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RESILIENT NEW YORK FLOOD MITIGATION INITIATIVE
BUTTERNUT CREEK, NEW YORK

Prepared for:

NEW YORK STATE OF OPPORTUNITY. Office of General Services

NEW YORK STATE OF OPPORTUNITY. Department of Environmental Conservation

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HIGHLAND PLANNING

IN NOVEMBER 2018, NEW YORK STATE GOVERNOR ANDREW CUOMO COMMITTED FUNDING TO UNDERTAKE ADVANCED MODELING TECHNIQUES AND FIELD ASSESSMENTS OF 48 FLOOD-PRONE STREAMS TO IDENTIFY PRIORITY PROJECTS AND ACTIONS TO REDUCE COMMUNITY FLOOD AND ICE JAM RISKS, WHILE IMPROVING HABITAT. THE OVERALL GOAL OF THE PROGRAM IS TO MAKE NEW YORK STATE MORE RESILIENT TO FUTURE FLOODING.

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LIST OF ABBREVIATIONS

1-D	one-dimensional
2-D	two-dimensional
ACE	annual chance flood event
BFE	base flood elevation
BIN	Bridge Identification Number
BRIC	Building Resilient Infrastructure and Communities
CDBG	Community Development Block Grants
CFA	Consolidated Funding Applications
CFR	Code of Federal Regulations
cfs	cubic feet per second
CIN	Culvert Identification Number
CMIP	Coupled Model Intercomparison Project
CRRA	Community Risk and Resiliency Act
CRREL	Cold Regions Research and Engineering Laboratory
CRS	Community Rating System
CSC	Climate Smart Communities
DEM	Digital Elevation Model
EWP	Emergency Watershed Protection
FEMA	Federal Emergency Management Agency
FIRM	Flood Insurance Rate Map
FIS	Flood Insurance Study
FMA	Flood Mitigation Assistance
ft	feet
GIS	Geographic Information Systems
GLS	Generalized Least-Squares
GSE	Gomez and Sullivan Engineers, D.P.C.
H&H	Hydrologic and Hydraulic
HEC	Hydrologic Engineering Center
HEC-RAS	Hydrologic Engineering Center's River Analysis System
Highland Planning	Highland Planning, LLC
HMGP	Hazard Mitigation Grant Program
IPaC	Information for Planning and Consultation
LiDAR	Light Detection and Ranging
LOMR	Letter of Map Revision
LP3	Log-Pearson III
mi^2	square miles
MSC	Map Service Center
NAVD88	North American Vertical Datum of 1988
NCEI	National Centers for Environmental Information
NFIP	National Flood Insurance Program
NLCD	National Land Cover Database
NRCS	Natural Resources Conservation Service
NWI	National Wetlands Inventory
NYSDEC	New York State Department of Environmental Conservation
NYSDHSES	New York State Division of Homeland Security and Emergency Services

NYSDOT	New York State Department of Transportation
NYSERDA	New York State Energy Research and Development Authority
NYSGOSR	New York State Governors Office of Storm Recovery
NYSOEM	New York State Office of Emergency Management
NYSOGS	New York State Office of General Services
NYSOPRHP	New York State Office of Parks, Recreation, and Historic Places
PDM	Pre-Disaster Mitigation
RCP	Representative Concentration Pathways
Ramboll	Ramboll Americas Engineering Solutions, Inc.
R_C	Circularity Ratio
R_E	Elongation Ratio
R_F	Form Factor
RF	Radio Frequency
RL	Repetitive Loss
ROM	Rough Order of Magnitude
SFHA	Special Flood Hazard Area
SRL	Severe Repetitive Loss
USACE	United States Army Corps of Engineers
USDHS	United States Department of Homeland Security
USDOT	United States Department of Transportation
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
WCRP	World Climate Research Programme
WGCM	Working Group Coupled Modelling
WQIP	Water Quality Improvement Project

Introduction

Historical Initiatives

Flood mitigation has historically been an initiative in western New York and in the Butternut Creek watershed. Flood hazards along Butternut Creek within the Town of DeWitt were first mapped by the Federal Insurance Administration, the predecessor to the Federal Emergency Management Agency (FEMA), during the late 1970’s (FEMA, 2016a). The Town of Dewitt implements programs, aimed at mitigating the impacts of flooding, whose activities include flood buyouts, public outreach, wetland enhancement, and tree planting.

The United States Army Corps of Engineers (USACE) has undertaken two separate studies for Butternut Creek; one in the early 1970’s that was summarized in a 1971 report (USACE, 1971) and a two-phase report in the 1980’s that was summarized in a preliminary 1983 report (USACE, 1983) and a final 1989 report (USACE, 1989). The first study summarized the flooding history of Butternut Creek and noted flood-susceptible areas along Butternut Creek included just upstream of the DeWitt Railroad Yard (now the CSX railroad crossing) to the Old Erie Canal (USACE, 1971). The report also mentioned that there is a history of ice jams, but all three recorded ice jams were located upstream of the Jamesville Reservoir without major damage or other consequence. The second study conducted a hydraulic and hydrologic study of Butternut Creek and completed a cost/benefit analysis of potential flood mitigation projects (USACE, 1989). This study ultimately concluded that the considered improvements, which included upsizing the DeWitt railroad yard (a.k.a. CSX) crossing and removing the abandoned railroad crossing upstream, would reduce upstream flooding along Butternut Drive but was not justifiable from a cost/benefit perspective.

Floodplain Development

General recommendations for high risk floodplain development follow four basic strategies:

1. Remove the flood prone facilities from the floodplain
2. Adapt the facilities to be flood resilient under repetitive inundation scenarios
3. Develop nature-based mitigation measures (e.g., floodplain benches, constructed wetlands, etc.) to lower flood stages in effected areas
4. Up-size bridges and culverts to be more resilient to ice jams, high flow events, and projected future flood flows due to climate change in effected areas

In order to effectively mitigate flooding along substantial lengths of a watercourse corridor, floodplain management should restrict the encroachment on natural floodplain areas. Floodplains act to convey floodwaters downstream, mitigate damaging velocities, and provide areas for sediment to accumulate safely. The reduction in floodplain width of one reach of a stream, often leads to the increase in flooding upstream or downstream. During a flood event, a finite amount of water with an unchanging volume must be conveyed and, as certain conveyance areas are encroached upon, floodwaters will often expand into other sensitive areas.

A critical evaluation of existing floodplain law and policies should be undertaken to evaluate the effectiveness of current practices and requirements within this watershed. Local floodplain regulations should be consistent with the National Flood Insurance Program (NFIP) and Federal Emergency Management Agency (FEMA) regulations since the Town of Dewitt is a participating community in the NFIP and should involve a floodplain coordinator and a site plan review process for all proposed developments. This review should be in accordance with local regulations and the NFIP requirements, which require the community to determine if any future proposed development could adversely impact the floodplain or floodway resulting in higher flood stages and sequentially greater economic losses to the community.

Resilient NY Initiative

In November of 2018, New York State Governor Andrew Cuomo announced the Resilient NY program in response to devastating flooding in communities across the State in the preceding years. A total of 48 high-priority flood prone watersheds across New York State are being addressed through the Resilient NY program. Flood mitigation studies were commissioned using advanced modeling techniques and field assessments to identify priority projects in these 48 flood-prone watersheds, develop state-of-the-art studies to reduce flooding and ice jams, and improve ecological habitats in the watersheds (NYSGPO, 2018). The Butternut Creek watershed was chosen as a study site for this initiative.

The New York State Department of Environmental Conservation (NYSDEC) is responsible for implementing the Resilient NY program with contractual assistance from the New York State Office of General Services (NYSOGS). High-priority watersheds were selected based on several factors, such as frequency and severity of flooding and ice jams, extent of previous flood damage, and susceptibility to future flooding and ice-jam formations (NYSGPO, 2018).

The Resilient NY flood studies will identify the causes of flooding within each watershed and develop effective and ecologically sustainable flood and ice-jam hazard mitigation projects. Potential flood mitigation measures will be evaluated using hydrologic and hydraulic (H&H) modeling to quantitatively determine flood mitigation strategies that would result in the greatest flood reduction benefits. In addition, the flood mitigation studies incorporate the latest climate change forecasts and assess open water and ice-jam hazards where future flood risks have been identified.

This report is not intended to address detailed design considerations for individual flood mitigation alternatives. The mitigation alternatives discussed are conceptual projects that have been initially developed and evaluated to determine their flood mitigation benefits. A more in-depth engineering design study would still be required for any mitigation alternative chosen to further define the engineering project details. However, the information contained within this study can inform such in-depth engineering design studies and be used in the application for state and federal funding and/or grant programs.

The goals of the Resilient NY Program are to:

1. Perform comprehensive flood and ice jam studies to identify known and potential flood risks in flood-prone watersheds
2. Incorporate climate change predictions into future flood models
3. Develop and evaluate flood hazard mitigation alternatives for each flood-prone stream area, with a focus on ice-jam hazards

The overarching purpose of the initiative is to evaluate a suite of flood and ice-jam mitigation projects that local municipalities can undertake to make their community more resilient to future floods. The projects should be affordable, attainable through grant funding programs, able to be implemented either individually or in combination in phases over the course of several years, achieve measurable improvement at the completion of each phase, and fit with the community way of life. The information developed under this initiative is intended to provide the community with a basis for assessing and selecting flood mitigation strategies to pursue; no recommendations are made as to which strategies the community should pursue.

The flood mitigation and resiliency study for Butternut Creek began in March of 2022 and a final flood study report was issued in September of 2022.

Data Collection

Initial Data Collection

Hydrological and meteorological data were obtained from readily available state and federal government databases, including ortho-imagery, flood zone maps, streamflow, precipitation, flooding and ice jam reports. Historical flood reports, newspaper articles, social media posts, community engagement meeting notes, and geographic information system (GIS) mapping were used to identify stakeholder concerns, produce watershed maps, and identify current high-risk areas. New York State Community Risk and Resiliency Act (NYSDEC, 2020) guidelines, New York State Department of Transportation (NYSDOT) bridge and culvert standards, and United States Geologic Service (USGS) *FutureFlow Explorer* v1.5 (USGS, 2016) and *StreamStats* v4.4.0 (USGS, 2020) software were used to develop current and future potential discharges and bankfull widths and depths at various points along the stream channel. H&H modeling was performed previously as part of the 2016 FEMA Flood Insurance Study (FIS) for Onondaga County, New York, which repackaged results from a previous 1978 Flood Insurance Study (FIS) for the Town of Dewitt from FEMA's predecessor, the Federal Insurance Administration.

Updated H&H modeling was performed in this study using the United States Army Corps of Engineers (USACE) Hydrologic Engineering Center's River Analysis System (HEC-RAS) v6.2 (USACE, 2022a) software to compute water stage at current and potential future levels for high risk areas and to evaluate the effectiveness of potential flood mitigation strategies. These studies and data were obtained and used, all or in part, as part of this effort. Appendix A is a summary listing of data and reports collected for this study.

Public Outreach

An initial virtual project kickoff meeting was held on March 1, 2022, with representatives of the NYSDEC, NYSOGS, Ramboll Americas Engineering Solutions, Inc. (Ramboll), Gomez & Sullivan Engineers, D.P.C. (GSE), Highland Planning, USACE – Buffalo District, Onondaga County Soil and Water Conservation District, the Town of Manlius, the City of Syracuse, and C&S Engineers (Appendix B). At the project kickoff meeting, project specifics including background, purpose, funding, roles, and timelines were discussed. Discussions included a variety of topics, including:

- Firsthand accounts of past flooding events
- Identification of specific areas that flooded along Butternut Creek, and the extent and severity of flood damage
- Information on post-flood mitigation efforts, such as temporary floodwalls
- Potential areas where debris jams have been observed

This outreach effort assisted in the identification of current high-risk areas to focus on during the future flood risk assessments.

Field Assessment

Following the initial data gathering and agency meetings, field staff from GSE undertook field data collection efforts with special attention given to high risk areas in the Town of DeWitt, as identified in the initial data collection process. Initial field assessments of Butternut Creek were conducted on April 21, 2022. Information collected during field investigations included the following:

- Rapid "windshield" river corridor inspection

- Photo documentation of inspected areas
- Measurement and rapid hydraulic assessment of bridges, culverts, and dams
- Geomorphic classification and assessment, including measurement of bankfull channel widths at key cross sections
- Field identification of potential flood storage areas
- Characterization of key stream bank failures, head cuts, bed erosion, aggradation areas, and other unstable stream channel features
- Preliminary identification of potential flood hazard mitigation alternatives, including those requiring further analysis

Included in Appendix C is a copy of the Stream Channel Classification Form and Field Observation Form for the inspection of bridges and culverts. Appendix D is a photo log of select locations within the river corridor. The collected field data was categorized, summarized, indexed, and geographically located within a GIS database. This GIS database will be made available to the NYSDEC and NYSOGS upon completion of the project.

All references to “right bank” and “left bank” in this report refer to "river right" and "river left," meaning the orientation assumes that the reader is standing in the river looking downstream.

Watershed Characteristics

Study Area

The Butternut Creek watershed lies primarily in Onondaga County, NY, with the extreme southern edge of the watershed located within Cortland County, NY. The watershed within Onondaga County includes the Towns of DeWitt, Manlius, Onondaga, Mompey, LaFayette, Fabius, and Tully and the City of Syracuse; within Cortland County the watershed includes the Towns of Preble and Truxton. The headwaters of Butternut Creek originate near the Onondaga/Courtland County line, and the creek then primarily flows from south to north before taking a turn to the east just before it drains into Limestone Creek. Butternut Creek has a total watershed area of 72.3 square miles at the confluence with Limestone Creek. Figure 1 depicts the location of the Butternut Creek watershed.

Within the watershed, the Town of DeWitt was chosen as the target study area due to the history of flooding in and along the creek and the amount of development along the creek. Figure 2 depicts the stationing of the creek for the watershed and identifies the study area. Figure 3 depicts the stationing along Butternut Creek within the Town of DeWitt, as well as the locations where field data was collected for this study.

The portion of Butternut Creek specifically included in this study is only within the limits of DeWitt, which starts just downstream of the Jamesville Reservoir. As a result, mitigation alternatives which would only affect flooding outside of DeWitt were not evaluated as part of this study. According to the Onondaga County FIS, the watershed area at the upstream (DeWitt/LaFayette Town Line, just downstream of Jamesville Reservoir) and downstream (DeWitt/Manlius Town Line) study extents are 43.3 and 63.7 sq. miles, respectively[1].

[1] For reference, a USGS StreamStats delineation for these same locations confirms the drainage area just downstream of Jamesville Reservoir, but suggests a watershed area of 69 sq. miles at the DeWitt/LaFayette Town Line (a difference of nearly 8%). For the purpose of this report and associated hydrologic/hydraulic analyses, the FIS watershed areas will be used.

Figure 1. Butternut Creek Watershed, Onondaga, NY

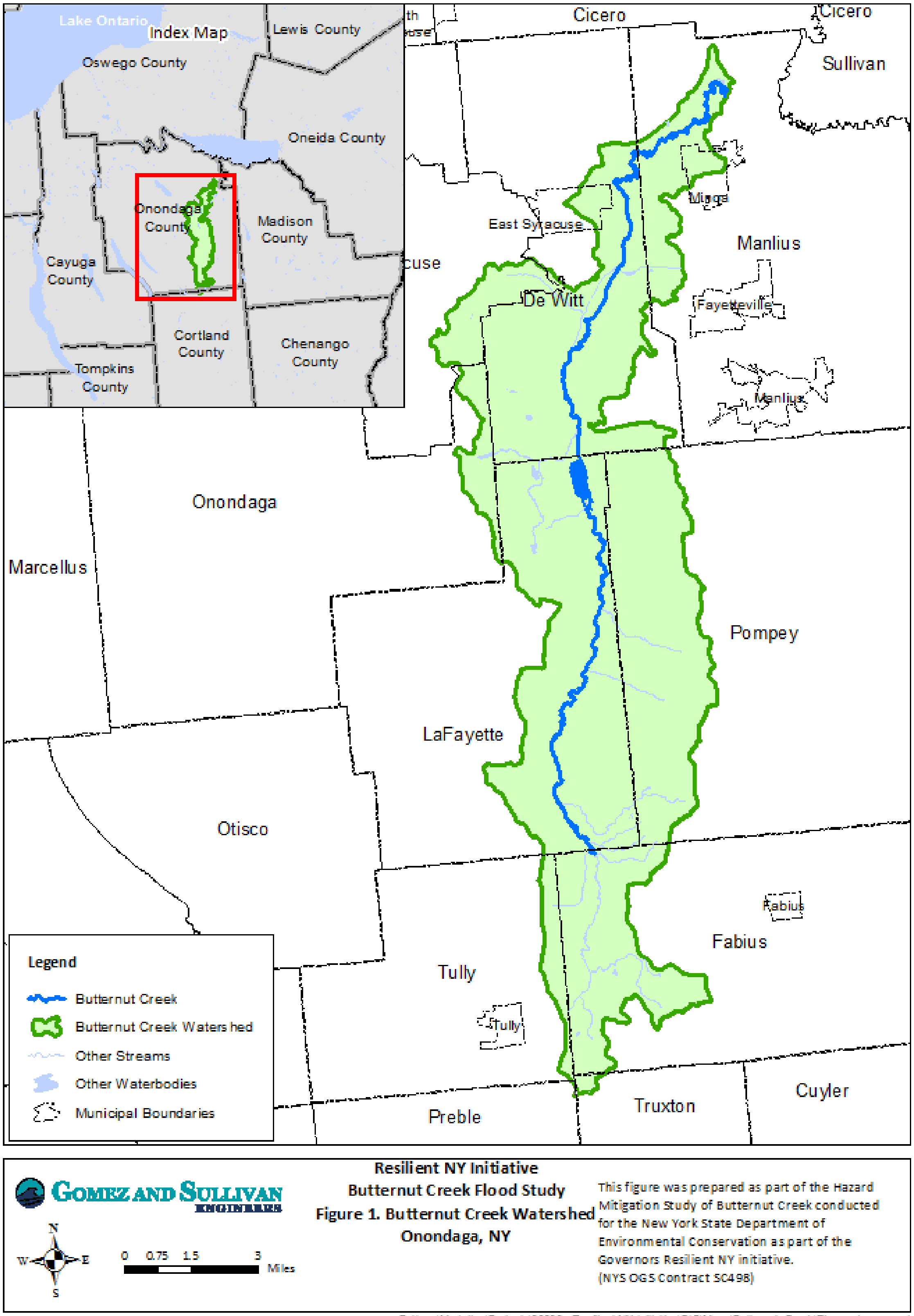

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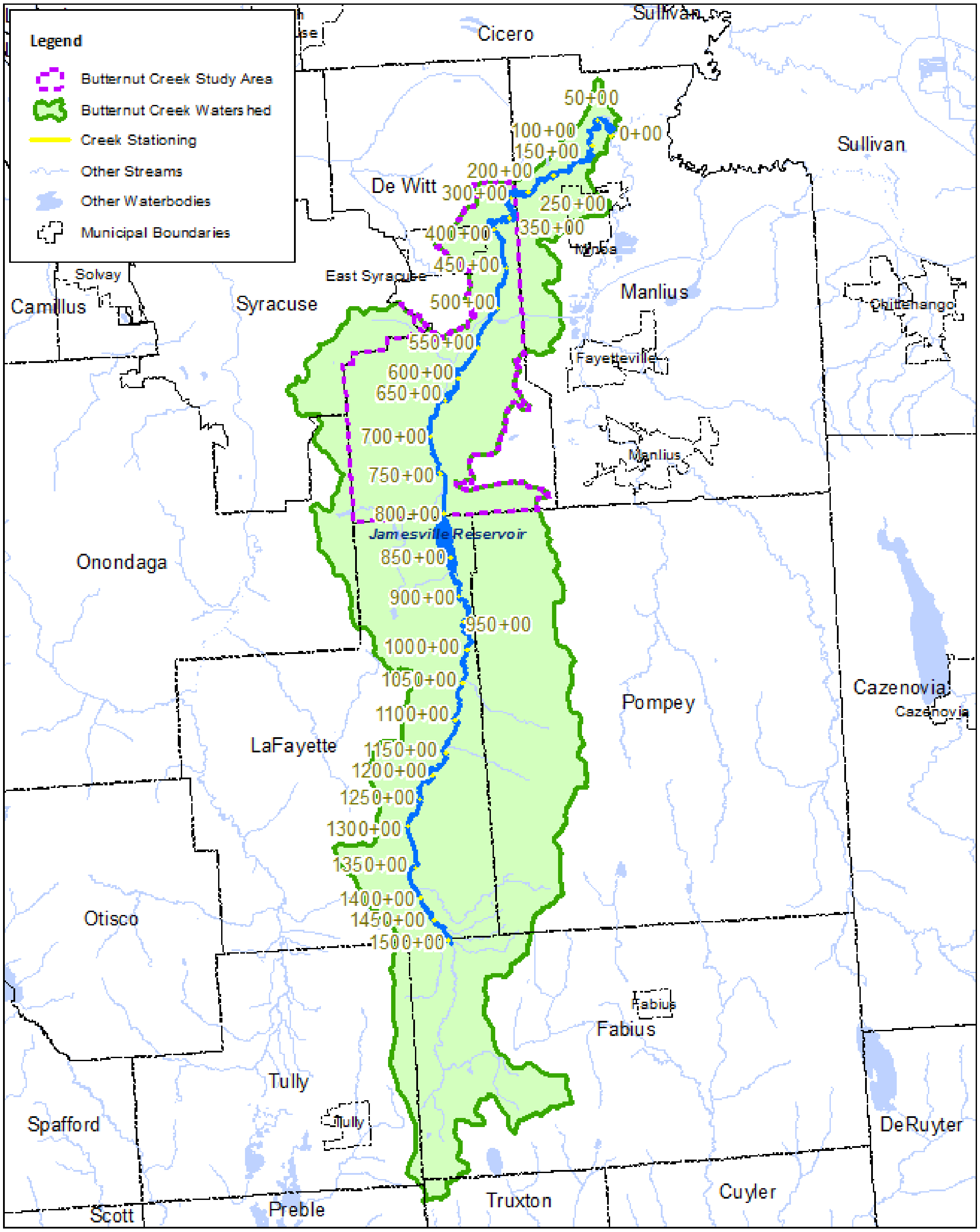
Figure 2. Butternut Creek Stationing, Onondaga County, NY



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Resilient NY Initiative
Butternut Creek Flood Study
Figure 2. Butternut Creek Stationing,
Onondaga County, NY

N W E S

0 2 4 8 Miles

This figure was prepared as part of the Hazard Mitigation Study of Butternut Creek conducted for the New York State Department of Environmental Conservation as part of the Governors Resilient NY initiative.
(NYS OGS Contract SC498)

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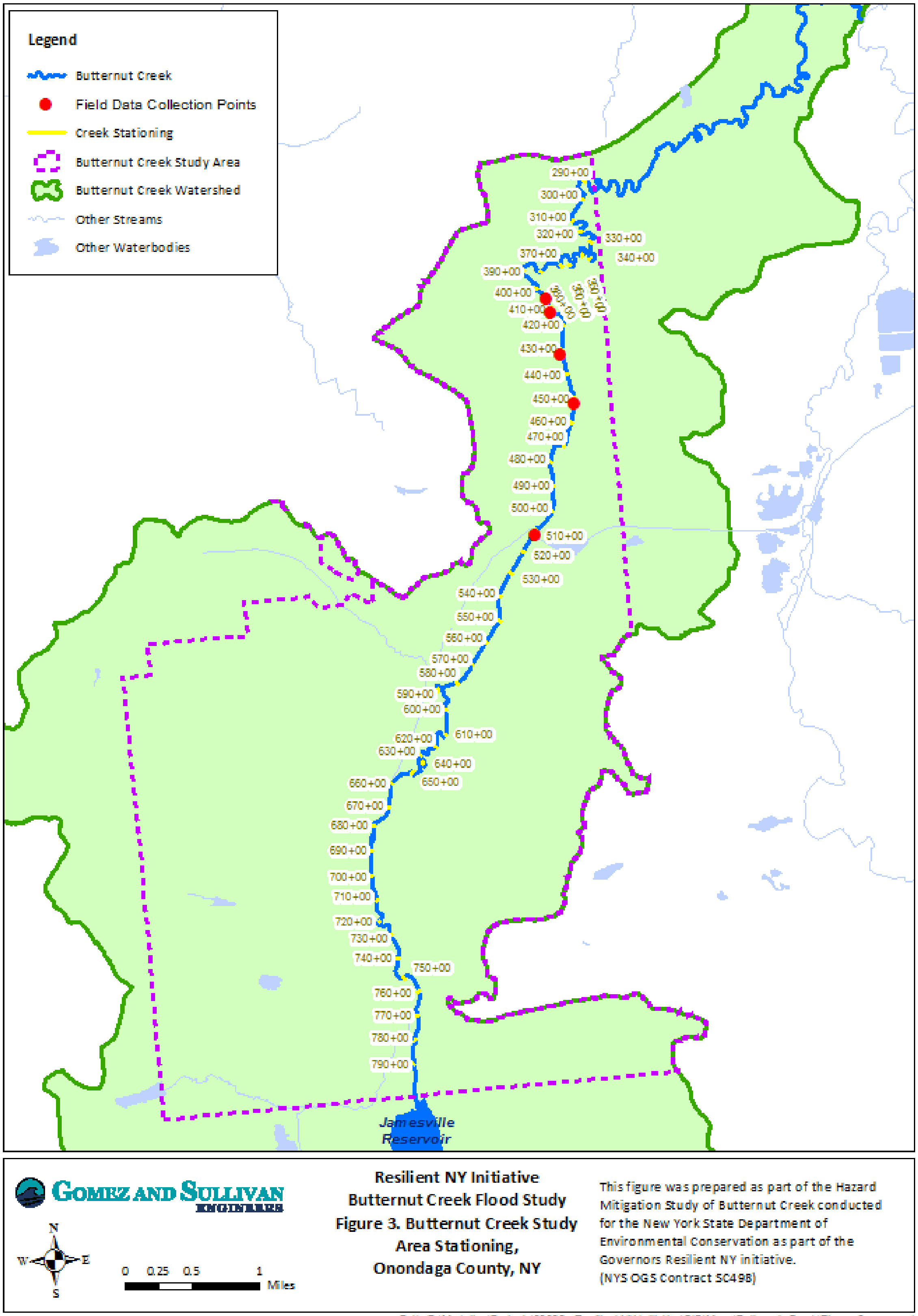
Figure 3. Butternut Creek Study Area Stationing, Onondaga County, NY



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Environmental Conditions

An overview of the environmental and cultural resources within the Butternut Creek study area was compiled using the following online tools:

- Environmental Resource Mapper: The Environmental Resource Mapper is a tool used to identify mapped federal and state wetlands, state designated significant natural communities, and plants and animals identified as endangered or threatened by the NYSDEC (NYSDEC, 2020a) (https://gisservices.dec.ny.gov/gis/erm/)
- National Wetlands Inventory (NWI): The NWI is a digital map database available on the Environmental Resource Mapper that provides information on the "status, extent, characteristics and functions of wetlands, riparian, and deep-water habitats" (NYSDEC, 2020a)
- Information for Planning and Consultation (IPaC): The IPaC database provides information about endangered/threatened species and migratory birds regulated by the United States Fish and Wildlife Service (USFWS, 2022) (https://ecos.fws.gov/ipac/)
- National Register of Historic Places: The National Register of Historic Places lists historic places worthy of preservation, as authorized by the National Historic Preservation Act of 1966 (NPS, 2014) (https://www.nps.gov/maps/full.html?mapId=7ad17cc9-b808-4ff8-a2f9-a99909164466)

Wetlands

The State-Regulated Freshwater Wetlands database shows the approximate location of wetlands regulated by New York State (Figure 4). According to the Environmental Resource Mapper, 47 wetlands are within or adjacent to the study area totaling approximately 2,170 acres (NYSDEC, 2020a).

The NWI was reviewed to identify national wetlands and surface waters (Figure 4). The Butternut Creek study area includes 147 wetland features totaling approximately 1,420 acres (NYSDEC, 2020a).

Sensitive Natural Resources

The Environmental Resource Mapper shows that the study area overlaps with high quality occurrences of maple-basswood rich mesic forest and northern wide cedar swamp, both significant natural community types in New York State (Figure 5) (NYSDEC, 2020a).

Endangered or Threatened Species

The Environmental Resource Mapper shows that the study area includes occurrences of rare plants and animals, including bats and other undisclosed species (Figure 5). The NYSDEC Regional Office should be contacted to determine the potential presence of the species identified (NYSDEC, 2020a).

The USFWS Information for Planning and Consultation (IPaC) results for the study area report that the following protected animals may occur within the project area: Indiana bat (endangered), northern long eared bat (currently threatened, proposed endangered), easter massasauga (threatened), and monarch butterfly (candidate). One protected plant, American hart's tongue fern (*Aspelnium scolopendrium var. americanum*) (threatened) may also occur within the study area. No critical habitat has been designated within the study area (USFWS, 2022).

The migratory bird species listed in Table 1 are reported in the IPaC review of the study area.

Table 1. USFWS IPaC Listed Migratory Bird Species

Common Name	Scientific Name	Level of Concern	Breeding Season
Bald Eagle	*Haliaeetus leucocephalus*	Non-BCC Vulnerable	Dec 1 to Aug 31
Black-billed Cuckoo	*Coccyzus erythropthalmus*	BCC Rangewide (CON)	May 15 to Oct 10
Blue-winged Warbler	*Vermivora pinus*	BCC - BCR	May 1 to Jun 30
Bobolink	*Dolichonyx oryzivorus*	BCC Rangewide (CON)	May 20 to Jul 31
Canada Warbler	*Cardellina canadensis*	BCC Rangewide (CON)	May 20 to Aug 10
Cerulean Warbler	*Dendroica cerulea*	BCC Rangewide (CON)	Apr 20 to Jul 20
Eastern Whip-poor-will	*Antrostomus vociferus*	BCC Rangewide (CON)	May 1 to Aug 20
Evening Grosbeak	*Coccothraustes vespertinus*	BCC Rangewide (CON)	May 15 to Aug 10
Golden-winged Warbler	*Vermivora chrysoptera*	BBC Rangewide (CON)	May 1 to Jul 20
Lesser Yellowlegs	*Tringa flavipes*	BCC Rangewide (CON)	Breeds elsewhere
Long-eared Owl	*Asio otus*	BBC Rangewide	Mar 1 to Jul 15
Red-headed Woodpecker	Melanerpes erythrocephalus	BCC Rangewide (CON)	May 10 to Sep 10
Ruddy Turnstone	Arenaria interpres morinella	BCC - BCR	Breeds elsewhere
Short-billed Dowitcher	Limnodromus griseus	BCC Rangewide (CON)	Breeds elsewhere
Wood Thrush	Hylocichla mustelina	BCC Rangewide (CON)	May 10 to Aug 31

Source: (USFWS, 2022)

Cultural Resources

According to the National Register of Historic Places, there are two registered historic places within the study area, the Dr John Ives House and Saint Mark's Church, which are both located on East Seneca Turnpike (Figure 6).

Consultation with New York State Office of Parks, Recreation, and Historic Places (NYSOPRHP) should be performed to identify the potential presence of archeological resources and the subsequent need to perform a cultural resources investigation (NPS, 2014).

Figure 4. Butternut Creek Study Area Wetlands and Hydrography, Onondaga County, NY

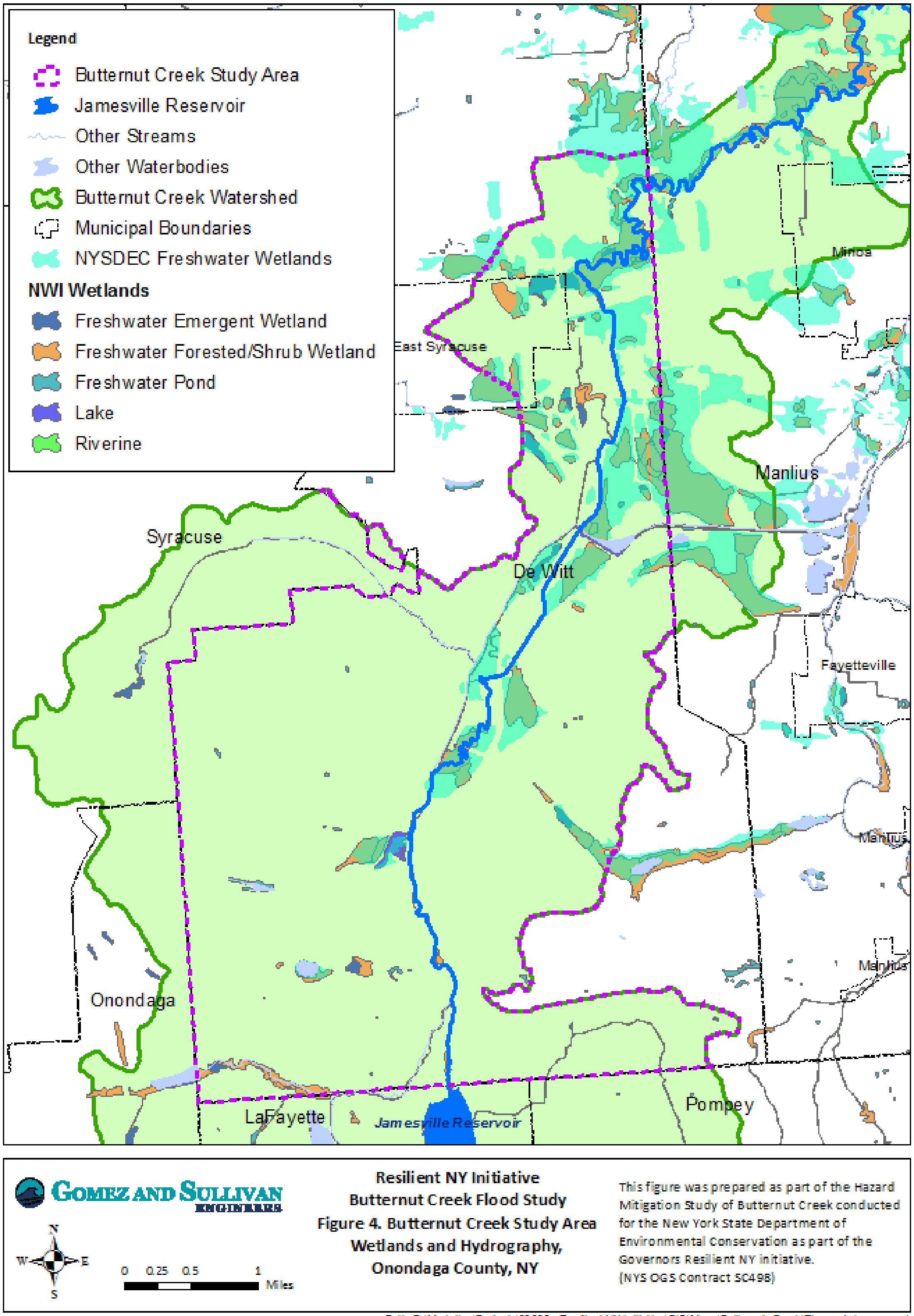
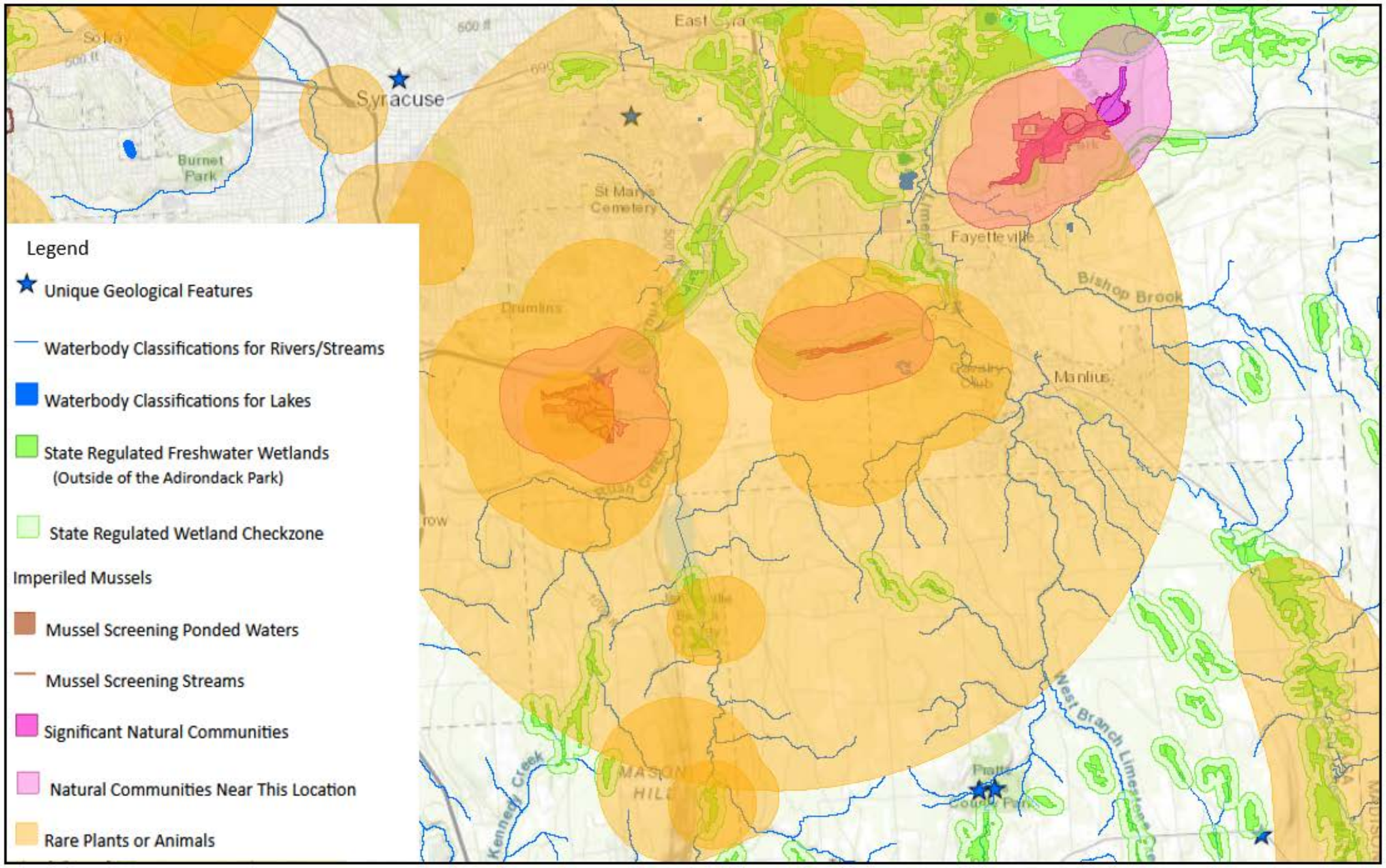


Figure 5. Significant Natural Communities and Rare Plants or Animals, Butternut Creek Study Area, Onondaga County, NY



May 10, 2022

Resilient NY Initiative
Butternut Creek Flood Study
Figure 5. Significant Natural Communities and Rare Plants or Animals, Butternut Creek Study Area, Onondaga County, NY

1:144,448

0 0.75 1.5 3 mi

0 1.25 2.5 5 km

Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri

NYS Department of Environmental Conservation
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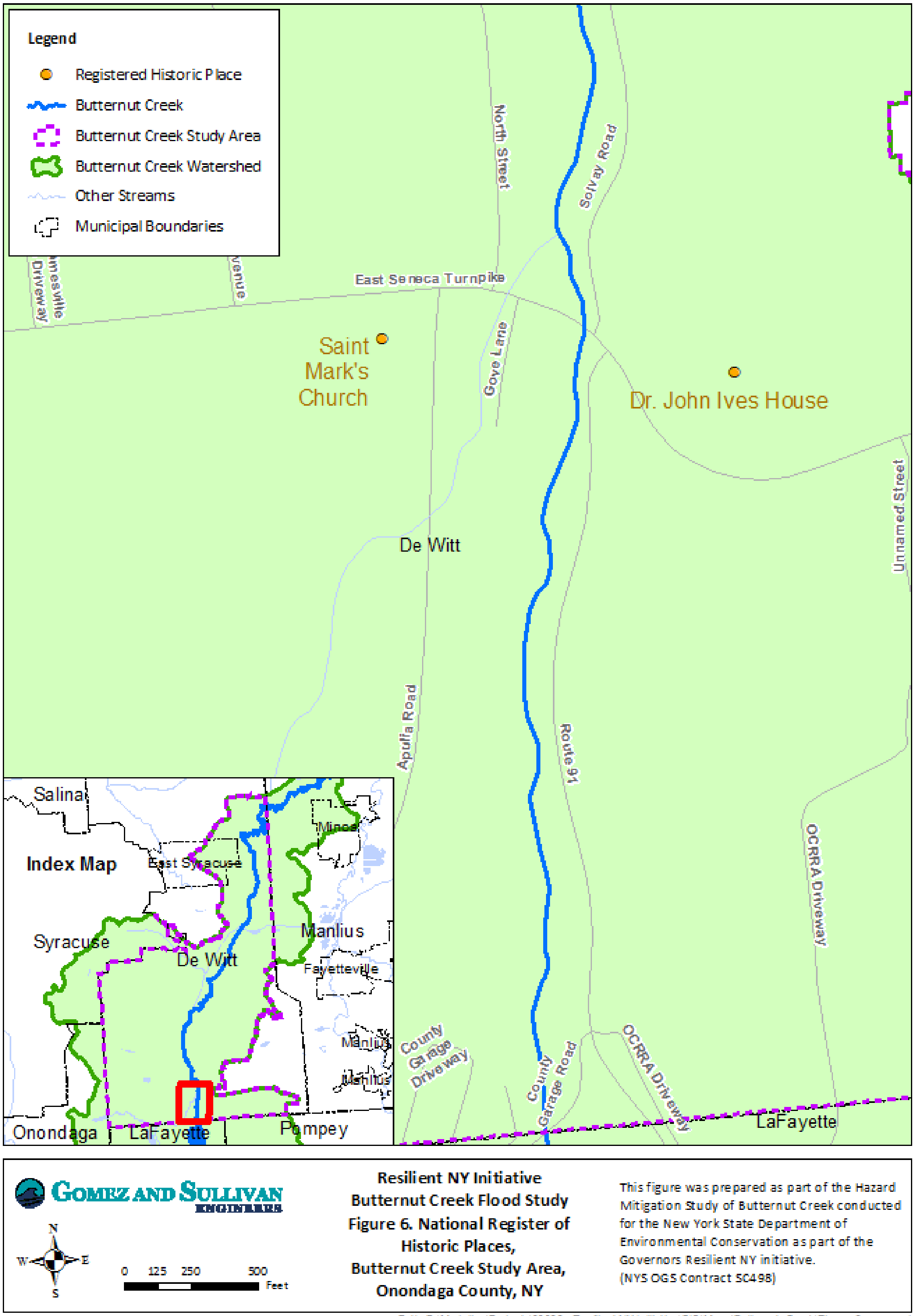
Figure 6. National Register of Historic Places, Butternut Creek Study Area, Onondaga County, NY



Floodplain Location

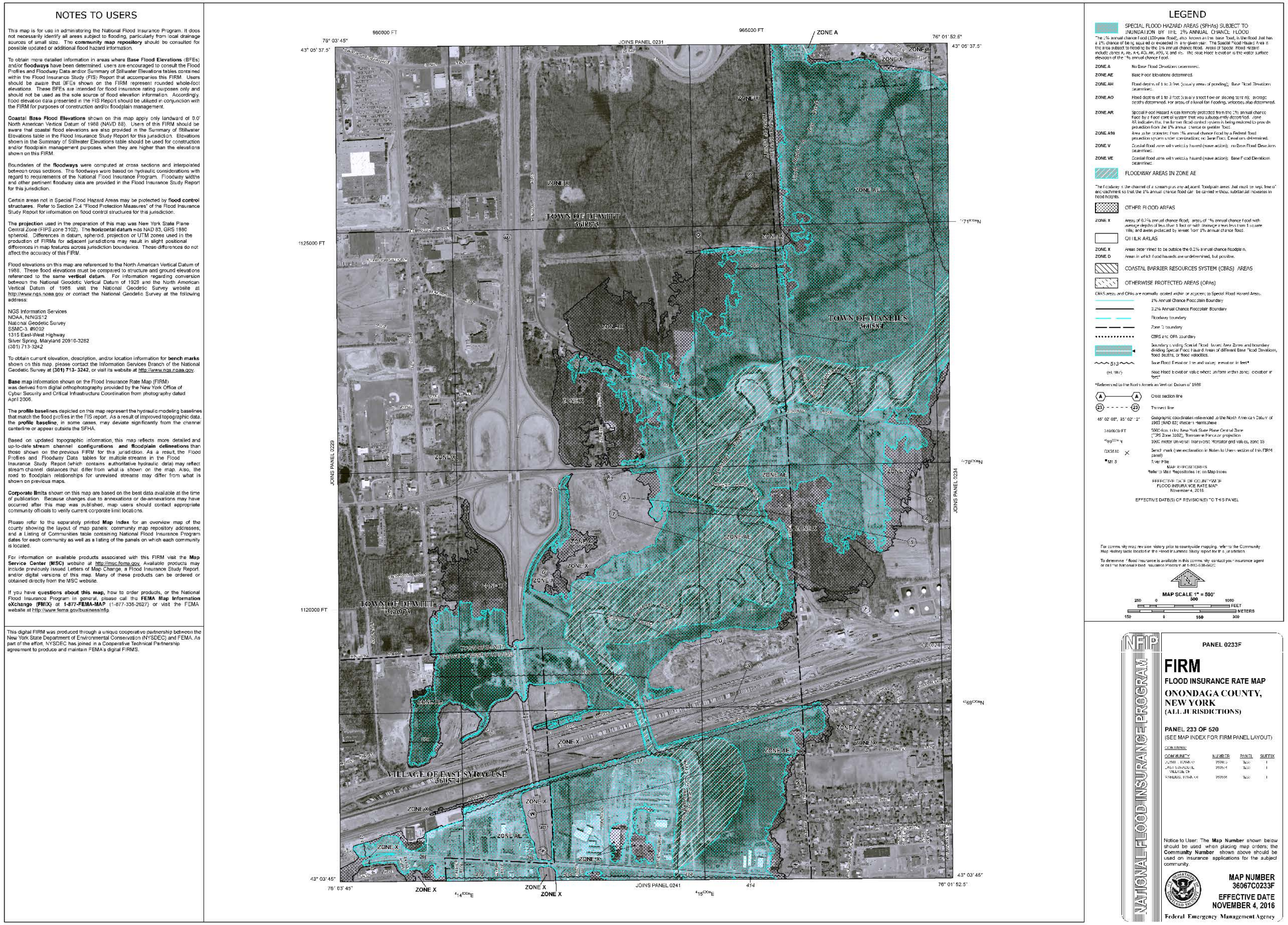
The FEMA Flood Map Service Center (MSC) (https://msc.fema.gov/portal/home) is a database that contains FEMA Flood Insurance Rate Maps (FIRMs) for areas that have had FEMA flood insurance studies completed throughout the United States. For the Town of DeWitt, the current effective FEMA FIS was completed on November 4, 2016. According to the FIS, the hydrologic and hydraulic analyses completed for the Town of DeWitt were a redelineation of the original FEMA H&H study. The FEMA FIS did not include Butternut Creek as a new detailed study (FEMA, 2016a).

