the confluence of Bush Kill using the area transfer method given in "Magnitude and Frequency of Floods in New York". Upstream of the confluence of Bush Kill, the full Regional Regression Equations were used to compute flows.

East Branch Delaware River

According the Delaware County, New York FIS (FEMA, 2012), this portion of East Branch Delaware River was previously analyzed using a gage analysis of the USGS gages. Since the previous analysis was performed, a new flood of record was experienced on this portion of the East Branch Delaware River; therefore all flood discharges were re-computed.

A Log-Pearson Type III distribution was computed for USGS gages 01413088 and 01413500, the gage analyses were weighted with the full Regional Regression Equations to compute the flood flows at the gages. The gage analysis for USGS gage 01413088 was transferred to the discharge locations between the Railroad crossing and the Roxbury Central School driveway, using the area transfer method given in "Magnitude and Frequency of Floods in New York". The gage analysis for USGS gage 01413500 was transferred to the discharge locations downstream of the confluence of Dry Brook, using the area transfer method given in "Magnitude and Frequency of Floods in New York". The Full Regional Regression Equations were used to compute flows for all other discharge locations.

An initial review of data for USGS gage 01413088 suggested that the gage may not provide an accurate record of the peak flows, based on the extremely low flows which have been reported for considerable rainfall. Upon further review of the measurements that have been taken at the gage, for development of the rating curve, it was shown that two measurements have been taken which are at or near three of the top five flows. As it has been confirmed that the gage is accurately recording peak flows, the gage record was utilized in this analysis, despite the significant difference between observed and expected flows.

Emory Brook

No flood discharge nominations are given for Emory Brook in the Delaware County FIS (FEMA, 2012). The full Regional Regression Equations were used to compute flows for Emory Brook.

Little Red Kill

No flood discharge nominations are given for Little Red Kill in the Delaware County FIS (FEMA, 2012). The full Regional Regression Equations were used to compute flows for Little Red Kill.

Red Kill

No flood discharge nominations are given for Red Kill in the Delaware County FIS (FEMA, 2012). The full Regional Regression Equations were used to compute flows for Red Kill.

Vly Creek and Lake Switzerland

Based on the Delaware County, New York FIS (FEMA, 2012), Vly Creek was previously analyzed using three regional analysis methods; the USGS Regional Regression Equations, the Stankowski Method and a USACE method based on gage data throughout the upper Delaware and Hudson River basins. The prior Flood Insurance Study only provided a discharge nomination at the downstream end of the Vly Creek. No prior flow nominations are given for Lake Switzerland.

The dam at Lake Switzerland is breached, therefore the lake does not provide any storage capacity, the flows were computed for Lake Switzerland in conjunction with Vly Creek. The full Regional Regression Equations were used to compute flows for Vly Creek and Lake Switzerland.

Bragg Hollow

No flood discharge nominations are given for Bragg Hollow in the Delaware County FIS (FEMA, 2012). The full Regional Regression Equations were used to compute flows for Bragg Hollow.

Table 3 contains a summary of the flows computed for detailed stream segments and backwater reaches.

Table 4 contains a comparison of the flows computed for the prior FIS, with the proposed flows.

Table 3: Summary of Discharges – Detailed Studies

FLOODING SOURCE AND LOCATION	DRAINAGE AREA (sq. miles)	PEAK DISCHARGES (cfs) 50-PERCENT	10-PERCENT	4-PERCENT	2-PERCENT	1-PERCENT	0.2-PERCENT
Dry Brook							
Approximately 450 Feet Downstream of Dry Brook Road	28.56	2,442	5,056	6,696	8,128	9,633	13,457
Approximately 7,045 Feet Upstream of Erpf Road	31.32	2,570	5,355	7,103	8,630	10,240	14,342
Upstream of Confluence of Bush Kill	33.95	2,684	5,611	7,448	9,054	10,750	15,077
Downstream of Confluence of Bush Kill	81.24	5,453	12,552	16,865	20,506	24,404	34,732
USGS Gage 01413408	82.09	5,501	12,678	17,035	20,711	24,644	35,068
At Confluence with East Branch Delaware River	82.31	5,514	12,703	17,067	20,751	24,691	35,136
Vly Creek							
Approximately 2,800 Feet Downstream of Ursum Way	18.27	1,303	2,896	3,951	4,896	5,913	8,599
Approximately 2,500 Feet Upstream of County Highway 37							
Approximately 1,750 Feet Downstream of County Highway 37	21.97	1,535	3,413	4,654	5,765	6,963	10,130
At Old Halcott Road							

Table 3: Summary of Discharges – Detailed Studies

FLOODING SOURCE AND LOCATION	DRAINAGE AREA (sq. miles)	PEAK DISCHARGES (cfs) 50-PERCENT	10-PERCENT	4-PERCENT	2-PERCENT	1-PERCENT	0.2-PERCENT
At Confluence with Bush Kill	22.60	1,572	3,492	4,760	5,896	7,120	10,356
Little Red Kill							
Approximately 240 Feet Upstream of Schneider Ave	1.63	114	257	358	449	547	805
At Main Street	1.65	116	263	366	460	560	827
At Confluence with Bush Kill	1.65	116	263	366	460	560	827
Emory Brook							
Approximately 400 Feet Upstream of Main Street	6.03	487	1,075	1,474	1,834	2,219	3,235
Approximately 1,520 Feet Downstream of Main Street	6.80	541	1,192	1,632	2,028	2,451	3,568
At Confluence with Bush Kill	6.92	550	1,212	1,659	2,062	2,492	3,627
Red Kill							
Approximately 2,580 Feet Upstream of Old Route 28	7.88	495	1,118	1,539	1,916	2,320	3,392
Approximately 1,180 Feet Upstream of Old Route 28	8.14	511	1,153	1,586	1,975	2,392	3,496
At Confluence with Bush Kill	8.65	541	1,222	1,681	2,092	2,533	3,702

