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UPPER SAUQUOIT CREEK FLOOD STUDY

SAUQUOIT CREEK, ONEIDA COUNTY, NEW YORK

RAMBOLL

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ACRONYMS/ABBREVIATIONS

1-D	1-Dimensional
2-D	2-Dimensional
ACE	Annual Chance Event
AEP	Annual Exceedance Probability
BFE	Base Flood Elevation
BRIC	Building Resilient Infrastructure and Communities
CAP	Continuing Authorities Program
CFS	Cubic Feet per Second
CRREL	Cold Regions Research and Engineering Laboratory
CSC	Climate Smart Communities
CDBG	Community Development Block Grants
CFA	Consolidated Funding Applications
DEM	Digital Elevation Model
EWP	Emergency Watershed Protection
FEMA	Federal Emergency Management Administration
FIS	Flood Insurance Study
FMA	Flood Mitigation Assistance
FT	Foot
FT/S	Feet per Second
GIS	Geographic information systems
H&H	Hydrologic and hydraulic
HEC	Hydrologic Engineering Center
HEC-RAS	Hydrologic Engineering Center River Analysis System
HMA	Hazard Mitigation Assistance
HOCCPP	Herkimer-Oneida Counties Comprehensive Planning Program
HUD	Department of Housing and Urban Development
LB/SQ FT	Pound per square foot
LiDAR	laser imaging, detection, and ranging
LOMR	Letter of Map Revision
MMI	Milone & MacBroom, Inc.
NAVD88	North American Vertical Datum of 1988
NASS	National Agricultural Statistics Service
NCEI	National Center for Environmental Information
NRCS	Natural Resources Conservation Services
NFIP	National Flood Insurance Program
NHD	National Hydrography Dataset
NY	New York
NYRCR	New York Rising Community Reconstruction
NYSOEM	New York State Office of Emergency Management
NYSPCS	New York State Plane Coordinate System
NYSWR	New York, Susquehanna and Western Railway Corporation
OBG	O'Brien & Gere Engineers, Inc.
OCPC	Oneida County Planning Committee

REHAB	Watershed Rehabilitation Program
RAMBOLL	Ramboll Americas Engineering Solutions, Inc.
ROM	Rough order of magnitude
RTE	Rare, threatened and endangered
SCBIC	Sauquoit Creek Basin Intermunicipal Commission
SHPO	State Office of Historic Preservation
SQ MI	Square mile
STORM	Safeguarding Tomorrow through Ongoing Risk Mitigation Act
USACE	United States Army Corps of Engineers
USDA	United States Department of Agriculture
USGS	United States Geologic Survey
WFPO	Watershed and Flood Prevention Operations
WQIP	Water Quality Improvement Project
WSEL	Water Surface Elevation

1. INTRODUCTION

1.1 Background

As the climate is changing, the key to developing a resilient environment in riparian areas is by improving the connection of the channel to the floodplain. Floodplains increase the buffer and water retention areas and are essential since the pressure to mitigate increases as more frequent and more intense precipitation events continue to rise. In addition, floodplains alleviate stress during drought periods as they store water, and provide many other ecosystem services such as recreation, wildlife and aquatic habitat, and increased biodiversity. River ecosystems can be restored and maintained along with adapting to human activities in a variety of ways. However, alterations to these ecosystems can potentially change the natural processes that occur along streams or rivers (Jakubínský et al. 2021).

Sauquoit Creek is a 20.6-mile stream located in Oneida County, New York (NY) that flows through multiple jurisdictions including the Towns of Paris, Whitestown, New Hartford, and the Villages of Clayville, New Hartford, New York Mills, and Whitesboro. Sauquoit Creek flows in a generally northern direction and parallels Routes 5A and 8 for much of its length. For over 50 years, the Sauquoit Creek corridor has been straightened and channelized along its middle and lower reaches to accommodate new development. The floodplain of Sauquoit Creek can be characterized as broad and flat along its lower reaches and is prone to flooding from intense weather events, including a combination of heavy rains and early snowmelts. Flooding has been exacerbated on the creek by ice jams and restrictive infrastructure (i.e., bridges, culverts, etc.), which act as hydraulic constrictions preventing water from moving naturally throughout the landscape.

1.2 Project Objectives

A number of previous studies by state and federal agencies, consultants, and the local municipalities are referenced in Section 1.4 below. These studies have analyzed and assessed the flood mitigation needs in affected areas along Sauquoit Creek; however, many of these studies are outdated and do not accurately reflect the present-day existing conditions in the watershed. Local officials recognize the critical and necessary steps to prevent future damage to the flood-prone properties along Sauquoit Creek.

The objective of this report is to identify problem areas in the upper Sauquoit Creek area associated with flooding, stream bed aggradation and degradation, bank instability, and floodplain connectivity. In the Town of New Hartford, the upper Sauquoit Creek project limits start at the sixth railroad bridge owned by the New York, Susquehanna and Western Railway Corporation (NYSWR) south of Elm Street and ends downstream at the Genesee Street bridge. Past and current data will be utilized from all available sources, field assessments and surveys, and historical report findings to evaluate proposed engineering solutions using hydrologic and hydraulic (H&H) modeling and geographic information systems (GIS) mapping software.

1.3 Project Goals

A primary goal will be to reduce flooding by lowering water surface elevations caused by undersized infrastructure, excessive deposition and debris, uncontrolled sediment sources, head cutting or downcutting of the channel, and loss of natural floodplains. Many of these situations are a result of basin-wide conditions related to changes in land use, land cover and runoff, stormwater management, upstream sediment sources, upstream woody debris, and stream bed and bank erosion. Practical solutions and actions will be presented to meet these goals in an ecologically sustainable manner.

1.4 Review Previous Studies

There have been multiple studies and planning reports developed for the Sauquoit Creek watershed basin:

- The United States Army Corps of Engineers (USACE) produced the *Detailed Project Report, Village of Whitesboro, NY* in 1981, which included detailed hydraulic analysis of multiple flood relief alternatives. The report also included delineation of wetlands, rare, threatened and endangered (RTE) species, and State Office of Historic Preservation (SHPO) reviews (USACE 1981a).
- The Herkimer-Oneida Counties Comprehensive Planning Program (HOCCPP) prepared the *Sauquoit Creek Basin Watershed Management Study* in 1997 to develop an overall scoping process and implementation strategy for the basin which will lead to a coordinated, comprehensive, intergovernmental, and interagency, approach to basin management. The *Sauquoit Creek Basin Watershed Management Study* provides the reader with an understanding of the many intricacies, complexities, and interrelationships involved in water resources management; outlines a number of common components of overall objectives within the basin; identifies specific tasks which need to be accomplished to meet these objectives; establishes a proposed priority for when those tasks should be completed in relation to other tasks; and suggests what agency or individual might be best suited to undertake each task (HOCCPP 1997).
- Milone & MacBroom, Inc. (MMI) completed the *Emergency Transportation Infrastructure Recovery Water Basin Assessment and Flood Hazard Mitigation Alternatives* (2014) study in response to an extensive flooding event in June of 2013. MMI conducted field surveys, hydrologic assessment; hydraulic modeling; and identification of long-term recommendations for mitigation of future flood hazards. The report recommended 11 flood mitigation strategies that ranged from infrastructure updates and/or removal to floodplain regulations and sediment management plans (MMI 2014).
- The New York Rising Community Reconstruction (NYRCR) Oneida County Planning Committee (OCPC) developed the *Oneida County NY Rising Resiliency Plan* in response to the extensive flooding events of 2013 and intense storm events in previous years, such as Superstorm Sandy, Hurricane Irene, and Tropical Storm Lee. The NYRCR Program was a planning and implementation process established to provide rebuilding and resiliency assistance to communities heavily damaged by flooding. Drawing on lessons learned from past recovery efforts, the NYRCR Program was a unique combination of bottom-up community participation and state-provided technical expertise. The approach was two-pronged, focusing first on

identification of remaining recovery needs, and then on developing countywide long-term resiliency strategies and actions. Resiliency projects ranged from infrastructure updates and/or removal to public education and emergency management coordination improvements (NYRCR 2014).

- O'Brien & Gere Engineers, Inc. (OBG), in coordination with the Town of Whitestown, completed the *Sauquoit Creek Channel and Floodplain Restoration Project, Lower Sauquoit Creek – Engineering Report* in November of 2018. The purpose of this project was to re-evaluate and assess the existing conditions of Sauquoit Creek in order to identify how and where to reconnect the floodplain and stabilize the banks. This information served as the basis for creating a detailed plan and design approach aimed at mitigating and reducing flooding along Sauquoit Creek as part of a long-term improvement strategy and program (OBG 2018).
- Ramboll Americas Engineering Solutions, Inc. (Ramboll), in coordination with the Sauquoit Creek Basin Intermunicipal Commission (SCBIC), produced two technical reports in response to the intense and extensive flooding event of October 31 – November 1, 2019: the *Sauquoit Creek Drainage Study: Findings of 2019 Halloween Storm – Hydraulic Modeling* (2020) and *Sauquoit Creek Drainage Study – Alternative Design* (2020) reports. The reports focused on analyzing the causes of the extensive flood damages by reproducing the Halloween Storm flooding and then assessing the impact of different flood mitigation strategies using 2-D models. Eight flood mitigation strategies were proposed involving infrastructure updates, including bridge widening, retention pond, flood bench, and floodwall strategies (Ramboll 2020a; Ramboll 2020b).
- Ramboll, in coordination with the SCBIC, produced the *Stream Sediment and Debris Management Plan of Sauquoit Creek, NY* in 2021, which was an extensive study that examined the impact of man-made infrastructure, streambank erosion, aggregation and degradation and bank failures on flood risk within the watershed. The management plan involved eight zones (A-H) that examined in-depth characteristics of Sauquoit Creek and proposed natural-based solutions to reconnect the floodplain to the creek and to mitigate flooding in high-risk areas (Ramboll 2021).

2. STUDY AREA

2.1 Study Area

The upper Sauquoit Creek is located within Oneida County, NY and flows through the City of Utica, Towns of New Hartford and Paris, and the Villages of Clayville and New Hartford. The upper two-thirds of the Sauquoit Creek watershed basin is relatively undeveloped and can be characterized as agricultural and forest land. Several small tributaries of Sauquoit Creek drain the eastern portion of the Town of Paris. The east side of the Sauquoit Creek valley is on the west slope of a local high point known as Burrstone Hill. The channel slopes in the upland area are in the range of 50 to 100 feet per mile. Development in the form of suburban, residential, and commercial institutions encompass Sauquoit Creek in the lower parts of the reach in the Villages of New Hartford, New York Mills, Yorkville and Whitesboro, and the City of Utica (Thompson 1966; USACE 1985; FEMA 2013).

As identified in the *Stream Sediment and Debris Management Plan of Sauquoit Creek, NY* (2021), this report is specific to the mid-upper portion of the creek, which correlates to three zones: Zones D, E, and F. The project area starts at the sixth Railroad Bridge owned by the NYSWR south of Elm Street and ends downstream where the stream is perpendicular to the Genesee Street Bridge in New Hartford, NY. The project area is approximately 4.5 miles in the stream's length and has a drainage area of 43.4 square miles. Figure 2-1 displays the location of the study area along Sauquoit Creek in the Town of New Hartford, NY.

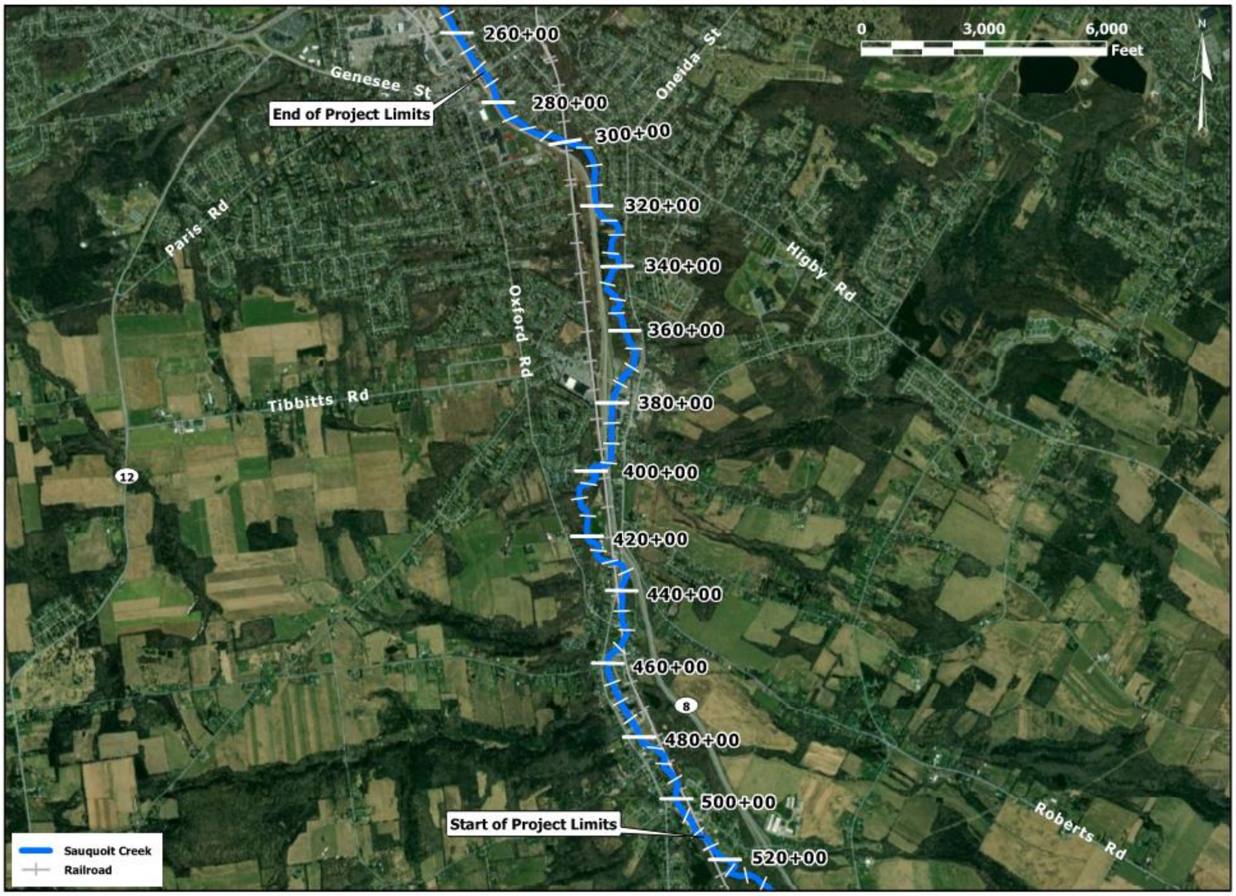

Figure 2-1. Project study area.

2.2 Principal Flooding Problems

The Sauquoit Creek watershed basin has experienced significant flooding historically. The residents and business-owners of the Sauquoit Creek area have experienced recurring flood-related economic losses and disruption of normal activity. Members of the community and local officials have recognized the potential for flood damages and threats to human life. Protection from these actual and potential losses has been sought by local interests for many years (USACE 1985).

Flooding occurs on Sauquoit Creek from two principal sources: fluvial flooding and ice jams. Fluvial flooding occurs when the water level in the stream rises and overtops the banks onto surrounding areas. Fluvial flooding typically occurs through the lower reaches of Sauquoit Creek during high intensity rainfall events that exceed the existing channel's capacity. During the late-winter and early spring months when the stream's ice cover breaks up, ice floats can become jammed in the meandering sections of Sauquoit Creek or on the upstream face of infrastructure crossing the waterway (i.e., bridges, culverts) causing water levels in the stream to rise upstream of the jam. If the water levels rise high enough, they can overtop the banks and flood surrounding areas (USACE 1985).

Development in the basin over the years has also contributed to increased runoff from rainfall and snowmelt. In addition, continued channel and bank instability is a source of eroded sediment which accumulates in some reaches of the stream and increases the potential for ice jams. Basements of some residences frequently require pumping due to seepage. Historically, floods were less frequent because mill ponds upstream provided limited storage, but over time these dam/pond systems have become silted-in and no longer contain excess floodwaters or ice (USACE 1985).

Within the study area, there are three principal areas that have historically flooded: in the City of Utica at Brookline Drive, and in the Town of New Hartford at Washington Mills Park and Hand Place. Figure 2-2 displays the locations of the three principal flooding areas within the City of Utica and Town of New Hartford, NY.

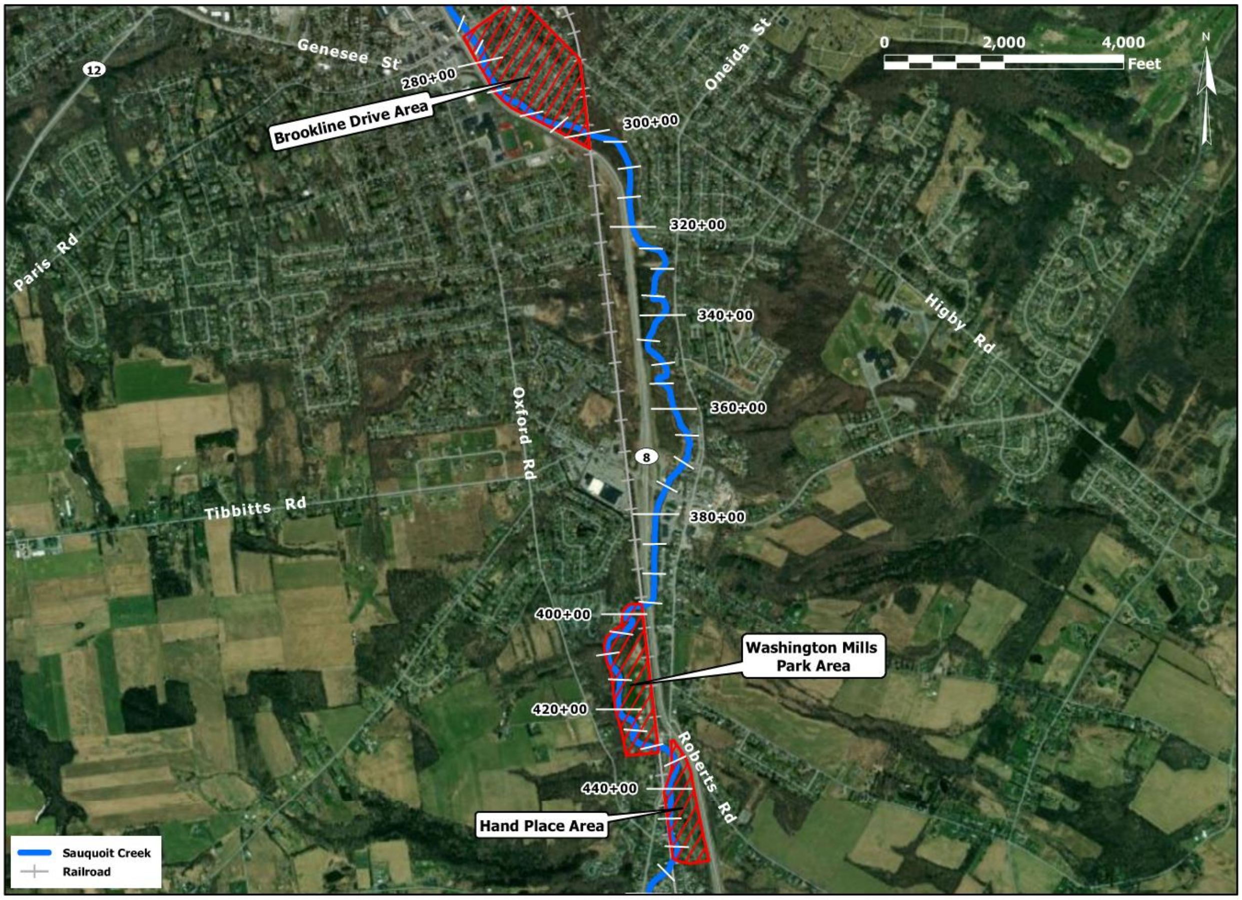

Figure 2-2. Principal flooding areas.

3. METHODOLOGY

3.1 Data Collection

Ramboll met with local officials and community stakeholders in April 2020 while completing the *Stream Sediment Debris Management Plan* (2021) and collected information on firsthand accounts of past flooding events, identified specific areas that flooded in each community and the extent and severity of the flood damage, and obtained information on post-flood efforts and any completed or planned flood mitigation projects throughout the watershed. The information gathered from this meeting informed this study.

Hydrological and meteorological data were obtained from readily available state and federal government databases including orthoimagery, flood zone maps, streamflow, precipitation, and flooding and ice jam reports. Historical flood reports, newspaper articles, social media posts, stakeholder engagement meeting notes, and geographic information system (GIS) mapping were used to identify flooding and sediment concerns, produce watershed maps, and identify current high-risk areas.

3.2 Field Survey

Field survey teams were sent to collect detailed survey data throughout the principal flooding areas in the upper Sauquoit Creek project area between October and November of 2022. Survey teams use specialized equipment to measure distances and angles along a specified path from which positions and elevations are calculated. All survey points were referenced to the North American Datum of 1983 (NAD83) New York State Plane Coordinate System (NYSPCS) for horizontal coordinates and the North American Vertical Datum of 1988 (NAVD88) for vertical coordinates.

Along Sauquoit Creek, a total of 33 locations and 885 survey points were collected from Susan M. Anacker, Professional Land Surveyor PLLC in Fall of 2022. Figure 3-1 displays the locations of the field survey data in the three principal flooding areas within the Town of New Hartford. Appendix A contains the field data collection forms, Appendix B contains the field survey data, and Appendix C contains the photo logs of the focus areas documented in June 2022.

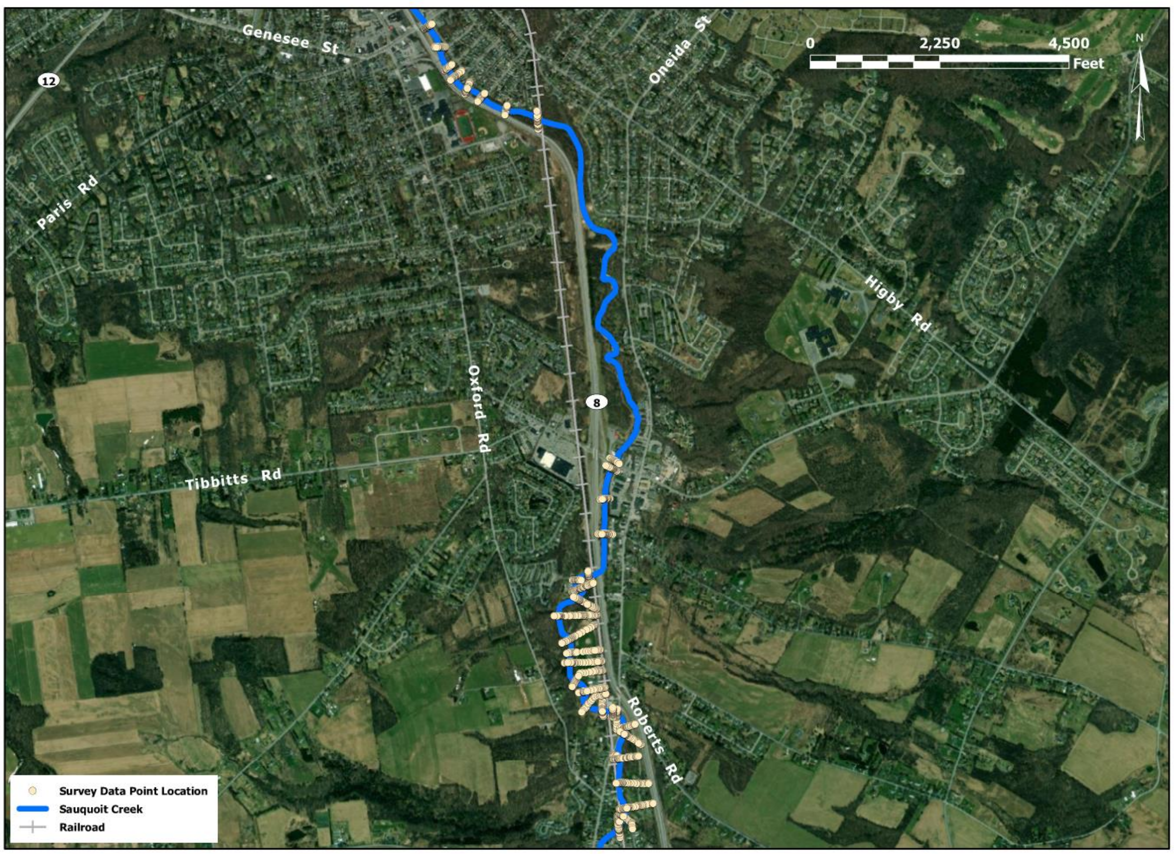

Figure 3-1. Field survey locations.

3.3 Precipitation

The average precipitation in this study area is 39.6 inches per year. Figure 3-2 displays the precipitation intensity statistics from the NOAA Atlas 14 for New Hartford, NY. Snowfall typically occurs in January, February, March, and December. The month of April is the time of the year when the snow melts and will rapidly increase the discharge of the creek. Typically, the wettest month in Oneida County is May and driest month of the year is February (NOAA 2017; NOAA 2020).

PDS-based point precipitation frequency estimates with 90% confidence intervals (in inches/hour)

Duration	Average recurrence interval (years)									
	1	2	5	10	25	50	100	200	500	1000
5-min	3.50 (2.78-4.34)	4.12 (3.28-5.12)	5.12 (4.04-6.37)	5.96 (4.70-7.48)	7.13 (5.42-9.17)	8.00 (5.96-10.4)	8.90 (6.43-11.9)	9.85 (6.80-13.5)	11.2 (7.42-15.6)	12.2 (7.91-17.3)
10-min	2.48 (1.97-3.08)	2.92 (2.32-3.62)	3.63 (2.87-4.52)	4.23 (3.33-5.29)	5.05 (3.84-6.49)	5.67 (4.23-7.40)	6.31 (4.55-8.44)	6.98 (4.82-9.52)	7.91 (5.26-11.1)	8.63 (5.60-12.3)
15-min	1.94 (1.55-2.42)	2.29 (1.82-2.84)	2.85 (2.26-3.54)	3.32 (2.61-4.14)	3.96 (3.01-5.09)	4.44 (3.32-5.80)	4.94 (3.58-6.62)	5.48 (3.78-7.47)	6.20 (4.12-8.68)	6.77 (4.40-9.62)
30-min	1.34 (1.07-1.66)	1.58 (1.25-1.96)	1.97 (1.56-2.45)	2.29 (1.80-2.86)	2.73 (2.08-3.52)	3.07 (2.29-4.01)	3.41 (2.47-4.57)	3.78 (2.61-5.16)	4.29 (2.85-5.99)	4.68 (3.04-6.65)
60-min	0.854 (0.679-1.06)	1.01 (0.799-1.25)	1.25 (0.992-1.56)	1.46 (1.15-1.82)	1.74 (1.33-2.24)	1.96 (1.46-2.56)	2.18 (1.58-2.92)	2.41 (1.67-3.29)	2.74 (1.82-3.83)	2.99 (1.94-4.25)
2-hr	0.528 (0.422-0.651)	0.620 (0.496-0.765)	0.770 (0.614-0.953)	0.896 (0.710-1.11)	1.07 (0.819-1.36)	1.20 (0.900-1.55)	1.33 (0.972-1.77)	1.48 (1.03-2.00)	1.68 (1.13-2.33)	1.84 (1.20-2.59)
3-hr	0.396 (0.318-0.487)	0.465 (0.373-0.571)	0.577 (0.461-0.710)	0.670 (0.532-0.828)	0.798 (0.614-1.01)	0.894 (0.675-1.16)	0.995 (0.729-1.32)	1.10 (0.771-1.49)	1.26 (0.845-1.74)	1.38 (0.907-1.93)
6-hr	0.244 (0.197-0.297)	0.285 (0.231-0.348)	0.354 (0.285-0.433)	0.410 (0.329-0.504)	0.488 (0.379-0.617)	0.547 (0.416-0.702)	0.609 (0.450-0.800)	0.676 (0.476-0.902)	0.771 (0.523-1.05)	0.848 (0.561-1.18)
12-hr	0.148 (0.121-0.180)	0.173 (0.141-0.210)	0.215 (0.174-0.261)	0.249 (0.201-0.303)	0.296 (0.231-0.371)	0.332 (0.254-0.422)	0.369 (0.274-0.481)	0.409 (0.290-0.542)	0.467 (0.319-0.633)	0.514 (0.343-0.706)
24-hr	0.089 (0.073-0.107)	0.104 (0.085-0.125)	0.128 (0.104-0.154)	0.148 (0.120-0.179)	0.175 (0.138-0.218)	0.196 (0.151-0.247)	0.217 (0.163-0.281)	0.241 (0.172-0.316)	0.274 (0.188-0.367)	0.300 (0.202-0.409)

Figure 3-2. NOAA Atlas 14 precipitation frequency estimates for New Hartford, NY (NOAA 2017).

3.4 Peak Streamflow

There is one United States Geologic Survey (USGS) gaging station located along Sauquoit Creek: USGS gage 01339060 at Whitesboro, NY. The gage is located along the right bank of Sauquoit Creek adjacent to Commercial Drive (NY-5A) approximately 1,000-feet upstream of the Village of Whitesboro and Town of Whitestown corporate limits. The period of record for the daily discharge data collected by the gage is seven years, starting on September 26, 2014. This period of record is insufficient to perform a flood frequency analysis and assign annual chance exceedance values to observed events using the USGS Bulletin 17C guidelines (USGS 2023b).

An effective Federal Emergency Management Administration (FEMA) Flood Insurance Study (FIS) for Oneida County was issued on September 27, 2013 and included drainage area and discharge information for Sauquoit Creek. The FEMA FIS flood-frequency discharges for upper Sauquoit Creek were developed were obtained from the USACE *Sauquoit Creek Basin Study, Hydrologic and Hydraulic Planning Models, Oneida County, NY* (1981) report as determined using the USACE Hydrologic Engineering Center Version 1 (HEC-1) flood hydrograph computer program in the Town of New Hartford. Table 1 lists the FEMA FIS drainage area and peak discharges for upper Sauquoit Creek in the principal flooding areas (USACE 1981b, FEMA 2013).

Table 1. FEMA FIS Peak Discharges for Upper Sauquoit Creek

Source: FEMA 2013					
Flooding Source and Location	**Drainage Area (sq mi)**	**Peak Discharges (cfs)**			
		10-percent	**2-percent**	**1-percent**	**0.2-percent**
Upstream of railroad (third crossing)	41.1	3,254	5,399	5,801	8,949
Upstream of Utica / New Hartford corporate limits	40.2	3,161	5,242	5,634	8,790
Upstream of Kellogg Road	37.0	2,920	4,838	5,226	8,227
Upstream of railroad (fourth crossing)	32.6	2,387	4,038	4,390	7,011
Upstream of Elm Street	28.5	2,074	3,486	3,786	6,025

Hydraulic analyses for Sauquoit Creek were completed for the FEMA FIS using detailed methods, the USACE HEC-2 step-backwater computer program, and the slope/area method. Detailed methods predict floodplain limits by using a wide range of tools, including semiautomated hydrologic, hydraulic, mapping tools and digital elevation data, and field-surveyed cross-sections including field surveys of bridges, culverts, and dams to perform a more rigorous hydrologic and hydraulic (H&H) analysis that includes products such as floodways, new calibrations for H&H models, and the modeling of additional frequencies. Detailed studies provide Base Flood Elevations (BFEs) information, which is defined as the computed elevation to which a flood is anticipated to rise during the 1% annual chance flood or 100-year flood (NRC 2007; FEMA 2013).

HEC-2 software involves outdated calculations and computational features and does not conduct an analysis for any changes in land development, which has been significant in the Sauquoit Creek watershed over the past 30 years. Thus, a new method is needed for calculating the discharge values in the channel.

An alternative method for determining discharge-frequency relationships is to use the *StreamStats* v4.13.0 web application. Developed by the USGS, the *StreamStats* software (https://streamstats.usgs.gov/ss/) is a map-based web application that provides an assortment of analytical tools that are useful for water-resources planning and management, and engineering purposes. *StreamStats* delineates the drainage basin boundary for a selected site by use of an updated digital elevation model (DEM) and a digital representation of the stream network. Using this data, the application calculates multiple basin characteristics including drainage area, main channel slope, and mean annual precipitation (Ries et al. 2017, USGS 2023a).

For this study, *StreamStats* was used to develop a full suite of peak discharge statistics including the 66.7-, 50-, 20-, 10-, 4-, 2-, 1-, and 0.2-percent annual exceedance probability (AEP) flood events (1.5-, 2-, 5-, 10-, 25-, 50-, 100-, and 500-year recurrence intervals). In addition, the Halloween Storm of 2019 peak discharges were obtained from the USGS Water Data for the Nation dataset and included in the hydraulic and hydrologic analyses in this study. During the 2019 Halloween Storm the gage recorded a peak discharge of 6,170 cfs, which is categorized as being between the 4- and 10-percent AEP flood event. Using a drainage area-discharge relationship, the peak discharge for the 2019 Halloween Storm was calculated for each discharge location. Table 2 is the summary output of peak discharges calculated by the USGS *StreamStats* software for Sauquoit Creek at selected FEMA FIS profile locations.