Redelineation is the method of updating effective flood hazard boundaries to match current topographic data based on the computed water surface elevations from FEMA effective models. The results of a redelineation update are more accurate floodplain boundaries when compared to current ground conditions. Redelineation of floodplain boundaries can be applied to both riverine and coastal studies. No new engineering analyses are performed as part of the redelineation methodology; however, redelineation can be paired with new engineering studies as part of a larger update. For riverine studies, effective flood profiles and data tables from the Flood Insurance Study (FIS) report, Base Flood Elevations (BFEs) from the Flood Insurance Rate Maps (FIRMs), and supporting hydrologic and hydraulic analyses are used in conjunction with the updated topographic data to formulate new floodplain boundaries. The coastal redelineation method also typically involves no new analyses. This method combines effective information from the FIRM and FIS Report and the supporting analyses with new, more detailed, or more up to-date topographic data to redelineate coastal high hazard areas (FEMA, 2015a).

The FIRM for Butternut Creek indicates Special Flood Hazard Areas (SFHAs), which are land areas covered by floodwaters during the 1% annual chance flood event (ACE), along the banks of the creek, for almost the entire length of the creek (FEMA, 2016b). Butternut Creek is a Regulatory Floodway, which is defined as the watercourse channel and the adjacent land areas that must be reserved in order to discharge the base flood without cumulatively increasing the water surface elevation more than 1-foot over the 1% annual chance flood hazard water surface elevation, referred to as the Base Flood Elevation (BFE). In the regulatory floodway, communities must regulate encroachments, including fill, new construction, substantial improvements, and other development within the adopted regulatory floodway and demonstrate through hydrologic and hydraulic analyses performed in accordance with standard engineering practice that the proposed encroachment would not increase flood levels within the community during the occurrence of the base flood. Development in the portions of the floodplain beyond the floodway, referred to as the floodway fringe, is allowed as long as it does not increase the BFE more than 1.0 foot (FEMA, 2000).

For watercourses where FEMA has provided BFEs, but no floodway has been designated, or where FEMA has not provided BFEs, the community must review floodplain development on a case-by-case basis to ensure that increases in water surface elevations do not occur or identify the need to adopt a floodway if adequate information is available. The flood zones indicated in the Butternut Creek study area are Zone AE, where mandatory flood insurance purchase requirements apply. AE Zones are areas that have a 1% annual chance of flooding where BFEs are provided by FEMA. Figure 7 is a FIRM that includes a portion of Butternut Creek in the Town of Dewitt, NY (FEMA, 2016b).

Figure 7. FEMA FIRM, Butternut Creek, Town of DeWitt, Onondaga County, NY



Study Area Land Use

The National Land Cover Database (MRLC, 2019) shows that, within the study area, the Developed, Low Intensity land use cover type makes up 19.4% of the study area. All developed land cover types total 48.3% of the study area and all upland forest cover types total 20.2%. Further details of the distribution of land cover within the watershed are shown in Table 2. The developed land cover types are located mostly in the central and eastern portion of the study area, with notably less development in the southern and far northeast portion of the study area which are primarily forested and/or agricultural uses.

Table 2. Land Use Cover Types in the Butternut Creek Study Area

Land Use Cover Type	Acres	Percentage
Developed, Low Intensity	2,025	19.4%
Deciduous Forest	1,687	16.1%
Developed, Open Space	1,599	15.3%
Developed, Medium Intensity	1,003	9.6%
Woody Wetlands	902	8.6%
Pasture/Hay	851	8.1%
Barren Land (Rock/Sand/Clay)	593	5.7%
Developed High Intensity	415	4.0%
Shrub/Scrub	310	3.0%
Grassland/Herbaceous	264	2.5%
Mixed Forest	240	2.3%
Cultivated Crops	205	2.0%
Evergreen Forest	191	1.8%
Emergent Herbaceous Wetlands	113	1.1%
Open Water	53	0.5%
Total	10,451	**100%**

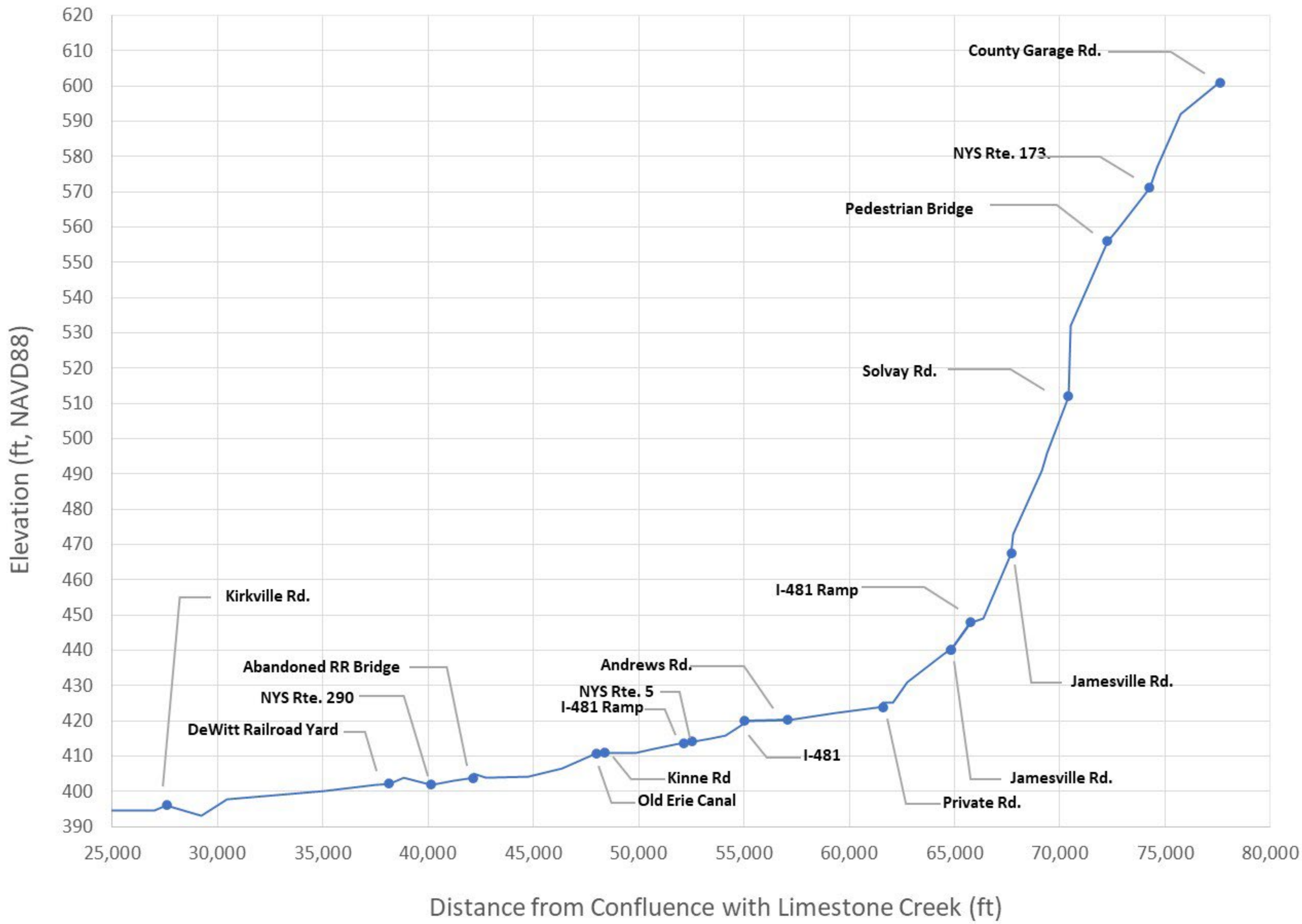
Source: (MRLC, 2019)

Geomorphology

Butternut Creek resides primarily in the Appalachian Plateau physiographic province within the Appalachian Highlands, while the downstream (northern) edge of the watershed is within the Central Lowland physiographic province within the Interior Plains. The stream and valley begin as relatively steep headwaters and remains so for the majority of the watershed before the creek's profile flattens out as it enters the lowland areas for the last several miles before draining into Limestone Creek. Surficial geology data (New York State Museum) indicate the headwaters consist primarily of till moraine and some till before transitioning mid-watershed to primarily till with some till moraine, lacustrine sand, outwash sand/gravel, and bedrock. The surficial geology in the downstream portion of the watershed, including most of the study area, consists of mixture of till, lacustrine silt/clay, and outwash sand/gravel. The bedrock geology varies relatively linearly through the watershed along the stream path, starting with primarily shale and limestone in the upper watershed, followed by limestone and sandstone in the middle of the watershed, followed by a mix of dolostone, shale, gypsum, and salt for the last several miles of the creek before entering Limestone Creek.

Figure 8 is a profile of stream bed elevation and channel distance within the study area based on the FIS profile. The figure includes the location of all stream crossings included within the hydraulic model.

Figure 8. Butternut Creek Study Area Profile of Stream Bed Elevation and Channel Distance



Hydrology

Butternut Creek has a total watershed area of approximately 72.3 square miles at its mouth. The creek is formed at the confluence of two second-order small streams in Fabian, NY which then travels northward approximately 44.2 miles before turning east just before it converges with Limestone Creek. Limestone Creek then travels east, draining into Chittenango Creek, which empties into Oneida Lake. Oneida lake outlets into the Oneida River, which then travels northeast until it empties into Lake Ontario. Butternut Creek has several minor tributaries throughout the watershed (Cascades Creek – 4.6 sq. mi, Rush Creek – 5.5 sq. mi, Meadow Brook – 4.4 sq. mi, and other unnamed tributaries), but no major tributaries that individually account for more than 15% of the total Butternut Creek watershed area. An aqueduct from the Old Erie Canal also crosses Butternut Creek just downstream of Kinne Road in DeWitt; according to the effective FIS (FEMA, 2016a) the Canal aqueduct flows away from Butternut Creek and is therefore not expected to contribute to flooding within the Butternut Creek watershed.

Table 3 is a summary of the basin characteristic formulas and calculated values for the Butternut Creek watershed, where A is the drainage area of the basin in square miles (mi^2), B_L is the basin length in miles, and B_P is the basin perimeter in miles (USGS, 1978).

Table 3. Butternut Creek Basin Characteristics Factors

Factor	Formula	Value
Form Factor (R_F)	A/B_L^2	0.06
Circularity Ratio (R_C)	$4\pi A/B_P^2$	0.10
Elongation Ratio (R_E)	$2(A/\pi)^{0.5}/B_L$	0.27

Form Factor (R_F) describes the shape of the basin (e.g., circular or elongated) and the intensity of peak discharges over a given duration of time. Circularity Ratio (R_C) gives an indication of topography where the higher the circularity ratio, the lower the relief and less disturbance to drainage systems by structures within the channel. Elongation Ratio (R_E) gives an indication of ground slope where values less than 0.7 correlate to steeper ground slopes and elongated basin shapes. Based on the basin characteristic factors, the Butternut Creek basin would be categorized as more elongated basin that is susceptible to erosion, and is expected to experience longer duration but lower peak discharges during storm events relative to a less elongated, circular watershed (Parveen, Kumar, & Singh, 2012). The drainage system within the basin would be expected to be steep with large impacts caused by structural disturbances in the drainage system (Waikar & Nilawar, 2014)].

There is one USGS stream gaging station on Butternut Creek, located about 3.5 miles upstream of Jamesville Reservoir and just downstream of where Wallburger Road crosses Butternut Creek in LaFayette, NY (USGS, 2022). The gage (USGS #04245200) has daily average discharge data available from July 1958 through September 1999 (41 years), after which it appears it has only been used to measure annual peak flows through present times (64 years). The drainage area at the gage is 32.2 square miles. A second historic USGS gage (Butternut Creek at DeWitt, NY – USGS Gage #04245250) was located near Old Erie Canal State Park, but it was only operable for approximately two years; no details were available on why the gage was discontinued.

Table 4. Summary of USGS Gaging Stations

Station ID	Station Name	Peak Streamflow Data	Daily Flow Data
04245200	Butternut Creek Near Jamesville, NY	1985-2021	7/1/1958 – 9/30/1999
04245250	Butternut Creek at DeWitt, NY	N/A	6/1/1964 – 6/30/1966

An effective FEMA Flood Insurance Study (FIS) for Onondaga County was issued on November 4, 2016, which included a redelineation study for Butternut Creek and included drainage area and discharge information for the portions of Butternut Creek included in this study. Table 5 summarizes the FEMA FIS drainage area and peak discharges, in cubic feet per second (cfs), for Butternut Creek within the study area (FEMA, 2016a). For reference, peak discharges at the USGS Gage No 04245200 are also included in this study, to represent a site upstream of Jamesville Reservoir.

Table 5. Butternut Creek FEMA FIS Peak Discharges

Flooding Source and Location	Drainage Area (mi^2)	River Station (ft)	Peak Discharge (cfs)			
			10%	2%	1%	0.2%
DeWitt/Manlius Town Line	63.7	283+00	2,056	2,932	3,477	4,190
DeWitt/LaFayette Town Line (Jamesville Reservoir outflow)	43.3	794+00	1,460	2,080	2,460	2,950
At USGS Gage No. 04245200	32.2	940+00	1,685	2,455	2,815	3,735

Source: (FEMA, 2016a)

According to the effective FEMA FIS, the hydrology estimates for the Town of DeWitt were determined through the log-Pearson Type III method for gage analysis of USGS gaging station No. 04242500 located on Butternut Creek four miles upstream of Jamesville, New York (period-of-record 1960-1976). The analysis followed the statistical analysis recommended by the Water Resources Council (U.S. Water Resources Council, 1976), also known as Bulletin 17. The estimates of peak discharges derived from this analysis were then transferred to Jamesville Reservoir using a drainage area relationship. Modified puls flood routing was then used to evaluate the impact of Jamesville Reservoir storage for Butternut Creek flows downstream of the reservoir where they enter DeWitt.

General limitations of the FEMA FIS methodology are the age of the effective FIS H&H analysis, the age of the methodology, and the relatively short flow record (16 years) used in the hydrologic statistics. The H&H analysis for Butternut Creek was completed in 1976 using the methodology stated above. The gaging analysis used approximately 16 years of record between 1960 and 1976; while this is more than the minimum record length of 10 years for these types of analyses, today there are nearly 64 years of peak flow data at the same gage available for use. Detailed information regarding the development of the drainage area relationship discussed in the FIS methodology was not found.

StreamStats v4.4.0 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. Developed by the USGS, the primary purpose of *StreamStats* is to provide estimates of streamflow statistics for user selected ungaged sites on streams and for USGS stream gages, which are locations where streamflow data are collected [(USGS, 2017); (USGS, 2020)].

Methods for computing a peak discharge estimate for a selected recurrence interval at a specific site depend on whether the site is gaged or ungaged, and whether the drainage area lies within a single hydrologic region or crosses into an adjacent hydrologic region or State. Hydrologic regions refer to areas in which streamflow-gaging stations indicate a similarity of peak-discharge response that differs from the peak-discharge response in adjacent regions. These similarities and differences are defined by the regression residuals, which are the differences between the peak discharges calculated from station records and the values computed through the regression equation. There are currently six hydrologic regions in New York State [(USGS, 1991); (USGS, 2006)].

For gaged sites, such as Butternut Creek in hydrologic region 6 of New York State, the generalized least-squares (GLS) regional-regression equations are used to improve streamflow-gaging-station estimates (based on log-Pearson type III (LP3) flood-frequency analysis of the gaged annual peak-discharge record) by using a weighted average of the two estimates (regression and gaged). Incorporating the regression estimate into the weighted average tends to decrease time sampling errors that result for sites with short periods of record. The weighted-average discharges are generally the most reliable and are computed from the equation:

$$Q_{T(W)} = [Q_{T(g)}(N) + Q_{T(r)}(E)] / (N + E)$$

Where,

$Q_{T(w)}$ is weighted peak discharge at the gaged site, in cubic feet per second, for the T-year recurrence interval;

$Q_{T(g)}$ is peak discharge at gage, in cubic feet per second, calculated through log-Pearson Type III frequency analysis of the station’s peak discharge record, for the T-year recurrence interval;

N is number of years of annual peak-discharge record used to calculate $Q_{T(g)}$ at the gaging station;

$Q_{T(r)}$ is regional regression estimate of the peak discharge at the gaged site, in cubic feet per second, for the T-year recurrence interval; and

E is average equivalent years of record associated with the regression equation that was used to calculate $Q_{T(r)}$ (USGS, 2006).

StreamStats delineates the drainage basin boundary for a selected site by use of an evenly spaced grid of land-surface elevations, known as a 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. By using these characteristics in the calculation, the peak discharge values have increased accuracy and decreased standard errors by approximately 20% for a 1% annual chance interval (100-year recurrence) discharge when compared to the drainage-area only regression equation [(USGS, 2006); (USGS, 2017)].

When *StreamStats* is used to obtain estimates of streamflow statistics for USGS stream gages, users should be aware that there are errors associated with estimates determined from available data for the stations as well as estimates determined from regression equations, and some disagreement between the two sets of estimates is expected. If the flows at the stations are affected by human activities, then users should not assume that the differences between the data-based estimates and the regression equation estimates are equivalent to the effects of human activities on streamflow at the stations (USGS, 2017).

StreamStats was used to calculate the current peak discharges for Butternut Creek and compared with the effective FIS peak discharges. Table 6 is the summary output of peak discharges calculated by the USGS *StreamStats* software for Butternut Creek at the same locations as the FEMA FIS peak discharges.

Table 6. USGS *StreamStats* Peak Discharge for Butternut Creek at the FEMA FIS Locations

Flooding Source and Location	Drainage Area (mi^2)	River Station (ft)	Peak Discharge (cfs)			
			10%	2%	1%	0.2%
DeWitt/Manlius Town Line	69.0	283+00	3,000	4,240	4,780	6,130
DeWitt/LaFayette Town Line (Jamesville Reservoir outflow)	43.6	794+00	2,240	3,170	3,580	4,580
At USGS Gage No. 04245200	32.5[2]	940+00	1,990	2,800	3,150	4,010

Source: (USGS, 2020)

Using the standard error calculations from the regression equation analysis in *StreamStats*, an acceptable range at the 95% confidence interval for peak discharge values at the 10%, 2%, 1%, and 0.2% annual chance flood hazards was determined. Standard error gives an indication of how accurate the calculated peak discharges are when compared to the actual peak discharges since approximately two-thirds (68.3%) of the calculated peak discharges would be within one standard error of the actual peak discharge, 95.4% would be within two standard errors, and almost all (99.7%) would be within three standard errors (McDonald 2014). Table 7 is a summary table of the USGS *StreamStats* standard errors at each percent annual chance flood hazard for Region 6 in New York State.

Table 7. USGS *StreamStats* Standard Errors for Full Regression Equations

Parameter	Annual Chance of Exceedance (%)			
	10%	2%	1%	0.2%
Standard Error of Peak Discharge (%)	32.9	35.8	37.2	41.4

Source: (USGS, 2006)

FEMA FIS peak discharges were determined to be within an acceptable range (95% confidence interval) based on the *StreamStats* standard error calculations, however the *StreamStats* peak discharges are higher. Further, when results from both the FEMA FIS and StreamStats were compared to peak flow estimates from the 1987 USACE study (USACE, 1989) at common locations, the USACE results aligned more closely with the *StreamStats* results. As a result, the *StreamStats* peak discharge values were used in the hydraulic model simulations for this study.

In addition to peak discharges, the *StreamStats* software also 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 (USGS, 2009).

[2] The USGS gage website lists the drainage area as 32.2 sq. mi.

Bankfull discharge is defined as the flow that reaches the transition between the channel and its flood plain. 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 (USGS, 2009). The bankfull width and depth of Butternut Creek is 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 & Silvey, 1996). Table 8 lists the estimated drainage area, bankfull discharge, width, and depth at select locations along Butternut Creek as derived from the USGS *StreamStats* program.

Table 8. USGS *StreamStats* Estimated Drainage Area, Bankfull Discharge, Width, and Depth

Flooding Source and Location	Drainage Area (mi^2)	River Station (ft)	Bankfull Depth (ft)	Bankfull Width (ft)	Bankfull Streamflow (cfs)
DeWitt/Manlius Town Line	69.0	283+00	3.41	75.1	946
DeWitt/LaFayette Town Line (Jamesville Reservoir outflow)	43.6	794+00	3.12	60.9	666

Source: (USGS, 2020)

Infrastructure

There are no existing active dams within the study area according to the NYSDEC Inventory of Dams (NYSDEC, 2020b). The inventory does, however, identify three Class D ("Negligible" or No Hazard") dams that are considered breached, removed, failed, or otherwise no longer materially impounding water. All three are located between Jamesville Dam and the Solvay Road crossing. Table 9 summarizes pertinent information about the nine NYSDOT owned bridges and culverts crossing Butternut Creek within the study area. In addition to the NYSDOT infrastructure, Butternut Creek is crossed by eleven structures within the study area, which are owned and maintained by Onondaga County, local municipalities, and private owners as summarized in Table 10. 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 (USDOT, 2012). In assessing hydraulic capacity of the culverts and bridges along Butternut Creek, the FEMA FIS profile of Butternut Creek was used to determine the lowest annual chance flood elevation to flow under the low chord of a bridge, without causing an appreciable backwater condition upstream (Table 9, Table 10). Figure 9 depicts the location of the infrastructure crossing Butternut Creek within the study area.

Table 9. NYSDOT Bridges/Culverts Crossing Butternut Creek

Roadway Carried (NY/US Route)	NYSDOT BIN/CIN	River Station (ft)	Bridge Length (ft)	Surface Width[1] (ft)	Hydraulic Capacity (% Annual Chance)
NYS Route 290	1044920	432+00	85	56.3	<10%
Ramp to I-481 NB	1096250	552+00	91	35	0.20%
NYS Route 5	1002140	556+00	57	106	0.20%
I-481	1044440	581+00	45	125	1%
Ramp to I-481 SB[2]	1069160	680+00	42	255	0.20%
I-481 SB	1069151	681+00	288	41	0.20%
I-481 NB	1069152	683+00	278	41	0.20%
Exit from I-481 NB	1069170	686+00	50	35	0.20%
NYS Route 173	1039190	772+00	44	32	0.20%

Notes:
1. Surface Width is measured parallel to creek flow and refers to the curb-to-curb width, which is the minimum distance between the curbs or the bridge railings (if there are no curbs), to the nearest 30 mm or tenth of a foot (NYSDOT, 2006).
2. At this crossing, Butternut Creek also passes under Jamesville Road in a combined hydraulic structure.

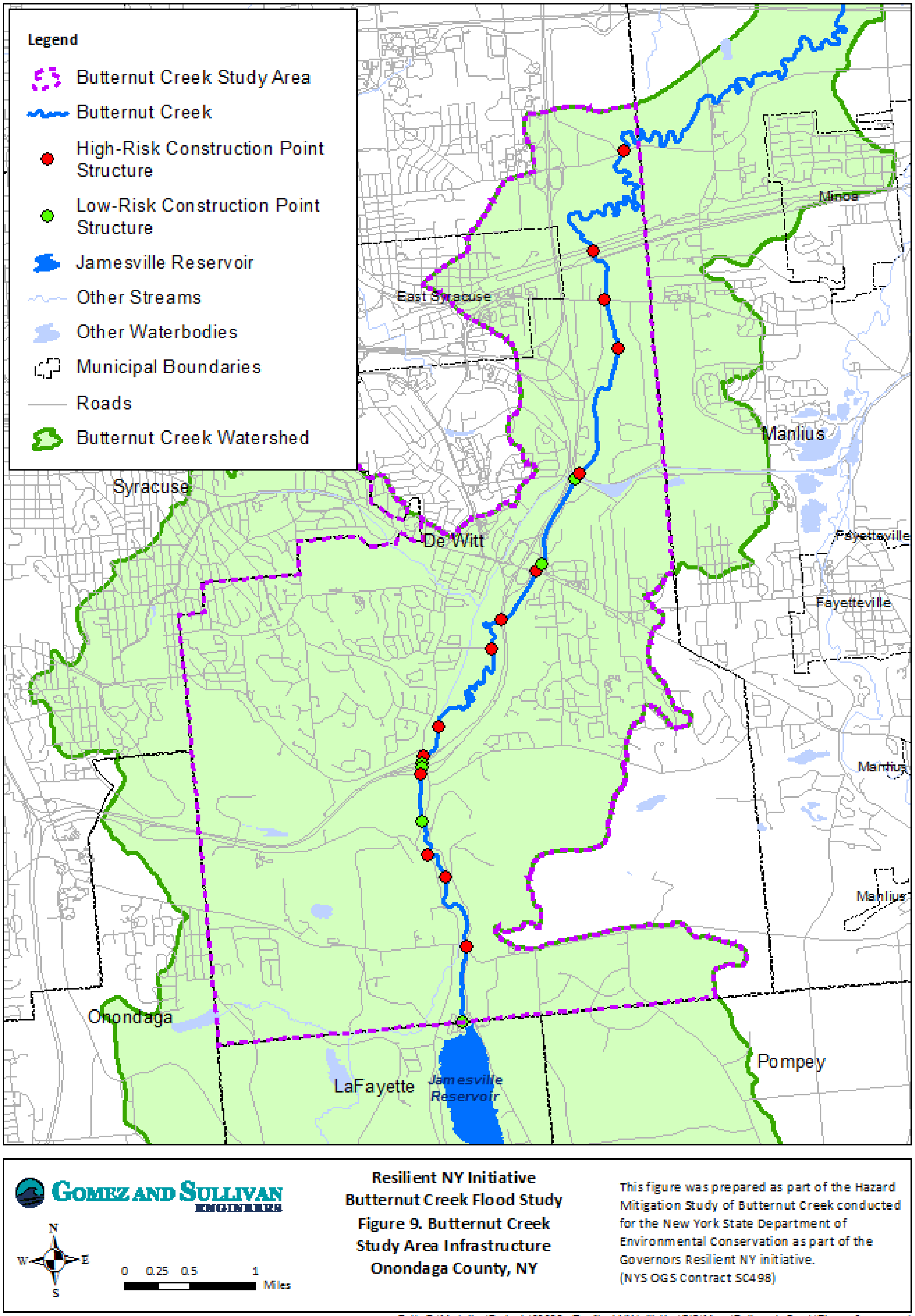
Source: (NYSDOT, 2019); (FEMA, 2016a)

Table 10. Non-NYSDOT Bridges/Culverts Crossing Butternut Creek

Roadway Carried	BIN/CIN	River Station (ft)	Owner	Bridge Length (ft)	Surface Width (ft)	Hydraulic Capacity (% Annual Chance)
Kirkville Road	3312700	301+00	Onondaga County	65	39	<10%
CSX RR Crossing	N/A	408+00	Private	44	600	<10%
Abandoned RR Crossing	N/A	452+00	Private	38	18	10%
Old Erie Canal Aqueduct	N/A	510+00	NYS Parks	45	12	<10%
Kinne Road	3064660	514+00	Town of DeWitt	126	34.5	0.20%
Andrews Road	N/A	606+00	Private	30	12	<10%
Private Driveway off Jamesville (Golf Course)	N/A	646+00	Private	40	10	<10%
Jamesville Road	3312910	706+00	Onondaga County	143	51.2	0.20%
RR bridge 0.3 mi. DS of Solvay Rd	N/A	721+50	Private	55	12	2%
Solvay Road	3207990	735+00	Onondaga County	53	26.2	0.20%
County Garage Road	3361520	803+00	Onondaga County	154	24	<10%

Source: (NYSDOT, 2019); (FEMA, 2016a)

Figure 9. Butternut Creek Study Area Infrastructure, Onondaga County, NY



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In New York State, hydraulic and hydrologic regulations for bridges 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, 2020).

The term “bridge” shall apply to any structure whether single or multiple span construction with a clear span in excess of 20 feet when measurement is made horizontally along the center line of roadway from face to face of abutments or sidewalls immediately below the copings or fillets; or, if there are no copings or fillets, at 6 inches below the bridge seats or immediately under the top slab, in the case of frame structures. In the case of arches, the span shall be measured from spring line to spring line. All measurements shall include the widths of intervening piers or division walls, as well as the width of copings or fillets (NYSDOT, 2020).

According to the NYSDOT bridge manual (2021) for Cayuga, Onondaga, Seneca, and Tompkins Counties within Region 3, new and replacement bridges are required to meet certain standards, which include (NYSDOT, 2021):

- The structure will not raise the water surface elevations anywhere when compared to the existing conditions for both the 2 and 1% 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 current 1% ACE (100-year flood), based on peak streamflow from the USGS *StreamStats* plus a 10% increase in flow, shall pass below the proposed low chord without touching it.
- The maximum skew of the pier to the flow shall not exceed 10 degrees.

In addition, current peak flows shall be increased to account for future projected peak flows based on the USGS *StreamStats* tool where current 2% ACE peak flows shall be increased by 10% in Onondaga County. For critical bridges, the minimum hydraulic design criteria is 3-feet of freeboard over the 2% annual chance flood elevation. A critical bridge is considered to be vital infrastructure that the incapacity or destruction of such would have a debilitating impact on security, national economic security, national public health or safety, or any combination of those matters [(NYSDOT, 2021); (USDHS, 2010)].

In an effort to improve flood resiliency of infrastructure 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* (2020) report. In the report, the NYSDEC outlined infrastructure guidelines, most notably that the new freeboard recommendation for normal bridges is 2-feet of freeboard over the elevation of a flood with a 1% chance of being equaled or exceeded in a given year (i.e., base flood elevation) and 3-feet for a critical structure (NYSDEC, 2020). When compared to current guidelines, the new CRRA climate change recommended freeboard is based on the 1% ACE water surface elevation, while the previous guidelines were based on the 2% ACE. This is a higher standard for freeboard.

Table 11 displays the 2% and 1% annual chance flood levels and their calculated difference at FEMA FIS infrastructure locations using the FIS profile for Butternut Creek.

Table 11. FEMA FIS Profile 2 and 1% Annual Chance Flood Hazard Levels with Differences at Infrastructure Locations

Bridge Crossing	River Station (ft)	2% Water Surface Elevation (ft NAVD88)	1% Water Surface Elevation (ft NAVD88)	Difference in Water Surface Elevations (ft NAVD88)
Kirkville Road	301+00	407.9	408.9	1.0
Existing RR Crossing (CSX)	408+00	412.7	413.5	0.8
NYS Route 290	432+00	412.8	413.6	0.8
Abandoned RR Crossing	452+00	413.2	414.8	1.6
Old Erie Canal Aqueduct	510+00	416.4	417.2	0.8
Kinne Road	514+00	418.0	418.8	0.8
Ramp to I-481 NB	552+00	422.8	423.2	0.4
NYS Route 5	556+00	422.8	423.2	0.4
I-481	581+00	426.8	426.9	0.1
Andrews Road	606+00	430.9	431.2	0.3
Private Driveway off Jamesville (Golf Course)	646+00	438.1	438.2	0.1
Ramp to I-481 SB	680+00	452.0	453.2	1.2
I-481 SB	681+00	452.7	453.2	0.5
I-481 NB	683+00	452.8	453.2	0.4
Exit from I-481 NB	686+00	453.0	453.4	0.4
Jamesville Road	706+00	482.0	482.7	0.7
RR bridge 0.3 mi. DS of Solvay Rd	721+50	497.4	499.7	2.3
Solvay Road	735+00	516.3	517.5	1.2
Footbridge	752+65	564.1	565.8	1.7
NYS Route 173	772+00	581.8	582.5	0.7
County Garage Road	803+00	607.8	608.8	1.0

Source: (FEMA, 2016a)

In assessing hydraulic capacity of the bridges located in the identified high-risk areas along Butternut Creek, the FEMA FIS profile was used to determine the lowest annual chance flood elevation to flow under the low chord of the bridge, without causing a significant backwater condition upstream (Table 9, Table 10). According to the FEMA FIS profiles, one NYSDOT-owned structure within the identified high-risk areas does not meet the NYSDOT guidelines for 2-feet of freeboard for bridges: the NYS Route 290 Bridge. In addition, this structure does not meet the new CRRA climate change infrastructure guidelines as described above. Its low chord elevation is below the 10% ACE and it does not provide the recommended hydraulic capacity (FEMA, 2016a). Even though this structure may have hydraulic capacity restraints, the NYSDOT has to balance both physical constraints along with cost versus benefit of replacing existing bridges to meet the new CRRA guidelines.

Route 290 (Manlius Center Road) was rebuilt in the mid 1980's and, as shown in the FIS, does not appear to contribute to upstream flooding even though the low chord is underwater for the 10%, 2%, and 1% ACE events. Water levels in this area appear to be primarily controlled by the downstream railroad crossing. As such, raising the bridge may have little benefit unless downstream hydraulics are improved. There is also a nearby intersection and building footprints that would need to be considered if the Route 290 bridge were raised any higher.

In addition to comparing the annual chance flood elevations and low chords for bridges that cross Butternut Creek, the structure width and bankfull width were compared for each of these structures. The USGS *StreamStats* tool was used to calculate the bankfull widths and discharge for each structure along Butternut Creek. The structures with bankfull widths that are wider than or close to the structures width indicate that water velocities have to slow and contract in order to pass through the structures, which can cause sediment depositional aggradation and the accumulation of sediment and debris. Aggradation can lead to the development of sediment and sand bars, which can cause upstream water surfaces to rise, increasing the potential for overtopping banks or backwater flooding. Table 12 indicates that in Onondaga County, NY, there are fourteen bridges within the study area that cross Butternut Creek that have bridge openings that are smaller than the bankfull widths: Kirkville Road, the CSX railroad crossing, the abandoned Railroad Crossing, the Old Erie Canal Aqueduct, the ramp to I-481 NB, NYS Route 5, I-481, Andrews Road, the Golf Course bridge, the ramp to I-481 SB, the offramp from I-481 NB, the Railroad bridge just downstream of Solvay Road, Solvay Road, and NYS Route 173. Structures with widths less than or within five feet of the bankfull width are considered high-risk constriction point structures, as depicted in Figure 9. Of the bridges listed in Table 12, five are within the identified high risk area: the CSX railroad crossing, NYS Route 290, the abandoned Railroad Crossing, the Old Erie Canal Aqueduct, and Kinne Road.

Table 12. Hydraulic Capacity of Potential Constriction Point Bridges Crossing Butternut Creek

Roadway Carried	Structure Type	River Station (ft)	Structure Width (ft)	Bankfull Width (ft)	Bankfull Discharge (cfs)	ACE Equivalent[1]
Kirkville Road	Bridge	276+00	65	76.1	1000	<80%
Existing RR Crossing (CSX)	Bridge	378+00	44	75.6	989	<80%
Abandoned RR Crossing	Bridge	421+50	38	75	978	<80%
Old Erie Canal Aqueduct	Bridge	480+00	45	73.3	943	<80%
Ramp to I-481 NB	Bridge	521+50	91[2] (45)	73	936	<80%
NYS Route 5	Bridge	524+50	57	73	936	<80%
I-481	Bridge	549+00	45	69.7	868	<80%
Andrews Road	Bridge	576+00	30	69.7	867	<80%
Private Driveway off Jamesville (Golf Course)	Bridge	616+00	40	68.9	853	<80%
Ramp to I-481 SB[1]	Bridge	649+00	42	68.6	847	<80%
Exit from I-481 NB	Bridge	658+00	50	68.6	845	<80%
RR bridge 0.3 mi. DS of Solvay Rd	Bridge	691+50	55	66.7	808	<80%
Solvay Road	Bridge	705+50	53	66.6	804	<80%
NYS Route 173	Bridge	742+50	44	62.5	727	<80%

Notes:

1. ACE Equivalent describes the equivalent ACE for the given bankfull discharge as calculated by the USGS *StreamStats* application. The 80% ACE is equal to a 1.25-year recurrence interval.
2. This bridge is highly skewed to Butternut Creek, and the abutment-to-abutment width in the direction of the stream is closer to 45 feet.

Source: (NYSDOT, 2019); (USGS, 2020);

Climate Change Implications

Future Projected Stream Flow in Butternut Creek

In New York State, climate change is expected to exacerbate flooding due to projected increases of 1-8% in total annual precipitation coupled with increases in the frequency, intensity, and duration of extreme precipitation events (events with more than 1, 2, or 4-inches of rainfall) (NYSERDA, 2011). In response to these projected changes in climate, New York State passed the CRRA in 2014 and provided guidelines for estimating projected future discharges in their 2020 report. In the report, two methods were discussed: an "end of design life multiplier", and the USGS *FutureFlow Explorer* map-based web application (NYSDEC, 2020).

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. For Western New York, the recommended design-flow multiplier is 10% for an end of design life of 2025-2100 (NYSDEC, 2020).

The USGS *FutureFlow* software is an extension of the *StreamStats* software where regionally specific peak flow regression equations are used to estimate the magnitude of future floods for any stream or river in New York State (excluding Long Island) and the Lake Champlain basin in Vermont. The *FutureFlow* software substitutes a new climate variable (either precipitation or runoff) to the peak flow regression equations. This climate variable is obtained from five climate models that were reviewed by the World Climate Research Programme's (WCRP) Working Group Coupled Modelling (WGCM) team during the 5th Phase of the Coupled Model Intercomparison Project (CMIP5). These five climate models were chosen because they best represent past trends in precipitation for the region (USGS, 2015).

With the USGS *FutureFlow* software, climate variable data is evaluated under two future scenarios, termed "Representative Concentration Pathways" (RCP) in CMIP5, that provide estimates of the extent to which greenhouse-gas concentrations in the atmosphere are likely to change through the 21st century. RCP refers to potential future emissions trajectories of greenhouse gases, such as carbon dioxide. Two scenarios, RCP 4.5 and RCP 8.5, were evaluated for each climate model in CMIP5. RCP 4.5 is considered a midrange-emissions scenario, and RCP 8.5 is a high-emissions scenario (Taylor, Stouffer, & Meehi, 2011).

Results of the climate models and the RCPs are averaged for three future periods, from 2025 to 2049, 2050 to 2074, and 2075 to 2099. The downscaled climate data for each model and the RCP scenario averaged over these 25-year periods were obtained from the developers of the USGS Climate Change Viewer (https://www.fs.usda.gov/ccrc/tools/national-climate-change-viewer). The USGS *FutureFlow* software calculates results based on all five climate models for any of the two greenhouse-gas scenarios, and the three time periods. These available results are meant to reflect a range of variations predicted from among the five models, and two greenhouse-gas scenarios (USGS, 2016). The predictions of future mean annual runoff, obtained from the USGS *FutureFlow* software were used with the USGS regional regression equations and the computed basin characteristics, described in previous sections, to compute the expected future peak flows. The USGS *FutureFlow* software provides five estimates of the mean annual runoff for each RCP and future time period, one corresponding to each of the five climate models used. Future flows were computed for each of the five models corresponding to RCP 8.5 and the 2075 to 2099 time period, and the mean computed from the five results are displayed (USGS, 2015). Table 13 is a summary of the USGS *FutureFlow* projected peak discharges at the FEMA FIS locations.

