Intended for

New York State Department of Environmental Conservation

625 Broadway

Albany, New York 12233

Document type

Final Report

Date

December 2020

RESILIENT NEW YORK FLOOD MITIGATION INITIATIVE

DONNER CREEK, NY

Prepared for:

Project Team:

TABLE OF CONTENTS

LIST OF APPENDICES

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

CFA	Regional Economic Development Councils/Consolidated Funding Applications
CFS	Cubic Feet per Second
CMIP	Coupled Model Intercomparison Project
CSC	Climate Smart Communities
CWSRF	Clean Water State Revolving Fund
DEM	Digital Elevation Model
DHS	U.S. Department of Homeland Security
DHSES	New York State Division of Homeland Security and Emergency Services
EPA	Environmental Protection Agency
EPG	NYS DEC/EFC Wastewater Infrastructure Engineering Planning Grant
EWP	Emergency Watershed Protection Program
FEMA	U.S. Federal Emergency Management Agency
FIRM	Flood Insurance Rate Map
FIS	Flood Insurance Study
FMA	Flood Mitigation Assistance Program
GIS	Geographic Information System
Gomez and Sullivan	Gomez and Sullivan Engineers, D.P.C.
H&H	Hydrologic and Hydraulic
HEC	USACE Hydrologic Engineering Center
HEC-2	USACE Water Surface Profiles Program
Highland Planning	Highland Planning, LLC
HMA	Unified Hazard Mitigation Program
HSGP	Homeland Security Grant Program
LIDAR	Light Detection and Ranging
NAVD88	North American Vertical Datum of 1988
NFIP	National Flood Insurance Program
NGVD29	National Geodetic Vertical Datum of 1929
NOAA	National Oceanic and Atmospheric Administration
NRCS	Natural Resources Conservation Service
NYSDEC	New York State Department of Environmental Conservation
NYSDOT	New York State Department of Transportation
OEM	New York State Office of Emergency Management
OBG	O'Brien and Gere, Part of Ramboll
PDM	Pre-Disaster Mitigation Grant Program
RCP	Representative Concentration Pathways
RF	Radio Frequency
RL	Repetitive Loss
ROM	Rough Order of Magnitude
SRL	Severe Repetitive Loss
USACE	U.S. Army Corps of Engineers
USGS	United States Geological Service
WCRP	World Climate Research Programme

WGCM	Working Group Coupled Modelling
WQIP	Water Quality Improvement Project

Introduction

Historical Initiatives

Flood mitigation efforts on Donner Creek (sometimes referred to as Donner Brook in prior studies) have been necessary in the Town of Lockport since at least 2003, when residents along Donner Creek began experiencing flooding events (Town of Lockport, 2014). Following 2003 to 2006 flooding events, the Town of Lockport and New York State Department of Environmental Conservation (NYSDEC) held meetings and carried out a study to determine mitigation measures for the creek's flooding problems. The study evaluated possible modifications to the existing Town detention ponds, possible additional detention ponds, the capacity of existing culverts, box culverts, bridges, and the existing cross sections of the stream, and the development of a system wide hydraulic model and capital improvement plan to identify problematic areas within the watershed and evaluate possible actions to address these problems. Results were compiled in the Donner Creek Watershed Analysis (Wendel Duchscherer, 2008).

Floodplain Development

General recommendations for high risk floodplain development follow three 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.) and right size bridges and culverts to lower flood stages 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 Association (FEMA) regulations 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 subsequently greater economic losses to the community.

Resilient NY Initiative

In November 2018, New York State Governor Andrew Cuomo announced the Resilient NY Initiative in response to devastating flooding in communities across the State in the preceding years. High priority watersheds were selected based on several factors, such as frequency and severity of flooding and ice jams (when applicable), extent of previous flood damage, and susceptibility to future flooding and ice jam formations (New York Sate Governor's Press Office, 2018). The Donner Creek watershed was chosen as a study site for this initiative.

The goals of the Resilient NY Initiative 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 this initiative is to recommend a suite of flood and ice jam mitigation projects that local municipalities can undertake to make their community more resilient to future floods. The proposed 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.

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, and flooding 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. United States Geologic Service (USGS) Future Flow Explorer v1.5 (Burns, Smith, & Freehafer, 2015) and Stream Stats v4.3.1 (Ries et al. 2017) software were used to develop current and future potential discharges and bank-full widths and depths at various points along the stream channel. Hydrologic and hydraulic (H&H) modeling was performed previously, as part of a FEMA Flood Insurance Study (FIS) using USACE Hydrologic Engineering Center's River Analysis System (HEC-RAS) or the USACE HEC-2 Water Surface Profiles (HEC-2) program to predict water stage at potential future high risk areas and to evaluate the effectiveness of flood mitigation strategies. These studies were obtained and used, all or in part, as part of this effort. Appendix A is a summary listing of data and reports collected.

Public Outreach

An initial project kickoff meeting was held on September 19, 2019, with representatives of the NYSDEC; Gomez & Sullivan Engineers, D.P.C. (Gomez and Sullivan); Highland Planning, LLC (Highland Planning); the Counties of Erie, Genesee, and Niagara; the Towns of Amherst, Batavia, Clarence, Newstead, and Royalton; the Village of Alexander; and Buffalo Niagara Waterkeeper (Appendix B). It was noted in a later meeting that the invitation to the kickoff meeting was not received by representatives from the Town of Lockport. Discussions included a variety of topics related to Donner Creek, Gott Creek, Eighteen-mile Creek, Tonawanda Creek, and Ransom Creek, including:

- Background and objectives of the Resilient NY Initiative,
- Background of the study areas,
- Firsthand accounts of past flooding events,
- Identification of specific areas that flooded in each community, and the extent and severity of flood damage, and
- Information on post-flood efforts, such as temporary floodwalls.

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

Following the formal kick-off meeting, Gomez and Sullivan had follow-up discussions with officials from the Town of Lockport and Niagara County in February and March, 2020 to obtain information on flooding issues contained in prior studies and additional information on structures spanning Donner Creek.

Comments received from these outreach activities indicated that most of the issues with Donner Creek occur in the Town of Lockport, where recent development is playing a role. Conveyance capacities of all of the road crossings were identified as areas to be evaluated, as were size and maintenance of private bridges over driveways.

Field Assessment

Gomez and Sullivan completed reconnaissance visits on September 19, 2019 and field assessments of high-risk flood areas at Donner Creek road crossings on February 4 and 17, 2020. Field data were collected on standard data collection sheets (Appendix C). Information collected during the field assessments included:

- Photo documentation of inspected areas (see Appendix D for photo log),
- Characteristics and measurements of bridges and culverts,
- Notes regarding additional features near the road crossing, such as dams
- Geomorphic classification and assessment, including measurement of bank-full channel width and depth,
- A Wolman pebble count,
- 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, and
- Preliminary identification of potential flood hazard mitigation alternatives, including those requiring further analysis.

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 us standing in the river, looking downstream.

Watershed Characteristics

Study Area

The Donner Creek watershed lies entirely within the Towns of Lockport and Pendleton and the City of Lockport, in Niagara County, NY. The creek generally flows from northeast to southwest, with its headwaters near Lincoln Avenue in the City of Lockport, near the northern boundary of the Niagara River watershed and flows into the Erie Canal in Pendleton. The creek has a total drainage area of 3.83 square miles, at its crossing under East Canal Road, from which point the creek has been straightened and parallels the Erie Canal. At the Town of Lockport/Pendleton boundary at South Transit Road, the watershed has a cumulative drainage area of 2.19 square miles.

Figure 1 depicts the location of the Donner Creek watershed. Within the watershed, the Town of Lockport was chosen as the target study area due to the history of flooding in and along the creek within the town, and the amount of development along the creek. Flooding has been identified as an issue along the creek in areas of the Town of Pendleton. However, due to the limited development along the creek in this area, hydraulic modeling of this portion of the creek has not been previously developed and the Town of Pendleton was not included in the target study area for this study. Figure 2 depicts the study area within the Town of Lockport and field data collection locations, as well as the study stationing along Donner Creek.

Watershed Land Use

The National Land Cover Database (U.S. Geological Survey, 2019) shows that, within the Donner Creek watershed, the land cover types of Developed, Open Space and Cultivated Crops each make up 20% of the watershed. All developed land cover types total 45% of the watershed and all agriculture cover types total 37%. Further details of the distribution of land cover within the watershed are shown on Table 1 and in Figure 3. Within the watershed, the upper approximate two thirds consist of mostly urban and sub-urban areas while the downstream approximate one third consists mainly of agricultural areas.

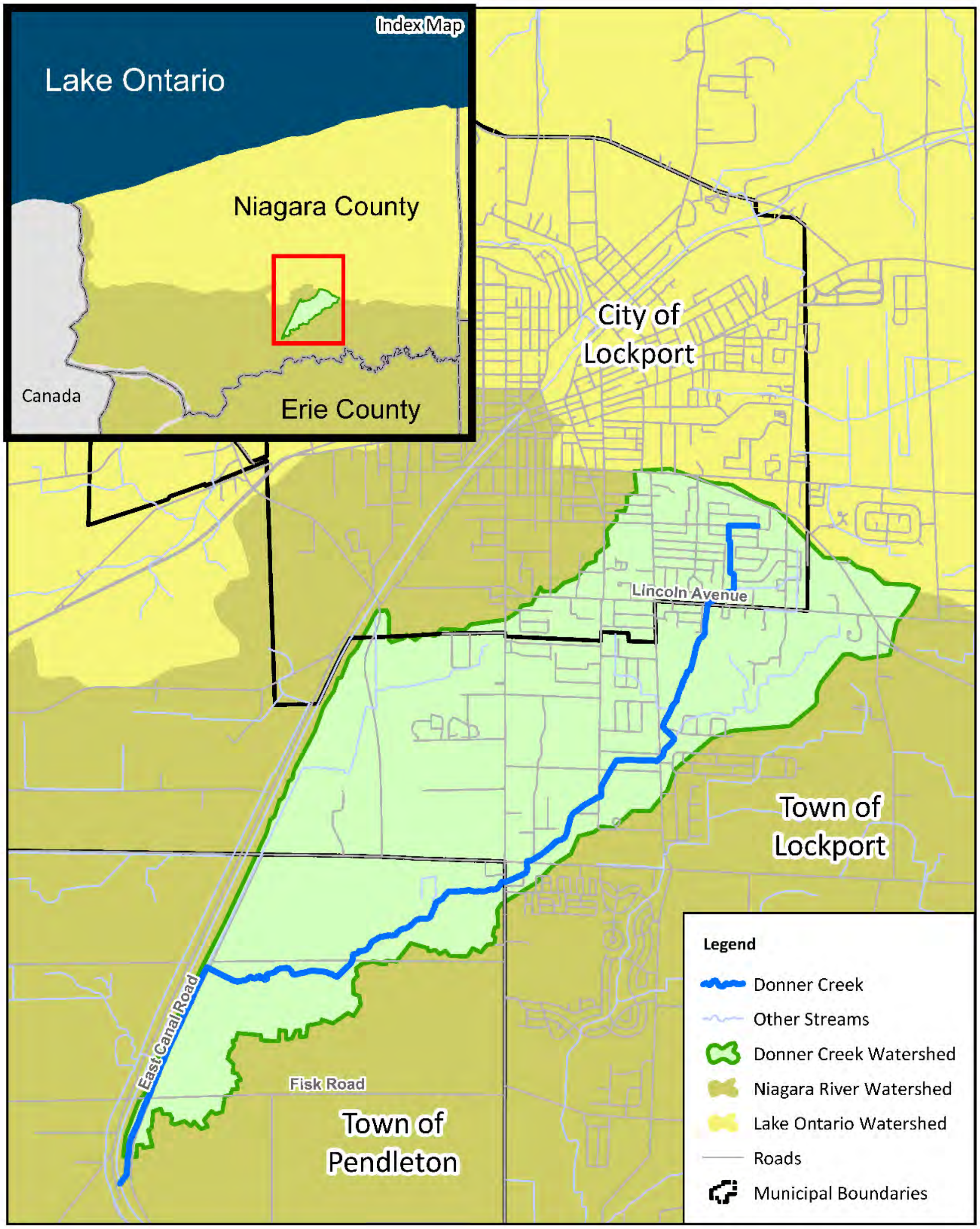
Table 1. Land Use Cover Types in the Donner Creek Watershed

Land Use Cover Type	Acres	Percentage
Developed, Open Space	742.3	20%
Cultivated Crops	739.9	20%
Pasture/Hay	645.0	17%
Developed, Low Intensity	590.6	16%
Deciduous Forest	369.8	10%
Woody Wetlands	277.1	7%
Developed, Medium Intensity	191.9	5%
Developed High Intensity	141.0	4%
Mixed Forest	22.9	1%
Emergent Herbaceous Wetlands	5.0	0%
Barren Land (Rock/Sand/Clay)	4.9	0%
Grassland/Herbaceous	4.6	0%
Shrub/Scrub	1.4	0%
Evergreen Forest	1.3	0%

Open Water	0.7	0%
Total	**3738.3**	**100%**

Source: USGS, 2019

Figure 1. Donner Creek Location



GOMEZ AND SULLIVAN ENGINEERS

N W E S

0 0.2 0.4 0.8 Miles

Resilient NY Initiative
Donner Creek Flood Study
Figure 1. Donner Creek Location

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

Path: P:\2065 - Resilient NY Initiative\GIS\Maps\Donner_Creek_Report\Figure_1.mxd

Geomorphology

Donner Creek's floodplain is relatively wide and flat, with little topographic relief. No significant topographic or geologic features were identified which affect the location or extent of the floodplain. Downstream of the study area, within the Town of Pendleton, much of the Donner Creek floodplain is classified as wetland area, owing to the flat topography which slows the passage of flows and allows runoff to collect in areas adjacent to the stream channel. Within the study area, the stream channel has two distinctly different slopes. Upstream of Amy Lane, the channel is relatively steep with an average slope of approximately 16.5 feet per mile (Federal Emergency Management Agency, 2010). Downstream of Amy Lane, the channel slope decreases significantly to approximately 7.5 feet per mile (Federal Emergency Management Agency, 2010). Within the portion of the study area downstream of Amy Lane, several segments of the creek channel appear to have been re-aligned, which may have altered the channel slope within this reach. Throughout the study area, the stream channel drops approximately 27.75 vertical feet from the upstream limit of detailed study to the South Transit Road Bridge. Figure 4 provides a profile of the Donner Creek channel bottom within the study area, the figure includes the location of several stream crossings for reference.

A channel profile or detailed topographic data is not available for the portion of Donner Creek within the Town of Pendleton. Based on available USGS topographic maps, it appears that the creek channel falls approximately an additional 10 to 15 feet in the 2.6-mile length between South Transit Road and East Canal Road, where the channel has been re-aligned to parallel the Erie Canal. Based on this information, the channel has a slope of approximately 3.8 to 5.8 feet per mile through Pendleton, and an overall slope between 7.5 and 8.5 feet per mile along its entire length upstream of East Canal Road.

Hydrology

Donner Creek is approximately 6.4 miles long and its watershed covers approximately 5.8 square miles (3,738 acres) beginning with ground water in the City of Lockport (Figure 1). The creek flows southwest, taking a sharp turn at Erie Canal Road to parallel the Erie Canal for about 1.3 miles. This section has been straightened and is considered a "Canal Ditch" in the USGS National Hydrography database. The creek empties into the Erie Canal north of the confluence of the canal and Tonawanda Creek. The Erie Canal/Tonawanda Creek then flows southwestward to its mouth at the Niagara River.

Upstream of East Canal Road, downstream of which the watershed characteristics have been modified by channel straightening, Donner Creek drains a long and narrow watershed with an approximately 5.05-mile long main watercourse through the 3.83 square mile drainage area. The Donner Creek watershed does not contain any named tributaries; however, the creek has four un-named tributaries which have a combined flow length of approximately 3.72 miles.

Characteristic factors were computed from various physical quantities for the drainage basin upstream of where the channel has been straightened, these factors are useful in comparing the relative magnitude of flood peaks across similar drainage basins. The three factors which were calculated for the Donner Creek drainage basin are Form Factor (R_F), Circularity Ratio (R_C) and Elongation Ratio (R_E). Form Factor (R_F) describes the shape of the basin (e.g., circular or elongated) and can be used as a predictor of 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 expected 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.

The physical quantities used in calculating the characteristic factors for the basin are summarized in Table 2, below. Table 3 summarizes the calculation of basin characteristic factors for Donner Creek.

Table 2. Summary of Donner Creek Basin Physical Quantities

Characteristic	Quantity
Drainage Area (A, mi^2)	3.83
Basin Length (B_L, mi)	4.44
Basin Perimeter (B_P, mi)	16.34

Table 3. Summary of Calculated Donner Creek Basin Characteristic Factors

Factor	Formula	Value
Form Factor (R_F)	A/B_L^2	0.19
Circularity Ratio (R_C)	$4\pi A/B_P^2$	0.18
Elongation Ratio (R_E)	$2(A/\pi)^{0.5}/B_L$	0.50

These calculated characteristic factors indicate that the Donner Creek basin should be categorized as an elongated basin for which peak discharges would be expected to be lower than less elongated basins; subsequently high flow events would be expected to occur with a longer duration (Parveen, Kumar, & Singh, 2012). The drainage system within the basin would be expected to have appreciable structural controls and have high relief topography (Waikar & Nilawar, 2014).

There are currently no active USGS stream gages on Donner Creek. The only historic stream gage within the drainage basin, USGS 04218592 (Donner Brook near Lockport, NY) was located near the East Canal Road crossing over Donner Brook. Daily discharge data was collected at this site for approximately 11 months between November 1977 and September 1978. The period of available data is not sufficient for use in evaluating the frequency of discharges within the watershed.

The level of urbanization within the drainage basin is expected to have a significant impact on the magnitude of peak flood discharges. For hydrologic purposes, basins are considered to be urbanized if more than 15 percent of the land use in the drainage area is classified as developed land; including open space, low, medium and high intensity. The regression equations developed by the USGS for both current and potential future conditions are not considered to be directly applicable to urbanized drainage basins. For urbanized drainage basins, the USGS Water-Supply Paper 2207 (*Flood Characteristics of* Urban Watersheds in the United States) (Sauer, Thomas, Stricker, & Wilson, 1983) provides a methodology for estimating peak discharges based on the expected peak discharge for an equivalent rural basin, the amount of development within the basin and other physical characteristics of the basin.