Table 2. USGS *StreamStats* Peak Discharges for Upper Sauquoit Creek

Source: USGS 2023a										
Flooding Source and Location	**Drainage Area (sq mi)**	**Peak Discharges (cfs)**								
		66.7-percent	**50-percent**	**20-percent**	**10-percent**	**4-percent**	**2-percent**	**1-percent**	**0.2-percent**	**2019 Halloween Storm**
Upstream of railroad (third crossing)	46.3	1,910	2,330	3,480	4,320	5,460	6,330	7,330	9,680	4,769
Upstream of Utica / New Hartford corporate limits	42.2	1,720	2,100	3,140	3,910	4,930	5,720	6,630	8,750	4,347
Upstream of Kellogg Road	37.4	1,530	1,870	2,800	3,480	4,390	5,100	5,900	7,790	3,852
Upstream of railroad (fourth crossing)	33.3	1,340	1,630	2,440	3,030	3,830	4,440	5,140	6,780	3,430
Upstream of Elm Street	28.8	1,160	1,420	2,120	2,640	3,330	3,860	4,470	5,900	2,967

3.5 Land Use

Sauquoit Creek has been substantially altered by human development, such as narrowing the floodplain in many areas along the creek to accommodate the development of roads, community parks, railroads, and neighborhoods. For a portion of the river's length in this project area, the banks have been armored using concrete or stacked rock walls that confine the channel, which creates a disconnect between the channel and its floodplain. In addition, bank armoring often has the unintended consequence of head cutting or downcutting in the channel and increases the potential for sediment erosion and accumulation in downstream areas. Development along the floodplain has been extensive with the use of fill and structures, especially along the lower reaches in the Towns of New Hartford and Whitestown where the creek flattens and the floodplain becomes increasingly broad. This affects the flow of the water upstream as the channel might experience backwater (MMI 2014).

Based on the 2018 land use data from the United States Department of Agriculture (USDA) National Agricultural Statistics Service (NASS) cropland database, a land cover analysis was performed to determine current land usage and changes in land use over time. Table 3 is a summary table of land use by class (NASS 2019).

Table 3. Summary of the 2018 Land Cover within the Sauquoit Creek Watershed

Source: NASS 2019		
Land Cover Class	**Area (sq mi)**	**Percent Area (%)**
Forest	19.24	30.88
Agricultural	18.12	29.08
Developed	11.46	19.39
Grassland/Pasture	6.25	10.03
Shrubland	6.00	9.62
Wetlands	1.15	1.85
Water	0.08	0.13
Barren	0.01	0.02
Total	**62.31**	**100**

Modification of non-cultivated land often involved deforestation and drainage activities. In combination with cropping and grazing practices, these disruptions of the natural vegetation and soil resulted in the loss of the land's sediment filtering capacity. Compared to naturally vegetated, forested, and/or areas with stream buffers, surface runoff from rural and/or agricultural lands enter nearby waterways and contain large amounts of sediments, fertilizers, manure, etc., which negatively affects water quality and increases sediment loads in a waterway (NRC 1993).

In addition, wetlands also play a vital role in sediment transport and flooding. The loss of wetlands within the Sauquoit Creek watershed has had significant effects on local ecosystems. Wetlands are adversely affected by many human activities, including hydrologic alterations (i.e., drainage for development, dredging, channelization, damming, etc.); pollution and runoff from urban, agricultural, mining, and industrial areas; and vegetation damage by grazing domestic animals and invasive plants species (USEPA 2001).

Using the 2002 cropland data, a land use change over time analysis was performed. Since 2002, there have been increases in forested and developed land areas with decreases in agricultural, grassland pasture, and water land areas. Table 4 summarizes the change in land cover data. Figure 3-3 displays the change in developed land cover from 2002 to 2018 within the Sauquoit Creek watershed. Within a span of 16 years, the Sauquoit Creek Watershed data shows an increase in about 28.8% of developed land, and a decrease in 27.7% and 55.8% of agriculture lands and grasslands, respectively (NASS 2019).

Table 4. Change in Land Cover from 2002 to 2018 within the Sauquoit Creek Watershed

Source: NASS 2019				
Land Cover Class	**2002 Area (sq mi)**	**2018 Area (sq mi)**	**Difference (sq mi)**	**Percent Difference (%)**
Forest	17.40	19.24	+ 1.85	+ 10.1
Agricultural	23.95	18.12	− 5.83	− 27.7
Developed	8.58	11.46	+ 2.88	+ 28.8
Grassland/Pasture	11.09	6.25	− 4.84	− 55.8
Water	0.17	0.08	− 0.09	− 71.7

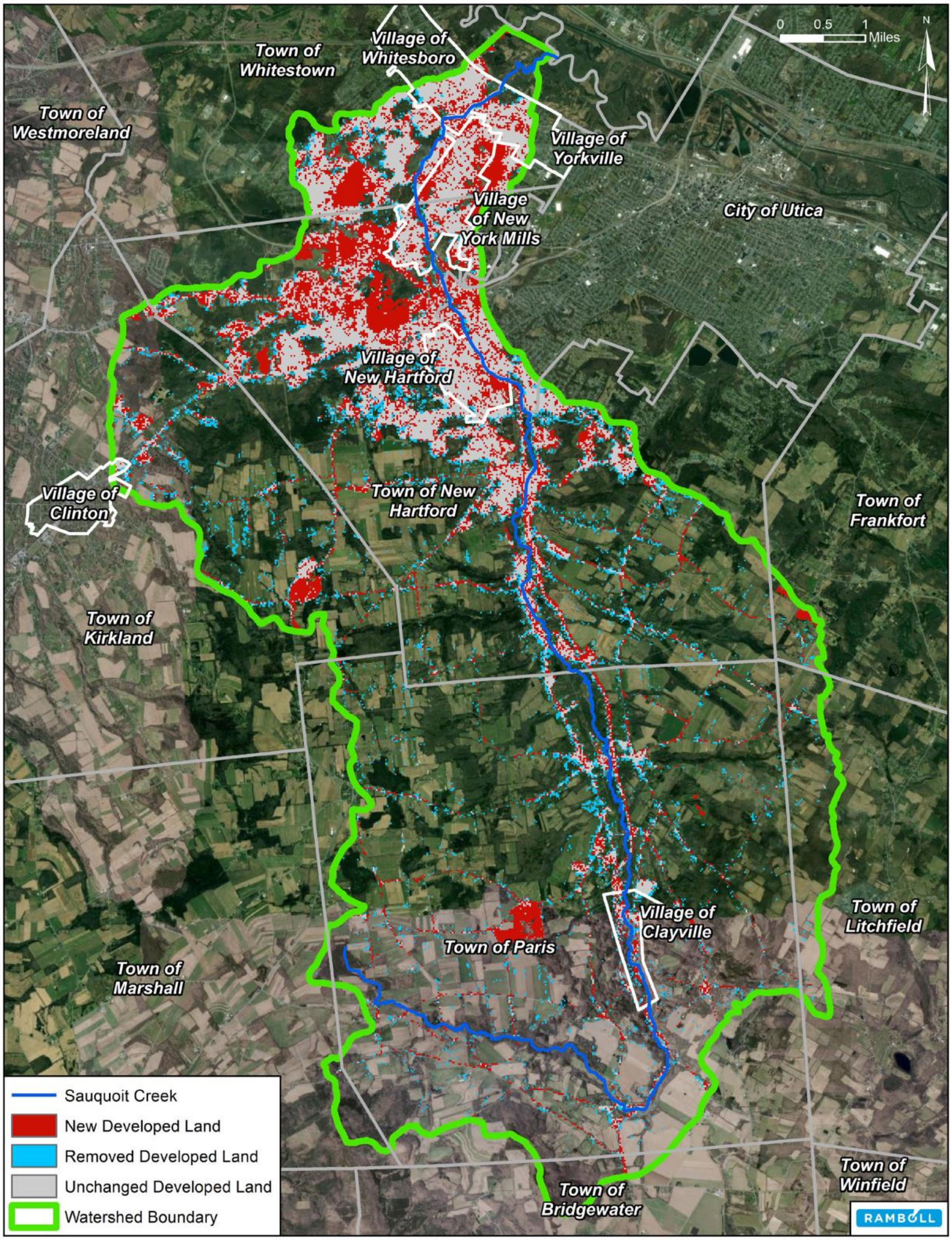

Figure 3-3. Change in developed land cover from 2002 to 2018, Sauquoit Creek Watershed, Oneida County, NY.

3.6 Infrastructure

There are no dams located in the project limits of the upper Sauquoit Creek study area (NYSDEC 2023). Hydraulic structures crossing Sauquoit Creek with no or incomplete existing data were measured using a combination of field surveys and orthoimagery made available by New York State (NYSOITS 2017). Table 5 summarizes the infrastructure data for structures that cross upper Sauquoit Creek. Figure 3-4 displays the locations of the hydraulic structures (i.e., bridges, culverts, and dams) that cross Sauquoit Creek in the project area (NYSDOT 2019; NYSDEC 2023; Ramboll 2020).

Table 5. Summary of Infrastructure Crossings in the Upper Sauquoit Creek Project Area

Source: NYSDOT 2019						
Infrastructure	**Type**	**River Station (ft)**	**Primary Owner**	**State ID**	**Structure Length (ft)**	**Structure Width [1] (ft)**
Genesee Street	Roadway Bridge	271+50	NYSDOT	105207	70	62
NYSWR Corporation (2)	Railroad Bridge	302+00	New York, Susquehanna and Western Railway Corp.	N/A	100	16
Kellogg Road	Roadway Bridge	376+00	Oneida County	3310860	80	52
NY-8 NB	Roadway Bridge	395+00	NYSDOT	1051502	92	30
NY-8 SB	Roadway Bridge	396+50	NYSDOT	1051501	92	30
NYSWR Corporation (3)	Railroad Bridge	397+ 00	New York, Susquehanna and Western Railway Corp.	N/A	106	16
NYSWR Corporation (4)	Railroad Bridge	431+ 00	New York, Susquehanna and Western Railway Corp.	N/A	76	16
Oneida Street	Roadway Bridge	434+ 00	Town of New Hartford	2255320	104	32.5
NYSWR Corporation (5)	Railroad Bridge	431+ 00	New York, Susquehanna and Western Railway Corp.	N/A	75	76
Bleachery Avenue / Newell Lane	Roadway Bridge	471+ 00	Town of New Hartford	2205900	50	25.6
Bleachery Place	Roadway Bridge	479+ 00	Town of New Hartford	N/A	58	15
Private Road	Roadway Bridge	485+00	Removed			
Elm Street	Roadway Bridge	507+50	Town of New Hartford	2205890	74	33
NYSWR Corporation (6)	Railroad Bridge	516+24	New York, Susquehanna and Western Railway Corp.	N/A	70	16

[1] Structure Width for bridges and culverts are measured parallel to creek flow and refers to the curb-to-curb width, which is the minimum distance between the curbs or the railings (if there are no curbs) (NYSDOT 2020).

Figure 3-4. Hydraulic structures crossing Sauquoit Creek within the project area.

3.7 Hydraulic Capacity

Hydraulic capacity is the measure of the amount of water that can pass through a structure or watercourse. Hydraulic design is an essential function of structures in watersheds; exceeding the capacity can result in damages or flooding to surrounding areas and infrastructure (Zevenbergen et al. 2012).

In New York State, hydraulic and hydrologic regulations for bridges and culverts were developed by the NYSDOT. The NYSDOT guidelines require a factor of safety for bridges that cross waterways, known as freeboard. Freeboard is the additional capacity, usually expressed as a distance in feet, in a waterway above the calculated capacity required for a specified flood level, usually the base flood elevation. Freeboard compensates for the many unknown factors that could contribute to flood heights being greater than calculated, such as wave action, minor silt and debris deposits, the hydrological effect of urbanization of the watershed, etc. However, freeboard is not intended to compensate for higher floods expected under future climatic conditions, such as those due to sea-level rise or more extreme precipitation events (NYSDEC 2018).

According to the NYSDOT bridge manual (2019) for Region 2, which includes Oneida County, new and replacement bridges are required to meet certain standards, which include the following (NYSDOT 2019):

- The structure will not raise the water surface elevations anywhere when compared to the existing conditions for both the 2- and 1% Annual Chance Event (ACE) (50- and 100-year flood) flows.
- The proposed low chord shall not be lower than the existing low chord.
- A minimum of 2'-0" of freeboard for the projected 2% ACE (50-year flood) is required for the proposed structure. The freeboard shall be measured at the lowest point of the superstructure between the two edges of the bottom angle for all structures.
- The projected 1% ACE (100-year flood) flow shall pass below the proposed low chord without touching it.
- The maximum skew of the pier to the flow shall not exceed 10°.

The NYSDOT guidelines currently require culverts to be designed based upon an assessment of the likely damage to the highway and adjacent landowners from a given flow, and the costs of the drainage facility. The design flood frequency for drainage structures and channels is typically the 2% (50-year) annual-chance flood hazard for Interstates and other Freeways, Principal Arterials, and Minor Arterials, Collectors, Local Roads, and Streets. If the proposed highway is in an established regulatory floodway or floodplain, then the 1% (100-year) annual chance flood hazard requirement must be checked (NYSDOT 2018).

For this study, hydraulic capacity was determined using the FEMA FIS profile plots to determine which annual exceedance probability (i.e., annual chance) flood events pass successfully through each hydraulic structure crossing upper Sauquoit Creek. Table 6 is a summary of the hydraulic capacity for the infrastructure crossing upper Sauquoit Creek.

Table 6. Summary of Hydraulic Capacity for Infrastructure along the Upper Sauquoit Creek Project Area

Source: FEMA 2013, NYSDOT 2019					
Infrastructure	**Type**	**River Station (ft)**	**Primary Owner**	**State ID**	**Hydraulic Capacity [1] (% Annual Chance)**
Genesee Street	Roadway Bridge	271+50	NYSDOT	105207	0.2%
NYSWR Corporation (2)	Railroad Bridge	302+00	New York, Susquehanna and Western Railway Corp.	N/A	0.2%
Kellogg Road	Roadway Bridge	376+00	Oneida County	3310860	1%
NY-8 NB	Roadway Bridge	395+00	NYSDOT	1051502	0.2%
NY-8 SB	Roadway Bridge	396+50	NYSDOT	1051501	0.2%
NYSWR Corporation (3)	Railroad Bridge	397+ 00	New York, Susquehanna and Western Railway Corp.	N/A	0.2%
NYSWR Corporation (4)	Railroad Bridge	431+ 00	New York, Susquehanna and Western Railway Corp.	N/A	10%
Oneida Street	Roadway Bridge	434+ 00	Town of New Hartford	2255320	10%
NYSWR Corporation (5)	Railroad Bridge	431+ 00	New York, Susquehanna and Western Railway Corp.	N/A	1%
Bleachery Avenue / Newell Lane	Roadway Bridge	471+ 00	Town of New Hartford	2205900	10%
Bleachery Place	Roadway Bridge	479+ 00	Town of New Hartford	N/A	10%
Private Road	Roadway Bridge	485+00	Removed		
Elm Street	Roadway Bridge	507+50	Town of New Hartford	2205890	10%
NYSWR Corporation (6)	Railroad Bridge	516+24	New York, Susquehanna and Western Railway Corp.	N/A	10%

[1] Hydraulic capacity is the measure of the amount of water that can pass through a structure or watercourse. The values listed are based on the FEMA FIS flood profiles for Sauquoit Creek (FEMA 2013).

In addition to hydraulic capacity, bankfull statistics, such as bankfull depth, width, and discharge, were calculated using the USGS *StreamStats* software. *StreamStats* calculates bankfull statistics by using stream survey data and discharge records from 281 cross-sections at 82 streamflow-gaging stations in a linear regression analysis to relate drainage area to bankfull discharge and bankfull-channel width, depth, and cross-sectional area for streams across New York State. These equations are intended to serve as a guide for streams in areas of the same hydrologic region, which contain similar hydrologic, climatic, and physiographic conditions (Mulvihill et al. 2009).

Bankfull discharge is defined as the flow that reaches the transition between the channel and its floodplain. Bankfull discharge is considered to be the most effective flow for moving sediment, forming or removing bars, forming or changing bends and meanders, and generally doing work that results in the average morphological characteristics of channels. Bankfull width refers to the width of the surface of the water at the point where water begins to overtop the banks and enter the floodplain. Bankfull depth is the average vertical distance between the channel bed and the water surface at bankfull (Mulvihill et al. 2009).

The bankfull width and depth are important in understanding the distribution of available energy within the stream channel and the ability of various discharges occurring within the channel to erode, deposit, and move sediment (Rosgen and Silvey 1996). Infrastructure where the bankfull width upstream of the structure exceeds the structure's width are particularly vulnerable to scour and bank de-stabilization. Table 7 displays the bankfull width, depth, and discharge for each hydraulic structure along the upper Sauquoit Creek project area.

Table 7. USGS *StreamStats* Estimated Bankfull Discharge, Width, and Depth

Source: NYSDOT 2013, NYSDOT 2019, USGS 2023a					
Infrastructure	**River Station (ft)**	**Bankfull Width (ft)**	**Bankfull Depth (ft)**	**Bankfull Discharge (cfs)**	**Infrastructure Hydraulic Capacity (ft)[1]**
Genesee Street	271+50	73.4	3.35	1,140	— 3
NYSWR Corporation (2)	302+00	72.4	3.31	1,110	28
Kellogg Road	376+00	68.6	3.17	1,010	11
NY-8 NB	395+00	68.5	3.16	1,000	24
NY-8 SB	396+50	68.5	3.16	1,000	24
NYSWR Corporation (3)	397+ 00	68.5	3.16	1,000	38
NYSWR Corporation (4)	431+ 00	67.1	3.11	964	9
Oneida Street	434+ 00	67.1	3.11	964	37
NYSWR Corporation (5)	431+ 00	65.1	3.03	911	10
Bleachery Avenue / Newell Lane	471+ 00	62.5	3.02	906	— 13
Bleachery Place	479+ 00	62.4	2.93	840	— 4
Private Road	485+00	Removed			
Elm Street	507+50	61	2.87	804	13
NYSWR Corporation (6)	516+24	60	2.83	778	10

[1]Infrastructure Hydraulic Capacity is the difference between the structure length and the bankfull width. The structure fails to meet the hydraulic capacity of the channel if the bankfull width is greater than the structure length (negative values).

Even though these structures may have hydraulic capacity restraints, for any structures owned and maintained by the NYSDOT, a balance between physical constraints and cost versus benefit of replacing existing bridges is often necessary in order to meet NYSDOT bridge design specifications or any future guidelines.

3.8 Hydrologic and Hydraulic (H&H) Model

Hydraulic analysis of Sauquoit Creek was conducted using the USACE Hydrologic Engineering Center River Analysis System (HEC-RAS) program. The HEC-RAS computer program was written by the Hydrologic Engineering Center and is considered the industry standard for riverine flood analysis. HEC-RAS version 6.2 was used for this study (USACE 2022).

HEC-RAS is used to compute water surface profiles for one-dimensional steady flow, one and two-dimensional unsteady flow calculations, sediment transport/mobile bed computations, and water temperature/water quality modeling. In one-dimensional solutions, the water surface profiles are computed from one cross section to the next by solving the one-dimensional St. Venant equation with an iterative procedure (i.e., standard step backwater 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 (USACE 2016).

A 1-D HEC-RAS existing conditions model was developed for this study using the following data and software:

- Oneida County, New York 2-meter LiDAR DEM data with an exposed ground vertical accuracy of 0.6-ft (NYSDEC 2008)
- New York State Digital Orthoimagery Program imagery for Oneida County (NYSOITS 2017)
- National Land Cover Database (NLCD) data (USGS 2019)
- HEC-RAS v6.2 software (USACE 2022)
- RAS Mapper extension in the HEC-RAS v6.2 software (USACE 2022)
- NYSDOT bridge data (NYSDOT 2019)
- Field survey data

Using the LiDAR DEM data, orthoimagery, land cover data, and the RAS Mapper extension in the HECRAS software, the 1-D HEC-RAS existing conditions model was developed using the following methodology:

- LiDAR DEM converted from horizontal North American Datum of 1983 (NAD83) Universal Transverse Mercator (UTM) coordinate system to the New York State Plane Central to convert DEM units from meters to feet;
- Main channel, bank lines, flow paths, and cross-sections, which were drawn along the main channel at stream meanders, contraction/expansion points, and at structures, were digitized using the RAS Mapper extension in the HEC-RAS software;

- LiDAR DEM data, and NLCD land cover data, terrain profiles with elevations, cross-section downstream reach lengths, and Manning's n Values were assigned to each cross-section using built-in tools within the RAS Mapper extension in the HECRAS software;
- Once all features were digitized, assigned, and updated, a 1-D steady flow simulation was performed using USGS *StreamStats* peak discharges in HEC-RAS.

Downstream boundary conditions for the existing and proposed conditions models were assessed using the Normal Depth method. Normal depth is calculated using the friction slope (Sf in Manning's equation), which is the slope of the energy grade line, and can be estimated by measuring the slope of the bed at the downstream reach (USACE 2022). For this model, the slope for the 300-ft immediately downstream of Genesee Street was used and calculated to be 0.004.

Note that stationing references for Sauquoit Creek for Sections 1 and 2 of this report are based on the USGS National Hydrography Dataset (NHD) for Sauquoit Creek (USGS 2021b); however, stationing references for the flood mitigation measures (Section 5) are based on the HEC-RAS model software. While every attempt was made to ensure consistency in the stationing values, the values may differ as a result of the differences in the data sources and methodologies.

3.8.1 Sediment Transport Modeling

For this study, the sediment transport model developed for the *Stream Sediment and Debris Management Plan* (Ramboll 2021) report was used to assess sediment movement in Sauquoit Creek through the study reach. HEC-RAS 1-D sediment transport computations follow the capability of the USACE legacy sediment transport model, HEC-6, very closely. HEC-6 is a 1-D moveable boundary open-channel flow and sediment movement model designed to simulate changes in river profiles due to scour and deposition over fairly long time periods (typically years, but single flood event applications are possible). The sediment transport functions in HEC-RAS compute a transport capacity for each cross section based on the hydrodynamic results (e.g., shear stress, shear velocity, friction slope, velocity, fall velocity, etc.) of the channel (USACE 1995; Gibson et al. 2017).

In the *Stream Sediment and Debris Management Plan* (Ramboll 2021) report, four sediment transport simulations were performed using quasi-unsteady flow for three different annual chance flood events (50-, 10- and 1%) and historical data from the 2019 Halloween Storm. Sediment data was obtained from field survey data and incorporated into the sediment transport model to assign grain sizes, bed gradation, and sediment load boundary conditions. The output results for four variables (invert change, velocity, shear stress, and cumulative mass bed change) were used to assess erosional or depositional characteristics at specific reaches along Sauquoit Creek.

3.8.2 1-D Model Limitations

For this study, a 1-D HECRAS model was developed to model the existing conditions and effectiveness of the proposed mitigation alternatives. USACE usually recommends choosing between 1-D and 2-D modeling on a case-by-case basis, but in general there are certain cases where 1-D models can produce results as good as 2-D models with less effort. Those cases include the following (USACE 2016):

- Rivers and floodplains in which the dominant flow directions and forces follow the general river flow path.
- Steep streams that are highly gravity driven and have small overbank areas.
- River systems that contain a lot of bridges/culvert crossings, weirs, dams and other gated structures, levees, pump stations, etc. (these structures impact the computed stages and flows within the river system).
- Medium to large river systems, where there is modeling of a large portion of the system (100 or more miles), and it is necessary to run longer time period forecasts (i.e., 2-week to 6-month forecasts).
- Areas in which the basic data does not support the potential gain of using a 2-D model (USACE 2016).

Based on the topographic and geomorphic features of the Sauquoit Creek watershed and the recommendations of the USACE for 1-D versus 2-D modeling, the project team concluded the best model for this study was 1-D due to the dominant flow direction/forces following the general flow path and the numerous infrastructure crossings. After developing the 1-D model for Sauquoit Creek, the project team did determine certain limitations in the 1-D model that should be noted. These limitations are included below.

- Potential overflow areas, which are areas where water surface elevation levels (WSELs) exceed the adjacent terrain geometry, were found in one location along upper Sauquoit Creek: the NY-8 and NYSWR crossing in the vicinity of Washington Mills Park. The overflow area is primarily caused by the low sloping terrain adjacent to the railroad and NY-8 embankments.
- The accuracy of a 1-D model in determining WSELs in the overbank areas outside of the main channel diminishes the further away from the main channel the user defines as an overbank area. Portions of the upper Sauquoit Creek watershed, including the areas in the vicinity of Genesee Street and Washington Mills Park, have wide and relatively flat floodplains, which led to relatively wide and distant overbank areas in the 1-D model. A more appropriate analysis of overbank areas would require lateral 2-D storage areas in the overbank parallel to the main channel. This type of analysis should be performed if a project is advanced.
- In general, LiDAR does not capture channel thalweg due to interference and scattering by water of the LiDAR signal. No bathymetric modifications were done to the existing model to correct for this limitation. However, for this study, field survey data was used to modify channel geometry at surveyed locations. For areas in between surveyed locations, the channel geometry was unmodified from the LiDAR DEM and the "error" associated with not modifying these areas can be considered minimal.

The 1-D model results for the existing conditions along upper Sauquoit Creek were compared to both the FEMA FIRM and FIS profile plots and were found to be in agreement with both. Therefore, the results from the proposed flood mitigation alternatives model simulations for this study can be accepted with a high degree of confidence.

3.9 Cost Estimate Analysis

Rough order of magnitude (ROM) cost estimates was prepared for each mitigation alternative. In order to reflect current construction market conditions, a semi-analogous cost estimating procedure was used by considering costs of a recently completed, similar scope construction project performed in Upstate New York. Phase I of the Sauquoit Creek Channel and Floodplain Restoration Project in Whitestown, New York contained many elements similar to those found in the proposed mitigation alternatives.

Where recent construction cost data was not readily available, RSMeans CostWorks 2023 was used to determine accurate and timely information (RSMeans Data Online 2023). Costs were adjusted for inflation and verified against current market conditions and trends.

For mitigation alternatives where increases in bridge sizes were evaluated, bridge size increases were initially analyzed based on 2 feet of freeboard over the base flood elevation for a 1% ACE event. For mitigation alternatives where increases in culvert sizes were evaluated, culvert size increases were initially analyzed based on the NYSDOT highway drainage standards of successfully passing the 2% ACE hazard.

Once the optimal bridge/culvert size was determined, further analyses were completed, including site constraints and constructability. Due to these additional constraints, for some mitigation measures the size necessary to meet existing and/or future freeboard requirements were not feasible. Cost estimates were only performed for projects determined to be constructible and practical.

Infrastructure and hydrologic modifications will require permits and applications to New York State, USACE, and/or FEMA, including construction and environmental permits from the state and accreditation, dam construction/removal, levee construction, Letter of Map Revision (LOMR) applications to FEMA, etc. Application and permit costs were not incorporated in the ROM costs estimates.

In addition, no benefit-cost analyses were performed for any mitigation alternative due to the conceptual nature and preliminary designs of these alternatives, which would require further analysis and engineering to determine the appropriate benefit cost ratios.

It should be noted that all ROM cost estimates are calculated at the time of the study. Cost data is based on current cost estimating data and is subject to change based on economic conditions.

3.10 Bank and Channel Stabilization

Streambank erosion is a natural process that occurs when the forces of flowing water exceed the ability of the soil and vegetation to hold the banks in place. The forces that cause erosion increase during flood events, and most erosion occurs at these times. Loss of streambank and streamside vegetation reduces the resisting forces and makes streambanks more susceptible to erosion. This is often the single greatest contributing factor to harmful or accelerated erosion on small and medium-size streams (GASWCC 2000).

Streambank stabilization measures work either by reducing the force of flowing water, by increasing the resistance of the bank to erosion, or by some combination of both. Generally speaking, there are four approaches to streambank protection: 1) the use of vegetation; 2) soil bioengineering; 3) the use of rock work in conjunction with plants; and 4) conventional bank armoring. Re-vegetation includes seeding and sodding of grasses, seeding in combination with erosion-control fabrics, and the planting of woody vegetation (shrubs and trees). Soil bioengineering systems use woody vegetation installed in specific configurations that offer immediate erosion protection, reinforcement of the soils, and in time a woody vegetative surface cover and root network. The use of rock work in conjunction with plants is a technique which combines vegetation with rock work. Over time, the established vegetation will flourish naturally, without maintenance, and will continue to protect the banks and channel from erosion. Conventional armoring is a fourth technique which includes the use of rock, known as riprap, to protect eroding streambanks.

Streambank stabilization can also play a vital role in flood risk management in areas located in flood prone areas. The magnitude of that risk is a function of the flood hazard, the characteristics of a particular location (i.e., elevation, proximity to the waterway, susceptibility to fast-moving flows, etc.), measures that have been taken to mitigate the potential impact of flooding, the vulnerability of people and property, and the consequences that result from a particular flood event (NRC 2013).

There are two types of engineering strategies to sediment and debris management and flood mitigation: structural and non-structural. Structural adjustments involve two different approaches: hard and soft structures. Hard engineering strategies act as a barrier between the river and the surrounding land where artificial structures are used to change or disrupt natural processes. Soft engineering does not involve building artificial structures but takes a more sustainable and natural approach to managing the potential for erosion, deposition, and flooding by enhancing or protecting a river’s natural features (NRC 2013). Examples of hard engineering strategies include the following (NRC 2013):

- Dams (new construction or restoration)
- Pump Stations
- Engineered Drainage Systems
- Increase Bridge & Culvert Openings
- Levees
- Floodways, Spillways, and Channels

Examples of soft engineering strategies include (USACE 2002; NRCS 2002a; NRC 2013):

- Flood Benches
- Streambank Stabilization and Protection:
    - Live willow staking with some biodegradable soil stabilization
    - Vegetated coir roles
    - Burlap tiers

    - Rootwads with boulders
    - Riprap with live stakes
    - Live fascines
    - Slope softening and vegetation
    - Hardwood tree planting
    - Brush layers
- Sediment Detention Basin/Retention Ponds
- Removal of Debris/Loose Vegetation from Floodplain
- In-channel Obstruction/Barrier Removal (i.e., dams, large debris, etc.)
- Sediment Removal

The purpose of non-structural flood mitigation is to change the way that people interact with the floodplain, minimize flood risk, and aims to move people away from flood-prone areas. Increasing numbers of communities have looked for alternatives to structural flood damage reduction techniques and have instead begun to pursue nonstructural techniques used to reduce flood damages that do not disturb the environment or can lead to environmental restoration. Non-structural flood damage reduction techniques have proven to be extremely viable in alternatives consisting of total non-structural, or a combination non-structural and structural measures. Examples of non-structural flood damage reduction measures are listed below (USACE 2001; NRC 2013).

- Riparian Vegetation Restoration
- Retention Basin and Wetland Management
- Soil and Watershed Promotion Legislation
- Land Use Planning/Ordinances
- Floodproofing Residential/Commercial Properties
- Flood Buyouts
- Flood Monitoring & Warning System
- Community Flood Awareness and Preparedness Programs/Education

4. CLIMATE CHANGE IMPLICATIONS

4.1 Projected Changes in Precipitation Trends and Peak Streamflows

Based on the current future flood projection models, flood magnitudes are expected to increase in nearly all cases in New York State, but the magnitudes vary among regions. In an effort to improve flood resiliency in light of future climate change, New York State passed the Community Risk and Resiliency Act (CRRA) in 2014. In accordance with the guidelines of the CRRA, the NYSDEC released the New York State Flood Risk Management Guidance for Implementation of the Community Risk and Resiliency Act (2018) draft report. In the report, the end of design life multiplier estimates for projected future discharges were the recommended methodology to account for projected climate change trends (NYSDEC 2018).

The end of design life multiplier is described as an adjustment to current peak-flow values by multiplying relevant peak-flow parameters by a factor specific to the expected service life of the structure and geographic location of the project to estimate future peak-flow conditions using the software HEC-RAS (NYSDEC 2018). For Sauquoit Creek, the recommended design-flow multiplier is 20% for an end of design life for a structure between 2025 and 2100 (Burns et al. 2015; NYSDEC 2018). Table 8 provides a summary of the projected future peak stream flows using the USGS *StreamStats* peak discharges and 20% CRRA design multiplier.

In general, climate models are better at forecasting temperature than precipitation and contain some level of uncertainty with their calculations and results. Based on the current future flood projection models, flood magnitudes are expected to increase in nearly all cases in New York State, but the magnitudes vary among regions. Climate model forecasts are expected to improve and as they do, the existing assessment approach can be evaluated and refined further in the future.

Table 8. USGS *StreamStats* Peak Discharges and 20% CRRA Design Multiplier

Source: USGS 2023a										
Flooding Source and Location	**Drainage Area (sq mi)**	**Peak Discharges (cfs)**								
		66.7-percent	**50-percent**	**20-percent**	**10-percent**	**4-percent**	**2-percent**	**1-percent**	**0.2-percent**	**2019 Halloween Storm**
Upstream of railroad (third crossing)	46.3	2,292	2,796	4,176	5,184	6,552	7,596	8,796	11,616	5,723
Upstream of Utica / New Hartford corporate limits	42.2	2,064	2,520	3,768	4,692	5,916	6,864	7,956	10,500	5,216
Upstream of Kellogg Road	37.4	1,836	2,244	3,360	4,176	5,268	6,120	7,080	9,348	4,623
Upstream of railroad (fourth crossing)	33.3	1,608	1,956	2,928	3,636	4,596	5,328	6,168	8,136	4,116
Upstream of Elm Street	28.8	1,392	1,704	2,544	3,168	3,996	4,632	5,364	7,080	3,560

5. MITIGATION STRATEGIES

Based on the FEMA FIS, National Center for Environmental Information (NCEI) storm events database, Cold Regions Research and Engineering Laboratory (CRREL) ice jam database, historical flood reports, and local municipal and stakeholder input, three areas along upper Sauquoit Creek were identified as high-risk flood areas: Brookline Drive in the City of Utica, and Washington Mills Park and Hand Place in the Town of New Hartford.