Table 3: Summary of Discharges – Detailed Studies

FLOODING SOURCE AND LOCATION	DRAINAGE AREA (sq. miles)	PEAK DISCHARGES (cfs) 50-PERCENT	10-PERCENT	4-PERCENT	2-PERCENT	1-PERCENT	0.2-PERCENT
Tributary 3 to Bush Kill							
At Hog Mountain Circle Road	0.07	13	18	22	25	29	41
Approximately 165 Feet Downstream of Hog Mountain Road	0.14	21	30	37	43	50	72
Approximately 1,530 Feet Downstream of Somerset Lake Road	0.42	27	62	88	111	135	201
Approximately 1,525 Feet Upstream of State Highway 28	0.74	47	107	151	190	232	344
At Confluence with Bush Kill	0.79	50	114	160	202	247	366
Bush Kill							
At Confluence of Vly Creek and Emory Brook	29.60	1,994	4,543	6,218	7,700	9,299	13,532
Upstream of Depot Street	31.52	2,079	4,786	6,568	8,140	9,838	14,341
Approximately 2,275 Feet Downstream of Depot Street	32.99	2,147	4,978	6,841	8,481	10,251	14,951
Upstream of Confluence of Red Kill	33.25	2,153	5,000	6,874	8,524	10,306	15,038
Downstream of Confluence of Red Kill	42.05	2,489	6,038	8,380	10,413	12,604	18,437
Upstream of Confluence of Tributary 3 to Bush Kill	43.96	2,556	6,259	8,706	10,823	13,104	19,181

Table 3: Summary of Discharges – Detailed Studies

FLOODING SOURCE AND LOCATION	DRAINAGE AREA (sq. miles)	PEAK DISCHARGES (cfs) 50-PERCENT	10-PERCENT	4-PERCENT	2-PERCENT	1-PERCENT	0.2-PERCENT
Downstream of Confluence of Tributary 3 to Bush Kill	44.93	2,589	6,372	8,872	11,033	13,361	19,562
USGS Gage 1413398	46.77	2,651	6,583	9,185	11,428	13,841	20,273
At Confluence with Dry Brook	47.22	2,678	6,636	9,253	11,511	13,940	20,412
East Branch Delaware River							
Approximately 6,225 Feet Upstream of Schuman Road	2.07	130	283	387	478	573	819
Approximately 5,190 Feet Upstream of Schuman Road	3.68	224	487	662	816	977	1,391
Approximately 2,690 Feet Upstream of Schuman Road	4.75	286	623	845	1,040	1,244	1,770
At Schuman Road	5.42	324	705	956	1,177	1,407	2,000
Approximately 1,150 Feet Downstream of Railroad Crossing	7.38	426	941	1,283	1,583	1,898	2,708
Approximately 290 Feet Upstream of Teichman Road	8.26	448	1,011	1,390	1,723	2,073	2,968
At South Montgomery Hollow Road	9.03	463	1,066	1,478	1,840	2,219	3,188
At USGS Gage 1413088	13.51	486	1,314	1,932	2,472	3,038	4,451

Table 3: Summary of Discharges – Detailed Studies

FLOODING SOURCE AND LOCATION	DRAINAGE AREA (sq. miles)	PEAK DISCHARGES (cfs) 50-PERCENT	10-PERCENT	4-PERCENT	2-PERCENT	1-PERCENT	0.2-PERCENT
Approximately 175 Feet Downstream of State Highway 30	18.65	944	2,126	2,910	3,596	4,316	6,159
At Roxbury Central School Driveway	19.09	988	2,198	2,994	3,689	4,420	6,294
Approximately 3,420 Feet Upstream of Cross Road	22.25	1,221	2,639	3,546	4,342	5,181	7,350
Approximately 4,700 Feet Downstream of Cross Road	25.02	1,311	2,810	3,767	4,607	5,492	7,780
Approximately 6,220 Feet Downstream of Cross Road	31.53	1,618	3,455	4,619	5,637	6,708	9,473
Upstream of Confluence with Meeker Hollow	32.39	1,659	3,543	4,735	5,777	6,875	9,708
At Cold Spring Road	38.16	1,925	4,100	5,466	6,658	7,912	11,140
Approximately 1,820 Feet Upstream of Horse Farm Road	39.92	1,975	4,194	5,589	6,806	8,087	11,384
Upstream of Confluence of Bragg Hollow	43.57	2,117	4,492	5,985	7,293	8,672	12,230
Downstream of Confluence of Bragg Hollow	47.34	2,274	4,812	6,400	7,788	9,248	13,010
Upstream of Confluence of Batavia Kill	49.76	2,380	5,047	6,722	8,187	9,733	13,728
Downstream of Confluence of Batavia Kill	69.08	3,301	7,047	9,394	11,456	13,644	19,325

Table 3: Summary of Discharges – Detailed Studies

FLOODING SOURCE AND LOCATION	DRAINAGE AREA (sq. miles)	PEAK DISCHARGES (cfs) 50-PERCENT	10-PERCENT	4-PERCENT	2-PERCENT	1-PERCENT	0.2-PERCENT
Approximately 1,375 Feet Downstream of State Highway 30	70.37	3,356	7,162	9,547	11,640	13,863	19,632
Approximately 2,105 Feet Upstream of County Highway 38	74.56	3,514	7,499	9,993	12,184	14,512	20,558
Upstream of Confluence of Dry Brook	76.47	3,567	7,610	10,142	12,367	14,731	20,877
Downstream of Confluence of Dry Brook	158.87	6,429	15,352	21,738	27,440	33,752	50,260
Approximately 795 Feet Downstream of Bridge Street	160.38	6,429	15,374	21,802	27,543	33,901	50,529
USGS Gage 1413500	163.33	6,429	15,443	21,962	27,789	34,247	51,138
Approximately 3,880 Feet Upstream of State Highway 28	167.50	6,699	15,998	22,656	28,600	35,177	52,371
Bragg Hollow							
Approximately 210 Feet Upstream of Old River Road	3.69	213	470	643	795	955	1,370
Downstream of Old River Road	3.70	213	471	645	797	957	1,374
At Confluence with East Branch Delaware River	3.74	215	476	651	805	967	1,388