Table 13. Butternut Creek Projected Peak Discharges

Flooding Source and Location	Drainage Area (mi^2)	River Station (ft)	Peak Discharge (cfs)			
			10%	2%	1%	0.2%
DeWitt/Manlius Town Line	69.0	283+00	3,194	4,241	5,048	6,440
DeWitt/LaFayette Town Line (Jamesville Reservoir outflow)	43.6	794+00	2,386	3,352	3,776	4,812
At USGS Gage No. 04245200	32.5[3]	940+00	2,092	2,992	3,284	4,168

Source: (USGS, 2016)

Appendix E contains the HEC-RAS simulation summary sheets for the current and projected future flow simulations. The HEC-RAS model simulation results for the future condition model parameters using the future projected discharge values are similar to the base-condition model output with the only difference being future projected water surface elevations are up to 0.9-foot higher at specific locations, generally upstream of bridges due to backwater, as a result of the increased discharges.

There are no FIS discharge locations within the identified risk area, therefore Table 14 provides a comparison of HEC-RAS base condition modeled water surface elevations at representative locations within the modeled risk area, using the USGS *StreamStats* flows, and future condition, using the USGS *FutureFlow* flows. There were no FIS discharge locations within the high risk area, therefore results are provided at representative locations.

The hydraulic model was developed for Butternut Creek beginning at FEMA XC U approximately 2,500 feet downstream of the CSX railroad crossing (river station 378+00) and extending upstream to just upstream to FEMA XC AF approximately 1,500 feet upstream of the Kinne Road crossing (river station 529+00).

Table 14. HEC-RAS Current and Projected Future Flow Water Surface Elevation Comparison

Flooding Source and Location	Drainage Area (mi^2)	River Station (ft)	Water Surface Elevation Change (ft)[1]			
			10%	2%	1%	0.2%
Butternut Creek, FEMA XC U	68.2	378+00	0.3	0.1	0.2	0.1
Butternut Creek, FEMA XC AF	63.1	529+00	0.2	0.3	0.6	0.5

Notes:
1. Positive changes in water surface elevation indicate the future conditions water surface elevation is higher than the base condition.

Source: (USGS, 2020); (USGS, 2016); (USACE, 2022a)

Table 15 provides a comparison of the current 1% annual change peak stream flows calculated using the USGS *StreamStats* software and the mean predicted future discharge calculated using the USGS *FutureFlow* software at each of the discharge locations included in the effective FIS.

[3] The USGS gage website lists the drainage area as 32.2 sq. mi.

Table 15. Comparison of 1% Annual Chance Current and Future Discharges

Flooding Source and Location	Drainage Area (mi^2)	River Station (ft)	Current *StreamStats* Discharge (cfs)	Predicted Future Discharge (cfs)	Change (%)
DeWitt/Manlius Town Line	69.0	283+00	4,780	5,048	5.6%
DeWitt/LaFayette Town Line (Jamesville Reservoir outflow)	43.6	794+00	3,580	3,776	5.5%
At USGS Gage No. 04245200	32.5[4]	940+00	3,150	3,284	4.3%

Source: (USGS, 2020); (USGS, 2016)

[4] The USGS gage website lists the drainage area as 32.2 sq. mi.

Flooding Characteristics

Flooding History

Floods along Butternut Creek have historically happened any time of the year, but over 50% of Butternut Creek's annual peak flows have occurred from January to March, with March and February as the most common months to experience an annual peak flow. Summer (July through September) has the fewest (<10%) of annual peaks, yet the two largest flows on record occurred in July 1974 and August 2021. Other major floods include 1898, 1915, 1940, 1960, 1964, according to the FIS (FEMA, 2016a), though the USGS gage records indicate additional high flow events occurred in 1975, 1976, 1977, 1979, 1981, 1984, 1993, 1996, 2016, and 2018. Flooding primarily occurs within the lowland portion of DeWitt where the stream gradient flattens considerably (at the developed portion of the Town) and tends to leave the channel and access the floodplain, particularly along Butternut Drive. During the construction of New York State 481 in the 1970's, portions of the channel of Butternut Creek between Jamesville Road and East Genesee Street (Route 5) were straightened and improved which may have changed the timing and impacts of flooding in this area. Flooding impacts on Butternut Creek are also altered by Jamesville Reservoir. Although the reservoir is not designed or managed for flood control, it does provide some attenuation and protection from downstream areas (FEMA, 2016a). FEMA FIRMs are available for Butternut Creek, depicting the extent of the expected floodplain. Figure 10 displays the floodway and 1% and 0.2% ACE boundaries for Butternut Creek as determined by FEMA for the Town of DeWitt (FEMA, 2016b).

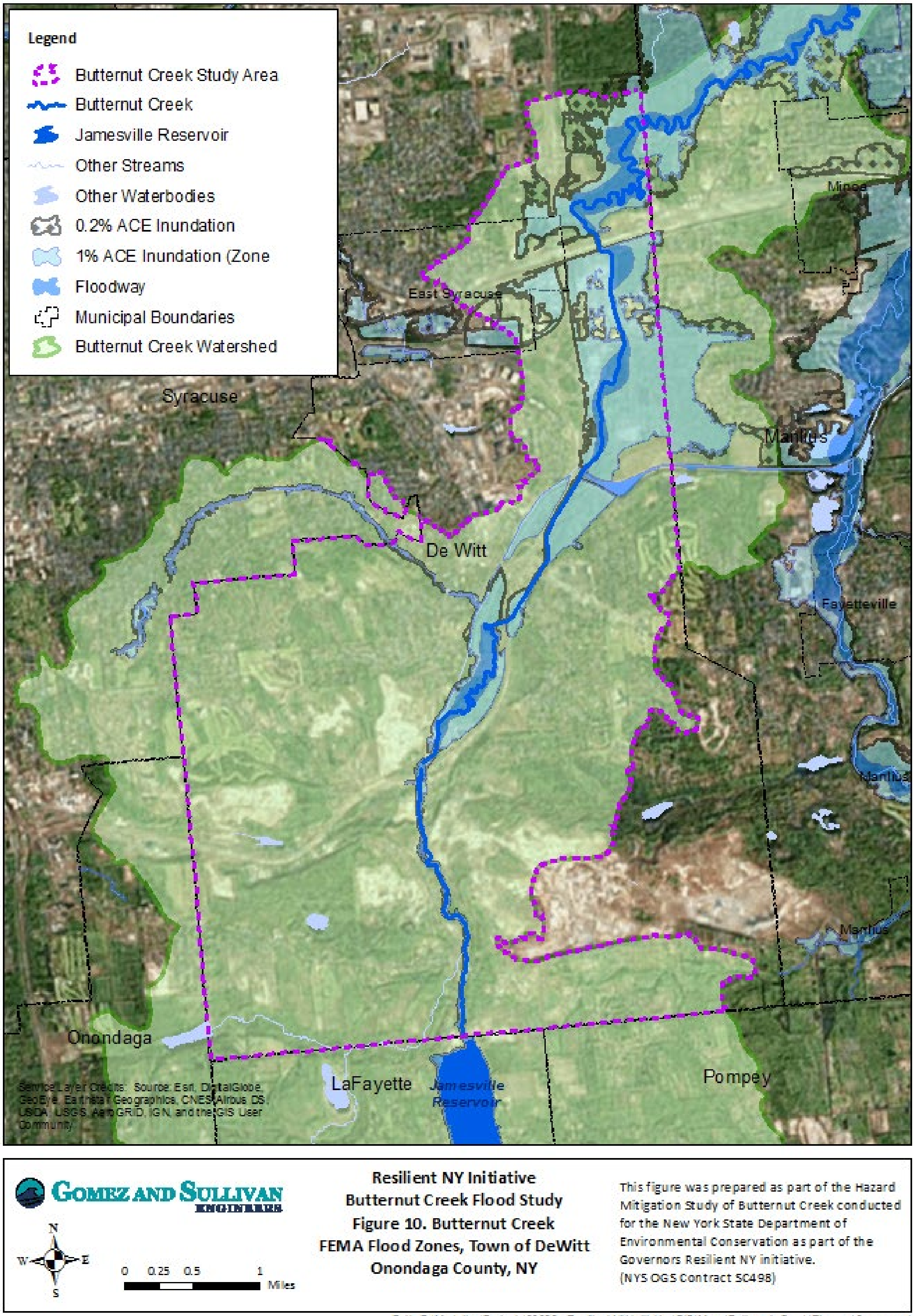
In the reach of Butternut Creek between the Old Erie Canal and Kirkville Road, past reports [(FEMA, 2016a); (USACE, 1971); (USACE, 1989)] indicate that Butternut Creek has spilled into adjacent watersheds (South Branch Ley Creek to the west, Limestone Creek to the east) under higher flow conditions. Spillage into adjacent watersheds are not considered as part of this study.

The Onondaga County Department of Water Environment Protection (WEP) indicated that during flood events along Butternut Creek, there can be considerable inflow spikes at the county wastewater treatment plant. This is believed to be due to significant leakage into flooded manholes and potential overtopping at the Butternut Drive pump station, located approximately 800 feet upstream of where NYS Rt. 290 crosses Butternut Creek. GPS information provided by WEP show that several sewer manhole rim elevations are in the range of 412 to 415 feet NAVD88 along Butternut Drive and NYS Route 290, which means these manholes may be inundated between the 10% and 2% AEP events. The provided pump station plans indicate that the manhole over the pump station stilling well is at elevation 416.7 feet, which should be above the estimated 500-year event under existing conditions.

According to the USACE Cold Regions Research and Engineering Laboratory (CRREL) ice jam database, there have been three ice jam events on Butternut Creek (USACE, 2020). However, according to the National Centers for Environmental Information (NCEI) storm events database and the stakeholder engagement meeting for Butternut Creek (NCEI, 2020) ice jams have not been a known problem on Butternut Creek. All three ice jams (1962, 1979, 1996) were noted to occur at the USGS streamflow gage just upstream of Jamesville Reservoir. There was no damage reported as a result of the ice jams, and it appears that the only reason any of the ice jams were reported was due to irregular stage patterns at the USGS gage. Since no ice jams have been identified in the target study area, ice jams were not investigated any further.

Butternut Creek has been prone to debris jams in the flatter sections downstream of the study area. The Onondaga County Soil and Water Conservation District conducted a survey in 2017 the focused on the reach between Fremont Road and Meyers Road, where over 30 debris and log jams were found over 2.5 miles of river (Onondaga Soil Water Conservation District, 2017). There is not a known history of debris jams within this project's study area within DeWitt.

Figure 10. Butternut Creek, FEMA Flood Zones, Town of DeWitt, Onondaga County, NY



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Flood Risk Assessment

Flood Mitigation Analysis

For this study of Butternut Creek, standard hydrologic and hydraulic study methods were used to determine and evaluate flood hazard data. Flood events of a magnitude which are expected to be equaled or exceeded once on the average during any 10-, 50-, 100-, or 500-year period (recurrence interval) have been selected as having special significance for floodplain management and for flood insurance rates. These events, commonly termed the 10-, 50-, 100-, and 500-year floods, have a 10%, 2%, 1%, and 0.2% chance, respectively, of being equaled or exceeded during any year. Although the recurrence interval represents the long-term average period between floods of a specific magnitude, rare floods could occur at short intervals or even within the same year. The risk of experiencing a rare flood increases when periods greater than 1 year are considered. The analyses reported herein reflect flooding potentials based on conditions existing in the county at the time of completion of the effective FIS (FEMA, 2016a).

Hydraulic analysis of Butternut Creek was conducted using the HEC-RAS v6.2 program (USACE, 2022a). The HEC-RAS computer program was written by the USACE Hydrologic Engineering Center (HEC) and is considered to be the industry standard for riverine flood analysis. The model is used to compute water surface profiles for one- and two-Dimensional (2-D), steady-state, or time-varied (unsteady) flow. In one-dimensional (1-D) solutions, the water surface profiles are computed from one cross section to the next by solving the one-dimensional St. Venant equations 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, 2022b).

Hydraulic and Hydrologic modeling of Butternut Creek in the Town of DeWitt was completed by FEMA in 1976. Due to the age and format of the FIS study, an updated 1-D HEC-RAS model was developed using the following data and software:

- New York State Digital Ortho-imagery Program imagery for Onondaga County (NYSOITS, 2018)
- Onondaga County, NY 1-meter LiDAR DEM data (USGS, 2016)
- National Land Cover Database (NLCD) data (MRLC, 2019)
- FIS Channel Profile (FEMA, 2016a) and survey information collected during this project
- RAS Mapper extension in HEC-RAS software (USACE, 2022a)
- USGS *StreamStats* peak discharge data (USGS, 2020)

The hydraulic model was developed for Butternut Creek beginning at FEMA XC U approximately 2,500 feet downstream of the CSX railroad crossing (river station 378+00) and extending upstream to just upstream to FEMA XC AF approximately 1,500 feet upstream of the Kinne Road crossing (river station 529+00).

Methodology of HEC-RAS Model Development

Using the orthoimagery, LiDAR DEM data, land cover data, available bathymetric data, and the RAS Mapper extension in the HEC-RAS software, a base condition hydraulic model was developed from the effective FEMA hydraulic model using the following methodology:

- 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 in RAS Mapper
- Using the 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
- The overland topographic data was combined with the channel bathymetry from the effective FEMA profile and survey information and a 1-D steady flow simulation was performed using the USGS *StreamStats* peak discharges

The base condition model water surface elevation results were then compared to the FEMA FIS water surface profiles, and the effective FEMA FIS streambed elevation profiles to validate the model. The new model was generally within +/- 0.5 feet of the FEMA FIS water surface elevations; the only exception was for the 10-yr event at the abandoned railroad crossing that is due to adjustments in the base condition model to reflect field-collected low and high chord information for that bridge (the low chord was approximately 0.7 feet lower than the FIS indicated). In that one event, the base condition model was approximately 0.9 feet higher than the FEMA FIS water surface elevation as the base model showed the event impacting the low chord of the bridge. After the base condition model was verified, it was then used to develop alternative condition models to simulate potential flood mitigation strategies. Generic renderings of various potential flood mitigation strategies are provided in Appendix F. The simulation results of the alternative conditions were evaluated based on their reduction in water surface elevations. As the potential flood mitigation strategies are, at this point, preliminary, inundation mapping was not developed from the computed water surface profiles for each potential mitigation alternative. Inundation shown on figures within this report reflects that of the effective FEMA FIS for the Town of DeWitt. The effectiveness of each potential mitigation strategy was evaluated based on reduction in water surface elevations. In addition to reduced water surface elevations at the inundated structures, some structures may be removed from the inundation area for a given annual chance exceedance (ACE) event by implementing the mitigation strategies.

The flood mitigation strategies that were modeled were:

- Modify the CSX railroad crossing
- Modify the CSX railroad crossing and construct a floodplain bench
- Modify the CSX railroad crossing and NYS Route 290
- Remove the abandoned railroad crossing

Stationing references for the flood mitigation measures are based on the NYSDEC hydrography GIS data for Butternut Creek, which differs from the FEMA FIS stationing values.

Cost Estimate Analysis

Rough order of magnitude (ROM) cost estimates were 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, NY contained many elements similar to those found in the potential mitigation alternatives.

Where recent construction cost data was not readily available, RSMeans CostWorks 2019 was used to determine accurate and timely information (Gordian, Inc., 2019). 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 freeboard over the base flood elevation for a 1% ACE. Once these optimal sizes were determined, further analysis was completed including site constraints and constructability. Due to these additional constraints, for some mitigation measures the size necessary to meet the freeboard requirement was 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 the New York State and / or FEMA, including construction and environmental permits from the State and accreditation, Letter of Map Revision (LOMR), etc. applications to FEMA. Application and permit costs were not incorporated in the ROM costs estimates.

High Risk Areas

Based on the FEMA FIS, NCEI storm events database, historical flood reports, and stakeholder input from engagement meetings, one area along Butternut Creek was identified as high-risk flood area in the Town of DeWitt.

High Risk Area #1: Butternut Drive (Station 378+00 to 529+00)

This risk area comprises approximately 2.9 miles of Butternut Creek, from approximately 2,500 feet downstream of the CSX railroad crossing to approximately 1,500 feet upstream of the Kinne Road crossing. This reach contains over 42 commercial structures within the 1% annual chance flood hazard zone. There are five bridge crossings within this reach, with two owned by New York State (NYS Route 290, Old Erie Canal Aqueduct), one owned by the Town of DeWitt (Kinne Road), and the other two being privately owned (CSX RR Crossing, Abandoned RR Crossing). This reach, located along a commercial/industrial corridor, was selected as it has a history of flooding damage as noted in the FEMA FIS and past USACE reports. Figure 11 depicts the extent of flooding within the risk area, while Figure 12 shows the water surface profiles within the risk area.

Figure 11. High Risk Area #1: Butternut Drive

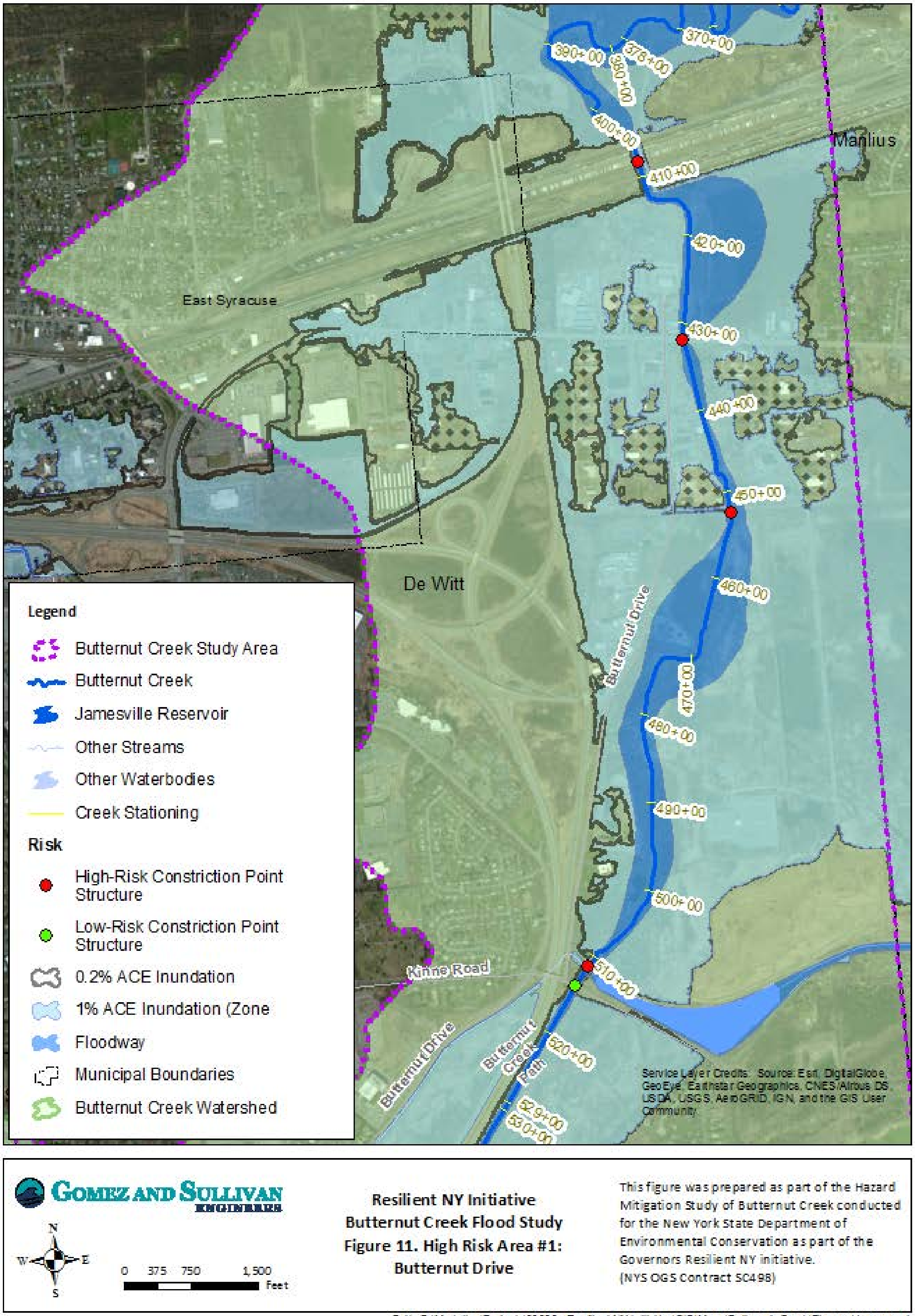
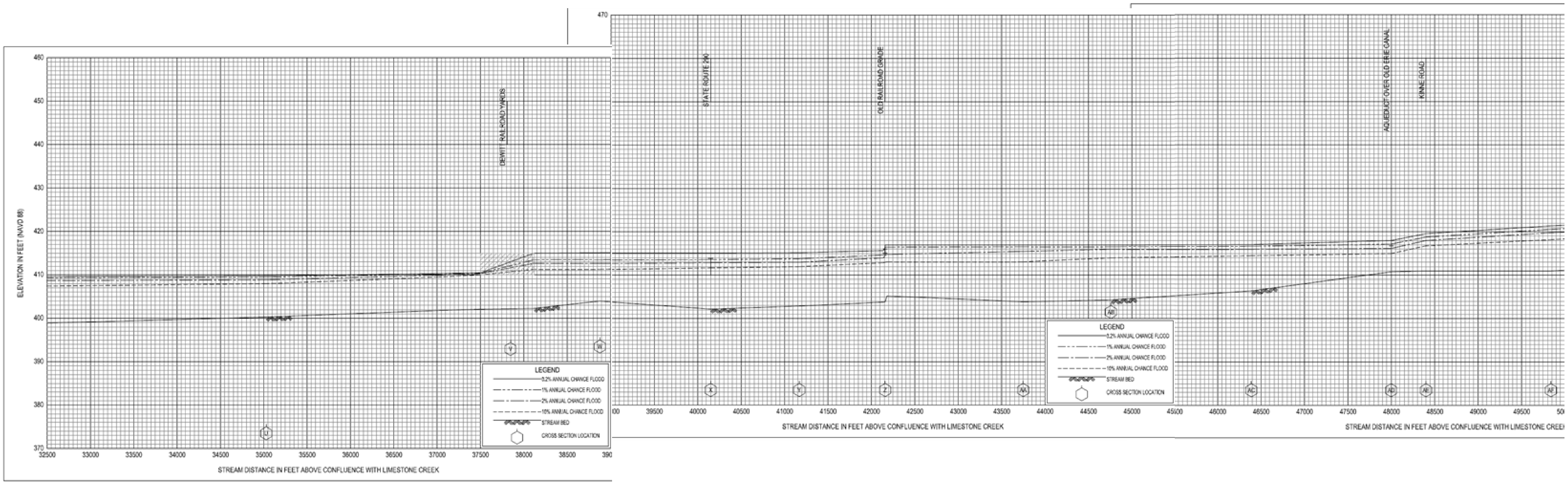


Figure 12. FEMA FIS Profile for Butternut Creek in the Vicinity of High Risk Area



Mitigation Alternatives

The following flood mitigation alternatives that have the potential to reduce water surface elevations were evaluated for the identified high-risk area along Butternut Creek. These alternatives could potentially reduce flood related damages in areas adjacent to the creek. The Town of DeWitt should evaluate each alternative and consider the potential effects to the community and the level of community buy-in for each before pursuing them further.

High Risk Area #1: Butternut Drive (Station 378+00 to 529+00)

Alternative #1-1: Modify CSX Railroad Crossing (Station 408+00)

The inundation extents for the effective FEMA FIRM indicate extensive residential and commercial flooding along this area. Water surface profiles for the base condition model and the FEMA FIS indicate that water levels along the lower portion of this high risk are due to a backwater effect from the CSX railroad crossing for events from the 10% ACE through the 0.2% ACE. The hydraulic width of the crossing (two 20-ft-wide box culverts) is less than the bankfull width according to StreamStats (approx. 75 feet).

This potential flood mitigation alternative is intended to provide additional flow area through the bridge by widening the 600-ft-long culvert to a width of 85 feet, which is 10 feet wider than the approximate bankfull width. The low and high chord of the crossing were not modified in this alternative, even though it does not meet the 2-foot freeboard recommendation as it is impractical to make significant adjustments to the existing railroad line grade. Figure 13 depicts the conceptual extents of this alternative.

Figure 14 depicts the difference in modeled water surface elevations for existing flood conditions under the base condition and Alternative #1-1 conditions in the vicinity of this alternative. The hydraulic analysis shows that this alternative results in water surface elevation reductions extending from immediately upstream of the crossing to just downstream of the Old Erie Canal nearly two miles upstream. Water surface elevation reductions under current discharges are computed to be as much as 1.8 ft for the 10% ACE discharge, 3.0 ft for the 2% ACE discharge, 2.5 ft for the 1% ACE discharge, and 1.1 ft for the 0.2% ACE discharge. Reductions under projected future discharges are computed to be as much as 2.0 ft for the 10% ACE discharge, 3.0 ft for the 2% ACE discharge, 2.2 ft for the 1% discharge, and 1.9 ft for the 0.2% ACE discharge. These water level reductions, in both existing and future projected flow cases, would reduce the frequency and magnitude of overflowing sewer manholes in the floodplain along Butternut Drive and NYS Route 290. Under existing conditions, the manholes are flooded under any modeled event, including the 10% ACE; the modifications for Alternative 1 show that several of the manholes would not be inundated until the 2% ACE or greater.

The Rough Order Magnitude cost is $48,600,000, which does not include land acquisition costs other than survey, appraisal, and engineering coordination. These costs are driven by the extensive modifications required, as the railroad crossing is approximately 600 feet long with more than 10 active rail lines and associated infrastructure.

Figure 13. Location Map for Alternative #1-1

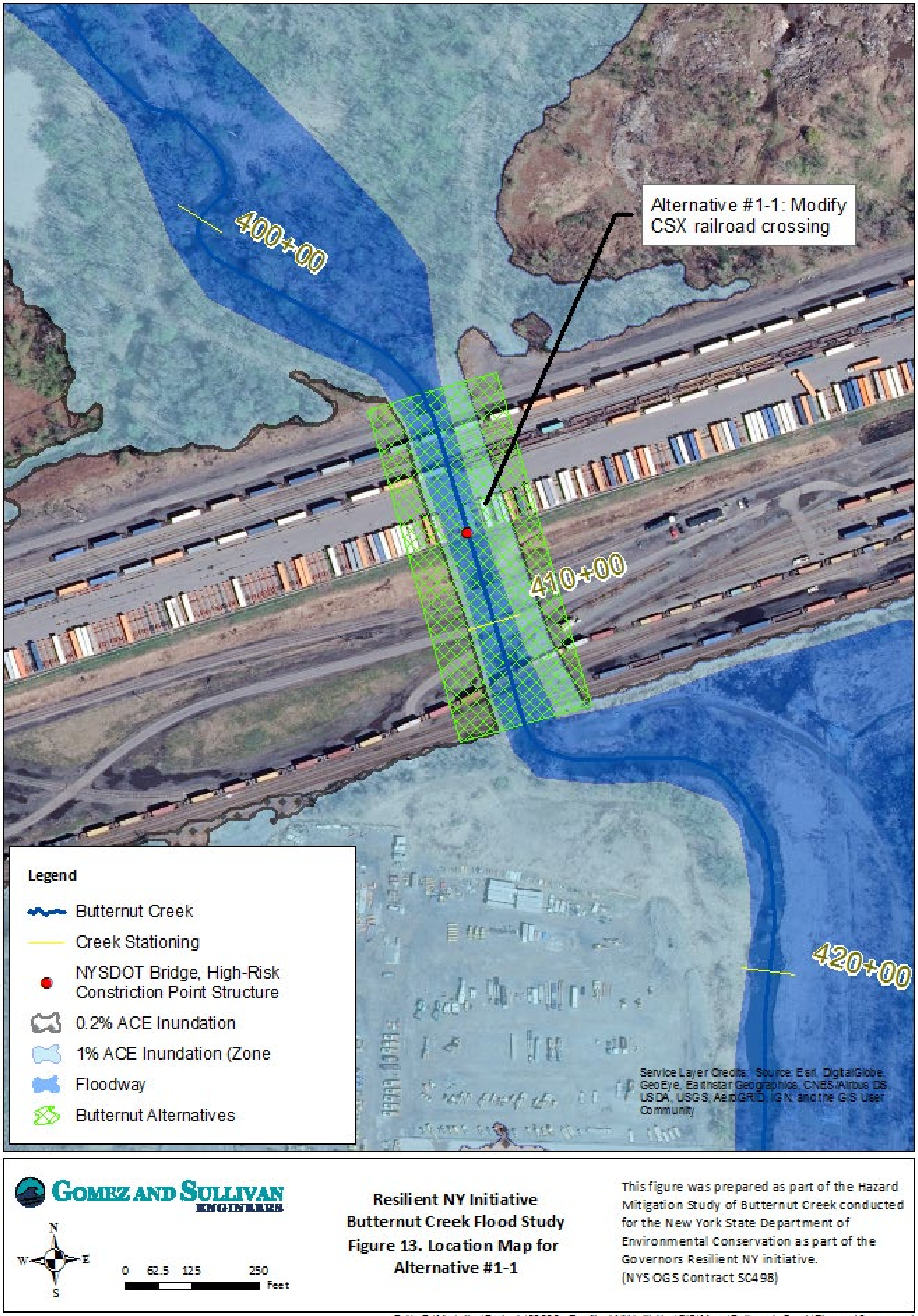


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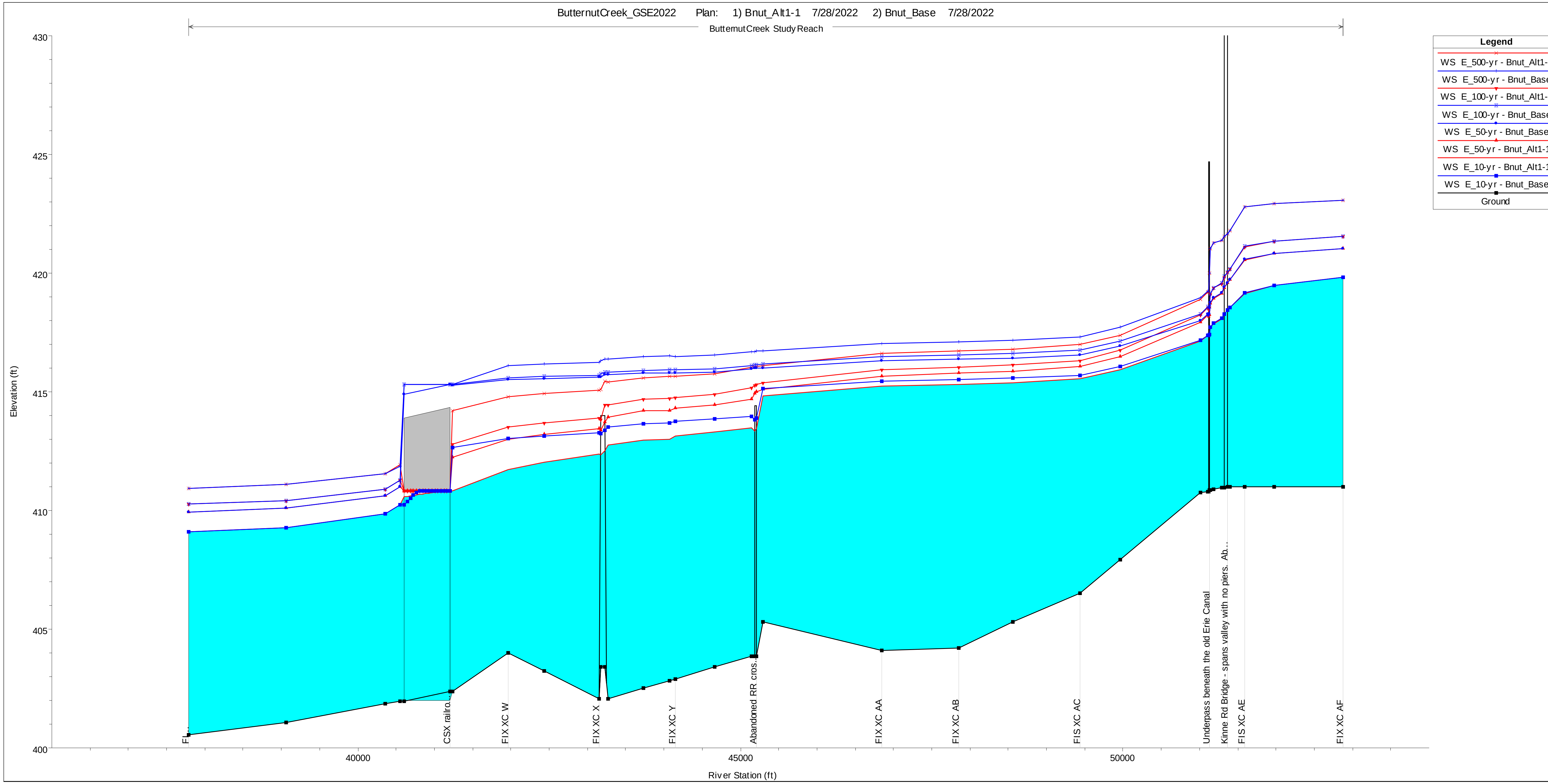
Figure 14. HEC-RAS Model Simulation Output Results for Alternative #1-1



Alternative #1-2: Modify CSX Railroad Crossing and Add Flood Bench (Station 408+00 to Station 430+00)

The inundation extents for the effective FEMA FIRM indicate extensive commercial flooding. Butternut Creek has been straightened with some berms built up along the banks in isolated locations. These activities have likely decreased the overall channel capacity during significant flood events.

This potential alternative is intended to provide additional flow area in the right overbank area between the CSX railroad crossing and the NYS Route 290 bridge by adding a 1,200-foot-long by 350-foot-wide flood bench, including expansion and contraction tapers. The existing topography was lowered by approximately 0.5 foot for this alternative to an elevation of approximately 409.0 feet, resulting in the removal of approximately 7,500 cubic yards of material. Flood bench construction includes the removal of approximately 1,000 feet of a man-made berm located downstream of NYS Route 290. Since this area was highly backwatered under the baseline condition and would provide little standalone benefit, the bench was modeled in conjunction with the CSX railroad crossing modifications described in Alternative #1-1. Figure 13 depicts the conceptual extents of this alternative.

Figure 14 depicts the difference in modeled water surface elevations for existing flood conditions under the base condition and Alternative #1-2 conditions in the vicinity of this alternative. The hydraulic analysis shows that this alternative results in water surface elevation reductions extending from immediately upstream of the crossing to beyond the extent of the high risk area over two miles upstream. The model extents were not extended further upstream as there is no at-risk infrastructure for several miles upstream of the high risk area. Water surface elevation reductions under current discharges are computed to be as much as 1.8 ft for the 10% ACE discharge, 3.0 ft for the 2% ACE discharge, 2.5 ft for the 1% ACE discharge, and 1.1 ft for the 0.2% ACE discharge. Reductions under projected future discharges are computed to be as much as 2.0 ft for the 10% ACE discharge, 3.0 ft for the 2% ACE discharge, 2.2 ft for the 1% discharge, and 1.9 ft for the 0.2% ACE discharge. These water level reductions, in both existing and future projected flow cases, would reduce the frequency and magnitude of overflowing sewer manholes in the floodplain along Butternut Drive and NYS Route 290. Under existing conditions, the manholes are flooded under any modeled event, including the 10% ACE; the modifications for Alternative #1-2 show that several of the manholes would not be inundated until the 2% ACE or greater. Relative to the benefits of Alternative #1-1, the incremental benefits of adding the flood bench would only marginally reduce water levels by approximately 0.1 ft for the 10% through the 0.2% ACE.

The Rough Order Magnitude cost is $51,400,000 ($48,600,000 for the railroad crossing, and $2,800,000 for the flood bench), which does not include land acquisition costs other than survey, appraisal, and engineering coordination. Expanding the flood bench or increasing the berm removal extents along Butternut Creek may provide additional reductions in water level. However, such measures would be more costly than the flood mitigation alternative evaluated in this study. If this alternative were selected, the flood bench and berm removal extents should be assessed during the final design as part of a cost benefit analysis.

Figure 15. Location Map for Alternative #1-2

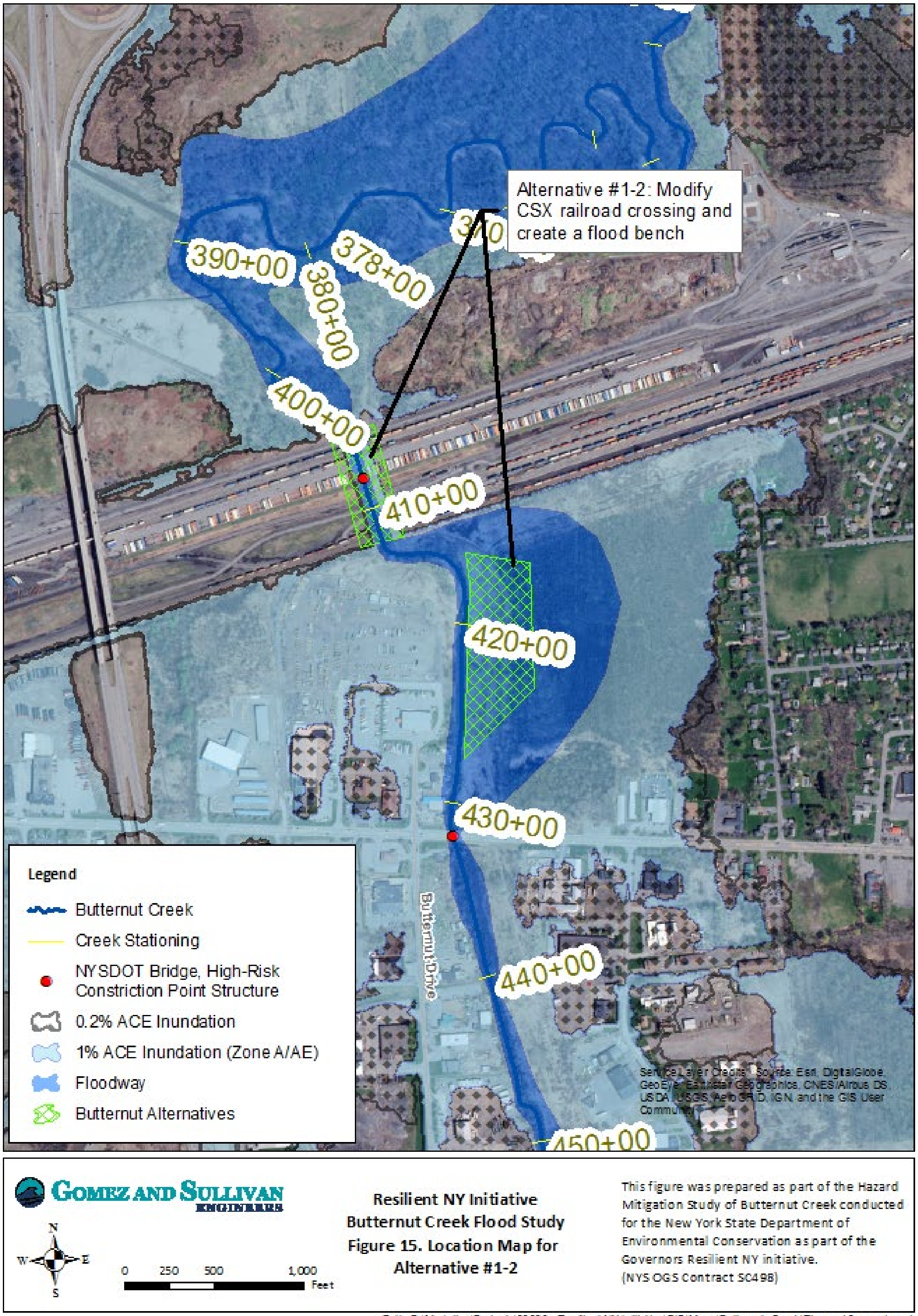
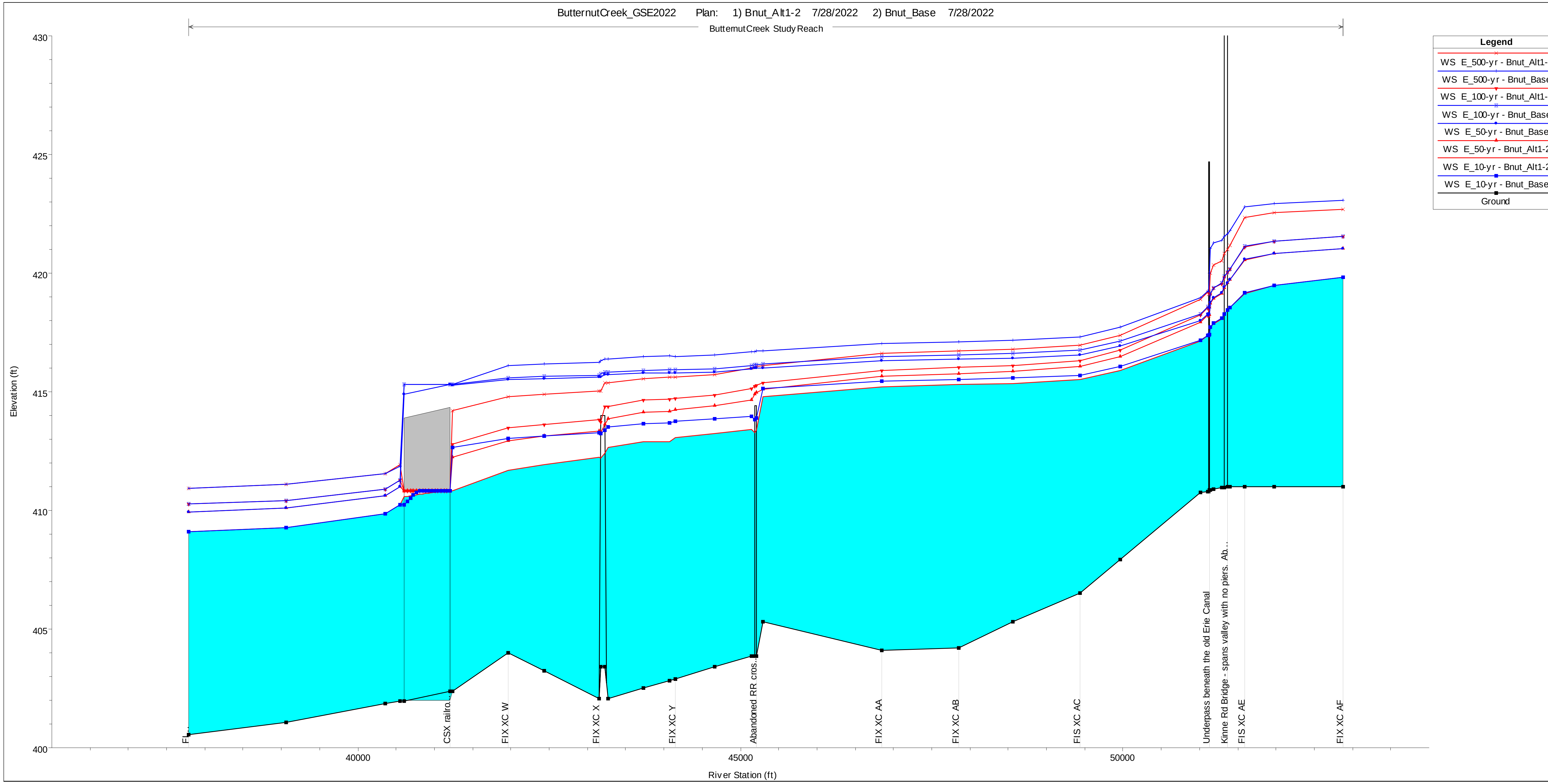


Figure 16. HEC-RAS Model Simulation Output Results for Alternative #1-2



Alternative #1-3: Modify NYS Route 290 Crossing (Station 432+00)

The bridge where NYS Route 290 crosses Butternut Creek is owned and maintained by the NYSDOT. The base condition hydraulic model indicates that the bridge at NYS Route 290 causes a water surface elevation increase upstream of the road of approximately 0.5 feet or less for all modeled events, including the baseline condition and Alternatives #1-1 and #1-2. In order to meet the freeboard requirements of either the CRRA or the NYSDOT standards, the bridge and its approaches would have to be raised at least four-plus feet. Since considerable (nearly 50%) amounts of discharge at this bridge in high flow events (2% annual chance event and larger events) passes due to overtopping of the bridge and approaches, any increase in bridge height would result in upstream water surface elevation increases unless the bridge span is significantly increased. Such an increase in bridge span is expected to be cost prohibitive as in addition to the bridge-related costs this alternative would involve major adjustments to the nearby signaled intersection of NYS Route 290 and Butternut Drive and possibly adjacent driveways. Further, a scenario which only widens the bridge opening without raising the low chord is not expected to significantly reduce water levels since the water level downstream of the bridge is within 0.2 feet of the low chord of the bridge under the 1% annual chance event for all modeled events, including the baseline condition and Alternatives #1-1 and #1-2. Similarly, the addition of culverts adjacent to the NYS Route 290 bridge is not expected to reduce water levels due to the backwater from downstream.