5.1 Brookline Drive

Brookline Drive is located in the City of Utica, NY upstream of the Genesee Street bridge, specifically between river stations 270+00 and 295+00. Flooding in this area affects numerous residential and commercial properties which are within the FEMA 1% and 0.2% ACE flood areas (Figure 5-1). This reach is also susceptible to sediment aggradation and tree and debris buildup from bank erosion and upstream sources. Aggradation and tree/debris buildup restrict the channel flow area, which can cause water surfaces to rise and potentially overtop banks or back water upstream of structures.

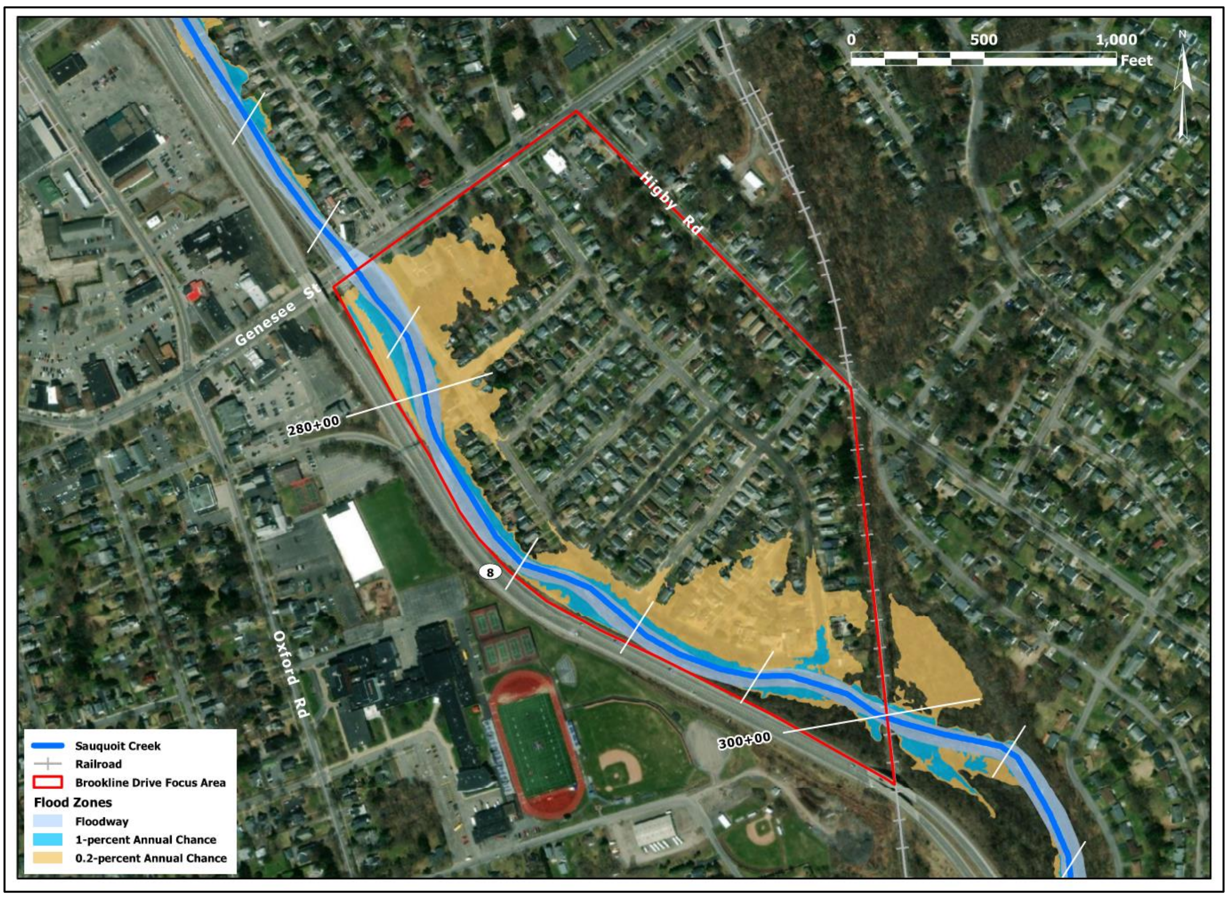

Figure 5-1. Location map for high-risk flood area along Brookline Drive, Utica, NY.

5.1.1 Stream and Channel Restoration Along Brookline Drive

The Sauquoit Creek channel corridor that runs adjacent to Brookline Drive was modified during the construction of a new North-South Arterial highway and realignment of NY-8 between the 1950s and 1970s. The Sauquoit Creek channel was partially channelized with large stone and concrete wall embankments on both banks of the creek. Since the 1970s, the channel within this reach has experienced numerous flood events where bank erosion from both upstream sources and in the Brookline Drive reach has deposited large amounts of sediment and debris in the channel while scouring away and destabilizing the banks (Figure 5-2). As a result, neither the original natural channel geometry nor the one designed by the NYSDOT in the 1970s exists in this reach.

Figure 5-2. Sauquoit Creek channel adjacent to Brookline Drive, Utica, NY.

Natural stream restoration techniques can improve water quality, enhance aesthetic value, improve wildlife habitat and enhance floodplain function. A successful natural stream restoration project requires following a multi-step process to ensure thorough consideration is given to the planning and design stage before any work in the stream corridor occurs. These steps include (Fleming et al. 2017):

- Defining the objectives such as flood control, improving recreation, improving habitat, or reducing bank erosion;
- Assessing the current condition of the stream including noting any downcutting or widening; the amount, type, and condition of bank vegetation; changes in the watershed upstream, or features downstream that are constricting flow;
- Determining the best course of action, which can include re-vegetation plans, riparian buffers, channel and bank stabilization, and other stream redesign and construction projects;

- Constructing the selected stream restoration strategy, which can involve reshaping the stream channel and floodplain, building in-stream structures, protecting the banks, and removing invasive vegetation.

This mitigation strategy proposes restoring the channel of Sauquoit Creek that runs adjacent to Brookline Drive to the original NYSDOT designs from the 1970s and employing the stream restoration techniques discussed to reduce sediment aggradation and flood risk for the residences in the Brookline Drive neighborhood (Figure 5-3).

Figure 5-3. Location map for proposed stream restoration along Brookline Drive, Utica, NY.

By removing sediment and debris within the channel, the cross-sectional flow area would increase allowing a larger volume of water to flow through this reach unobstructed thereby reducing flood risk, while stabilizing the channel banks would make the banks more resistant to erosion and bank failure, which would reduce overall sediment loads in this reach and the lower reaches of Sauquoit Creek. Both of these benefits would reduce flood risk to areas adjacent to Brookline Drive .

The proposed design of this alternative restored the thalweg elevation of Sauquoit Creek along Brookline Drive to the original 1970s NYSDOT design specifications by modifying the channel geometry to match the trapezoidal shape of the DOT designs and the minimum channel elevation. No modifications were made to the channel width since bank failures and erosion over time have increased the channel width beyond the original DOT designs. Table 9 displays the results of the HEC-RAS model simulations for restoring the channel geometry of Sauquoit Creek along Brookline Drive. Figure 5-4 displays the profile plot for the proposed channel restoration scenario. Full model outputs for this alternative can be found in Appendix E.

Table 9. Existing and Future Conditions Results for Restoring the Channel Geometry of Sauquoit Creek in the Vicinity of Brookline Drive

Existing Conditions	**Increased Hydraulic Capacity**
Reduction in Water Surface Elevations	Up to 3.0 feet
Total Length of Benefited Area	4,250 feet
River Stations	255+50 to 280+00
Future Conditions	
Reduction in Water Surface Elevations	Up to 3.1 feet
Total Length of Benefited Area	4,750 feet
River Stations	255+50 to 303+00

The potential benefits of this strategy are limited to the area in the vicinity of Brookline Drive. The primary benefits of restoring the channel geometry of Sauquoit Creek in this reach would be to increase the flow capacity through the bridge structure and help prevent debris and ice from catching on sediment bars and large debris that have accumulated in this reach.

It is important to note that the removal of aggraded sediment and debris alone is not an adequate flood mitigation strategy unless the upstream sources of sediment and debris are addressed. The sources and potential strategies were analyzed to address sediment and debris into Sauquoit Creek in the *Stream Sediment and Debris Management Plan* (2021). The NYSDEC highly recommends that any potential mitigation strategy that includes sediment and/or debris removal address upstream sediment and debris sources.

The ROM cost for this strategy is approximately $2.1 million, which does not include land acquisition costs for survey, appraisal, and engineering coordination.

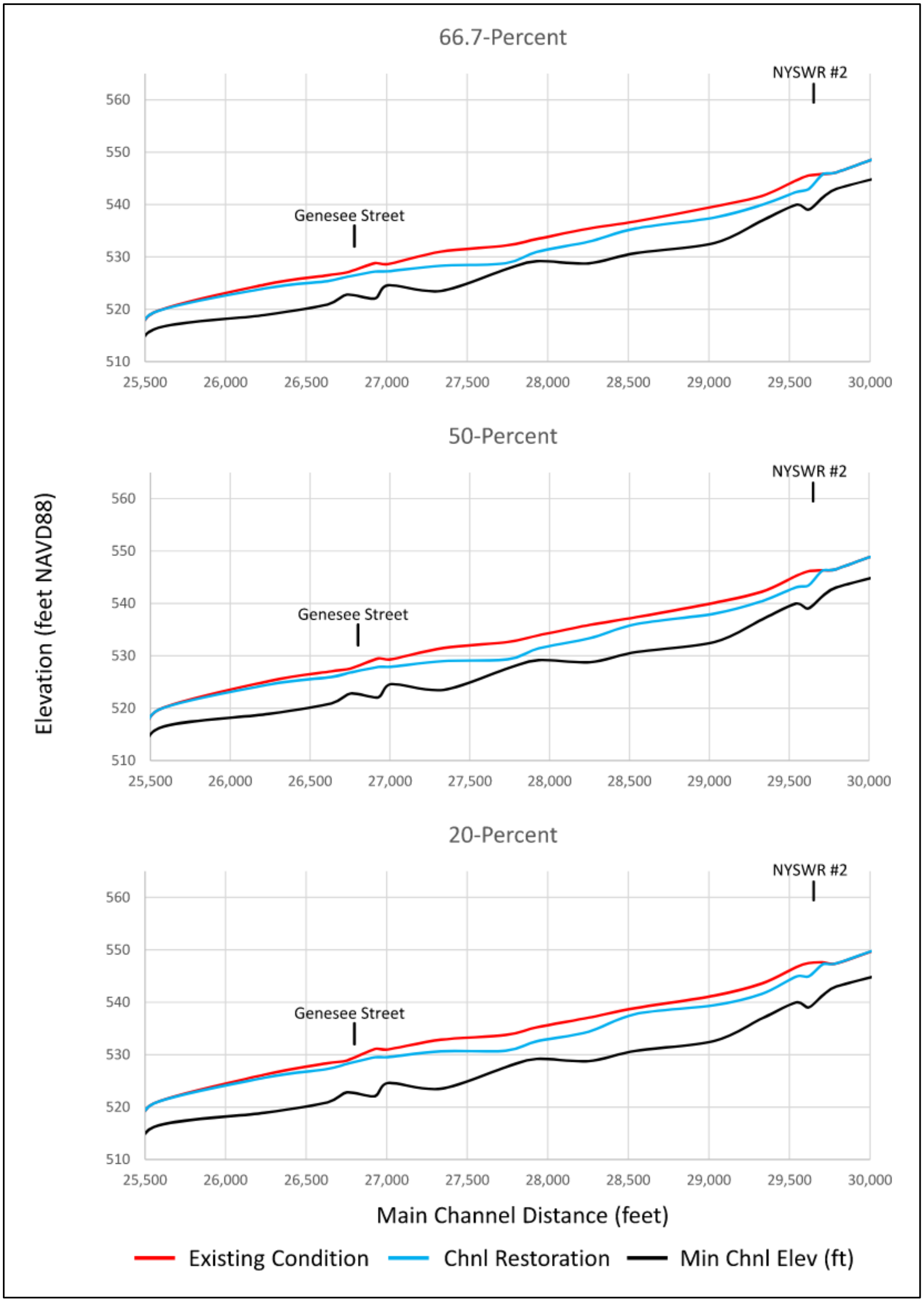

Figure 5-4. HEC-RAS model output for the existing conditions (red) and proposed stream and channel restoration (blue) scenarios.

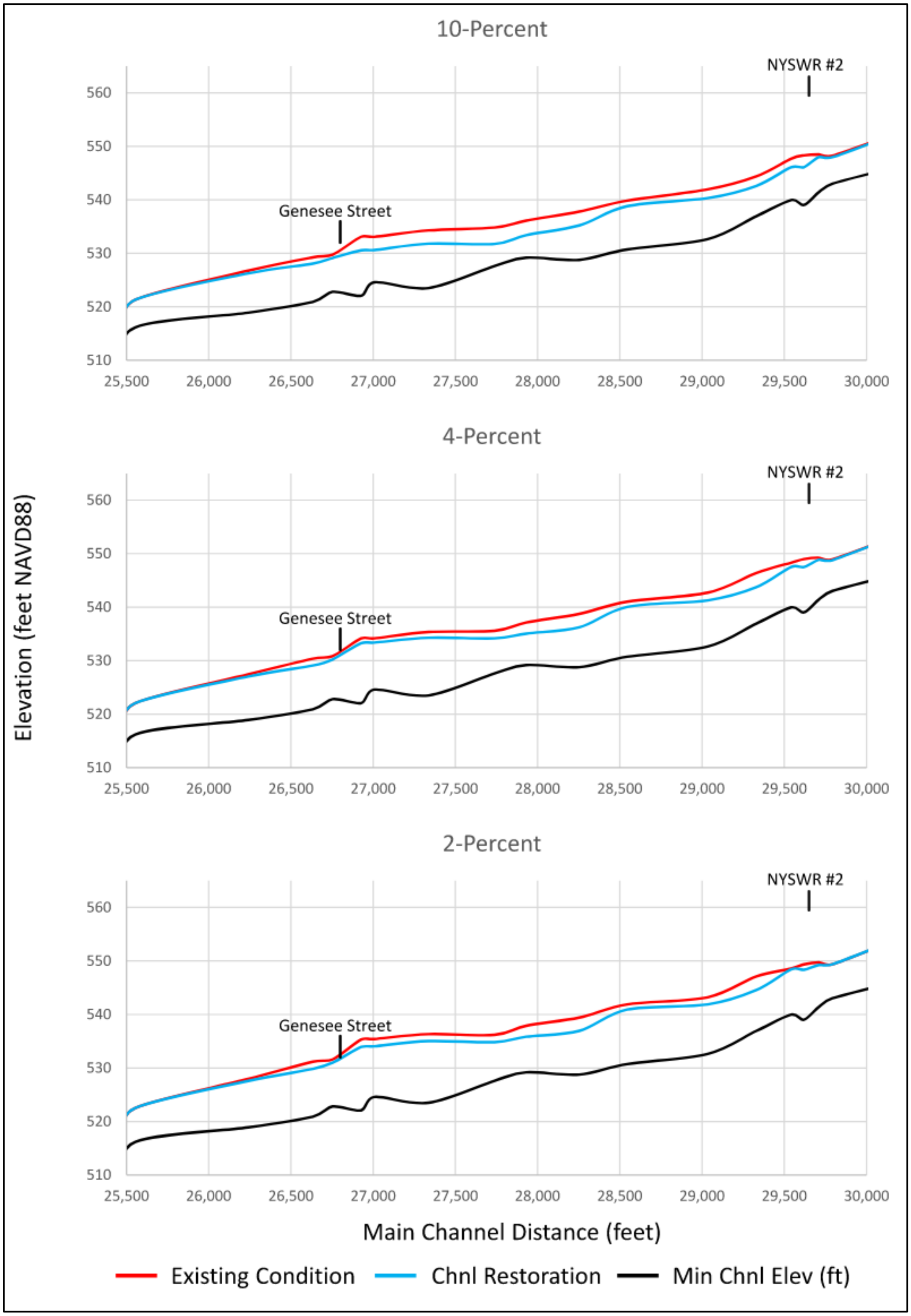

Figure 5-4. (continued) HEC-RAS model output for the existing conditions (red) and proposed stream and channel restoration (blue) scenarios.

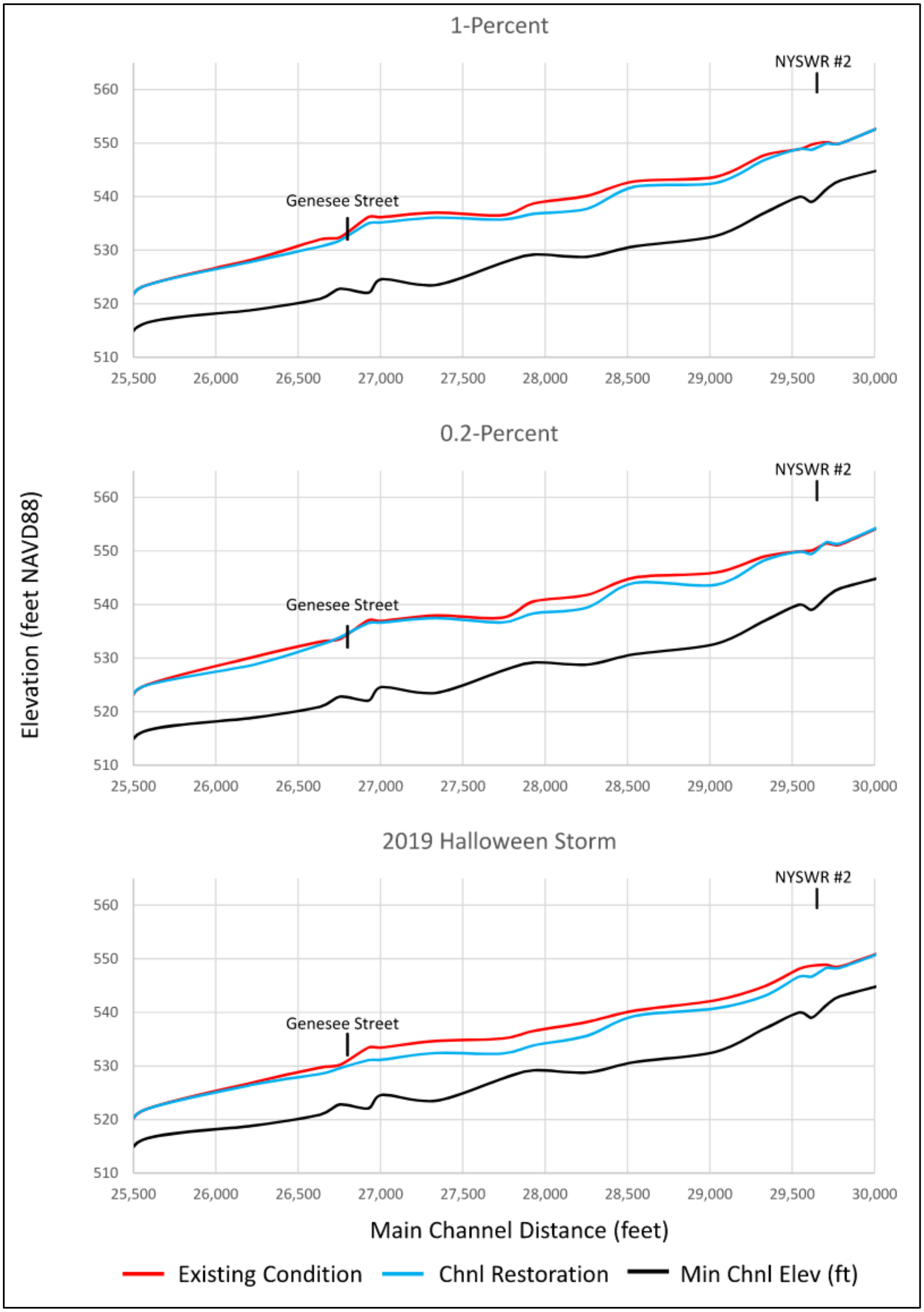

Figure 5-4. (continued) HEC-RAS model output for the existing conditions (red) and proposed stream and channel restoration (blue) scenarios.

5.1.2 Bank and Channel Stabilization

Within a particular reach, sediment fluxes can originate from land surface erosion, streambank erosion, upstream reach sediment input, or remobilization of sediments previously deposited within the reach. Bank and channel erosion is a significant contributor to sediment in a stream or river. The erosion and deposition of sediments within a stream network is highly dependent on the geomorphological features of the stream network (i.e., channel width, flow depth and cross-sectional geometry, bed slope and roughness, and discharge velocity and volume). In general, reaches with smaller cross-sectional flow area, steeper slopes, and higher flow velocities discourage the deposition of sediments, while wider channels with lower bed slopes and flow velocities, act as regions of relative sediment deposition (USEPA 2009).

In order to recommend the most appropriate bank and channel stabilization strategies, engineers and scientists need to have an understanding of how sediment enters, moves through, and exits a stream network. By using sediment transport models, engineers and scientists can quantify and evaluate sediment transport using four key variables: invert change, mass bed change, shear stress, and velocity. Table 10 displays the sediment transport model output for the 10% ACE/24-hour storm for upper Sauquoit Creek in the vicinity of Brookline Drive.

Table 10. HEC-RAS Sediment Transport Model Output for the 10-Percent ACE/24-hours Storm Event

Main Channel Distance (ft)	Invert Change (ft)	Mass Bed Change (ton)	Shear Stress (lb/sq ft)	Velocity (ft/s)
26735	-1.13	-124.65	0.18	2.25
26847	-1.13	-546.06	0.17	2.00
27038	-0.26	-150.56	0.21	2.68
27503	0.06	185.06	3.07	2.80
28092	0.50	911.42	0.14	1.90
28975	-0.37	-438.57	0.52	3.33
29170	0.93	406.61	0.14	2.26
29382	-1.50	-489.95	0.38	2.90
29472	0.54	293.41	0.33	2.36

Table 11 displays the velocity (ft/s) and shear stress (lb/sq ft) from the upper Sauquoit Creek existing conditions model output for the 50-, 20-, and 10% ACE peak discharge in the vicinity of Brookline Drive.

Table 11. Upper Sauquoit Creek HEC-RAS Model Output for the 50-, 20-, and 10-Percent ACE Peak Discharges

Main Channel Distance (ft)	50-Percent ACE		20-Percent ACE		10-Percent ACE	
	Shear Stress (lb/sq ft)	Velocity (ft/s)	Shear Stress (lb/sq ft)	Velocity (ft/s)	Shear Stress (lb/sq ft)	Velocity (ft/s)
26927	0.9	5.3	1.1	6.1	1.0	5.8
27007	1.7	8.6	1.8	8.7	1.2	7.3
27337	0.7	5.7	0.8	6.4	0.7	6.0
27738	1.6	8.6	2.2	10.3	2.2	10.7
27931	1.7	8.8	1.9	9.8	2.0	10.3
28253	1.3	7.9	1.8	9.6	2.2	10.6
28545	1.5	8.1	1.5	8.7	1.6	9.0
29034	1.6	8.7	2.1	10.4	2.5	11.4
29330	2.9	11.5	3.3	12.6	3.6	13.5
29541	1.4	7.9	1.4	8.2	1.4	8.3
29619	0.6	5.4	0.7	6.5	0.9	7.2

Based on the sediment transport, Table 12 summarizes the applicability of potential streambank strategies along Brookline Drive.

Table 12. Potential Streambank Stabilization Strategies for the Brookline Drive Area

Source: NRCS 2009	
Type of Treatment	**Type of Sub-Treatment**
Brush Mattress	Staked only w/rock riprap toe (initial)
	Staked only w/rock riprap toe (grown)
Coir Geotextile Roll	Roll with Polypropylene rope mesh staked and with rock riprap toe
Live Fascine	LF Bundle w/rock riprap toe
Gravel/Cobble	12-inch
Vegetation	Class A turf (ret class)
Soil Bioengineering	Coir roll
	Vegetated coir mat
	Live brush mattress (initial)
	Brush layering (initial/grown)
	Live fascine
	Live willow stakes
Boulder Clusters	Boulder: Very large (>80-inch diameter) *
	Boulder: Large (>40-inch diameter) *
	Boulder: Medium (>20-inch diameter) *
	Boulder: Small (>10-inch diameter)

*Note: These strategies would be applicable for both precipitation (as identified in the sediment transport model) and peak discharge (as identified in the upper Sauquoit Creek model) based velocity and shear stress values.

Due to the variable, conceptual, and site-specific nature of streambank stabilization strategies, no ROM cost estimates were determined for this measure. Additional geomorphic and engineering analyses, including additional modeling (i.e., coupled 1D/2D unsteady flow, 2D unsteady flow and rain-on-grid), would be necessary in order to determine the most appropriate streambank stabilization strategy and its associated costs.

5.1.3 Flood Prone Property Buyout Along Brookline Drive

Buyouts allow state and municipal agencies the ability to purchase developed properties within areas vulnerable to flooding from willing owners. Buyouts are effective management tools in response to natural disasters to reduce or eliminate future losses of vulnerable or repetitive loss properties. Buyout programs include the acquisition of private property, demolition of existing structures, and conversion of land into public space or natural buffers. The land is maintained in an undeveloped state for public use in perpetuity. Buyout programs not only assist individual homeowners, but are also intended to improve the resiliency of the entire community in the following ways (Siders 2013):

- Reduce exposure by limiting the people and infrastructure located in vulnerable areas
- Reduce future disaster response costs and flood insurance payments
- Restore natural buffers such as wetlands in order to reduce future flooding levels
- Reduce or eliminate the need to maintain and repair flood-control structures
- Reduce or eliminate the need for public expenditures on emergency response, garbage collection and other municipal services in the area
- Provide open space for the community

Resilience achieved through buyouts can have real economic consequences in addition to improved social resilience. According to FEMA, voluntary buyouts cost $1 for every $2 saved in future insurance claims, an estimate which does not include money saved on flood recovery and response actions, such as local flood fighting, evacuation and rescue, and recovery expenses that will not be incurred in the future. In order to achieve these goals, buyouts need to acquire a continuous swatch of land, rather than individual homes in isolated areas or only some of the homes within flood-prone areas. A potential negative consequence of buyout programs is the permanent removal of properties from the floodplain, and resulting tax revenue, which would have long-term implications for local governments and should be considered prior to implementing a buyout program (Siders 2013).

Buyout programs can be funded through a combination of federal, state or local funds, and are generally made available following a nationally recognized disaster. FEMA administers programs to help with buyouts under the Stafford Disaster Act, and the Department of Housing and Urban Development (HUD) administers another program through Community Development Block Grants (CDBG). These funding sources can reduce the economic burden on the local community. However, these funds also come with guidelines and regulations that may constrain policy makers' options on whether to pursue a buyout strategy, and how to shape their programs. FEMA funds may be used to cover 75% of the expenses, but the remaining 25% must come from another non-federal source. In most cases, the buyout must be a cost-effective measure that will substantially reduce the risk of future flooding damage (Siders 2013).

In the flood prone neighborhood of Brookline Drive, there are 15 properties on the right bank of Sauquoit Creek that could be purchased and either removed from the floodplain or converted to a multi-purpose natural public area and flood mitigation project (Figure 5-5). The sum of the full market value for all 15 tax parcels is $1,437,248 (NYSOITS 2023). Table 13 summarizes the tax parcel data available for the proposed buyout properties.

Figure 5-5. Flood-prone property buyout tax parcels along Brookline Drive.

Table 13. Tax Parcel Data for Proposed Buyout Properties along Brookline Drive (NYSOITS 2023)

Print Key	Street Number	Street Name	Zip Code	Owner Type	Property Class	Property Description
329.019-1-1	0	Brookline Drive	13501	City of Utica	311	Vacant Land - Residential vacant land
329.019-1-2	16	Brookline Drive	13501	Private	210	Residential - One family year-round residence
329.019-1-3	18	Brookline Drive	13501	Private	210	Residential - One family year-round residence
329.019-1-4	20	Brookline Drive	13501	Private	210	Residential - One family year-round residence
329.019-1-5	22	Brookline Drive	13501	Private	210	Residential - One family year-round residence
329.019-1-6	24	Brookline Drive	13501	Private	210	Residential - One family year-round residence
329.019-1-7	26	Brookline Drive	13501	Private	210	Residential - One family year-round residence
329.019-1-8	28	Brookline Drive	13501	Private	210	Residential - One family year-round residence
329.019-1-9	30	Brookline Drive	13501	Private	210	Residential - One family year-round residence
329.019-1-10	32	Brookline Drive	13501	Private	210	Residential - One family year-round residence
329.019-1-11	34	Brookline Drive	13501	Private	210	Residential - One family year-round residence
329.019-1-12	36	Brookline Drive	13501	Private	210	Residential - One family year-round residence
329.019-1-13	38	Brookline Drive	13501	Private	210	Residential - One family year-round residence
329.019-1-14	40	Brookline Drive	13501	Private	210	Residential - One family year-round residence
329.019-1-15	42	Brookline Drive	13501	Private	210	Residential - One family year-round residence

Due to the variable, conceptual, and site-specific nature of a buyout program, no ROM cost estimates were determined for this measure. Additional engineering and cost-benefit analyses would be necessary in order to determine the most appropriate buyout program strategy and its associated costs.

5.1.4 Flood Prone Property Buyout and Flood Bench Along Brookline Drive

Buyouts allow state and municipal agencies the ability to purchase developed properties within areas vulnerable to flooding from willing owners. Buyouts are effective management tools in response to natural disasters to reduce or eliminate future losses of vulnerable or repetitive loss properties. In the flood prone neighborhood of Brookline Drive, there are 15 properties on the right bank of Sauquoit Creek that could be purchased and converted to a multi-purpose natural public area and flood mitigation project (Table 12). Installing a flood bench would provide additional storage and floodplain width over and above the current storage and width provided by the adjacent developed land, which could potentially reduce damages in the event of flooding and address issues in the Brookline Drive area. One potential flood bench was modeled in the vicinity of Brookline Drive, which is approximately 2.8 acres in size and located between river stations 280+00 to 290+00 (Figure 5-6).

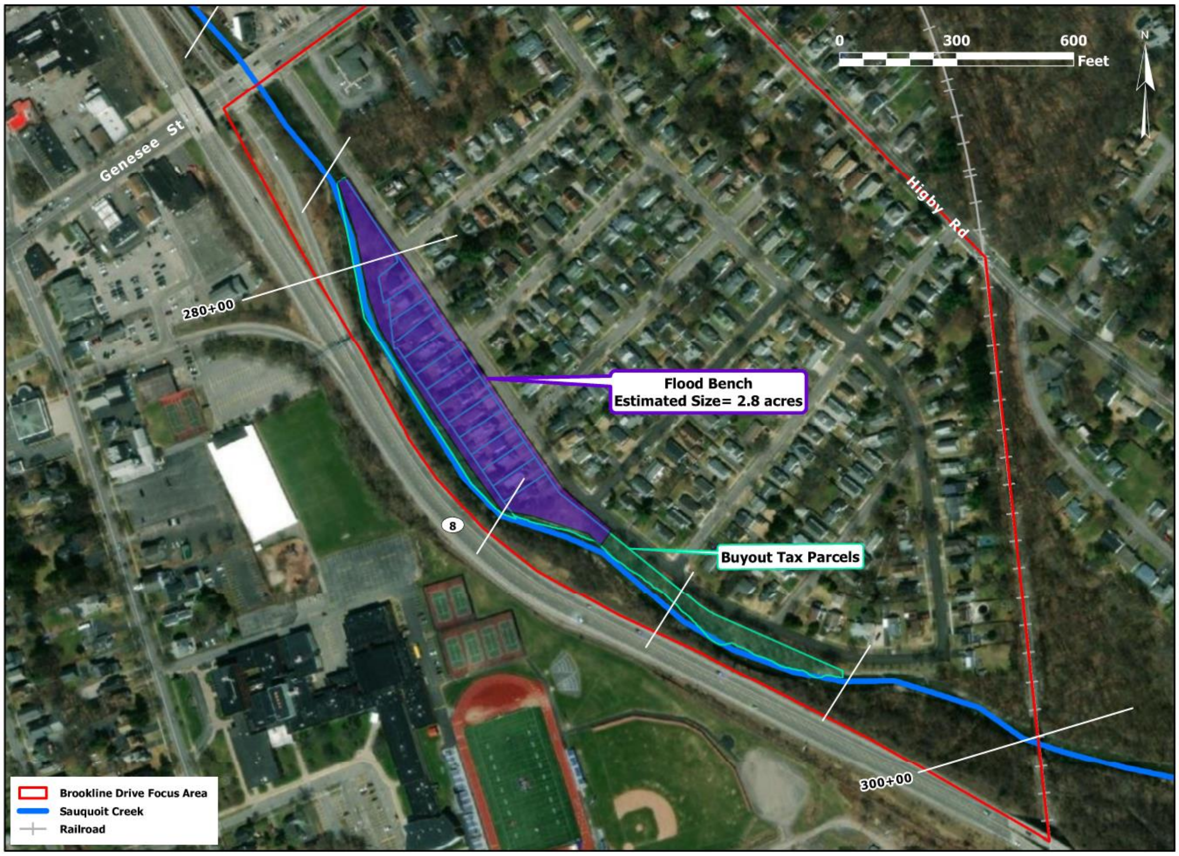

Figure 5-6. Conceptual depiction of flood-prone property buyout and flood bench proposed for the Brookline Drive area.

The flood bench designs used for the proposed condition model simulation set the minimum bench elevation approximately equal to the bankfull elevation, which was an average depth of 6-ft for the flood bench.

The flood bench is within the FEMA designated SFHA or Zone AE, which are areas subject to inundation by the 1% ACE (100-year flood) as determined in the FIS by detailed methods and where base flood elevations are provided (FEMA 2013). Appendix D depicts a flood mitigation rendering of a flood bench illustrating before and after landscape features.

Table 14 outlines the results of the proposed conditions model simulations for the flood bench scenario under existing and future conditions. Figure 5-17 displays the profile plot for the flood bench scenario. Full model outputs for this alternative can be found in Appendix E.