The effective FEMA Flood Insurance Study (FIS) for Niagara County, NY was issued on November 3, 2017, and includes computed peak discharges for three locations along Donner Creek (note that a preliminary revision to the FIS, dated April 5, 2019, includes the same hydrologic analysis for Donner Creek). At each location, the peak discharges were computed using the methods described above for urban watersheds and the regional regression equations for New York, published in 1991 (Lumia, Regionalization of Flood

Discharges for Rural, Unregulated Streams in New York, Excluding Long Island, 1991). At the most downstream location for which peak discharges were computed (At South Transit Road), the U.S. Army Corps of Engineers (USACE) previously performed a hydrologic analysis which resulted in significantly higher estimates of the peak discharges; therefore the results from the USACE analysis were used at this location for the purposes of developing the hydraulic modeling of the creek. The sources of differences in the USACE results could not be assessed, as part of this study as neither the details of the USACE hydrologic analysis, nor a reference to the report summarizing that analysis was provided in the FIS. The peak discharges from the FEMA FIS report are summarized in Table 4, below.

Table 4. Summary of FEMA FIS Peak Discharges (2017)

Location	Drainage Area (mi^2)	River Station (ft)	Peak Discharge (cfs)			
			10%	2%	1%	0.2%
At South Transit Road	2.77	3+24	420	620	880	950
At Beattie Road	2.16	66+65	334	446	526	631
At Lincoln Road	0.72	119+66	190	267	300	362

For this study, the USGS *Stream Stats* software was used to calculate the peak discharges for Donner Creek. The *Stream Stats* application was selected due to the fact that the program uses regionally specific full regression equations developed by the USGS to estimate streamflow statistics that take into account multiple basin characteristics, including drainage area, main channel slope, basin slope, storage and mean annual runoff. These additional characteristics increase accuracy and decrease standard errors by approximately 10% for a 100-year recurrence interval discharge when compared to the drainage area only regression equation (Lumia, Freehafer, & Smith, Magnitude and Frequency of Floods in New York, 2006); (Ries, et al., 2017). The regional regression equations utilized by the *Stream Stats* application in the area of Donner Creek includes a measure of basin slope which is computed based on the length of topographic contours which cross the basin and the drainage area of the basin. Due to the small drainage area of the creek, and the contour interval of the dataset used by the *Stream Stats* application to compute the basin slope parameter, the calculated parameter was zero at each of the three peak discharge locations used in the FIS. Therefore, the basin slope was re-calculated using GIS, using a topographic contour dataset with a ten-foot contour interval, and the discharges were recomputed using the computed slope. Although more detailed LiDAR elevation data is available for the basin, the *Stream Stats* software utilizes a 20-foot contour interval. Therefore, the ten-foot contour interval was used in order to maintain as much consistency with the software, as possible.

The *Stream Stats* application uses the regional regression equations for New York which were published in 2006, while the FEMA FIS discharge calculations are based on the regional regression equations for New York which were published in 1991. The 2006 regional regression equations are based on an analysis of peak discharges recorded at 388 gaging sites which have periods of record ranging from 10 to 99 years (Lumia, Freehafer, & Smith, Magnitude and Frequency of Floods in New York, 2006), whereas the 1991 equations were based on an analysis of peak discharge records at 313 gaging sites with periods of record ranging from 10 to 84 years (Lumia, Regionalization of Flood Discharges for Rural, Unregulated Streams in New York, Excluding Long Island, 1991). Table 5 is the summary output of peak discharges calculated by the regional regression equations used in the USGS *Stream Stats* software, and basin slope calculation discussed above, for Donner Creek at the same locations as the FEMA FIS peak discharges.

Table 5. Summary of Peak Discharges at FEMA FIS Locations from StreamStats

Location	Drainage Area (mi2)	River Station (ft)	Peak Discharge (cfs)			
			10%	2%	1%	0.2%
At South Transit Road	2.77	3+24	204	262	284	334
At Beattie Road	2.16	66+65	170	219	238	281
At Lincoln Road	0.72	119+66	58	72	76	87

Source: USGS (2020)

As the drainage basin has a significant amount of development, with greater than 15 percent of the drainage area being characterized as being developed, the urban flow computations used in the FIS were updated with the revised peak discharges from the *Stream Stats calculations*. With the exception of the rural peak discharge, the urban flow computations were performed using the same methodology and parameters as were used in the 2017 FIS. The urban flow computations require the input of the 2-year, 2-hour precipitation, as part of the calculation. NOAA Atlas 14 (National Weather Service Hydrometeorological Design Studies Center, 2017) was queried to evaluate the 2-year, 2-hour flow for Donner Creek, and the value used in the 2017 FIS report was confirmed. The parameters used in computing the urban peak discharges are summarized in Table 6, the results of the urban flow computations are included in Table 7.

Table 6. Summary of Donner Creek Urban Flow Computation Parameters

Location	Drainage Area (mi2)	Channel Slope (ft/mi)	2-hr, 2-yr Rainfall Depth (in)	Basin Storage (%)	Basin Development Factor	Impervious Area (%)
At South Transit Road	2.77	10	1.2	1.28	3	15
At Beattie Road	2.16	14	1.2	0.2	3	14
At Lincoln Road	0.72	18.64	1.2	0.24	5	15.4

Table 7. Summary of Computed Donner Creek Urban Peak Discharges at FEMA FIS Locations

Location	Drainage Area (mi2)	River Station (ft)	Peak Discharge (cfs)			
			10%	2%	1%	0.2%
At South Transit Road	2.77	3+24	318	413	452	515
At Beattie Road	2.16	66+65	294	380	416	475
At Lincoln Road	0.72	119+66	130	161	171	191

Comparing the flow estimates used in the FIS, given in Table 4, with the flow estimates from the current regional regression equations and urban flow methodologies, the current estimates result in lower peak flows for all locations and recurrence intervals. Notably, the flow estimates at South Transit Road are significantly lower than those used in the FIS. While the documentation of the analysis performed at that location by the USACE is not available, the description given in the FIS implies that a more detailed hydrologic analysis was performed at this location. As the current analysis does not indicate that the peak flows have increased since the FIS analysis was performed and for consistency with the FIS, the peak flow values presented in the FIS (Table 4) were used to evaluate current hydraulic conditions.

The Donner Creek drainage basins currently contains two detention ponds. These detention ponds serve to offset the increases in flood peaks due to development by slowing the travel of runoff from the development to the receiving stream. The existing detention basins are computed to reduce the current peak flows computed using the urban flow computations by approximately 20 to 26 cfs at Beattie Avenue and by approximately 19 to 26 cfs, for the 10- to 0.2-percent annual chance floods. As noted above, the existing hydrologic analysis that was the basis of the computed peak flows at South Transit Road for the FIS study was not available for review during this study. Therefore, a detailed analysis of the impact detention storage on the FIS peaks could not be performed at South Transit Road. The impacts of detention storage are included in the peak flows used in performing the hydraulic analyses for this study.

In addition to peak flows of various recurrence intervals, *Stream Stats* calculates bank-full statistics by using stream survey data and discharge records from 281 cross-sections at 82 streamflow-gaging stations in a linear regression analyses to relate drainage area to bank-full discharge and bank-full channel width, depth, and cross-sectional area for streams across New York State. This regionally specific model of calculating bank-full statistics was determined to be more accurate when compared to a statewide (or pooled) model (Mulvihill, Baldigo, Miller, DeKoskie, & DuBois, 2009).

The bank-full width and depth of Donner Creek is important in understanding the distribution of available energy within the channel and the ability of various discharges occurring within the channel to erode, deposit, and move sediment (Rosgen & Silvey, 1996). The bank-full discharge is defined as the flow which reaches the transition between the channel and its floodplain (Mulvihill, Baldigo, Miller, DeKoskie, & DuBois, 2009). The bank-full width and depth describe the top width and depth of water at the bank-full discharge, respectively. Table 8 summarizes the estimated bank-full discharge, width, and depth at select locations along Donner Creek as derived from the USGS *Stream Stats* program (Ries, et al., 2017). It should be noted that the Donner Creek drainage basin upstream of Lincoln Ave (identified as Lincoln Road in the FIS), is smaller than the lower limit for which the bank-full regression equations are considered to be valid.

Table 8. Summary of Donner Creek Bank-Full Discharge Characteristics

Location	Drainage Area (mi^2)	River Station (ft)	Bank-Full Discharge (cfs)	Bank-Full Width (ft)	Bank-Full Depth (ft)
At South Transit Road	2.77	3+24	114	26	1.34
At Beattie Road	2.16	66+65	90.4	23.2	1.25
At Lincoln Road	0.72	119+66	31.2	13.6	0.918

Source: USGS (2020)

Infrastructure

Road crossings over Donner Creek include Lincoln Avenue, Amy Lane, Beattie Avenue, Hamm Road, Locust Street Extension, Snyder Drive and Robinson Road in the Town of Lockport, Transit Road on the border of the Towns of Lockport and Pendleton, and then Donner Road, East Canal Road. and Fisk Road in the Town of Pendleton. The crossings at Lincoln Avenue, Amy Lane and Snyder Drive are culverts, whereas all other road crossings are bridges.

Table 9 summarizes NYSDOT bridges crossing Donner Creek in the Town of Lockport (New York State Department of Transportation, 2019). Bridge crossings that were considered high risk for potentially being constriction points based on the FEMA Flood Insurance Rate Maps (FIRMs), community outreach, and site visits are detailed on Table 10. At these locations, bank-full widths were determined in the USGS StreamStats program (Ries, et al., 2017). Utilizing the existing FEMA flood profiles, the hydraulic capacity was estimated for each of the bridge locations, based on the highest profile which can pass below the low chord, or does not show a significant rise across the bridge.

Table 9. NYSDOT Bridges Crossing Donner Creek

Roadway Carried	NYSDOT Bin	Bridge Length (ft)	Bridge Width (ft)
Robinson Road	3329530	23	46.5
S. Transit Road	1030360	23	71.7

Source: (New York State Department of Transportation, 2019)

Table 10. High Flood Risk Bridge Crossing over Donner Creek

Roadway Carried	River Station (ft)	Bank-full Width (ft)[1]	Hydraulic Capacity (% Annual Chance)[2]
S. Transit Road	2+87	26.0	10
Robinson Road	12+69	25.9	10
Locust Street Extension	44+03	24.5	2[3]
Hamm Road	54+33	24.1	10

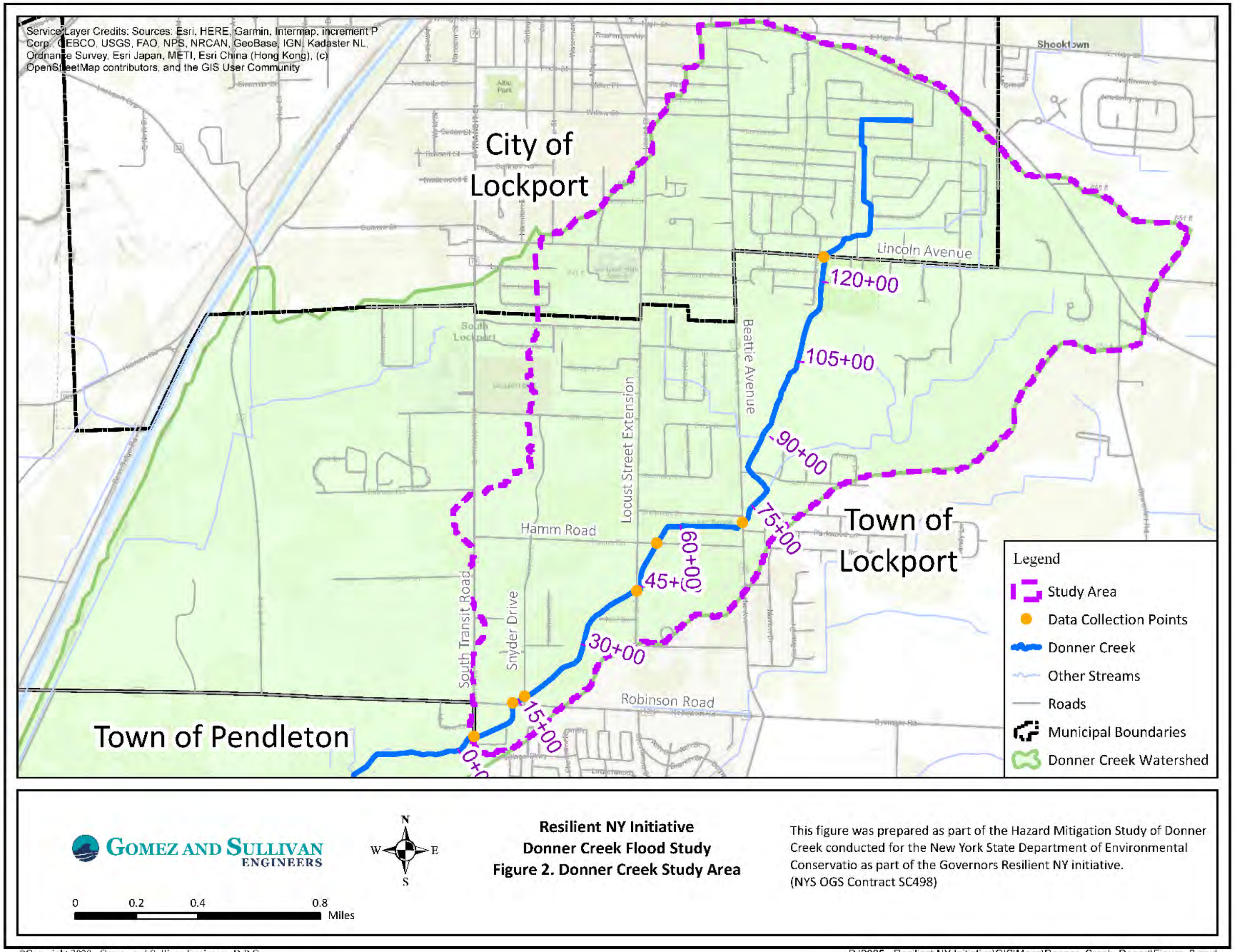
Source: [1] (Ries, et al., 2017), [2] (Federal Emergency Management Agency, 2010)
Notes: 3 Bridge has been modified since FIS, however capacity has not been significantly increased

As summarized in Table 11, the hydraulic capacity for all of the stream crossings within the modeled area were estimated from the existing FIS flood profile, as discussed above.

Table 11. Hydraulic Capacity of Modeled Stream Crossings over Donner Creek

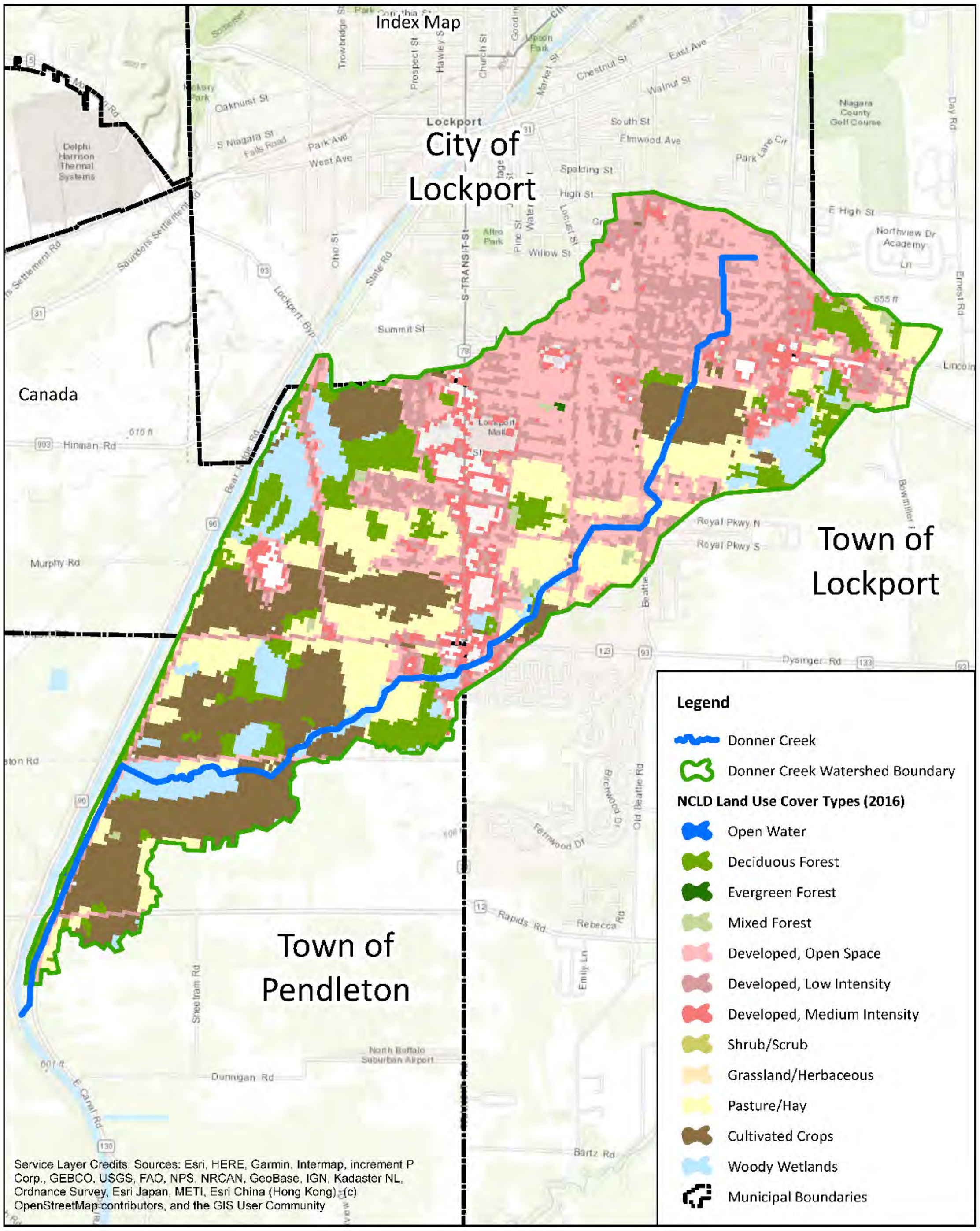
Roadway Carried	River Station (ft)	Hydraulic Capacity (% Annual Chance)
S. Transit Road	2+87	10
Robinson Road	12+69	10
Snyder Road	15+97	Not Included in Existing FIS Profile
Locust Street Extension	44+03	2
Pedestrian Bridge	46+47	10
Hamm Road	54+33	10
Beattie Ave	71+21	>10
Amy Lane	81+32	>10
Access Drive	83+90	>10
Access Drive	109+25	>10
Lincoln Ave	127+04	>10