Table 4: Comparison Between Computed and Effective Discharges

FLOODING SOURCE AND LOCATION	DRAINAGE AREA (sq. miles)	PROPOSED DISCHARGES				EFFECTIVE DISCHARGES				CHANGE IN DISCHARGES			
		10-PERCENT	2-PERCENT	1-PERCENT	0.2-PERCENT	10-PERCENT	2-PERCENT	1-PERCENT	0.2-PERCENT	10-PERCENT	2-PERCENT	1-PERCENT	0.2-PERCENT
Dry Brook													
Upstream of Confluence of Bush Kill	33.95	5,611	9,054	10,750	15,077	*	*	6,020	*	*	*	78.57%	*
At Confluence with East Branch Delaware River	82.31	12,703	20,751	24,691	35,136	*	*	11,970	*	*	*	106.28%	*
Vly Creek													
Approximately 1,750 Feet Downstream of County Highway 37 [1]	21.97	3,413	5,765	6,963	10,130	*	*	4,170	*	*	*	66.97%	*
Bush Kill													
At Confluence with Dry Brook	47.22	6,636	11,511	13,940	20,412	*	*	6,420	*	*	*	117.13%	*
East Branch Delaware River													
Upstream of Confluence of Batavia Kill	49.76	5,047	8,187	9,733	13,728	*	*	9,736	*	*	*	-0.03%	*
Upstream of Confluence of Dry Brook	76.47	7,610	12,367	14,731	20,877	*	*	13,414	*	*	*	9.82%	*
Approximately 795 Feet Downstream of Bridge Street [2]	160.38	15,374	27,543	33,901	50,529	*	*	23,330	*	*	*	45.31%	*
USGS Gage 1413500	163.33	15,443	27,789	34,247	51,138	10,600	16,200	19,000	26,600	45.69%	71.53%	80.25%	92.25%

Notes

[1] Location in Delaware County FIS is given as approximately 785 feet further downstream, however drainage area given in Delaware County FIS is approximately 0.07 mi^2 less, therefore drainage points are considered to be comparable.

[2] Location in Delaware County FIS is approximately 3,115 feet upstream, however drainage area of point in Delaware County FIS is only approximately 0.38 mi^2 less, therefore drainage points are considered to be comparable.

4. NOMINATION METHODS FOR LIMITED DETAILED STREAMS,

Methods used for nominating discharges for the limited detailed study streams include the "area-only" USGS 2006 New York State Regional Regression equations and the rational method, or a combination of these methods. The computed flood discharges were compared along the stream to ensure internal consistency with regard to the variation of discharge with drainage area. This consistency check is especially important for streams where multiple nomination methods were employed.

Newly-calculated discharges were be compared to the effective FIS discharges where they exist. The decision to revise a discharge value or reuse the effective value was be based on standard practices described in Appendix C of FEMA Guidelines and Specifications for Flood Hazard Mapping Partners (November 2009) (Section C.2.2.2 under the heading "Determining Statistical Significance of Flood Discharges"). Differences between the new and effective discharges are discussed below, as appropriate.

4.1 Nominate Discharges Using Regional Regression Equation

For limited detailed streams, discharges were be nominated using the "area-only" Regional Regression equation method in accordance with the USGS Scientific Investigations Report 2006-5112 "Magnitude and Frequency of Floods in New York" (Lumia, 2006). The entire portion of the East Branch Delaware River Watershed which is being studied is within Region 3 as defined for the Regional Regression equations. The regression equations were used for nominating flows in basins as small as 0.41 mi^2, the lower limit for the Region 3 regression equations (maximum area is 3480 mi^2) (Lumia, 2006).

The 2006 New York Region 3 "area-only" regression equations are provided in Appendix A.

4.2 Rational Method

The Rational Method was be employed at discharge points where the drainage area is less than the 0.41 mi^2 lower limit of applicability of the "area-only" Regional Regression equations. Time of concentration was computed for each basin using the NRCS Curve Number method as described in the "National Engineering Handbook" Chapter 15 (Kent 1972). Rainfall intensity was estimated using the data available from the "Extreme Precipitation in New York & New England Interactive Web Tool" from the Northeast Regional Climate Center (NRCC). Peak stream flows were computed using a rainfall intensity for a storm with a duration equal to the time of concentration.

5. DISCHARGE NOMINATION FOR LIMITED DETAILED STUDY STREAMS

The limited detailed study streams are listed in Table 3. The proposed discharge nomination method for each stream is detailed below.

Table 5: Limited Detailed Study Reaches

Stream	Length (mi)	Study Limits
Dry Brook	8.10	From Approximately 450 Feet Downstream of Dry Brook Road to Approximately 1,560 Feet Upstream of Eagle Lodge Road
Rider Hollow	3.72	From Its Confluence with Dry Brook to Approximately 6,780 Feet Upstream of Todd Brook Road

Dry Brook

No flood discharge nominations are given for this portion of Dry Brook in the Delaware County FIS (FEMA, 2012). The full Regional Regression Equations were used to compute flows for Dry Brook to ensure consistency with the portion of the stream studied by detailed methods. The Rational Method was employed for the two locations having drainage area less than 0.41 mi^2.

Rider Hollow

No flood discharge nominations are given for Rider Hollow in the Delaware County FIS (FEMA, 2012). The “area-only” Regional Regression Equations were used to compute flows for Little Red Kill.