Table 14. Existing and Future Conditions Results for Each Flood Bench Scenario

Existing Conditions	**Flood Bench**
Reduction in Water Surface Elevations	Up to 2.7 feet
Total Length of Benefited Area	1,300 feet
River Stations	277+50 to 290+50
Future Conditions	
Reduction in Water Surface Elevations	Up to 4.1 feet
Total Length of Benefited Area	1,300 feet
River Stations	277+50 to 290+50

Flood benches generally provide flood protection for localized areas in the vicinity of and immediately upstream and/or downstream of the bench. Based on the analysis of the Brookline Drive area, a flood bench located upstream of the Genesee Street bridge would provide significant flood protection in this reach from open-water flooding. For areas that experience significant flood damages or chronic flooding, it is recommended that multiple flood mitigation strategies in conjunction be considered and evaluated by affected communities.

In addition, flood benches can be designed to reduce velocity and shear stress forces in the channel and overbank areas allowing sediment and debris to settle out of the channel water column and deposit in the flood bench. Table 15 displays the velocity (ft/s) and shear stress (lb/sq ft) for the existing and proposed flood bench scenarios at the 10-percent ACE peak discharge.

Table 15. Velocity (ft/s) and Shear Stress (lb/sq ft) values for the existing and proposed flood bench scenarios.

Main Channel Distance (ft)	**Existing Conditions**		**Flood Bench**	
	Shear Stress (lb/sq ft)	**Velocity (ft/s)**	**Shear Stress (lb/sq ft)**	**Velocity (ft/s)**
26927	1.0	5.8	1.0	5.8
27007	1.2	7.3	1.2	7.3
27337	0.7	6.0	0.5	4.8
27738	2.2	10.7	1.0	7.0
27931	2.0	10.3	1.7	9.3
28253	2.2	10.6	1.7	9.2
28545	1.6	9.0	3.2	12.3
29034	2.5	11.4	2.0	10.5
29330	3.6	13.5	3.6	13.5
29541	1.4	8.3	1.4	8.3
29619	0.9	7.2	0.9	7.2

The Rough Order Magnitude cost for this flood bench alternative is $9.5 million. This ROM cost estimate does not include land acquisition costs for survey, appraisal, and engineering coordination. In addition, the NYSDEC will require wetland delineations, an analysis for any endangered and/or threatened species within the proposed project area, and information regarding access during construction for this mitigation alternative.

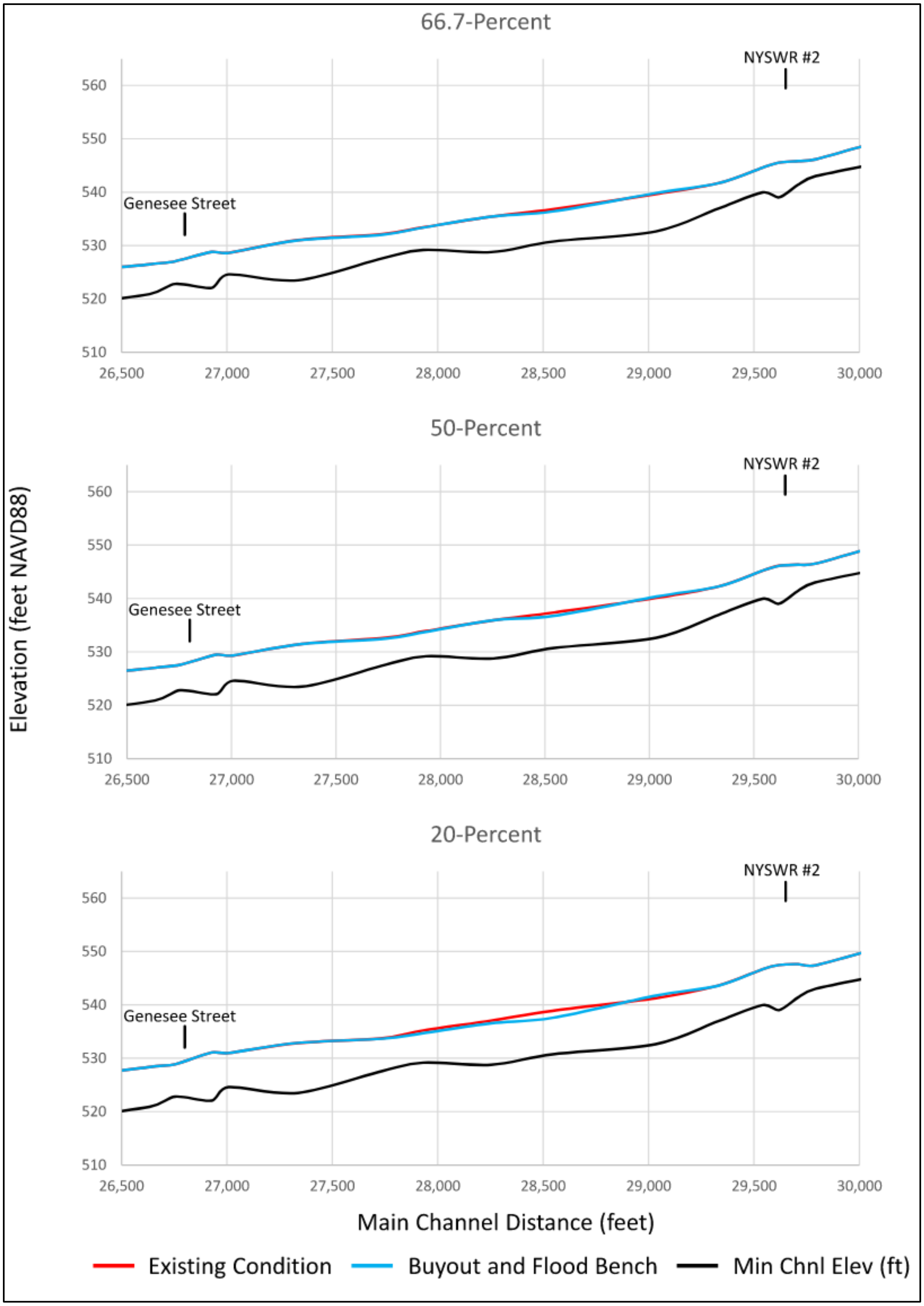

Figure 5-7. HEC-RAS model output for the existing conditions (red) and proposed buyout and flood bench (blue) scenarios.

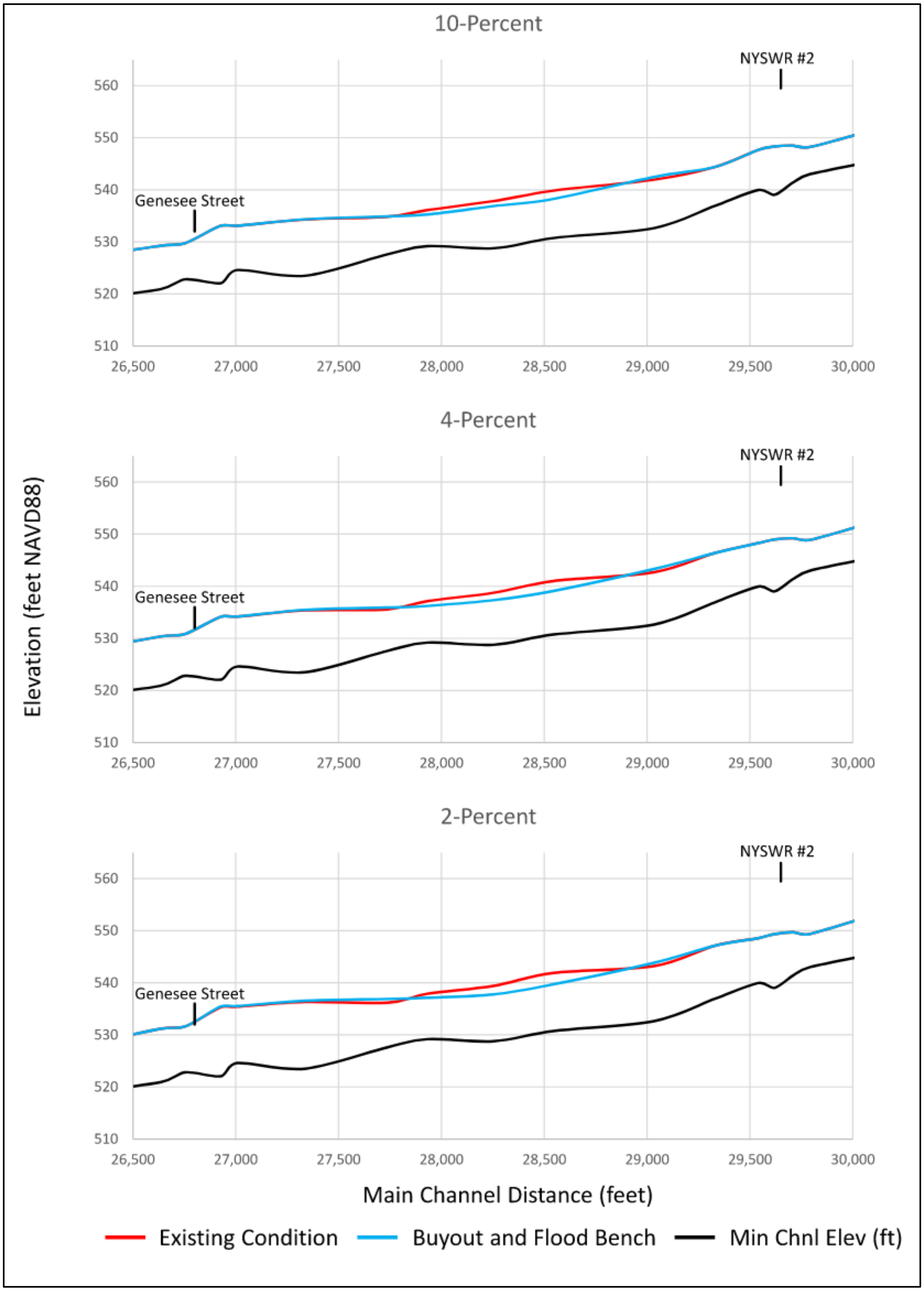

Figure 5-7. (continued) HEC-RAS model output for the existing conditions (red) and proposed buyout and flood bench (blue) scenarios.

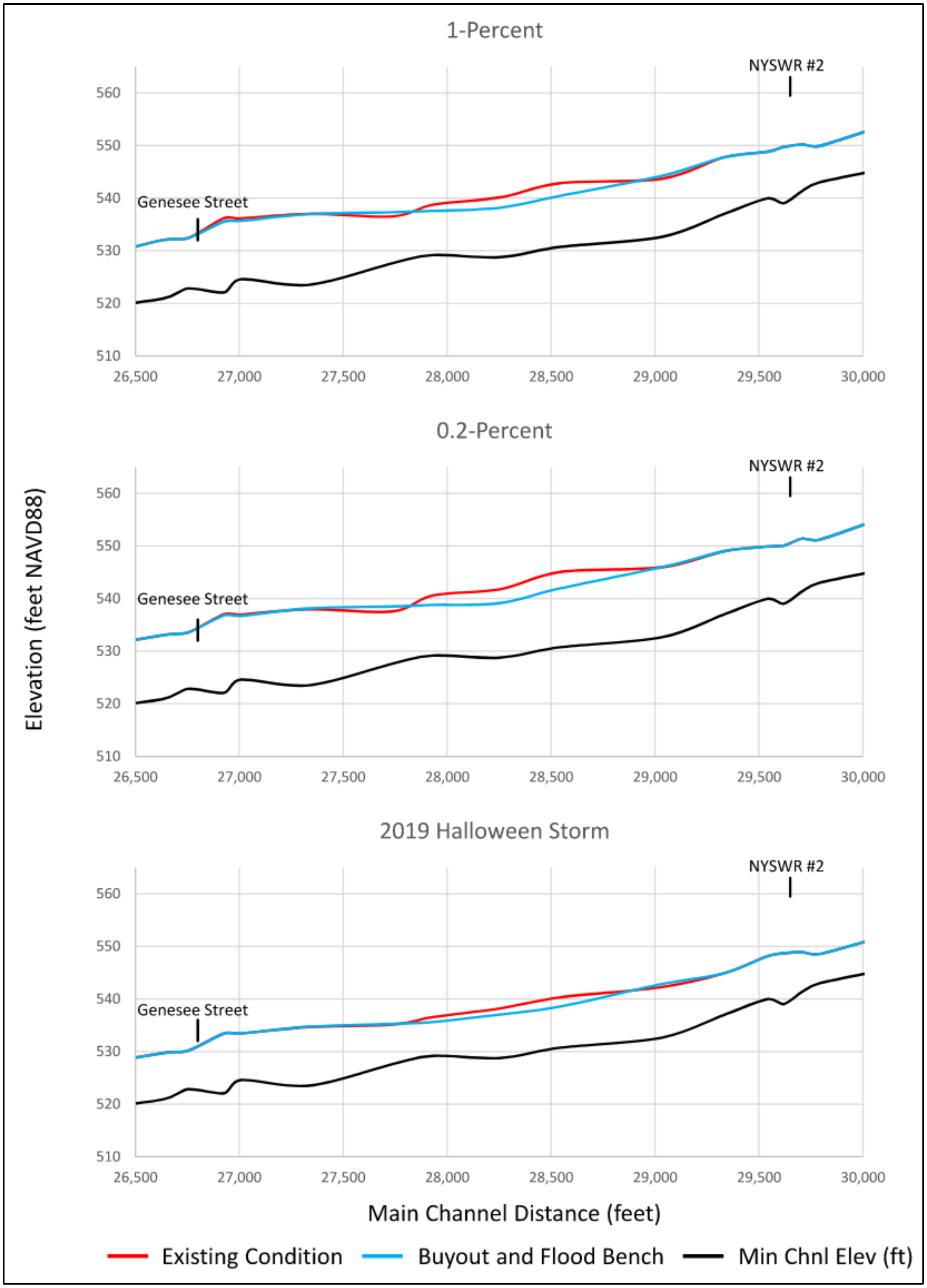

Figure 5-7. (continued) HEC-RAS model output for the existing conditions (red) and proposed buyout and flood bench (blue) scenarios.

5.2 Washington Mills Park

Washington Mills Park is located in the Town of New Hartford, NY between the NY-8 and Oneida Street bridges, specifically between river stations 390+00 and 430+00. Flooding in this area affects the Town Park and nearby publicly-owned facilities, which are within the FEMA 1% and 0.2% ACE flood areas (Figure 5-8). This reach is also susceptible to erosion, bank failures, and sediment aggradation and tree and debris buildup from upstream sources. Aggradation and tree/debris buildup restrict the channel flow area, which can cause water surfaces to rise and potentially overtop banks or back water upstream of structures.

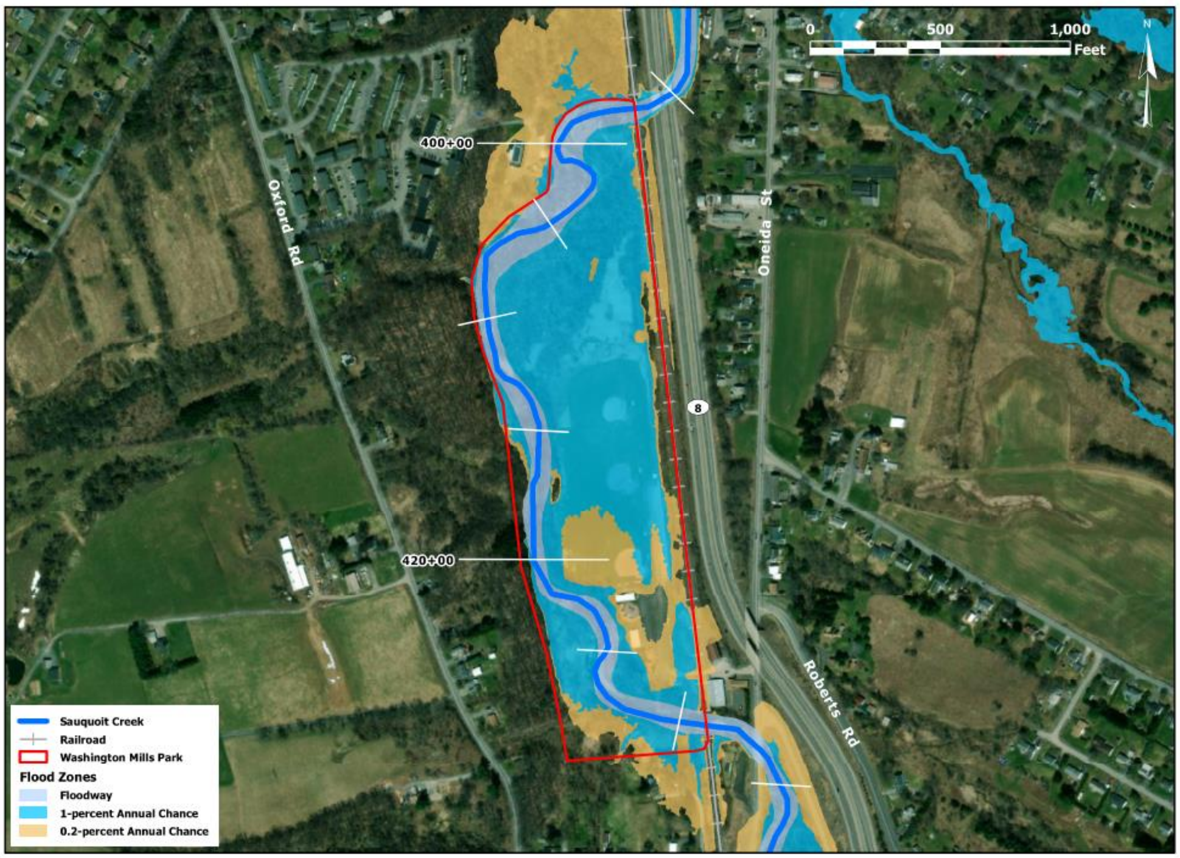

Figure 5-8. Location map for Washington Mills Park high-risk flood area.

5.2.1 Flood Benches

Installing a flood bench would provide additional storage and floodplain width over and above the current storage and width provided by the adjacent undeveloped land and park area, which could potentially reduce damages in the event of flooding and address issues in the Washington Mills Park area.

Three potential flood benches were modeled in the vicinity of the park (Figure 5-9):

- Flood Bench A is approximately 2 acres in size and located between river stations 393+50 to 401+00
- Flood Bench B, which includes Flood Bench A, is approximately 8.5 acres in size and located between river stations 393+50 to 410+50
- Flood Bench C, which includes Flood Benches A and B, is approximately 11 acres in size and located between river stations 393+50 to 413+00

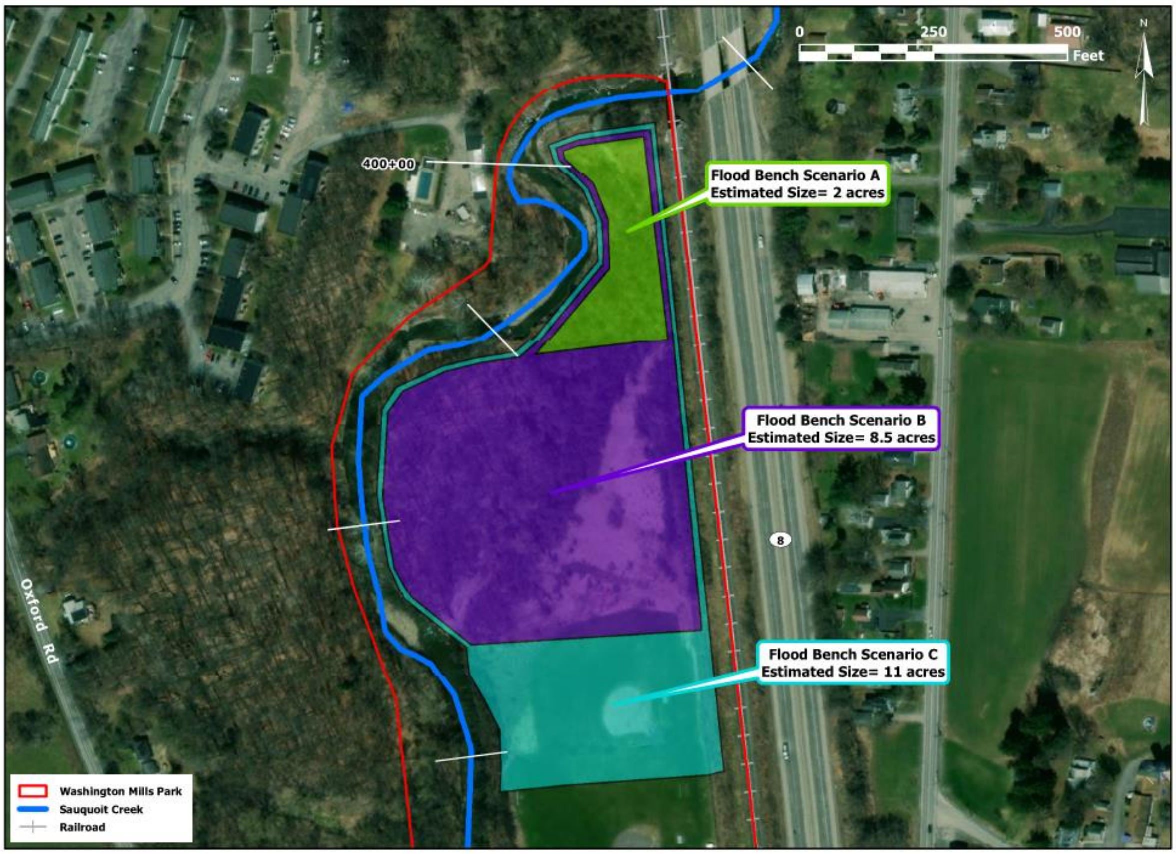

Figure 5-9. Conceptual depiction of flood benches proposed for the Washington Mills Park area.

The flood bench designs used for the proposed condition model simulation set the minimum bench elevation approximately equal to the bankfull elevation, which was an average depth between 2-3 ft for all three benches.

The flood benches are within the FEMA designated SFHA or Zone AE, which are areas subject to inundation by the 1% ACE (100-year flood) as determined in the FIS by detailed methods and where base flood elevations are provided (FEMA 2013). Appendix D depicts a flood mitigation rendering of a flood bench illustrating before and after landscape features.

Table 16 outlines the results of the proposed conditions model simulations for each flood bench scenario under existing and future conditions. Figures 5-10 through 5-12 display the profile plots for each flood bench scenario. Full model outputs for this alternative can be found in Appendix E.

Table 16. Existing and Future Conditions Results for Each Flood Bench Scenario

Existing Conditions	Flood Bench A	Flood Bench B	Flood Bench C
Reduction in Water Surface Elevations	Up to 2.2 feet	Up to 4.2 feet	Up to 4.2 feet
Total Length of Benefited Area	650 feet	1,350 feet	1,975 feet
River Stations	396+00 to 402+50	398+25 to 411+75	398+25 to 418+00
Future Conditions			
Reduction in Water Surface Elevations	Up to 2.2 feet	Up to 4.4 feet	Up to 4.4 feet
Total Length of Benefited Area	650 feet	1,225 feet	1,500 feet
River Stations	396+00 to 402+50	399+50 to 411+75	399+50 to 414+50

Flood benches generally provide flood protection for localized areas in the vicinity of and immediately upstream and/or downstream of the bench. Based on the analysis of the Washington Mills Park area, flood benches located upstream of the NY-8/NYSWR bridges would provide significant flood protection in this reach from open-water flooding. For areas that experience significant flood damages or chronic flooding, it is recommended that multiple flood mitigation strategies in conjunction be considered and evaluated by affected communities.

In addition, flood benches can be designed to reduce velocity and shear stress forces in the channel and overbank areas allowing sediment and debris to settle out of the channel water column and deposit in the flood bench. Table 17 displays the velocity (ft/s) and shear stress (lb/sq ft) for the existing and each proposed flood bench scenario at the 10-percent ACE peak discharge.

Table 17. Velocity (ft/s) and Shear Stress (lb/sq ft) Values for the Existing and Each Proposed Flood Bench Scenario

Main Channel Distance (ft)	Existing Conditions		Flood Bench A		Flood Bench B		Flood Bench C	
	Shear Stress (lb/sq ft)	Velocity (ft/s)	Shear Stress (lb/sq ft)	Velocity (ft/s)	Shear Stress (lb/sq ft)	Velocity (ft/s)	Shear Stress (lb/sq ft)	Velocity (ft/s)
39332	0.9	6.7	0.9	6.7	0.9	6.7	0.9	6.7
39371	0.2	3.2	0.1	2.3	0.1	2.3	0.1	2.3
39599	0.4	4.5	0.1	1.8	0.1	1.8	0.1	1.8
39826	0.6	5.5	0.2	3.1	0.2	3.1	0.2	3.1
39909	2.6	11.5	1.0	6.9	1.0	6.9	1.0	6.9
40068	0.4	4.9	0.2	3.0	0.2	3.0	0.2	3.0
40250	2.7	11.0	2.7	11.0	1.8	8.3	1.8	8.3
40393	2.1	9.7	2.1	9.7	1.2	6.5	1.2	6.5
40556	0.7	5.8	0.7	5.8	0.3	3.5	0.3	3.5
40687	0.1	2.2	0.1	2.2	0.9	4.7	0.9	4.7
40847	0.1	1.6	0.1	1.6	0.3	2.9	0.3	2.9
41040	0.4	3.7	0.4	3.7	1.1	6.0	1.0	5.9

The Rough Order Magnitude cost for each flood bench alternative is:

- Flood Bench A: $2.0 million
- Flood Bench B: $5.8 million
- Flood Bench C: $6.3 million

These ROM cost estimates do not include land acquisition costs for survey, appraisal, and engineering coordination. In addition, the NYSDEC will require wetland delineations, an analysis for any endangered and/or threatened species within the proposed project area, and information regarding access during construction for this mitigation alternative.

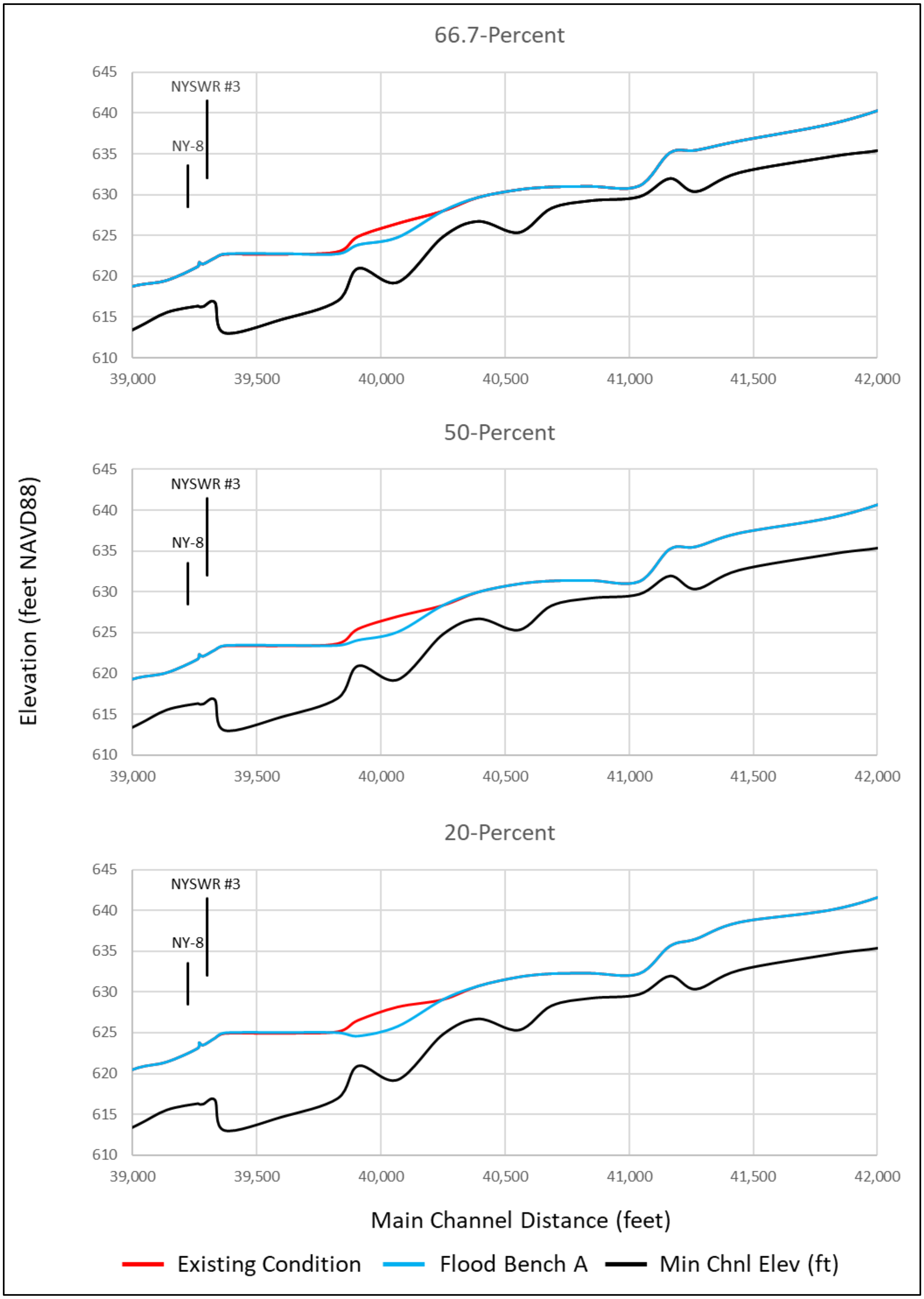

Figure 5-10. HEC-RAS model output for the existing conditions (red) and proposed Flood Bench A (blue) scenarios.

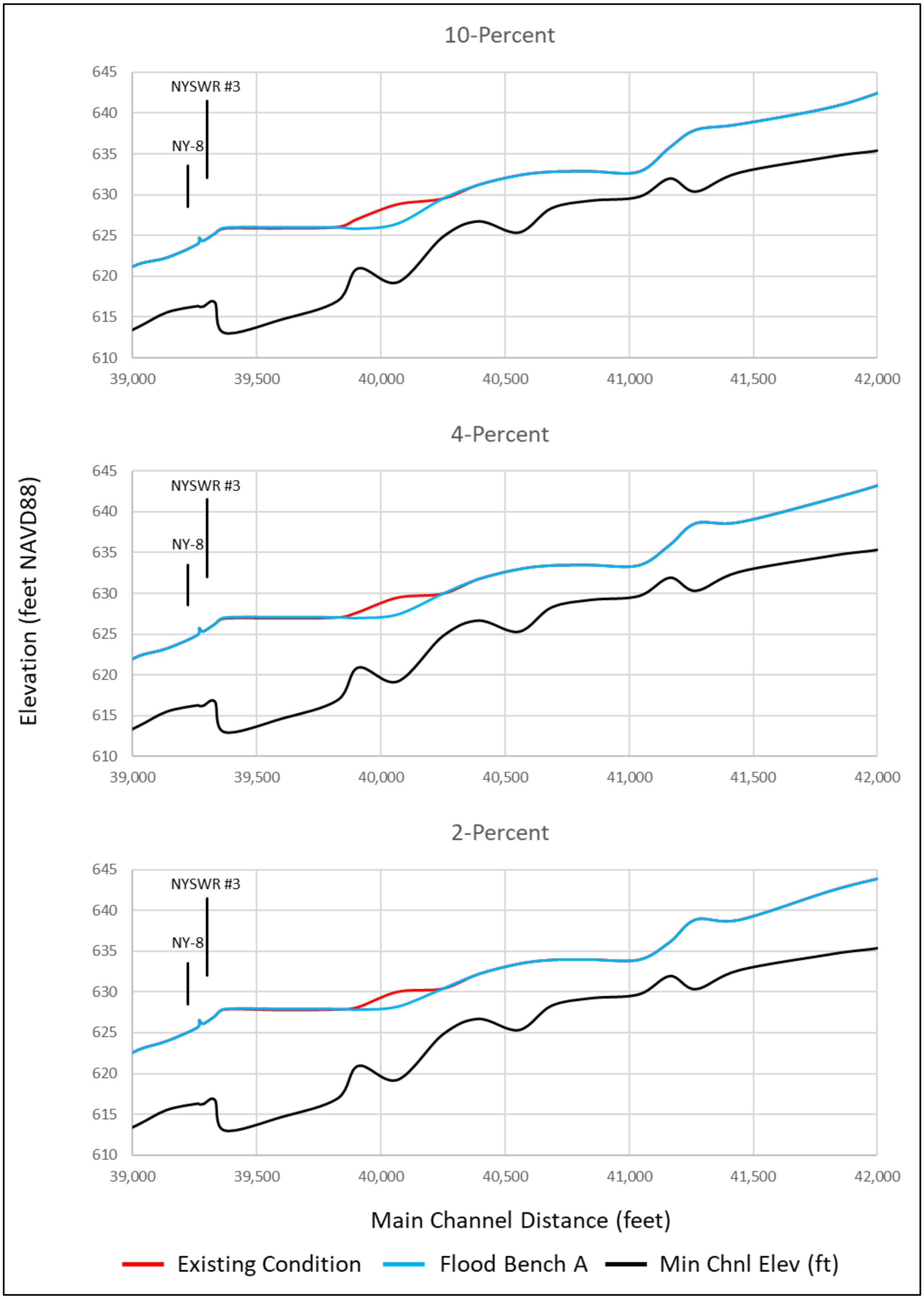

Figure 5-10. (continued) HEC-RAS model output for the existing conditions (red) and proposed Flood Bench A (blue) scenarios.