Figure 2. Donner Creek Study Area



P:\2065 - Resilient NY Initiative\GIS\Maps\Donner_Creek_Report\Figure_2.mxd

Figure 3. Donner Creek Watershed National Land Cover Database Land Use



GOMEZ AND SULLIVAN ENGINEERS

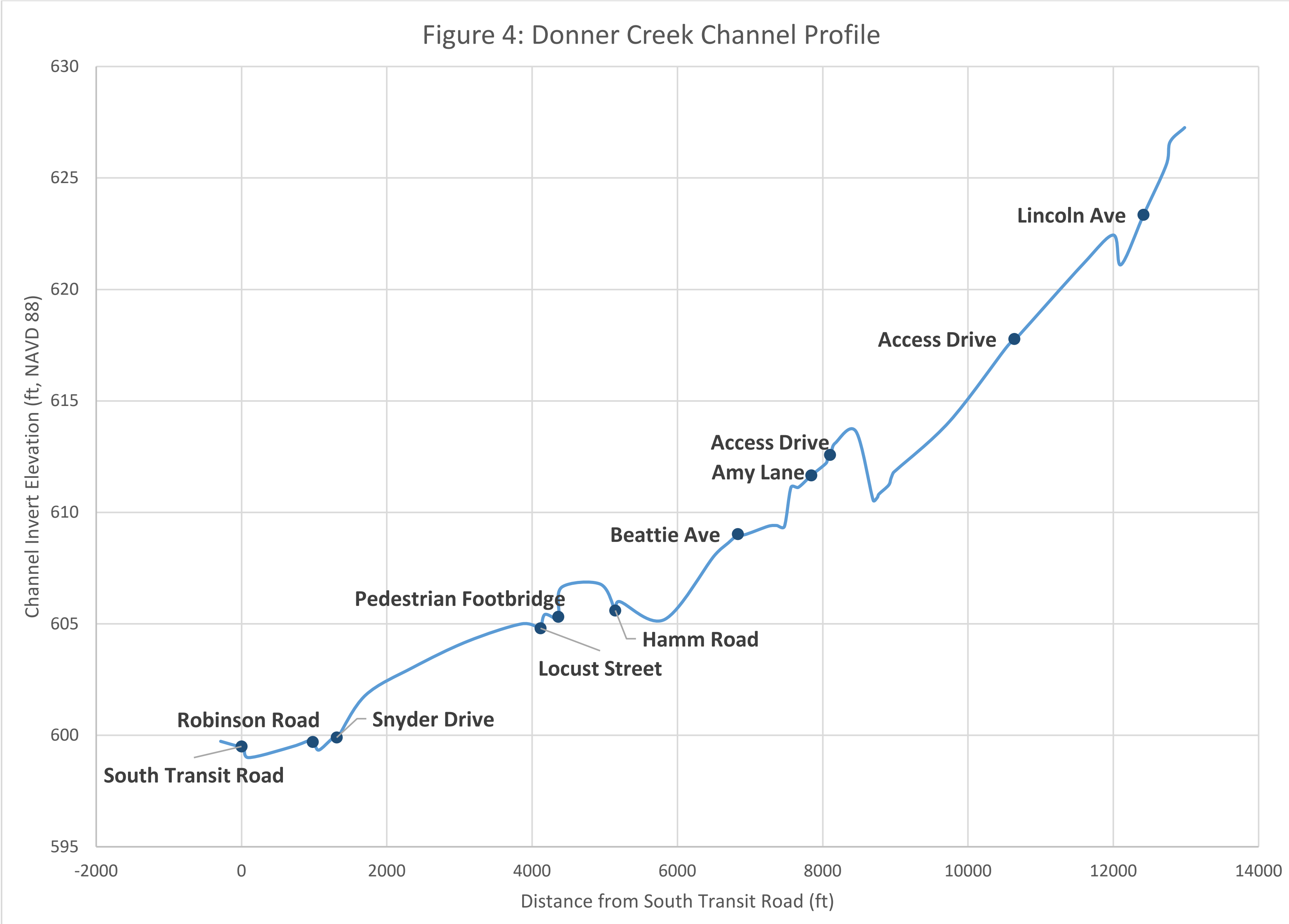
0 0.175 0.35 0.7 Miles

Resilient NY Initiative
Donner Creek Flood Study
Figure 3. Donner Creek Watershed National Land Cover Database Land Use

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

Path: P:\2065 - Resilient NY Initiative\GIS\Maps\Donner_Creek_Report\Figure_3.mxd

Figure 4. Donner Creek Channel Profile



Climate Change Implications

Future Projected Discharges

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) (Rosenzweig, et al., 2011). In response to these projected changes in climate, NYS passed the Community Risk and Resiliency Act (CRRA) in 2014. In accordance with the guidelines of the CRRA, the NYSDEC released the New York State Flood Risk Management Guidance for Implementation of the Community Risk and Resiliency Act (2018) draft report. In this report, the NYSDEC outlined infrastructure guidelines, most notably that the new low chord elevation recommendation for normal bridges is 2-feet of freeboard over the base flood elevation for a 1-percent annual chance flood event and 3-feet over for a critical structure (New York State Department of Environmental Conservation, 2018). The NYSDOT similarly has standards for sizing infrastructure to accommodate flows which are projected to increase; their standard is to size a bridge to pass 10% more than the current 2-percent annual chance flow with two feet of freeboard.

To account for climate change in the potential flood mitigation strategies, projected future streamflow values were computed using results from the USGS *Future Flow* software. The USGS *Future Flow* software is an extension of the Stream Stats 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 USGS *Future Flow* 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 (Burns et al. 2015).

With the USGS *Future Flow* 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, & Meehl, 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*. The USGS *Future Flow* 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 variation predicted from among the five models, and two greenhouse-gas scenarios (Alder & Hostetler, 2017). As with the USGS *Stream Stats* application, the USGS *Future* Flow software results in a computed basin slope of zero for all of the flow computation locations on Donner Creek. Therefore, the predictions of future mean annual runoff, obtained from the USGS *Future* Flow software were used with the USGS regional regression equations and the computed basin slope, described in the previous section, to compute the expected future peak flows. The USGS *Future* Flow 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. Table 12 provides a comparison of the current 1-percent annual chance peak stream flows calculated using the USGS *Stream Stats* software and the mean predicted future discharge calculated using the USGS *Future Flow* software at each of the discharge locations included in the effective FIS.

Table 12. Comparison of Rural 1-Percent Annual Chance Current and Future Discharges at Donner Creek

Location	Drainage Area (mi2)	River Station (ft)	Current Stream Stats 1-Percent Annual Chance Discharge (cfs)	Predicted Future Flow 1-Percent Annual Chance Discharge (cfs)	Change (%)
At South Transit Road	2.77	3+24	284	300	5.5%
At Beattie Road	2.16	66+65	238	250	5.2%
At Lincoln Road	0.72	119+66	76	81	6.3%

The Donner Creek drainage basin is considered to be urbanized currently, and development within the basin is unlikely to decrease significantlycp in the future. Therefore, future urban flows were computed for the basin using the urban peak discharge computations discussed previously and the future rural flows computed using the results of the USGS *Future Flow* software. The future urban flow computations performed for this study only account for the expected change in mean annual runoff, not an increase to the basin development factor or the 2-year, 2-hour precipitation. While these factors may increase in the future, there are no readily available means for estimating their future value. A comparison between the current and future urban 1-percent annual chance discharges computed for Donner Creek is provided in Table 13.

Table 13. Comparison of Urban 1-Percent Annual Chance Current and Future Discharges at Donner Creek

Location	Drainage Area (mi2)	River Station (ft)	Current Urban 1-Percent Annual Chance Discharge (cfs)	Predicted Urban Future Flow 1-Percent Annual Chance Discharge (cfs)	Change (%)
At South Transit Road	2.77	3+24	452	468	3.5%
At Beattie Road	2.16	66+65	416	430	3.4%
At Lincoln Road	0.72	119+66	171	178	4.1%

Comparing the current and predicted future discharges, computed with the *Stream Stats* and *Future Flow* programs, respectively, with the flows utilized in the modeling reported in the effective FIS, it can be seen that the current regional regression equations estimate significantly lower flows than the effective analysis for each recurrence interval modeled. As the hydrologic analysis utilized for the effective FIS appears to be based partially on a more detailed hydrologic analysis of the basin (South Transit Road location), the discharges used in the effective FIS are expected to provide a more accurate estimate of the current flows within the basin. Since sufficient information is not available to re-produce the analysis at South Transit Road, the hydrologic analyses used in the effective FIS were not updated to include expected increases in the mean annual precipitation, due to climate change estimates. Rather, the comparison between the current and future flow estimates from the *Stream Stats* and *Future Flow* applications, adjusted for urbanization, was used to estimate an average increase in discharges across locations within the Donner Creek watershed. The percent change ranged from a 2.9% increase in the 0.2-percent annual chance discharge at Beattie Ave., to a 4.1% increase in the 1-percent annual chance discharge at Lincoln Ave., with an average increase of 3.4% across all locations and recurrence intervals. Given the small range of increases, the average was assumed to provide a reasonable estimate of the expected increase in discharges due to climate change, and was applied to the discharges utilized in the effective FIS. Table 14 provides a summary of the estimated future peak discharges based on the 2017 effective FIS discharges and the average increase computed from the current regional regression equations and expected climate change impacts. The values presented in Table 14 were utilized in performing the hydraulic model runs for future flow conditions.

Table 14. Summary of Estimated Future Peak Discharges for Donner Creek based on 2017 Effective FFEMA FIS Discharges

Location	Drainage Area (mi^2)	River Station (ft)	Peak Discharge (cfs)			
			10%	2%	1%	0.2%
At South Transit Road	2.77	3+24	434	641	910	982
At Beattie Road	2.16	66+65	345	461	544	652
At Lincoln Road	0.72	119+66	196	276	310	374

Flooding Characteristics

Flooding History

Residents in the Town of Lockport have experienced infrequent but notable flooding along Donner Creek since at least 2003 (Town of Lockport, 2014). Following flooding from 2003 to 2006, the Town of Lockport had an analysis completed on the creek (Wendel Duchscherer, 2008). The analysis included a survey of the Donner's creek throughout the Town of Lockport, and it was concluded that siltation and vegetative growth contributed to the flooding events. In 2007, the Buffalo News reported that the town held meetings with residents of Hamm Road, Locust Street Extension, and Beattie Avenue to discuss recent flooding events, but no potential solutions were determined (Prohaska, 2007). In 2008, the Town Board decided to carry out limited flood control efforts (Robinson & Prohaska, 2008). These efforts included vegetation removal and clearing of detention ponds.

The Town has repeatedly considered dredging the creek to address the siltation and vegetation issues, but has been unable to acquire the necessary NYSDEC permit approvals (R. Klavoon, Town of Lockport Engineer, personal communication, March 6, 2020). Between January 2005, when the permit for dredging was originally submitted and March 2007, a series of meetings were held between the Town of Lockport and NYSDEC, to discuss the application and information required for approval of the permit. Based on these meetings, a survey of the channel was completed which showed that between two and four feet of material had accumulated in the channel since 1976. Considering this result, the NYSDEC requested that the Town of Lockport evaluate the need to modify existing detention ponds, the need to add additional detention ponds, the capacity of existing hydraulic structures (Wendel Duchscherer, 2008). This request resulted in the 2008 watershed analysis by Wendel Duchsherer.

Flood Risk Assessment

Flood Mitigation Analysis

Hydraulic analysis of Donner Creek was conducted using the HEC-RAS program. 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-dimensional, steady-state, or time-varied flow. Water surface profiles are computed from one cross section to the next by solving the one-dimensional energy equation with an iterative procedure (i.e. standard step backwater method). Energy losses are evaluated by friction (Manning's Equation) and the contraction/expansion of flow through the channel. The momentum equation is used in situations where the water surface profile is rapidly varied, such as hydraulic jumps, mixed flow regime calculations, hydraulics of dams and bridges, and evaluating profiles at a river confluence (United States Army Corps of Engineers, 2016).

Hydraulic modeling of Donner Creek in the Town of Lockport was completed under contract for FEMA as part of the original March 1981 FIS for the Town of Lockport (Federal Emergency Management Agency, 1981) and the original September 2010 countywide FIS for Niagara County (Federal Emergency Management Agency, 2010). The hydraulic model for the Town of Lockport was produced in a non-georeferenced HEC-2 format and began at the Town of Lockport/Town of Pendleton corporate limits, and extended upstream approximately 6,740 feet to the Hamm Road/Sherman Drive neighborhood in the Town of Lockport covering the majority of the high flood risk areas, discussed below. Included within this reach are South Transit Road, Robinson Road, Locust Street, pedestrian and Hamm Road bridge hydraulic obstructions. Beginning with the September 2010 countywide FIS, the channel profile for a portion of the original model reach (from approximately 400 feet downstream of Locust Street to approximately 1,660 feet upstream of Hamm Road) has been depicted as significantly lower than was shown in prior FIS reports. No revision to the hydraulic model appears to have been completed to update the FIS profile as a result of the apparent difference in channel profile. Hydraulic modeling performed for the September 2010 countywide FIS was developed in a georeferenced HEC-RAS format and extended the original analysis and flood profile to approximately 1,000 feet upstream of Lincoln Avenue, and utilized the water surfaces from the existing flood profile as the downstream boundary condition for the model.

For this study, the downstream HEC-2 hydraulic model was converted into the HEC-RAS format and combined with the upstream model. The portion of the combined model which developed from the original HEC-2 model was then geo-referenced using GIS and ortho-imagery of the Donner Creek watershed, aligning the locations of lettered cross sections and bridge crossings from the model and GIS data. Elevations for this portion of the model were also adjusted to account for the difference between the National Geodetic Vertical Datum of 1929 (NGVD 29) datum used by the original downstream model and the North American Vertical Datum of 1988 (NAVD 88), which was used in the upstream model and the current FIS. Using the updated HEC-RAS input data, a duplicate model was developed without any changes to the original H&H data and run in HEC-RAS. Next, a base condition model was produced, which corrected errors and updated the original H&H data based on field assessments of Donner Creek. The following changes were made in the development of the base condition model:

- Updated the terrain with the most current available bare earth light detection and ranging (LiDAR) digital elevation model (DEM) from FEMA

- Compared cross-section geometry between the existing hydraulic models and the current terrain data
- Adjusted cross-section geometry, for areas outside of the stream channel, at cross sections where the hydraulic model showed appreciable differences from the available terrain
- Adjusted left and right bank stations to match the adjusted cross section geometry
- Updated Manning n-values to better reflect channel, bank, and floodplain roughness, based on field observation and current aerial imagery
- Adjusted ineffective flow areas to account for floodplain expansion and contraction with terrain
- Revised expansion and contraction coefficients to correspond with hydraulic conditions near structures
- Revised reach lengths between cross sections, within original HEC-2 model area, using GIS
- Verified structure geometry for critical hydraulic structures based on field measurements
- For structures where existing modeling could not be verified, updated structure geometry, within original HEC-2 model area, was based on field measurements and LiDAR elevation data
- Added Snyder Drive culvert based on field measurements and LiDAR elevation data

The base condition model was then compared to the duplicate model, and the effective FEMA FIS elevation profiles to validate the model. After the base condition model was verified, it was then used to develop proposed condition models to simulate potential flood mitigation strategies. The simulation results of the proposed conditions were evaluated based on their reduction in water surface elevations.

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 proposed mitigation alternatives; namely floodplain benches and associated stabilization measures.

Where recent construction cost data was not readily available, *RSMeans CostWorks 2019* was used to determine accurate and timely information (RS Means: Gordian, Inc., 2019). Additionally, a 2016 USACE report focused on flood mitigation measures in the Lexington Green area (USACE 2016a) was used for pricing information for some of the mitigation alternatives. Costs were adjusted for inflation and verified against current market conditions and trends.

Where the mitigation analyses require the acquisition of land to construct, the parcel or parcels where the project is proposed to be constructed were assumed to be purchased in their entirety. However, due to the highly variable nature of land costs, the cost of the property was not included in the cost estimate, but the cost estimate does include legal and survey fees associated with acquiring the properties. For the purposes of developing these cost estimates, it was assumed that engineering, legal and administrative costs equal to 25% of the construction cost would be incurred. These costs are intended to account for the cost of performing the final design of the mitigation alternative and provide the appropriate oversight of construction. Due to the preliminary nature of the mitigation alternatives evaluated as part of this study, the cost estimates also include a 30% contingency.

Infrastructure and hydrologic modifications will require permits and applications to the NYS 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.

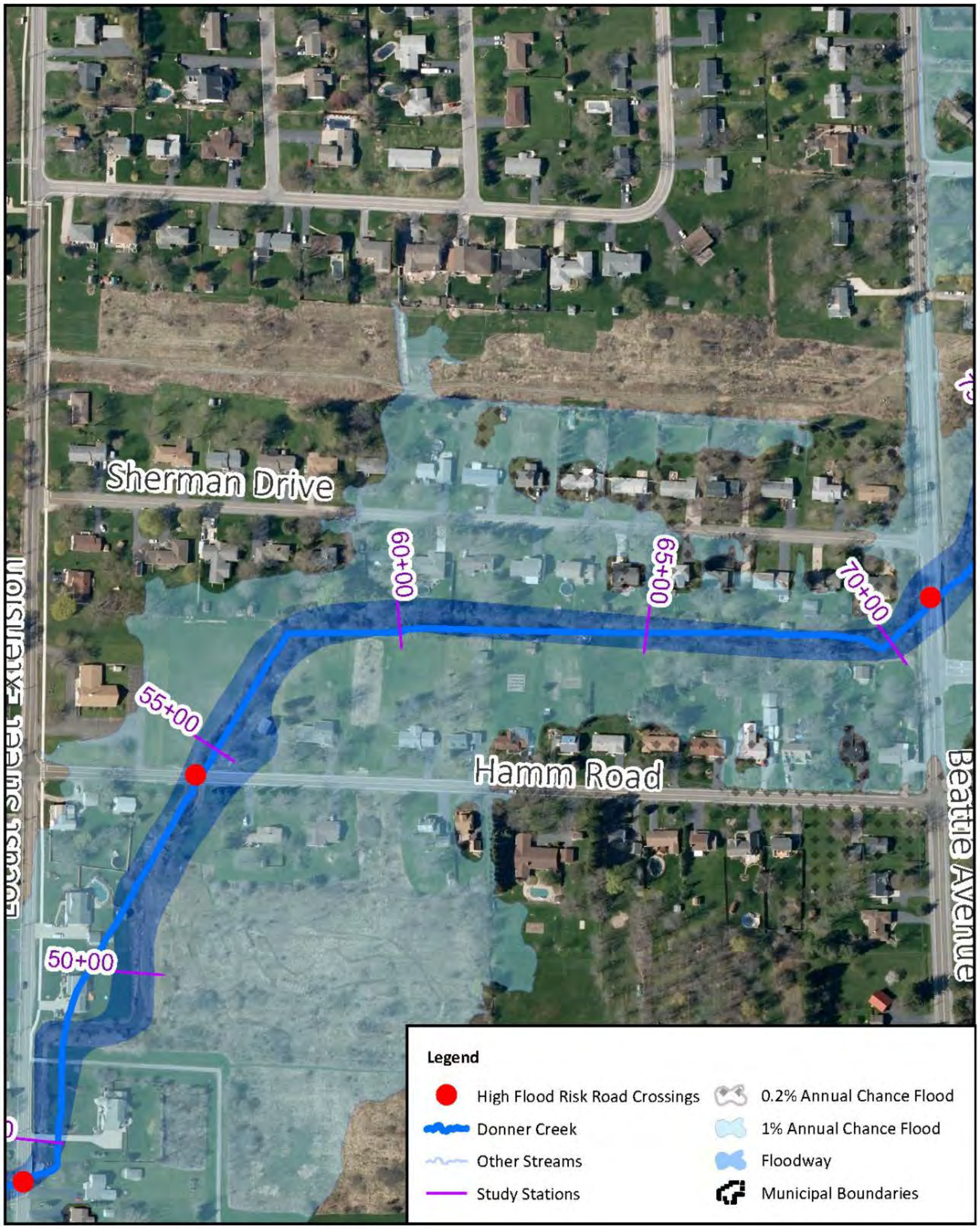
High Flood Risk Area #1: Hamm Road/Sherman Drive (Station 54+39 – 70+95)

High Risk Area #1 is the neighborhood between Sherman Drive and Hamm Road, west of Beattie Ave. in the Town of Lockport (Figure 5). The homes within this residential neighborhood are located on either side of the creek. Approximately 25 homes are located between Sherman Drive and Hamm Road, within this flood prone neighborhood, however none of these homes have been identified as repetitive or severe repetitive loss properties by FEMA. Throughout most of this neighborhood, the channel appears to have been straightened along the property lines between the two streets. This high flood risk area is just upstream of the Hamm Road bridge over Donner Creek (Figure 5).