Alternative #1-4: Remove Abandoned Railroad Crossing (Station 452+00)

The inundation extents for the effective FEMA FIRM indicate extensive flooding upstream of the abandoned railroad crossing. The channel has been straightened as part of the construction of I-481 and other surrounding infrastructure, which has likely decreased the overall channel and floodplain capacity to pass higher flows. This bridge opening is approximately 30 feet wide, which is less than the bankfull width of 75 feet according to StreamStats (USGS, 2017).

This potential flood mitigation alternative is intended to provide additional hydraulic capacity through the removal of the constriction caused by the abandoned railroad grade. This includes removal of the crossing deck and supporting abutments to the bankfull width of 75 feet, and then tying the new bankfull-width opening into the historic railroad embankment at a 3:1 (horizontal to vertical) slope. Figure 13 depicts the conceptual extents of this alternative.

Figure 14 depicts the difference in modeled water surface elevations for existing flood conditions under the base condition and Alternative #1-4 conditions in the vicinity of this alternative. The hydraulic analysis shows that this alternative results in water surface elevation reductions, particularly for smaller events, extending from immediately upstream of the crossing to just downstream of the Old Erie Canal just over one mile upstream. Water surface elevation reductions under current discharges are computed to be as much as 0.9 ft for the 10% ACE discharge, and 0.1 ft for the 2%, 1%, and 0.2% ACE discharge. Similar results, relative to the extent and magnitude of water surface elevation reductions, were found under this alternative for the projected future discharges. Reductions under projected future discharges are computed to be as much as 0.8 ft for the 10% ACE discharge, and 0.1 ft for the 2%, 1% and 0.2% ACE discharge. These water level reductions are not in the vicinity of the sewer manholes of concern and would not have an impact on the frequency and magnitude of overflowing into the sewer structures

The Rough Order Magnitude cost is $700,000, which does not include land acquisition costs other than survey, appraisal, and engineering coordination. Lowering the remaining portion of the historic railroad embankment or increasing the width of complete railroad embankment removal may provide additional reductions in water level. However, such measures would be more costly than the flood mitigation alternative evaluated in this study. If this alternative were selected, the railroad embankment removal extents should be assessed during the final design as part of a cost benefit analysis.

Figure 17. Location Map for Alternative #1-4

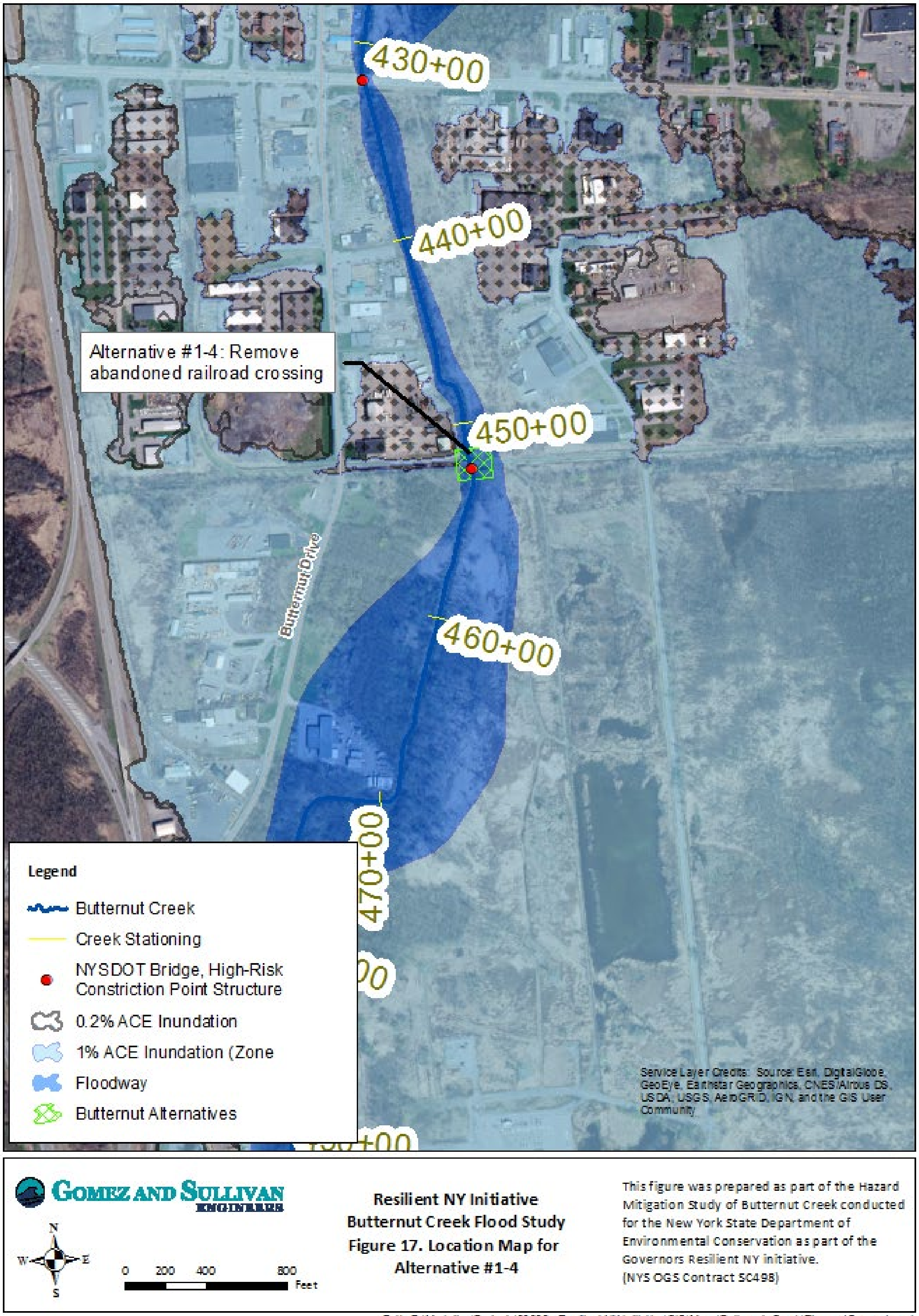


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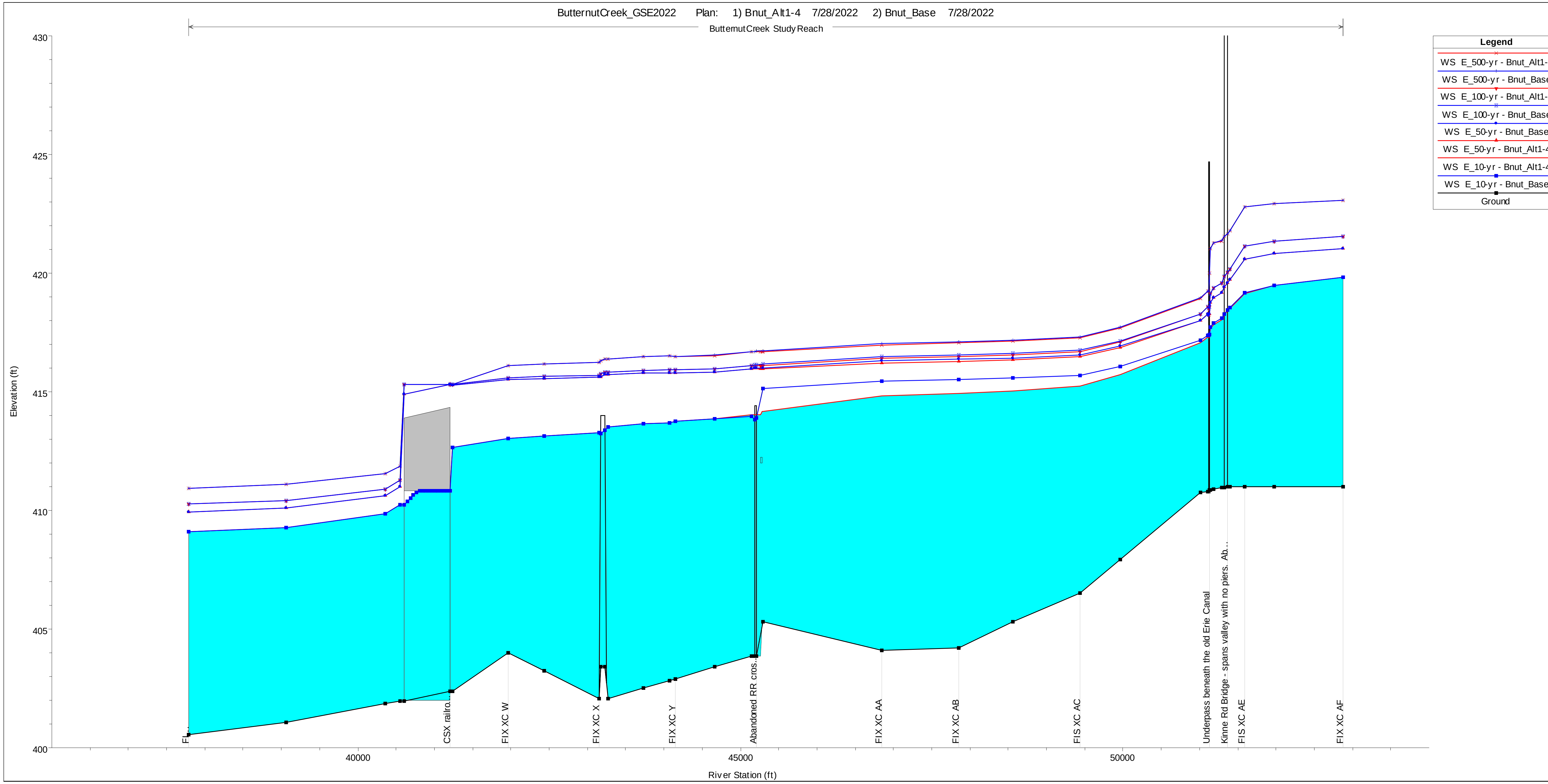
Figure 18. HEC-RAS Model Simulation Output Results for Alternative #1-4



Basin-wide Mitigation Alternatives

Non-structural measures attempt to avoid flood damages by modifying or removing properties currently located within flood-prone areas. These measures do not affect the frequency or level of flooding within the floodplain; rather, they affect floodplain activities. In considering the range of non-structural measures, the community needs to assess the type of flooding which occurs (depth of water, velocity, duration) prior to determining which measure best suits its needs (USACE, 2016).

Alternative #2-1: Early Warning Flood Detection System

Early warning flood detection systems can be implemented, which can provide communities with more advanced warning of potential flood conditions. Early forecast and warning involve the identification of imminent flooding, implementation of a plan to warn the public, and assistance in evacuating persons and some personal property. A typical low-cost early warning flood detection system consists of commercially available off-the-shelf-components. The major components of an early warning flood detection system are a sensor connected to a data acquisition device with built-in power supply or backup, some type of notification or warning equipment, and a means of communication.

The system can be powered from an alternating current source via landline or by batteries that are recharged by solar panels. The notification process can incorporate standard telephone or cellular telephone. Transfer of data from the system can be achieved using standard or cellular telephone, radio frequency (RF) telemetry, wireless internet, or satellite transceivers. Emergency management notification techniques can be implemented through the use of radio, siren, individual notification, or a reverse 911 system. More elaborate means include remote sensors that detect water levels and automatically warn residents. These measures normally serve to reduce flood hazards to life, and damage to portable personal property (USACE, 2016).

The Rough Order Magnitude cost for this strategy is approximately $150,000, not including annual maintenance and operational costs.

Alternative #2-2: Debris Maintenance around Bridges/Culverts

Debris, such as trees, branches and stumps, are an important feature of natural and healthy stream systems. In a healthy stream network, woody debris helps to stabilize the stream and its banks, reduce sediment erosion, and slow storm-induced high streamflow events. Fallen trees and brush also form the basis for the entire aquatic ecosystem by providing food, shelter, and other benefits to fish and wildlife. In the headwaters of many streams, woody debris influences flooding events by increasing channel roughness, dissipating energy, and slowing floodwaters, which can potentially reduce flood damages in the downstream reaches. Any woody debris that does not pose a hazard to infrastructure or property should be left in place and undisturbed, thereby saving time and money for more critical work at other locations (NYSDEC, 2013).

However, in some instances, significant sediment and debris can impact flows by blocking bridge and culvert openings and accumulating along the stream path at meanders, contraction / expansion points, etc., which can divert stream flow and cause backwater and bank erosion. When debris poses a risk to infrastructure, such as bridges or homes, it should be removed. Provided fallen trees, limbs, debris and trash can be pulled, cabled or otherwise removed from a stream or stream bank without significant disruption of the stream bed and banks, a permit from the NYSDEC is not required. Woody debris and trash can be removed from a stream without the need for a permit under the following guidelines:

- Fallen trees and debris may be pulled from the stream by vehicles and motorized equipment operating from the top of the streambanks using winches, chains and or cables.
- Hand-held tools, such as chainsaws, axes, handsaws, etc., may be used to cut up the debris into manageable sized pieces.
- Downed trees that are still attached to the banks should be cut off near the stump. Do not grub (pull out) tree stumps from the bank; stumps hold the bank from eroding.
- All trees, brush, and trash that is removed from the channel should not be left on the floodplain. Trash should be properly disposed of at a waste management facility. Trees and brush can be utilized as firewood. To prevent the spread of invasive species, such as Emerald Ash Borer, firewood cannot be moved more than 50 miles from its point of origin.
- Equipment may not be operated in the water, and any increase in stream turbidity from the removal must be avoided (NYSDEC 2013).

Any work that will disturb the bed or banks of a protected stream (gravel removal, stream restoration, bank stabilization, installation, repair, replacements of culverts or bridges, objects embedded in the stream that require digging out, etc.) will require an Article 15 permit from the NYSDEC. Projects that will require disturbance of the stream bed or banks, such as excavating sand and gravel, digging embedded debris from the streambed or the use of motorized, vehicular equipment, such as a tractor, backhoe, bulldozer, log skidder, four-wheel drive truck, etc. (any heavy equipment), in the stream channel, or anywhere below the top of banks, will require either a Protection of Waters or Excavation or Fill in Navigable Waters Permit (NYSDEC, 2013).

In addition, sediment control basins along Butternut Creek could be established to reduce watercourse and gully erosion, trap sediment, reduce and manage runoff near and downstream of the basin, and to improve downstream water quality. A sediment control basin is an earth embankment, or a combination ridge and channel, generally constructed across the slope and minor watercourses to form a sediment trap and water detention basin. The basin should be configured to enhance sediment deposition by using flow deflectors, inlet and outlet selection, or by adjusting the length to width ratio of the creek channel. Additional hydrologic and hydraulic studies should be performed to identify the optimal locations for the sediment control basins. Operation and maintenance costs to maintain the embankment, design capacity, vegetative cover, and outlet of the basin should be considered (NRCS, 2002).

Consultation with the NYSDEC can help determine if, when and how sediment and debris should be managed and whether a permit will be required.

The Rough Order Magnitude cost for this strategy is up to $25,000, not including annual maintenance and operational costs.

Alternative #2-3: Flood Buyout Programs

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 swath of land, rather than individual homes in isolated areas, or only some of the homes within flood-prone areas (Siders, 2013).

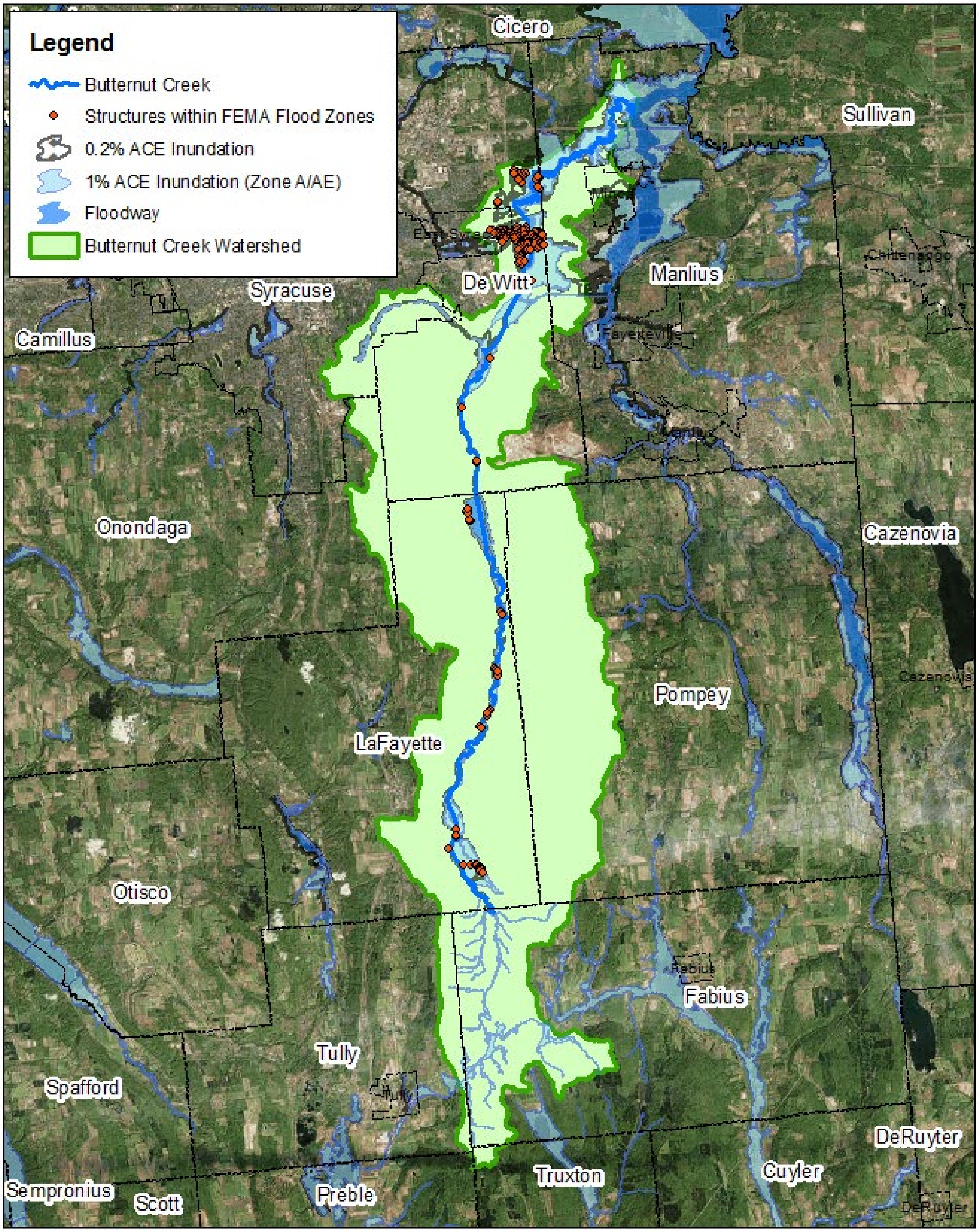
Buyout programs can be funded through a combination of federal, state or local funds, and are generally made available following a nationally recognized disaster. FEMA administers programs to help with buyouts under the Stafford Disaster Act, and the Department of Housing and Urban Development (HUD) administers another program through Community Development Block Grants (CDBG) [(FEMA, 2020), (NYSGOSR, 2019)]. 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).

For homes in the special flood hazard area (SFHA), FEMA has developed precalculated benefits for property acquisition and structure elevation of buildings. Based on a national analysis that derived the average benefits for acquisition and elevation projects, FEMA has determined that acquisition projects that cost $276,000 or less, or elevation projects that costs $175,000 or less, and which are located in the 1% ACE (i.e., 100 year recurrence interval) floodplain are considered cost-effective and do not require a separate benefit-cost analysis. For projects that contain multiple structures, the average cost of all structures in the project must meet the stated criteria. If the cost to acquire or elevate a structure exceeds the amount of benefits listed above, then a traditional FEMA approved benefits-cost analysis must be completed (FEMA, 2015b).

In the Butternut Creek watershed, there are approximately 157 structures within the FEMA 1% and 0.2% annual chance flood hazard zones (Figure 19). In addition, three of these structures are FEMA Repetitive Loss (RL) properties located within the Butternut Creek watershed.

Due to the variable nature of buyout programs, no ROM cost estimate was produced for this study. It is recommended that any buyout program begin with a cost-benefit analysis for each property. After a substantial benefit has been established, a buyout strategy study should be developed that focuses on properties closest to Butternut Creek in the highest-risk flood areas and progresses outwards from there to maximize flood damage reductions. In addition, structures located adjacent to flood prone infrastructure (i.e., bridges, culverts, etc.) should also be considered high-risk and prioritized in any buyout program strategy. 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.

Figure 19. Structures within FEMA Flood Zones, Butternut Creek Watershed, NY



GOMEZ AND SULLIVAN ENGINEERS

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Resilient NY Initiative
Butternut Creek Flood Study
Figure 19. Structures within FEMA Flood Zones, Butternut Creek Watershed, NY

This figure was prepared as part of the Hazard Mitigation Study of Butternut Creek conducted for the New York State Department of Environmental Conservation as part of the Governors Resilient NY initiative.
(NYS OGS Contract SC498)

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Alternative #2-4: Floodproofing

Floodproofing is defined as any combination of structural or nonstructural adjustments, changes, or actions that reduce or eliminate flood damage to a building, contents, and attendant utilities and equipment (FEMA, 2000). Floodproofing can prevent damage to existing buildings and can be used to meet compliance requirements for new construction of residential and non-residential buildings.

The most effective flood mitigation methods are relocation (i.e., moving a home to higher ground outside of a high-risk flood area) and elevation (i.e., raising the entire structure above BFE). The relationship between the BFE and a structure's elevation is one of many factors in determining the flood insurance premium. Buildings that are situated at or above the level of the BFE have lower flood risk than buildings below BFE and tend to have lower insurance premiums than buildings situated below the BFE (FEMA, 2015c).

In some communities, where non-structural flood mitigation alternatives are not feasible, structural alternatives such as flood proofing may be a viable alternative. The NFIP has specific rules related to flood proofing for residential and non-residential structures. These can be found in the Code of Federal Regulations (CFR) 44 CFR 60.3 (FEMA, 2000).

For existing residential structures, structures should be raised above the BFE or above the freeboard required by local regulations. Floodproofing is allowed for non-residential structures, with design guidelines outlined in FEMA P-936 – Floodproofing Non-Residential Structures [(FEMA, 2000); (FEMA, 2013)]. The local floodplain administrator should carefully review local ordinances, the CFR and available design guidelines before issuing a permit for structural flood proofing. Floodproofing strategies include:

Interior Modification/Retrofit Measures

Interior modification and retrofitting involve making changes to an existing building to protect it from flood damage. When the mitigation is properly completed in accordance with NFIP floodplain management requirements, interior modification / retrofit measures could achieve somewhat similar results as elevating a home above the BFE. Keep in mind, in areas where expected base flood depths are high, the flood protection techniques below may not provide protection on their own to the BFE or, where applicable, the locally required freeboard elevation (FEMA, 2015c).

Examples include:

- *Basement Infill*: This measure involves filling a basement located below the BFE to grade (ground level)
- *Abandon Lowest Floor*: This measure involves abandoning the lowest floor of a two or more story slab-on-grade residential building
- *Elevate Lowest Interior Floor*: This measure involves elevating the lowest interior floor within a residential building with high ceilings

Dry floodproofing

A combination of measures that results in a structure, including the attendant utilities and equipment, being watertight with all elements substantially impermeable to the entrance of floodwater and with structural components having the capacity to resist flood loads (FEMA, 2015c).

Although NFIP regulations require non-residential buildings to be watertight and protected only to the BFE for floodplain management purposes (to meet NFIP regulations), protection to a higher level is necessary for dry floodproofing measures to be considered for NFIP flood insurance rating purposes. Because of the additional risk associated with dry floodproofed buildings, to receive an insurance rating based on 1% annual chance (100-year) flood protection, a building must be dry floodproofed to an elevation at least 1-foot above the BFE (FEMA, 2013).

In New York State, only non-residential buildings are allowed to be dry floodproofed and the building must be dry floodproofed to an elevation of at least 2 feet above the BFE. New York State has higher freeboard standards than federal regulations at 44 CFR Part 60.3. Care must be taken to check the New York State Building Code for more stringent guidelines.

Examples include:

- *Passive Dry Floodproofing System*: This measure involves installing a passive (works automatically without human assistance) dry floodproofing system around a home to protect the building from flood damage.
- *Elevation*: This measure involves raising an entire residential or non-residential building structure above the BFE or above the freeboard required by local regulations.

Wet floodproofing

The use of flood-damage-resistant materials and construction techniques to minimize flood damage to areas below the flood protection level of a structure, which is intentionally allowed to flood (FEMA, 2015c).

Examples include:

- *Flood Openings*: This measure involves installing openings in foundation and enclosure walls located below the BFE that allow automatic entry and exit of floodwaters to prevent collapse from the pressures of standing water.
- *Elevate Building Utilities*: This measure involves elevating all building utility systems and associated equipment (e.g., furnaces, septic tanks, and electric and gas meters) to protect utilities from damage or loss of function from flooding.
- *Floodproof Building Utilities*: This measure involves floodproofing all building utility systems and associated equipment to protect it from damage or loss of function from flooding.
- *Flood Damage-Resistant Materials*: This measure involves the use of flood damage-resistant materials such as non-paper-faced gypsum board and terrazzo tile flooring for building materials and furnishings located below the BFE to reduce structural and nonstructural damage and post-flood event cleanup.

Barrier Measures

Barriers, such as floodwalls and levees, can be built around single or multiple residential and non-residential buildings to contain or control floodwaters (FEMA, 2015c). Although floodwalls or levees can be used to keep floodwaters away from buildings, implementing these measures will not affect a building's flood insurance rating unless the flood control structure is accredited in accordance with NFIP requirements (44 CFR §65.10) and provides protection from at least the 1% annual chance (100-year) flood. Furthermore, floodwalls or levees as a retrofit measure will not bring the building into compliance with NFIP requirements for Substantial Improvement/Damage (FEMA, 2013). Barrier measures require ongoing maintenance (i.e., mowing, etc.) which should be factored into any cost analysis. In addition, barrier measures tend to create a false sense of security for the property owners and residents that are protected by them. If a barrier structure is not properly constructed or maintained and fails, catastrophic damages to surrounding areas can occur.

- *Floodwall with Gates and Floodwall without Gates*: These two measures involve installing a reinforced concrete floodwall, which works automatically without human assistance, constructed to a maximum of four feet above grade (ground level). The floodwall with gates is built with passive flood gates that are designed to open or close automatically due to the hydrostatic pressure caused by the floodwater. The floodwall without gates is built using vehicle ramps or pedestrian stairs to avoid the need for passive flood gates.
- *Levee with Gates and Levee without Gates*: These two measures involve installing an earthen levee around a home, which works automatically without human assistance, with a clay or concrete core constructed to a maximum of six feet above grade (ground level). The levee with gates is built with passive flood gates that are designed to open or close automatically due to hydrostatic pressure caused by the floodwater. The levee without gates is built using vehicle access ramps to avoid the need for passive flood gates.

Modifying a residential or non-residential building to protect it from flood damage requires extreme care, will require permits, and may also require complex engineered designs. Therefore, the following process is recommended to ensure proper and timely completion of any floodproofing project (FEMA, 2015c):

- Consult a registered design professional (i.e., architect or engineer) who is qualified to deal with the specifics of a flood mitigation project
- Check your community's floodplain management ordinances
- Contact your insurance agent to find out how your flood insurance premium may be affected
- Check what financial assistance might be available
- Hire a qualified contractor
- Contact the local building department to learn about development and permit requirements and to obtain a building permit
- Determine whether the mitigation project will trigger a Substantial Improvement declaration
- See the project through to completion
- Obtain an elevation certificate and an engineering certificate (if necessary)

No cost estimates were prepared for this alternative due to the variable and case-by-case nature of the flood mitigation strategy. Local municipal leaders should contact residential and non-residential building owners that are currently at a high flood risk to inform them about floodproofing measures, the recommended process to complete a floodproofing project, and the associated costs and benefits.

Alternative #2-5: Area Preservation / Floodplain Ordinances

This alternative proposes that municipalities within the Butternut Creek watershed consider watershed and floodplain management practices such as preservation and/or conservation of areas along with land use ordinances that could minimize future development of sensitive areas such as wetlands, forests, riparian areas, and other open spaces. It could also include areas in the floodplain that are currently free from development and are providing floodplain storage.

A watershed approach to planning and management is an important part of water protection and restoration efforts. New York State's watersheds are the basis for management, monitoring, and assessment activities. The New York State Open Space Conservation Plan, NYSDEC's Smart Growth initiative and the Climate Smart Communities Program address land use within a watershed (NYSDEC, Date Unknown).

Natural floodplains provide flood risk reduction benefits by slowing runoff and storing flood water. They also provide other benefits of considerable economic, social, and environmental value that should be considered in local land-use decisions. Floodplains frequently contain wetlands and other important ecological areas which directly affect the quality of the local environment. Floodplain management is the operation of a community program of preventive and corrective measures to reduce the risk of current and future flooding, resulting in a more resilient community. These measures take a variety of forms, are carried out by multiple stakeholders with a vested interest in responsible floodplain management and generally include requirements for zoning, subdivision or building, building codes and special-purpose floodplain ordinances. While FEMA has minimum floodplain management standards for communities participating in the NFIP, best practices demonstrate that the adoption of higher standards will lead to safer, stronger, and more resilient communities (FEMA, 2006).

For floodplain ordinances, the NYSDEC has a sample of regulatory requirements for floodplain management that a community can adopt within their local flood damage prevention ordinance. If a community is interested in updating their local law to include regulatory language promoting floodplain management, it is recommended that they reach out to the NYSDEC through floodplain@dec.ny.gov or (518) 402-8185 for more information.

In addition, the Community Rating System (CRS) program through FEMA is a voluntary incentive program that recognizes and encourages community floodplain management activities that exceed the minimum NFIP requirements. Participating communities are able to get discounted rates on the flood insurance premiums for residents in the community. Adopting these enhanced requirements and preserving open space for floodplain storage earns points in the CRS program, which can lead to discounted flood insurance premiums.

Further hydrology and hydraulic model scenarios could be performed to illustrate how future watershed and floodplain management techniques could benefit the communities within the Butternut Creek watershed.

Next Steps

Before selecting a flood mitigation strategy, securing funding or commencing an engineering design phase, Gomez and Sullivan recommends that additional modeling simulations and wetland investigations be performed.

Additional Data 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.

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 pursued for consideration.

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 Division of Homeland Security and Emergency Services (NYSDHSES)
- Regional Economic Development Councils/Consolidated Funding Applications (CFA)
- Natural Resources Conservation Services (NRCS) Emergency Watershed Protection (EWP) Program
- FEMA Hazard Mitigation Grant Program (HMGP)

New York State Division of Homeland Security and Emergency Services (NYSDHSES)

The New York State Office of Emergency Management (NYSOEM), which is a part of the NYSDHSES, in conjunction with the United States Department of Homeland Security (USDHS) and FEMA, offers several funding opportunities through federal grant programs. Two primary programs are available through FEMA's Hazard Mitigation Grant Program (HMGP): Public Assistance, which includes post-disaster recovery grants enabled by Presidential declaration to reimburse for the emergency protective measures and the repair of eligible public facilities and infrastructure; and Hazard Mitigation, which includes pre-disaster project grants to eligible government sub-applicants to avoid or reduce the loss of life and property in future events. The NYSOEM would be the primary point of contact for all aspects of these programs.

Regional Economic Development Councils/Consolidated Funding Applications (CFA)

The CFA is a single application for state economic development resources from numerous state agencies. The ninth round of the CFA was offered in 2019.

Water Quality Improvement Project (WQIP) Program

The WQIP Program, administered through the NYSDEC, is a statewide reimbursement grant program to address documented water quality impairments. Eligible parties include local governments and not-for-profit corporations. Funding is available for construction/implementation projects; projects exclusively for planning are not eligible. Match for WQIP is a percentage of the award amount, not the total project cost. Deadlines are in accordance with the CFA application cycle.

Climate Smart Communities (CSC) Grant Program

The CSC Grant Program is a 50/50 matching grant program for municipalities under the New York State Environmental Protection Fund, offered through the CFA by the New York State Office of Climate Change. The purpose of the program is to fund climate change adaptation and mitigation projects and includes support for projects that are part of a strategy to become a Certified Climate Smart Community. The eligible project types that may be relevant include the following:

- The construction of natural resiliency measures, conservation or restoration of riparian areas and tidal marsh migration areas
- Nature-based solutions such as wetland protections to address physical climate risk due to water level rise, and/or storm surges and/or flooding
- Relocation or retrofit of facilities to address physical climate risk due to water level rise, and/or storm surges and/or flooding
- Flood risk reduction
- Climate change adaptation planning and supporting studies

Eligible projects include implementation and certification projects. Deadlines are in accordance with the CFA cycle.

NRCS Emergency Watershed Protection (EWP) Program

Through the EWP Program, the United States Department of Agriculture's (USDA) NRCS can assist communities in addressing watershed impairments that pose imminent threats to lives and property. Most EWP projects involve the protection of threatened infrastructure from continued stream erosion. Projects must have a project sponsor, defined as a legal subdivision of the State, such as a city, county, general improvement district, or conservation district, or an Indian Tribe or Tribal organization. Sponsors are responsible for providing land rights to do repair work, securing the necessary permits, furnishing the local cost share (25%), and performing any necessary operation and maintenance for a ten-year period. Through EWP, the NRCS may pay up to 75% of the construction costs of emergency measures, with up to 90% paid for projects in limited-resource areas. The remaining costs must come from local services. Eligible projects include, but are not limited to, debris-clogged stream channels, undermined and unstable streambanks, and jeopardized water control structures and public infrastructures.

FEMA Hazard Mitigation Grant Program (HMGP)

The HMGP, offered by FEMA and administered by the NYSDHSES, provides funding for creating/updating hazard mitigation plans and implementing hazard mitigation projects. The HMGP program consolidates the application process for FEMA's annual mitigation grant programs not tied to a State's Presidential disaster declaration. Funds are available under the Building Resilient Infrastructure and Communities (BRIC) and Flood Mitigation Assistance (FMA) Programs.

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.

Building Resilient Infrastructure and Communities (BRIC) Program

Beginning in 2020, the BRIC grant program, which was created as part of Disaster Recovery Reform Act of 2018 (DRRA), replaced the existing Pre-Disaster Mitigation (PDM) program and is funded by a 6% set-aside from federal post-disaster grant expenditures. BRIC will support states, local communities, tribes and territories as they undertake hazard mitigation projects, reducing the risks they face from disasters and natural hazards. BRIC aims to categorically shift the federal focus away from reactive disaster spending and toward research-supported, proactive investment in community resilience. Through BRIC, FEMA will invest in a wide variety of mitigation activities, including community-wide public infrastructure projects. Moreover, FEMA anticipates BRIC will fund projects that demonstrate innovative approaches to partnerships, such as shared funding mechanisms and/or project design.

Flood Mitigation Assistance (FMA) Program

The FMA Program provides resources to reduce or eliminate long-term risk of flood damage to structures insured under the NFIP. The FMA project funding categories include Community Flood Mitigation – Advance Assistance (up to $200,000 total federal share funding) and Community Flood Mitigation Projects (up to $10 million total). Federal funding is available for up to 75% of the eligible activity costs. FEMA may contribute up to 100% federal cost share for severe repetitive loss properties, and up to 90% cost share for repetitive loss properties. Eligible project activities include the following:

- Infrastructure protective measures
- Floodwater storage and diversion
- Utility protective measures
- Stormwater management
- Wetland restoration/creation
- Aquifer storage and recovery
- Localized flood control to protect critical facility
- Floodplain and stream restoration
- Water and sanitary sewer system protective measures

Summary

The Town of DeWitt has had a history of flooding events along Butternut Creek. Flooding in the Town of DeWitt primarily occurs during the summer and winter months due to heavy rains by convective systems and snowmelt. In response to persistent flooding, the State of New York in conjunction with the Town of DeWitt, and Onondaga County, are studying and evaluating potential flood mitigation projects for Butternut Creek as part of the Resilient NY Initiative.

This study analyzed the historical and present day causes of flooding in the Butternut 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 high-risk areas of Butternut Creek, which could potentially reduce flood related damages in areas adjacent to the creek. Constructing multiple flood mitigation measures would increase the overall flood reduction potential along Butternut Creek by combining the reduction potential of the mitigation measures being constructed.

Based on the flood mitigation analyses performed in this report, the mitigation measures that provided the greatest reductions in water surface elevations included Alternative #1-1: Modify CSX Railroad Crossing (Station 408+00). There would be an overall greater effect in water surface elevations if multiple alternatives were built along Butternut Creek 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.

Based on the analysis of the bridge widening simulations, the CSX railroad bridge crossings benefited from an increased bridge opening. However, the bridge widening measures are the costliest of the discussed flood mitigation measures. The benefits of the measures in their respective reaches should be balanced with the associated costs of each bridge widening measure to determine if it would be feasible to move a bridge widening measure forward. In addition, other complications, such as maintenance of railroad traffic and construction on private property, should be taken into account when considering any of the bridge widening measures.

The debris maintenance alternatives around culverts / bridges would maintain the flow channel area in Butternut Creek. As sediment and debris build up at the openings of bridges and culverts, the channel flow area is reduced. This can lead to potential backwater and flooding due to the inability of the creek channel to pass stream flows of the same annual chance event. A debris maintenance program could address any concerns with the debris jams occurring between Fremont Road and Meyers Road.

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. The case-by-case nature of buyouts and acquisitions requires widespread property owner participation to maximize flood risk reductions. An unintended consequence of buyout programs is the permanent removal of properties from the floodplain, including tax revenue, which would have long-term implications for local governments and should be considered prior to implementing a buyout program.

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 potential but leaves buildings in flood risk areas so that the potential for future flood damages remain. A benefit to floodproofing versus buyouts is that properties remain in the community and the tax base for the local municipality remains intact. Table 16 is a summary of the potential flood mitigation measures, including modeled water surface elevation reductions and estimated ROM costs.

Table 16. Summary of Flood Mitigation Measures

Alternative No.	Description	Change in Water Surface Elevation (ft)		ROM cost ($U.S. dollars)
		Current Flows	Projected Flows	
1-1	Modify CSX Railroad Crossing	1.1 - 3.0	1.9 - 3.0	$48,600,000
1-2	Modify CSX Railroad Crossing and Add Flood Bench	1.1 - 3.0	1.9 - 3.0	$51,400,000
1-4	Remove Abandoned Railroad Crossing	0.1 - 0.9	0.1 - 0.8	$700,000
2-1	Early Flood Warning Detection System	N/A	N/A	$150,000 (not including annual operational costs)
2-2	Debris Maintenance Around Bridges/Culverts	N/A	N/A	$25,000 (not including annual operational costs)
2-3	Flood Buyout Programs	N/A	N/A	Variable (case-by-case)
2-4	Floodproofing	N/A	N/A	Variable (case-by-case)
2-5	Area Preservation/Floodplain Ordinances	N/A	N/A	Variable (case-by-case)

Conclusion

Municipalities affected by flooding along Butternut Creek can use this report to support flood mitigation initiatives within their communities. This report is intended to be a high-level overview of potential flood mitigation strategies, their impacts on water surface elevations, and the associated ROM cost for each mitigation strategy. The research and analysis that went into each potential strategy should be considered preliminary, and additional research, field observations, and modeling are recommended before final mitigation strategies are chosen.