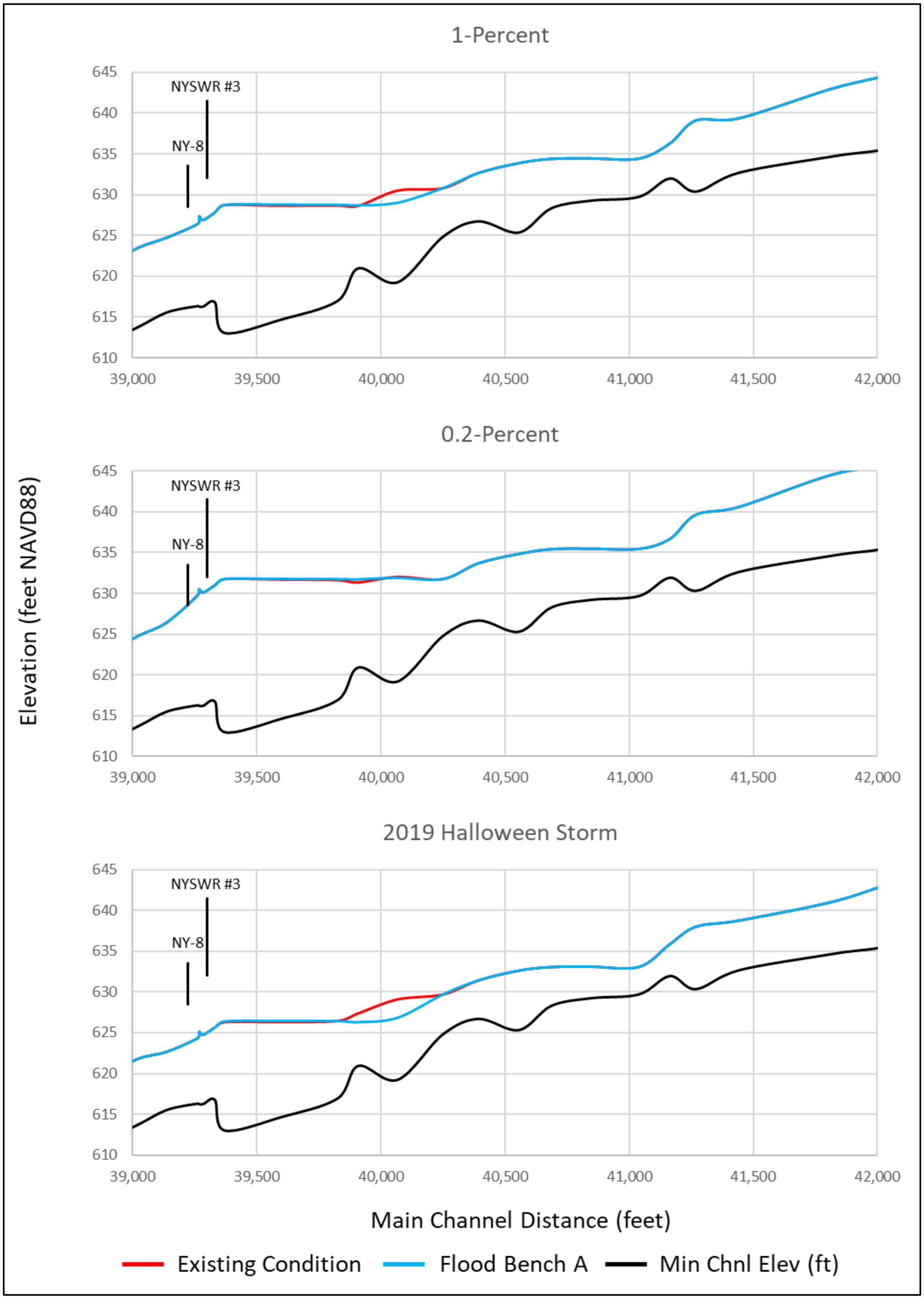

Figure 5-10. (continued) HEC-RAS model output for the existing conditions (red) and proposed Flood Bench A (blue) scenarios.

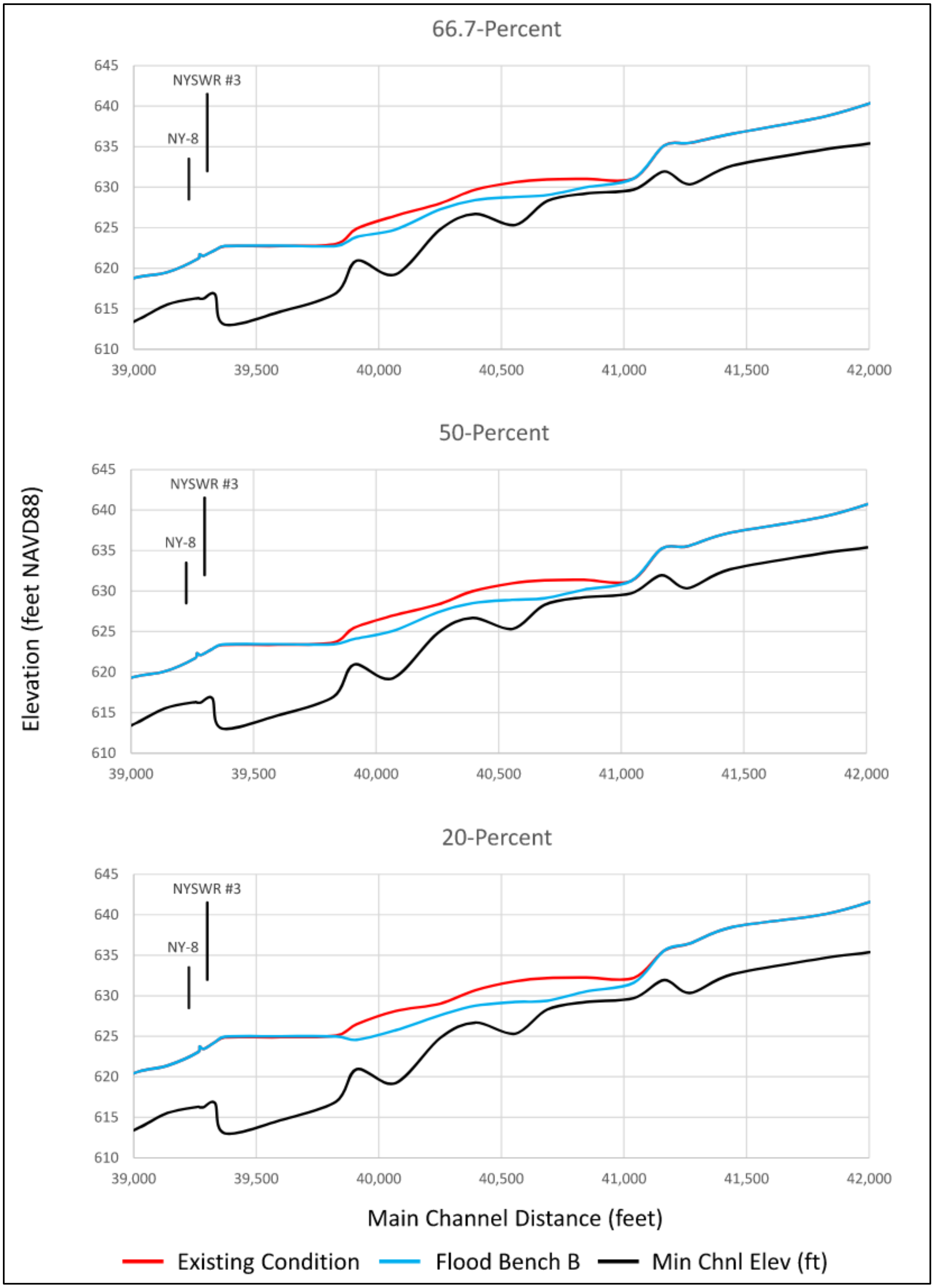

Figure 5-11. HEC-RAS model output for the existing conditions (red) and proposed Flood Bench B (blue) scenarios.

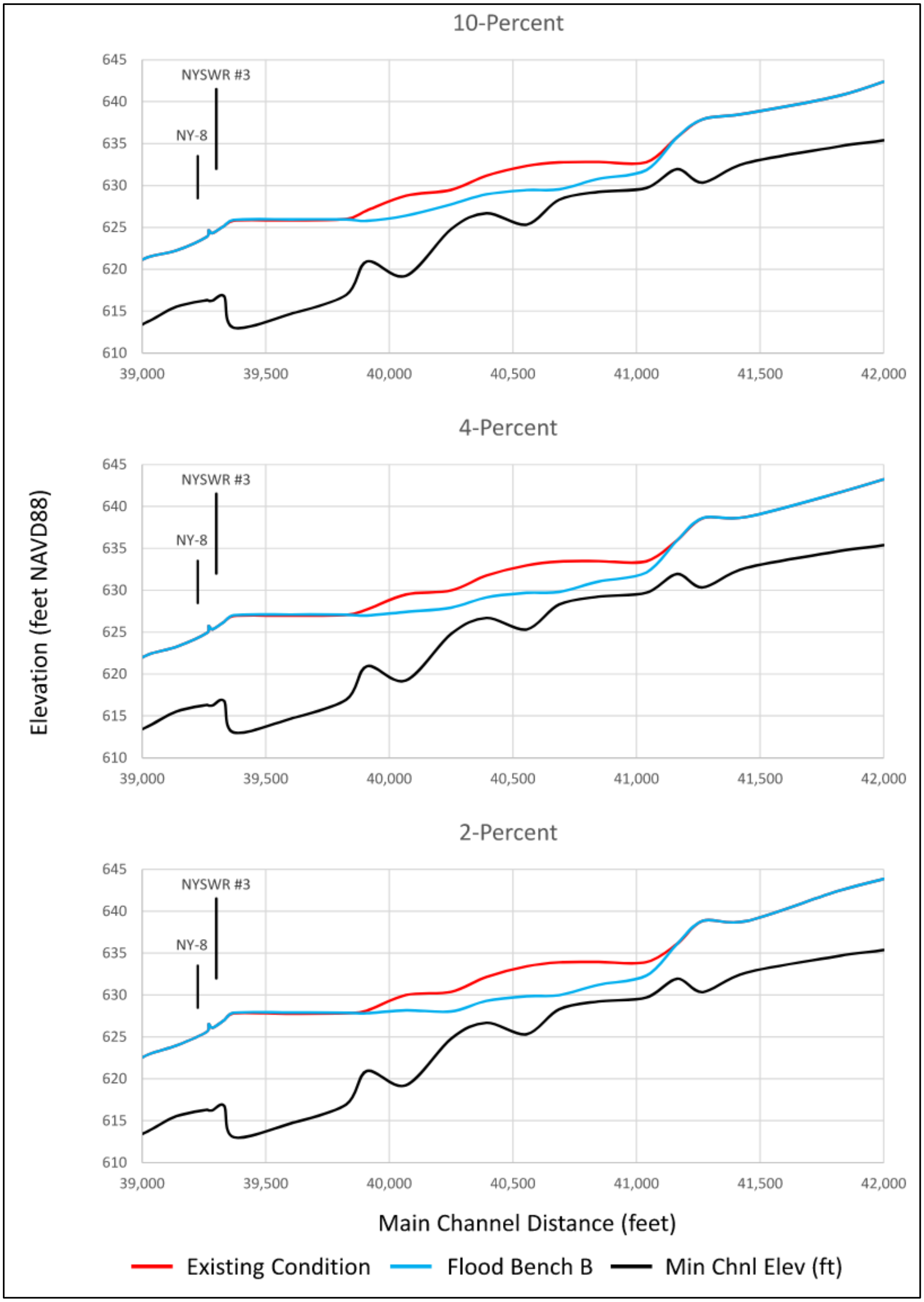

Figure 5-11. (continued) HEC-RAS model output for the existing conditions (red) and proposed Flood Bench B (blue) scenarios.

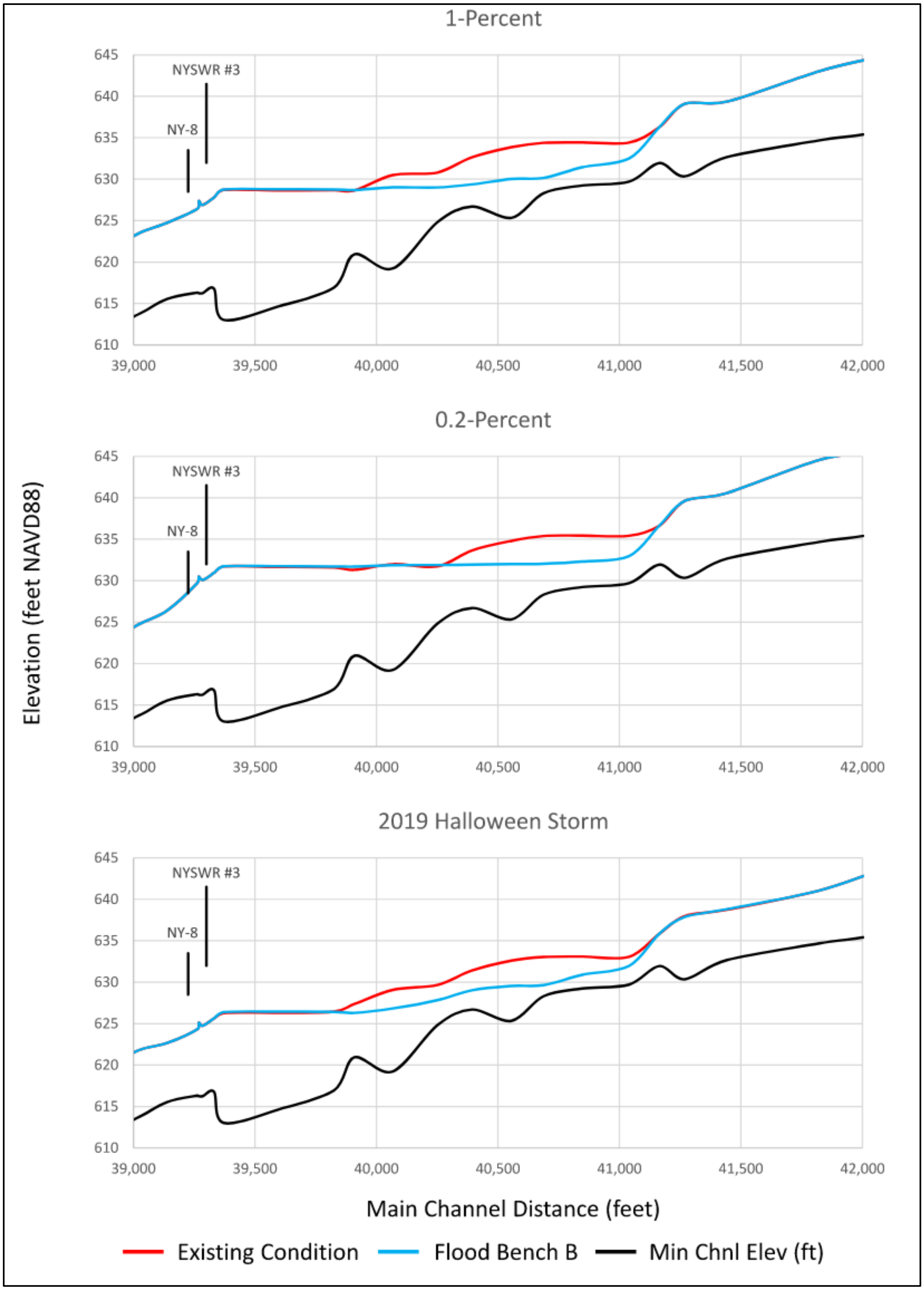

Figure 5-11. (continued) HEC-RAS model output for the existing conditions (red) and proposed Flood Bench B (blue) scenarios.

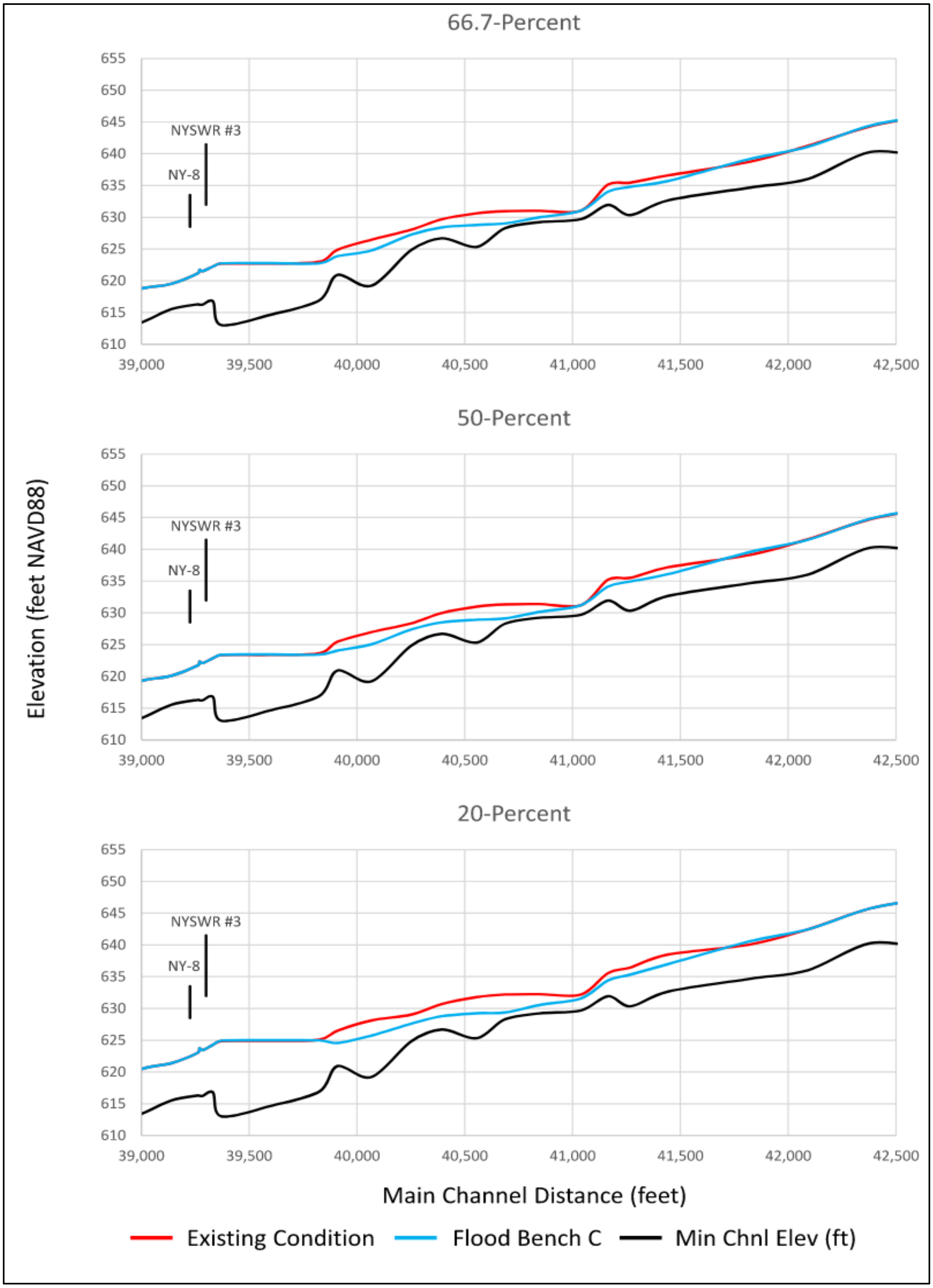

Figure 5-12. HEC-RAS model output for the existing conditions (red) and proposed Flood Bench C (blue) scenarios.

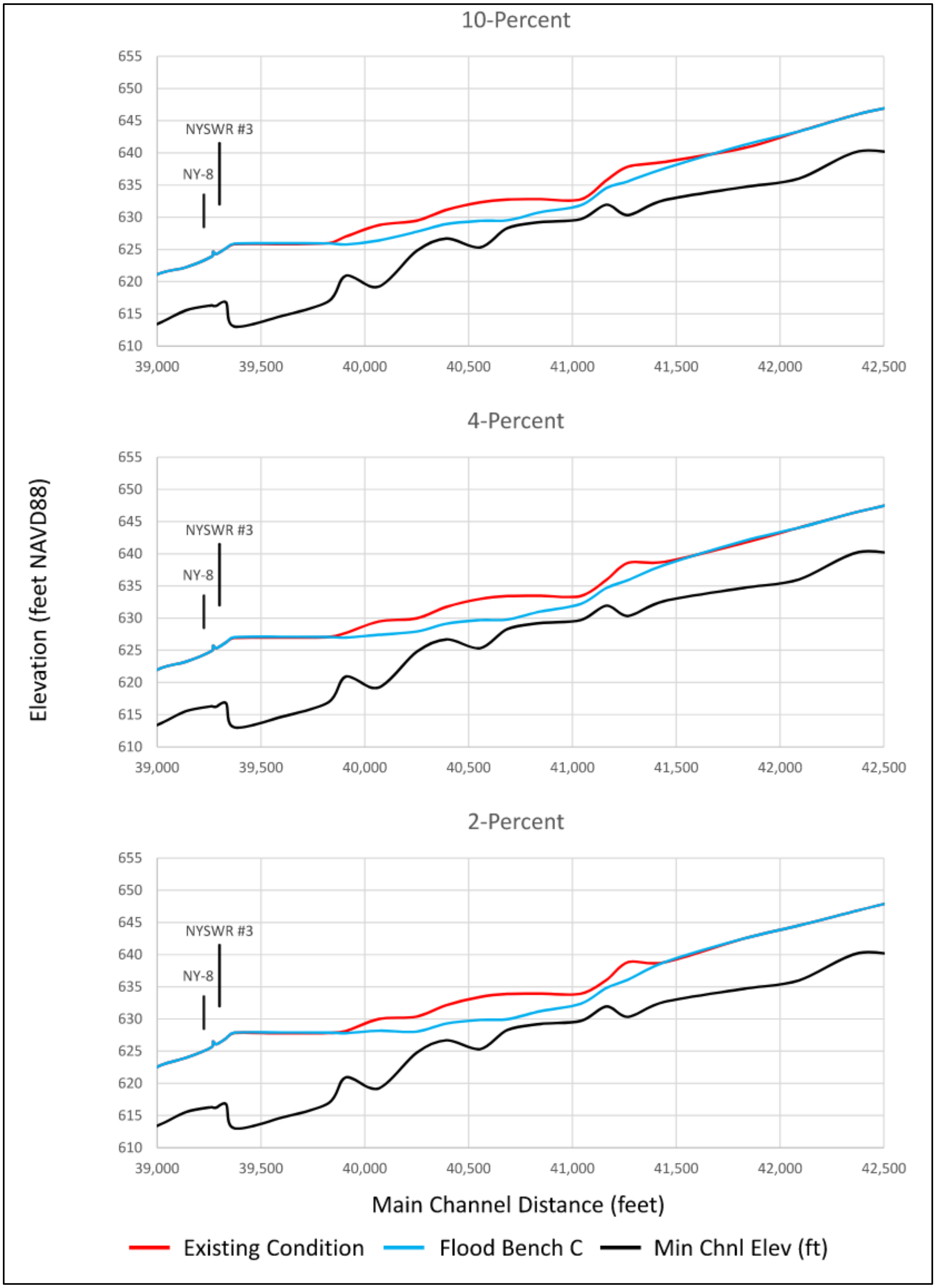

Figure 5-12. (continued) HEC-RAS model output for the existing conditions (red) and proposed Flood Bench C (blue) scenarios.

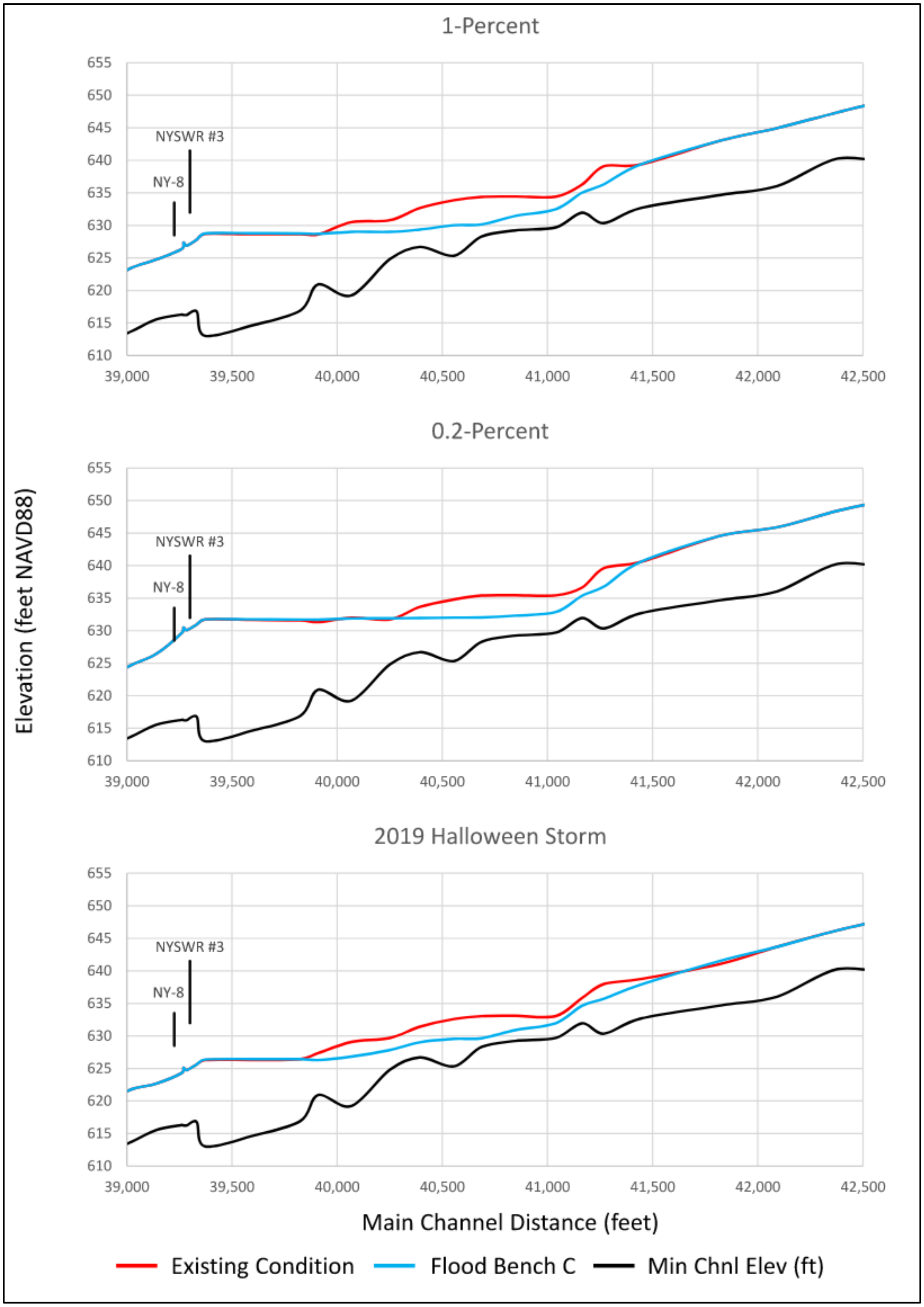

Figure 5-12. (continued) HEC-RAS model output for the existing conditions (red) and proposed Flood Bench C (blue) scenarios.

5.2.2 Increase Hydraulic Capacity of the NYSWR #4 Bridge

This measure is intended to address issues in the vicinity of Hand Place by increasing the width of the NYSWR #4 bridge opening, which would increase the cross-sectional flow area of the channel located at river station 427+50. The bridge is owned by the New York, Susquehanna and Western Railway Corporation and has no pier in the channel. The existing bridge structure has a bridge span of 76 ft and a width of 16 ft (Figure 5-13). The flooding in the vicinity of the NYSWR #4 bridge poses a flood-risk threat to nearby residential properties and publicly-owned infrastructure. Appendix D depicts a flood mitigation rendering of a bridge widening scenario.

Figure 5-13. New York, Susquehanna and Western Railway Corp. #4 Bridge, New Hartford, NY.

The FEMA FIS for the New York, Susquehanna and Western Railway Corporation Bridge is able to successfully pass the 10-, 2-, 1-, or 0.2% ACE without significant backwater upstream the of the bridge (FEMA 2013). However, the FEMA FIRM displays significant backwater upstream of the NYSWR #4 bridge crossing (FEMA 2013).

By increasing the cross-sectional area of the existing bridge structure, the cross-sectional flow area of the channel would increase and the potential for sediment, debris, and ice to accumulate or catch on the upstream face of the bridge would be reduced, thereby reducing flood risk to areas adjacent to and immediately upstream of the bridge.

The proposed design for this alternative increased the hydraulic capacity of the NYSWR #4 bridge by removing the sediment and debris that has aggraded and accumulated at the base of the bridge. The design proposes the removal of approximately 10,600 cubic feet of sediment and debris in the vicinity and at the base of the NYSWER #4 bridge. Table 18 displays the results of the HEC-RAS model simulations for increasing the hydraulic capacity of the NYSWR#4 bridge.

Figure 5-14 displays the profile plot for the proposed increased hydraulic capacity scenario. Full model outputs for this alternative can be found in Appendix E.

Table 18. Existing and Future Conditions Results for Increasing the Hydraulic Capacity of the NYSWR #4 Bridge

Existing Conditions	**Increased Hydraulic Capacity**
Reduction in Water Surface Elevations	Up to 3.1 feet
Total Length of Benefited Area	500 feet
River Stations	426+50 to 431+50
Future Conditions	
Reduction in Water Surface Elevations	Up to 3.0 feet
Total Length of Benefited Area	500 feet
River Stations	426+50 to 431+50

The potential benefits of this strategy are limited to the area in the immediate vicinity of the NYSWR #4 bridge due to the close proximity of the Oneida Street bridge, which acts to constrict flow upstream. The primary benefits of increasing the hydraulic capacity of the bridge would be to increase the flow capacity through the bridge structure, reduce the potential of backwater from high-flow events, and help prevent debris and ice from catching on the structure and sediment bars at the base of the structure.

It is important to note that the removal of aggraded sediment and debris alone is not an adequate flood mitigation strategy unless the upstream sources of sediment and debris are addressed. Ramboll analyzed the sources and potential strategies to address sediment and debris into Sauquoit Creek in the *Stream Sediment and Debris Management Plan* (2021). The NYSDEC highly recommends that any potential mitigation strategy that includes sediment and/or debris removal address upstream sediment and debris sources.

The ROM cost for this strategy is approximately $1.1 million, which does not include land acquisition costs for survey, appraisal, and engineering coordination.

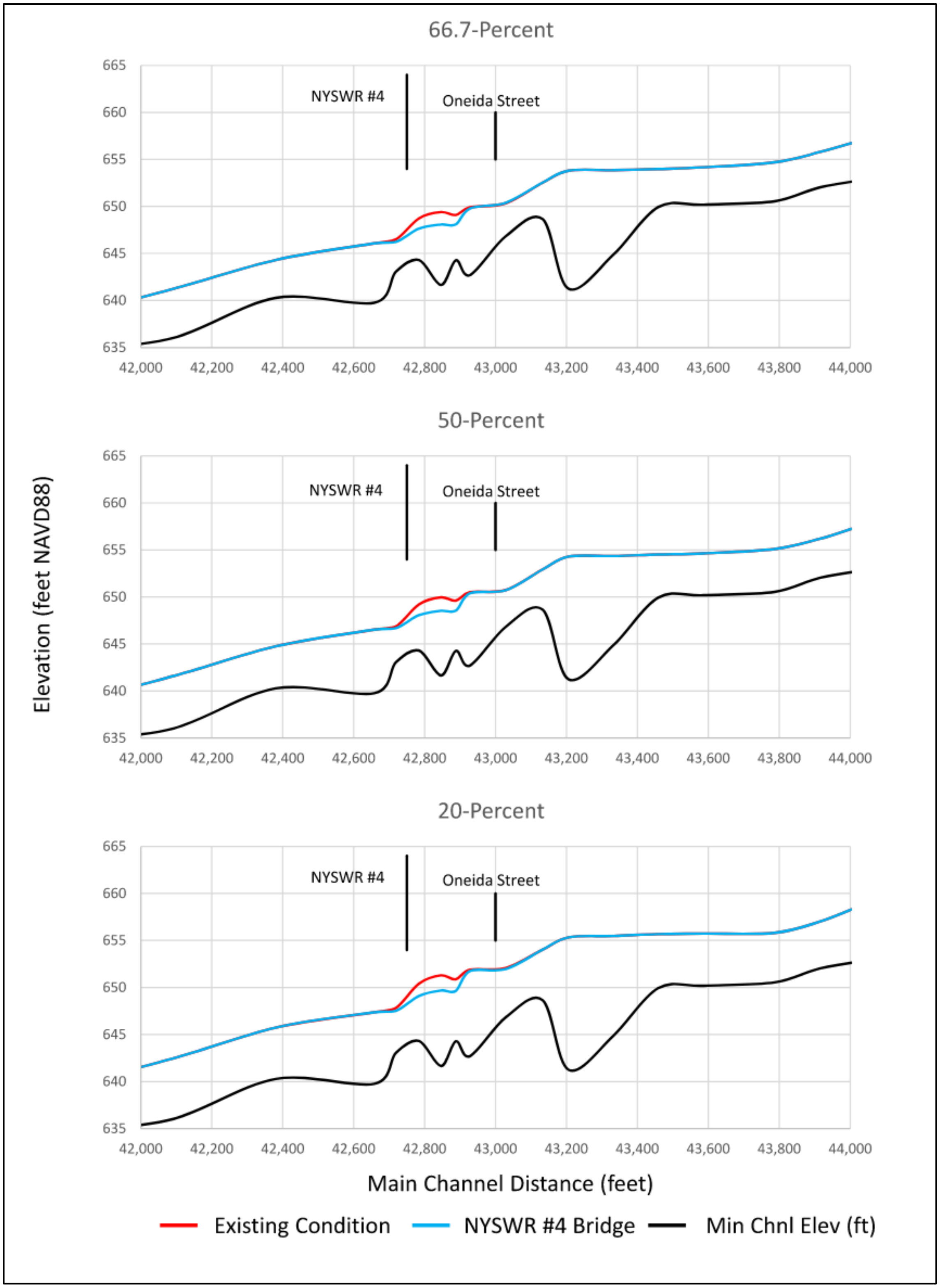

Figure 5-14. HEC-RAS model output for the existing conditions (red) and proposed increased hydraulic capacity of NYSWR #4 bridge (blue) scenarios.