The effective FIS and FIRMs indicate that the Hamm Road bridge is undersized, with only the 10-percent annual chance discharge passing through the bridge without contacting the low chord. For the 2-percent annual chance discharge, the FIS flood profile indicates that the bridge causes an increase in the upstream water surface elevation of approximately 0.75 feet from the downstream to upstream side of the bridge, with the extent of the water surface increases being no more than approximately 650 feet. Similarly, the flood profile indicates that the 1-percent annual chance water surface elevation is increased by approximately 1.25 feet, across the bridge, due to the bridge constriction, with the water surface increases extending approximately 650 feet. Additionally, 1-percent annual chance discharge is expected to overtop Hamm Road.

Photo 1: Upstream Face of Hamm Road Bridge over Donner Creek

Figure 5. Donner Creek High Flood Risk Area 1



Resilient NY Initiative
Donner Creek Flood Study
Figure 5. Donner Creek
High Flood Risk Area 1

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

Path: P:\Modeling\Projects\02065 - Resilient NY Initiative\GIS\Maps\Donner_Creek_Report\Figure_5_Rev.mxd

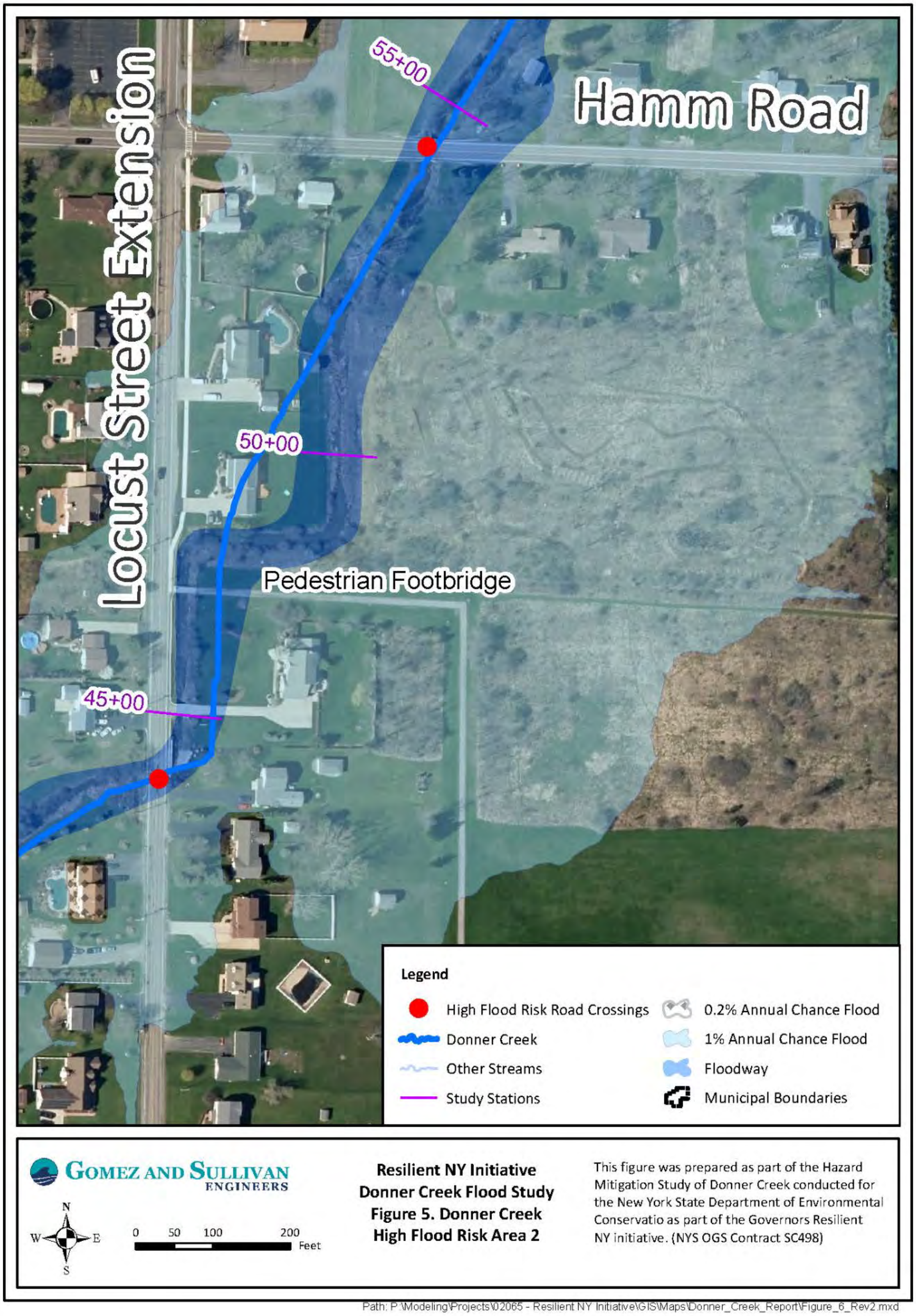
High Flood Risk Area #2: Locust Street/Hamm Road (Station 44+12 – 54+27)

High Risk Area #2 is the residential area east of Locust Street and south of Hamm Road. In this area, Donner Creek runs through many of the homes' yards, and the 1-percent annual chance floodplain is calculated to inundate approximately ten homes in this area. Within this high flood risk area, the creek channel appears to have been re-aligned along some of the property lines, and retaining walls were observed along the stream channel in some locations. This high flood risk area is located just upstream of the Locust Street bridge over Donner Creek (Figure 6).

Immediately upstream of the Locust Street bridge, Donner Creek runs along and parallel to the east side of Locust street, making a hard turn to pass through the bridge. A review of the effective FIS profile indicates that the bridge is not adequately sized to pass the 1-percent annual chance flood discharge, with the low chord being lower than the computed flood elevation both upstream and downstream of the bridge. The flood profile indicates that the bridge causes an increase of nearly one foot for the 1-percent annual chance flood upstream of Locust Street, with the backwater from the bridge opening extending approximately 240 feet upstream to the pedestrian bridge. Within this backwater area, there is one private driveway bridge which was not specifically included in the existing FIS hydraulic model. A review of the results in this area do not indicate that the bridge poses a significant hydraulic constriction beyond the elevated floodplain modeled within this area. The Locust Street bridge has been modified recently, with the height of the opening increased by approximately 0.6 feet from the bridge which was analyzed as part of the FEMA FIS.

Photo 2: Upstream Face of Locust Street Bridge over Donner Creek

Figure 6. Donner Creek High Flood Risk Area 2



High Flood Risk Area #3: South Transit Road/Robinson Road (Station 2+87 – 15+32)

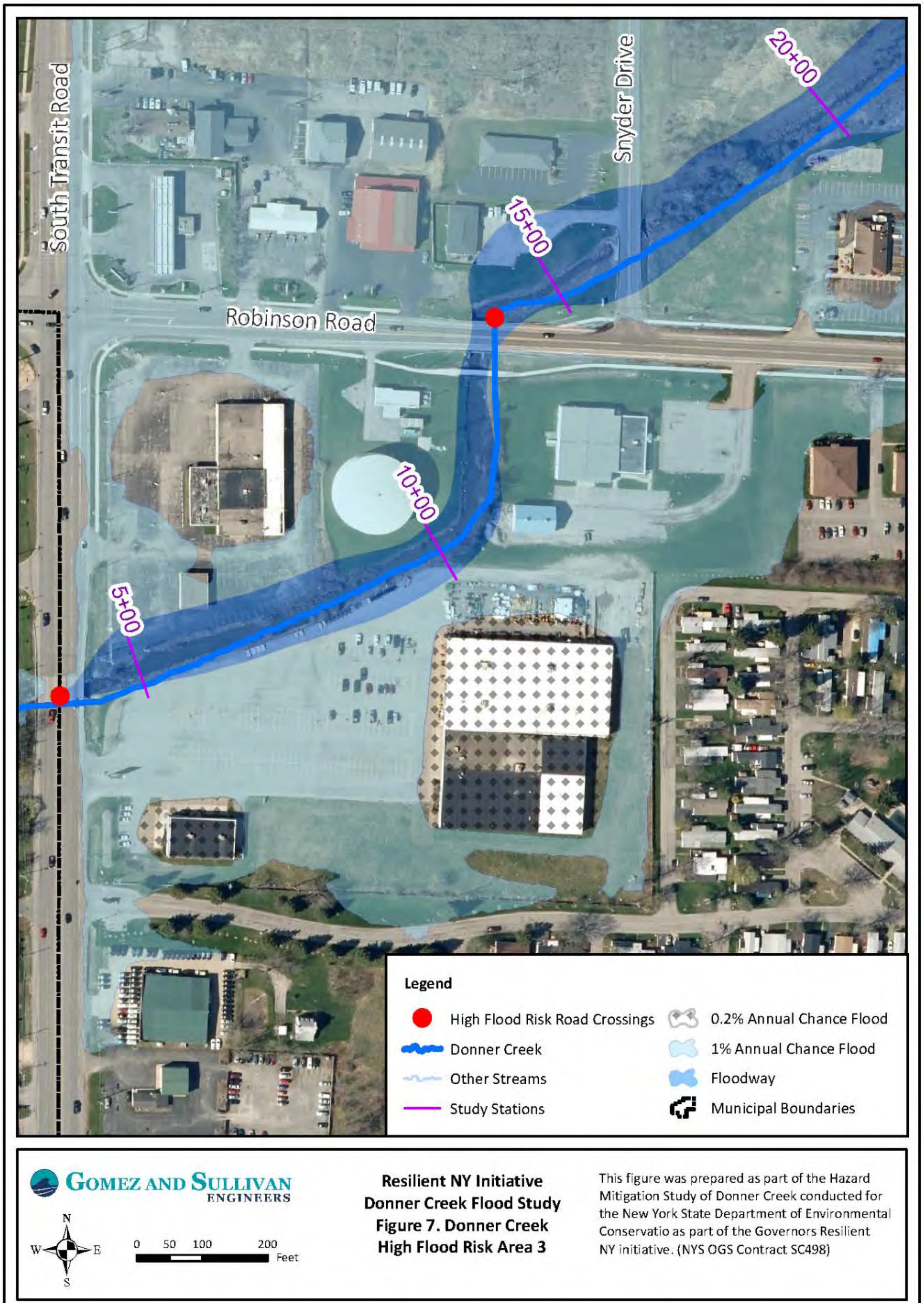
High Flood Risk Area #3 is the commercial area to the west of South Transit Road and along Robinson Road near the intersection with South Transit Road (Figure 7). Also, within this flood prone area are some municipal facilities, including the Town of Lockport building department offices and a Niagara County Water District facility. Based on a review of the effective FEMA FIS and FIRMS, the size of the bridge openings at South Transit (Photo 4) and Robinson Road (Photo 3) are expected to have a significant impact on computed water surface elevations within this area. Additionally, Donner Creek makes a hard turn when entering the Robinson Road bridge. Based on the flood profile, the Robinson Road bridge appears to cause an approximate 1.5-foot increase in the computed 2-percent annual chance flood elevation upstream of the bridge, and an approximate 1.25-foot increase in the computed 1-percent annual chance flood elevation. While the South Transit Road bridge is not included on the effective flood profile, the flood profile does start at the bridge, and indicates that the bridge causes appreciable increases in the computed flood elevations for the 2- and 1- percent annual chance flood discharges for approximately 920 feet upstream, to the Robinson Road bridge.

A pebble count was performed just upstream of the Robinson Road bridge, with silt being the main channel substrate which was encountered. This result reinforces the indication that the South Transit and Robinson Road bridges are not appropriately sized. The predominance of silt in the channel substrate indicates that flow velocities must be significantly reduced upstream of Robinson Road, in order for silt to fall out of suspension in the flow. As flow velocities reduce, the sediments suspended within the flow will start to settle to the channel bottom, with larger sediments falling out first, and smaller sediments falling out last. Comments collected during the community meeting indicated that sedimentation of the channel was a concern for Donner Creek, the results of the pebble count confirm the issue. Field observations at both the South Transit Road and Robinson Road bridges included the presence of high vegetation typical of wetland areas within the creek channel, including cattails. This type of dense vegetation indicates that channel velocities within this portion of the creek are typically very low and may contribute to increased channel roughness and subsequent friction losses leading to reduced channel conveyance.

Photo 3: Upstream Face of Robinson Road Bridge over Donner Creek

Photo 4: Upstream Face of South Transit Road Bridge over Donner Creek

Figure 7. Donner Creek High Flood Risk Area 3



Path: P:\Modeling\Projects\02065 - Resilient NY Initiative\GIS\Maps\Donner_Creek_Report\Figure_7_Rev.mxd

Mitigation Recommendations

Alternative #1: Create Flood Bench to East of Locust Street (Station 46+77 – 53+27)

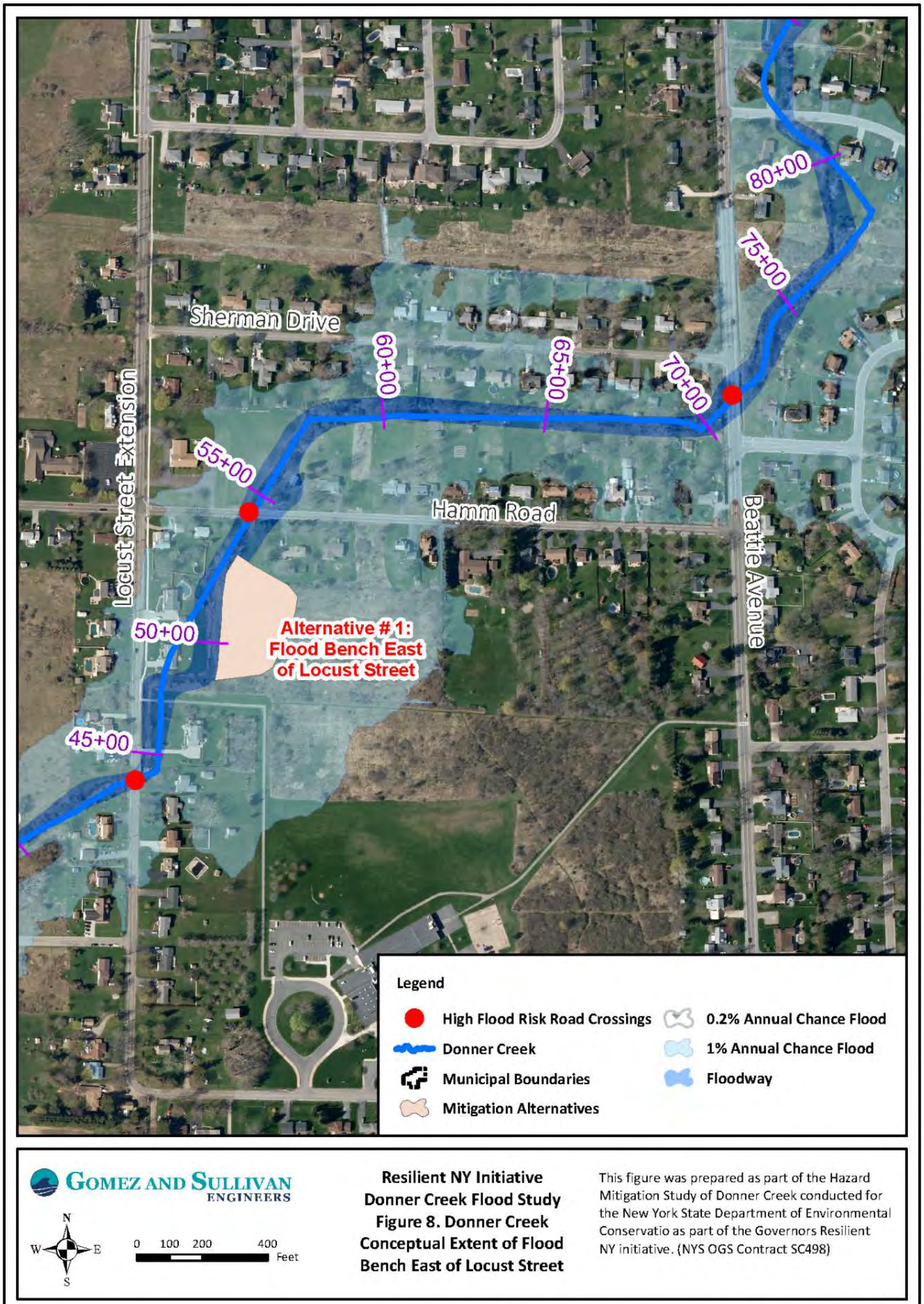
Based on the effective FIS flood profile, between the Locust Street and Hamm Road bridge crossings, computed water surface elevations increase between approximately 1.75 feet for the 1-percent annual chance flood and approximately 3.25 feet for the 10-percent annual chance flood. The majority of the water surface increases were shown to occur between the pedestrian foot bridge and Hamm Road on the effective flood profile. However, the corrected base condition hydraulic modeling indicates that these rises mainly occur between the Locust Street and pedestrian foot bridges, with the Locust Street bridge causing a backwater condition at the pedestrian foot bridge and upstream to the Hamm Road bridge. These computed water surface elevations pose an issue for the ability of the Hamm Road bridge to convey flood discharges, with downstream water surface elevations during the 1- and 2-percent annual chance floods shown to be higher than the low chord of the structure on the effective flood profile. The corrected base conditions hydraulic model indicates that downstream water surfaces would cause a backwater condition at the Hamm Road bridges for discharges as low as the 10-percent annual chance event. Within the area of Locust Street, the cross sections used in the hydraulic model do not indicate that there is a significant amount of conveyance area within the 1-percent annual chance floodplain, outside of the stream channel. To the east of the residences which sit between Locust Street and Donner Creek, there is what appears to be a vacant parcel with approximately 3.5 acres of land within the 1-percent annual chance floodplain. Much of this vacant land sits at a higher elevation than the residential parcels along Locust Street.