Table 6 contains a summary of the flows computed for limited detailed stream segments.

Table 6: Summary of Discharges – Limited Detailed Studies

FLOODING SOURCE AND LOCATION	DRAINAGE AREA (sq. miles)	PEAK DISCHARGES (cfs) 50-PERCENT	10-PERCENT	4-PERCENT	2-PERCENT	1-PERCENT	0.2-PERCENT
Rider Hollow							
Approximately 6,780 Feet Upstream of Todd Brook Road	0.76	72	*	*	*	292	*
Approximately 5,575 Feet Upstream of Todd Brook Road	0.95	87	*	*	*	352	*
Approximately 4,025 Feet Upstream of Todd Brook Road	1.15	102	*	*	*	412	*
Approximately 3,000 Feet Upstream of Todd Brook Road	1.68	141	*	*	*	566	*
Approximately 2,010 Feet Upstream of Todd Brook Road	1.94	160	*	*	*	639	*
Approximately 440 Feet Upstream of Todd Brook Road	2.06	168	*	*	*	672	*
Approximately 100 Feet Downstream of Todd Brook Road	2.88	224	*	*	*	889	*
Approximately 890 Feet Downstream of Rider Hollow Road	3.54	267	*	*	*	1,056	*
Approximately 2,600 Feet Downstream of Rider Hollow Road	4.00	296	*	*	*	1,169	*
Approximately 4,820 Feet Downstream of Rider Hollow Road	5.17	369	*	*	*	1,449	*

Table 6: Summary of Discharges – Limited Detailed Studies

FLOODING SOURCE AND LOCATION	DRAINAGE AREA (sq. miles)	PEAK DISCHARGES (cfs) 50-PERCENT	10-PERCENT	4-PERCENT	2-PERCENT	1-PERCENT	0.2-PERCENT
Approximately 1,660 Feet Upstream of Todd Mountain Road	6.00	419	*	*	*	1,641	*
Approximately 530 Feet Upstream of Todd Mountain Road	7.90	529	*	*	*	2,066	*
At Confluence with Dry Brook	8.10	541	*	*	*	2,109	*
Dry Brook							
Approximately 15,060 Feet Upstream of Eagle Lodge Road	0.21	47	*	*	*	101	*
Approximately 14,250 Feet Upstream of Eagle Lodge Road	0.31	56	*	*	*	126	*
Approximately 13,160 Feet Upstream of Eagle Lodge Road	0.43	56	*	*	*	209	*
Approximately 12,300 Feet Upstream of Eagle Lodge Road	0.49	61	*	*	*	234	*
Approximately 11,900 Feet Upstream of Eagle Lodge Road	0.96	115	*	*	*	437	*
Approximately 10,000 Feet Upstream of Eagle Lodge Road	1.10	131	*	*	*	498	*
Approximately 9,520 Feet Upstream of Eagle Lodge Road	1.50	177	*	*	*	668	*

Table 6: Summary of Discharges – Limited Detailed Studies

FLOODING SOURCE AND LOCATION	DRAINAGE AREA (sq. miles)	PEAK DISCHARGES (cfs) 50-PERCENT	10-PERCENT	4-PERCENT	2-PERCENT	1-PERCENT	0.2-PERCENT
Upstream of Confluence of Shandaken Brook	1.68	197	*	*	*	744	*
Downstream of Confluence of Shandaken Brook	3.12	356	*	*	*	1,338	*
Upstream of Confluence of Flatiron Brook	3.26	371	*	*	*	1,395	*
Downstream of Confluence of Flatiron Brook	4.25	475	*	*	*	1,773	*
Approximately 2,280 Feet Upstream of Eagle Lodge Road	5.11	564	*	*	*	2,108	*
Approximately 900 Feet Downstream of Eagle Lodge Road	6.00	656	*	*	*	2,451	*
Approximately 550 Feet Downstream of Dry Brook Road	7.76	822	*	*	*	3,042	*
Approximately 790 Feet Downstream of Erickson Road	8.61	903	*	*	*	3,350	*
Upstream of Confluence of Haynes Hollow	9.24	963	*	*	*	3,574	*
Downstream of Confluence of Haynes Hollow	13.60	1,348	*	*	*	5,047	*
Approximately 220 Feet Downstream of Dry Brook Road	14.26	1,402	*	*	*	5,261	*

Table 6: Summary of Discharges – Limited Detailed Studies

FLOODING SOURCE AND LOCATION	DRAINAGE AREA (sq. miles)	PEAK DISCHARGES (cfs) 50-PERCENT	10-PERCENT	4-PERCENT	2-PERCENT	1-PERCENT	0.2-PERCENT
Approximately 2,850 Feet Upstream of Dry Brook Road	16.11	1,529	*	*	*	5,777	*
Upstream of Confluence of Rider Hollow	18.79	1,696	*	*	*	6,507	*
Downstream of Confluence of Rider Hollow	26.94	2,335	*	*	*	9,174	*

6. LAKE STUDY

A lake study is indicated for Wawaka Lake on East Branch Delaware River. An inspection of the lake shows that the lake does not provide any usable storage volume which would attenuate flood flows. Wawaka Lake was included in the hydrologic analysis for East Branch Delaware River as the lake does not affect flood flows. No nomination points were chosen in the lake, however in the area immediately downstream of Wawaka Lake, flows were computed using the full Regional Regression Equations.

7. DISCHARGE NOMINATION FOR APPROXIMATE STUDY STREAMS

Flow nominations for approximate study streams were computed using the "area-only" Regional Regression Equations and the Rational Method for drainage areas less than 0.41 mi^2. These methods were applied as described in Section 4: Nomination Methods for Limited Detailed Streams.

Table 7 contains a summary of the flows computed for approximate stream segments.