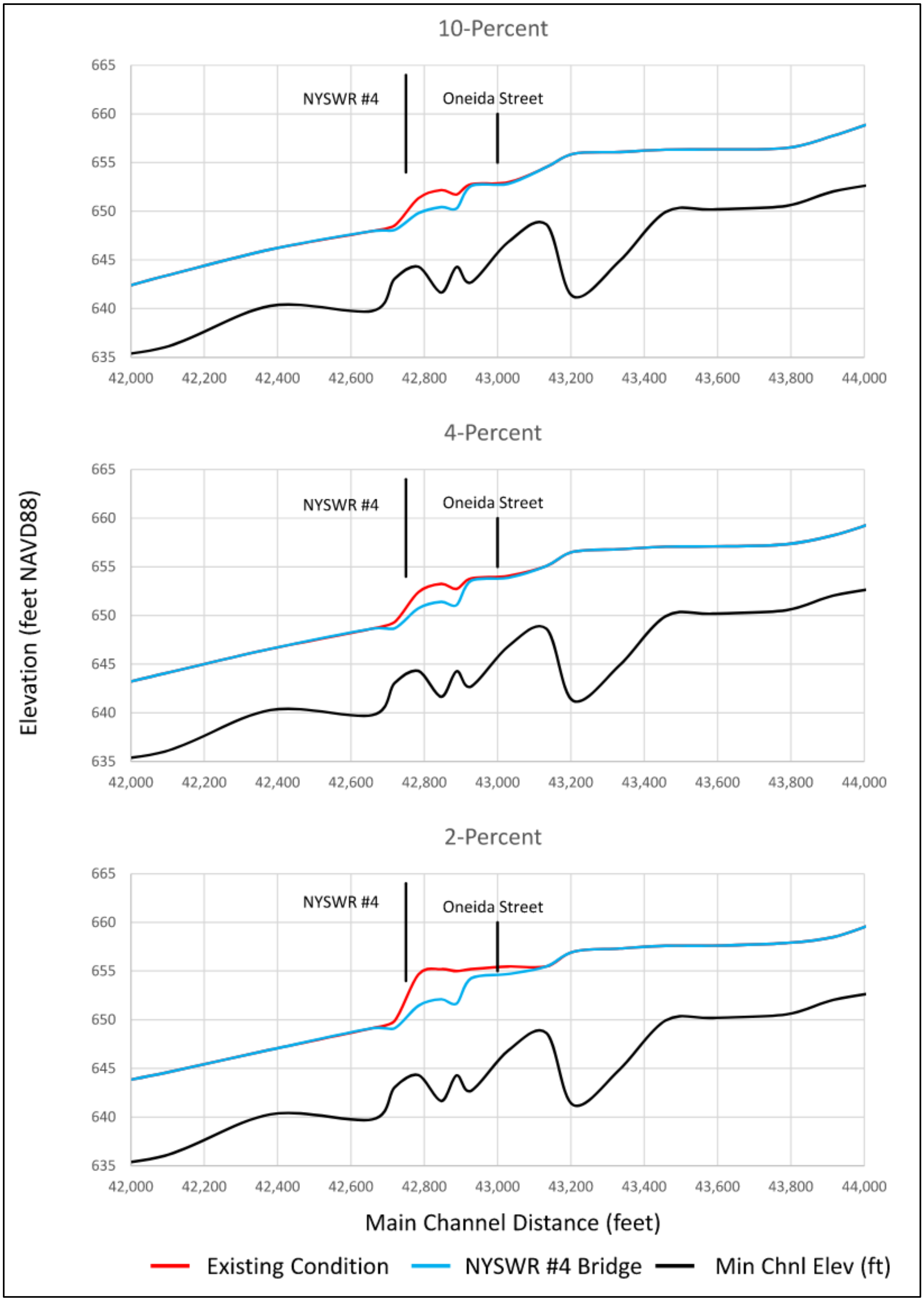

Figure 5-14. (continued) HEC-RAS model output for the existing conditions (red) and proposed increased hydraulic capacity of NYSWR #4 bridge (blue) scenarios.

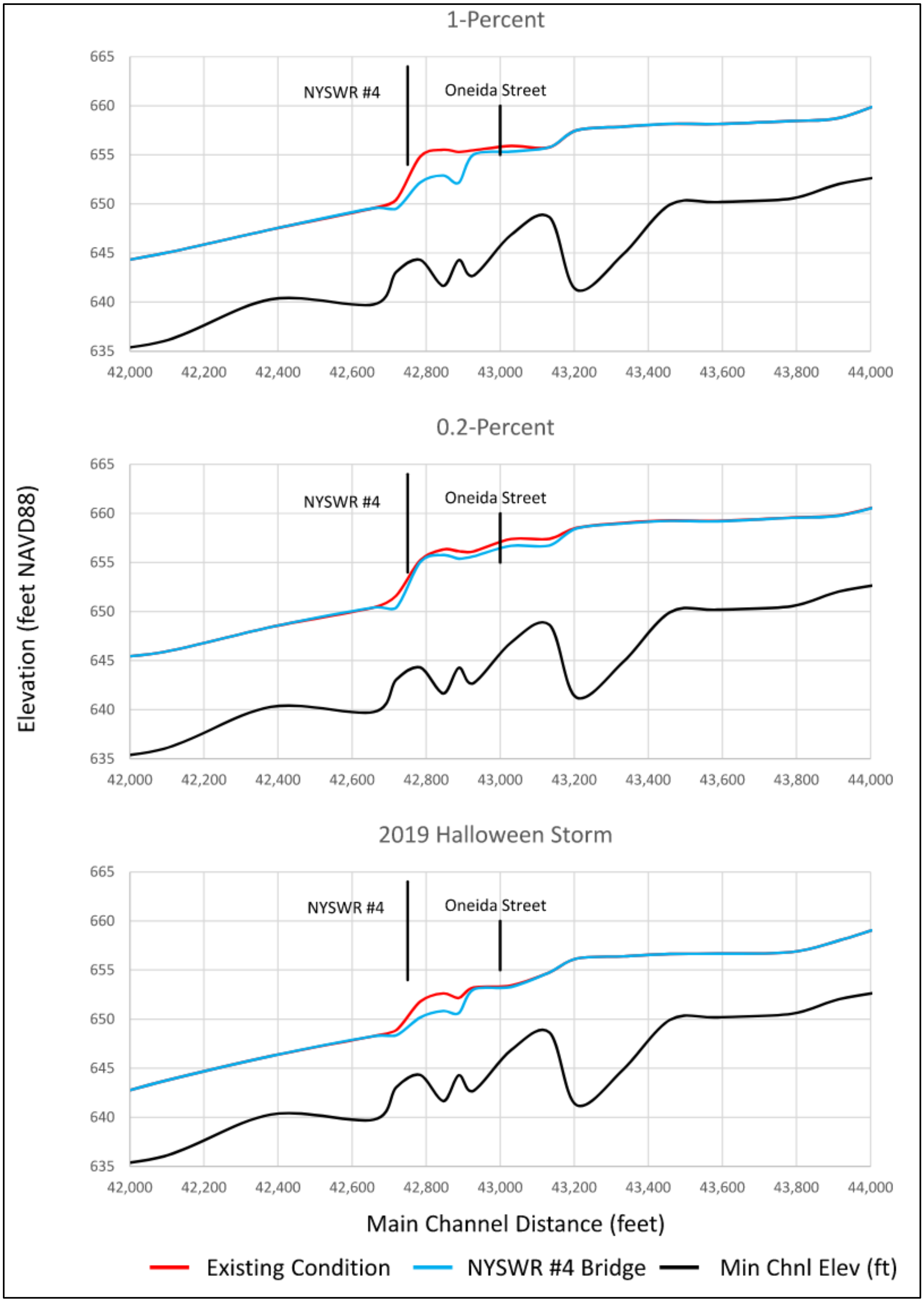

Figure 5-14. (continued) HEC-RAS model output for the existing conditions (red) and proposed increased hydraulic capacity of NYSWR #4 bridge (blue) scenarios.

5.2.3 Bank and Channel Stabilization

In order to recommend the most appropriate bank and channel stabilization strategies, engineers and scientists need to have an understanding of how sediment enters, moves through, and exits a stream network. By using sediment transport models, engineers and scientists can quantify and evaluate sediment transport using four key variables: invert change, mass bed change, shear stress, and velocity. Table 19 displays the sediment transport model output for the 10% ACE/24-hour storm for upper Sauquoit Creek in the vicinity of Washington Mills Park.

Table 19. HEC-RAS Sediment Transport Model Output for the 10% ACE/24-hours Storm Event

Main Channel Distance (ft)	Invert Change (ft)	Mass Bed Change (ton)	Shear Stress (lb/sq ft)	Velocity (ft/s)
39232	-0.35	484.14	0.58	2.66
39286	-0.30	-159.26	0.17	1.99
39528	1.25	1070.36	0.24	2.31
39827	-1.87	-1492.33	0.32	2.69
40518	0.01	535.80	0.44	2.67
40997	0.11	919.06	0.17	1.76
41403	-1.26	-1431.30	0.49	3.15
41940	0.24	1028.75	0.29	2.51
42537	-0.74	-672.89	0.30	2.53
42589	0.68	128.14	0.23	2.27
42618	0.28	192.46	0.36	2.29

Table 20 displays the velocity (ft/s) and shear stress (lb/sq ft) from the upper Sauquoit Creek existing conditions model output for the 50-, 20-, and 10-percent ACE peak discharge in the vicinity of Brookline Drive.

Table 20. Upper Sauquoit Creek HEC-RAS Model Output for the 50-, 20-, and 10-Percent ACE Peak Discharges

Main Channel Distance (ft)	50-Percent ACE		20-Percent ACE		10-Percent ACE	
	Shear Stress (lb/sq ft)	Velocity (ft/s)	Shear Stress (lb/sq ft)	Velocity (ft/s)	Shear Stress (lb/sq ft)	Velocity (ft/s)
39332	0.7	5.8	0.8	6.4	0.9	6.7
39371	0.1	2.4	0.2	2.9	0.2	3.2
39599	0.4	4.0	0.4	4.3	0.4	4.5
39826	0.4	4.5	0.5	5.1	0.6	5.5
39909	2.1	9.7	2.3	10.7	2.6	11.5
40068	0.3	3.6	0.4	4.4	0.4	4.9
40250	2.0	9.0	2.4	10.2	2.7	11.0
40393	1.5	7.9	1.9	9.1	2.1	9.7
40556	0.5	4.8	0.6	5.5	0.7	5.8
40687	0.1	1.7	0.1	2.0	0.1	2.2
40847	0.1	1.2	0.1	1.5	0.1	1.6
41040	0.9	5.1	0.4	3.9	0.4	3.7

Based on the sediment transport model output, Table 21 summarizes the applicability of potential streambank strategies along Washington Mills Park.

Table 21. Potential Streambank Stabilization Strategies for the Washington Mills Park Area

Source: NRCS 2009	
Type of Treatment	**Type of Sub-Treatment**
Brush Mattress	Staked only w/rock riprap toe (initial)
	Staked only w/rock riprap toe (grown) *
Coir Geotextile Roll	Roll with coir rope mesh staked only without rock riprap toe
	Roll with Polypropylene rope mesh staked only without rock riprap toe
	Roll with Polypropylene rope mesh staked and with rock riprap toe *
Live Fascine	LF Bundle w/rock riprap toe
Soils	Shales and hardpan
Gravel/Cobble	2-inch
	6-inch
	12-inch *
Vegetation	Class A turf (ret class)
	Class B turf (ret class)
	Class C turf (ret class)
	Long native grasses
	Short native and bunch grass
Soil Bioengineering	Reed fascine
	Coir roll
	Vegetated coir mat
	Live brush mattress (initial)
	Live brush mattress (grown) *
	Brush layering (initial/grown) *
	Live fascine
	Live willow stakes
Boulder Clusters	Boulder: Very large (>80-inch diameter) *
	Boulder: Large (>40-inch diameter) *
	Boulder: Medium (>20-inch diameter) *
	Boulder: Small (>10-inch diameter)
	Cobble: Large (>5-inch diameter)
	Cobble: Small (>2.5-inch diameter)

*Note: These strategies would be applicable for both precipitation (as identified in the sediment transport model) and peak discharge (as identified in the upper Sauquoit Creek model) based velocity and shear stress values.

Due to the variable, conceptual, and site-specific nature of streambank stabilization strategies, no ROM cost estimates were determined for this measure. Additional geomorphic and engineering analyses, including additional modeling (i.e., coupled 1-D/2-D unsteady flow, 2-D unsteady flow and rain-on-grid), would be necessary in order to determine the most appropriate streambank stabilization strategy and its associated costs.

5.3 Hand Place

Hand Place is located in the Town of New Hartford, NY upstream of the Oneida Street bridge, specifically between river stations 430+00 and 450+00. Flooding in this area affects numerous residential properties which are within the FEMA 1% and 0.2% ACE flood areas (Figure 5-15). Historically, when Hand Place floods, residents are cut off from other evacuation routes and require water rescue by local emergency services personnel. This reach is also susceptible to sediment aggradation and tree and debris buildup from bank erosion and upstream sources. Aggradation and tree/debris buildup restrict the channel flow area, which can cause water surfaces to rise and potentially overtop banks or back water upstream of structures.

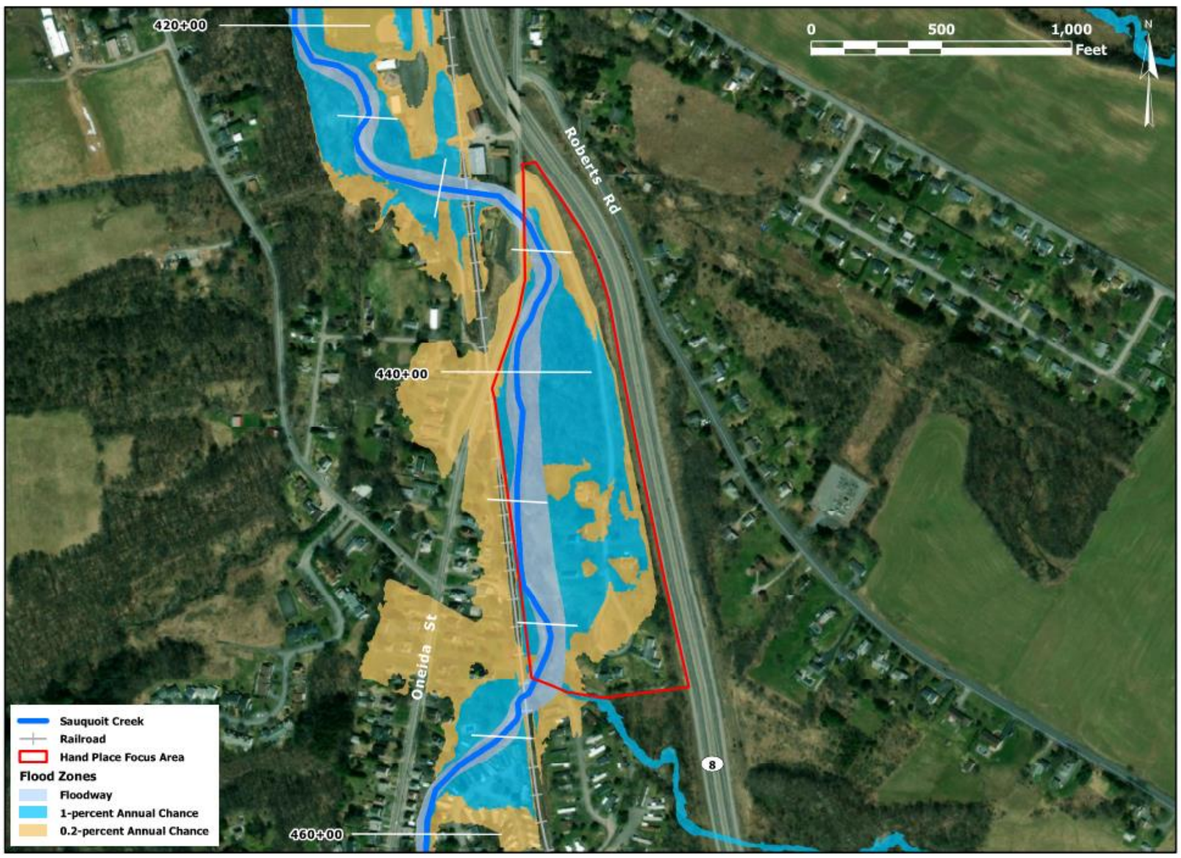

Figure 5-15. Location map for Hand Place high-risk flood area.

5.3.1 Flood Bench

Installing a flood bench would provide additional storage and floodplain width over and above the current storage and width provided by the adjacent undeveloped land, which could potentially reduce damages in the event of flooding and address issues in the Hand Place area. One potential flood bench was modeled in the vicinity of Hand Place, which is approximately 4.0 acres in size and located between river stations 432+00 to 439+50 (Figure 5-16).

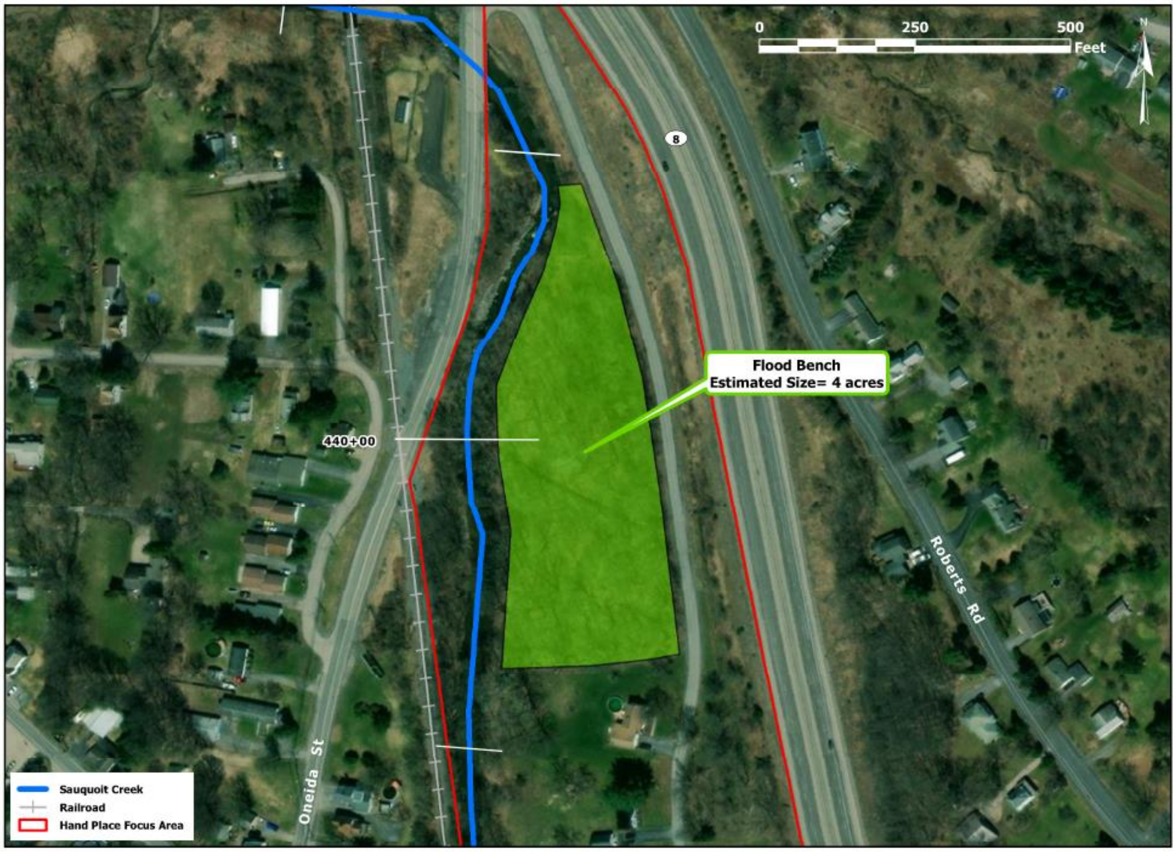

Figure 5-16. Conceptual depiction of flood benches proposed for the Hand Place area.

The flood bench designs used for the proposed condition model simulation set the minimum bench elevation approximately equal to the bankfull elevation, which was an average depth of 2 ft for the flood bench.

The flood bench is within the FEMA designated SFHA or Zone AE, which are areas subject to inundation by the 1% ACE (100-year flood) as determined in the FIS by detailed methods and where base flood elevations are provided (FEMA 2013). Appendix D depicts a flood mitigation rendering of a flood bench illustrating before and after landscape features.

Table 22 outlines the results of the proposed conditions model simulations for the flood bench scenario under existing and future conditions. Figure 5-17 displays the profile plot for the flood bench scenario. Full model outputs for this alternative can be found in Appendix E.

Table 22. Existing and Future Conditions Results for Each Flood Bench Scenario

Existing Conditions	**Flood Bench**
Reduction in Water Surface Elevations	Up to 1.4 feet
Total Length of Benefited Area	750 feet
River Stations	433+00 to 440+50
Future Conditions	
Reduction in Water Surface Elevations	Up to 1.5 feet
Total Length of Benefited Area	750 feet
River Stations	433+00 to 440+50

Flood benches generally provide flood protection for localized areas in the vicinity of and immediately upstream and/or downstream of the bench. Based on the analysis of the Hand Place area, a flood bench located upstream of the Oneida Street bridge would not provide significant flood protection in this reach from open-water flooding. For areas that experience significant flood damages or chronic flooding, it is recommended that multiple flood mitigation strategies in conjunction be considered and evaluated by affected communities.

In addition, flood benches can be designed to reduce velocity and shear stress forces in the channel and overbank areas allowing sediment and debris to settle out of the channel water column and deposit in the flood bench. Table 23 displays the velocity (ft/s) and shear stress (lb/sq ft) for the existing and proposed flood bench scenarios at the 10-percent ACE peak discharge.

Table 23. Velocity (ft/s) and Shear Stress (lb/sq ft) Values for the Existing and Proposed Flood Bench Scenarios.

Main Channel Distance (ft)	**Existing Conditions**		**Flood Bench**	
	Shear Stress (lb/sq ft)	**Velocity (ft/s)**	**Shear Stress (lb/sq ft)**	**Velocity (ft/s)**
43029	1.3	7.8	1.3	7.8
43133	2.3	10.5	2.3	10.5
43206	0.4	5.0	0.2	3.4
43333	0.5	5.2	0.1	1.8
43458	0.5	4.8	0.1	2.7
43587	0.8	6.2	0.1	2.7
43787	2.1	10.2	0.2	3.2
43916	1.8	9.4	0.5	4.6
44063	1.7	9.2	1.7	9.2
44217	0.7	6.2	0.7	6.2
44369	1.7	9.1	1.7	9.1
44686	1.9	9.9	1.9	9.9
44849	0.4	4.5	0.4	4.5
44929	2.8	11.5	2.8	11.5

The Rough Order Magnitude cost for this flood bench alternative is 3.0 million. This ROM cost estimate does not include land acquisition costs for survey, appraisal, and engineering coordination. In addition, the NYSDEC will require wetland delineations, an analysis for any endangered and/or threatened species within the proposed project area, and information regarding access during construction for this mitigation alternative.

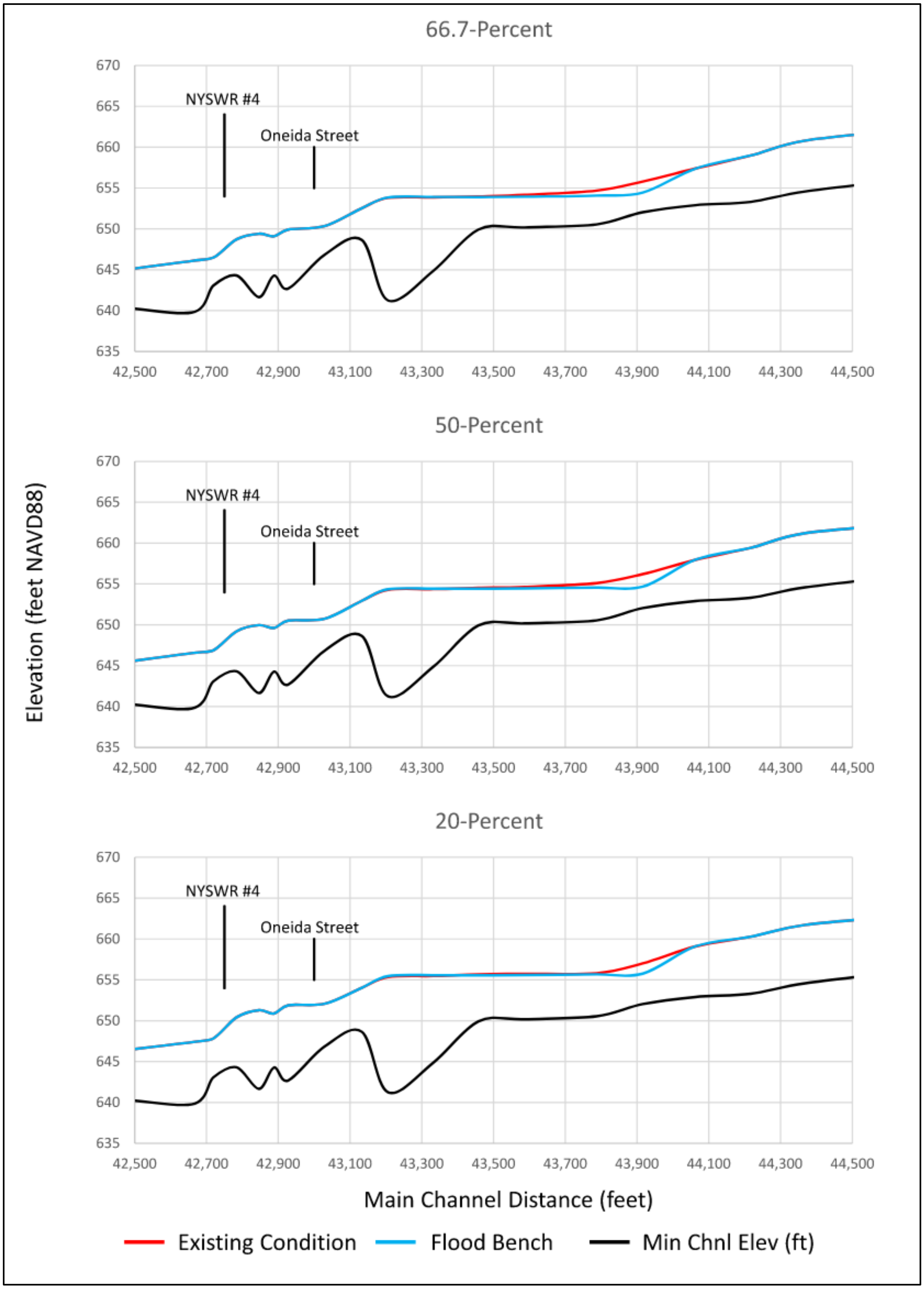

Figure 5-17. HEC-RAS model output for the existing conditions (red) and proposed flood bench (blue) scenarios.

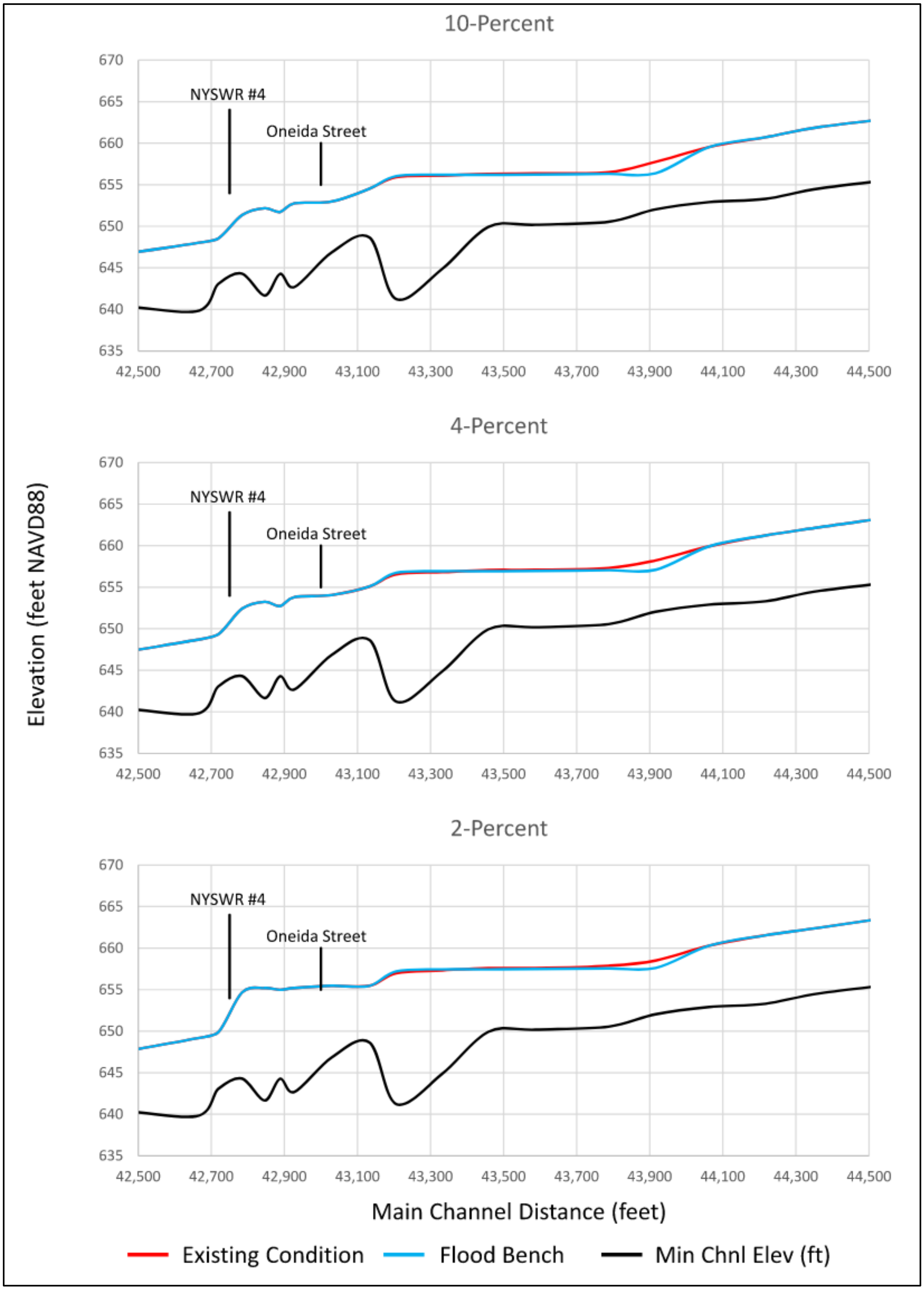

Figure 5-17. (continued) HEC-RAS model output for the existing conditions (red) and proposed flood bench (blue) scenarios.

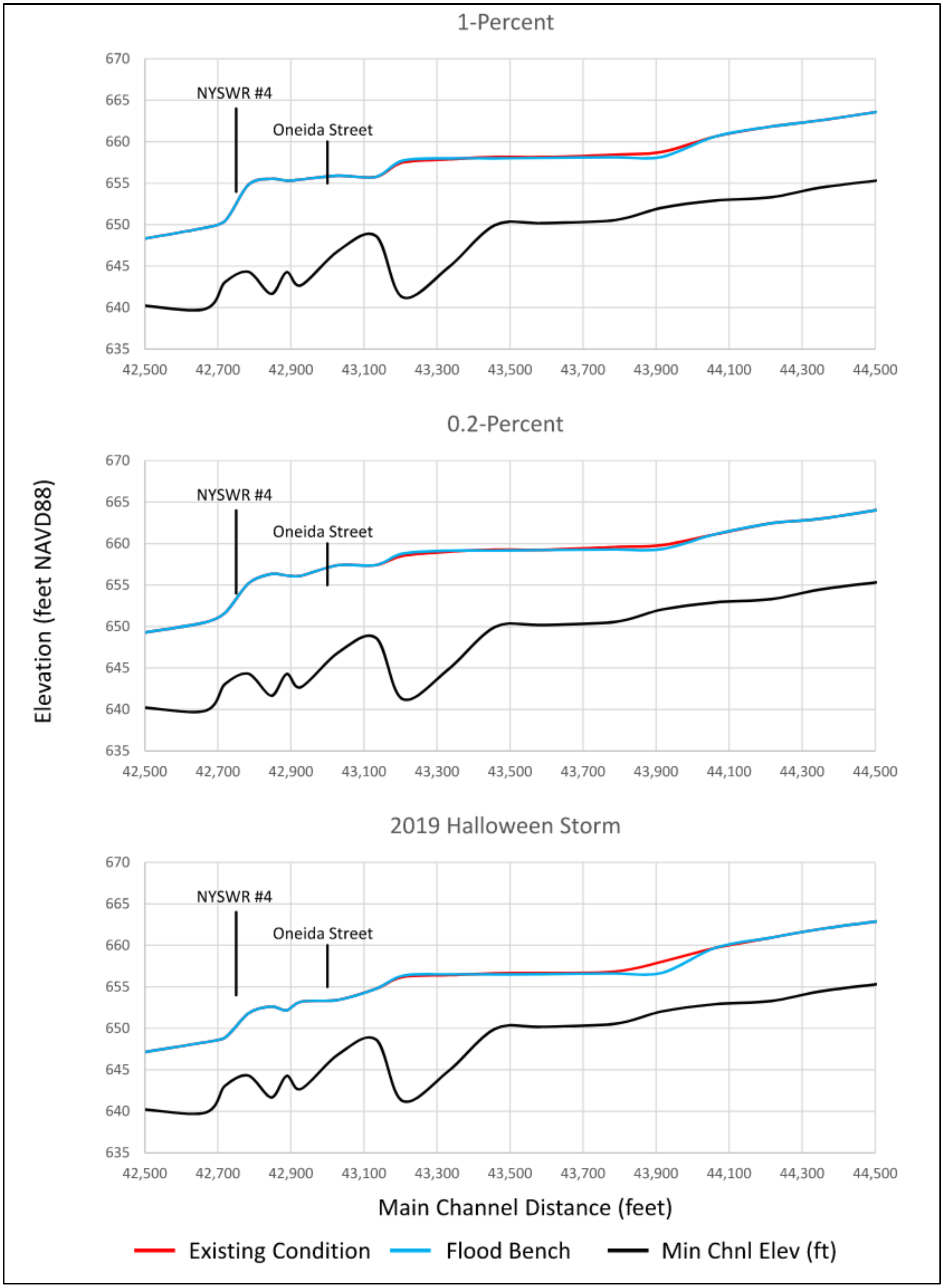

Figure 5-17. (continued) HEC-RAS model output for the existing conditions (red) and proposed flood bench (blue) scenarios.