This alternative is intended to increase flow area within an intermediate floodplain by lowering the elevation of the land to the east of Donner Creek to create a flood bench. This modification is expected to decrease computed flood elevations in the Locust Street Area and improve the hydraulics of the Hamm Road bridge by lowering water surface elevations downstream of the bridge. Additionally, this flood bench would help to provide flood storage, which could help to mitigate downstream flooding and provide an area where the sediment load of flood waters could safely be deposited.

The modeled alternative consists of widening the left overbank floodplain from approximately 80 feet wide to approximately 250 feet wide. Within the modeled flood bench, the ground elevations would be lowered to approximate elevation 609.4, or approximately 0.3 feet lower than the existing topography adjacent to the channel and 3.5 feet lower than the existing grade at the eastern edge of the modeled flood bench. The conceptual extent of the flood bench is shown in Figure 8. Hydraulic modeling of this alternative, by itself, indicates that adding the flood bench would a minor impact on water surface elevations for the flood discharge events modeled. As shown in Figure 9, the maximum computed decrease in water surface elevations was approximately 0.2 feet immediately upstream of the Hamm Road bridge for the 10-percent annual chance flood discharge, with the impact of the flood bench being diminished by approximately 700 feet upstream of Hamm Road. Similar reductions of 0.2 feet in water surface elevations just upstream of Hamm Road were also computed for the estimated 10-percent annual chance future flood discharge. Note that, for clarity, this figure does not include the computed water surface elevations for the 0.2-percent annual chance discharge, as these water surface elevations are extremely close to the computed water surface elevations for the 1-percent annual chance discharge.

The rough order of magnitude cost for this alternative is $0.6 million, not including land acquisition costs beyond survey, appraisal, and engineering coordination for the parcel upon which the flood bench would be constructed. The majority of the costs for this mitigation alternative relate to the removal and disposal of fill and the creation and planting of wetland within the floodplain bench. Implementation of this alternative would require the cooperation of the current land owner to sell or otherwise transfer rights to the land. As this analysis is intended to be a preliminary evaluation of the mitigation potential of this alternative, the land owner has not been consulted.

Figure 8. Conceptual Extent of Flood Bench East of Locust Street



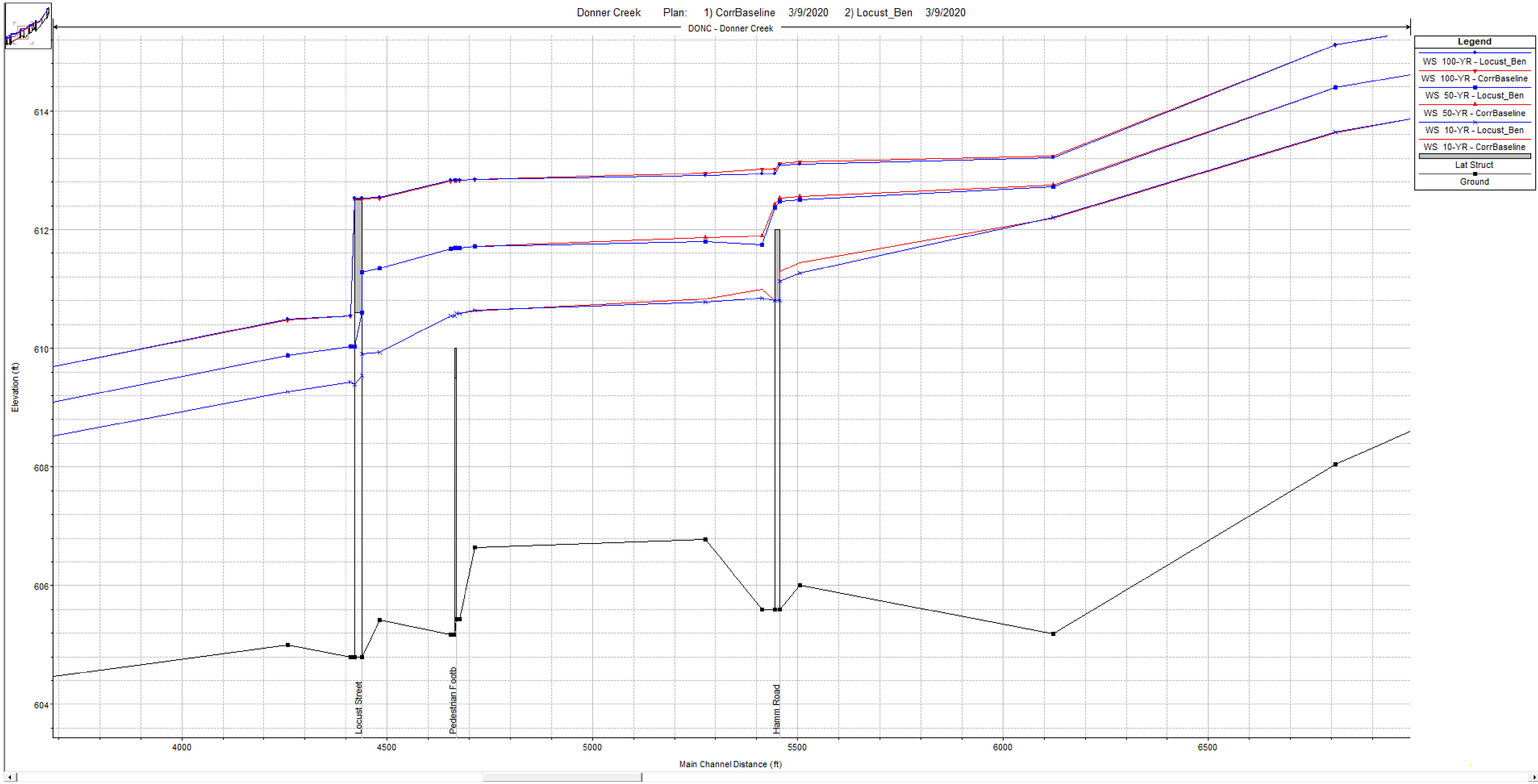


Figure 9. Comparison of Computed Water Surface Elevations for Alternative #1: Locust Street Flood Bench

Alternative #2: Modify Locust Street Bridge (Station 44+03)

The effective FIS flood profile and corrected base condition hydraulic model both indicate that the Locust Street bridge has a significant impact on upstream water surface elevations for all of the modeled discharge events. The hydraulic model developed for this study, indicates that the constriction of the floodplain due to the Locust Street bridge causes increased water surface elevations from downstream to upstream of the bridge ranging from approximately 0.5 feet for the 10-percent annual chance flood discharge to approximately two feet for the 1- and 0.2-percent annual chance flood discharges. Both the FIS flood profile and the corrected base condition model indicate that the bridge's low chord is approximately equal to the downstream water surface elevation for the 1-percent annual chance flood discharge. In order to comply with the draft CRRA infrastructure guidelines, the low chord of the bridge would have to be raised approximately two feet in order to provide the appropriate freeboard, assuming that the modified bridge does not cause a significant rise in the water surface elevation upstream of the bridge. Additionally, the width of the bridge opening is currently narrower than the channel upstream and the estimated bank full width at the bridge. Utilizing the NYSDOT's standards, the low chord would need to be raised at least 1.6 feet. Given the minor difference between the modifications required by the two low chord standards, this alternative is based on meeting the draft CFFA guidelines. The proposed alternative would replace the existing bridge with a wider bridge which corresponds to the already constricted upstream channel, and has a low chord elevation which is two feet above the computed 1-percent annual chance flood elevation, resulting in a bridge opening that is 30 feet wide, with a low chord elevation of 612.8 feet (NAVD 88). Due to the high downstream water surface elevation, this bridge cannot be modified without raising the low chord while still meeting the current NYSDOT criteria.

This alternative is expected to have the greatest impact on the computed 1-percent annual chance water surface elevations, with an approximate reduction of 1.5 feet in the computed water surface elevation immediately upstream of the Locust Street bridge, 0.7 feet just downstream of the Hamm Road Bridge and the impacts extending to approximately 700 feet upstream of Hamm Road, as shown in Figure 10. Figure 11 depicts the computed water surfaces for the 0.2-percent annual chance discharge for this alternative, where the maximum reduction in water surface elevation is approximately 1.3 feet immediately upstream of the Locust Street bridge, and the computed reduction is approximately 0.6 feet just downstream of Hamm Road. Approximately the same water surface reductions were computed for the predicted future 1-, and 0.2-percent annual chance flows. Computed water surface elevations for the 2-percent annual chance discharge are shown in Figure 12, the maximum computed reduction in water surface elevations is approximately 1.1 feet at the Locust Street bridge, and 0.3 feet downstream of the Hamm Road bridge. For the 2-percent annual chance future flow, similar water surface reductions were computed just upstream of the Locust Street Bridge, however a slightly greater reduction of 0.4 feet was computed downstream of Hamm Road. This alternative, for the modification of the Locust Street Bridge is not computed to have an appreciable impact on the computed water surface elevations for the 10-percent annual chance discharge, beyond the pedestrian bridge. Although raising the bridge will result in some fill within the overbank area, the floodplain within the area of this bridge is currently constricted, which minimizes the potential negative effects of raising the bridge.

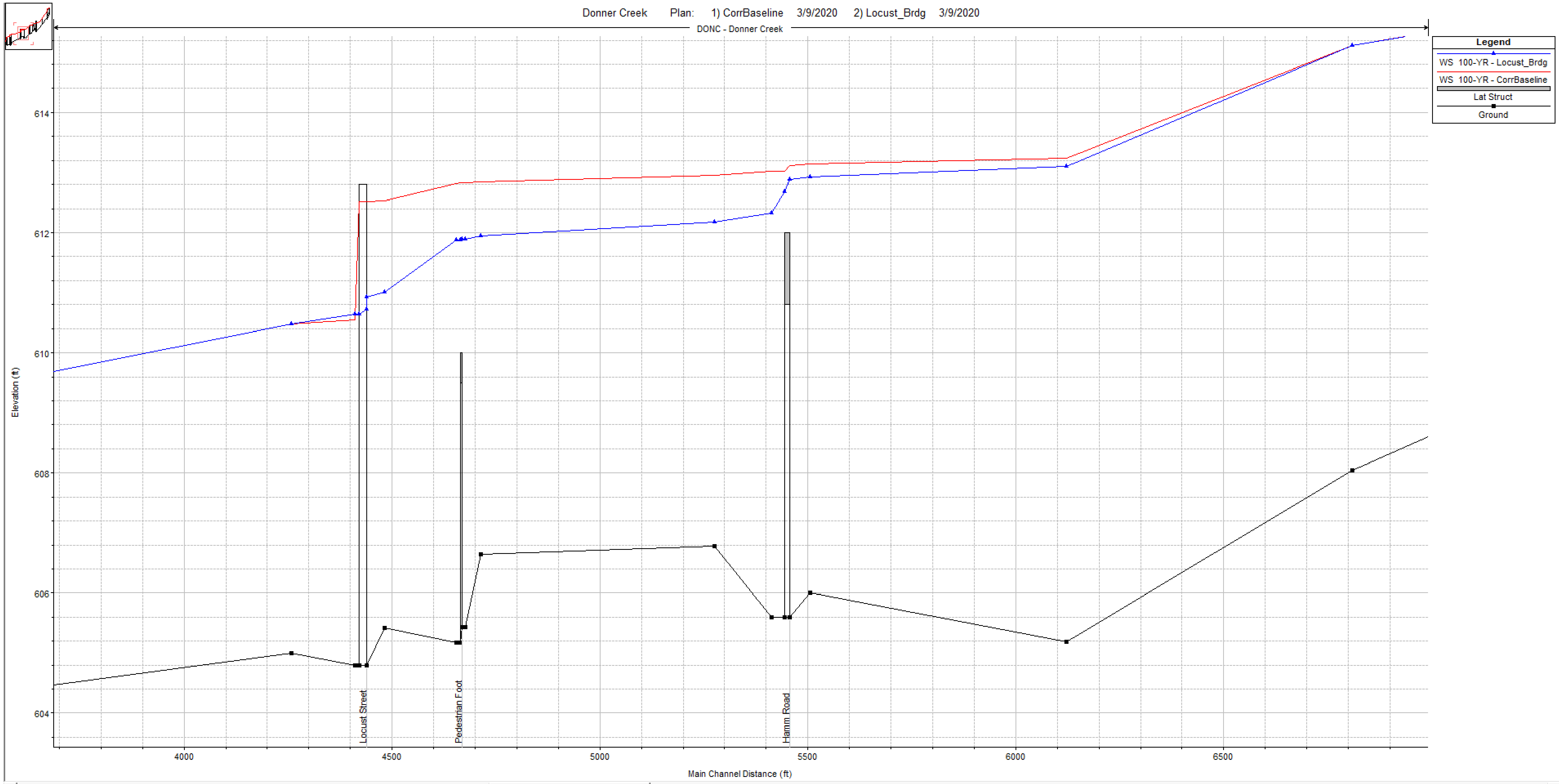


Figure 10. Comparison of 1-Percent Annual Chance Water Surface Elevations for Locust Street Bridge Modification Alternative

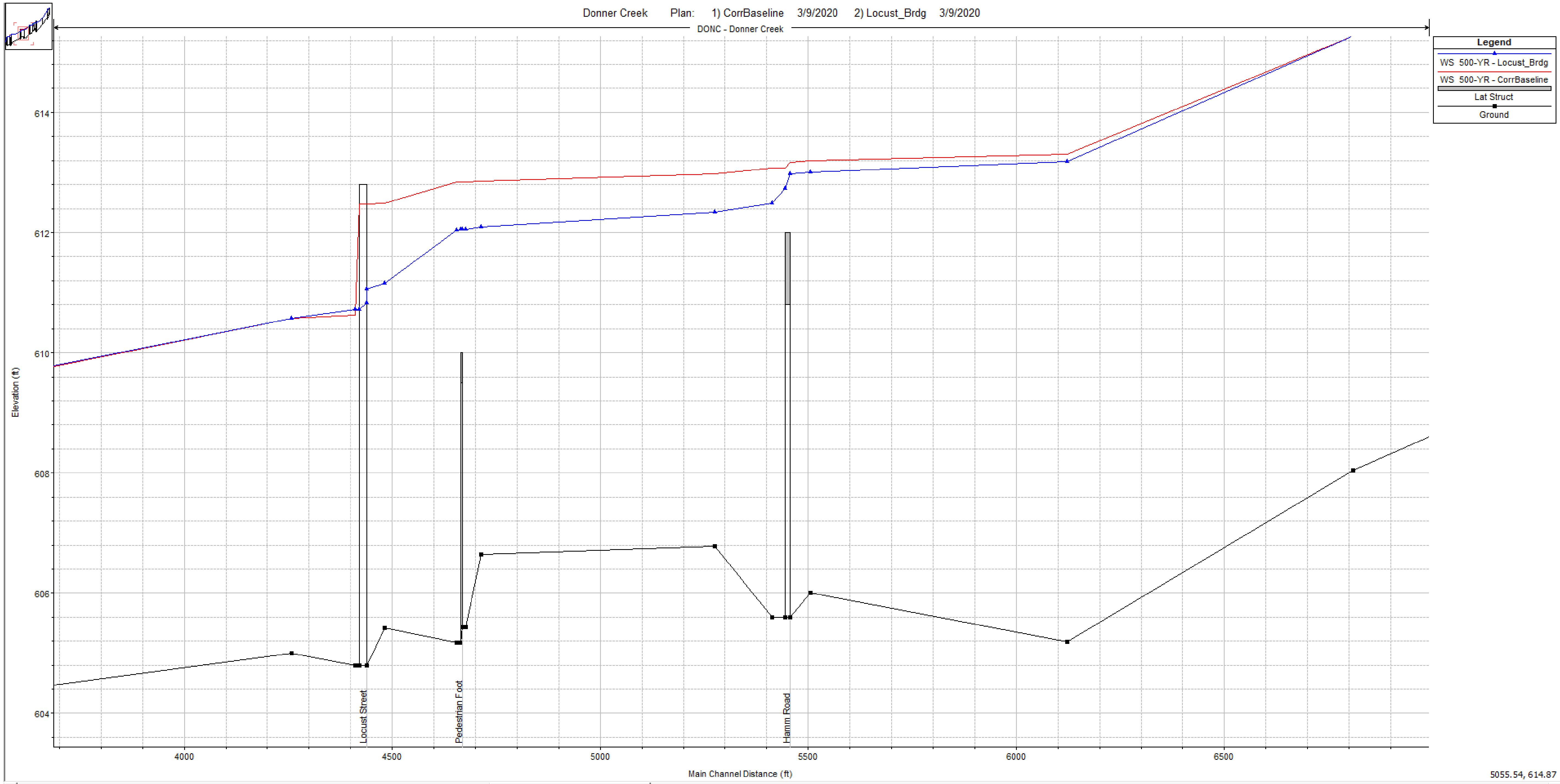


Figure 11. Comparison of 0.2-Percent Annual Chance Water Surface Elevations for Locust Street Bridge Modification Alternative