In order to implement the flood mitigation strategies presented in this report, communities should engage in a process that follows the following steps:

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 potential flood mitigation strategies.
3. Develop a list of final flood mitigation strategies based on the additional data collection and modeling results.
4. Select a final flood mitigation strategy or series of strategies to be completed for Butternut Creek 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. Summary of Data and Reports Collected

Year	Type	Document Title	Author	Publisher
1971	Report	Flood Plain Information		USACE
1978	Report	National Handbook of Recommended Methods for Water-Data Acquisition	Office of Water Data Coordination	USGS
1983	Report	Reconnaissance Report on Flooding of Butternut Creek in the Town of DeWitt, NY		USACE
1989	Report	Detailed Project Report on Flood Damage Reduction Along Butternut Creek		USACE
1991	Report	Regionalization of Flood Discharges for Rural, Unregulated Streams in New York, Excluding Long Island	Richard Lumia	USGS
1995	Article	Numerical Simulation of River Ice Processes	H. T. Shen, D. S. Wang, and L. A. Wasantha,	Journal of Cold Region Engineering
1996	Book	Applied River Morphology, 2nd Edition	D. L. Rosgen and H. L. Silvey	Wildland Hydrology Books
2000	Code	Title 44: Emergency Management and Assistance, Chapter 1		FEMA
2002	Standard	National Conservation Practice Standard No. 638: Water and Sediment Control Basin		NRCS
2002	Report	Engineering Manual 1110-2-1612: Engineering and Design – Ice Engineering		USACE
2006	Report	Floodplain Management Requirements: A Study Guide and Desk Reference for Local Officials		FEMA

Year	Type	Document Title	Author	Publisher
2006	Report	Bridge Inventory Manual		NYSDOT
2006	Report	Magnitude and Frequency of Floods in New York	Richard Lumia, Douglas A. Freehafer, and Martyn J. Smith	USGS
2007	Book	Elevation Data for Floodplain Mapping		NRC
2009	Report	Bankfull Discharge and Channel Characteristics of Streams in New York State	Christiane I. Mulvihill, Barry P. Baldigo, Sarah J. Miller, Douglas DeKoskie, and Joel DuBois	USGS
2010	Report	DHS Risk Lexicon		USDHS
2011	Report	Responding to Climate Change in New York State: The ClimAID Integrated Assessment for Effective Climate Change Adaptation in New York State, Final Report		NYSERDA
2011	Article	A Unified Degree-Day Method for River Ice Cover Thickness Simulation	H. T. Shen and P. Yapa	Canadian Journal of Civil Engineering
2011	Article	An Overview of CMIP5 and the Experiment Design	K. E. Taylor, R. J. Stouffer, and G. A. Meehi	Bulletin of the American Meteorological Society
2012	Report	Hydraulic Design of Safe Bridges	L. W. Zevenbergen, L. A. Arneson, J.H. Hunt, and A.C. Miller	USDOT
2012	Article	Geomorphic Characterization of Upper South Koel Basin, Jharkhand: A Remove Sensing and GIS Approach	R. Parveen, U. Kumar, and V. K. Singh	Journal of Water Resource and Protection, 1042-1050
2013	Report	Floodproofing Non-Residential Buildings		FEMA
2013	Report	Removal of Woody Debris and Trash from Rivers and Streams		NYSDEC

Year	Type	Document Title	Author	Publisher
2013	Article	Anatomy of a Buyout Program – New York Post-Superstorm Sandy	A. R. Siders	Vermont Law School
2014	Book	Handbook of Biological Statistics, 3rd Edition	J. H. McDonald	Sparky House Publishing
2014	Report	National Register of Historical Places and National Historic Landmarks Program Records for New York State		NPS
2014	Article	Morphometric Analysis of a Drainage Basin Using Geographical Information System: A Case Study	M. L. Waikar and A. P. Nilawar	International Journal of Multidisciplinary and Current Research
2015	Report	Guidance for Flood Risk Analysis and Mapping: Redelineation Guidance		FEMA
2015	Report	Hazard Mitigation Assistance Program Digest, September 2015		FEMA
2015	Report	Reducing Flood Risk to Residential Buildings That Cannot Be Elevated		FEMA
2015	Article	Influence of Aggradation and Degradation on River Channels: A Review	U. R. Mugade and J. B. Sapkale	International Journal of Engineering and Technical Research
2015	Report	Development of Flood Regressions and Climate Change Scenarios to Explore Estimates of Future Peak Flows	Douglas A. Burns, Martyn J. Smith, and Douglas A. Freehafer	USGS
2016	Data	USGS one-meter digital elevation models		USGS
2016	Report	Flood Insurance Study: Town of DeWitt, New York		FEMA

Year	Type	Document Title	Author	Publisher
2016	Report	Lexington Greene – Section 2015 of the 1948 Flood Control Act – Flood Risk Management	Buffalo District	USACE
2016	Software	Application of Flood Regressions and Climate Change Scenarios to Explore Estimates of Future Peak Flows, Version 1.5 Web Application		USGS
2017	Report	Butternut Creek Stream Debris Assessment		Onondaga County Soil & Water Conservation District
2017	Data	New York State Digital Ortho-Imagery Program	GIS Program Office	NYSOITS
2017	Report	Fact Sheet 2017-3046: *StreamStats*, Version 4	Kernell G. Ries III, Jeremy K. Newsom, Martyn J. Smith, John D. Guthrie, Peter A. Steeves, Tiana L Haluska, Katharine R. Kolb, Ryan F. Thompson, Richard D. Santoro, and Hans W. Vraga	USGS
2018	Report	DRAFT New York State Flood Risk Management Guidance for Implementation of the Community Risk and Resiliency Act		NYSDEC
2018	Report	Highway Design Manual	Engineering Division, Office of Design	NYSDOT
2018	Article	Governor Cuomo Announces $3 Million for Studies to Reduce Community Flood Risk		NYSGPO
2019	Software	ArcGIS for Desktop 10		ESRI
2019	Data	2016 Land Cover: Conterminous United States	NLCD	MRLC
2019	Data	Bridge Point Locations and Select Attributes	Structures Division	NYSDOT

Year	Type	Document Title	Author	Publisher
2019	Data	CostsWorks 2019	RS Means Data Online	Gordian, Inc.
2019	Report	Policy Manual: NY Rising Buyout and Acquisition Program, Version 7.0		NYSGOSR
2020	Report	New York State Flood Risk Management Guidance for Implementation of the Community Risk and Resiliency Act		NYSDEC
2020	Data	Storm Events Database	NCEI	NOAA
2020	Software	Environmental Resource Mapper Web Application		NYSDEC
2020	Data	Inventory of Dams – New York State		NYSDEC
2020	Standard	Standard Specifications (US Customary Units), Volume 1	Engineering Division	NYSDOT
2020	Data	Ice Jam Database	CRREL	USACE
2020	Software	Information for Planning and Consultation Web Application	ECOS	USFWS
2020	Software	*StreamStats*, Version 4.4.0 Web Application		USGS
2020	Website	Hazard Mitigation Grant Program (HMGP)		FEMA
2021	Report	Bridge Manual		NYSDOT
2022	Software	Hydrologic Engineering Center's River Analysis System, Version 6.2	HEC	USACE
2022	Report	HEC-RAS: River Analysis System User's Manual, Version 6.2	HEC	USACE
Unk	Article	Watershed Management		NYSDEC

Appendix B. Agency and Stakeholder Meeting Attendees List

Initial Project Kickoff Virtual Meeting: March 1, 2022

Last	First	Affiliation
Baurle	Eric	NYS OGS
Bollinger	Sara	Town of Manlius
Buchta	Aaron	Onondaga County Soil and Water
Camp	John	Syracuse C&S Engineers
Choe	Trendon	NYS DEC Region 7
Cushing	Robert	Highway Superintendent, Town of Manlius
Deer	John	Town of Manlius
Fuller	Daniel	NYS DEC Region 7
Gannon	Shaun	Ramboll
Golick	Geoffrey	NYS DEC
Gomez	Damien	Gomez & Sullivan
Goz	Kadir	Ramboll
Houck	Russell	City of Syracuse Engineering Department
Jones	Tyra	Highland-Planning
Ortiz	Laura	Buffalo District Army Corps
Manning	Karis	DEC Flood Hub
Marco	Matthew	NYS DEC Region 7
Miller	Kevin	Gomez & Sullivan
Snow	Tom	NYS DEC Central Office
Topa	Jen	Highland Planning
Toukatly	Tiffany	NYS DEC Region 7
Wirely	Brienna	NYS DEC Western Flood Hub
Zollweg-Horan	Emily	NYS DEC Central Office

Appendix C. Field Data Collection Forms

Stream Channel Classification (Level II)

Wisconsin Job Sheet 811

U.S. Department of Agriculture
Natural Resources Conservation Service

Natural Resources Conservation Service (NRCS) **Wisconsin**

Project: ______________________	Date: ______________________
County: ______________________	Stream: ______________________
Reach No.: ______________________	Logged By: ______________________

Horizontal Datum: NAD ________ Projection: ☐ Transverse Mercator ☐ Lambert Conformal Conical

Coordinate System: ☐ __________ County Coordinates ☐ WTM ☐ State Plane Coordinates ☐ UTM

Units: ☐ Meters ☐ Feet Horizontal Control: N or Lat. ___________ E or Long. ___________

Elevation: ____________ ☐ Assumed ☐ DOT ☐ NAVD (29 / 88) Units: ☐ Meters ☐ Feet

Fluvial Geomorphology Features (3 Cross Sections) for Stream Classification

				Average
Bankfull Width (W_{bkf}):	________ ft.	________ ft.	________ ft.	0.00 ft.
Width of the stream channel, at bankfull stage elevation, in a riffle section.				
Mean Depth (d_{bkf}):	________ ft.	________ ft.	________ ft.	0.00 ft.
Mean depth of the stream channel cross section, at bankfull stage elevation, in a riffle section. ($d_{bkf}=A_{bkf}/W_{bkf}$)				
Bankfull X-Section Area (A_{bkf}):	________ sq. ft.	________ sq. ft.	________ sq. ft.	0.00 sq. ft.
Area of the stream channel cross section, at bankfull stage elevation, in a riffle section.				
Width / Depth Ratio (W_{bkf}/d_{bkf}):	________ ft.	________ ft.	________ ft.	0.00 ft.
Bankfull width divided by bankfull mean depth, in a riffle section.				
Maximum Depth (d_{mbkf}):	________ ft.	________ ft.	________ ft.	0.00 ft.
Maximum depth of the Bankfull channel cross section, or distance between the bankfull stage and thalweg elevations, in a riffle section.				
Width of Flood-Prone Area (W_{fpa}):	________ ft.	________ ft.	________ ft.	0.00 ft.
Twice maximum depth, or (2 x d_{mbkf}) = the stage/elevation at which flood-prone area width is determined (riffle section).				
Entrenchment Ratio (ER):	________ ft.	________ ft.	________ ft.	0.00 ft.
The ratio of flood-prone area width divided by bankfull channel width. (W_{fpa}/W_{bkf}) (riffle section)				

Reach Characteristics

Channel Materials (Particle Size Index) D50: _________ mm

The D50 particle size index represents the median diameter of channel materials, as sampled from the channel surface, between the bankfull stage and thalweg elevations.

Water Surface Slope (S): ________________ ft./ft.

Channel slope = "rise" over "run" for a reach approximately 20-30 bankfull channel widths in length, with the "riffle to riffle" water surface slope representing the gradient at bankfull stage.

Channel Sinuosity (K): ________________.

Sinuosity is an index of channel pattern, determined from a ratio of stream length divided by valley length (SL/VL); or estimated from a ratio of valley slope divided by channel slope (VS/S).

Distance to Up-Stream Structures: _____________________________.

Stream Type: _____________________ (For reference, note Stream Type Chart and Classification Key)

Dominant Channel Soils at an Eroding Bank Location

Bed Material: __________________________ Left Bank: ___________ Right Bank: ___________

Description of Soil Profiles (from base of bank to top):

Left: ____

____

Right: ____

____

Riparian Vegetation at an Eroding Bank Location

Left Bank: _____________________________ Right Bank: ____________________________

Percent Total Area (Mass): Left: __________________ Right: ___________________________

Percent Total Height with Roots: Left: __________________ Right: ____________________

Other Bank Features at an Eroding Bank Location

Actual Bank Height: _______________________ Bankfull Height: ________________________

Bank Slope (Horizontal to Vertical):

Left:
- ☐ 0-20° (flat)
- ☐ 21-60° (moderate)
- ☐ 61-80° (steep)
- ☐ 81-90° (vertical)
- ☐ 90°+ (undercut)

Right:
- ☐ 0-20° (flat)
- ☐ 21-60° (moderate)
- ☐ 61-80° (steep)
- ☐ 81-90° (vertical)
- ☐ 90°+ (undercut)

Visible Seepage in Bank? ☐ Yes ☐ No Where? _______________________________

Thalweg Location: ☐ Near 1/3 ☐ Mid 1/3 ☐ Far 1/3

NRCS
U.S. Department of Agriculture
Natural Resources Conservation Service

Pebble Count (Data Collection)

Wisconsin Job Sheet 810

Natural Resources Conservation Service (NRCS) **Wisconsin**

Project: ______________________ Date: ______________________

County: ______________________ Stream: ______________________

Reach No.: ______________________ Logged By: ______________________

Horizontal Datum: NAD ________ Projection: ☐ Transverse Mercator ☐ Lambert Conformal Conical

Coordinate System: ☐ __________ County Coordinates ☐ WTM ☐ State Plane Coordinates ☐ UTM

Units: ☐ Meters ☐ Feet Horizontal Control: N or Lat. ___________ E or Long. ___________

Elevation: ___________ ☐ Assumed ☐ DOT ☐ NAVD (29 / 88) Units: ☐ Meters ☐ Feet

Inches	Millimeters	Particle	Particle Count			
			1	Total #	2	Total #
<.002	<.062	Silt/Clay				
.002 - .005	.062 - .125	Very Fine Sand				
.005 - .01	.125 - .25	Fine Sand				
.01 - .02	.25 - .50	Medium Sand				
.02 - .04	.50 - 1.0	Coarse Sand				
.04 - .08	1.0 - 2	Very Coarse Sand				
.08 - .16	2 - 4	Very Fine Gravel				
.16 - .22	4 - 5.7	Fine Gravel				
.22 - .31	5.7 - 8	Fine Gravel				
.31 - .44	8 - 11.3	Medium Gravel				
.44 - .63	11.3 - 16	Medium Gravel				
.63 - .89	16 - 22.6	Coarse Gravel				
.89 - 1.26	22.6 - 32	Coarse Gravel				
1.26 - 1.77	32 - 45	Very Coarse Gravel				
1.77 - 2.5	45 - 64	Very Coarse Gravel				
2.5 - 3.5	64 - 90	Small Cobbles				
3.5 - 5.0	90 - 128	Small Cobbles				
5.0 - 7.1	128 - 180	Large Cobbles				
7.1 - 10.1	180 - 256	Large Cobbles				
10.1 - 14.3	256 - 362	Small Boulders				
14.3 - 20	362 - 512	Small Boulders				
20 - 40	512 - 1024	Medium Boulders				
40 - 80	1024 - 2048	Large-Very Large Boulders				
		Bedrock				

Inches

Millimeters

GOMEZ AND SULLIVAN ENGINEERS

Resilient New York

Date:

Field crew:

Stream:

Road crossing:

Structure data: ☐ Bridge

Height at edge[1]: _____ Width at top of opening: _____

Height at deepest point: _____ Bank slope: Rise: _____ Run: _____

Piers _____ Pier shape: round triangle square

Span between piers: _____ Width of piers: _____

☐ Culvert (see data below)

Length in direction of flow:

Manning value: Top: Bottom:

Deck thickness:

Height of rail:

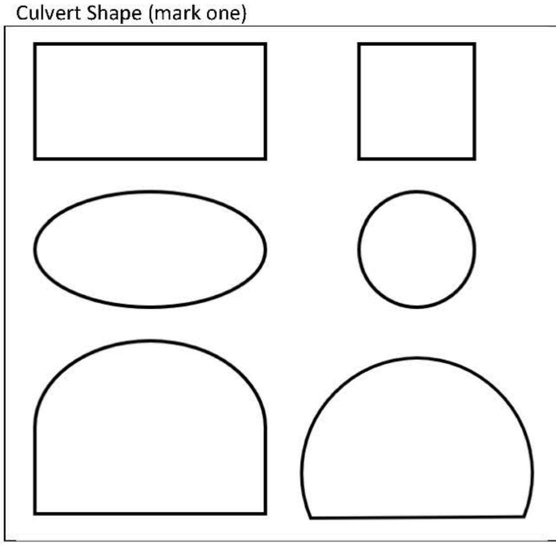
Type of rail:

Structure material:

Bottom substrate:

Description:

Culvert Shape (mark one)



Depth from top of opening to bottom of stream

at edge: _____

at deepest location: _____

Opening width: _____

[1] All measurements should be taken to 0.1 feet

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Appendix D. Photo Log

List of Additional Field Photos

Photo D-1. *Looking downstream standing on the right bank just downstream of the CSX railroad crossing.*

Photo D-2. *Looking across the downstream face of the CSX railroad crossing.*

Photo D-3. *Looking toward the upstream face of the CSX railroad crossing from the right bank.*

Photo D-4. *Looking upstream toward Butternut Creek from the upstream face of the CSX railroad crossing. Photo taken 4/21/2022 by GSE.*

Photo D-5. *Looking across the downstream face of the NYS Rt. 290 bridge, taken from just downstream of the bridge on the right bank. Photo taken 4/21/22 by GSE.*

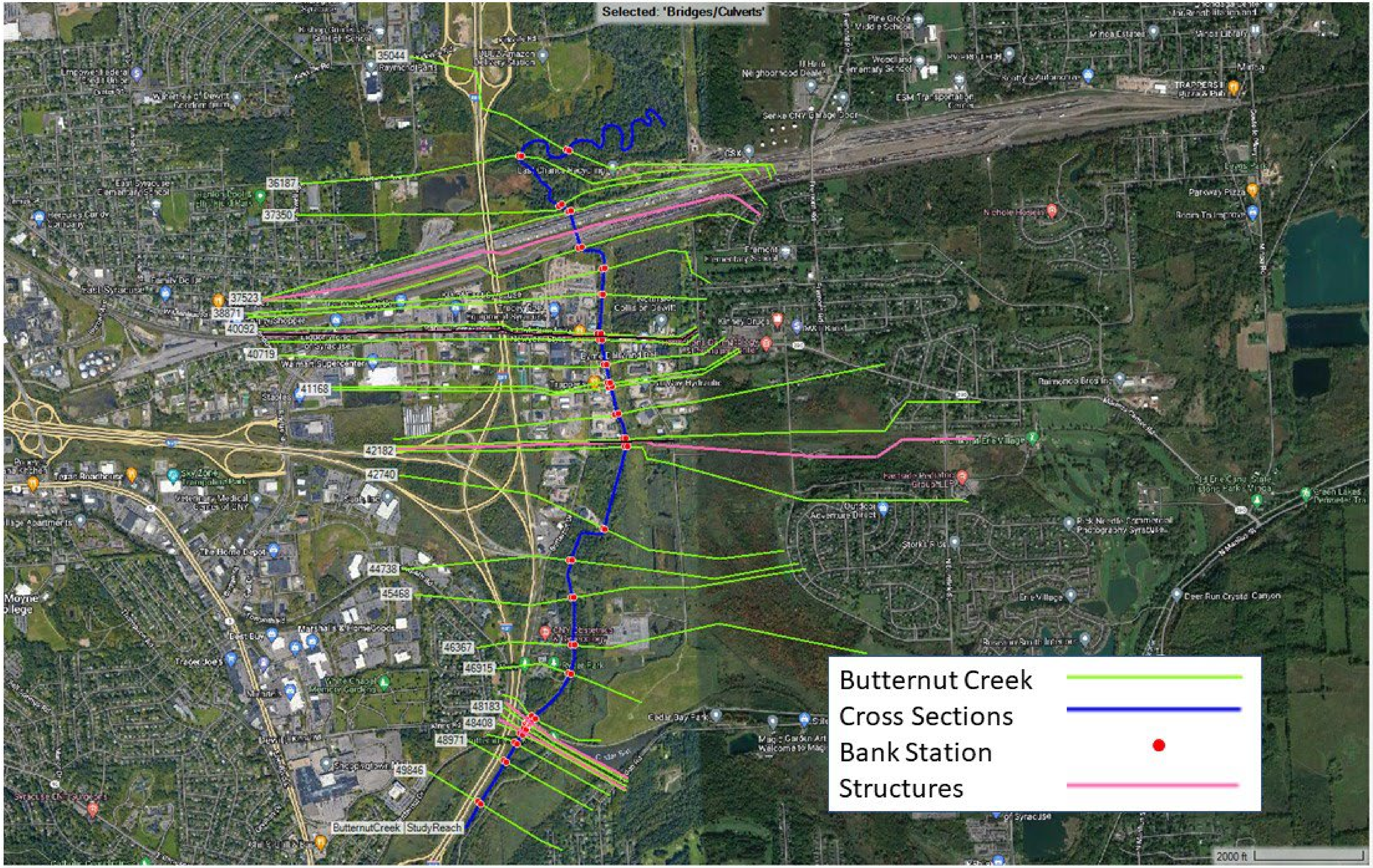
Photo D-6. *Looking downstream standing at the upstream face of the NYS Rt. 290 bridge.*

Photo D-7. *Looking downstream standing on the left bank just upstream of the abandoned railroad crossing*

Photo D-8. *Looking upstream at the Old Erie Canal crossing. Kinne Road bridge can be seen in the background.*

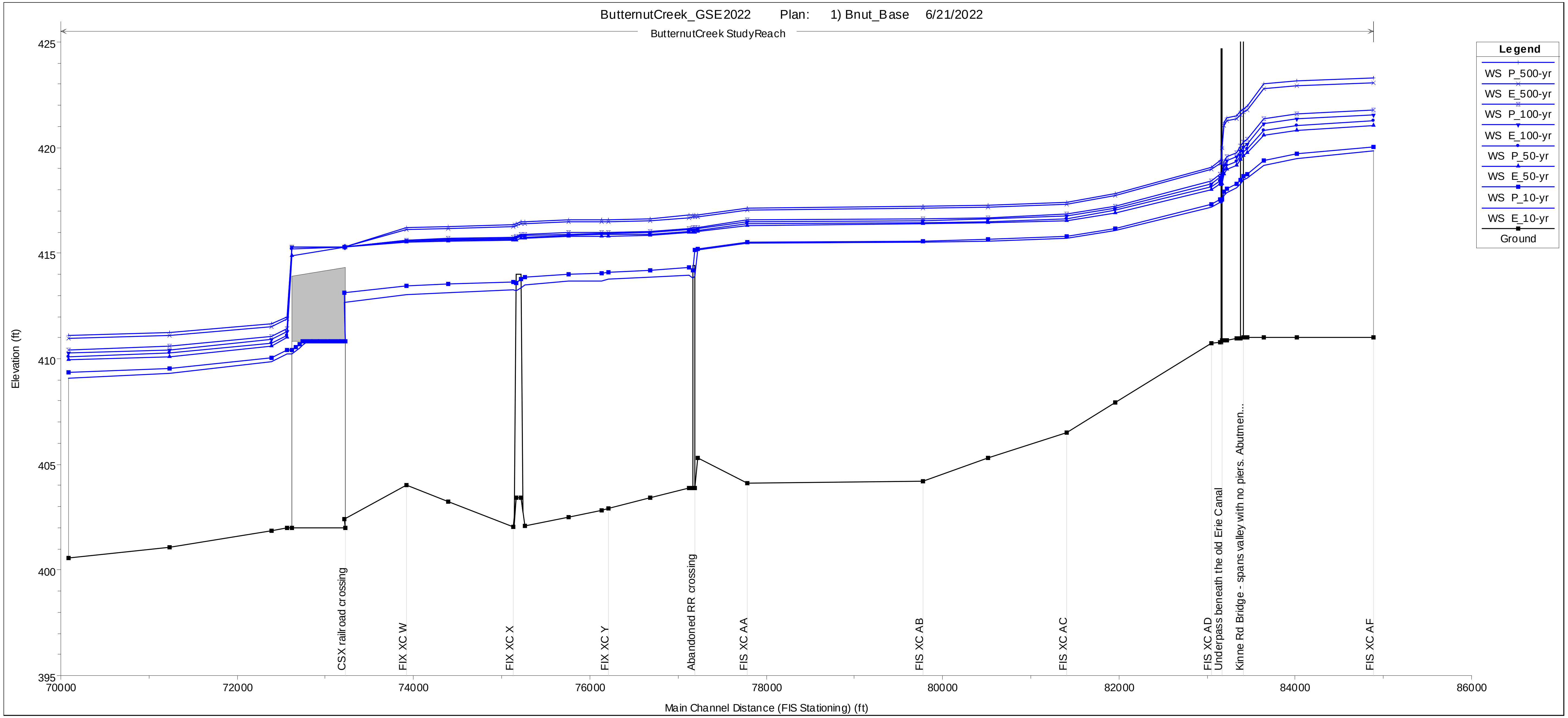
Photo D-9. *Looking upstream toward the Kinne Road bridge from the right bank.*

Appendix E. HEC-RAS Simulation Output



Plan: Base Condition

Flows: Current



Plan: Base Condition

Flows: Current

Reach	River Sta	Profile	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
StudyReach	49846	E_10-yr	2240	411	419.83		419.88	0.000393	2.36	3110.02	1651.88	0.15
StudyReach	49846	E_50-yr	3170	411	421.05		421.08	0.000278	2.19	4744.54	1961.44	0.13
StudyReach	49846	E_100-yr	3580	411	421.55		421.58	0.000247	2.15	5426.44	1983.51	0.12
StudyReach	49846	E_500-yr	4580	411	423.07		423.09	0.000162	1.92	7534.1	2125.96	0.1
StudyReach	48971	E_10-yr	2240	411	419.49		419.54	0.000366	2.38	3347.19	1685.24	0.15
StudyReach	48971	E_50-yr	3170	411	420.82		420.85	0.000229	2.1	5271.4	1767.12	0.12
StudyReach	48971	E_100-yr	3580	411	421.35		421.38	0.0002	2.04	6035.58	1777.7	0.12
StudyReach	48971	E_500-yr	4580	411	422.94		422.96	0.000127	1.81	8344.96	1805.3	0.1
StudyReach	48599	E_10-yr	2240	411	419.16		419.32	0.000885	3.66	1440.79	1652.35	0.24
StudyReach	48599	E_50-yr	3170	411	420.58		420.7	0.000656	3.54	2312.85	1709.69	0.21
StudyReach	48599	E_100-yr	3580	411	421.13		421.24	0.000601	3.53	2656.55	1717.74	0.2
StudyReach	48599	E_500-yr	4580	411	422.78		422.87	0.000415	3.27	3711.59	1733.36	0.17
StudyReach	48408	E_10-yr	2240	411	418.55	415.16	419.03	0.002193	5.6	444.67	1276.38	0.37
StudyReach	48408	E_50-yr	3170	411	419.73	416.15	420.42	0.002591	6.75	548.67	1355.95	0.41
StudyReach	48408	E_100-yr	3580	411	420.19	416.54	420.96	0.002734	7.18	594.61	1412.92	0.43
StudyReach	48408	E_500-yr	4580	411	421.79	417.46	422.63	0.002432	7.58	769.09	1535.86	0.42
StudyReach	48344 KinneRd		Bridge									
StudyReach	48292	E_10-yr	2240	410.95	418.09		418.67	0.003964	6.18	398.46	427.45	0.44
StudyReach	48292	E_50-yr	3170	410.95	419.17		419.99	0.004611	7.41	492.14	608.18	0.48
StudyReach	48292	E_100-yr	3580	410.95	419.58		420.51	0.004847	7.88	532.77	659.9	0.5
StudyReach	48292	E_500-yr	4580	410.95	421.36		422.28	0.003716	7.93	734.17	940.76	0.45
StudyReach	48183	E_10-yr	2240	410.89	417.88		418.22	0.002557	4.73	502.88	99.25	0.35
StudyReach	48183	E_50-yr	3170	410.89	418.98		419.45	0.002825	5.59	613.96	103.78	0.38
StudyReach	48183	E_100-yr	3580	410.89	419.39		419.93	0.002945	5.94	657.57	105.75	0.39
StudyReach	48183	E_500-yr	4580	410.89	421.27		421.8	0.002182	5.96	861.5	130.43	0.35
StudyReach	48143	E_10-yr	2240	410.87	417.73	414.72	418.11	0.002591	5.05	484.82	90.49	0.36
StudyReach	48143	E_50-yr	3170	410.87	418.76	415.56	419.31	0.003059	6.08	579.71	93.64	0.4
StudyReach	48143	E_100-yr	3580	410.87	419.14	415.88	419.78	0.003262	6.5	616.1	94.84	0.42
StudyReach	48143	E_500-yr	4580	410.87	421.03	416.65	421.67	0.002489	6.58	800.07	100.02	0.38

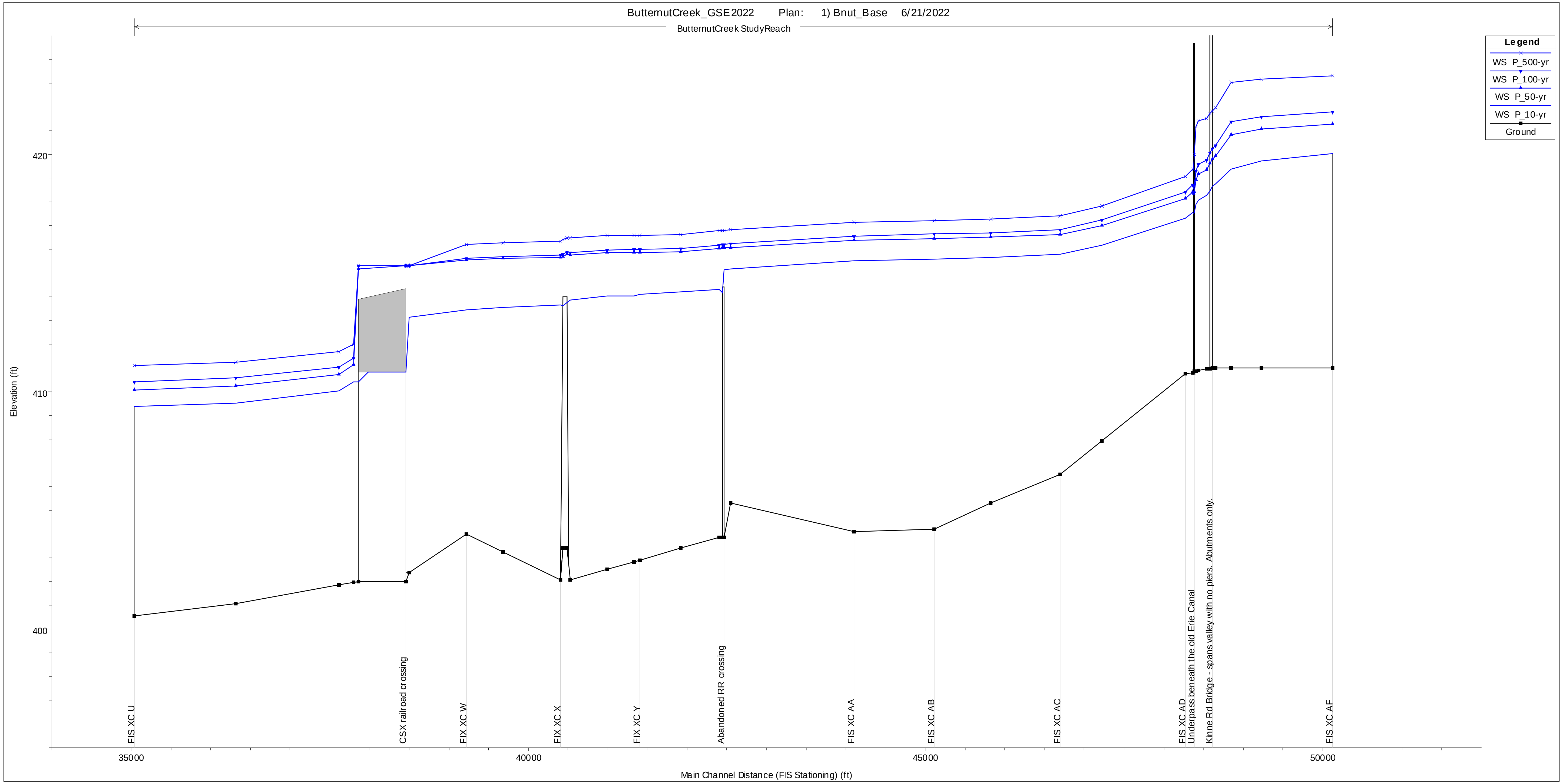
Reach	River Sta	Profile	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
StudyReach	48119 OldErieCanal		Bridge									
StudyReach	48104	E_10-yr	2240	410.8	417.4		417.76	0.002606	4.85	462.22	70.14	0.33
StudyReach	48104	E_50-yr	3170	410.8	418.28		418.85	0.00344	6.06	523.87	70.16	0.39
StudyReach	48104	E_100-yr	3580	410.8	418.58		419.25	0.003834	6.57	545.54	70.17	0.42
StudyReach	48104	E_500-yr	4580	410.8	419.26		420.19	0.004756	7.74	592.88	70.18	0.47
StudyReach	48002	E_10-yr	2240	410.75	417.17		417.48	0.002607	4.56	567.79	1136.84	0.33
StudyReach	48002	E_50-yr	3170	410.75	418		418.47	0.003294	5.59	717.49	1249.07	0.38
StudyReach	48002	E_100-yr	3580	410.75	418.29		418.83	0.003583	6	777.87	1296.4	0.39
StudyReach	48002	E_500-yr	4580	410.75	418.95		419.63	0.004178	6.86	917.74	1341.27	0.43
StudyReach	46915	E_10-yr	2240	407.94	416.09		416.13	0.000651	2.47	3041.93	1154.05	0.16
StudyReach	46915	E_50-yr	3170	407.94	416.91		416.96	0.00064	2.63	4013.85	1255.59	0.16
StudyReach	46915	E_100-yr	3580	407.94	417.14		417.19	0.000686	2.78	4296.33	1286.27	0.17
StudyReach	46915	E_500-yr	4580	407.94	417.73		417.78	0.000738	3.02	5072.39	1395.71	0.18
StudyReach	46367	E_10-yr	2240	406.52	415.71		415.77	0.000698	2.6	2832.88	4608.34	0.17
StudyReach	46367	E_50-yr	3170	406.52	416.54		416.6	0.000684	2.76	4196.18	5658.2	0.17
StudyReach	46367	E_100-yr	3580	406.52	416.74		416.8	0.00073	2.9	4541.77	5735.48	0.17
StudyReach	46367	E_500-yr	4580	406.52	417.32		417.38	0.000727	3.02	5586.61	5882.23	0.18
StudyReach	45468	E_10-yr	2240	405.32	415.58		415.58	0.000086	0.98	10116.68	4560.43	0.06
StudyReach	45468	E_50-yr	3170	405.32	416.42		416.42	0.00008	1.01	13086.53	5011.42	0.06
StudyReach	45468	E_100-yr	3580	405.32	416.61		416.61	0.000088	1.07	13745.57	5046.04	0.06
StudyReach	45468	E_500-yr	4580	405.32	417.17		417.18	0.000095	1.16	15745.9	5193.3	0.06
StudyReach	44738	E_10-yr	2240	404.2	415.53		415.53	0.000066	1.02	11075.93	5367.43	0.05
StudyReach	44738	E_50-yr	3170	404.2	416.37		416.38	0.000064	1.06	14122.08	5586.85	0.05
StudyReach	44738	E_100-yr	3580	404.2	416.56		416.56	0.000072	1.13	14779.82	5618.59	0.06
StudyReach	44738	E_500-yr	4580	404.2	417.12		417.12	0.000079	1.22	16816.46	5796.52	0.06
StudyReach	42740	E_10-yr	2240	404.11	415.46		415.46	0.000111	1.21	9102.47	6092.83	0.06
StudyReach	42740	E_50-yr	3170	404.11	416.31		416.31	0.000102	1.22	12185.38	6490.81	0.06
StudyReach	42740	E_100-yr	3580	404.11	416.48		416.49	0.000113	1.29	12838.01	6571.83	0.07
StudyReach	42740	E_500-yr	4580	404.11	417.04		417.04	0.000119	1.36	14939.87	6736.9	0.07
StudyReach	42182	E_10-yr	2240	405.3	415.15	410.95	415.17	0.000347	1.98	4940.71	6439.59	0.12
StudyReach	42182	E_50-yr	3170	405.3	416.01	411.54	416.03	0.000358	2.15	7618.75	6526.23	0.13

Reach	River Sta	Profile	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
StudyReach	42182	E_100-yr	3580	405.3	416.16	411.73	416.18	0.000382	2.24	8157.97	6534	0.13
StudyReach	42182	E_500-yr	4580	405.3	416.73	412.15	416.74	0.000339	2.2	10188.21	6563.32	0.12
StudyReach	42133 AbandonedRR		Bridge									
StudyReach	42078	E_10-yr	2240	403.87	413.97	408.38	414.3	0.001486	4.7	498.95	5686.6	0.27
StudyReach	42078	E_50-yr	3170	403.87	415.97		415.98	0.000133	1.6	8273.08	8437.42	0.08
StudyReach	42078	E_100-yr	3580	403.87	416.12		416.13	0.000135	1.63	9080.25	8449.91	0.08
StudyReach	42078	E_500-yr	4580	403.87	416.69		416.7	0.0001	1.44	12272.61	8501.24	0.07
StudyReach	41637	E_10-yr	2240	403.4	413.87		413.96	0.00022	2.86	1794.67	2716.97	0.17
StudyReach	41637	E_50-yr	3170	403.4	415.84		415.9	0.000133	2.56	4192.78	4331.82	0.14
StudyReach	41637	E_100-yr	3580	403.4	415.98		416.04	0.000155	2.78	4382.38	4436.89	0.15
StudyReach	41637	E_500-yr	4580	403.4	416.54		416.62	0.000183	3.13	5293.76	5102.37	0.17
StudyReach	41168	E_10-yr	2240	402.91	413.75		413.85	0.000185	2.93	2123.83	2164.09	0.16
StudyReach	41168	E_50-yr	3170	402.91	415.81		415.84	0.000076	2.13	7197.58	4895.09	0.11
StudyReach	41168	E_100-yr	3580	402.91	415.93		415.97	0.000086	2.28	7610.82	4961.87	0.12
StudyReach	41168	E_500-yr	4580	402.91	416.5		416.53	0.000084	2.32	9450.92	5280.96	0.12
StudyReach	41087	E_10-yr	2240	402.83	413.69		413.83	0.000311	3.64	2096.03	2233.3	0.21
StudyReach	41087	E_50-yr	3170	402.83	415.81		415.83	0.000078	2.08	8062.29	4946.29	0.11
StudyReach	41087	E_100-yr	3580	402.83	415.93		415.96	0.000087	2.21	8498.46	4995.69	0.11
StudyReach	41087	E_500-yr	4580	402.83	416.5		416.52	0.000082	2.22	10445.35	5343.19	0.11
StudyReach	40719	E_10-yr	2240	402.51	413.67		413.74	0.000146	2.69	2621.75	2895.32	0.15
StudyReach	40719	E_50-yr	3170	402.51	415.79		415.81	0.000056	1.89	8594.53	5827	0.09
StudyReach	40719	E_100-yr	3580	402.51	415.91		415.93	0.000064	2.03	9023.11	5918.1	0.1
StudyReach	40719	E_500-yr	4580	402.51	416.48		416.5	0.000065	2.09	11000.37	6281.89	0.1
StudyReach	40223	E_10-yr	2240	402.08	413.51	406.55	413.65	0.000255	3.25	1413.2	4277.95	0.19
StudyReach	40223	E_50-yr	3170	402.08	415.71	407.69	415.77	0.000114	2.49	4388.21	6591.48	0.13
StudyReach	40223	E_100-yr	3580	402.08	415.83	408.15	415.89	0.000134	2.72	4561.81	6658.98	0.14
StudyReach	40223	E_500-yr	4580	402.08	416.38	409.56	416.45	0.000152	2.98	5427.11	6846.77	0.15
StudyReach	40143 NYS Rt 290		Bridge									
StudyReach	40092	E_10-yr	2240	402.06	413.26		413.42	0.00048	3.34	1246.97	5009.06	0.19
StudyReach	40092	E_50-yr	3170	402.06	415.61		415.67	0.000194	2.47	3912.04	6662.14	0.13

Reach	River Sta	Profile	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
StudyReach	40092	E_100-yr	3580	402.06	415.7		415.77	0.000233	2.72	4020.55	6721.29	0.14
StudyReach	40092	E_500-yr	4580	402.06	416.26		416.33	0.000271	3.03	4703.63	7129.17	0.15
StudyReach	39352	E_10-yr	2240	403.23	413.13		413.16	0.000174	1.98	4077.35	3309.6	0.12
StudyReach	39352	E_50-yr	3170	403.23	415.57		415.58	0.000059	1.35	8427.23	5864.44	0.07
StudyReach	39352	E_100-yr	3580	403.23	415.65		415.66	0.000071	1.49	8573.78	5925.84	0.08
StudyReach	39352	E_500-yr	4580	403.23	416.19		416.2	0.000086	1.69	9601.19	6410.69	0.09
StudyReach	38871	E_10-yr	2240	404	413.03		413.06	0.000226	2.13	3161.25	3898.12	0.13
StudyReach	38871	E_50-yr	3170	404	415.52		415.54	0.000097	1.68	5333.23	5638.84	0.09
StudyReach	38871	E_100-yr	3580	404	415.59		415.61	0.00012	1.87	5391.97	5717.66	0.1
StudyReach	38871	E_500-yr	4580	404	416.12		416.14	0.000153	2.18	5848.6	6232.72	0.12
StudyReach	38170	E_10-yr	2240	402.39	412.66	406.9	412.77	0.000841	3.01	1044.68	3631.99	0.18
StudyReach	38170	E_50-yr	3170	402.39	415.29	408.45	415.39	0.00058	2.96	1532.54	4839.53	0.15
StudyReach	38170	E_100-yr	3580	402.39	415.3	408.83	415.43	0.000738	3.34	1534.07	4842.1	0.17
StudyReach	38170	E_500-yr	4580	402.39	415.3	409.49	415.82	0.002364	5.98	1534.31	4842.12	0.31
StudyReach	37849 CSX RR Bridge		Culvert									
StudyReach	37523	E_10-yr	2240	401.98	410.25		410.72	0.005687	5.58	420.91	1555.04	0.36
StudyReach	37523	E_50-yr	3170	401.98	411		411.75	0.00801	7.05	488.03	2048.72	0.43
StudyReach	37523	E_100-yr	3580	401.98	411.28		412.16	0.009006	7.65	518.51	2383.72	0.46
StudyReach	37523	E_500-yr	4580	401.98	411.88		413.06	0.011264	8.95	589.56	3679.75	0.52
StudyReach	37350	E_10-yr	2240	401.85	409.85		409.93	0.001908	2.91	1265.75	2166.92	0.21
StudyReach	37350	E_50-yr	3170	401.85	410.61		410.7	0.002125	3.22	1575.94	2744.54	0.22
StudyReach	37350	E_100-yr	3580	401.85	410.9		411	0.00219	3.37	1698.15	2987.92	0.23
StudyReach	37350	E_500-yr	4580	401.85	411.54		411.66	0.002377	3.72	1972.79	3371.58	0.24
StudyReach	36187	E_10-yr	2240	401.07	409.29		409.3	0.000327	1.27	3911.93	2571.89	0.08
StudyReach	36187	E_50-yr	3170	401.07	410.11		410.12	0.000281	1.26	5434.79	3019.96	0.08
StudyReach	36187	E_100-yr	3580	401.07	410.43		410.44	0.000266	1.26	6048.79	3042.78	0.08
StudyReach	36187	E_500-yr	4580	401.07	411.1		411.1	0.000247	1.28	7356.84	3064.74	0.08
StudyReach	35044	E_10-yr	2240	400.56	409.09	406.04	409.1	0.000247	1.17	4227.57	1775.86	0.07
StudyReach	35044	E_50-yr	3170	400.56	409.94	406.27	409.94	0.000254	1.27	5850.99	2556.58	0.07
StudyReach	35044	E_100-yr	3580	400.56	410.26	406.75	410.27	0.000236	1.25	6597.11	2655.27	0.07
StudyReach	35044	E_500-yr	4580	400.56	410.95	406.96	410.96	0.000211	1.24	8181.87	2818.95	0.07