Table 7: Summary of Discharges – Approximate Studies

FLOODING SOURCE AND LOCATION	DRAINAGE AREA (sq. miles)	PEAK DISCHARGES (cfs)					
		50-PERCENT	10-PERCENT	4-PERCENT	2-PERCENT	1-PERCENT	0.2-PERCENT
Montgomery Hollow							
Approximately 520 Feet Upstream of South Montgomery Hollow Road	3.72	278	*	*	*	1,101	*
Approximately 45 Feet Downstream of South Montgomery Hollow Road	3.75	280	*	*	*	1,108	*
At Confluence with East Branch Delaware River	3.76	281	*	*	*	1,111	*
Meeker Hollow							
Approximately 1,320 Feet Upstream of Henry Williams Road	5.48	387	*	*	*	1,522	*
Approximately 380 Feet Downstream of Henry Williams Road	5.68	400	*	*	*	1,568	*
At Confluence with East Branch Delaware River	5.73	403	*	*	*	1,579	*
Batavia Kill							
Approximately 610 Feet Upstream of George Lawrence Road	6.29	436	*	*	*	1,707	*
Approximately 1,460 Feet Downstream of George Lawrence Road	6.51	449	*	*	*	1,757	*

Table 7: Summary of Discharges – Approximate Studies

FLOODING SOURCE AND LOCATION	DRAINAGE AREA (sq. miles)	PEAK DISCHARGES (cfs)					
		50-PERCENT	10-PERCENT	4-PERCENT	2-PERCENT	1-PERCENT	0.2-PERCENT
Approximately 2,190 Feet Downstream of George Lawrence Road	7.28	494	*	*	*	1,929	*
Approximately 1,940 Feet Upstream of Cartwright Road	9.04	594	*	*	*	2,312	*
Approximately 840 Feet Downstream of Cartwright Road	9.74	633	*	*	*	2,461	*
Approximately 1,010 Feet Downstream of Stewart Road	9.96	645	*	*	*	2,507	*
Approximately 130 Feet Downstream of County Highway 36	10.82	692	*	*	*	2,687	*
Approximately 2,860 Feet Downstream of County Highway 36	11.19	712	*	*	*	2,764	*
Approximately 2,450 Feet Upstream of County Highway 8	13.44	833	*	*	*	3,221	*
Approximately 670 Feet Downstream of County Highway 8	14.51	889	*	*	*	3,434	*
Approximately 865 Feet Upstream of County Highway 36	15.30	930	*	*	*	3,590	*
Tributary 1 to Emory Brook							
Approximately 380 Feet Downstream of Green Hill Road	0.34	35	*	*	*	84	*

Table 7: Summary of Discharges – Approximate Studies

FLOODING SOURCE AND LOCATION	DRAINAGE AREA (sq. miles)	PEAK DISCHARGES (cfs) 50-PERCENT	10-PERCENT	4-PERCENT	2-PERCENT	1-PERCENT	0.2-PERCENT
Approximately 750 Feet Upstream of Moran Road	0.38	35	*	*	*	86	*
At Confluence with Emory Brook	0.48	49	*	*	*	199	*
Tributary 6 to Emory Brook							
Approximately 630 Feet Upstream of Townsend Hollow Road Spur	0.49	49	*	*	*	202	*
Approximately 300 Feet Upstream of Townsend Hollow Road Spur	0.50	50	*	*	*	206	*
At Confluence with Emory Brook	0.51	51	*	*	*	209	*
Emory Brook							
Approximately 1,605 Feet Upstream of Townsend Hollow Road	0.78	73	*	*	*	298	*
Downstream of Confluence of Tributary 6 to Emory Brook	1.29	113	*	*	*	454	*
Approximately 350 Feet Upstream of Townsend Hollow Road	1.65	139	*	*	*	558	*
Approximately 1,080 Feet Downstream of Townsend Hollow Road	1.92	158	*	*	*	633	*
Approximately 3,150 Feet Downstream of Townsend Hollow Road	2.29	184	*	*	*	734	*

Table 7: Summary of Discharges – Approximate Studies

FLOODING SOURCE AND LOCATION	DRAINAGE AREA (sq. miles)	PEAK DISCHARGES (cfs) 50-PERCENT	10-PERCENT	4-PERCENT	2-PERCENT	1-PERCENT	0.2-PERCENT
Approximately 7,000 Feet Downstream of Townsend Hollow Road	2.90	225	*	*	*	894	*
Approximately 9,290 Feet Downstream of Townsend Hollow Road	3.69	277	*	*	*	1,093	*
Approximately 12,420 Feet Downstream of Townsend Hollow Road	4.52	329	*	*	*	1,295	*
Upstream of Confluence of Tributary 1 to Emory Brook	5.12	366	*	*	*	1,438	*

8. REFERENCES

Federal Emergency Management Agency (FEMA). June19, 2012. Flood Insurance Study, Delaware County, New York.

Kent, Kenneth M. 1972. National Engineering Handbook, Section4: Hydrology, Chapter 15: Travel Time, Time of Concentration and Lag. 16 p.

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Northeast Regional Climate Center (NRCC). 2012. Extreme Precipitation in New York & New England. Retrieved from http://precip.eas.cornell.edu/.

U.S. Geological Survey. 1982. Guidelines for determining flood flow frequency. U.S. Water Resources Council, Interagency Advisory Committee of Water Data. Bulletin #17B of the Hydrology Subcommittee. Revised 1981. Reston, Virginia.

FEMA, April 2003, Guidelines and Specifications for Flood Hazard Mapping Partners; Appendix C: Guidance for Riverine Flooding Analyses and Mapping.

APPENDIX A: NEW YORK STATE REGION 3 REGRESSION EQUATIONS (SOURCE: LUMIA, 2006)

Regression equations for estimating peak discharges for rural, unregulated streams are assigned in each of six hydrologic regions of New York, excluding Long Island. The full and "area-only" Regression Equations for the East Branch Delaware River Watershed are included below.