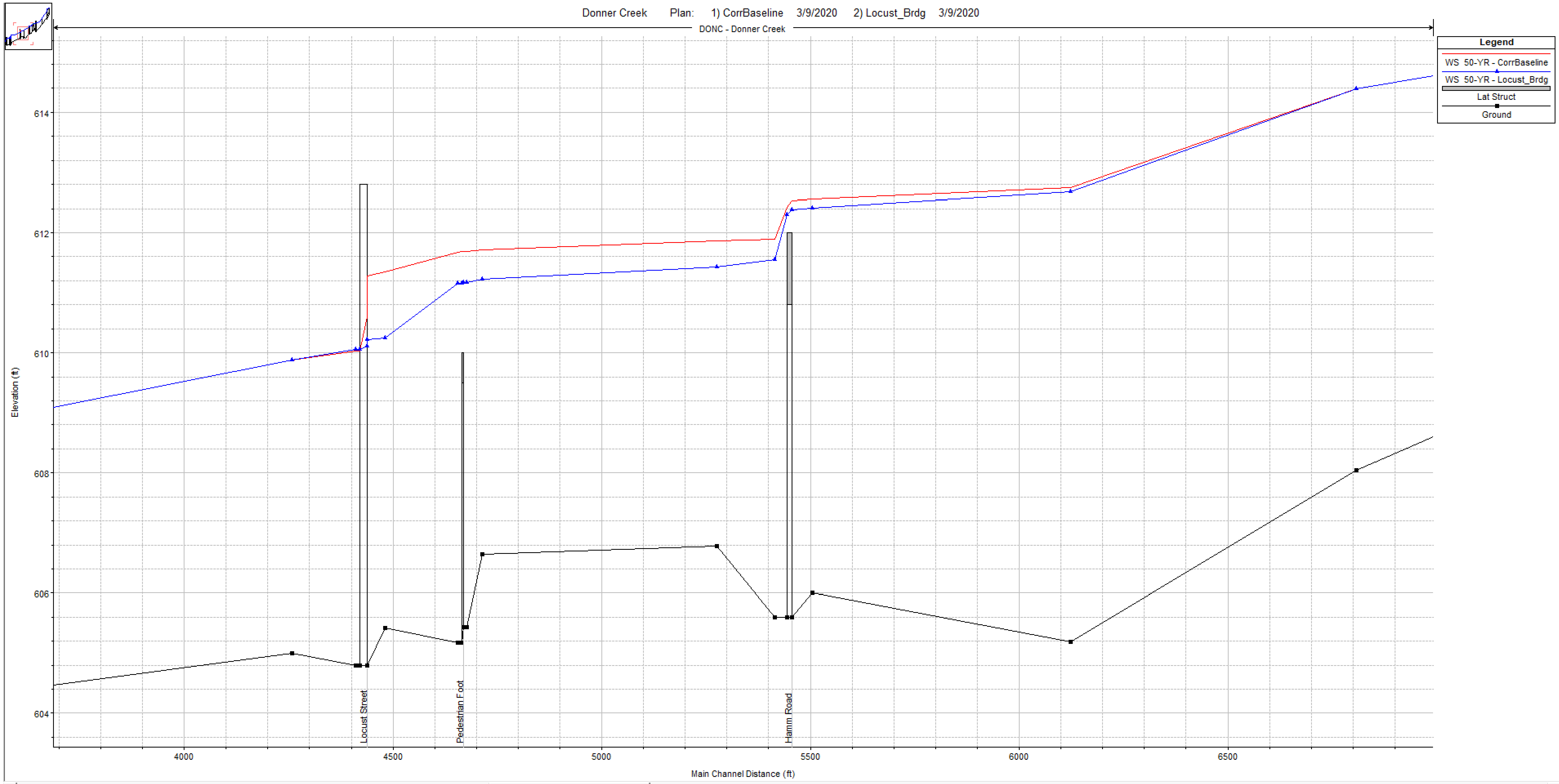


Figure 12. Comparison of 2-Percent Annual Chance Water Surface Elevations for Locust Street Bridge Modification Alternative

The rough order of magnitude cost for this alternative is $1.1 million, including the cost of raising the road approaches to either side of the bridge.

Alternative #3: Modify Locust Street Bridge and Create Flood Bench to East of Locust Street (Station 44+03 – 53+27)

This potential flood mitigation alternative combines the addition of a flood bench to the east of Locust Street, and modification to the Locust Street bridge, as described in Alternative #1 and Alternative #2, respectively. The intent of this alternative is to improve the hydraulic capacity of the Hamm Road bridge, in addition to lowering water surface elevations along Locust Street, by increasing the flow area within the floodplain, to minimize the computed increases in water surface elevations between the Locust Street and Hamm Road bridges. Hydraulic modeling of this alternative indicates that the addition of the flood bench would decrease computed water surface elevations just downstream of the Hamm Road bridge between approximately 0.1 and 0.2 feet for the 10-percent to 0.2-percent annual chance discharges, beyond the modification of the Locust Street bridge described in Alternative #2, for both the current and future predicted flows. Additional decreases, from that alternative, are computed to extend approximately 700 feet upstream of Hamm Road. Figure 13 provides a comparison of computed water surface elevations for this alternative with the base condition.

The rough order of magnitude cost for this alternative $1.7 million, not including land acquisition costs beyond survey, appraisal, and engineering coordination for the parcel upon which the flood bench would be constructed. Implementation of this alternative would require the cooperation of the current land owner to sell or otherwise transfer rights to the land. As this analysis is intended to be a preliminary evaluation of the mitigation potential of this alternative, the land owner has not been consulted.

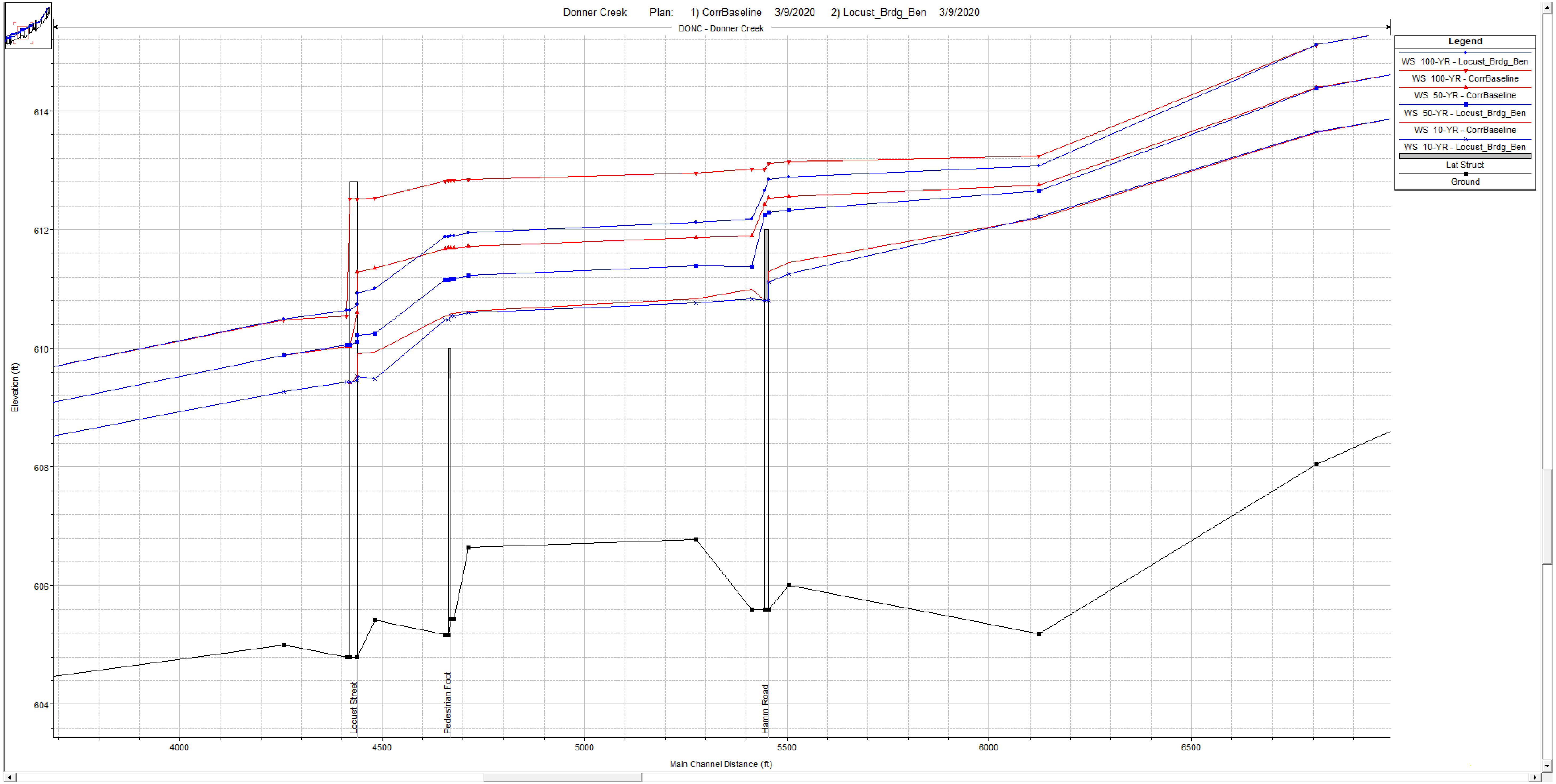


Figure 13. Comparison of Computed Water Surface Elevations between Baseline Conditions and Locust Street Modification and East Flood Bench Alternative

Alternative #4: Create Flood Bench to West of Locust Street (Station 23+19 – 39+50)

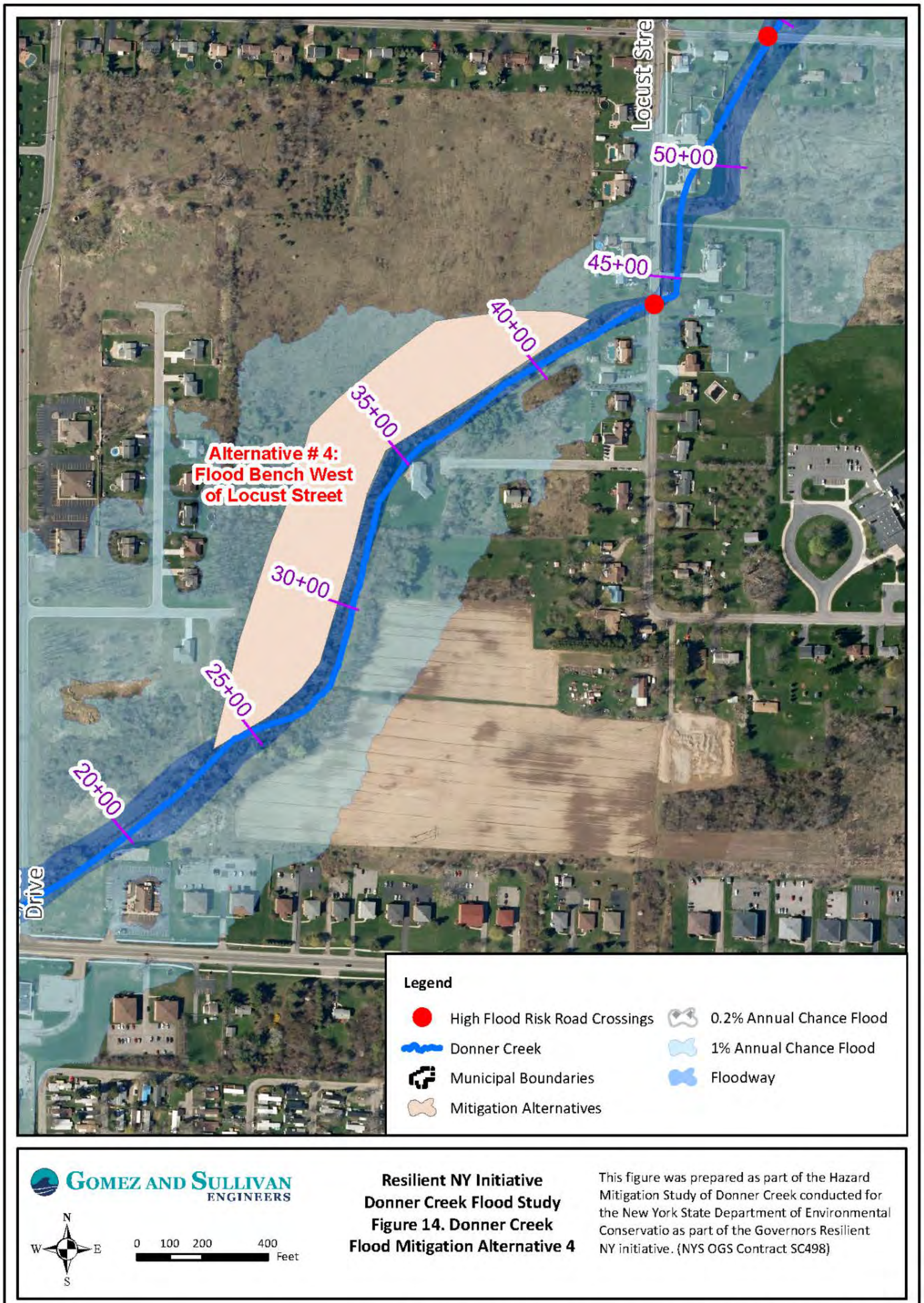
As noted above, water surface elevation downstream of the Locust Street bridge are computed to be at approximately the same elevation as the low chord for the 1-percent annual chance discharge. This high downstream water surface elevation reduces the hydraulic capacity of the bridge and likely increases upstream water surface elevations. Providing additional flow area downstream of the bridge may improve the bridge hydraulics and translate into lowered upstream water surface elevations as well. To the west of Locust Street, there is an approximately 34-acre plot of mostly vacant land, to the north of Donner Creek. Throughout this area, the floodplain for the 10-, and 2-percent annual chance floodplain is relatively constricted, and the 1-percent annual chance floodplain is constricted immediately downstream of Locust Street. This alternative would include the construction of a flood bench to the northwest of Donner Creek, within an approximate 1,200-foot long reach of the creek, and reaching an approximate width of 250 feet. The elevations of the terrain within the flood bench would be lowered to between the approximate bank-full and 10-percent annual chance water surface elevations. The conceptual extent of this flood bench is shown in Figure 14.

As shown in Figure 15, this alternative would have the greatest impact on the computed water surface elevation for the 1-percent annual chance discharge just downstream of the Locust Street bridge. The mitigation alternative is computed to lower the water surface elevation downstream of the bridge approximately 0.3 feet just downstream of the Locust Street bridge for current flow conditions, a decrease of approximately 0.4 feet was computed at this location for the future flow. The mitigation alternative is computed to have a similar impact on the 0.2-percent annual chance water surface elevation for both current and future flows, and lesser impacts on the higher frequency discharge events.

This mitigation alternative is not expected to have an appreciable impact on the level of flooding at more than one or two residences. However, it could contribute to additional decreases in flooding when combined with other mitigation alternatives which include modification of the Locust Street bridge and could limit the amount which the low chord of the bridge would need to be raised to meet the CRRA freeboard requirements.

The rough order of magnitude cost for this alternative is $2.5 million, not including land acquisition costs beyond survey, appraisal, and engineering coordination for the parcel upon which the flood bench would be constructed. The majority of the costs for this alternative relate to the removal and disposal of fill and the creation and planting of wetland within the floodplain bench. Implementation of this alternative would require the cooperation of the current land owner to sell or otherwise transfer rights to the land. As this analysis is intended to be a preliminary evaluation of the mitigation potential of this alternative, the land owner has not been consulted.

Figure 14. Conceptual Extent of Flood Bench West of Locust Street



Path: P:\Modeling\Projects\02065 - Resilient NY Initiative\GIS\Maps\Donner_Creek_Report\Figure_14_Rev.mxd

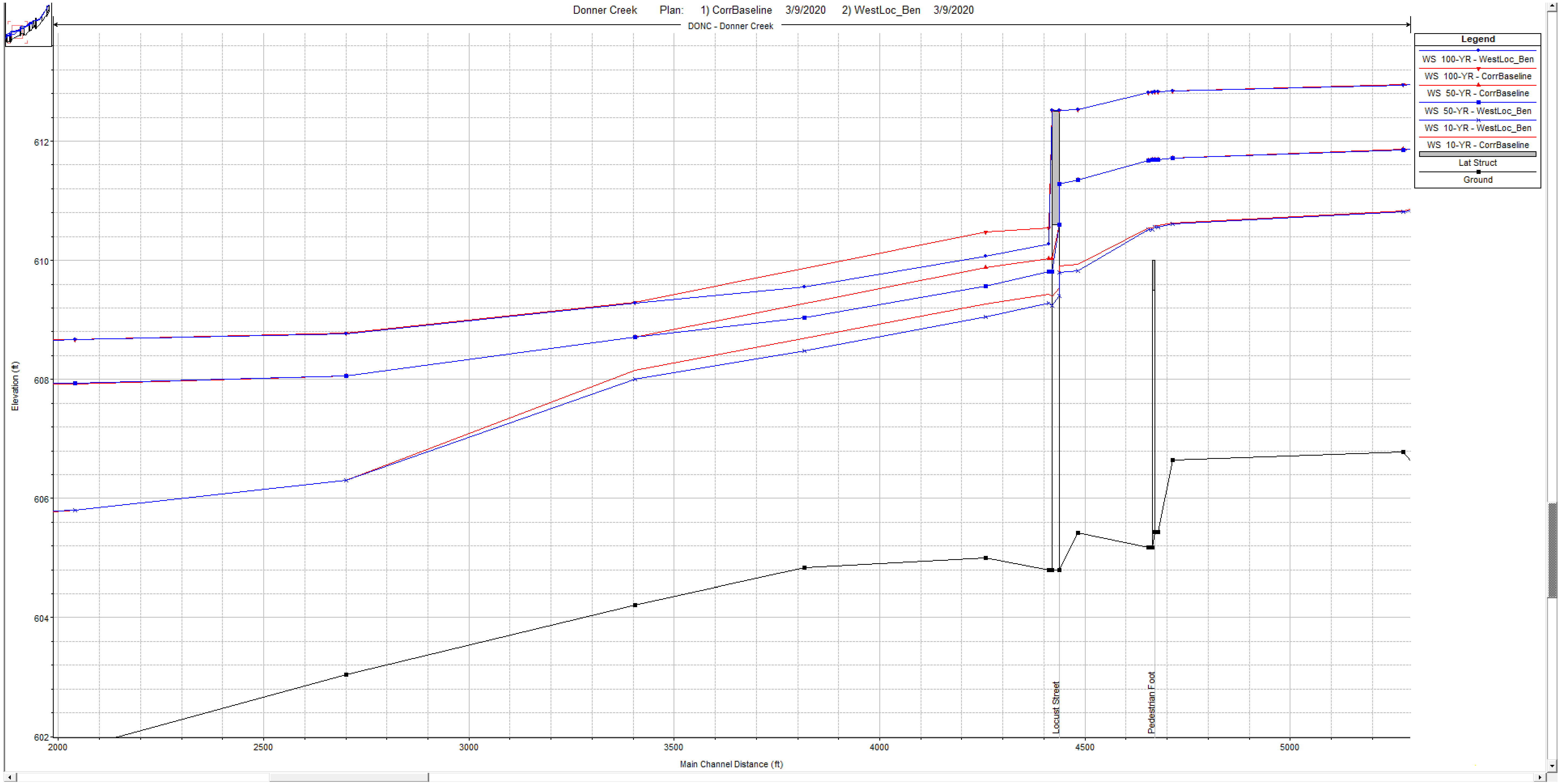


Figure 15. Comparison of Computed Water Surface Elevations between Baseline Conditions and Flood Bench West of Locust Street Alternative

Alternative #5: Create Flood Bench to West of Locust Street and Modify Locust Street Bridge (Station 23+19 – 44+03)

This potential flood mitigation alternative combines the modification to the Locust Street bridge, and addition of a flood bench to the west of Locust Street, as described in Alternative #2 and Alternative #4, respectively. The decrease in water surface elevations downstream of bridge may allow the modified bridge to have a low chord elevation that is slightly lower than that discussed in Alternative #4; such details would be part of the final design for the mitigation approach. The intent of this alternative is to improve the hydraulic capacity of the Locust Street bridge, and lower water surface elevations along Locust Street including just downstream of Hamm Road. Hydraulic modeling of this alternative indicates that the addition of the flood bench would decrease computed water surface elevations just upstream of the Locust Street bridge approximately 0.2 feet for the 10-percent to 0.2-percent annual chance current and future predicted discharges, beyond the modification of the Locust Street bridge described in Alternative #2. Appreciable additional decreases, from that alternative, are only computed to extend to the pedestrian footbridge, approximately 225 feet upstream of Locust Street.