Plan: Base Condition

Flows: Projected Future



Reach	River Sta	Profile	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
StudyReach	49846	P_10-yr	2386	411	420.02		420.07	0.000371	2.33	3369.47	1696.45	0.15
StudyReach	49846	P_50-yr	3352	411	421.27		421.3	0.000263	2.17	5048.65	1972.05	0.13
StudyReach	49846	P_100-yr	3776	411	421.78		421.81	0.000235	2.13	5746.35	1993.34	0.12
StudyReach	49846	P_500-yr	4812	411	423.3		423.32	0.000158	1.92	7859.42	2148.45	0.1
StudyReach	48971	P_10-yr	2386	411	419.71		419.75	0.000334	2.32	3664.13	1703.4	0.15
StudyReach	48971	P_50-yr	3352	411	421.06		421.09	0.000215	2.07	5614.02	1771.97	0.12
StudyReach	48971	P_100-yr	3776	411	421.6		421.62	0.00019	2.02	6389.34	1782.02	0.11
StudyReach	48971	P_500-yr	4812	411	423.18		423.19	0.000125	1.81	8685.35	1808.83	0.1
StudyReach	48599	P_10-yr	2386	411	419.4		419.55	0.000839	3.64	1584.47	1685.17	0.23
StudyReach	48599	P_50-yr	3352	411	420.82		420.95	0.00063	3.53	2466.91	1713.31	0.21
StudyReach	48599	P_100-yr	3776	411	421.38		421.49	0.000579	3.53	2815.66	1720.97	0.2
StudyReach	48599	P_500-yr	4812	411	423.02		423.11	0.000412	3.3	3862.36	1734.65	0.17
StudyReach	48408	P_10-yr	2386	411	418.75	415.32	419.26	0.002264	5.8	460.58	1300.46	0.38
StudyReach	48408	P_50-yr	3352	411	419.94	416.33	420.66	0.002659	6.95	569.02	1373.16	0.42
StudyReach	48408	P_100-yr	3776	411	420.4	416.72	421.21	0.002795	7.38	616.3	1457.03	0.43
StudyReach	48408	P_500-yr	4812	411	421.97	417.66	422.86	0.00252	7.8	789.77	1539.96	0.42
StudyReach	48344 KinneRd		Bridge									
StudyReach	48292	P_10-yr	2386	410.95	418.27		418.89	0.004092	6.4	412.33	458.86	0.45
StudyReach	48292	P_50-yr	3352	410.95	419.35		420.23	0.00472	7.62	510.07	631.12	0.49
StudyReach	48292	P_100-yr	3776	410.95	419.77		420.75	0.004943	8.09	552.74	693.85	0.51
StudyReach	48292	P_500-yr	4812	410.95	421.53		422.49	0.003853	8.16	753.82	952.25	0.46
StudyReach	48183	P_10-yr	2386	410.89	418.06		418.42	0.002614	4.89	520.65	100.01	0.35
StudyReach	48183	P_50-yr	3352	410.89	419.16		419.66	0.002881	5.75	633.48	104.62	0.38
StudyReach	48183	P_100-yr	3776	410.89	419.59		420.15	0.002994	6.09	678.23	106.75	0.39
StudyReach	48183	P_500-yr	4812	410.89	421.43		421.99	0.002267	6.15	879.46	134.58	0.36
StudyReach	48143	P_10-yr	2386	410.87	417.89	414.86	418.31	0.002681	5.23	500.14	91.01	0.37
StudyReach	48143	P_50-yr	3352	410.87	418.93	415.7	419.52	0.003152	6.27	596.03	94.18	0.41
StudyReach	48143	P_100-yr	3776	410.87	419.32	416.04	419.99	0.003348	6.69	633.25	95.36	0.42
StudyReach	48143	P_500-yr	4812	410.87	421.17	416.82	421.86	0.002607	6.81	814.58	100.41	0.39
StudyReach	48119 OldErieCanal		Bridge									

Reach	River Sta	Profile	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
StudyReach	48104	P_10-yr	2386	410.8	417.54		417.94	0.002751	5.06	472.35	70.15	0.34
StudyReach	48104	P_50-yr	3352	410.8	418.42		419.03	0.003615	6.29	533.72	70.17	0.4
StudyReach	48104	P_100-yr	3776	410.8	418.73		419.45	0.004014	6.81	555.55	70.17	0.43
StudyReach	48104	P_500-yr	4812	410.8	419.4		420.39	0.004977	8	602.46	70.19	0.48
StudyReach	48002	P_10-yr	2386	410.75	417.3		417.64	0.002738	4.75	588.02	1152.25	0.34
StudyReach	48002	P_50-yr	3352	410.75	418.13		418.63	0.003424	5.77	744.74	1262.61	0.38
StudyReach	48002	P_100-yr	3776	410.75	418.43		418.99	0.003706	6.18	806.63	1307.21	0.4
StudyReach	48002	P_500-yr	4812	410.75	419.08		419.8	0.004313	7.05	946.64	1342.95	0.44
StudyReach	46915	P_10-yr	2386	407.94	416.18		416.23	0.000678	2.54	3146.6	1156.48	0.17
StudyReach	46915	P_50-yr	3352	407.94	417.02		417.06	0.00066	2.7	4141.93	1269.91	0.17
StudyReach	46915	P_100-yr	3776	407.94	417.24		417.29	0.00071	2.85	4426.98	1307.71	0.17
StudyReach	46915	P_500-yr	4812	407.94	417.84		417.89	0.000754	3.08	5229.84	1407.73	0.18
StudyReach	46367	P_10-yr	2386	406.52	415.78		415.84	0.000737	2.69	2945.78	4663.34	0.17
StudyReach	46367	P_50-yr	3352	406.52	416.64		416.7	0.000702	2.82	4354.38	5699.1	0.17
StudyReach	46367	P_100-yr	3776	406.52	416.83		416.9	0.000748	2.96	4702.11	5758.21	0.18
StudyReach	46367	P_500-yr	4812	406.52	417.43		417.49	0.000735	3.06	5792.61	5918.53	0.18
StudyReach	45468	P_10-yr	2386	405.32	415.64		415.64	0.000092	1.02	10339.42	4592.67	0.06
StudyReach	45468	P_50-yr	3352	405.32	416.51		416.51	0.000084	1.04	13392.07	5027.48	0.06
StudyReach	45468	P_100-yr	3776	405.32	416.69		416.7	0.000092	1.1	14044.83	5076.29	0.06
StudyReach	45468	P_500-yr	4812	405.32	417.28		417.28	0.000098	1.18	16115.88	5208.83	0.06
StudyReach	44738	P_10-yr	2386	404.2	415.59		415.59	0.000071	1.06	11291.44	5377.06	0.06
StudyReach	44738	P_50-yr	3352	404.2	416.46		416.46	0.000067	1.09	14427.4	5601.66	0.06
StudyReach	44738	P_100-yr	3776	404.2	416.64		416.64	0.000075	1.16	15078.4	5652.27	0.06
StudyReach	44738	P_500-yr	4812	404.2	417.22		417.23	0.000082	1.25	17190.93	5818.89	0.06
StudyReach	42740	P_10-yr	2386	404.11	415.51		415.52	0.000119	1.25	9296.36	6122.37	0.07
StudyReach	42740	P_50-yr	3352	404.11	416.39		416.39	0.000106	1.25	12488.6	6515.81	0.06
StudyReach	42740	P_100-yr	3776	404.11	416.56		416.57	0.000117	1.32	13135.89	6596.79	0.07
StudyReach	42740	P_500-yr	4812	404.11	417.14		417.14	0.000121	1.39	15322.34	6747.76	0.07
StudyReach	42182	P_10-yr	2386	405.3	415.18	411.08	415.2	0.000381	2.08	5029	6447.72	0.13
StudyReach	42182	P_50-yr	3352	405.3	416.08	411.62	416.11	0.000367	2.19	7876.05	6530.06	0.13
StudyReach	42182	P_100-yr	3776	405.3	416.23	411.82	416.25	0.000393	2.29	8399.93	6537.39	0.13
StudyReach	42182	P_500-yr	4812	405.3	416.82	412.22	416.84	0.000341	2.22	10535.58	6569.15	0.12

Reach	River Sta	Profile	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
StudyReach	42133 AbandonedRR		Bridge									
StudyReach	42078	P_10-yr	2386	403.87	414.31	408.57	414.57	0.00124	4.4	1369.29	6125.58	0.25
StudyReach	42078	P_50-yr	3352	403.87	416.04		416.05	0.000133	1.61	8647.51	8443.4	0.08
StudyReach	42078	P_100-yr	3776	403.87	416.18		416.2	0.000136	1.64	9452.92	8455.14	0.09
StudyReach	42078	P_500-yr	4812	403.87	416.79		416.8	0.000098	1.44	12812.71	8508.36	0.07
StudyReach	41637	P_10-yr	2386	403.4	414.2		414.28	0.000202	2.81	2084.57	2937.82	0.17
StudyReach	41637	P_50-yr	3352	403.4	415.91		415.97	0.000142	2.66	4284.64	4390.79	0.14
StudyReach	41637	P_100-yr	3776	403.4	416.04		416.11	0.000166	2.89	4468.06	4513.43	0.16
StudyReach	41637	P_500-yr	4812	403.4	416.63		416.71	0.000188	3.19	5451.79	5164.62	0.17
StudyReach	41168	P_10-yr	2386	402.91	414.1		414.19	0.000169	2.86	2609.09	2633.14	0.16
StudyReach	41168	P_50-yr	3352	402.91	415.87		415.9	0.00008	2.19	7399.31	4929.09	0.11
StudyReach	41168	P_100-yr	3776	402.91	415.99		416.03	0.000091	2.35	7795.15	4990.26	0.12
StudyReach	41168	P_500-yr	4812	402.91	416.59		416.63	0.000086	2.36	9757.31	5328.97	0.12
StudyReach	41087	P_10-yr	2386	402.83	414.04		414.17	0.000279	3.54	2703.51	2990.4	0.2
StudyReach	41087	P_50-yr	3352	402.83	415.87		415.89	0.000081	2.14	8275.32	4970.72	0.11
StudyReach	41087	P_100-yr	3776	402.83	415.99		416.02	0.000091	2.28	8692.86	5016.85	0.12
StudyReach	41087	P_500-yr	4812	402.83	416.59		416.62	0.000084	2.25	10772.37	5386.78	0.11
StudyReach	40719	P_10-yr	2386	402.51	414.03		414.08	0.000128	2.57	3276.83	3620.55	0.14
StudyReach	40719	P_50-yr	3352	402.51	415.85		415.87	0.00006	1.95	8804.1	5872.06	0.1
StudyReach	40719	P_100-yr	3776	402.51	415.97		415.99	0.000068	2.09	9214.48	5957.83	0.1
StudyReach	40719	P_500-yr	4812	402.51	416.57		416.59	0.000066	2.13	11331.92	6339.48	0.1
StudyReach	40223	P_10-yr	2386	402.08	413.87	406.73	414	0.000239	3.22	1737.85	4851.93	0.18
StudyReach	40223	P_50-yr	3352	402.08	415.77	407.9	415.83	0.000122	2.59	4474.58	6624.75	0.13
StudyReach	40223	P_100-yr	3776	402.08	415.87	408.36	415.94	0.000144	2.83	4638.07	6682.86	0.14
StudyReach	40223	P_500-yr	4812	402.08	416.47	409.88	416.54	0.000158	3.06	5566.62	6875.22	0.15
StudyReach	40143 NYS Rt 290		Bridge									
StudyReach	40092	P_10-yr	2386	402.06	413.65		413.79	0.000438	3.28	1639.25	5739.83	0.19
StudyReach	40092	P_50-yr	3352	402.06	415.66		415.72	0.000211	2.58	3963.73	6689.65	0.13
StudyReach	40092	P_100-yr	3776	402.06	415.74		415.82	0.000253	2.84	4071.41	6745.11	0.15
StudyReach	40092	P_500-yr	4812	402.06	416.34		416.42	0.000284	3.11	4809.92	7167.16	0.16

Reach	River Sta	Profile	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
StudyReach	39352	P_10-yr	2386	403.23	413.54		413.56	0.000139	1.82	4761.04	3808.47	0.1
StudyReach	39352	P_50-yr	3352	403.23	415.61		415.62	0.000064	1.41	8498.05	5889.66	0.07
StudyReach	39352	P_100-yr	3776	403.23	415.68		415.69	0.000078	1.56	8641.96	5945	0.08
StudyReach	39352	P_500-yr	4812	403.23	416.27		416.28	0.00009	1.74	9758.15	6450.72	0.09
StudyReach	38871	P_10-yr	2386	404	413.46		413.48	0.000187	2.01	3534.36	4228.47	0.12
StudyReach	38871	P_50-yr	3352	404	415.56		415.57	0.000107	1.76	5362.12	5681.2	0.1
StudyReach	38871	P_100-yr	3776	404	415.62		415.64	0.000132	1.96	5418.93	5745.82	0.11
StudyReach	38871	P_500-yr	4812	404	416.19		416.22	0.000163	2.26	5915.75	6294.78	0.12
StudyReach	38170	P_10-yr	2386	402.39	413.13	407.08	413.24	0.000771	2.98	1131.43	3798.72	0.17
StudyReach	38170	P_50-yr	3352	402.39	415.3	408.62	415.41	0.000647	3.13	1534.07	4842.1	0.16
StudyReach	38170	P_100-yr	3776	402.39	415.3	408.95	415.44	0.000821	3.52	1534.07	4842.1	0.18
StudyReach	38170	P_500-yr	4812	402.39	415.3	409.63	415.87	0.002609	6.28	1534.19	4842.11	0.32
StudyReach	37849 CSX RR Bridge		Culvert									
StudyReach	37523	P_10-yr	2386	401.98	410.41		410.93	0.005961	5.79	434.95	1617.97	0.37
StudyReach	37523	P_50-yr	3352	401.98	411.12		411.93	0.008465	7.32	501.15	2178.14	0.45
StudyReach	37523	P_100-yr	3776	401.98	411.41		412.34	0.009448	7.91	533.43	2549.89	0.47
StudyReach	37523	P_500-yr	4812	401.98	412		413.25	0.011806	9.24	604.1	4009.68	0.53
StudyReach	37350	P_10-yr	2386	401.85	410.03		410.11	0.001868	2.91	1339.8	2338.13	0.2
StudyReach	37350	P_50-yr	3352	401.85	410.74		410.83	0.002155	3.29	1630.08	2859.99	0.22
StudyReach	37350	P_100-yr	3776	401.85	411.04		411.14	0.002211	3.43	1757.43	3106.54	0.23
StudyReach	37350	P_500-yr	4812	401.85	411.67		411.8	0.002404	3.78	2030.36	3408.48	0.24
StudyReach	36187	P_10-yr	2386	401.07	409.53		409.54	0.000287	1.21	4322.84	2865.66	0.08
StudyReach	36187	P_50-yr	3352	401.07	410.25		410.26	0.000274	1.26	5707.11	3030.66	0.08
StudyReach	36187	P_100-yr	3776	401.07	410.58		410.59	0.000259	1.26	6343.94	3052.21	0.08
StudyReach	36187	P_500-yr	4812	401.07	411.23		411.24	0.000244	1.29	7625.99	3067.07	0.08
StudyReach	35044	P_10-yr	2386	400.56	409.36	406.11	409.37	0.000221	1.13	4667.69	2021.74	0.07
StudyReach	35044	P_50-yr	3352	400.56	410.08	406.63	410.09	0.000247	1.26	6180.99	2589.96	0.07
StudyReach	35044	P_100-yr	3776	400.56	410.42	406.76	410.43	0.000227	1.24	6956.51	2689.75	0.07
StudyReach	35044	P_500-yr	4812	400.56	411.09	406.97	411.09	0.000208	1.24	8507.59	2848.69	0.07

Plan: Alternative 1-1 Flows: Current and Projected Future

Reach	River Sta	Profile	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
StudyReach	49846	E_10-yr	2240	411	419.83		419.87	0.000395	2.37	3104.65	1651.28	0.15
StudyReach	49846	E_50-yr	3170	411	421.04		421.07	0.00028	2.2	4730.61	1958.81	0.13
StudyReach	49846	E_100-yr	3580	411	421.54		421.57	0.000248	2.15	5415.32	1983.17	0.12
StudyReach	49846	E_500-yr	4580	411	423.07		423.09	0.000161	1.92	7535.51	2126.04	0.1
StudyReach	49846	P_10-yr	2386	411	420.02		420.07	0.000371	2.34	3366.66	1695.93	0.15
StudyReach	49846	P_50-yr	3352	411	421.26		421.29	0.000265	2.18	5035.67	1971.66	0.13
StudyReach	49846	P_100-yr	3776	411	421.77		421.8	0.000236	2.13	5735.36	1992.99	0.12
StudyReach	49846	P_500-yr	4812	411	423.3		423.32	0.000158	1.92	7858.87	2148.4	0.1
StudyReach	48971	E_10-yr	2240	411	419.48		419.53	0.000368	2.39	3338.88	1684.59	0.15
StudyReach	48971	E_50-yr	3170	411	420.81		420.84	0.000231	2.11	5253.71	1766.87	0.12
StudyReach	48971	E_100-yr	3580	411	421.34		421.37	0.000202	2.05	6022.1	1777.54	0.12
StudyReach	48971	E_500-yr	4580	411	422.95		422.96	0.000127	1.81	8346.52	1805.32	0.1
StudyReach	48971	P_10-yr	2386	411	419.71		419.75	0.000335	2.33	3659.9	1703.16	0.15
StudyReach	48971	P_50-yr	3352	411	421.05		421.07	0.000217	2.08	5597.85	1771.74	0.12
StudyReach	48971	P_100-yr	3776	411	421.59		421.61	0.000191	2.03	6376.17	1781.86	0.11
StudyReach	48971	P_500-yr	4812	411	423.18		423.19	0.000125	1.81	8684.73	1808.82	0.1
StudyReach	48599	E_10-yr	2240	411	419.15		419.31	0.00089	3.66	1436.17	1651.19	0.24
StudyReach	48599	E_50-yr	3170	411	420.56		420.69	0.000662	3.55	2303.87	1709.47	0.21
StudyReach	48599	E_100-yr	3580	411	421.12		421.23	0.000605	3.54	2649.82	1717.58	0.2
StudyReach	48599	E_500-yr	4580	411	422.79		422.87	0.000415	3.27	3712.33	1733.36	0.17
StudyReach	48599	P_10-yr	2386	411	419.39		419.54	0.000841	3.64	1582.18	1684.68	0.23
StudyReach	48599	P_50-yr	3352	411	420.81		420.93	0.000635	3.55	2458.81	1713.12	0.21
StudyReach	48599	P_100-yr	3776	411	421.37		421.48	0.000582	3.53	2809.12	1720.85	0.2
StudyReach	48599	P_500-yr	4812	411	423.02		423.11	0.000412	3.3	3862.07	1734.65	0.17
StudyReach	48408	E_10-yr	2240	411	418.54	415.16	419.02	0.002203	5.61	443.91	1275.26	0.37
StudyReach	48408	E_50-yr	3170	411	419.71	416.15	420.4	0.002612	6.76	546.76	1355.37	0.41
StudyReach	48408	E_100-yr	3580	411	420.17	416.54	420.95	0.00275	7.19	593.09	1407.66	0.43
StudyReach	48408	E_500-yr	4580	411	421.79	417.46	422.64	0.002431	7.58	769.26	1535.9	0.41
StudyReach	48408	P_10-yr	2386	411	418.74	415.32	419.26	0.002269	5.8	460.19	1300.2	0.38
StudyReach	48408	P_50-yr	3352	411	419.92	416.33	420.65	0.002678	6.96	567.25	1368.68	0.42
StudyReach	48408	P_100-yr	3776	411	420.38	416.72	421.2	0.002811	7.39	614.8	1456.16	0.44
StudyReach	48408	P_500-yr	4812	411	421.97	417.66	422.86	0.00252	7.8	789.7	1539.94	0.42
StudyReach	48344	KinneRd	Bridge									

Reach	River Sta	Profile	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
StudyReach	48292	E_10-yr	2240	410.95	418.08		418.66	0.003992	6.19	397.47	425.24	0.44
StudyReach	48292	E_50-yr	3170	410.95	419.14		419.97	0.004674	7.44	489.45	604.6	0.49
StudyReach	48292	E_100-yr	3580	410.95	419.56		420.49	0.004897	7.91	530.52	658.1	0.5
StudyReach	48292	E_500-yr	4580	410.95	421.37		422.28	0.003713	7.93	734.4	940.96	0.45
StudyReach	48292	P_10-yr	2386	410.95	418.26		418.88	0.004106	6.4	411.82	458.17	0.45
StudyReach	48292	P_50-yr	3352	410.95	419.33		420.21	0.004776	7.65	507.57	627.59	0.49
StudyReach	48292	P_100-yr	3776	410.95	419.75		420.73	0.004991	8.11	550.46	691.14	0.51
StudyReach	48292	P_500-yr	4812	410.95	421.53		422.49	0.003854	8.16	753.72	952.2	0.46
StudyReach	48183	E_10-yr	2240	410.89	417.87		418.21	0.00258	4.75	501.37	99.18	0.35
StudyReach	48183	E_50-yr	3170	410.89	418.94		419.42	0.002872	5.62	610.59	103.63	0.38
StudyReach	48183	E_100-yr	3580	410.89	419.37		419.91	0.00298	5.96	654.91	105.63	0.39
StudyReach	48183	E_500-yr	4580	410.89	421.27		421.8	0.00218	5.96	861.72	130.48	0.35
StudyReach	48183	P_10-yr	2386	410.89	418.05		418.42	0.002625	4.89	519.89	99.97	0.36
StudyReach	48183	P_50-yr	3352	410.89	419.13		419.64	0.002922	5.77	630.41	104.49	0.39
StudyReach	48183	P_100-yr	3776	410.89	419.56		420.13	0.003028	6.12	675.61	106.62	0.4
StudyReach	48183	P_500-yr	4812	410.89	421.43		421.99	0.002267	6.15	879.37	134.55	0.36
StudyReach	48143	E_10-yr	2240	410.87	417.71	414.72	418.1	0.002615	5.06	483.33	90.44	0.36
StudyReach	48143	E_50-yr	3170	410.87	418.72	415.56	419.28	0.003112	6.11	576.35	93.53	0.4
StudyReach	48143	E_100-yr	3580	410.87	419.11	415.88	419.75	0.003304	6.52	613.44	94.76	0.42
StudyReach	48143	E_500-yr	4580	410.87	421.03	416.65	421.67	0.002487	6.58	800.25	100.02	0.38
StudyReach	48143	P_10-yr	2386	410.87	417.89	414.86	418.3	0.002693	5.23	499.39	90.98	0.37
StudyReach	48143	P_50-yr	3352	410.87	418.9	415.7	419.49	0.0032	6.3	592.97	94.08	0.41
StudyReach	48143	P_100-yr	3776	410.87	419.3	416.04	419.97	0.003389	6.71	630.62	95.28	0.43
StudyReach	48143	P_500-yr	4812	410.87	421.17	416.82	421.86	0.002609	6.81	814.45	100.41	0.39
StudyReach	48119 OldErieCanal		Bridge									
StudyReach	48104	E_10-yr	2240	410.8	417.38		417.74	0.002633	4.87	460.8	70.14	0.33
StudyReach	48104	E_50-yr	3170	410.8	418.23		418.81	0.003514	6.1	520.54	70.16	0.39
StudyReach	48104	E_100-yr	3580	410.8	418.55		419.22	0.003898	6.6	542.8	70.17	0.42
StudyReach	48104	E_500-yr	4580	410.8	419.22		420.16	0.004824	7.77	590.38	70.18	0.47
StudyReach	48104	P_10-yr	2386	410.8	417.53		417.93	0.002765	5.06	471.63	70.15	0.34
StudyReach	48104	P_50-yr	3352	410.8	418.37		418.99	0.003686	6.32	530.64	70.16	0.41
StudyReach	48104	P_100-yr	3776	410.8	418.69		419.41	0.004081	6.84	552.8	70.17	0.43
StudyReach	48104	P_500-yr	4812	410.8	419.36		420.36	0.005042	8.03	600.13	70.19	0.48
StudyReach	48002	E_10-yr	2240	410.75	417.14		417.46	0.002642	4.58	564.35	1135.28	0.33

Reach	River Sta	Profile	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
StudyReach	48002	E_50-yr	3170	410.75	417.94		418.42	0.003402	5.65	705.72	1234.36	0.38
StudyReach	48002	E_100-yr	3580	410.75	418.24		418.79	0.003677	6.05	767.84	1286.4	0.4
StudyReach	48002	E_500-yr	4580	410.75	418.9		419.6	0.004275	6.92	907.92	1340.7	0.44
StudyReach	48002	P_10-yr	2386	410.75	417.29		417.63	0.002757	4.76	586.14	1147.87	0.34
StudyReach	48002	P_50-yr	3352	410.75	418.08		418.59	0.003527	5.83	733.64	1256.19	0.39
StudyReach	48002	P_100-yr	3776	410.75	418.38		418.95	0.003803	6.23	796.39	1304.41	0.41
StudyReach	48002	P_500-yr	4812	410.75	419.04		419.77	0.004406	7.1	937.41	1342.41	0.45
StudyReach	46915	E_10-yr	2240	407.94	415.92		415.97	0.000763	2.63	2850.57	1147.95	0.18
StudyReach	46915	E_50-yr	3170	407.94	416.5		416.56	0.000902	3.02	3512.17	1164.59	0.19
StudyReach	46915	E_100-yr	3580	407.94	416.77		416.83	0.000919	3.12	3830.96	1229.5	0.2
StudyReach	46915	E_500-yr	4580	407.94	417.39		417.46	0.000937	3.31	4618.94	1328.16	0.2
StudyReach	46915	P_10-yr	2386	407.94	416.09		416.15	0.000733	2.62	3050.76	1154.26	0.17
StudyReach	46915	P_50-yr	3352	407.94	416.6		416.67	0.000921	3.08	3637.11	1175.09	0.2
StudyReach	46915	P_100-yr	3776	407.94	416.89		416.96	0.000922	3.16	3988.33	1252.33	0.2
StudyReach	46915	P_500-yr	4812	407.94	417.52		417.59	0.00094	3.35	4795.27	1356.28	0.2
StudyReach	46367	E_10-yr	2240	406.52	415.54		415.59	0.000651	2.48	3407.5	4334.91	0.16
StudyReach	46367	E_50-yr	3170	406.52	416.06		416.11	0.00075	2.78	4539.07	5093.25	0.17
StudyReach	46367	E_100-yr	3580	406.52	416.32		416.38	0.000753	2.85	5148.02	5488	0.18
StudyReach	46367	E_500-yr	4580	406.52	416.99		417.03	0.000635	2.76	6725.35	5787.68	0.16
StudyReach	46367	P_10-yr	2386	406.52	415.75		415.79	0.000582	2.39	3853.08	4637.63	0.15
StudyReach	46367	P_50-yr	3352	406.52	416.16		416.22	0.000751	2.81	4776.49	5266.47	0.17
StudyReach	46367	P_100-yr	3776	406.52	416.46		416.52	0.000722	2.82	5469.95	5611.28	0.17
StudyReach	46367	P_500-yr	4812	406.52	417.13		417.17	0.000616	2.74	7068.82	5813.77	0.16
StudyReach	45468	E_10-yr	2240	405.32	415.38		415.38	0.000106	1.07	9426.8	4483.7	0.06
StudyReach	45468	E_50-yr	3170	405.32	415.86		415.86	0.000132	1.24	11098.63	4683.71	0.07
StudyReach	45468	E_100-yr	3580	405.32	416.12		416.13	0.000132	1.27	12032.13	4879.94	0.07
StudyReach	45468	E_500-yr	4580	405.32	416.8		416.81	0.000125	1.29	14424.26	5110.16	0.07
StudyReach	45468	P_10-yr	2386	405.32	415.6		415.61	0.000095	1.04	10202.04	4573.29	0.06
StudyReach	45468	P_50-yr	3352	405.32	415.96		415.96	0.000134	1.26	11454.94	4758.53	0.07
StudyReach	45468	P_100-yr	3776	405.32	416.26		416.27	0.00013	1.27	12534.06	4938.94	0.07
StudyReach	45468	P_500-yr	4812	405.32	416.94		416.95	0.000124	1.3	14927.04	5144.73	0.07
StudyReach	44738	E_10-yr	2240	404.2	415.32		415.33	0.000079	1.11	10333.09	5297.63	0.06
StudyReach	44738	E_50-yr	3170	404.2	415.78		415.79	0.000105	1.31	11980.4	5429.21	0.07
StudyReach	44738	E_100-yr	3580	404.2	416.04		416.05	0.000107	1.34	12932.39	5518.91	0.07
StudyReach	44738	E_500-yr	4580	404.2	416.73		416.73	0.000104	1.37	15395.72	5686	0.07

Reach	River Sta	Profile	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
StudyReach	44738	P_10-yr	2386	404.2	415.55		415.55	0.000073	1.08	11143.52	5370.45	0.06
StudyReach	44738	P_50-yr	3352	404.2	415.88		415.89	0.000107	1.33	12338.86	5472.45	0.07
StudyReach	44738	P_100-yr	3776	404.2	416.19		416.19	0.000106	1.34	13449.74	5551.62	0.07
StudyReach	44738	P_500-yr	4812	404.2	416.87		416.87	0.000103	1.38	15912.91	5726.47	0.07
StudyReach	42740	E_10-yr	2240	404.11	415.23		415.24	0.000142	1.34	8314.14	5905.05	0.07
StudyReach	42740	E_50-yr	3170	404.11	415.66		415.67	0.000181	1.56	9841.26	6203.4	0.08
StudyReach	42740	E_100-yr	3580	404.11	415.93		415.94	0.000179	1.57	10795.32	6321.5	0.08
StudyReach	42740	E_500-yr	4580	404.11	416.62		416.63	0.000165	1.57	13350.67	6614.2	0.08
StudyReach	42740	P_10-yr	2386	404.11	415.47		415.47	0.000125	1.28	9138.35	6098.01	0.07
StudyReach	42740	P_50-yr	3352	404.11	415.76		415.77	0.000184	1.58	10190.78	6246.37	0.08
StudyReach	42740	P_100-yr	3776	404.11	416.07		416.08	0.000174	1.57	11327.62	6407.7	0.08
StudyReach	42740	P_500-yr	4812	404.11	416.76		416.77	0.000162	1.57	13893.66	6658.18	0.08
StudyReach	42182	E_10-yr	2240	405.3	414.81	410.95	414.85	0.000516	2.35	3923.97	6362.31	0.15
StudyReach	42182	E_50-yr	3170	405.3	415.11	411.54	415.16	0.000729	2.86	4818.13	6428.28	0.18
StudyReach	42182	E_100-yr	3580	405.3	415.38	411.73	415.43	0.000709	2.89	5667.88	6491.91	0.17
StudyReach	42182	E_500-yr	4580	405.3	416.11	412.15	416.16	0.00066	2.94	7988.06	6531.63	0.17
StudyReach	42182	P_10-yr	2386	405.3	415.11	411.08	415.14	0.00041	2.15	4833.4	6429.7	0.13
StudyReach	42182	P_50-yr	3352	405.3	415.2	411.62	415.25	0.000733	2.89	5098.81	6453.99	0.18
StudyReach	42182	P_100-yr	3776	405.3	415.56	411.82	415.6	0.000645	2.79	6207.17	6501.2	0.17
StudyReach	42182	P_500-yr	4812	405.3	416.28	412.22	416.32	0.000599	2.83	8599.5	6540.18	0.16
StudyReach	42133 AbandonedRR		Bridge									
StudyReach	42078	E_10-yr	2240	403.87	413.48		413.86	0.001789	4.97	469.98	5117.8	0.3
StudyReach	42078	E_50-yr	3170	403.87	414.7		414.9	0.001142	4.33	2554.94	6681.12	0.24
StudyReach	42078	E_100-yr	3580	403.87	415.17		415.26	0.000658	3.39	4037.65	7964.27	0.18
StudyReach	42078	E_500-yr	4580	403.87	416.02		416.05	0.000315	2.47	6850.79	8441.72	0.13
StudyReach	42078	P_10-yr	2386	403.87	413.68		414.09	0.00188	5.18	481.79	5327.26	0.3
StudyReach	42078	P_50-yr	3352	403.87	414.88		415.03	0.000926	3.95	3126.32	7201.65	0.22
StudyReach	42078	P_100-yr	3776	403.87	415.39		415.46	0.000511	3.03	4770.35	8140.59	0.16
StudyReach	42078	P_500-yr	4812	403.87	416.2		416.23	0.000273	2.33	7589.62	8456.55	0.12
StudyReach	41637	E_10-yr	2240	403.4	413.31		413.43	0.000312	3.25	1419.05	2339.95	0.2
StudyReach	41637	E_50-yr	3170	403.4	414.45		414.6	0.00034	3.71	2340.78	3324.62	0.22
StudyReach	41637	E_100-yr	3580	403.4	414.89		415.03	0.000315	3.69	2894.04	3634.57	0.21
StudyReach	41637	E_500-yr	4580	403.4	415.74		415.87	0.000298	3.8	4050.61	4215.99	0.21
StudyReach	41637	P_10-yr	2386	403.4	413.52		413.64	0.000311	3.3	1540.95	2452.83	0.2

Reach	River Sta	Profile	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
StudyReach	41637	P_50-yr	3352	403.4	414.63		414.77	0.000334	3.73	2561.5	3433.79	0.22
StudyReach	41637	P_100-yr	3776	403.4	415.09		415.24	0.000326	3.81	3153.3	3807.78	0.22
StudyReach	41637	P_500-yr	4812	403.4	415.94		416.06	0.000287	3.78	4333.42	4414.04	0.21
StudyReach	41168	E_10-yr	2240	402.91	413.14		413.28	0.000265	3.36	1534.19	1464.09	0.19
StudyReach	41168	E_50-yr	3170	402.91	414.3		414.44	0.000269	3.65	2960.28	3082.55	0.2
StudyReach	41168	E_100-yr	3580	402.91	414.75		414.88	0.000252	3.64	3992.72	3889.9	0.19
StudyReach	41168	E_500-yr	4580	402.91	415.65		415.73	0.000182	3.26	6700.11	4801.47	0.17
StudyReach	41168	P_10-yr	2386	402.91	413.36		413.49	0.000264	3.4	1707.58	1680.41	0.19
StudyReach	41168	P_50-yr	3352	402.91	414.48		414.62	0.000257	3.62	3353.05	3425.2	0.2
StudyReach	41168	P_100-yr	3776	402.91	414.96		415.08	0.000238	3.58	4571.87	4254.03	0.19
StudyReach	41168	P_500-yr	4812	402.91	415.86		415.93	0.000167	3.16	7367.45	4923.32	0.16
StudyReach	41087	E_10-yr	2240	402.83	412.99		413.24	0.000542	4.6	1299.59	1478.29	0.27
StudyReach	41087	E_50-yr	3170	402.83	414.22		414.41	0.000428	4.43	3114.8	3432.7	0.25
StudyReach	41087	E_100-yr	3580	402.83	414.74		414.86	0.000316	3.93	4550.59	4131.19	0.21
StudyReach	41087	E_500-yr	4580	402.83	415.65		415.71	0.000192	3.24	7533.95	4854.52	0.17
StudyReach	41087	P_10-yr	2386	402.83	413.22		413.46	0.000518	4.55	1525.08	1628.59	0.27
StudyReach	41087	P_50-yr	3352	402.83	414.44		414.59	0.000379	4.23	3675.57	3705.86	0.23
StudyReach	41087	P_100-yr	3776	402.83	414.96		415.06	0.000273	3.71	5237.01	4282.71	0.2
StudyReach	41087	P_500-yr	4812	402.83	415.86		415.91	0.000169	3.08	8244.86	4967.17	0.16
StudyReach	40719	E_10-yr	2240	402.51	412.97		413.08	0.000231	3.23	1782.62	1790.45	0.18
StudyReach	40719	E_50-yr	3170	402.51	414.19		414.28	0.000197	3.23	3654.64	3981.54	0.17
StudyReach	40719	E_100-yr	3580	402.51	414.7		414.77	0.000168	3.07	5026.44	4818.25	0.16
StudyReach	40719	E_500-yr	4580	402.51	415.6		415.65	0.000141	2.96	7960.32	5693.43	0.15
StudyReach	40719	P_10-yr	2386	402.51	413.19		413.3	0.000229	3.27	2000.52	2216.07	0.18
StudyReach	40719	P_50-yr	3352	402.51	414.4		414.48	0.000188	3.19	4182.63	4466.8	0.17
StudyReach	40719	P_100-yr	3776	402.51	414.92		414.98	0.000154	2.97	5691.5	5106.02	0.15
StudyReach	40719	P_500-yr	4812	402.51	415.81		415.86	0.000127	2.84	8687.37	5847.47	0.14
StudyReach	40223	E_10-yr	2240	402.08	412.75	406.55	412.94	0.000387	3.78	967.9	3144.82	0.23
StudyReach	40223	E_50-yr	3170	402.08	413.93	407.68	414.14	0.000409	4.23	1796.28	4927.57	0.24
StudyReach	40223	E_100-yr	3580	402.08	414.45	408.15	414.64	0.000372	4.17	2469.02	5673.25	0.23
StudyReach	40223	E_500-yr	4580	402.08	415.41	409.56	415.55	0.000296	3.95	3919.11	6402.62	0.21
StudyReach	40223	P_10-yr	2386	402.08	412.96	406.73	413.16	0.000392	3.87	1070.46	3456.39	0.23
StudyReach	40223	P_50-yr	3352	402.08	414.13	407.9	414.35	0.000402	4.25	2041.43	5121.35	0.23
StudyReach	40223	P_100-yr	3776	402.08	414.69	408.35	414.86	0.000347	4.09	2812.72	5956.33	0.22
StudyReach	40223	P_500-yr	4812	402.08	415.64	409.87	415.77	0.000277	3.87	4267.94	6546.37	0.2

Reach	River Sta	Profile	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
StudyReach	40143	NYS Rt 290	Bridge									
StudyReach	40092	E_10-yr	2240	402.06	412.37		412.6	0.000765	3.94	764.46	2435.22	0.24
StudyReach	40092	E_50-yr	3170	402.06	413.44		413.72	0.000864	4.54	1420.68	5480.92	0.26
StudyReach	40092	E_100-yr	3580	402.06	413.9		414.16	0.00082	4.56	1910.35	5986.71	0.26
StudyReach	40092	E_500-yr	4580	402.06	415.08		415.26	0.000574	4.12	3271.56	6553.31	0.22
StudyReach	40092	P_10-yr	2386	402.06	412.56		412.8	0.000794	4.08	831.98	3050.02	0.25
StudyReach	40092	P_50-yr	3352	402.06	413.64		413.92	0.000868	4.61	1632.74	5734.39	0.26
StudyReach	40092	P_100-yr	3776	402.06	414.12		414.37	0.000773	4.5	2157.56	6115.01	0.25
StudyReach	40092	P_500-yr	4812	402.06	415.37		415.52	0.000524	4	3610.57	6595.67	0.21
StudyReach	39352	E_10-yr	2240	403.23	412.03		412.1	0.000459	2.95	2582.37	1791.93	0.18
StudyReach	39352	E_50-yr	3170	403.23	413.19		413.24	0.00033	2.74	4176.49	3426.23	0.16
StudyReach	39352	E_100-yr	3580	403.23	413.69		413.73	0.000277	2.6	5013.94	4014.73	0.15
StudyReach	39352	E_500-yr	4580	403.23	414.94		414.97	0.000187	2.32	7248.69	5090.76	0.12
StudyReach	39352	P_10-yr	2386	403.23	412.24		412.31	0.000429	2.9	2840.11	1929.91	0.18
StudyReach	39352	P_50-yr	3352	403.23	413.41		413.46	0.000306	2.68	4538.86	3681.8	0.15
StudyReach	39352	P_100-yr	3776	403.23	413.93		413.97	0.000255	2.53	5434.12	4299.4	0.14
StudyReach	39352	P_500-yr	4812	403.23	415.24		415.26	0.000168	2.24	7803.87	5572.35	0.12
StudyReach	38871	E_10-yr	2240	404	411.74		411.83	0.000695	3.33	2039.29	3259.33	0.23
StudyReach	38871	E_50-yr	3170	404	412.99		413.05	0.000469	3.06	3122.36	3849.81	0.19
StudyReach	38871	E_100-yr	3580	404	413.51		413.56	0.000407	2.98	3577.26	4261.76	0.18
StudyReach	38871	E_500-yr	4580	404	414.8		414.85	0.000297	2.79	4705.95	4955.93	0.16
StudyReach	38871	P_10-yr	2386	404	411.97		412.05	0.000628	3.24	2240.67	3305.61	0.22
StudyReach	38871	P_50-yr	3352	404	413.22		413.27	0.00044	3.02	3323.39	4017.78	0.19
StudyReach	38871	P_100-yr	3776	404	413.76		413.81	0.000381	2.94	3797.11	4348.57	0.17
StudyReach	38871	P_500-yr	4812	404	415.11		415.15	0.000278	2.76	4971.95	5231.83	0.15
StudyReach	38170	E_10-yr	2240	402.39	410.84	406.9	411.04	0.001967	3.96	806.43	2606.19	0.26
StudyReach	38170	E_50-yr	3170	402.39	412.24	408.57	412.45	0.001813	4.28	1102.56	3427.04	0.26
StudyReach	38170	E_100-yr	3580	402.39	412.81	408.93	413.03	0.00173	4.36	1240.04	3734.36	0.25
StudyReach	38170	E_500-yr	4580	402.39	414.21	409.54	414.43	0.001497	4.46	1577.31	4132.19	0.24
StudyReach	38170	P_10-yr	2386	402.39	411.13	407.08	411.33	0.00188	3.98	861.84	2778.35	0.26
StudyReach	38170	P_50-yr	3352	402.39	412.49	408.72	412.7	0.001779	4.32	1163.32	3512.85	0.26
StudyReach	38170	P_100-yr	3776	402.39	413.08	409.04	413.3	0.001685	4.39	1306.32	3794.55	0.25
StudyReach	38170	P_500-yr	4812	402.39	414.54	409.66	414.75	0.001445	4.47	1655.81	4367.12	0.24