Region 3 – Area Only

$Q_{1.25} = 57.4\,(A)^{0.861}$

$Q_{1.5} = 71.8\,(A)^{0.0.857}$

$Q_{2} = 90.8\,(A)^{0.853}$

$Q_{5} = 144\,(A)^{0.850}$

$Q_{10} = 185\,(A)^{0.848}$

$Q_{25} = 249(A)^{0.843}$

$Q_{50} = 304\,(A)^{0.840}$

$Q_{100} = 367\,(A)^{0.836}$

$Q_{200} = 436\,(A)^{0.832}$

$Q_{500} = 539(A)^{0.827}$

Region 3 – Full Regression

$Q_{1.25} = 0.038\,(A)^{0.959}\,(LAG+1)^{-0.141}\,(RUNF)^{1.234}\,(MXSNO)^{1.037}$

$Q_{1.5} = 0.052\,(A)^{0.961}\,(LAG+1)^{-0.161}\,(RUNF)^{1.142}\,(MXSNO)^{1.110}$

$Q_{2} = 0.051\,(A)^{0.962}\,(LAG+1)^{-0.179}\,(RUNF)^{1.009}\,(MXSNO)^{1.360}$

$Q_{5} = 0.083\,(A)^{0.965}\,(LAG+1)^{-0.215}\,(RUNF)^{0.776}\,(MXSNO)^{1.632}$

$Q_{10} = 0.103\,(A)^{0.963}\,(LAG+1)^{-0.228}\,(RUNF)^{0.658}\,(MXSNO)^{1.794}$

$Q_{25} = 0.117\,(A)^{0.957}\,(LAG+1)^{-0.239}\,(RUNF)^{0.524}\,(MXSNO)^{2.016}$

$Q_{50} = 0.119\,(A)^{0.953}\,(LAG+1)^{-0.244}\,(RUNF)^{0.430}\,(MXSNO)^{2.195}$

$Q_{100} = 0.115\,(A)^{0.951}\,(LAG+1)^{-0.249}\,(RUNF)^{0.341}\,(MXSNO)^{2.375}$

$Q_{200} = 0.111\,(A)^{0.949}\,(LAG+1)^{-0.253}\,(RUNF)^{0.255}\,(MXSNO)^{2.547}$

$Q_{500} = 0.105\,(A)^{0.948}\,(LAG+1)^{-0.258}\,(RUNF)^{0.147}\,(MXSNO)^{2.759}$

Subscript is recurrence interval; thus, Q_2 refers to discharge with 2-year recurrence interval

A = Drainage area, in square miles

Q = Flow, in cfs

LAG = Basin lag factor[1].

RUNF = Mean annual runoff, in inches

MXSNO = Seasonal maximum snow depth (50th percentile), in inches

[1] Basin Lag Factor calculated as: $\dfrac{\text{Main Channel Length (in miles)} \div}{\sqrt{(\text{Slope of upper half of main channel (ft/mi)} \times (\text{Slope of lower half of main channel (ft/mi)})}}$

APPENDIX C

COST ESTIMATES

Alt BC-1

Properties to be purchased

Parcel #	**Address**	**Value**	**Demolition costs**
307.1-1-38	65 Pavilion Road	$76,900	$50,000
	Total:	$76,900	$50,000

Cost of bridge for bypass $2,000,000

Restoration

Area to restore (SF)	0
Topsoil cost ($25/CY), assume 0.5 ft topsoil	$0
Seedmix cost ($0.75/SF)	$0

Volume Calculations

XS	XS Area Removed (SF)	Dist to next XS (FT)	Volume (CF)
Start of bypass channel	0	466	93433
3797.652	401	384.02	161499.611
3414.24	440.1	70.4491	30969.42436
3343.79	439.1	104.544	45068.9184
3239.25	423.1	200.97	72771.237
3038.28	301.1	353.19	53172.7545
2684.479	0	401.71	
		Total CF:	456914.9453

Excavation costs ($4/CY)	$67,691
Export costs ($20/CY)	$338,456
Total Costs:	$2,533,047

Alt BR-2

Properties to be purchased

Parcel #	**Address**	**Value**	**Demolition costs**
307.1-1-38	65 Pavilion Road	$76,900	$50,000
307.1-1-40	49 Pavilion Road	$115,800	$50,000
307.1-1-41	43141 State Highway 28	$94,400	$50,000
307.1-3-2	13 Riverside Drive	$52,300	$50,000
307.1-3-3	41 Riverside Drive	$132,700	$50,000
307.1-3-41	60 Riverside Drive	$104,900	$50,000
307.1-3-1	30 Riverside Drive	$19,900	$20,000
	Total:	$596,900	$320,000

Cost of bridge	$7,000,000

Restoration

Area to restore (SF)	241259
Topsoil cost ($25/CY), assume 0.5 ft topsoil	$111,694
Seedmix cost ($0.75/SF)	$180,944

Volume Calculations

XS	XS Area Removed (SF)	Dist to next XS (FT)	Volume (CF)
Start of Floodplain	0	300	49230
3797	328.2	384.02	308406.462
3414.24	1278	70.4491	96585.7161
3343.79	1464	104.544	127230.048
3239.25	970	200.97	149682.456
3038.28	519.6	353.19	91758.762
2684.479	0	401.71	
		Total CF:	822893.4441

Excavation costs ($4/CY)	$121,910
Export costs ($20/CY)	$609,551
Total Costs:	$8,940,999

Alt FP-5

Properties to be purchased

Parcel #	**Address**		**Value**	**Demolition costs**
307.1-1-1.3	183 Pavilion Road		$65,400	$20,000
307.1-1-40	49 Pavilion Road		$115,800	$50,000
307.1-1-38	65 Pavilion Road		$76,900	$50,000
		Total:	$258,100	$120,000