The largest decrease in computed water surface elevation, for this combined alternative is approximately 1.8 feet, for the current 1-percent annual chance discharge, upstream of the Locust Street bridge, as compared to the base case model; under the predicted future 1-percent annual chance discharge the computed reduction is approximately 1.7 feet in this location. Decreases of approximately 1.3 feet and 0.6 feet were computed at this location for both the current and future predicted 2-, and 10-percent annual chance discharges, respectively. Decreases in the computed water surface elevations for this mitigation alternative extend to approximately 700 feet upstream of Hamm Road, with appreciable decreases being limited to downstream of the pedestrian footbridge for the 10-percent annual chance discharge. Figure 16 depicts the computed results of this mitigation alternative, in relation to the base case model.

The rough order of magnitude cost for this alternative $3.6 million, not including land acquisition costs beyond survey, appraisal, and engineering coordination for the parcel upon which the flood bench would be constructed. The possibility of slightly lowering the bridge elevation from Alternative #4, as discussed above, is expected to have a negligible impact on the rough order of magnitude cost estimate. Implementation of this alternative would require the cooperation of the current land owner to sell or otherwise transfer rights to the land. As this analysis is intended to be a preliminary evaluation of the mitigation potential of this alternative, the land owner has not been consulted.

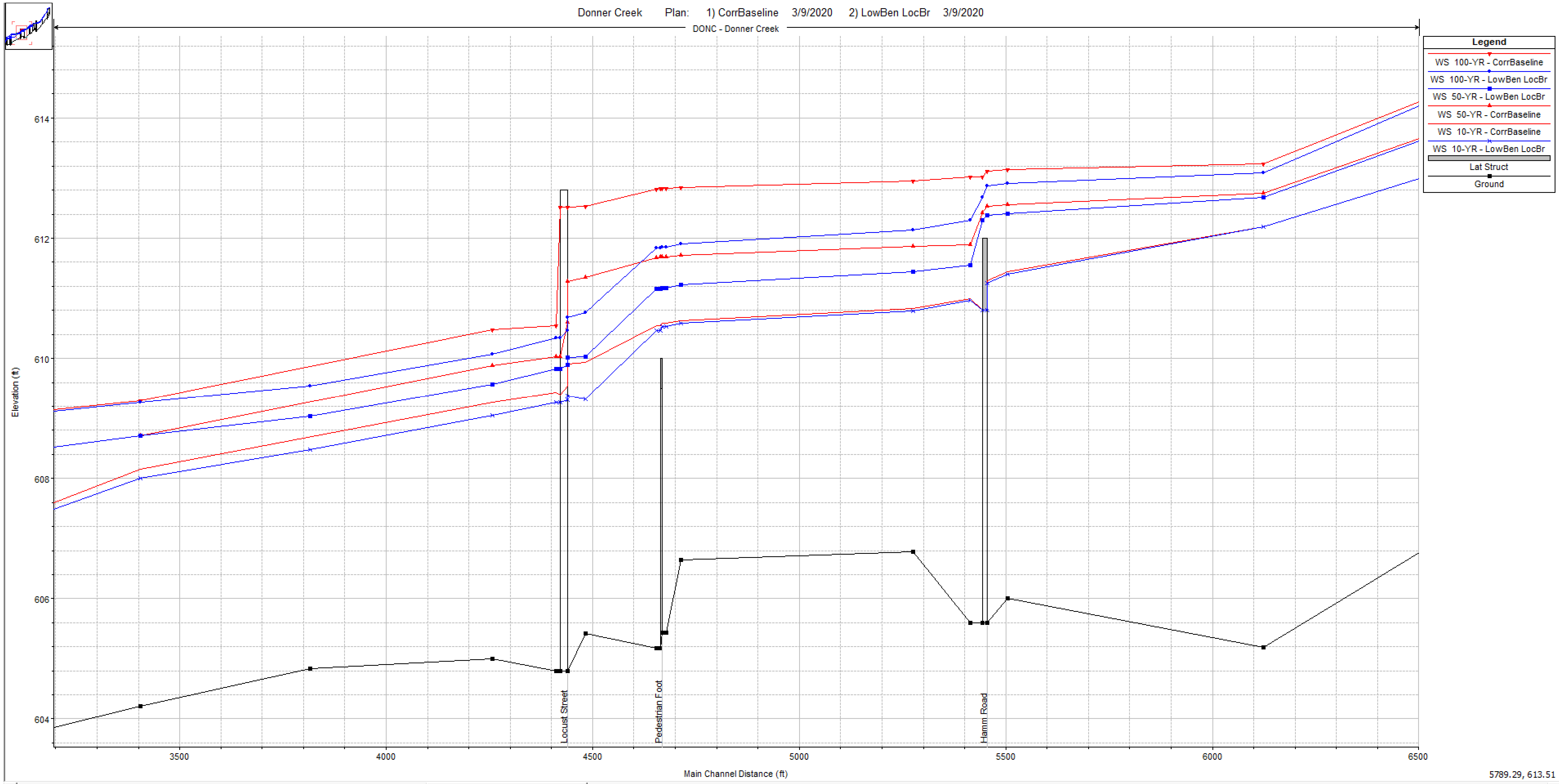


Figure 16. Comparison of Computed Water Surface Elevations between Baseline Conditions and Flood Bench West of Locust Street and Locust Street Bridge Modification Alternative

Alternative #6: Modify Hamm Road Bridge (Station 54+33)

The effective flood profile indicates that the bridge at Hamm Road causes significant increases in water surface elevations upstream of the road, ranging from just under 0.5 feet for the 10-percent annual chance discharge to over one foot for the 1-percent annual chance discharge, with the low chord of bridge shown to below both the upstream and downstream water surface elevations. Within the approximately 1,500 feet downstream of Hamm Road, the current flood profile indicates that the stream channel elevation is significantly different than was assumed in the hydraulic analysis which was the source of the water surface elevations shown on the profile. The elevation data from the current LiDAR dataset provides channel elevations in this area which more closely match the current flood profile than the source modeling. The current base condition model was based on the LiDAR elevation data and field measurements of the structures, this change to the channel elevations resulted in significantly different computed water surface elevations near the Hamm Road bridge. The current base condition model indicates that the 1- and 0.2-percent annual chance discharges are relatively unaffected by the bridge due to the high downstream water surface elevations. Based on the current condition base model, the limited flow capacity of the Hamm Road bridge opening is computed to cause an approximate rise of 0.5 feet upstream of the bridge for the 10-percent annual chance discharge, and a rise of approximately 0.7 feet upstream of the bridge for the 2-percent annual chance discharge.

Modeling of the current base condition, and the five alternatives discussed above, indicate that water surface elevations downstream of the bridge are at or above the low chord elevation for the Hamm Road bridge for the 10-percent annual chance discharge and above. For higher flows, such as the 2-, 1-, and 0.2-percent annual chance discharges, the roadway is expected to overtop, with up to approximately one quarter of the discharge flowing over the roadway for the lower frequency discharges. In order to meet either the draft freeboard requirements of CRRA or the NYSDOT freeboard standards, the bridge would have to be raised significantly, even taking into account the potential impacts of other mitigation alternatives. A modification to the bridge which doesn't meet either of the freeboard requirements, but raises the low chord above the computed water surface elevation for higher frequency discharges is likely to have a limited impact on upstream water surface elevations for the lower frequency discharges, and may raise those upstream water surface elevations. The computed water surface elevations that are above the current low chord of the bridge make meeting the NYSDOT freeboard guidelines impossible by only widening the bridge opening. Therefore, modification of the Hamm Road bridge was not considered to be feasible and modeling of this alternative was not performed.

Alternative #7: Modify Robinson Road Bridge (Station 12+69)

Constriction of the floodplain by the Robinson Road bridge is expected to result in increases to the upstream water surface elevation between approximately 1.5 and 1.2 feet, for the 2- and 1-percent annual chance discharges, based on the effective flood profile. The corrected base condition model indicates that the Robinson Road Bridge causes an increase of approximately 1.3 feet for the 1-percent annual chance discharge, and approximately 0.8 feet for the 2-percent annual chance discharge. While the limited hydraulic capacity of the bridge does cause significant increases in the upstream water surfaces, their extent and flooding impact are limited by the slope of the channel upstream of Snyder Drive, and the lack of structures within the floodplain north of the area along Robinson Road. The low chord of the bridge is computed to be lower than the downstream water surface elevations for these discharges, partially due to a backwater condition from the bridge at South Transit Road. Based on the current base conditions model, the downstream water surface elevation for 1-percent annual chance discharge is approximately 1.6 feet higher than the low chord of the bridge. Meeting the draft CRRA recommendations for freeboard, the low chord of the bridge would have to be raised a minimum of 3.6

feet, and likely more to provide adequate freeboard at the upstream side. Adhering to the NYSDOT freeboard standards would require raising the low chord at least three feet, based on the current downstream hydraulics. While the existing bridge geometry may be able to be optimized to reduce the deck thickness and limit the impact of the higher bridge on the road grade, it is expected the bridge modification would result in a raise in the road grade of at least 2.5 feet in the area of the bridge. Given the proximity of the bridge to South Transit Road, such a change to the road grade would require a modification of South Transit Road. It was noted by the NYSDOT in discussion of this alternative that there are currently no plans to replace or improve this bridge; implementation of this alternative would require coordination with the NYSDOT, who owns this bridge. Given the limited potential impact of this modification on flood inundation, this alternative was not explored further; modifying the downstream South Transit Road bridge is expected to have a more significant impact on flood inundation at a similar cost.

Alternative #8: Modify South Transit Road Bridge (Station 2+87)

The effective flood profile does not include the South Transit Road bridge. However, the rapid rise in the plotted water surface elevations within the approximate first 40 feet of the flood profile indicate that the bridge was included in the modeling used for the FIS, and that the bridge is not adequately sized to pass at least the 2- and 1-percent annual chance discharges. The results of the current base condition model lead to the same conclusion regarding the size of the South Transit Road bridge, with elevation rises of approximately two feet for 1-percent annual chance discharge and 1.6 feet for the 2-percent annual chance discharge computed across the bridge. The high water surface elevations upstream of the bridge also appear to limit the capacity of the Robinson Road bridge by creating a backwater condition for the 2, and 1-percent annual chance discharges.

This mitigation alternative includes raising the South Transit Road bridge, and widening the opening to decrease flood elevations for higher frequency discharges. In order to meet the draft CRRA guidelines for freeboard, the low chord of the bridge would have to be raised a minimum of approximately two feet, and likely more to provide adequate freeboard at the upstream side. Based on the computed water surface elevation at the downstream side of the bridge, meeting the NYSDOT freeboard standards would require raising the bridge at least 1.3 feet. As the current bridge deck is relatively thin, it is expected that a similar raise to the roadway would be required to accommodate the higher low chord elevation. An iterative modeling procedure was performed to select an appropriate modified bridge opening. The proposed bridge modification would result in a bridge opening width of 40 feet and a low chord elevation of 607.5 feet (NAVD 88), meeting the draft CRRA guidelines. Modifications to the bridge which do not raise the low chord would not meet the NYSDOT freeboard criteria, based on the downstream channel hydraulics. A slightly lower bridge opening, with a low chord elevation of approximately 606.8 feet (NAVD 88) could be used to only meet the NYSDOT freeboard criteria, and still produce the same reductions in upstream water surface elevations, as that low chord would not contact the computed upstream water surfaces for any of the current or future predicted flows evaluated. In discussion of this alternative, the NYSDOT noted that there is currently no plan to replace or improve this bridge; implementation of this alternative would require coordination with the NYSDOT, who owns this bridge.

Modeling of this alternative indicates that this mitigation alternative will have the greatest impact on the computed 1-percent annual chance water surface elevation, with a computed 0.9 feet of reduction in water surface elevation just upstream of the South Transit Road bridge, for both current and predicted future flows. Appreciable impacts on the computed water surface elevation for the 1-percent annual chance event are limited to the area between South Transit Road and Snyder Drive. For the 2-percent annual chance discharge, the proposed modification to the South Transit Road bridge is computed to have a similar impact at the bridge, lowering the computed water surface upstream of the bridge approximately 0.9 feet for the current flow and approximately 0.8 feet for the predicted future flow. For the 2-percent annual chance flood, reduced water surface elevations were computed to extend approximately 1,050 feet upstream of Snyder Drive. Figure 17 provides a comparison of the computed water surface elevations for the corrected base condition and South Transit Road bridge modification alternative models, under current the 1-, 2-, and 10-percent annual chance discharges.

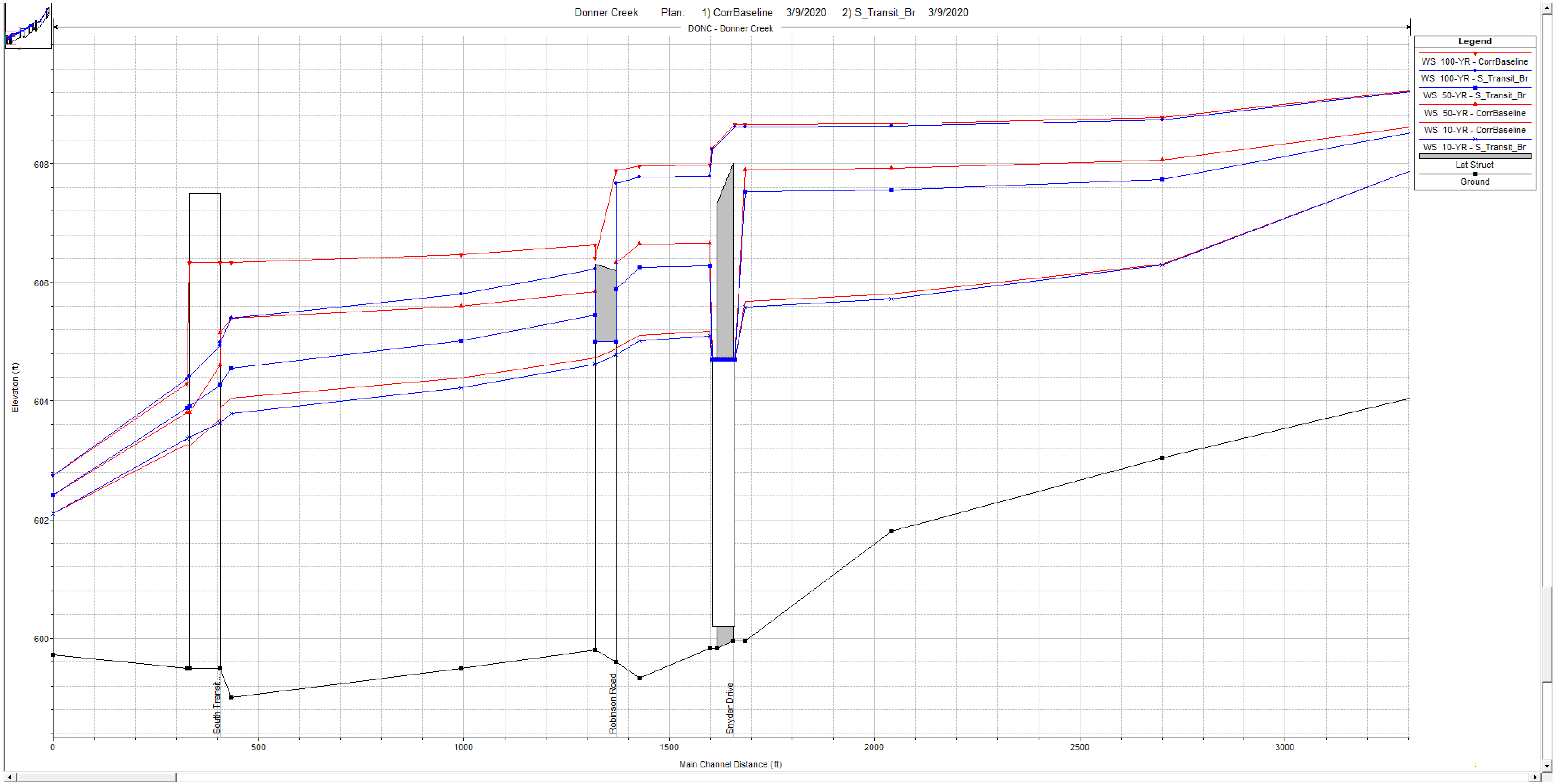


Figure 17. Comparison of Computed Water Surface Elevations between Baseline Conditions and South Transit Road Bridge Modification Alternative

The rough order of magnitude cost estimate for this mitigation alternative is $3.3 million.

As shown in Figure 17, above, even a significant modification to the bridge at South Transit Road is not expected to significantly reduce the computed 2- and 1-percent annual chance water surface elevations downstream of the Robinson Road bridge. These limited reductions mean that even after modifying the Transit Road bridge, a modification to the Robinson Road bridge would need to include a significant raise to the low chord in order to meet either the CRRA or NYSDOT freeboard criteria, with expected minimal reductions in structure flooding. Therefore, a combined mitigation alternative to modify both the Robinson Road and Transit Road bridges was not explored, as the additional impact on flooding of structures is not expected to be significant is comparison to the additional cost of modifying the Robinson Road bridge.