5.3.2 Flood-Prone Property Buyout and Flood Bench

Buyouts allow state and municipal agencies the ability to purchase developed properties within areas vulnerable to flooding from willing owners. Buyouts are effective management tools in response to natural disasters to reduce or eliminate future losses of vulnerable or repetitive loss properties. In the flood-prone neighborhood of Hand Place, there are 11 properties on the right bank of Sauquoit Creek that could be purchased and converted to a multi-purpose natural public area and flood mitigation project. Installing a flood bench would provide additional storage and floodplain width over and above the current storage and width provided by the adjacent undeveloped land, which could potentially reduce damages in the event of flooding and address issues in the Hand Place area. One potential flood bench was modeled in the vicinity of Hand Place, which is approximately 14 acres in size and located between river stations 433+00 to 448+50 (Figure 5-18).

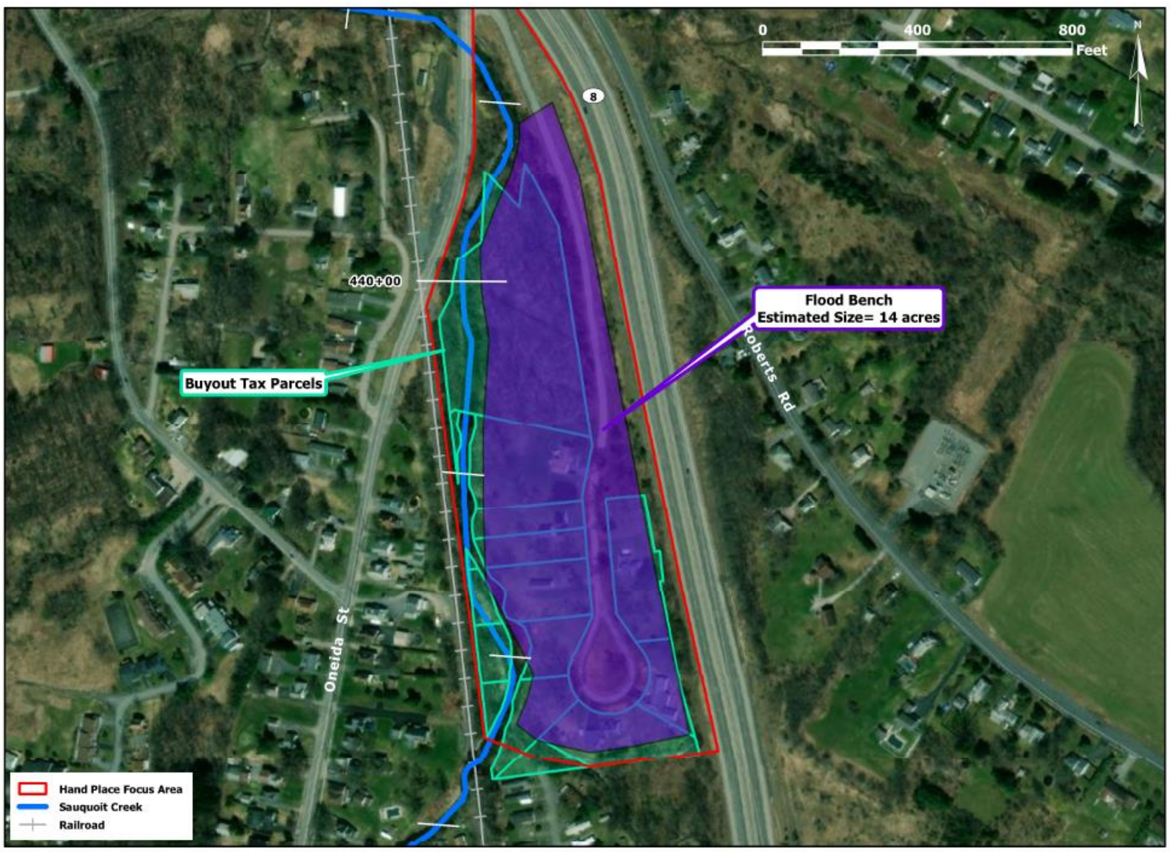

Figure 5-18. Conceptual depiction of flood prone property buyout and flood bench proposed for the Hand Place area.

The flood bench designs used for the proposed condition model simulation set the minimum bench elevation approximately equal to the bankfull elevation, which was an average depth of 2 ft for the flood bench.

The flood bench is within the FEMA designated SFHA or Zone AE, which are areas subject to inundation by the 1% ACE (100-year flood) as determined in the FIS by detailed methods and where base flood elevations are provided (FEMA 2013). Appendix D depicts a flood mitigation rendering of a flood bench illustrating before and after landscape features.

In the flood-prone neighborhood of Hand Place, there are 11 properties on the right bank of Sauquoit Creek that could be purchased and either removed from the floodplain or converted to a multi-purpose natural public area and flood mitigation project (Figure 5-18). The sum of the full market value for all 11 tax parcels is $797,427 (NYSOITS 2023). Table 24 summarizes the tax parcel data available for the proposed buyout properties.

Table 24. Tax Parcel Data for Proposed Buyout Properties along Hand Place (NYSOITS 2023)

Print Key	Street Number	Street Name	Zip Code	Owner Type	Property Class	Property Description
349.008-2-4	0	Hand Place	13456	N/A	N/A	N/A
349.012-1-10	3777	Hand Place	13456	Private	210	Residential - One family year-round residence
349.012-1-11	3787	Hand Place	13456	Private	210	Residential - One family year-round residence
349.012-1-13.1	0	Hand Place	13456	Private	311	Vacant Land - Residential vacant land
349.012-1-13.2	3792	Hand Place	13456	Private	210	Residential - One family year-round residence
349.012-1-14.1	3778	Hand Place	13456	Private	210	Residential - One family year-round residence
349.012-1-14.2	0	Hand Place	13456	Private	311	Vacant Land - Residential vacant land
349.012-1-14.3	0	Hand Place	13456	Private	311	Vacant Land - Residential vacant land
349.012-1-15	0	Hand Place	13456	Private	311	Vacant Land - Residential vacant land
349.012-1-16	3772	Hand Place	13456	Private	210	Residential - One family year-round residence
349.012-1-9	3766	Hand Place	13456	Private	210	Residential - One family year-round residence

Table 25 outlines the results of the proposed conditions model simulations for the flood bench scenario under existing and future conditions. Figure 5-19 displays the profile plot for the flood bench scenario. Full model outputs for this alternative can be found in Appendix E.

Table 25. Existing and Future Conditions Results for Each Flood Bench Scenario

Existing Conditions	**Flood Bench**
Reduction in Water Surface Elevations	Up to 3.8 feet
Total Length of Benefited Area	1,600 feet
River Stations	433+00 to 449+00
Future Conditions	
Reduction in Water Surface Elevations	Up to 3.9 feet
Total Length of Benefited Area	1,600 feet
River Stations	433+00 to 449+00

Flood benches generally provide flood protection for localized areas in the vicinity of and immediately upstream and/or downstream of the bench. Based on the analysis of the Hand Place area, a flood bench located upstream of the Oneida Street bridge would provide significant flood protection in this reach from open-water flooding. For areas that experience significant flood damages or chronic flooding, it is recommended that multiple flood mitigation strategies in conjunction be considered and evaluated by affected communities.

In addition, flood benches can be designed to reduce velocity and shear stress forces in the channel and overbank areas allowing sediment and debris to settle out of the channel water column and deposit in the flood bench. Table 26 displays the velocity (ft/s) and shear stress (lb/sq ft) for the existing and proposed buyout and flood bench scenarios at the 10-percent ACE peak discharge.

Table 26. Velocity (ft/s) and Shear Stress (lb/sq ft) Values for the Existing and Proposed Buyout and Flood Bench Scenarios

Main Channel Distance (ft)	Existing Conditions		Buyout and Flood Bench	
	Shear Stress (lb/sq ft)	Velocity (ft/s)	Shear Stress (lb/sq ft)	Velocity (ft/s)
43029	1.3	7.8	1.3	7.8
43133	2.3	10.5	2.3	10.5
43206	0.4	5.0	0.2	3.4
43333	0.5	5.2	0.0	1.6
43458	0.5	4.8	0.1	2.3
43587	0.8	6.2	0.1	2.3
43787	2.1	10.2	0.2	2.7
43916	1.8	9.4	0.4	4.2
44063	1.7	9.2	1.8	8.4
44217	0.7	6.2	0.8	6.0
44369	1.7	9.1	1.3	7.0
44686	1.9	9.9	1.3	7.6
44849	0.4	4.5	1.6	8.4
44929	2.8	11.5	2.8	11.5

The Rough Order Magnitude cost for this flood bench alternative is 8.8 million. This ROM cost estimate does not include land acquisition costs for survey, appraisal, and engineering coordination. In addition, the NYSDEC will require wetland delineations, an analysis for any endangered and/or threatened species within the proposed project area, and information regarding access during construction for this mitigation alternative.

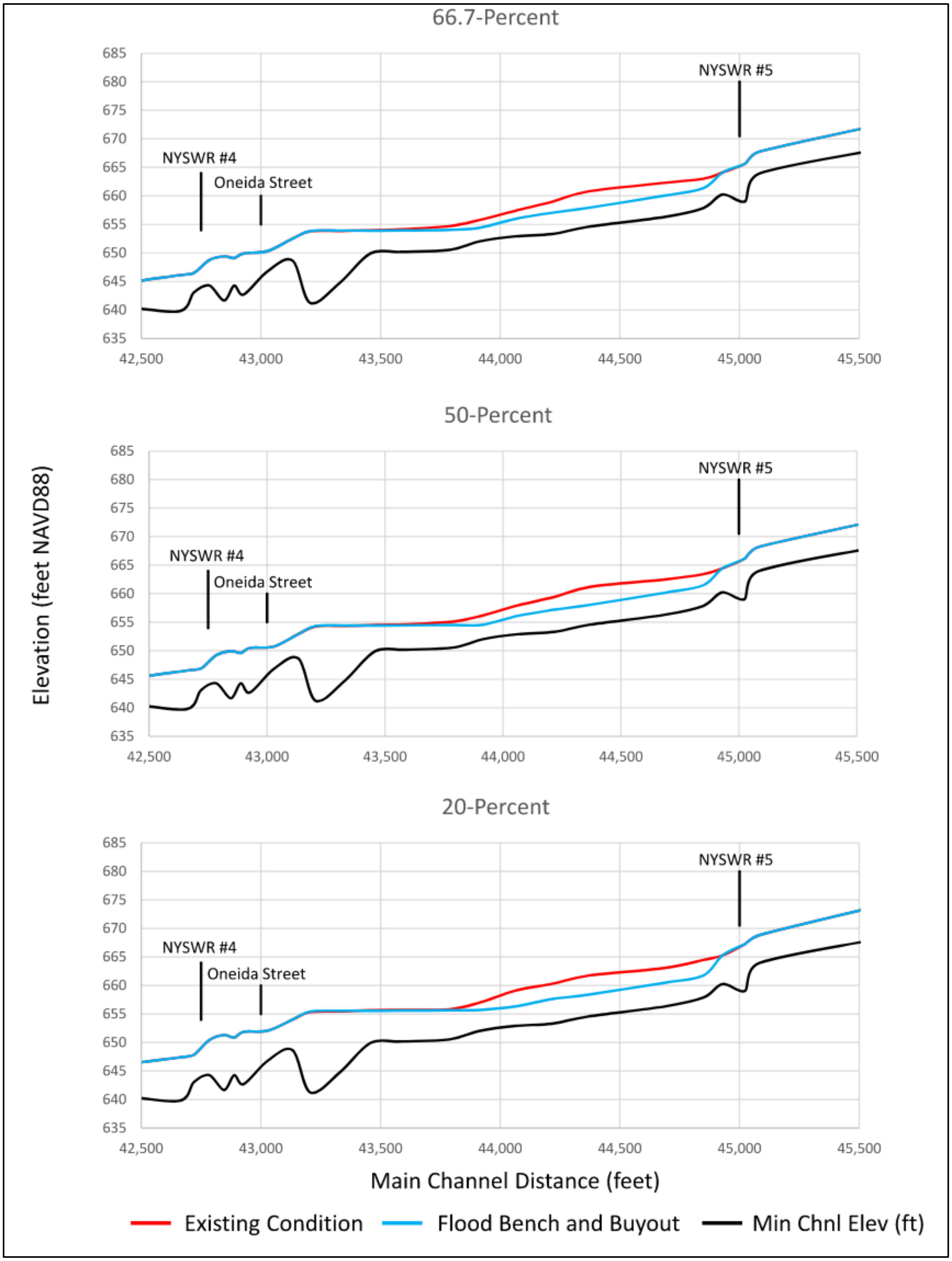

Figure 5-19. HEC-RAS model output for the existing conditions (red) and proposed flood bench (blue) scenarios.

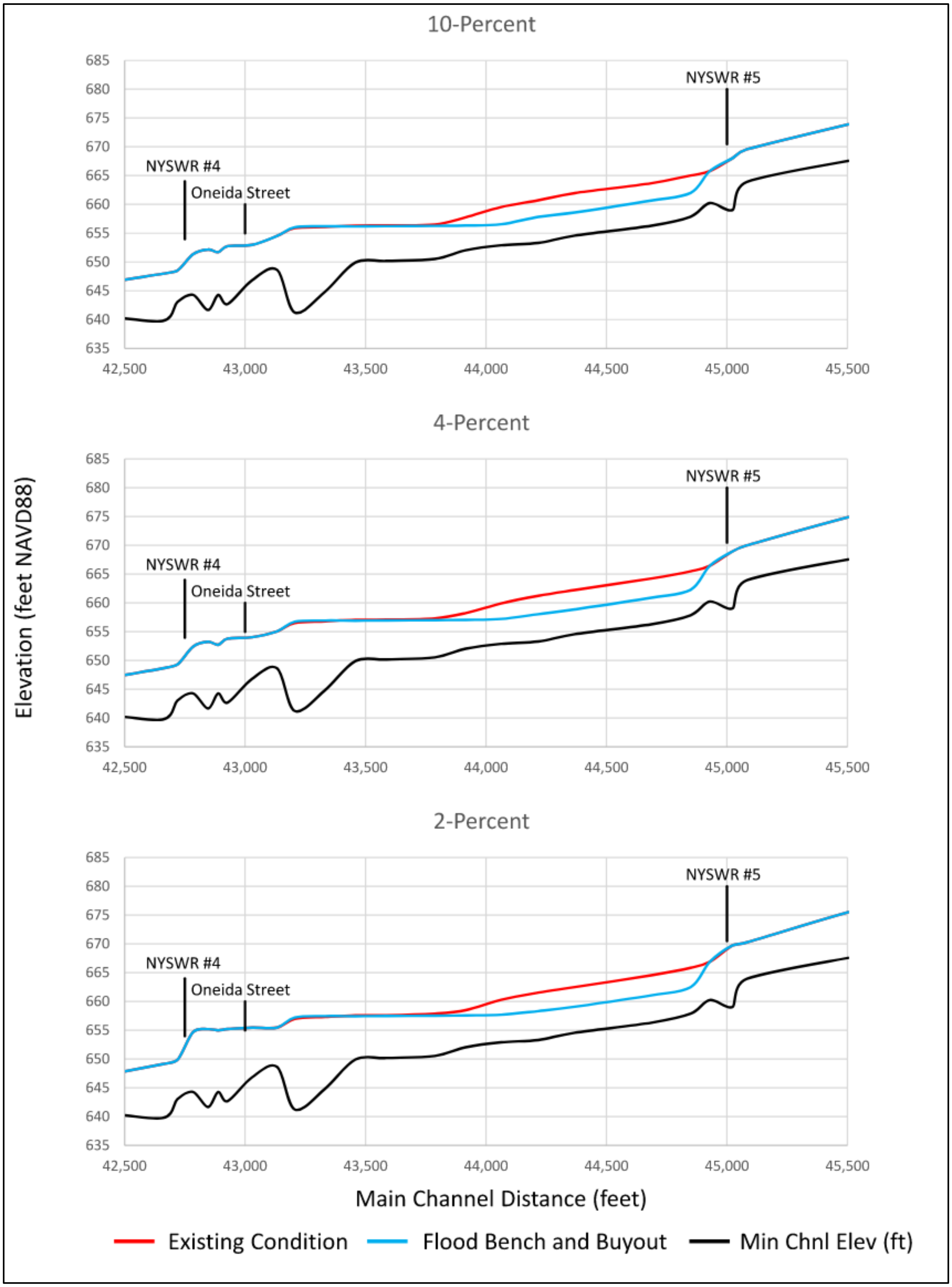

Figure 5-19. (continued) HEC-RAS model output for the existing conditions (red) and proposed flood bench (blue) scenarios.

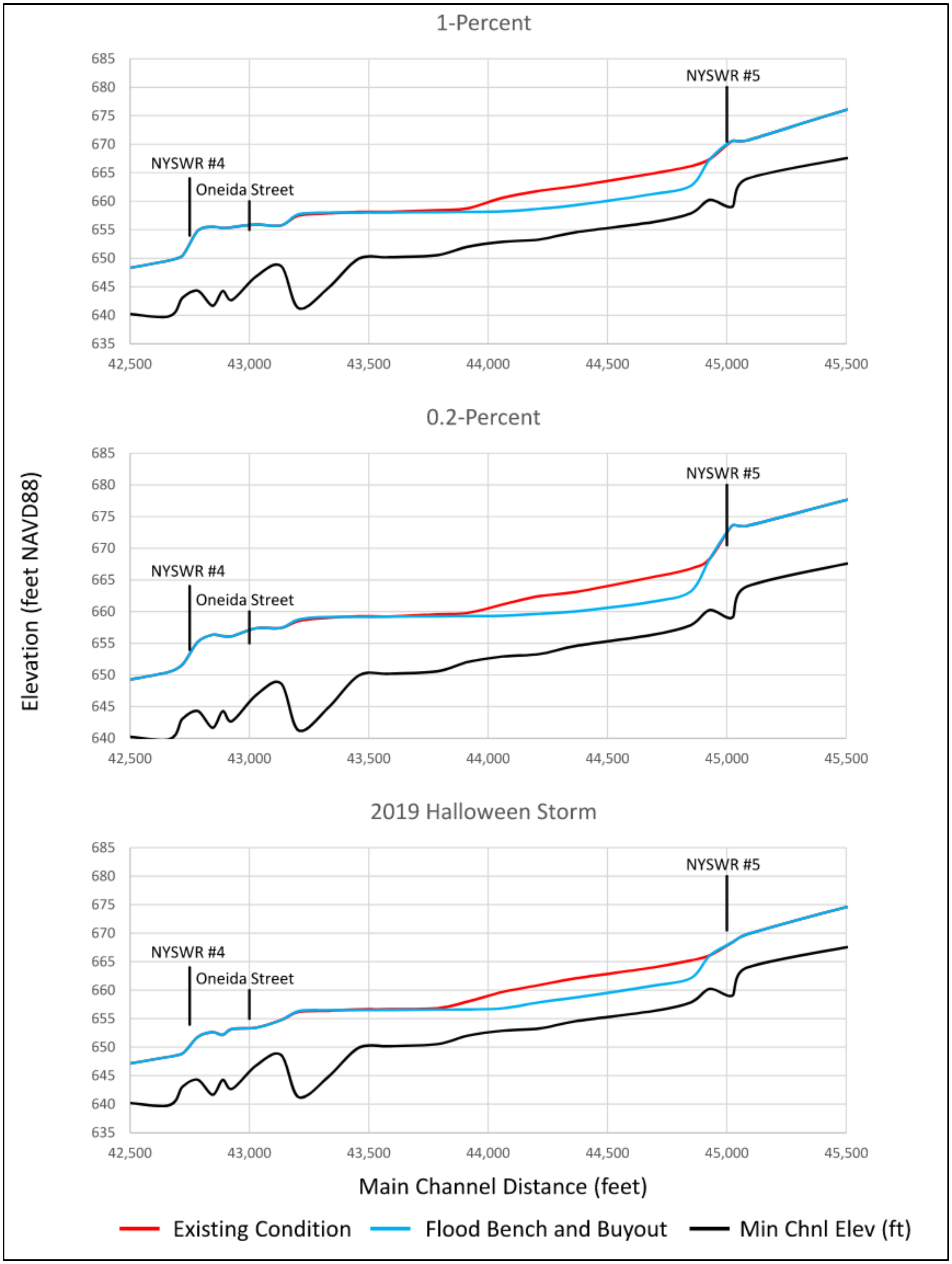

Figure 5-19. (continued) HEC-RAS model output for the existing conditions (red) and proposed flood bench (blue) scenarios.

5.3.3 Increase Hydraulic Capacity of Oneida Street Bridge

This measure is intended to address issues in the vicinity of Hand Place by increasing the width of the Oneida Street bridge opening, which would increase the cross-sectional flow area of the channel located at river station 430+00. The bridge is owned by the Town of New Hartford and has no pier in the channel. The existing bridge structure has a bridge span of 104 ft and a width of 32.5 ft (Figure 5-20). The flooding in the vicinity of the Oneida Street bridge poses a flood-risk threat to nearby residential properties and publicly-owned infrastructure. Appendix D depicts a flood mitigation rendering of a bridge widening scenario.

Figure 5-20. Oneida Street bridge, New Hartford, NY.

The FEMA FIS for the Oneida Street bridge is unable to successfully pass the 2-, 1-, or 0.2% ACE without significant backwater upstream the of the bridge (FEMA 2013). In addition, the FEMA FIRM displays significant backwater upstream of the Oneida Street bridge crossing (FEMA 2013). Two different strategies were evaluated for the Oneida Street bridge: restoring the natural channel geomorphology and increasing the bridge span by 20%. Restoring the natural channel geomorphology would involve removing the aggraded sediment and debris in the vicinity of the bridge, which would increase the cross-sectional flow area of the channel in this reach. Increasing the opening span of the bridge structure would increase the cross-sectional flow area of the channel as well. Increasing the hydraulic capacity of the Oneida Street bridge by increasing the cross-sectional flow area of the channel in this reach could potentially reduce flood risk to nearby areas and the potential for sediment, debris, and ice to accumulate or catch on the upstream face of the bridge.

It is important to note that the removal of aggraded sediment and debris alone is not an adequate flood mitigation strategy unless the upstream sources of sediment and debris are addressed. Ramboll analyzed the sources and potential strategies to address sediment and debris into Sauquoit Creek in the *Stream Sediment and Debris Management Plan* (2021). The NYSDEC highly recommends that any potential mitigation strategy that includes sediment and/or debris removal address upstream sediment and debris sources.

Restoring the natural channel geomorphology would require of the removal of approximately 22,000 cubic feet of aggraded sediment and debris at the base and in the vicinity of the Oneida Street bridge. The proposed bridge span for the Oneida Street bridge is 125 ft, which is 20% larger than the existing span of 104 ft.

The proposed condition modeling confirmed that the Oneida Street bridge is a constriction point along Sauquoit Creek. Table 27 outlines the results of the proposed conditions model simulations for both the restoring the natural geomorphology and increasing the bridge span scenarios under existing and future conditions. Figures 5-21 and 5-22 display the profile plots for each increased hydraulic capacity scenario. Full model outputs for this alternative can be found in Appendix E.

Table 27. Existing and Future Conditions Results for Increasing the Hydraulic Capacity of the Oneida Street Bridge

Existing Conditions	**Restore Natural Channel Geomorphology**	**Increase Bridge Span by 20%**
Reduction in Water Surface Elevations	No Reduction – Increase of up to 0.7 feet	No Reduction – Increase of 0.6 feet
Total Length of Benefited Area	No Benefit – 275 Feet	No Benefit – 275 Feet
River Stations	428+75 to 431+50	428+75 to 431+50
Future Conditions		
Reduction in Water Surface Elevations	No Reduction – Increase of up to 0.8 feet	No Reduction – Increase of 0.6 feet
Total Length of Benefited Area	No Benefit – 275 Feet	No Benefit – 275 Feet
River Stations	428+75 to 431+50	428+75 to 431+50

The results of the proposed conditions modeling indicate that neither proposed alternative for the Oneida Street bridge would provide flood mitigation benefits. This is most likely a result of the existing channel geomorphology and close proximity downstream of the NYSWR #4 bridge. Sauquoit Creek in this reach has two significant meanders, which force water velocities to slow as water navigates the meanders. Water flow that changes from fast to slow quickly causes water to rise, known as the backwater effect. There is significant backwater upstream of Oneida Street according to both the HEC-RAS modeling and FEMA FIS profile plots. Restoring the natural channel geomorphology and increasing the bridge span both allow a greater volume of water to flow through the bridge, but the meanders are the primary driver of water velocity in this reach and, in turn, water surface elevations.

The ROM cost for restoring the natural channel geomorphology is approximately $650,000, while the ROM cost for increasing the bridge span is approximately $5.6 million. These ROM cost estimates do not include land acquisition costs for survey, appraisal, and engineering coordination. Additional engineering consideration would also be required to determine if increasing the bridge opening would alter the structural integrity of the bridge in any way.

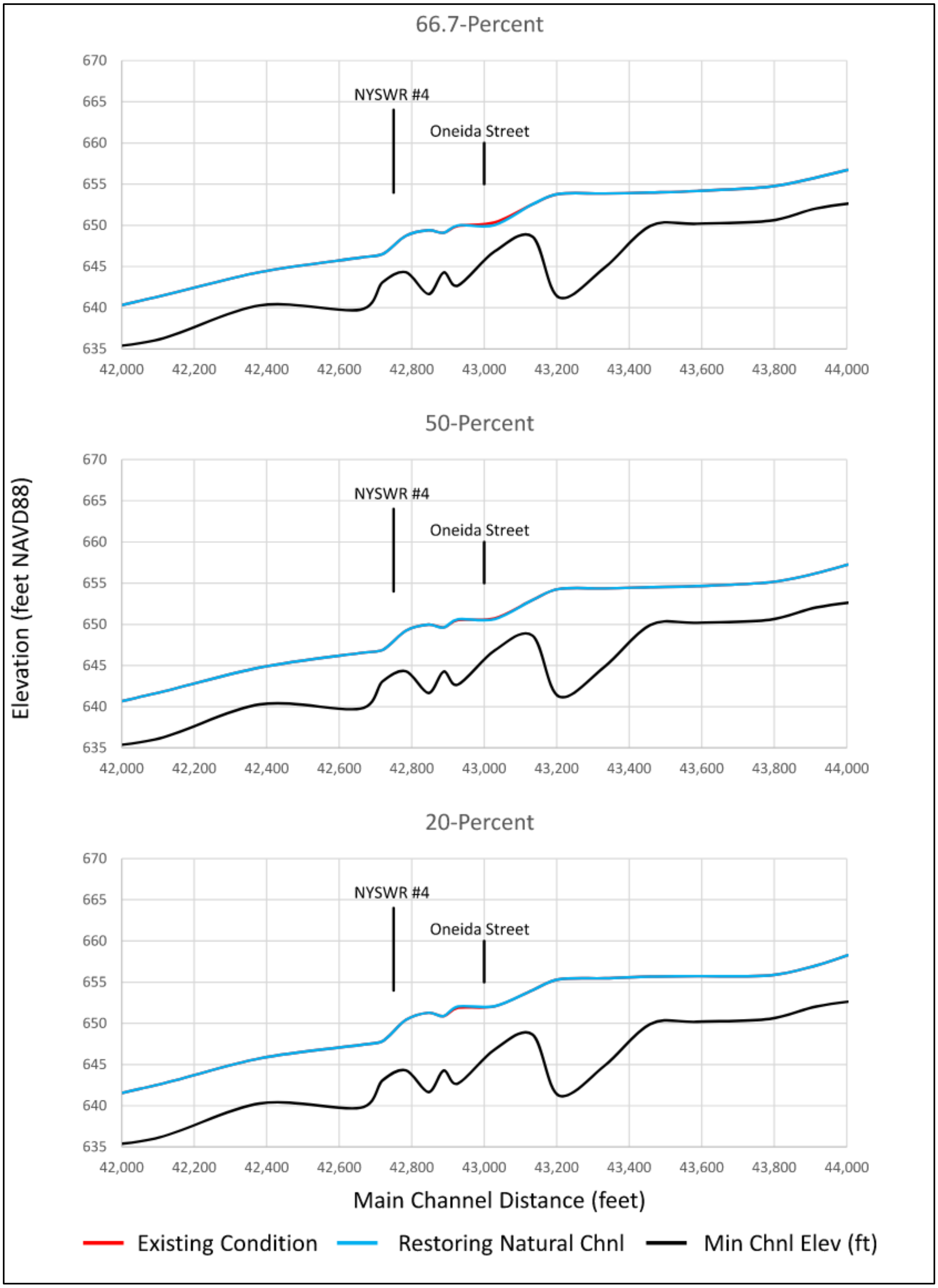

Figure 5-21. HEC-RAS model output for the existing conditions (red) and proposed restoring natural channel geomorphology of the Oneida Street bridge (blue) scenarios.

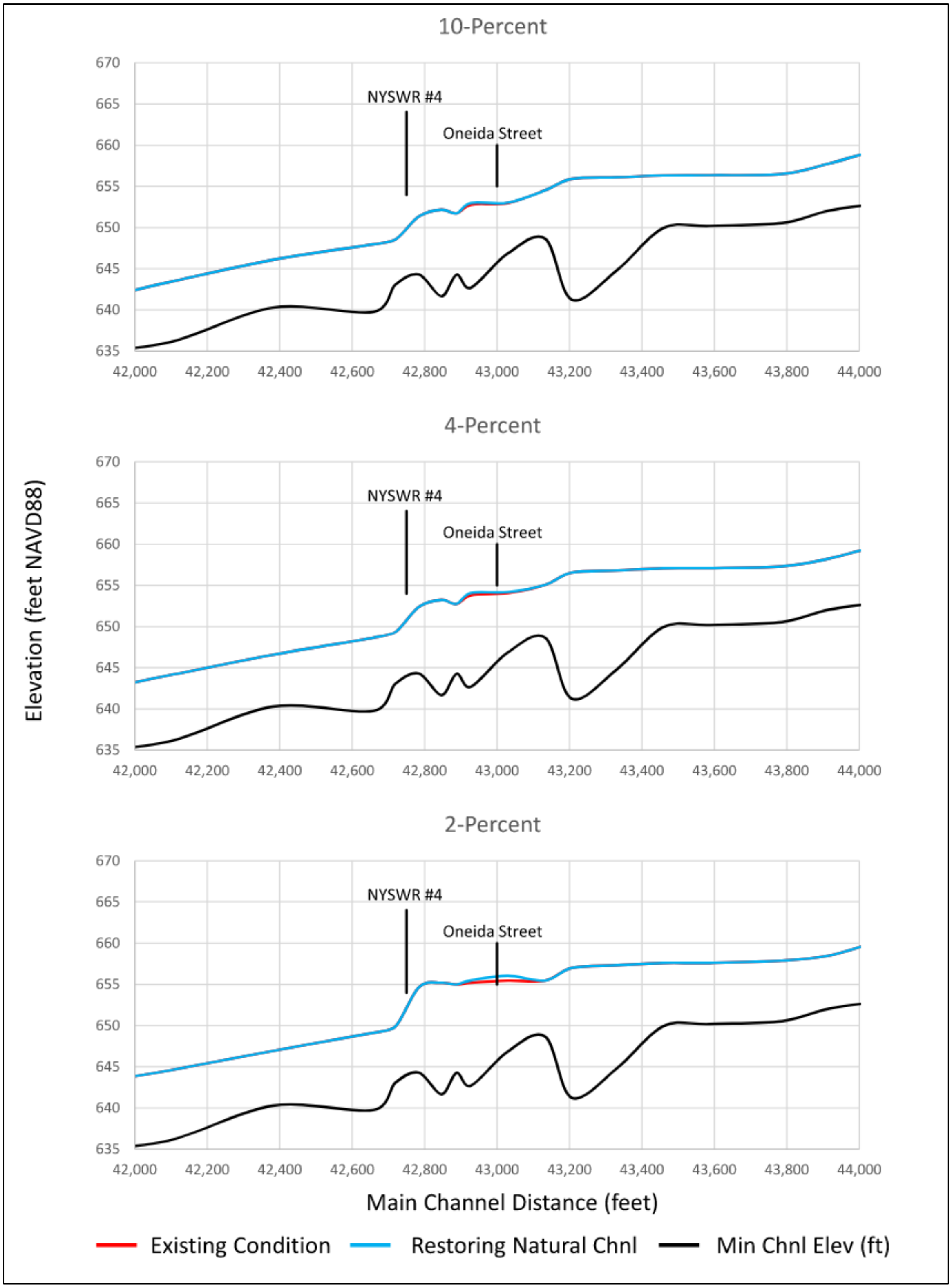

Figure 5-21. (continued) HEC-RAS model output for the existing conditions (red) and proposed restoring natural channel geomorphology of the Oneida Street bridge (blue) scenarios.