Restoration

Area to restore (SF)	155516
Topsoil cost ($25/CY), assume 0.5 ft topsoil	$71,998
Seedmix cost ($0.75/SF)	$116,637

Volume Calculations

XS	XS Area Removed (SF)	Dist to next XS (FT)	Volume (CF)
3239.25	0	200.97	33069.6135
3038.28	329.1	353.19	109612.5165
2684.479	291.6	401.71	88637.3115
2283.38	149.7	506	37874.1
End of Floodplain	0		
		Total CF:	269193.5415

Excavation costs ($4/CY)	$39,881
Export costs ($20/CY)	$199,403
Total Costs:	$806,018

Combo 1

Properties to be purchased

Parcel #	Address	Value	Demolition costs
307.1-1-38	65 Pavilion Road	$76,900	$50,000
307.1-1-1.3	183 Pavilion Road	$65,400	$20,000
	Total:	$142,300	$70,000

Cost of bridge for bypass	$2,000,000

Restoration (Floodplains)

Area to restore (SF)	301490
Topsoil cost ($25/CY), assume 0.5 ft topsoil	$139,579
Seedmix cost ($0.75/SF)	$226,118

Volume Calculations

XS	XS Area Removed (SF)	Dist to next XS (FT)	Volume (CF)
Start of bypass channel	0	466	93433
3797.652	401	384.02	161499.611
3414.24	440.1	70.4491	30969.42436
3343.79	439.1	104.544	45068.9184
3239.25	423.1	200.97	72771.237
3038.28	301.1	353.19	53172.7545
2684.479	0		
Start of Floodplain downstream of bypass channel	0	220	33407
2684	303.7	401.71	90886.8875
2283.38	148.8	503	37423.2
End of Floodplain	0		
Floodplain Upstream of bypass			
5645.89	0	427.08	73564.53
5218.81	344.5	448.53	100268.8815
4769	102.6	464.61	99984.072
4305.68	327.8	113	18520.7
End of Floodplain Upstream of bypass	0		
		Total CF:	910970.2163

Excavation costs ($4/CY)	$134,959
Export costs ($20/CY)	$674,793
Total Costs:	$3,387,748

Combo 2

Properties to be purchased

Parcel #	**Address**	**Value**	**Demolition costs**
307.1-1-1.3	183 Pavilion Road	$65,400	$20,000
307.1-1-40	49 Pavilion Road	$115,800	$50,000
307.1-1-41	43141 State Highway 28	$94,400	$50,000
307.1-3-2	13 Riverside Drive	$52,300	$50,000
307.1-3-3	41 Riverside Drive	$132,700	$50,000
307.1-3-41	60 Riverside Drive	$104,900	$50,000
307.1-1-38	65 Pavilion	$76,900	$50,000
307.1-3-1	30 Riverside Drive	$19,900	$20,000
	Total:	$662,300	$340,000

Cost of bridge	$7,000,000

Restoration (Floodplains)

Area to restore (SF)	542749
Topsoil cost ($25/CY), assume 0.5 ft topsoil	$251,273
Seedmix cost ($0.75/SF)	$407,062

Volume Calculations

XS	XS Area Removed (SF)	Dist to next XS (FT)	Volume (CF)
Start of Floodplain under Bridge	0	300	49230
3797	328.2	384.02	308406.462
3414.24	1278	70.4491	96585.7161
3343.79	1464	104.544	127230.048
3239.25	970	200.97	149682.456
3038.28	519.6	353.19	91758.762
2684.479	0	401.71	
Floodplain Upstream of Bridge			
5645.89	0	427.08	73564.53
5218.81	344.5	448.53	100268.8815
4769	102.6	464.61	99984.072
4305.68	327.8	113	18520.7
End of Floodplain Upstream of bridge	0		
Start of Floodplain downstream of bridge	0	220	33407
2684	303.7	401.71	90886.8875
2283.38	148.8	503	37423.2
End of Floodplain	0		
		Total CF:	1276948.715

Excavation costs ($4/CY)	$189,178
Export costs ($20/CY)	$945,888
Total Costs:	$9,795,700

APPENDIX D

INCORPORATING WATER QUALITY BENEFITS INTO BENEFIT COST ANALYSIS

A DISCUSSION OF APPROACHES THAT CAN BE USED BY THE EAST BRANCH FLOOD COMMISSION

Incorporating Water Quality Benefits into Benefit Cost Analysis (BCA)

A discussion of approaches that can be used by the East Branch Flood Commission

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Standard FEMA BCA relies on the reduction of flood inundation to calculate benefits (in units of dollars) from avoided losses and damages. Over the years, FEMA's BCA program has been modified to include other factors that can be quantified and summed with flood inundation benefits, such as open space and riparian benefits, mental health, and volunteer costs. As of 2017, calculation of water quality benefits has not been added to the BCA program. Nevertheless, flooding is known to cause impaired water quality. Therefore, reduction of flooding is believed to proportionally reduce water quality impairment by reducing the area of land and buildings exposed to floodwaters and by reducing the depth and velocity of floodwaters that mobilize pollutants. Two approaches to including water quality benefits are discussed in this memorandum.

Approach Number 1

When the Local Flood Hazard Mitigation Analysis (LFHMA) [now LFA] program was being discussed in 2012, discussions about incorporating water quality benefits focused on developing appropriate "scores" that would correspond to "multipliers" that would then be applied to the benefit cost ratio (BCR) when proposed flood mitigation projects would result in reduced water quality impairment if implemented. Discussions centered on a set of scores for "chemical release prevention" ranging from zero (no water quality benefits) to 2.0 ("will protect at least one but less than six contaminant sources") to 4.0 ("will protect more than six potential contaminant sources"). Separate scores were developed for sediment transport from properties (as opposed to sediment transport from stream banks) and wetland preservation.