Reach	River Sta	Profile	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
StudyReach	37849 CSX RR Bridge		Culvert									
StudyReach	37523	E_10-yr	2240	401.98	410.24		410.72	0.005664	5.56	434.63	1553.63	0.36
StudyReach	37523	E_50-yr	3170	401.98	411		411.73	0.007824	6.97	540.7	2047.44	0.43
StudyReach	37523	E_100-yr	3580	401.98	411.29		412.1	0.008545	7.45	596.17	2392.68	0.45
StudyReach	37523	E_500-yr	4580	401.98	411.92		412.91	0.009903	8.41	724.85	3806.56	0.49
StudyReach	37523	P_10-yr	2386	401.98	410.41		410.92	0.005912	5.77	456.53	1616.94	0.37
StudyReach	37523	P_50-yr	3352	401.98	411.13		411.9	0.008167	7.2	564.85	2181.08	0.44
StudyReach	37523	P_100-yr	3776	401.98	411.42		412.27	0.00883	7.66	623.11	2578.95	0.46
StudyReach	37523	P_500-yr	4812	401.98	412.05		413.08	0.010199	8.62	751.7	4123.14	0.5
StudyReach	37350	E_10-yr	2240	401.85	409.85		409.92	0.001896	2.9	1277.09	2166.62	0.21
StudyReach	37350	E_50-yr	3170	401.85	410.61		410.7	0.002101	3.2	1596.74	2744.34	0.22
StudyReach	37350	E_100-yr	3580	401.85	410.9		411	0.002162	3.34	1723.19	2987.83	0.22
StudyReach	37350	E_500-yr	4580	401.85	411.54		411.66	0.002338	3.69	2008.3	3371.67	0.24
StudyReach	37350	P_10-yr	2386	401.85	410.03		410.11	0.001853	2.9	1353.23	2338.04	0.2
StudyReach	37350	P_50-yr	3352	401.85	410.74		410.83	0.00213	3.27	1652.72	2859.87	0.22
StudyReach	37350	P_100-yr	3776	401.85	411.04		411.14	0.002181	3.4	1784.64	3106.54	0.23
StudyReach	37350	P_500-yr	4812	401.85	411.67		411.79	0.002365	3.75	2068.27	3408.58	0.24
StudyReach	36187	E_10-yr	2240	401.07	409.29		409.3	0.000327	1.27	3911.93	2571.89	0.08
StudyReach	36187	E_50-yr	3170	401.07	410.11		410.12	0.000281	1.26	5434.79	3019.96	0.08
StudyReach	36187	E_100-yr	3580	401.07	410.43		410.44	0.000266	1.26	6048.79	3042.78	0.08
StudyReach	36187	E_500-yr	4580	401.07	411.1		411.1	0.000247	1.28	7356.84	3064.74	0.08
StudyReach	36187	P_10-yr	2386	401.07	409.53		409.54	0.000287	1.21	4322.84	2865.66	0.08
StudyReach	36187	P_50-yr	3352	401.07	410.25		410.26	0.000274	1.26	5707.11	3030.66	0.08
StudyReach	36187	P_100-yr	3776	401.07	410.58		410.59	0.000259	1.26	6343.94	3052.21	0.08
StudyReach	36187	P_500-yr	4812	401.07	411.23		411.24	0.000244	1.29	7625.99	3067.07	0.08
StudyReach	35044	E_10-yr	2240	400.56	409.09	406.04	409.1	0.000247	1.17	4227.57	1775.86	0.07
StudyReach	35044	E_50-yr	3170	400.56	409.94	406.27	409.94	0.000254	1.27	5850.99	2556.58	0.07
StudyReach	35044	E_100-yr	3580	400.56	410.26	406.75	410.27	0.000236	1.25	6597.11	2655.27	0.07
StudyReach	35044	E_500-yr	4580	400.56	410.95	406.96	410.96	0.000211	1.24	8181.87	2818.95	0.07
StudyReach	35044	P_10-yr	2386	400.56	409.36	406.11	409.37	0.000221	1.13	4667.69	2021.74	0.07
StudyReach	35044	P_50-yr	3352	400.56	410.08	406.63	410.09	0.000247	1.26	6180.99	2589.96	0.07
StudyReach	35044	P_100-yr	3776	400.56	410.42	406.76	410.43	0.000227	1.24	6956.51	2689.75	0.07
StudyReach	35044	P_500-yr	4812	400.56	411.09	406.97	411.09	0.000208	1.24	8507.59	2848.69	0.07

Plan: Alternative 1-2

Flows: Current and Projected Future

Reach	River Sta	Profile	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
StudyReach	49846	E_10-yr	2240	411	419.83		419.87	0.000395	2.37	3104.4	1651.25	0.15
StudyReach	49846	E_50-yr	3170	411	421.04		421.07	0.00028	2.2	4730.61	1958.81	0.13
StudyReach	49846	E_100-yr	3580	411	421.54		421.57	0.000248	2.15	5415.23	1983.17	0.12
StudyReach	49846	E_500-yr	4580	411	422.69		422.72	0.000199	2.08	7003.79	2058.61	0.11
StudyReach	49846	P_10-yr	2386	411	420.02		420.07	0.000372	2.34	3366.29	1695.86	0.15
StudyReach	49846	P_50-yr	3352	411	421.26		421.29	0.000265	2.18	5035.67	1971.66	0.13
StudyReach	49846	P_100-yr	3776	411	421.77		421.8	0.000236	2.13	5735.28	1992.99	0.12
StudyReach	49846	P_500-yr	4812	411	423.3		423.32	0.000158	1.92	7858.78	2148.39	0.1
StudyReach	48971	E_10-yr	2240	411	419.48		419.53	0.000368	2.39	3338.48	1684.56	0.15
StudyReach	48971	E_50-yr	3170	411	420.81		420.84	0.000231	2.11	5253.71	1766.87	0.12
StudyReach	48971	E_100-yr	3580	411	421.34		421.37	0.000202	2.05	6021.97	1777.54	0.12
StudyReach	48971	E_500-yr	4580	411	422.54		422.56	0.000159	1.97	7751.73	1798.57	0.11
StudyReach	48971	P_10-yr	2386	411	419.71		419.75	0.000335	2.33	3659.37	1703.13	0.15
StudyReach	48971	P_50-yr	3352	411	421.05		421.07	0.000217	2.08	5597.85	1771.74	0.12
StudyReach	48971	P_100-yr	3776	411	421.59		421.61	0.000191	2.03	6376.08	1781.86	0.11
StudyReach	48971	P_500-yr	4812	411	423.18		423.19	0.000125	1.81	8684.64	1808.82	0.1
StudyReach	48599	E_10-yr	2240	411	419.15		419.31	0.00089	3.66	1435.95	1651.14	0.24
StudyReach	48599	E_50-yr	3170	411	420.56		420.69	0.000662	3.55	2303.87	1709.47	0.21
StudyReach	48599	E_100-yr	3580	411	421.12		421.23	0.000605	3.54	2649.76	1717.58	0.2
StudyReach	48599	E_500-yr	4580	411	422.34		422.45	0.000514	3.54	3427.33	1730.32	0.19
StudyReach	48599	P_10-yr	2386	411	419.39		419.54	0.000841	3.64	1581.88	1684.62	0.23
StudyReach	48599	P_50-yr	3352	411	420.81		420.93	0.000635	3.55	2458.81	1713.12	0.21
StudyReach	48599	P_100-yr	3776	411	421.37		421.48	0.000583	3.53	2809.08	1720.85	0.2
StudyReach	48599	P_500-yr	4812	411	423.02		423.11	0.000412	3.3	3862.03	1734.65	0.17
StudyReach	48408	E_10-yr	2240	411	418.54	415.16	419.02	0.002204	5.61	443.88	1275.2	0.37
StudyReach	48408	E_50-yr	3170	411	419.71	416.15	420.4	0.002612	6.76	546.76	1355.37	0.41
StudyReach	48408	E_100-yr	3580	411	420.17	416.54	420.95	0.00275	7.19	593.09	1407.63	0.43
StudyReach	48408	E_500-yr	4580	411	421.18	417.46	422.16	0.003036	8.13	700.69	1521.79	0.46
StudyReach	48408	P_10-yr	2386	411	418.74	415.32	419.25	0.002269	5.8	460.14	1300.16	0.38
StudyReach	48408	P_50-yr	3352	411	419.92	416.33	420.65	0.002678	6.96	567.25	1368.68	0.42
StudyReach	48408	P_100-yr	3776	411	420.38	416.72	421.2	0.002811	7.39	614.79	1456.15	0.44
StudyReach	48408	P_500-yr	4812	411	421.97	417.66	422.86	0.00252	7.8	789.69	1539.94	0.42
StudyReach	48344	KinneRd	Bridge									

Reach	River Sta	Profile	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
StudyReach	48292	E_10-yr	2240	410.95	418.07		418.66	0.003993	6.19	397.41	425.12	0.44
StudyReach	48292	E_50-yr	3170	410.95	419.14		419.97	0.004674	7.44	489.45	604.6	0.49
StudyReach	48292	E_100-yr	3580	410.95	419.56		420.49	0.004897	7.91	530.52	658.09	0.5
StudyReach	48292	E_500-yr	4580	410.95	420.5		421.66	0.005271	8.86	633.51	805.52	0.53
StudyReach	48292	P_10-yr	2386	410.95	418.26		418.88	0.004108	6.4	411.76	458.01	0.45
StudyReach	48292	P_50-yr	3352	410.95	419.33		420.21	0.004777	7.65	507.57	627.59	0.49
StudyReach	48292	P_100-yr	3776	410.95	419.75		420.73	0.004991	8.11	550.45	691.13	0.51
StudyReach	48292	P_500-yr	4812	410.95	421.53		422.49	0.003854	8.16	753.72	952.2	0.46
StudyReach	48183	E_10-yr	2240	410.89	417.87		418.21	0.002581	4.75	501.28	99.18	0.35
StudyReach	48183	E_50-yr	3170	410.89	418.94		419.42	0.002872	5.62	610.59	103.63	0.38
StudyReach	48183	E_100-yr	3580	410.89	419.37		419.91	0.002981	5.96	654.89	105.63	0.39
StudyReach	48183	E_500-yr	4580	410.89	420.33		421	0.003173	6.69	758.5	112.95	0.41
StudyReach	48183	P_10-yr	2386	410.89	418.05		418.42	0.002627	4.89	519.8	99.97	0.36
StudyReach	48183	P_50-yr	3352	410.89	419.13		419.64	0.002922	5.77	630.4	104.49	0.39
StudyReach	48183	P_100-yr	3776	410.89	419.56		420.13	0.003028	6.12	675.59	106.62	0.4
StudyReach	48183	P_500-yr	4812	410.89	421.43		421.99	0.002267	6.15	879.36	134.55	0.36
StudyReach	48143	E_10-yr	2240	410.87	417.71	414.72	418.1	0.002617	5.06	483.25	90.44	0.36
StudyReach	48143	E_50-yr	3170	410.87	418.72	415.56	419.28	0.003112	6.11	576.35	93.53	0.4
StudyReach	48143	E_100-yr	3580	410.87	419.11	415.88	419.75	0.003304	6.52	613.42	94.76	0.42
StudyReach	48143	E_500-yr	4580	410.87	420	416.65	420.83	0.003697	7.43	698.48	97.28	0.45
StudyReach	48143	P_10-yr	2386	410.87	417.89	414.86	418.3	0.002694	5.24	499.3	90.98	0.37
StudyReach	48143	P_50-yr	3352	410.87	418.9	415.7	419.49	0.0032	6.3	592.97	94.08	0.41
StudyReach	48143	P_100-yr	3776	410.87	419.29	416.04	419.97	0.00339	6.71	630.6	95.28	0.43
StudyReach	48143	P_500-yr	4812	410.87	421.17	416.82	421.86	0.002609	6.81	814.45	100.41	0.39
StudyReach	48119 OldErieCanal		Bridge									
StudyReach	48104	E_10-yr	2240	410.8	417.38		417.74	0.002635	4.87	460.72	70.14	0.33
StudyReach	48104	E_50-yr	3170	410.8	418.23		418.81	0.003514	6.1	520.54	70.16	0.39
StudyReach	48104	E_100-yr	3580	410.8	418.54		419.22	0.003899	6.6	542.78	70.17	0.42
StudyReach	48104	E_500-yr	4580	410.8	419.22		420.16	0.004824	7.77	590.36	70.18	0.47
StudyReach	48104	P_10-yr	2386	410.8	417.53		417.93	0.002767	5.07	471.55	70.15	0.34
StudyReach	48104	P_50-yr	3352	410.8	418.37		418.99	0.003686	6.32	530.63	70.16	0.41
StudyReach	48104	P_100-yr	3776	410.8	418.69		419.41	0.004082	6.84	552.78	70.17	0.43
StudyReach	48104	P_500-yr	4812	410.8	419.36		420.36	0.005043	8.03	600.11	70.19	0.48
StudyReach	48002	E_10-yr	2240	410.75	417.14		417.46	0.002644	4.58	564.14	1135.18	0.33

Reach	River Sta	Profile	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
StudyReach	48002	E_50-yr	3170	410.75	417.94		418.42	0.003402	5.65	705.72	1234.36	0.38
StudyReach	48002	E_100-yr	3580	410.75	418.24		418.79	0.003677	6.05	767.78	1286.33	0.4
StudyReach	48002	E_500-yr	4580	410.75	418.9		419.6	0.004276	6.92	907.86	1340.69	0.44
StudyReach	48002	P_10-yr	2386	410.75	417.29		417.63	0.002759	4.76	585.94	1147.39	0.34
StudyReach	48002	P_50-yr	3352	410.75	418.08		418.59	0.003527	5.83	733.62	1256.18	0.39
StudyReach	48002	P_100-yr	3776	410.75	418.38		418.95	0.003804	6.23	796.29	1304.37	0.41
StudyReach	48002	P_500-yr	4812	410.75	419.04		419.77	0.004407	7.1	937.33	1342.41	0.45
StudyReach	46915	E_10-yr	2240	407.94	415.9		415.96	0.000775	2.65	2832.44	1147.36	0.18
StudyReach	46915	E_50-yr	3170	407.94	416.49		416.56	0.000904	3.02	3509.85	1164.54	0.19
StudyReach	46915	E_100-yr	3580	407.94	416.76		416.82	0.000924	3.13	3821.35	1227.52	0.2
StudyReach	46915	E_500-yr	4580	407.94	417.38		417.45	0.000941	3.32	4611.68	1327.4	0.2
StudyReach	46915	P_10-yr	2386	407.94	416.08		416.13	0.000741	2.64	3037.6	1153.95	0.17
StudyReach	46915	P_50-yr	3352	407.94	416.6		416.67	0.000923	3.08	3633.67	1173.84	0.2
StudyReach	46915	P_100-yr	3776	407.94	416.88		416.95	0.000931	3.17	3974.5	1250.56	0.2
StudyReach	46915	P_500-yr	4812	407.94	417.52		417.58	0.000944	3.36	4786.76	1354.55	0.2
StudyReach	46367	E_10-yr	2240	406.52	415.52		415.58	0.000646	2.46	3374.7	4302.01	0.16
StudyReach	46367	E_50-yr	3170	406.52	416.05		416.11	0.000753	2.79	4531.68	5087.1	0.17
StudyReach	46367	E_100-yr	3580	406.52	416.31		416.37	0.000764	2.87	5118.3	5474.75	0.18
StudyReach	46367	E_500-yr	4580	406.52	416.98		417.03	0.000639	2.76	6705.8	5786.18	0.16
StudyReach	46367	P_10-yr	2386	406.52	415.73		415.78	0.000594	2.41	3815.24	4623.55	0.15
StudyReach	46367	P_50-yr	3352	406.52	416.16		416.21	0.000754	2.81	4765.84	5258.35	0.18
StudyReach	46367	P_100-yr	3776	406.52	416.44		416.5	0.000736	2.84	5428.67	5598.62	0.17
StudyReach	46367	P_500-yr	4812	406.52	417.12		417.16	0.000621	2.75	7046.56	5812.08	0.16
StudyReach	45468	E_10-yr	2240	405.32	415.36		415.37	0.000108	1.08	9359.93	4479.06	0.07
StudyReach	45468	E_50-yr	3170	405.32	415.85		415.86	0.000132	1.24	11084.36	4681.64	0.07
StudyReach	45468	E_100-yr	3580	405.32	416.11		416.11	0.000134	1.27	11977.23	4871.76	0.07
StudyReach	45468	E_500-yr	4580	405.32	416.79		416.8	0.000126	1.29	14391	5107.65	0.07
StudyReach	45468	P_10-yr	2386	405.32	415.58		415.59	0.000097	1.05	10131.69	4562.59	0.06
StudyReach	45468	P_50-yr	3352	405.32	415.95		415.96	0.000135	1.26	11434.97	4751.89	0.07
StudyReach	45468	P_100-yr	3776	405.32	416.24		416.25	0.000132	1.28	12458.82	4925.31	0.07
StudyReach	45468	P_500-yr	4812	405.32	416.93		416.94	0.000125	1.3	14889.77	5142.49	0.07
StudyReach	44738	E_10-yr	2240	404.2	415.3		415.31	0.000081	1.12	10260.49	5284.63	0.06
StudyReach	44738	E_50-yr	3170	404.2	415.78		415.78	0.000105	1.31	11964.82	5427.67	0.07
StudyReach	44738	E_100-yr	3580	404.2	416.03		416.03	0.000108	1.35	12872.4	5514.28	0.07
StudyReach	44738	E_500-yr	4580	404.2	416.72		416.72	0.000104	1.37	15359.72	5683.48	0.07

Reach	River Sta	Profile	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
StudyReach	44738	P_10-yr	2386	404.2	415.53		415.53	0.000075	1.09	11067.71	5367.06	0.06
StudyReach	44738	P_50-yr	3352	404.2	415.87		415.88	0.000108	1.33	12317.03	5469.68	0.07
StudyReach	44738	P_100-yr	3776	404.2	416.17		416.17	0.000108	1.35	13367.69	5546.45	0.07
StudyReach	44738	P_500-yr	4812	404.2	416.86		416.86	0.000104	1.38	15872.55	5723.15	0.07
StudyReach	42740	E_10-yr	2240	404.11	415.21		415.22	0.000145	1.36	8236.65	5887.58	0.07
StudyReach	42740	E_50-yr	3170	404.11	415.66		415.67	0.000182	1.56	9823.92	6201.3	0.08
StudyReach	42740	E_100-yr	3580	404.11	415.91		415.92	0.000182	1.59	10728.11	6311.61	0.08
StudyReach	42740	E_500-yr	4580	404.11	416.61		416.61	0.000166	1.58	13309.76	6610.89	0.08
StudyReach	42740	P_10-yr	2386	404.11	415.44		415.45	0.000128	1.29	9057.25	6086.8	0.07
StudyReach	42740	P_50-yr	3352	404.11	415.75		415.76	0.000185	1.58	10166.22	6243.23	0.08
StudyReach	42740	P_100-yr	3776	404.11	416.05		416.06	0.000178	1.58	11235.55	6392.55	0.08
StudyReach	42740	P_500-yr	4812	404.11	416.75		416.76	0.000164	1.58	13847.92	6654.48	0.08
StudyReach	42182	E_10-yr	2240	405.3	414.78	410.95	414.82	0.000539	2.4	3814.8	6357.13	0.15
StudyReach	42182	E_50-yr	3170	405.3	415.1	411.54	415.15	0.000736	2.88	4791.21	6425.8	0.18
StudyReach	42182	E_100-yr	3580	405.3	415.36	411.73	415.41	0.000696	2.85	5607.56	6490.25	0.17
StudyReach	42182	E_500-yr	4580	405.3	416.09	412.15	416.14	0.000675	2.97	7922.52	6530.71	0.17
StudyReach	42182	P_10-yr	2386	405.3	415.08	411.08	415.11	0.000427	2.19	4729.82	6420.12	0.13
StudyReach	42182	P_50-yr	3352	405.3	415.19	411.62	415.24	0.000743	2.91	5060.65	6450.63	0.18
StudyReach	42182	P_100-yr	3776	405.3	415.51	411.82	415.56	0.000677	2.85	6072.47	6498.74	0.17
StudyReach	42182	P_500-yr	4812	405.3	416.26	412.22	416.3	0.000612	2.86	8530.19	6539.21	0.16
StudyReach	42133 AbandonedRR		Bridge									
StudyReach	42078	E_10-yr	2240	403.87	413.43		413.81	0.001828	5.01	466.71	5064.99	0.3
StudyReach	42078	E_50-yr	3170	403.87	414.65		414.87	0.001231	4.48	2420.4	6534.09	0.25
StudyReach	42078	E_100-yr	3580	403.87	415.14		415.23	0.000692	3.47	3939.52	7930.04	0.19
StudyReach	42078	E_500-yr	4580	403.87	416		416.03	0.000322	2.5	6768.79	8439.97	0.13
StudyReach	42078	P_10-yr	2386	403.87	413.63		414.04	0.001918	5.21	478.65	5274.8	0.31
StudyReach	42078	P_50-yr	3352	403.87	414.84		415	0.000985	4.06	3015.55	7096.18	0.22
StudyReach	42078	P_100-yr	3776	403.87	415.33		415.4	0.000561	3.16	4575	8104.39	0.17
StudyReach	42078	P_500-yr	4812	403.87	416.18		416.21	0.000281	2.36	7502.56	8454.93	0.12
StudyReach	41637	E_10-yr	2240	403.4	413.24		413.37	0.000325	3.3	1384.44	2298.61	0.21
StudyReach	41637	E_50-yr	3170	403.4	414.4		414.55	0.000346	3.74	2288.79	3231.75	0.22
StudyReach	41637	E_100-yr	3580	403.4	414.86		415	0.000323	3.73	2849.47	3608.05	0.21
StudyReach	41637	E_500-yr	4580	403.4	415.72		415.85	0.000303	3.83	4013.55	4188.19	0.21
StudyReach	41637	P_10-yr	2386	403.4	413.45		413.59	0.000323	3.35	1502.77	2424.77	0.21

Reach	River Sta	Profile	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
StudyReach	41637	P_50-yr	3352	403.4	414.58		414.74	0.000344	3.78	2510.46	3407.39	0.22
StudyReach	41637	P_100-yr	3776	403.4	415.04		415.18	0.00032	3.76	3088.19	3771.18	0.21
StudyReach	41637	P_500-yr	4812	403.4	415.92		416.04	0.000292	3.81	4294.66	4395.57	0.21
StudyReach	41168	E_10-yr	2240	402.91	413.07		413.22	0.000277	3.41	1479	1363.72	0.2
StudyReach	41168	E_50-yr	3170	402.91	414.25		414.39	0.000278	3.7	2864.63	2989.5	0.2
StudyReach	41168	E_100-yr	3580	402.91	414.71		414.85	0.000261	3.7	3888.85	3792.59	0.2
StudyReach	41168	E_500-yr	4580	402.91	415.62		415.7	0.000187	3.3	6606.98	4776.85	0.17
StudyReach	41168	P_10-yr	2386	402.91	413.28		413.43	0.000276	3.45	1646.95	1619.35	0.2
StudyReach	41168	P_50-yr	3352	402.91	414.44		414.58	0.000268	3.68	3248.86	3342.42	0.2
StudyReach	41168	P_100-yr	3776	402.91	414.9		415.03	0.000252	3.67	4403.58	4139.95	0.19
StudyReach	41168	P_500-yr	4812	402.91	415.83		415.9	0.000172	3.2	7271.45	4906.74	0.16
StudyReach	41087	E_10-yr	2240	402.83	412.9		413.17	0.00058	4.74	1216.9	1411.83	0.28
StudyReach	41087	E_50-yr	3170	402.83	414.16		414.36	0.00045	4.53	2976.68	3281.33	0.25
StudyReach	41087	E_100-yr	3580	402.83	414.69		414.82	0.000329	4.01	4422.5	4087.65	0.22
StudyReach	41087	E_500-yr	4580	402.83	415.62		415.68	0.000198	3.29	7434.7	4827.85	0.17
StudyReach	41087	P_10-yr	2386	402.83	413.13		413.39	0.000552	4.67	1439.3	1576.14	0.27
StudyReach	41087	P_50-yr	3352	402.83	414.38		414.55	0.000404	4.35	3522.24	3633.02	0.24
StudyReach	41087	P_100-yr	3776	402.83	414.9		415	0.000291	3.81	5048.62	4236.33	0.2
StudyReach	41087	P_500-yr	4812	402.83	415.83		415.88	0.000175	3.13	8143.63	4955.49	0.16
StudyReach	40719	E_10-yr	2240	402.51	412.88		413	0.000244	3.31	1706.98	1711.09	0.19
StudyReach	40719	E_50-yr	3170	402.51	414.14		414.23	0.000206	3.29	3520.81	3853.2	0.17
StudyReach	40719	E_100-yr	3580	402.51	414.65		414.73	0.000175	3.12	4899.21	4787.3	0.16
StudyReach	40719	E_500-yr	4580	402.51	415.57		415.62	0.000145	3	7856.15	5672.13	0.15
StudyReach	40719	P_10-yr	2386	402.51	413.11		413.23	0.000241	3.34	1912.84	2049.94	0.19
StudyReach	40719	P_50-yr	3352	402.51	414.34		414.43	0.000196	3.25	4032.76	4394.11	0.17
StudyReach	40719	P_100-yr	3776	402.51	414.85		414.92	0.000163	3.05	5500.28	5014.57	0.16
StudyReach	40719	P_500-yr	4812	402.51	415.78		415.83	0.00013	2.87	8582.12	5824.35	0.14
StudyReach	40223	E_10-yr	2240	402.08	412.65	406.55	412.85	0.000406	3.85	930.92	2974.07	0.23
StudyReach	40223	E_50-yr	3170	402.08	413.86	407.68	414.09	0.000424	4.29	1724.8	4833.65	0.24
StudyReach	40223	E_100-yr	3580	402.08	414.4	408.15	414.6	0.000386	4.24	2394.19	5578.46	0.23
StudyReach	40223	E_500-yr	4580	402.08	415.37	409.56	415.52	0.000304	3.99	3863.65	6381.62	0.21
StudyReach	40223	P_10-yr	2386	402.08	412.87	406.73	413.08	0.000412	3.94	1022.99	3349.62	0.23
StudyReach	40223	P_50-yr	3352	402.08	414.07	407.9	414.29	0.00042	4.33	1959.1	5056.52	0.24
StudyReach	40223	P_100-yr	3776	402.08	414.61	408.35	414.8	0.000367	4.19	2701.87	5887.72	0.23
StudyReach	40223	P_500-yr	4812	402.08	415.6	409.87	415.74	0.000284	3.91	4213.04	6524.76	0.2

Reach	River Sta	Profile	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
StudyReach	40143	NYS Rt 290	Bridge									
StudyReach	40092	E_10-yr	2240	402.06	412.26		412.49	0.000803	4	729.5	2126.56	0.25
StudyReach	40092	E_50-yr	3170	402.06	413.34		413.64	0.000914	4.64	1323.78	5202.43	0.27
StudyReach	40092	E_100-yr	3580	402.06	413.81		414.1	0.000872	4.68	1820.08	5913.1	0.26
StudyReach	40092	E_500-yr	4580	402.06	415.03		415.21	0.000596	4.19	3207.52	6547.41	0.22
StudyReach	40092	P_10-yr	2386	402.06	412.45		412.7	0.000834	4.14	790.62	2684.63	0.25
StudyReach	40092	P_50-yr	3352	402.06	413.55		413.85	0.000928	4.74	1534.95	5655.68	0.27
StudyReach	40092	P_100-yr	3776	402.06	414.05		414.31	0.000818	4.6	2072.88	6061.31	0.26
StudyReach	40092	P_500-yr	4812	402.06	415.32		415.48	0.000541	4.06	3551.62	6586.92	0.21
StudyReach	39352	E_10-yr	2240	403.23	411.94		412	0.000419	2.8	2740.23	1779.91	0.18
StudyReach	39352	E_50-yr	3170	403.23	413.12		413.16	0.000301	2.6	4331.26	3293.16	0.15
StudyReach	39352	E_100-yr	3580	403.23	413.63		413.66	0.000255	2.48	5178.43	3872.08	0.14
StudyReach	39352	E_500-yr	4580	403.23	414.9		414.92	0.000174	2.23	7441.56	4975.13	0.12
StudyReach	39352	P_10-yr	2386	403.23	412.15		412.21	0.000388	2.74	3001.78	1881.85	0.17
StudyReach	39352	P_50-yr	3352	403.23	413.35		413.38	0.00028	2.55	4697.05	3608.43	0.15
StudyReach	39352	P_100-yr	3776	403.23	413.87		413.91	0.000234	2.42	5605.37	4260.7	0.14
StudyReach	39352	P_500-yr	4812	403.23	415.2		415.22	0.000157	2.15	8003.1	5524.48	0.11
StudyReach	38871	E_10-yr	2240	404	411.68		411.75	0.000597	3.06	2241.79	3256.73	0.21
StudyReach	38871	E_50-yr	3170	404	412.94		412.99	0.000402	2.81	3336.36	3804.31	0.18
StudyReach	38871	E_100-yr	3580	404	413.47		413.51	0.000352	2.75	3796.31	4236.23	0.17
StudyReach	38871	E_500-yr	4580	404	414.78		414.81	0.000262	2.61	4935.13	4944.88	0.15
StudyReach	38871	P_10-yr	2386	404	411.92		411.98	0.000538	2.97	2447.9	3310.66	0.2
StudyReach	38871	P_50-yr	3352	404	413.17		413.22	0.000379	2.79	3539.7	3975.27	0.17
StudyReach	38871	P_100-yr	3776	404	413.72		413.77	0.000331	2.72	4018.44	4344.63	0.16
StudyReach	38871	P_500-yr	4812	404	415.08		415.12	0.000246	2.58	5202.96	5196.57	0.14
StudyReach	38170	E_10-yr	2240	402.39	410.84	406.9	411.04	0.001967	3.96	806.43	2606.19	0.26
StudyReach	38170	E_50-yr	3170	402.39	412.24	408.57	412.45	0.001813	4.28	1102.56	3427.04	0.26
StudyReach	38170	E_100-yr	3580	402.39	412.81	408.93	413.03	0.00173	4.36	1240.04	3734.36	0.25
StudyReach	38170	E_500-yr	4580	402.39	414.21	409.54	414.43	0.001497	4.46	1577.31	4132.19	0.24
StudyReach	38170	P_10-yr	2386	402.39	411.13	407.08	411.33	0.00188	3.98	861.84	2778.35	0.26
StudyReach	38170	P_50-yr	3352	402.39	412.49	408.72	412.7	0.001779	4.32	1163.32	3512.85	0.26
StudyReach	38170	P_100-yr	3776	402.39	413.08	409.04	413.3	0.001685	4.39	1306.32	3794.55	0.25
StudyReach	38170	P_500-yr	4812	402.39	414.54	409.66	414.75	0.001445	4.47	1655.81	4367.12	0.24

Reach	River Sta	Profile	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
StudyReach	37849 CSX RR Bridge		Culvert									
StudyReach	37523	E_10-yr	2240	401.98	410.24		410.72	0.005664	5.56	434.63	1553.63	0.36
StudyReach	37523	E_50-yr	3170	401.98	411		411.73	0.007824	6.97	540.7	2047.44	0.43
StudyReach	37523	E_100-yr	3580	401.98	411.29		412.1	0.008545	7.45	596.17	2392.68	0.45
StudyReach	37523	E_500-yr	4580	401.98	411.92		412.91	0.009903	8.41	724.85	3806.56	0.49
StudyReach	37523	P_10-yr	2386	401.98	410.41		410.92	0.005912	5.77	456.53	1616.94	0.37
StudyReach	37523	P_50-yr	3352	401.98	411.13		411.9	0.008167	7.2	564.85	2181.08	0.44
StudyReach	37523	P_100-yr	3776	401.98	411.42		412.27	0.00883	7.66	623.11	2578.95	0.46
StudyReach	37523	P_500-yr	4812	401.98	412.05		413.08	0.010199	8.62	751.7	4123.14	0.5
StudyReach	37350	E_10-yr	2240	401.85	409.85		409.92	0.001896	2.9	1277.09	2166.62	0.21
StudyReach	37350	E_50-yr	3170	401.85	410.61		410.7	0.002101	3.2	1596.74	2744.34	0.22
StudyReach	37350	E_100-yr	3580	401.85	410.9		411	0.002162	3.34	1723.19	2987.83	0.22
StudyReach	37350	E_500-yr	4580	401.85	411.54		411.66	0.002338	3.69	2008.3	3371.67	0.24
StudyReach	37350	P_10-yr	2386	401.85	410.03		410.11	0.001853	2.9	1353.23	2338.04	0.2
StudyReach	37350	P_50-yr	3352	401.85	410.74		410.83	0.00213	3.27	1652.72	2859.87	0.22
StudyReach	37350	P_100-yr	3776	401.85	411.04		411.14	0.002181	3.4	1784.64	3106.54	0.23
StudyReach	37350	P_500-yr	4812	401.85	411.67		411.79	0.002365	3.75	2068.27	3408.58	0.24
StudyReach	36187	E_10-yr	2240	401.07	409.29		409.3	0.000327	1.27	3911.93	2571.89	0.08
StudyReach	36187	E_50-yr	3170	401.07	410.11		410.12	0.000281	1.26	5434.79	3019.96	0.08
StudyReach	36187	E_100-yr	3580	401.07	410.43		410.44	0.000266	1.26	6048.79	3042.78	0.08
StudyReach	36187	E_500-yr	4580	401.07	411.1		411.1	0.000247	1.28	7356.84	3064.74	0.08
StudyReach	36187	P_10-yr	2386	401.07	409.53		409.54	0.000287	1.21	4322.84	2865.66	0.08
StudyReach	36187	P_50-yr	3352	401.07	410.25		410.26	0.000274	1.26	5707.11	3030.66	0.08
StudyReach	36187	P_100-yr	3776	401.07	410.58		410.59	0.000259	1.26	6343.94	3052.21	0.08
StudyReach	36187	P_500-yr	4812	401.07	411.23		411.24	0.000244	1.29	7625.99	3067.07	0.08
StudyReach	35044	E_10-yr	2240	400.56	409.09	406.04	409.1	0.000247	1.17	4227.57	1775.86	0.07
StudyReach	35044	E_50-yr	3170	400.56	409.94	406.27	409.94	0.000254	1.27	5850.99	2556.58	0.07
StudyReach	35044	E_100-yr	3580	400.56	410.26	406.75	410.27	0.000236	1.25	6597.11	2655.27	0.07
StudyReach	35044	E_500-yr	4580	400.56	410.95	406.96	410.96	0.000211	1.24	8181.87	2818.95	0.07
StudyReach	35044	P_10-yr	2386	400.56	409.36	406.11	409.37	0.000221	1.13	4667.69	2021.74	0.07
StudyReach	35044	P_50-yr	3352	400.56	410.08	406.63	410.09	0.000247	1.26	6180.99	2589.96	0.07
StudyReach	35044	P_100-yr	3776	400.56	410.42	406.76	410.43	0.000227	1.24	6956.51	2689.75	0.07
StudyReach	35044	P_500-yr	4812	400.56	411.09	406.97	411.09	0.000208	1.24	8507.59	2848.69	0.07

Plan: Alternative 1-4

Flows: Current and Projected Future

Reach	River Sta	Profile	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
StudyReach	49846	E_10-yr	2240	411	419.81		419.86	0.0004	2.38	3088.69	1649.49	0.15
StudyReach	49846	E_50-yr	3170	411	421.04		421.08	0.000278	2.19	4741.64	1960.89	0.13
StudyReach	49846	E_100-yr	3580	411	421.55		421.57	0.000247	2.15	5424.64	1983.46	0.12
StudyReach	49846	E_500-yr	4580	411	423.07		423.09	0.000162	1.92	7533.03	2125.9	0.1
StudyReach	49846	P_10-yr	2386	411	420.02		420.06	0.000372	2.34	3363.39	1691	0.15
StudyReach	49846	P_50-yr	3352	411	421.27		421.3	0.000263	2.17	5046.66	1971.99	0.13
StudyReach	49846	P_100-yr	3776	411	421.78		421.81	0.000235	2.13	5743.64	1993.25	0.12
StudyReach	49846	P_500-yr	4812	411	423.3		423.32	0.000158	1.92	7859.42	2148.45	0.1
StudyReach	48971	E_10-yr	2240	411	419.47		419.51	0.000374	2.41	3314.11	1682.67	0.15
StudyReach	48971	E_50-yr	3170	411	420.82		420.85	0.00023	2.1	5267.7	1767.07	0.12
StudyReach	48971	E_100-yr	3580	411	421.35		421.37	0.000201	2.04	6033.46	1777.68	0.12
StudyReach	48971	E_500-yr	4580	411	422.94		422.96	0.000127	1.81	8343.77	1805.29	0.1
StudyReach	48971	P_10-yr	2386	411	419.7		419.75	0.000336	2.33	3655.15	1702.89	0.15
StudyReach	48971	P_50-yr	3352	411	421.06		421.08	0.000216	2.07	5611.54	1771.94	0.12
StudyReach	48971	P_100-yr	3776	411	421.59		421.62	0.00019	2.02	6386.07	1781.98	0.11
StudyReach	48971	P_500-yr	4812	411	423.18		423.19	0.000125	1.81	8685.35	1808.83	0.1
StudyReach	48599	E_10-yr	2240	411	419.13		419.29	0.000906	3.69	1422.38	1648.9	0.24
StudyReach	48599	E_50-yr	3170	411	420.58		420.7	0.000658	3.54	2310.97	1709.64	0.21
StudyReach	48599	E_100-yr	3580	411	421.13		421.24	0.000602	3.53	2655.47	1717.71	0.2
StudyReach	48599	E_500-yr	4580	411	422.78		422.87	0.000416	3.27	3711	1733.35	0.17
StudyReach	48599	P_10-yr	2386	411	419.39		419.54	0.000844	3.64	1579.56	1684.12	0.23
StudyReach	48599	P_50-yr	3352	411	420.82		420.94	0.000631	3.54	2465.67	1713.28	0.21
StudyReach	48599	P_100-yr	3776	411	421.38		421.49	0.00058	3.53	2814.02	1720.94	0.2
StudyReach	48599	P_500-yr	4812	411	423.02		423.11	0.000412	3.3	3862.36	1734.65	0.17
StudyReach	48408	E_10-yr	2240	411	418.51	415.16	418.99	0.002234	5.64	441.64	1269.67	0.37
StudyReach	48408	E_50-yr	3170	411	419.73	416.15	420.42	0.002595	6.75	548.27	1355.82	0.41
StudyReach	48408	E_100-yr	3580	411	420.18	416.54	420.96	0.002736	7.18	594.37	1412.08	0.43
StudyReach	48408	E_500-yr	4580	411	421.79	417.46	422.63	0.002433	7.58	768.95	1535.84	0.42
StudyReach	48408	P_10-yr	2386	411	418.74	415.32	419.25	0.002275	5.81	459.75	1299.89	0.38
StudyReach	48408	P_50-yr	3352	411	419.93	416.33	420.66	0.002662	6.95	568.74	1372.46	0.42
StudyReach	48408	P_100-yr	3776	411	420.39	416.72	421.21	0.002799	7.38	615.92	1456.81	0.43
StudyReach	48408	P_500-yr	4812	411	421.97	417.66	422.86	0.00252	7.8	789.77	1539.96	0.42
StudyReach	48344	KinneRd	Bridge									

Reach	River Sta	Profile	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
StudyReach	48292	E_10-yr	2240	410.95	418.04		418.62	0.004076	6.23	394.49	420.06	0.44
StudyReach	48292	E_50-yr	3170	410.95	419.16		419.99	0.004624	7.42	491.57	607.42	0.48
StudyReach	48292	E_100-yr	3580	410.95	419.57		420.51	0.004855	7.89	532.41	659.6	0.5
StudyReach	48292	E_500-yr	4580	410.95	421.36		422.28	0.003719	7.93	733.97	940.6	0.45
StudyReach	48292	P_10-yr	2386	410.95	418.25		418.87	0.004122	6.41	411.24	456.73	0.45
StudyReach	48292	P_50-yr	3352	410.95	419.35		420.22	0.004728	7.63	509.69	630.66	0.49
StudyReach	48292	P_100-yr	3776	410.95	419.76		420.74	0.004955	8.1	552.17	693.04	0.51
StudyReach	48292	P_500-yr	4812	410.95	421.53		422.49	0.003853	8.16	753.81	952.25	0.46
StudyReach	48183	E_10-yr	2240	410.89	417.82		418.17	0.002652	4.79	496.79	98.96	0.35
StudyReach	48183	E_50-yr	3170	410.89	418.97		419.44	0.002835	5.6	613.26	103.75	0.38
StudyReach	48183	E_100-yr	3580	410.89	419.39		419.92	0.002951	5.94	657.13	105.73	0.39
StudyReach	48183	E_500-yr	4580	410.89	421.26		421.8	0.002183	5.96	861.31	130.39	0.35
StudyReach	48183	P_10-yr	2386	410.89	418.04		418.41	0.002638	4.9	519.03	99.94	0.36
StudyReach	48183	P_50-yr	3352	410.89	419.16		419.66	0.002887	5.75	633.01	104.6	0.38
StudyReach	48183	P_100-yr	3776	410.89	419.58		420.14	0.003002	6.1	677.57	106.72	0.39
StudyReach	48183	P_500-yr	4812	410.89	421.43		421.99	0.002267	6.15	879.45	134.58	0.36
StudyReach	48143	E_10-yr	2240	410.87	417.66	414.72	418.05	0.00269	5.11	478.78	90.29	0.36
StudyReach	48143	E_50-yr	3170	410.87	418.75	415.56	419.31	0.00307	6.09	579.01	93.62	0.4
StudyReach	48143	E_100-yr	3580	410.87	419.14	415.88	419.77	0.003269	6.5	615.66	94.83	0.42
StudyReach	48143	E_500-yr	4580	410.87	421.03	416.65	421.67	0.00249	6.58	799.88	100.01	0.38
StudyReach	48143	P_10-yr	2386	410.87	417.88	414.86	418.29	0.002707	5.24	498.53	90.95	0.37
StudyReach	48143	P_50-yr	3352	410.87	418.93	415.7	419.52	0.003159	6.27	595.57	94.16	0.41
StudyReach	48143	P_100-yr	3776	410.87	419.32	416.04	419.99	0.003359	6.69	632.59	95.34	0.42
StudyReach	48143	P_500-yr	4812	410.87	421.17	416.82	421.86	0.002608	6.81	814.57	100.41	0.39
StudyReach	48119 OldErieCanal		Bridge									
StudyReach	48104	E_10-yr	2240	410.8	417.31		417.69	0.002718	4.91	456.45	70.14	0.34
StudyReach	48104	E_50-yr	3170	410.8	418.27		418.84	0.003455	6.07	523.18	70.16	0.39
StudyReach	48104	E_100-yr	3580	410.8	418.58		419.25	0.003844	6.58	545.09	70.17	0.42
StudyReach	48104	E_500-yr	4580	410.8	419.25		420.18	0.004766	7.74	592.5	70.18	0.47
StudyReach	48104	P_10-yr	2386	410.8	417.52		417.92	0.002781	5.07	470.81	70.15	0.35
StudyReach	48104	P_50-yr	3352	410.8	418.41		419.02	0.003626	6.29	533.26	70.17	0.4
StudyReach	48104	P_100-yr	3776	410.8	418.72		419.44	0.004031	6.81	554.86	70.17	0.43
StudyReach	48104	P_500-yr	4812	410.8	419.39		420.39	0.004987	8	602.1	70.19	0.48
StudyReach	48002	E_10-yr	2240	410.75	417.07		417.4	0.002756	4.64	553.87	1120.32	0.34