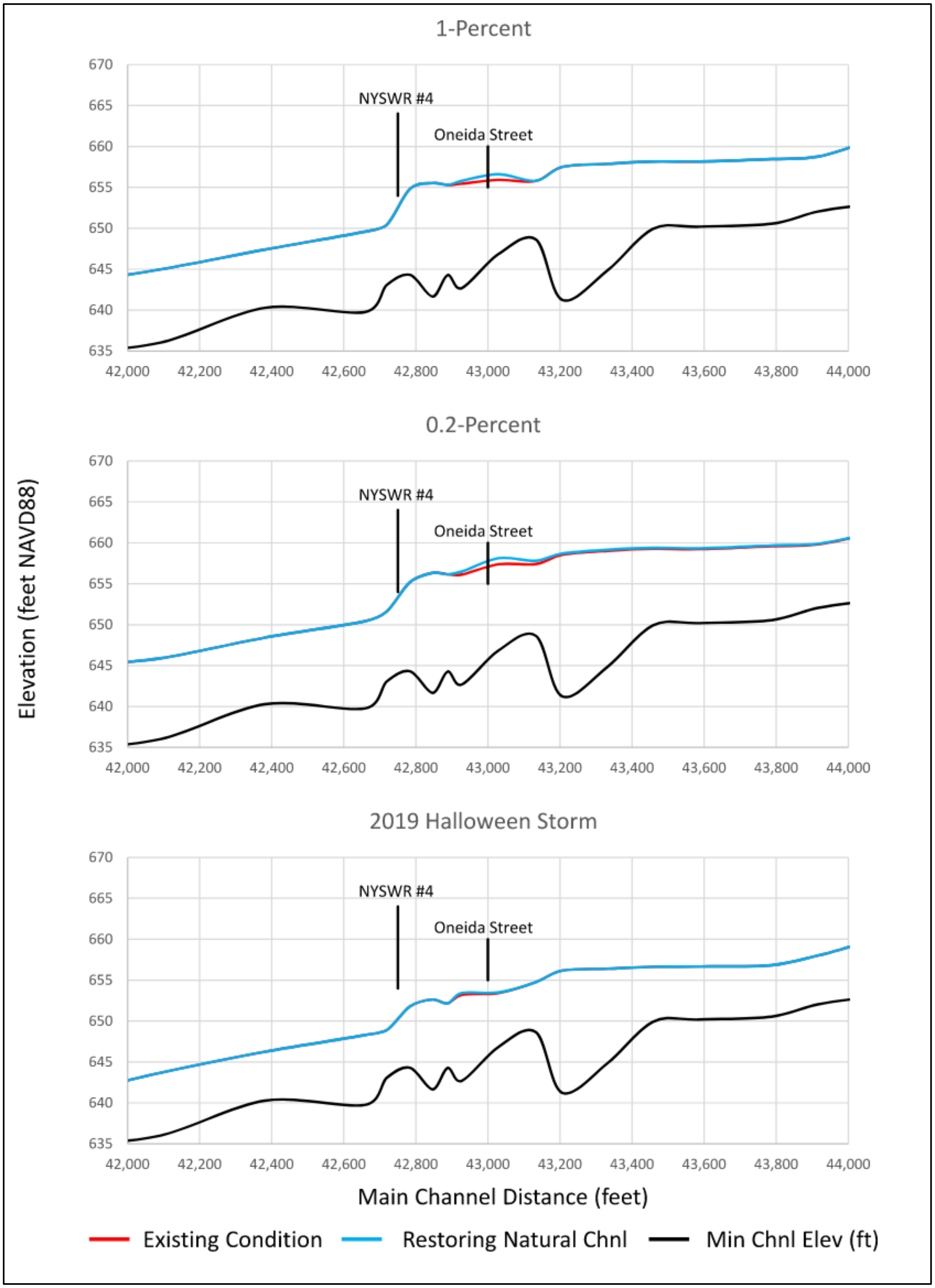

Figure 5-21. (continued) HEC-RAS model output for the existing conditions (red) and proposed restoring natural channel geomorphology of the Oneida Street bridge (blue) scenarios.

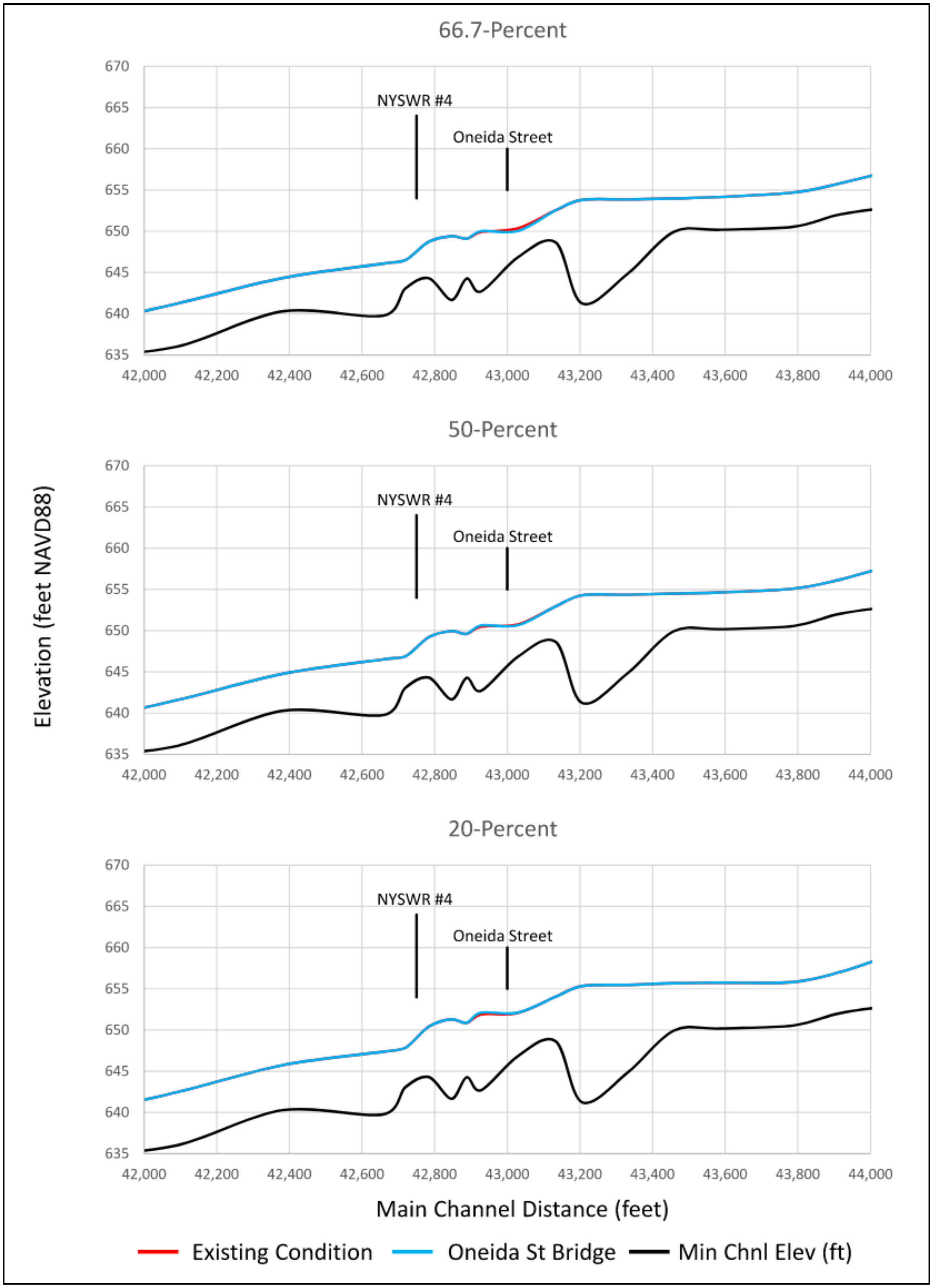

Figure 5-22. HEC-RAS model output for the existing conditions (red) and proposed increase bridge span of the Oneida Street bridge (blue) scenarios.

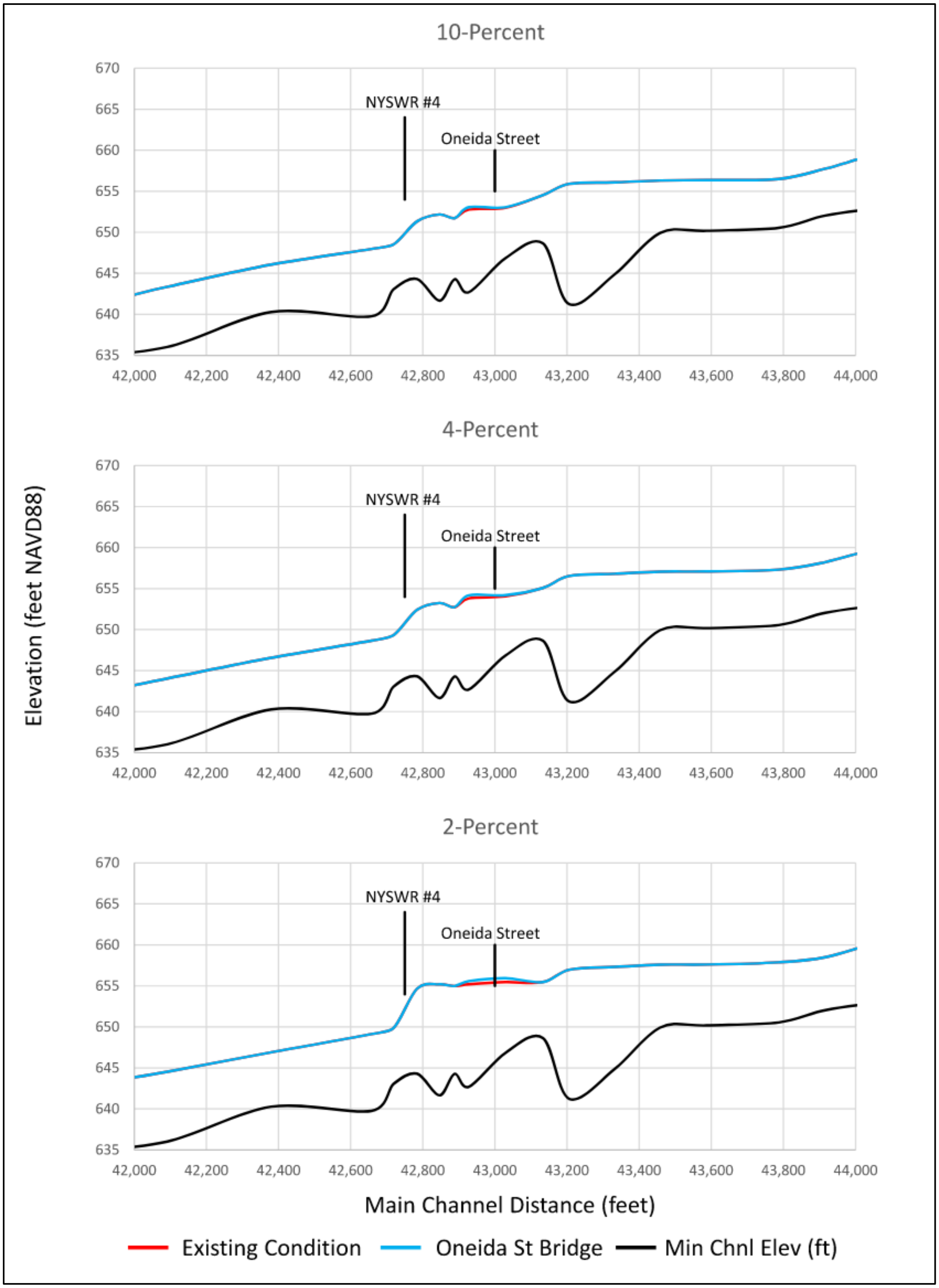

Figure 5-22. (continued) HEC-RAS model output for the existing conditions (red) and proposed increase bridge span of the Oneida Street bridge (blue) scenarios.

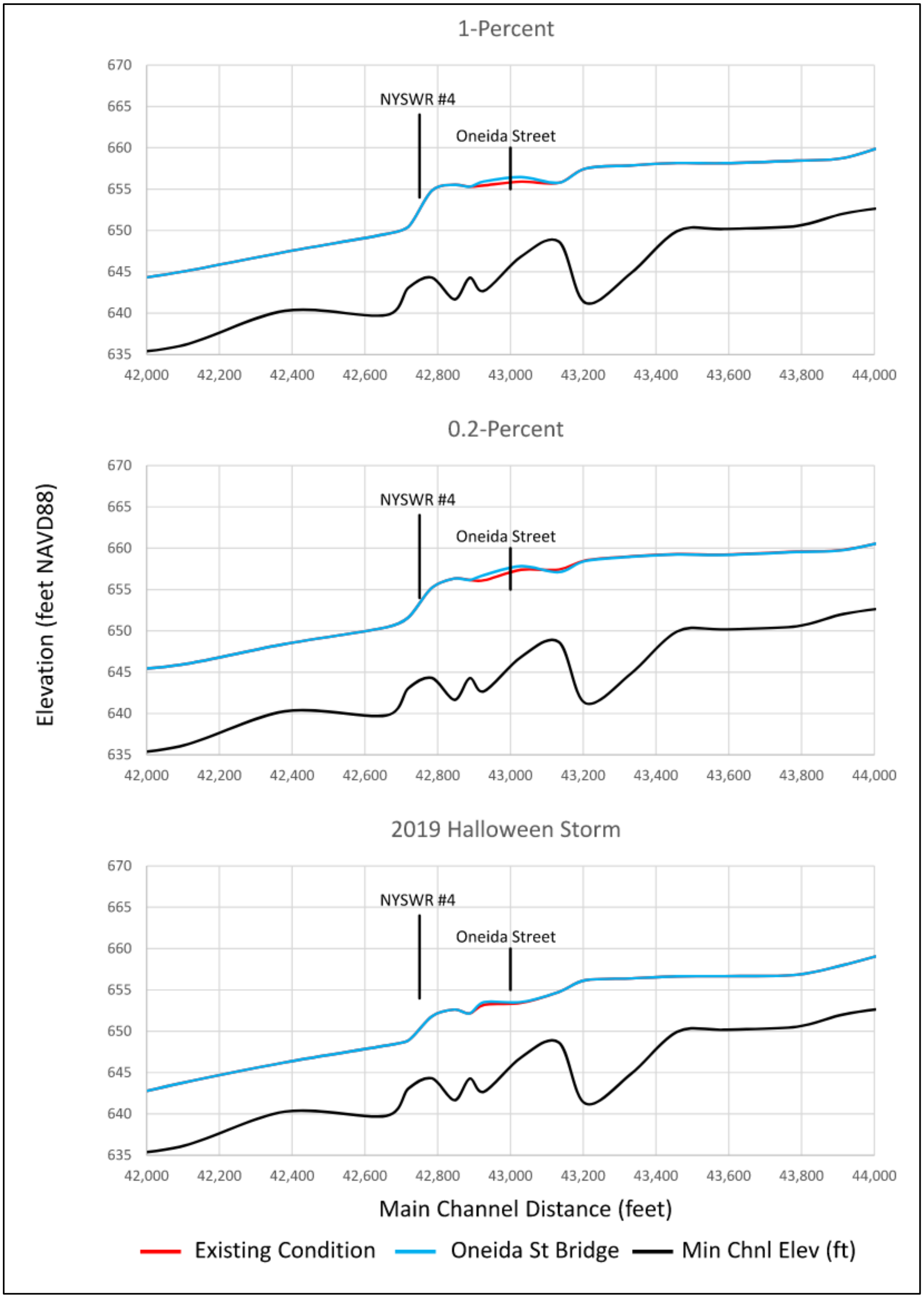

Figure 5-22. (continued) HEC-RAS model output for the existing conditions (red) and proposed increase bridge span of the Oneida Street bridge (blue) scenarios.

5.3.4 Bank and Channel Stabilization

In order to recommend the most appropriate bank and channel stabilization strategies, engineers and scientists need to have an understanding of how sediment enters, moves through, and exits a stream network. By using sediment transport models, engineers and scientists can quantify and evaluate sediment transport using four key variables: invert change, mass bed change, shear stress, and velocity. Table 28 displays the sediment transport model output for the 10% ACE/24-hour storm for upper Sauquoit Creek in the vicinity of Hand Place.

Table 28. HEC-RAS Sediment Transport Model Output for the 10% ACE/24-hours Storm Event

Main Channel Distance (ft)	Invert Change (ft)	Mass Bed Change (ton)	Shear Stress (lb/sq ft)	Velocity (ft/s)
42997	-1.78	-432.77	0.15	1.91
43121	1.29	819.96	0.24	2.74
43511	-0.58	-641.17	0.78	3.77
44050	-0.17	14.62	0.30	2.54
44670	0.42	453.94	0.29	2.55

Table 29 displays the velocity (ft/s) and shear stress (lb/sq ft) from the upper Sauquoit Creek existing conditions model output for the 50-, 20-, and 10-percent ACE peak discharge in the vicinity of Brookline Drive.

Table 29. Upper Sauquoit Creek HEC-RAS Model Output for the 50-, 20-, and 10-Percent ACE Peak Discharges

Main Channel Distance (ft)	50-Percent ACE		20-Percent ACE		10-Percent ACE	
	Shear Stress (lb/sq ft)	Velocity (ft/s)	Shear Stress (lb/sq ft)	Velocity (ft/s)	Shear Stress (lb/sq ft)	Velocity (ft/s)
43029	1.2	7.1	1.2	7.5	1.3	7.8
43133	2.1	9.5	2.1	9.9	2.3	10.5
43206	0.2	3.5	0.3	4.4	0.4	5.0
43333	0.3	4.1	0.4	4.7	0.5	5.2
43458	0.5	4.6	0.4	4.6	0.5	4.8
43587	0.7	5.7	0.7	5.9	0.8	6.2
43787	1.9	9.2	2.3	10.5	2.1	10.2
43916	1.8	8.9	2.0	9.8	1.8	9.4
44063	1.9	9.1	1.7	8.9	1.7	9.2
44217	0.8	6.0	0.7	6.0	0.7	6.2
44369	1.2	7.5	1.5	8.3	1.7	9.1
44686	1.1	7.4	1.8	9.6	1.9	9.9
44849	0.3	3.8	0.3	4.2	0.4	4.5
44929	2.1	9.4	2.5	10.7	2.8	11.5

Based on the sediment transport model output, Table 30 summarizes the applicability of potential streambank strategies along Hand Place.

Table 30. Potential Streambank Stabilization Strategies for the Hand Place Area

Source: NRCS 2009	
Type of Treatment	**Type of Sub-Treatment**
Brush Mattress	Staked only w/rock riprap toe (initial)
	Staked only w/rock riprap toe (grown) *
Coir Geotextile Roll	Roll with coir rope mesh staked only without rock riprap toe
	Roll with Polypropylene rope mesh staked only without rock riprap toe
	Roll with Polypropylene rope mesh staked and with rock riprap toe *
Live Fascine	LF Bundle w/rock riprap toe
Soils	Shales and hardpan
Gravel/Cobble	6-inch
	12-inch *
Vegetation	Class A turf (ret class)
	Class B turf (ret class)
	Long native grasses
	Short native and bunch grass
Soil Bioengineering	Reed fascine
	Coir roll
	Vegetated coir mat
	Live brush mattress (initial)
	Live brush mattress (grown) *
	Brush layering (initial/grown) *
	Live fascine
	Live willow stakes
Boulder Clusters	Boulder: Very large (>80-inch diameter) *
	Boulder: Large (>40-inch diameter) *
	Boulder: Medium (>20-inch diameter) *
	Boulder: Small (>10-inch diameter)
	Cobble: Large (>5-inch diameter)
	Cobble: Small (>2.5-inch diameter)

*Note: These strategies would be applicable for both precipitation (as identified in the sediment transport model) and peak discharge (as identified in the upper Sauquoit Creek model) based velocity and shear stress values.

Due to the variable, conceptual, and site-specific nature of streambank stabilization strategies, no ROM cost estimates were determined for this measure. Additional geomorphic and engineering analyses, including additional modeling (i.e., coupled 1-D/2-D unsteady flow, 2-D unsteady flow and rain-on-grid), would be necessary in order to determine the most appropriate streambank stabilization strategy and its associated costs.

6. SUMMARY

The Sauquoit Creek Intermunicipal Basin Commission funded this flood mitigation study for the upper portion of Sauquoit Creek in the Town of New Hartford, NY. Within the upper Sauquoit Creek project area, major flooding events have been most prominent in three main areas: the Brookline Drive area, Washington Mills Park area, and Hand Place area. Flooding typically occurs at any time within the year, but is more frequent from spring rain and snowmelt, heavy rains by connective systems, log and debris jams, and sediment piles that act as an obstruction to water flow.

This report analyzed the present day causes of flooding in the upper Sauquoit Creek watershed. Hydraulic and hydrologic data was used to model potential flood mitigation measures. The model simulation results indicated that there are flood mitigation measures that have the potential to reduce water surface elevations along the three high-risk areas, which could potentially reduce flood-related damages in areas adjacent to the creek.

Based on the flood mitigation analyses performed in this report, the mitigation measures that provided the greatest reductions in water surface elevations were the flood bench alternatives and increasing the hydraulic capacity of the New York State, Susquehanna and Western Railroad Bridge in the Washington Mills Park focus area.

Based on the analysis of the flood benches, results showed a significant decrease in the current water surface elevation along Sauquoit Creek within the Washington Mills Park and Hand Place focus areas. Flood bench alternative C would have the most beneficial effect in lowering the water surface elevation. However, flood bench measures generally tend to be costly flood mitigation projects so the benefits of these measures in their respective reaches should be balanced with the associated costs of each flood bench measure to determine if it would be feasible to move a flood bench project forward.

It should be noted that flood benches generally only benefit the areas immediately adjacent to and upstream of the constructed bench, so downstream areas would observe a decrease in water surface elevations. A design plan would effectively store water during the wet seasons, and during the dry seasons, these areas could be used for recreation such as a park, or as a nature trail. Plantings of biodiverse, native, and riparian plants are suggested to adequately store water, act as a buffer to decrease erosion, and increase the adaptability to wildlife habitats.

In addition, flood benches can be designed to reduce velocity and shear stress forces in areas that are highly susceptible to erosion and bank failures while providing additional storage to reduce flood risk. During high flow events, sediments and debris can flow into the flood bench and settle out due to the drop in velocity, removing them from the channel water column and downstream areas.

A buyout program where residential properties are located within the Sauquoit Creek floodplain such as Brookline Drive and Hand Place, are probable locations for a residential buyout and potential construction of a flood mitigation project, for example a flood bench. In the case of Hand Place, the H&H modeling results indicate a significant decrease in the current water surface elevations when a buyout and flood bench alternative was analyzed. Any municipality considering a buyout program should weigh the advantages and disadvantages for the acquisition and removal of properties in high-risk flood areas.

Floodproofing is an effective mitigation measure but requires a large financial investment in individual residential and non-residential buildings. Floodproofing can reduce the future risk and flood damage but leaves buildings in flood risk areas so that future flood damages remain. A benefit to floodproofing versus buyouts is that property and structures remain intact, thereby maintaining the tax base for the local municipality.

Increasing the hydraulic capacity of the NYSWR bridge would decrease the water surface elevation in the Washington Mills focus area. Alternatively, the two proposed strategies to increase the hydraulic capacity for Oneida Street bridge would not reduce the water surface elevation. Bridge widening measures are most expensive of the discussed flood mitigation measures. The benefits of the measures in their respective reaches should be balanced with the associated costs of each widening measure to determine if it would be feasible to move a widening measure forward. Additionally, other complications such as traffic re-routing should be considered when considering any of the bridge widening measures.

Natural stream restoration and bank and channel stabilization strategies would maintain the flow channel area along Sauquoit Creek, trap and/or reduce sediment entering the waterway, and improve overall water quality. Sediment and debris that enters the waterway reduces the channel flow area, which over time can reduce the flow capacity of the channel and potentially lead to greater occurrences of, and more damaging flooding.

For flood mitigation measures that are being considered for funding through FEMA grant programs, a benefit-to-cost analysis will be required. In order to qualify for FEMA grants and/or funding, the benefit to cost ratio must be greater than one. Flood buyouts/property acquisitions can qualify for FEMA grant programs with a 75% match of funds. The remaining 25% of funds is the responsibility of state, county, and local governments.

In general, there would be an overall greater effect in water surface elevations if multiple alternatives were built in different phases, rather than a single mitigation project. For example, building multiple flood benches along a single reach would compound the flood mitigation benefits of each bench. Table 31 is a summary of the proposed flood mitigation measures, including modeled water surface elevation reductions and estimated ROM costs.

Table 31. Potential Streambank Stabilization Strategies for the Hand Place Area

Focus Area	Description	Benefits Related to Alternative	ROM Cost Estimate ($ US Dollars)
Brookline Drive	Natural Stream Restoration	Restores natural habitats, reduces/manages runoff, and improves water quality	$2.1 million
	Bank and Channel Stabilization	Reduction in bank and channel erosion, lower flow velocities, decreases in sediment accumulation	Variable[1]
	Flood Prone Property Buyout	Reduces and/or eliminates future losses	Variable[1]
	Flood Prone Property Buyout and Flood Bench	Model simulated WSEL reductions of up to 2.7-ft	$9.5 million
Washington Mills Park	Flood Benches	Model simulated WSEL reductions of: Flood Bench A: up to 2.2-ft Flood Bench B: up to 4.0-ft Flood Bench C: up to 4.0-ft	A: $2.0 million B: $5.8 million C: $6.3 million
	Increase Hydraulic Capacity of NYSWR #4 Bridge	Model simulated WSEL reductions of up to 1.8-ft	$1.1 million
	Bank and Channel Stabilization	Reduction in bank and channel erosion, lower flow velocities, decreases in sediment accumulation	Variable[1]
Hand Place	Flood Bench	Model simulated WSEL reductions of up to 1.1-ft	$3.0 million
	Flood Prone Property Buyout and Flood Bench	Model simulated WSEL reductions of up to 3.8-ft	$8.8 million
	Increase Hydraulic Capacity of Oneida Street Bridge – Restore Natural Channel Geomorphology	No benefit; Model simulated no WSEL reductions	$650,000
	Increase Hydraulic Capacity of Oneida Street Bridge	No benefit; Model simulated no WSEL reductions	$5.6 million
	Bank and Channel Stabilization	Reduction in bank and channel erosion, lower flow velocities, decreases in sediment accumulation	Variable[1]

[1]Note: Due to the conceptual nature of this measure, and significant amount of data required to produce a reasonable ROM cost, it is not feasible to quantify the costs of this measure without further engineering analysis and modeling.

7. NEXT STEPS

7.1 Additional Data Collection and Modeling

Additional data collection and modeling would be necessary to more precisely model water surface elevations and the extent of potential flooding in overbank areas and the floodplain. 2-D unsteady flow modeling using the HEC-RAS program would incorporate additional spatial information in model simulations producing more robust results with a higher degree of confidence than the currently modeled 1-D steady flow simulations. 2-D ice simulations are highly recommended to access the wintery condition with the suggested alternatives to evaluate the water level rises due to presence of ice, ice-jam or break-up ice jam conditions.

7.2 Regulatory & Permitting Requirements

Prior to implementation of any mitigation alternative, pertinent local municipalities' Flood Damage Prevention laws, NYSDEC Part 502 regulations (for state-related facilities), and any other applicable state and local laws or regulations should be determined and appropriate steps taken to ensure compliance. These laws and regulations should also reflect the FEMA requirements for work within the regulated floodplain.

Stream restoration and design activities are subject to various federal, state, and local regulatory programs. Most of these regulations are aimed at protecting natural resources and the integrity of the Nation’s water resources. Designers should be aware of project permitting requirements and develop a project plan and budget identifying resources and project approaches that meet permit conditions. Depending on the type of project and its location, these can range from minimal to a full set of required federal, state, and local permits. The applicable programs and permits can include the following (NRCS 2007):

- National Environmental Policy Act
- Endangered Species Act
- National Historic Preservation Act
- Wild and Scenic Rivers Act
- Fish and Wildlife Coordination Act
- Clean Water Act
- Rivers and Harbors Act of 1899
- Magnuson-Stevens Fishery Conservation and Management Act
- Local and state water quality permits
- Water rights
- National Flood Insurance Program (NFIP)
- Local and state flood permits
- Local zoning permits

Permitting agencies should be approached as soon as conceptual plans are developed. In regulatory intensive areas, as well as in areas of high environmental risk, it may be advisable to consult with them in the early planning stages. In general, designers and planners should provide at least the following to the permitting agency (NRCS 2007):

- Site map
- Description of existing environmental conditions (written and maps, photos, drawings)
- Description of the proposed work (written and drawings)
- Property ownership
- Access and staging information
- Preferred times of implementation

Each state has individual statutes and codes that provide the legal framework for developing and managing water resource-related projects. A variety of permits are required to work within rivers, streams, and/or wetlands. State fish and wildlife agencies and land management agencies are the typical implementing agency. Local permit requirements should be fully identified when developing project plans, designs, and construction specifications. Prior to initiation of any in-stream activities, the NYSDEC should be contacted, and appropriate local, state, and federal permitting should be obtained (NRCS 2007).

7.3 State/Federal Wetlands Investigation

Any flood mitigation strategy that proposes using wetlands in any capacity, needs to be evaluated based on federal and state wetland criteria before that mitigation strategy can be recommended for final consideration.

None of the proposed mitigation alternatives involved any jurisdictional NYSDEC wetlands; however, several alternatives are on lands that historically were designated wetlands. The NYSDEC recommends wetland delineations where mapped NYSDEC wetlands have historically existed or are in close proximity, such as near the outlet of Oneida Creek into Oneida Lake. Wetland delineations will verify whether the NYSDEC would require an Article 24 Wetland Permit for any mitigation project.

7.4 Example Funding Sources

There are numerous potential funding programs and grants for flood mitigation projects that may be used to offset municipal financing, including:

- New York State Office of Emergency Management (NYSOEM)
- New York State Department of Transportation Bridge NY Program
- Regional Economic Development Councils/Consolidated Funding Applications (CFA)
    - Water Quality Improvement Project (WQIP) Program
    - Climate Smart Communities (CSC) Grant Program

- Natural Resources Conservation Services (NRCS) Watershed Funding Programs
    - Emergency Watershed Protection (EWP) Program
    - Watershed and Flood Prevention Operations (WFPO) Program
    - Watershed Rehabilitation (REHAB) Program
- FEMA Unified Hazard Mitigation Assistance (HMA) Program
    - Building Resilient Infrastructure and Communities (BRIC)
    - Flood Mitigation Assistance (FMA) Program
- FEMA Safeguarding Tomorrow through Ongoing Risk Mitigation (STORM) Act
- USACE Continuing Authorities Program (CAP)

Each potential funding source should be evaluated based on appropriateness of the flood mitigation project with regards to the objectives of the funding program.

8. CONCLUSION

Within the Upper Sauquoit Creek project limits, three focus areas were identified to have historical issues along the channel related to high water surface elevations, sediment aggradation and degradation, channel bed and streambank instability, and floodplain connectivity. Based on the technical analysis set forth in this report, a basis of potential solutions was identified and designed to address the flooding and sediment issues within the Upper Sauquoit Creek project area. This study provides an understanding of the complexity, feasibility, cost effectiveness, and benefits for the different alternatives. The proposed alternatives outlined in this report should be used to support flood mitigation and resiliency projects and is intended to be a high-level overview of proposed flood mitigation strategies and their potential impacts on water surface elevations within the Upper Sauquoit Creek project limits.

The research and analysis that supported each proposed strategy should be considered preliminary but provides the guidance necessary for implementation of the proposed solutions identified for each focus area. Additional design and hydraulic modeling and analyses would be necessary to implement many of the strategies discussed within this study. A comprehensive, organized, effective flood mitigation plan outlines a path for successful results in improving flood resiliency throughout the watershed.

In order to implement the flood mitigation strategies proposed in this report, a process of engagement follows the steps below:

1. Obtain stakeholder and public input to assess the feasibility and public support of each mitigation strategy presented in this report
2. Complete additional data collection and modeling efforts to assess the effectiveness of the proposed flood mitigation strategies
3. Develop a final flood mitigation plan based on the additional data collection and modeling results
4. Select a final flood mitigation strategy or series of strategies to be completed for the Upper Sauquoit Creek project area based on feasibility, permitting, effectiveness, and available funding
5. Develop a preliminary engineering design report and cost estimate for each selected mitigation strategy
6. Assess funding sources for the selected flood mitigation strategy

Once funding has been secured and the engineering design has been completed for the final mitigation strategy, construction and/or implementation of the measure should begin

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APPENDIX A:
FIELD COLLECTION FORMS

APPENDIX B:
FIELD SURVEY DATA

APPENDIX C:
FIELD PHOTO LOGS

APPENDIX D:
FLOOD MITIGATION RENDERINGS

APPENDIX E:
HEC-RAS SIMULATION OUTPUT