During these early discussions, stakeholders understood that low BCRs such as 0.3 would have a low likelihood of increasing above 1.0 when multipliers corresponding to moderate benefit were applied (0.3 x 2.0 = 0.6) but would have a higher likelihood of increasing above 1.0 when multipliers corresponding to significant benefit were applied (0.3 x 4 = 1.2). For this reason, the multipliers were set as follows:

- If total score is less than 4, multiplier = 1.0
- If total score is between 4 and 7, multiplier = 1.1
- If total score is greater than 7, multiplier = 1.2

Although this approach gained modest traction, it was not incorporated into the final LFHMA rules.

Since 2012, the additional factors incorporated into the BCA tool (open space and riparian benefits, mental health, and volunteer costs) were programmed to become available only when flood inundation benefits alone were sufficient to generate a BCR of 0.75 or greater[1]. In other words, these benefits can help make a "nearly cost effective" project into a cost effective project. This has set a reasonable precedent and a benchmark for considering water quality benefits in the BCA completed for LFAs.

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[1] According to FEMA (2013), "green open space and riparian area benefits can now be included in the project benefit cost ratio (BCR) once the project BCR reaches 0.75 or greater."

The rollout of the LFA program has reflected a wide range in the number of buildings contributing to BCA for a particular community, from 20 or 30 (for Lexington Hamlet) to more than 180 (for the Village of Walton). Some of the properties are residential and therefore would be expected to contribute to water quality impairment from heating fuels, vehicles, and sanitary wastewater. Other properties are nonresidential and would be expected to contribute to water quality impairment from heating fuels, vehicles, sanitary wastewater, and pollutants that are associated with the land use such as gasoline, oils, chemicals, food products, fertilizers, herbicides, pesticides, etc. In light of the differences from community to community, the approach discussed in 2012 (a set of scores for chemical release prevention ranging from zero to 2.0 [will protect at least one but less than six contaminant sources] to 4.0 [will protect more than six potential contaminant sources]) seems somewhat arbitrary. A community like Walton will easily have more than six potential contaminant sources whereas a community like Arkville may not.

For this reason, it may be more appropriate to apply multipliers to the *individual* benefits associated with each property rather than apply multipliers to the sum of all benefits associated with a mitigation project. A new scoring system could be developed, with new multipliers associated with each sum of scores. Scores would be higher for commercial and industrial properties than they would be for residential properties, and the multipliers would therefore be greater for commercial and industrial properties than they would be for residential properties.

Approach Number 2

In a review of the literature, direct studies that provide an impact value to reduced water quality are limited. Turbidity and sediment loading are the issues most frequently studied in relation to water quality benefits in watersheds. Most studies use indirect methods, such as impact to tourism or "willingness to pay" surveys to compute the perceived value of water quality.

Three studies were reviewed to estimate a dollar figure ($) of water quality benefits per acre per year that could be utilized within the context of a BCA for LFAs.

- A study conducted by the State of New Hampshire focused on the potential impact to tourism from a perceived water quality reduction. The study predicted that the statewide impact would be $69 million per year, equivalent to a water quality value of $11.5/acre/year.

- A USDA study of New York State found that the societal benefits of reducing erosion are greater than $9/ton/year for all counties in the state. In other words, a one-ton reduction in soil erosion can increase societal benefits by $9/year. In an effort to apply this value to the West-of-Hudson region, the Upper Esopus Creek Management Plan was consulted. Using the long-term average sediment yield from Appendix III and applying the figure on an area basis, the societal benefits of reducing erosion in that watershed were $10.8/acre/year, reasonably close to the New Hampshire figure.

- Several "willingness to pay" studies were also reviewed. One of the studies summarized a significant amount of previous work nationwide. This study found an overall "willingness to pay" for improved water quality to range from $90 to $112 per person per year. In an effort to relate this value to the West-of-Hudson region, this data was applied to the Upper Esopus Creek Management Plan, resulting in a "willingness to pay" figure for water quality of $10.8/acre/year, in line with the USDA study.

The average of these three methods is approximately $11/acre/year. The range of figures is narrow and although this may be somewhat coincidental, it suggests that the average may be defensible in the West-of-Hudson region.

If per-acre figures were to be used to quantify water quality benefits, the calculation could be conducted on a parcel-by-parcel basis. As an alternative, it could be applied to the entire flooded area. Two additional choices are available: the per-acre figure could be allowed as a benefit on a "pass/fail" basis (either the land floods or it will not flood because a mitigation project has been completed in the future); or the per-acre figure could be used to generate a "depth-impact" function similar to the depth-damage curves currently used by the BCA. These depth-impact functions would then be combined with reductions in flood elevations to generate water quality benefits that vary from a minimum to a maximum according to depth of flooding avoided or reduced. Borrowing from approach #1 above, multipliers could still be applied to these calculations based on the type of parcel. For example, an industrial parcel should have the potential to have a greater impact on water quality than a residential parcel.

Ultimately, approach #2 may not generate sufficient benefits for use in LFAs. This is likely because per-acre benefits are typically estimated from watershed-scale studies or greater, including the three described above. In contrast to a watershed, the SFHA within any given watershed is only a fraction of the total area. If $11/acre/year were multiplied by the total acreage of Arkville center in the SFHA (perhaps 20 acres), the result is only $220 per year. Projected over 50 years (the projection used by the BCA program for flood mitigation projects) without considering flood recurrence intervals, the benefit would be only $11,000. This is a nominal figure when compared to the benefits typically generated by the BCA program from flood reductions at numerous buildings.

Summary

Approach #1 appears to offer the most significant potential for quantifying water quality benefits, and it is most consistent with the approach discussed when the LFHMA rules were initially developed. Two recommendations are offered if this approach is used to generate water quality benefits:

- The BCR must be 0.75 or greater to allow water quality benefits.
- Multipliers should be applied to the individual benefits generated for each property, and should differ for residential vs. nonresidential properties.