Reach	River Sta	Profile	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
StudyReach	48002	E_50-yr	3170	410.75	417.99		418.46	0.003316	5.6	715.05	1247.21	0.38
StudyReach	48002	E_100-yr	3580	410.75	418.29		418.82	0.003598	6	776.25	1295.26	0.4
StudyReach	48002	E_500-yr	4580	410.75	418.94		419.63	0.004192	6.87	916.27	1341.18	0.43
StudyReach	48002	P_10-yr	2386	410.75	417.28		417.62	0.002779	4.77	584.05	1144	0.34
StudyReach	48002	P_50-yr	3352	410.75	418.12		418.62	0.003439	5.78	743.07	1261.21	0.39
StudyReach	48002	P_100-yr	3776	410.75	418.42		418.98	0.00373	6.19	804.07	1306.59	0.4
StudyReach	48002	P_500-yr	4812	410.75	419.08		419.8	0.004327	7.06	945.21	1342.86	0.44
StudyReach	46915	E_10-yr	2240	407.94	415.74		415.79	0.000844	2.72	2645.13	1119.73	0.18
StudyReach	46915	E_50-yr	3170	407.94	416.86		416.91	0.000667	2.68	3948.97	1247.22	0.17
StudyReach	46915	E_100-yr	3580	407.94	417.1		417.15	0.000705	2.81	4249.52	1281.3	0.17
StudyReach	46915	E_500-yr	4580	407.94	417.69		417.75	0.000756	3.05	5025.85	1391.1	0.18
StudyReach	46915	P_10-yr	2386	407.94	415.9		415.97	0.000877	2.82	2835.39	1147.45	0.19
StudyReach	46915	P_50-yr	3352	407.94	416.98		417.03	0.000679	2.73	4096.2	1265.04	0.17
StudyReach	46915	P_100-yr	3776	407.94	417.2		417.25	0.000727	2.88	4378.25	1298.23	0.18
StudyReach	46915	P_500-yr	4812	407.94	417.81		417.86	0.000771	3.1	5183.18	1404.16	0.18
StudyReach	46367	E_10-yr	2240	406.52	415.26		415.33	0.000882	2.81	2238.02	3638.24	0.19
StudyReach	46367	E_50-yr	3170	406.52	416.47		416.53	0.000735	2.85	4067.03	5614.05	0.17
StudyReach	46367	E_100-yr	3580	406.52	416.69		416.75	0.000767	2.96	4447.24	5717.95	0.18
StudyReach	46367	E_500-yr	4580	406.52	417.27		417.34	0.000755	3.07	5497.59	5862.59	0.18
StudyReach	46367	P_10-yr	2386	406.52	415.42		415.49	0.000887	2.86	2416.26	4030.26	0.19
StudyReach	46367	P_50-yr	3352	406.52	416.58		416.65	0.000737	2.88	4263.53	5676.91	0.17
StudyReach	46367	P_100-yr	3776	406.52	416.78		416.85	0.000786	3.02	4605.65	5746.71	0.18
StudyReach	46367	P_500-yr	4812	406.52	417.38		417.45	0.000763	3.11	5702.61	5903.48	0.18
StudyReach	45468	E_10-yr	2240	405.32	415.03		415.03	0.000157	1.27	8179.66	4365.35	0.08
StudyReach	45468	E_50-yr	3170	405.32	416.34		416.34	0.000086	1.04	12787.84	4984.92	0.06
StudyReach	45468	E_100-yr	3580	405.32	416.55		416.55	0.000093	1.09	13532.88	5034.87	0.06
StudyReach	45468	E_500-yr	4580	405.32	417.12		417.13	0.000099	1.17	15558.59	5182.21	0.06
StudyReach	45468	P_10-yr	2386	405.32	415.2		415.2	0.000146	1.24	8787.61	4433.84	0.08
StudyReach	45468	P_50-yr	3352	405.32	416.45		416.45	0.000088	1.06	13185.04	5016.6	0.06
StudyReach	45468	P_100-yr	3776	405.32	416.63		416.64	0.000096	1.12	13829.28	5050.46	0.06
StudyReach	45468	P_500-yr	4812	405.32	417.23		417.23	0.000101	1.2	15929.59	5203.62	0.07
StudyReach	44738	E_10-yr	2240	404.2	414.94		414.95	0.000102	1.22	8985.49	5075.52	0.07
StudyReach	44738	E_50-yr	3170	404.2	416.29		416.29	0.000069	1.09	13803.84	5571.4	0.06
StudyReach	44738	E_100-yr	3580	404.2	416.49		416.5	0.000075	1.15	14552.64	5607.65	0.06
StudyReach	44738	E_500-yr	4580	404.2	417.06		417.07	0.000082	1.24	16616.33	5784.56	0.06

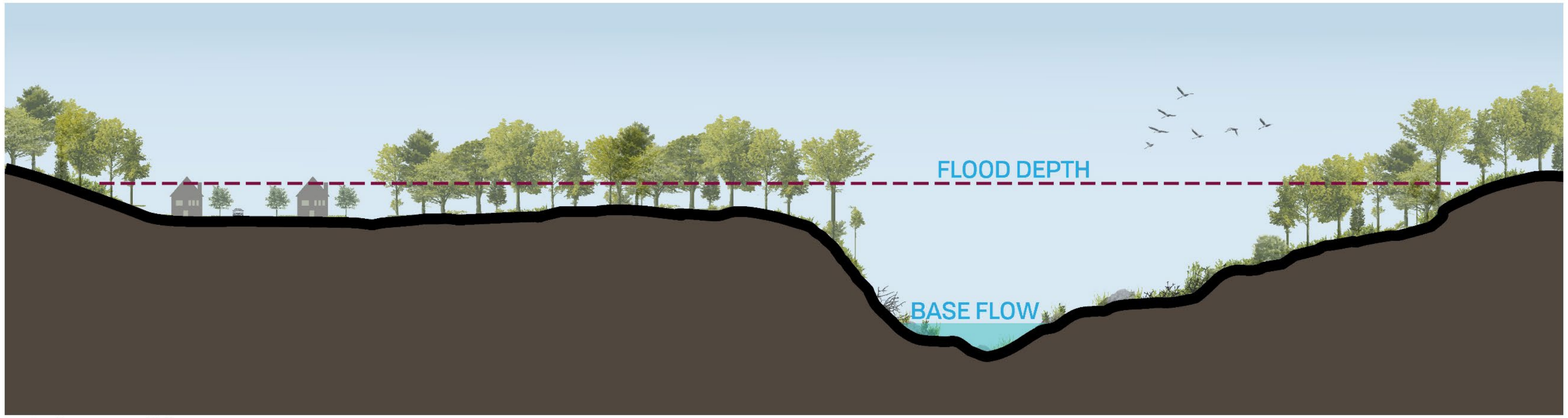
Reach	River Sta	Profile	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
StudyReach	44738	P_10-yr	2386	404.2	415.12		415.12	0.000108	1.27	9602.31	5175.39	0.07
StudyReach	44738	P_50-yr	3352	404.2	416.4		416.4	0.000071	1.11	14206.79	5590.96	0.06
StudyReach	44738	P_100-yr	3776	404.2	416.58		416.58	0.000079	1.18	14847.88	5622.79	0.06
StudyReach	44738	P_500-yr	4812	404.2	417.17		417.17	0.000085	1.27	16991.53	5806.98	0.06
StudyReach	42740	E_10-yr	2240	404.11	414.81		414.82	0.00023	1.67	6892.28	5658.94	0.09
StudyReach	42740	E_50-yr	3170	404.11	416.21		416.22	0.000109	1.25	11841.61	6463.83	0.06
StudyReach	42740	E_100-yr	3580	404.11	416.41		416.42	0.000119	1.32	12587.82	6532.27	0.07
StudyReach	42740	E_500-yr	4580	404.11	416.98		416.99	0.000124	1.39	14718.19	6730.29	0.07
StudyReach	42740	P_10-yr	2386	404.11	414.99		415	0.000212	1.62	7480.29	5709.46	0.09
StudyReach	42740	P_50-yr	3352	404.11	416.32		416.33	0.000112	1.28	12247.46	6495.07	0.07
StudyReach	42740	P_100-yr	3776	404.11	416.49		416.5	0.000124	1.35	12880.75	6575.84	0.07
StudyReach	42740	P_500-yr	4812	404.11	417.08		417.09	0.000127	1.41	15101.46	6741.49	0.07
StudyReach	42182	E_10-yr	2240	405.3	414.19	410.82	414.24	0.000707	2.61	2631.91	6006.36	0.17
StudyReach	42182	E_50-yr	3170	405.3	415.96	411.32	415.97	0.000239	1.75	8033.08	6523.5	0.1
StudyReach	42182	E_100-yr	3580	405.3	416.1	411.5	416.12	0.000341	2.11	8524.11	6531.01	0.12
StudyReach	42182	E_500-yr	4580	405.3	416.67	411.86	416.69	0.000306	2.08	10584.96	6560.24	0.12
StudyReach	42182	P_10-yr	2386	405.3	414.41	410.93	414.46	0.000642	2.53	3261.51	6143.19	0.16
StudyReach	42182	P_50-yr	3352	405.3	416.02	411.4	416.04	0.000326	2.05	8250.14	6526.99	0.12
StudyReach	42182	P_100-yr	3776	405.3	416.17	411.57	416.19	0.000352	2.15	8761.53	6534.33	0.12
StudyReach	42182	P_500-yr	4812	405.3	416.77	411.93	416.79	0.000307	2.1	10932.93	6566.08	0.12
StudyReach	42133 AbandonedRR		Culvert									
StudyReach	42078	E_10-yr	2240	403.87	414.02		414.17	0.000857	3.58	1371.12	5782.65	0.21
StudyReach	42078	E_50-yr	3170	403.87	415.96		415.97	0.000104	1.41	9145.07	8436.57	0.07
StudyReach	42078	E_100-yr	3580	403.87	416.1		416.11	0.000109	1.46	9938.82	8448.92	0.08
StudyReach	42078	E_500-yr	4580	403.87	416.68		416.68	0.000084	1.32	13110.87	8500.09	0.07
StudyReach	42078	P_10-yr	2386	403.87	414.35		414.45	0.00066	3.22	2323.12	6158.84	0.18
StudyReach	42078	P_50-yr	3352	403.87	416.03		416.04	0.000108	1.44	9513.02	8442.5	0.08
StudyReach	42078	P_100-yr	3776	403.87	416.17		416.18	0.000111	1.48	10305.54	8454.17	0.08
StudyReach	42078	P_500-yr	4812	403.87	416.77		416.78	0.000082	1.32	13648.54	8507.19	0.07
StudyReach	41637	E_10-yr	2240	403.4	413.87		413.96	0.00022	2.86	1794.08	2716.42	0.17
StudyReach	41637	E_50-yr	3170	403.4	415.84		415.9	0.000133	2.56	4189.25	4329.32	0.14
StudyReach	41637	E_100-yr	3580	403.4	415.97		416.04	0.000155	2.79	4378.03	4435.03	0.15
StudyReach	41637	E_500-yr	4580	403.4	416.53		416.61	0.000184	3.13	5285.95	5099.53	0.17
StudyReach	41637	P_10-yr	2386	403.4	414.2		414.28	0.000202	2.81	2084.11	2937.33	0.17

Reach	River Sta	Profile	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
StudyReach	41637	P_50-yr	3352	403.4	415.91		415.97	0.000143	2.66	4280.74	4388.93	0.14
StudyReach	41637	P_100-yr	3776	403.4	416.03		416.1	0.000166	2.89	4463.12	4505.6	0.16
StudyReach	41637	P_500-yr	4812	403.4	416.63		416.71	0.000189	3.2	5443.63	5161.34	0.17
StudyReach	41168	E_10-yr	2240	402.91	413.75		413.85	0.000185	2.93	2123.83	2164.09	0.16
StudyReach	41168	E_50-yr	3170	402.91	415.81		415.84	0.000076	2.13	7197.58	4895.09	0.11
StudyReach	41168	E_100-yr	3580	402.91	415.93		415.97	0.000086	2.28	7610.82	4961.87	0.12
StudyReach	41168	E_500-yr	4580	402.91	416.5		416.53	0.000084	2.32	9450.92	5280.96	0.12
StudyReach	41168	P_10-yr	2386	402.91	414.1		414.19	0.000169	2.86	2609.09	2633.14	0.16
StudyReach	41168	P_50-yr	3352	402.91	415.87		415.9	0.00008	2.19	7399.31	4929.09	0.11
StudyReach	41168	P_100-yr	3776	402.91	415.99		416.03	0.000091	2.35	7795.15	4990.26	0.12
StudyReach	41168	P_500-yr	4812	402.91	416.59		416.63	0.000086	2.36	9757.31	5328.97	0.12
StudyReach	41087	E_10-yr	2240	402.83	413.69		413.83	0.000311	3.64	2096.03	2233.3	0.21
StudyReach	41087	E_50-yr	3170	402.83	415.81		415.83	0.000078	2.08	8062.29	4946.29	0.11
StudyReach	41087	E_100-yr	3580	402.83	415.93		415.96	0.000087	2.21	8498.46	4995.69	0.11
StudyReach	41087	E_500-yr	4580	402.83	416.5		416.52	0.000082	2.22	10445.35	5343.19	0.11
StudyReach	41087	P_10-yr	2386	402.83	414.04		414.17	0.000279	3.54	2703.51	2990.4	0.2
StudyReach	41087	P_50-yr	3352	402.83	415.87		415.89	0.000081	2.14	8275.32	4970.72	0.11
StudyReach	41087	P_100-yr	3776	402.83	415.99		416.02	0.000091	2.28	8692.86	5016.85	0.12
StudyReach	41087	P_500-yr	4812	402.83	416.59		416.62	0.000084	2.25	10772.37	5386.78	0.11
StudyReach	40719	E_10-yr	2240	402.51	413.67		413.74	0.000146	2.69	2621.75	2895.32	0.15
StudyReach	40719	E_50-yr	3170	402.51	415.79		415.81	0.000056	1.89	8594.53	5827	0.09
StudyReach	40719	E_100-yr	3580	402.51	415.91		415.93	0.000064	2.03	9023.11	5918.1	0.1
StudyReach	40719	E_500-yr	4580	402.51	416.48		416.5	0.000065	2.09	11000.37	6281.89	0.1
StudyReach	40719	P_10-yr	2386	402.51	414.03		414.08	0.000128	2.57	3276.83	3620.55	0.14
StudyReach	40719	P_50-yr	3352	402.51	415.85		415.87	0.00006	1.95	8804.1	5872.06	0.1
StudyReach	40719	P_100-yr	3776	402.51	415.97		415.99	0.000068	2.09	9214.48	5957.83	0.1
StudyReach	40719	P_500-yr	4812	402.51	416.57		416.59	0.000066	2.13	11331.92	6339.48	0.1
StudyReach	40223	E_10-yr	2240	402.08	413.51	406.55	413.65	0.000255	3.25	1413.2	4277.95	0.19
StudyReach	40223	E_50-yr	3170	402.08	415.71	407.69	415.77	0.000114	2.49	4388.21	6591.48	0.13
StudyReach	40223	E_100-yr	3580	402.08	415.83	408.15	415.89	0.000134	2.72	4561.81	6658.98	0.14
StudyReach	40223	E_500-yr	4580	402.08	416.38	409.56	416.45	0.000152	2.98	5427.11	6846.77	0.15
StudyReach	40223	P_10-yr	2386	402.08	413.87	406.73	414	0.000239	3.22	1737.85	4851.93	0.18
StudyReach	40223	P_50-yr	3352	402.08	415.77	407.9	415.83	0.000122	2.59	4474.58	6624.75	0.13
StudyReach	40223	P_100-yr	3776	402.08	415.87	408.36	415.94	0.000144	2.83	4638.07	6682.86	0.14
StudyReach	40223	P_500-yr	4812	402.08	416.47	409.88	416.54	0.000158	3.06	5566.62	6875.22	0.15

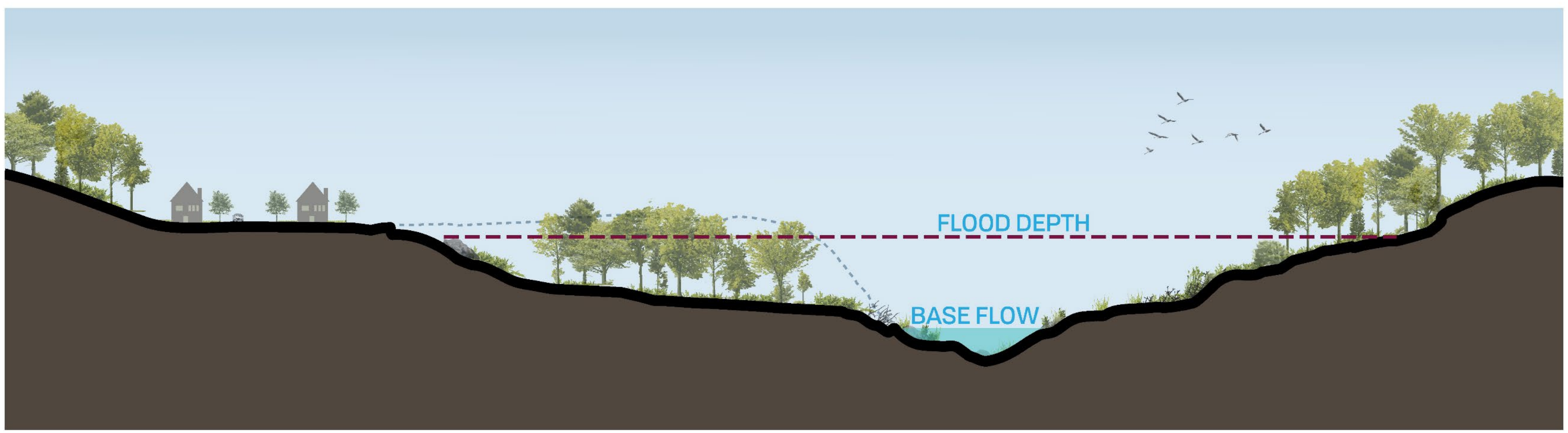
Reach	River Sta	Profile	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
StudyReach	40143	NYS Rt 290	Bridge									
StudyReach	40092	E_10-yr	2240	402.06	413.26		413.42	0.00048	3.34	1246.97	5009.06	0.19
StudyReach	40092	E_50-yr	3170	402.06	415.61		415.67	0.000194	2.47	3912.04	6662.14	0.13
StudyReach	40092	E_100-yr	3580	402.06	415.7		415.77	0.000233	2.72	4020.55	6721.29	0.14
StudyReach	40092	E_500-yr	4580	402.06	416.26		416.33	0.000271	3.03	4703.63	7129.17	0.15
StudyReach	40092	P_10-yr	2386	402.06	413.65		413.79	0.000438	3.28	1639.25	5739.83	0.19
StudyReach	40092	P_50-yr	3352	402.06	415.66		415.72	0.000211	2.58	3963.73	6689.65	0.13
StudyReach	40092	P_100-yr	3776	402.06	415.74		415.82	0.000253	2.84	4071.41	6745.11	0.15
StudyReach	40092	P_500-yr	4812	402.06	416.34		416.42	0.000284	3.11	4809.92	7167.16	0.16
StudyReach	39352	E_10-yr	2240	403.23	413.13		413.16	0.000174	1.98	4077.35	3309.6	0.12
StudyReach	39352	E_50-yr	3170	403.23	415.57		415.58	0.000059	1.35	8427.23	5864.44	0.07
StudyReach	39352	E_100-yr	3580	403.23	415.65		415.66	0.000071	1.49	8573.78	5925.84	0.08
StudyReach	39352	E_500-yr	4580	403.23	416.19		416.2	0.000086	1.69	9601.19	6410.69	0.09
StudyReach	39352	P_10-yr	2386	403.23	413.54		413.56	0.000139	1.82	4761.04	3808.47	0.1
StudyReach	39352	P_50-yr	3352	403.23	415.61		415.62	0.000064	1.41	8498.05	5889.66	0.07
StudyReach	39352	P_100-yr	3776	403.23	415.68		415.69	0.000078	1.56	8641.96	5945	0.08
StudyReach	39352	P_500-yr	4812	403.23	416.27		416.28	0.00009	1.74	9758.15	6450.72	0.09
StudyReach	38871	E_10-yr	2240	404	413.03		413.06	0.000226	2.13	3161.25	3898.12	0.13
StudyReach	38871	E_50-yr	3170	404	415.52		415.54	0.000097	1.68	5333.23	5638.84	0.09
StudyReach	38871	E_100-yr	3580	404	415.59		415.61	0.00012	1.87	5391.97	5717.66	0.1
StudyReach	38871	E_500-yr	4580	404	416.12		416.14	0.000153	2.18	5848.6	6232.72	0.12
StudyReach	38871	P_10-yr	2386	404	413.46		413.48	0.000187	2.01	3534.36	4228.47	0.12
StudyReach	38871	P_50-yr	3352	404	415.56		415.57	0.000107	1.76	5362.12	5681.2	0.1
StudyReach	38871	P_100-yr	3776	404	415.62		415.64	0.000132	1.96	5418.93	5745.82	0.11
StudyReach	38871	P_500-yr	4812	404	416.19		416.22	0.000163	2.26	5915.75	6294.78	0.12
StudyReach	38170	E_10-yr	2240	402.39	412.66	406.9	412.77	0.000841	3.01	1044.68	3631.99	0.18
StudyReach	38170	E_50-yr	3170	402.39	415.29	408.45	415.39	0.00058	2.96	1532.54	4839.53	0.15
StudyReach	38170	E_100-yr	3580	402.39	415.3	408.83	415.43	0.000738	3.34	1534.07	4842.1	0.17
StudyReach	38170	E_500-yr	4580	402.39	415.3	409.49	415.82	0.002364	5.98	1534.31	4842.12	0.31
StudyReach	38170	P_10-yr	2386	402.39	413.13	407.08	413.24	0.000771	2.98	1131.43	3798.72	0.17
StudyReach	38170	P_50-yr	3352	402.39	415.3	408.62	415.41	0.000647	3.13	1534.07	4842.1	0.16
StudyReach	38170	P_100-yr	3776	402.39	415.3	408.95	415.44	0.000821	3.52	1534.07	4842.1	0.18
StudyReach	38170	P_500-yr	4812	402.39	415.3	409.63	415.87	0.002609	6.28	1534.19	4842.11	0.32

Reach	River Sta	Profile	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
StudyReach	37849 CSX RR Bridge		Culvert									
StudyReach	37523	E_10-yr	2240	401.98	410.25		410.72	0.005687	5.58	420.91	1555.04	0.36
StudyReach	37523	E_50-yr	3170	401.98	411		411.75	0.00801	7.05	488.03	2048.72	0.43
StudyReach	37523	E_100-yr	3580	401.98	411.28		412.16	0.009006	7.65	518.51	2383.72	0.46
StudyReach	37523	E_500-yr	4580	401.98	411.88		413.06	0.011264	8.95	589.56	3679.75	0.52
StudyReach	37523	P_10-yr	2386	401.98	410.41		410.93	0.005961	5.79	434.95	1617.97	0.37
StudyReach	37523	P_50-yr	3352	401.98	411.12		411.93	0.008465	7.32	501.15	2178.14	0.45
StudyReach	37523	P_100-yr	3776	401.98	411.41		412.34	0.009448	7.91	533.43	2549.89	0.47
StudyReach	37523	P_500-yr	4812	401.98	412		413.25	0.011806	9.24	604.1	4009.68	0.53
StudyReach	37350	E_10-yr	2240	401.85	409.85		409.93	0.001908	2.91	1265.75	2166.92	0.21
StudyReach	37350	E_50-yr	3170	401.85	410.61		410.7	0.002125	3.22	1575.94	2744.54	0.22
StudyReach	37350	E_100-yr	3580	401.85	410.9		411	0.00219	3.37	1698.15	2987.92	0.23
StudyReach	37350	E_500-yr	4580	401.85	411.54		411.66	0.002377	3.72	1972.79	3371.58	0.24
StudyReach	37350	P_10-yr	2386	401.85	410.03		410.11	0.001868	2.91	1339.8	2338.13	0.2
StudyReach	37350	P_50-yr	3352	401.85	410.74		410.83	0.002155	3.29	1630.08	2859.99	0.22
StudyReach	37350	P_100-yr	3776	401.85	411.04		411.14	0.002211	3.43	1757.43	3106.54	0.23
StudyReach	37350	P_500-yr	4812	401.85	411.67		411.8	0.002404	3.78	2030.36	3408.48	0.24
StudyReach	36187	E_10-yr	2240	401.07	409.29		409.3	0.000327	1.27	3911.93	2571.89	0.08
StudyReach	36187	E_50-yr	3170	401.07	410.11		410.12	0.000281	1.26	5434.79	3019.96	0.08
StudyReach	36187	E_100-yr	3580	401.07	410.43		410.44	0.000266	1.26	6048.79	3042.78	0.08
StudyReach	36187	E_500-yr	4580	401.07	411.1		411.1	0.000247	1.28	7356.84	3064.74	0.08
StudyReach	36187	P_10-yr	2386	401.07	409.53		409.54	0.000287	1.21	4322.84	2865.66	0.08
StudyReach	36187	P_50-yr	3352	401.07	410.25		410.26	0.000274	1.26	5707.11	3030.66	0.08
StudyReach	36187	P_100-yr	3776	401.07	410.58		410.59	0.000259	1.26	6343.94	3052.21	0.08
StudyReach	36187	P_500-yr	4812	401.07	411.23		411.24	0.000244	1.29	7625.99	3067.07	0.08
StudyReach	35044	E_10-yr	2240	400.56	409.09	406.04	409.1	0.000247	1.17	4227.57	1775.86	0.07
StudyReach	35044	E_50-yr	3170	400.56	409.94	406.27	409.94	0.000254	1.27	5850.99	2556.58	0.07
StudyReach	35044	E_100-yr	3580	400.56	410.26	406.75	410.27	0.000236	1.25	6597.11	2655.27	0.07
StudyReach	35044	E_500-yr	4580	400.56	410.95	406.96	410.96	0.000211	1.24	8181.87	2818.95	0.07
StudyReach	35044	P_10-yr	2386	400.56	409.36	406.11	409.37	0.000221	1.13	4667.69	2021.74	0.07
StudyReach	35044	P_50-yr	3352	400.56	410.08	406.63	410.09	0.000247	1.26	6180.99	2589.96	0.07
StudyReach	35044	P_100-yr	3776	400.56	410.42	406.76	410.43	0.000227	1.24	6956.51	2689.75	0.07
StudyReach	35044	P_500-yr	4812	400.56	411.09	406.97	411.09	0.000208	1.24	8507.59	2848.69	0.07

Appendix F. Mitigation Renderings

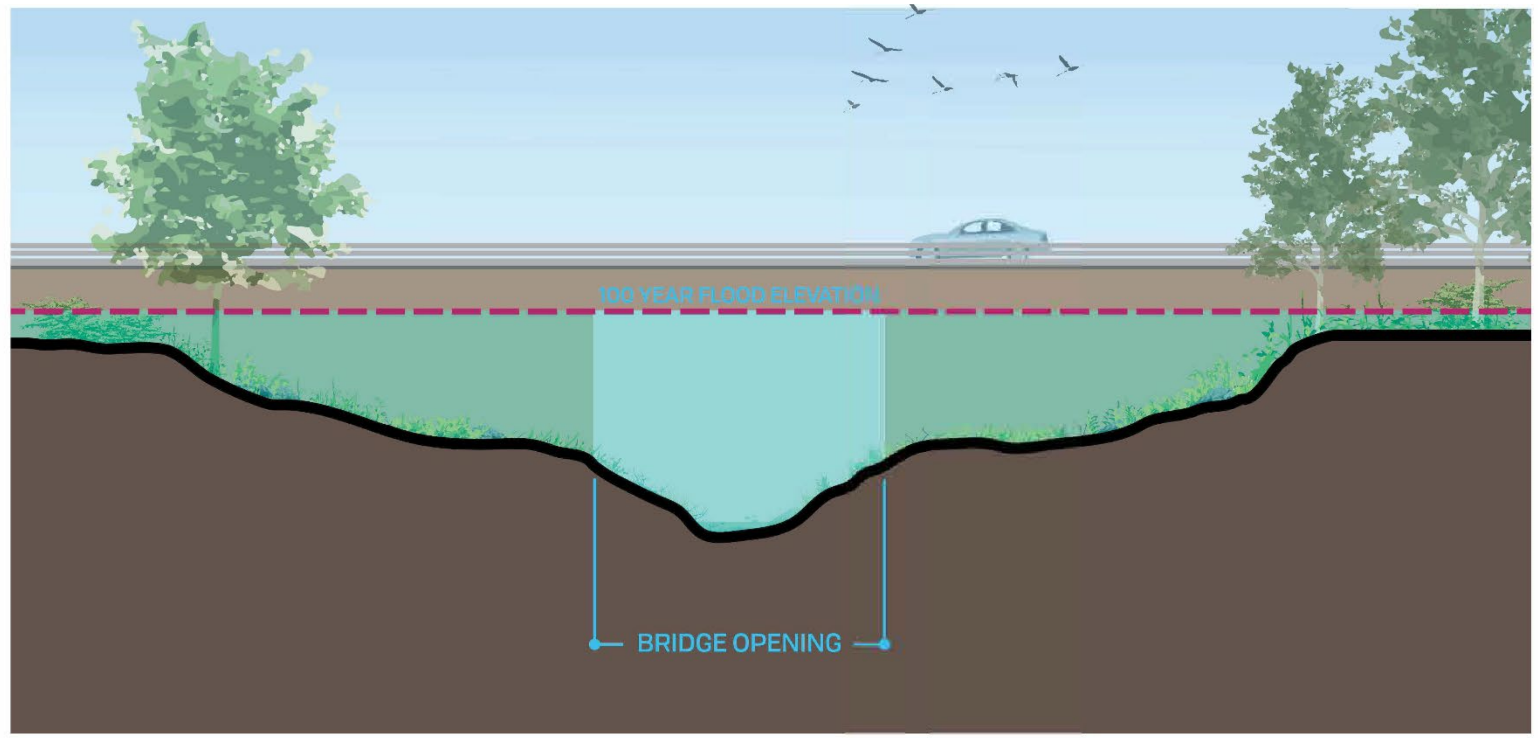


Existing Condition

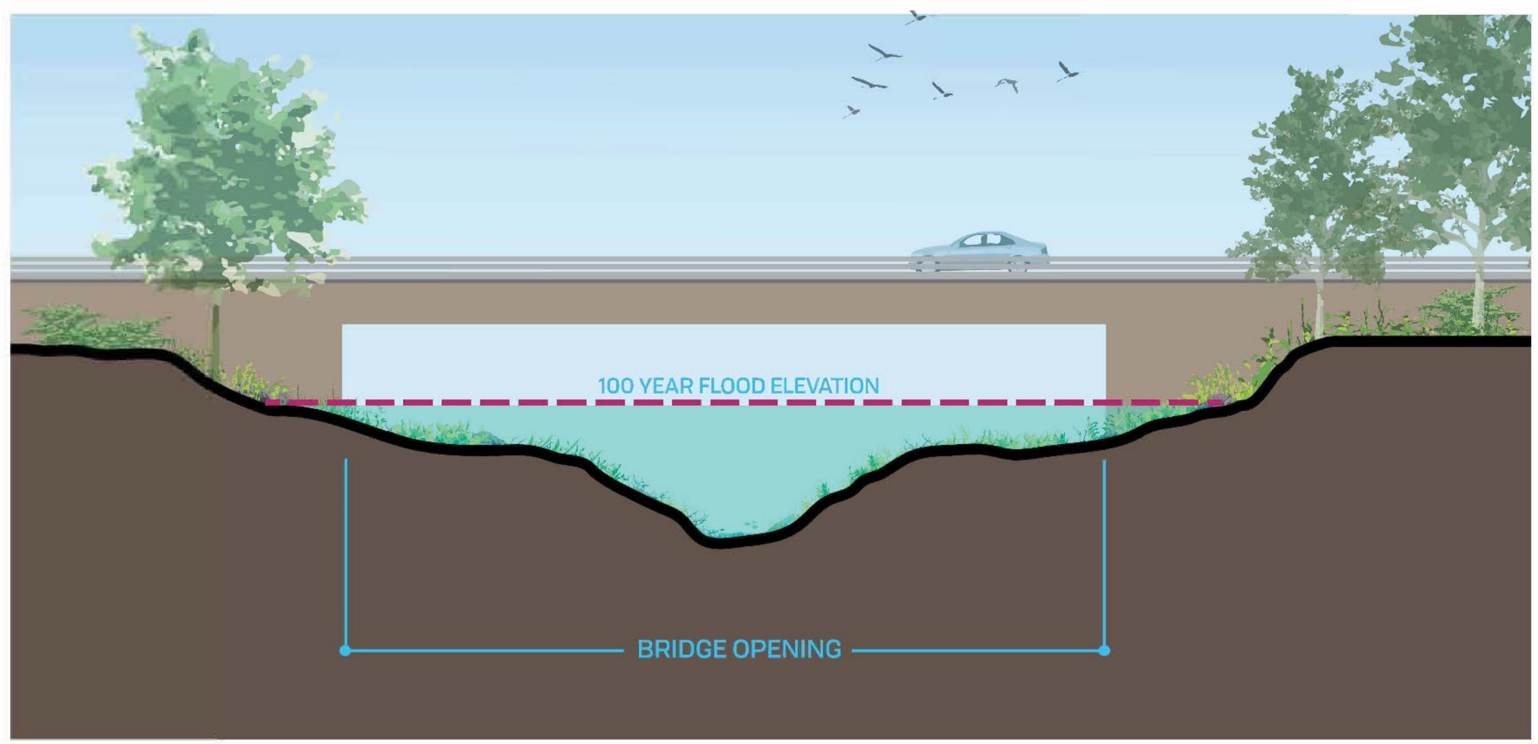


Future Condition

FLOODPLAIN BENCH

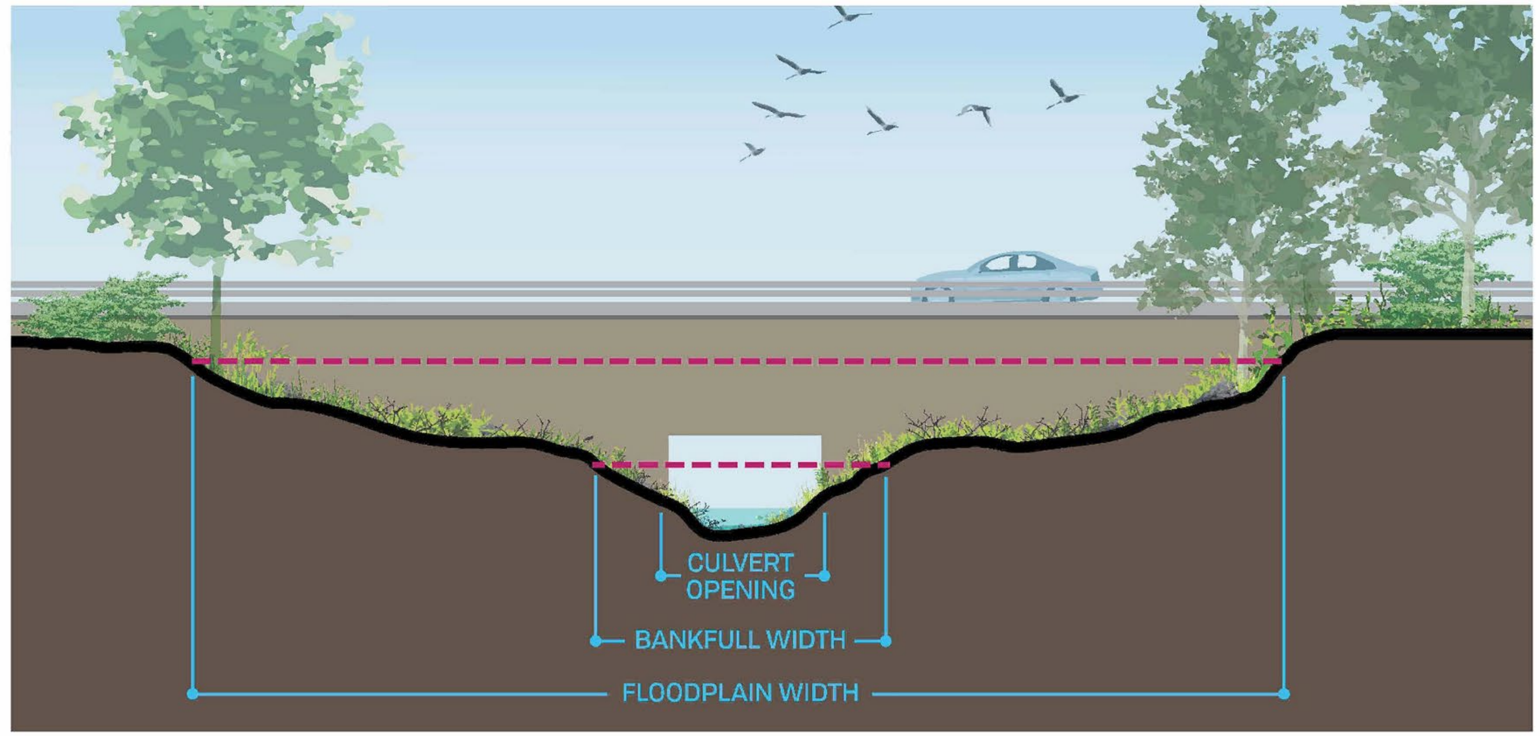


Existing Condition

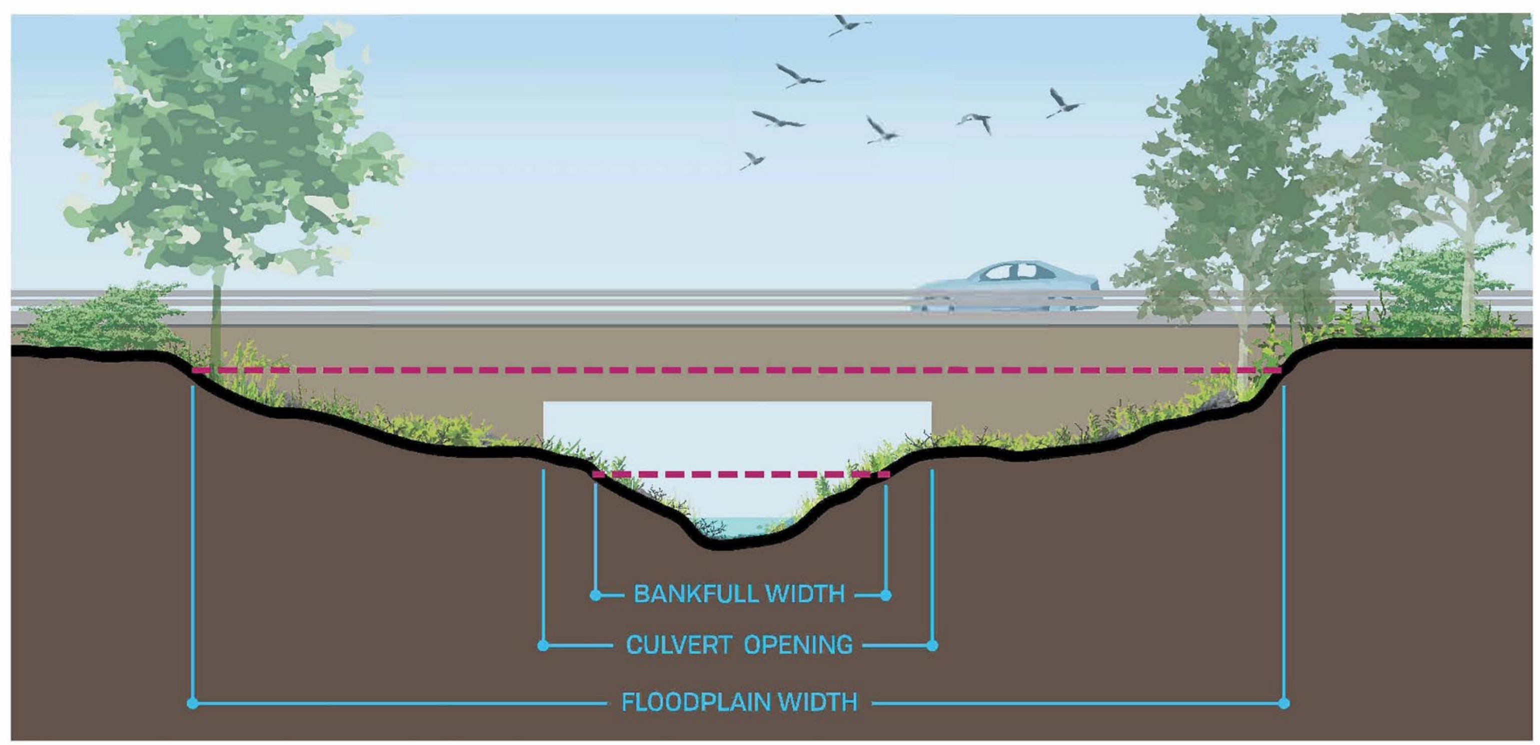


Future Condition

EXPANDED BRIDGE OPENING



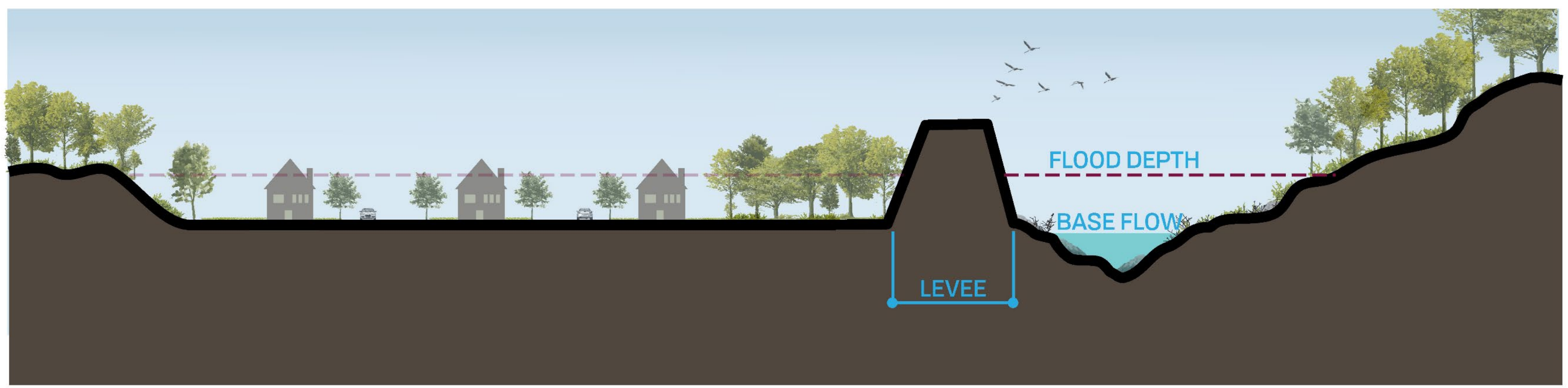
Existing Condition



Future Condition

EXPANDED CULVERT OPENING

Existing Condition



Future Condition

PROTECTIVE LEVEE