Alternative #9: Channel Maintenance

The 2008 Donner Creek Watershed Analysis Report stated that survey at that time had indicated the buildup of sediment between two and four feet deep, since the 1976 FIS flood profile (Wendel Duchscherer, 2008). Field observations during site visits for this study indicated that some sedimentation had occurred in the channel, based on the accumulation of silt at the channel bottom. The survey referenced in the 2008 report was not available for review until after the draft study report was prepared. Following completion of the draft report, the channel profile comparisons from the 2008 report were obtained and reviewed. The plots indicate a significantly lower channel profile based on a 1976 survey than was modeled in the original FIS (1980); the elevations from the 2008 survey are much closer to the elevations modeled in the original FIS. The source data from the 1976 profile could not be located for review. Therefore, the effects of sediment removal were evaluated for two scenarios; the first to more closely replicate the channel profile that was modeled in the original FIS, and the second to more closely replicate the channel profile identified as the 1976 profile.

Current data collected during this study were compared with the original HEC-2 hydraulic model and 1992 FIS flood profile to evaluate the extent of sedimentation within the channel since the original FIS study. A comparison of field measurements made at the South Transit Road and Hamm Road bridges indicated that, at most, minor sedimentation has occurred at these locations. At South Transit Road, the greatest measured opening height closely matches the difference between the ground and low chord elevation shown on the original FIS flood profile, and included in the HEC-2 model. Multiple heights were measured across the upstream face of the opening, with a maximum decrease of 0.7 feet from that shown on the original FIS flood profile. The field measurements indicate that between 0 and 0.7 feet of sediment has accumulated at the South Transit Road bridge. At Hamm Road, the maximum height of opening measured during field work for this study was 0.7 feet more than that used in the original FIS model, no significant difference in the height between the low chord and the channel bottom was measured across the width of the opening. Other bridges within the original FIS model reach, where field measurements were taken, include Locust Street and Robinson Road. Field measurements and observations at these locations indicate that the bridges have been replaced since the original FIS model. Removal of sediment at the bridges and culverts should be limited to the natural channel bottom, as further removal can lead to undermining of the structures. Given the limited amount of sediment at the bridge locations, indicated by the field measurements, sediment removal was not modeled for the bridges.

For the current base condition model, cross section elevations within the channel were based on the available LiDAR elevation data and field measurements at hydraulic structures. This information indicates channel bottom elevations that are no more than 0.2 feet higher than shown on the original FIS profile. Excavation of the channel below the natural slope can cause downcutting of the channel leading to bank erosion and significant sediment loading to the stream, which can actually exacerbate future flooding and increased the need for future channel maintenance.

Between Locust Street and Beattie Avenue, the existing flood profile indicates that the channel bottom elevation is significantly lower than what was shown on the original FIS profile, and included in the HEC-2 model. The field measurements at the bridges correspond closely with the channel elevations given on the current FIS flood profile, in this area. However, between the pedestrian foot bridge and Hamm Road, the channel bottom elevations from the LiDAR are approximately 1.3 to 1.5 feet higher than at the bridges. Channel maintenance within this area, to lower the channel grade in-line with the invert elevations measured at the Locust Street and Hamm Road bridges was modeled as a potential mitigation alternative. Within this reach, the elevation of the cross sections between the bank stations were lowered to produce a trapezoidal channel with a straight-line channel slope from Locust Street to the pedestrian bridge, and from the pedestrian bridge to Hamm Road.

Modeling of this alternative indicates that dredging of the channel between Locust Street and Hamm Road would have the greatest impact on the 10-percent annual chance water surface elevation, with a maximum decrease of 0.3 feet just downstream of Hamm Road for both current and future predicted flow conditions. For the 2-percent annual chance flow, this mitigation alternative was computed result in a decrease of 0.1 feet just downstream of the Hamm Road bridge for current conditions and 0.2 feet under predicted future flow conditions. Water surface reductions of 0.1 feet were computed downstream of the Hamm Road bridge for the current and future predicted 1- and 0.2-percent annual chance flows. Appreciable reductions in computed water surface elevations were confined to the stream reach between Locust Street and approximately 700 feet upstream of Hamm Road. The stream currently has a fair amount of tall vegetation (cattails, etc.), which can increase the friction losses and subsequently water surface elevations during high flow events. The channel was modeled using Manning's roughness appropriate for weedy streams (0.045). Dredging would include removal of some of the vegetation and temporarily reduce the friction losses. A sensitivity analysis was performed using Manning's roughness values more appropriate for a clean stream channel (0.035). The lower roughness would only result in minor additional reductions in computed water surface elevations, up to approximately 0.3 feet. The reduction in friction losses due to vegetation removal is only expected to be temporary, immediately following the dredging activity, and is not considered to be a viable flood mitigation approach.

Figure 18 provides a comparison of the computed water surface elevations for the corrected base condition and channel maintenance modification alternative models.

The rough order of magnitude cost estimate for this alternative is $200 thousand per occurrence. It should be noted that removal of sediment from the channel does not eliminate the sources of sediment and the effects may be short-lived due to future sedimentation within the channel.

Utilizing the 1976 stream profile from the 2008 Donner Creek Watershed Analysis Report, a second dredging scenario was evaluated assuming that the channel bottom would be lowered to match that stream profile. This analysis results in significant reductions in computed water surface elevations at Transit Road; the effects of the dredging would be reduced to nearly nothing upstream of Hamm Road. It should be noted that the 1976 profile results in a channel bottom that is approximately two feet below the invert of the culvert at Snyder Drive. The invert of this culvert and the foundation elevation of other crossing structures in the area would limit the extent to which the stream can be dredged in this area. Dredging to the 1976 stream profile is not considered to be a viable mitigation alternative.

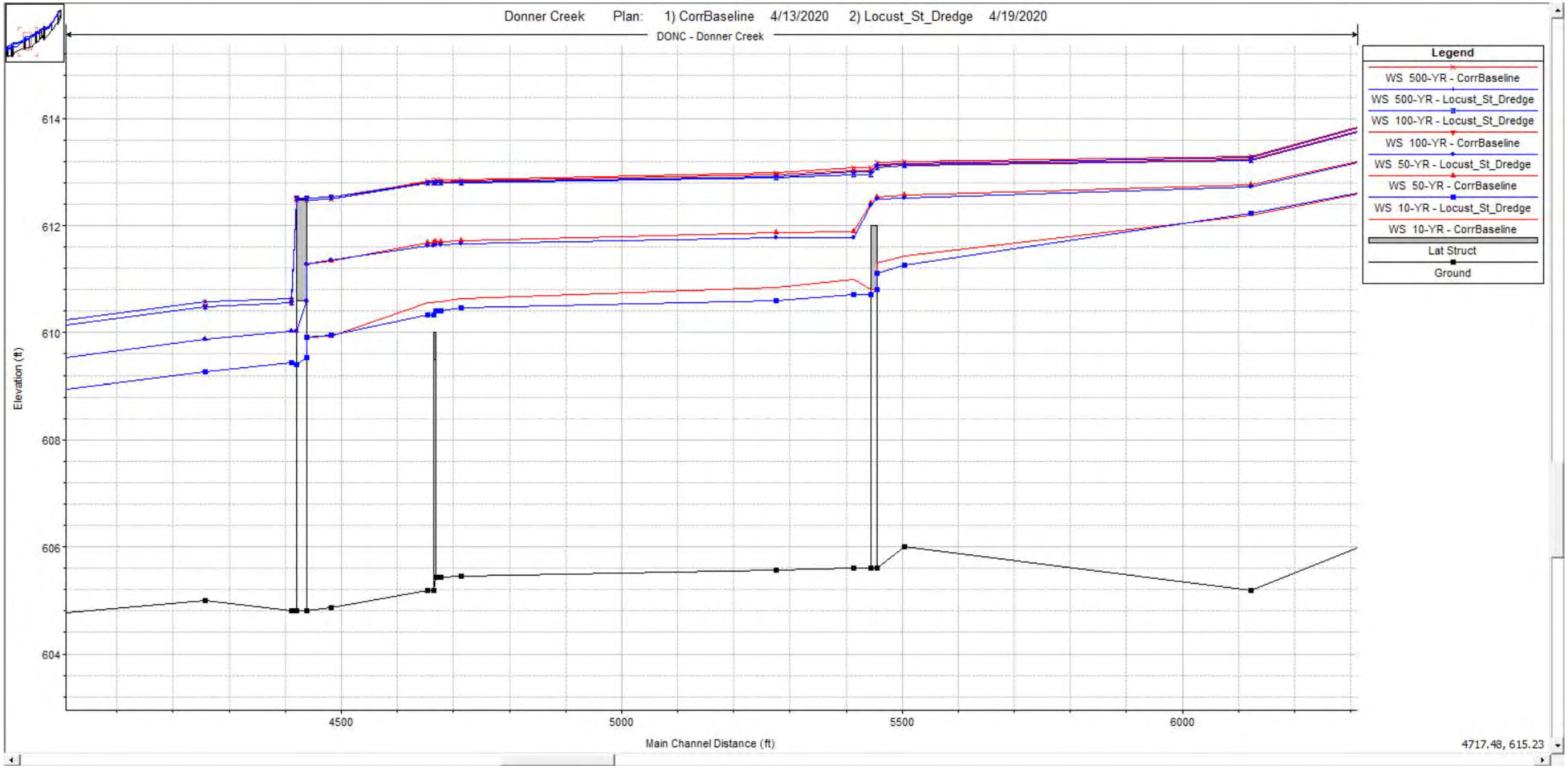


Figure 18. Comparison of Computed Water Surface Elevations between Baseline Conditions and Channel Maintenance Alternative

Alternative #10: Add Upstream Detention Basins

The Donner Creek drainage basins currently contains two detention ponds, and the Town requires the construction of additional detention ponds for all new developments. These detention ponds serve to offset the increases in flood peaks due to the development by slowing the travel of runoff from the development to the receiving stream. While the previous alternatives have dealt with the ability of the peak flow rates for floods of given recurrence intervals, the addition of upstream detention basins would lower the computed peak flow rates for each recurrence interval.

Utilizing the regional regression and urban flow equations discussed previously, the impact of additional detention storage was evaluated for both current and future predicted flow conditions. Computed reductions for current flow conditions, range from 18 cfs at South Transit Road for the 10-percent annual chance flow, to 29 cfs for the 0.2-percent annual chance flow at Beattie Avenue, for an additional five-acre detention pond between Lincoln Avenue and Beattie Avenue. Computed reductions for predicted future flows range from 20 cfs for the 10-percent annual chance flow at South Transit Road to 30 cfs at Beattie Ave under the 0.2-percent annual chance flow, for the same additional detention pond. These flow reductions were applied to the peak flows used in the hydraulic modeling and the hydraulic model was re-run for the current hydraulic conditions in the creek to evaluate the impact of storage on the water surface elevations. The addition of detention ponds upstream of Beattie Ave would produce relatively consistent reductions in water surface elevations throughout the downstream reach. With an additional five acres of detention ponds, the maximum water surface reductions are approximately 0.1 feet for either current or predicted future flows, with nearly no decrease in the 1-percent annual chance flood elevation.

The regional regression equations only account for the surface area of the detention pond, not the volume of the pond or the hydraulics of the outlet structure. Appropriate sizing of the detention pond and outlet works would require a more detailed hydrologic analysis of the basin. The rough order of magnitude cost estimate for only the excavation of this mitigation alternative is $1.5 million, assuming the required depth of the detention pond is two feet. The rough order or magnitude cost does not include land acquisition costs beyond survey, appraisal, and engineering coordination for the parcel(s) upon which the detention pond(s) would be constructed.

Adding further detention ponds has diminishing returns; doubling the size of the new detention pond to 10 acres from five acres only provides an additional reduction in flow of approximately 75%, at nearly a 100% increase in cost.

Alternative #11: Flood Early Warning Detection System

Flood early warning detection systems can be implemented which can provide communities with more advance 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 flood early warning system consists of commercially available off-the-shelf-components. The major components of a flood early warning 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 (United States Army Corps of Engineers, 2016).

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 (United States Army Corps of Engineers, 2016).

The rough order magnitude cost for this strategy is approximately $100,000.

Alternative #12: Flood Buyouts / Property Acquisition

Buyouts and acquisitions allow state and municipal agencies the ability to purchase developed properties within areas vulnerable to flooding from willing owners. Buyouts and acquisitions are effective management tools in response to natural disasters to reduce or eliminate future losses of vulnerable or repetitive loss properties. The terms buyout and acquisition are often used interchangeably, but they are distinct and serve distinct purposes (Siders, 2013).

Acquisition is the general term and refers to the purchase of private property by government for public use. It is not confined to a particular purpose or end use for the property. Buyout programs, on the other hand, are a specific subset of acquisition in which private lands are purchased, existing structures demolished, and the land maintained in an undeveloped state for public use in perpetuity. Both buyout and acquisition programs can be conducted without the consent of the landowners by using eminent domain, but most often they are conducted with voluntary sales from landowners who have recently experienced a natural disaster (Siders, 2013).

Acquisition programs can be designed for many purposes. Most often, following a disaster, they are intended to purchase damaged parcels from homeowners who are unwilling or unable to rebuild, thereby granting the homeowners the financial resources to relocate to a less vulnerable area. The parcels are then re-sold to a developer, who is held to stricter building requirements to make the new structure more resilient to natural threats. Acquisition programs designed in this way are intended to maintain similar amounts of housing and a similar local tax base in the affected community. Such programs may also improve the resilience of the community, by requiring developers to meet more stringent mitigation standards, but they will be no more resilient than communities where the original homeowners undertake mitigation programs. The main benefit is to the homeowner who is enabled to relocate (Siders, 2013).

Buyout programs, on the other hand, are designed to permanently remove built structures and replace them with public space or natural buffers. Buyout programs not only assist individual homeowners but are also intended to improve the resiliency of the entire community in the following ways:

- 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. Acquisition programs do not produce the same results because the newly-built homes, even if built to be more resilient, are still vulnerable and may still suffer damage during subsequent events (Siders, 2013).

In order to achieve these goals, buyouts need to acquire a continuous swatch of land, rather than individual homes in isolated areas, or only some of the homes within flood-prone areas. Acquisition programs can be effective even if they purchase individual isolated homes, but buyout programs will be most effective when they purchase entire streets or neighborhoods (Siders, 2013).

Acquisition and buyout programs can be funded entirely through state or local funds, but most often such programs occur after a nationally recognized disaster and use a combination of federal and state funds. The Federal Emergency Management Agency (FEMA) administers programs to help with buyouts under the Stafford Disaster Act, and the Department of Housing and Urban Development (HUD) administers another program through Community Development Block Grants (CDBG). These funding sources can reduce the economic burden on the local community. However, these funds also come with guidelines and regulations that may constrain policy makers' options on whether to pursue an acquisition or 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).

Within the three high flood risk areas discussed in this report, 62 structures were identified as being within the 1-percent annual chance floodplain. For the purposes of this analysis, structures were considered to be within the floodplain if the structure is either shown to be at least partially inundated or mostly surrounded by the inundation area. Due to the methods used to processes the LiDAR data into the elevation model, structures can appear to be elevated above the inundation area without having been placed on fill. Therefore, the structures which appear to be elevated above the 1-percent annual chance floodplain were conservatively included in this structure count. Table 15 summarizes the number of structures and their full market value, available from the Niagara County Tax Parcel database (NYS Department of Tax and Finance's Office of Real Property Tax Services, 2019).

Table 15. Summary of Flood Mitigation Alternatives

High Flood Risk Area	Number of Structures	Full Market Value[1]
#1: Hamm Road / Sherman Drive	28	$ 3,273,900
#2: Locust Street / Hamm Road	13	$ 2,056,300
#3: South Transit Road / Robinson Road	21	$ 8,140,050
Total	**62**	**$ 13,470,250**

Source: 1 (NYS Department of Tax and Finance's Office of Real Property Tax Services, 2019)

Due to the variable nature of buyout or acquisition programs, no ROM cost estimate was produced for this study. It is recommended that any buyout or acquisition program begin with a cost-benefit analysis for each property. After a substantial benefit has been established, a buyout or acquisition strategy study should be developed that focuses on properties closest to Donner Creek in the highest risk flood areas and progresses outwards from there to maximize flood damage reductions. A potentially negative consequence of buyout programs is the permanent removal of properties from the floodplain and resulting reduced tax revenue, which would have long-term implications for local governments and should be considered prior to implementing a buyout program.

Alternative #13: 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 Donner 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 $20,000, not including annual maintenance and operational costs.

Next Steps

Additional Data Modeling

The results of hydraulic modeling for mitigation alternatives discussed above, are based on conceptual projects, which have not been designed. Additional data modeling would be necessary to more precisely model water surface elevations and the extent of potential flooding in overbank areas and the floodplain, based on actual mitigation designs. 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, particularly for those alternatives which include the addition of flood benches which may attenuate flood peaks.

State/Federal Wetlands Investigation

A portion of the land within the proposed flood bench to the west of Locust Street (Mitigation Alternative #4) has been identified as a wetland area by the U.S. Fish and Wildlife Service. Any mitigation strategies which utilize this area need to be evaluated in relation to federal and state wetland criteria before those strategies can be progressed forward. Additionally, there is an area within the 1-percent annual chance floodplain to the northeast of the intersection of South Transit and Robinson Roads, which the U.S. Fish and Wildlife Service has identified as a wetland area. Mitigation strategies, such as a modification of the South Transit Road bridge (Mitigation Alternative #8), which could lower the normal water surface elevations, should be reviewed for potential negative impacts to either wetland.

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 Revolving Funds
- NYS Office of Emergency Management (OEM)
- Regional Economic Development Councils/Consolidated Funding Applications (CFA)
- Natural Resources Conservation Service (NRCS) Emergency Watershed Protection Program
- U.S. Federal Emergency Management Agency (FEMA) Unified Hazard Mitigation Program

NYS Office of Emergency Management (OEM)

The NYS Office of Emergency Management (OEM), through the U.S. Department of Homeland Security (DHS), offers several funding opportunities under the Homeland Security Grant Program (HSGP). The priority for these programs is to provide resources to strengthen national preparedness for catastrophic events. These include improvements to cybersecurity, economic recovery, housing, infrastructure systems, natural and cultural resources, and supply chain integrity and security. In 2018, there was no cost share or match requirement.

Consolidated Funding Applications (CFA)

The Consolidated Funding Application (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 Water Quality Improvement Project (WQIP) Program, administered through the Department of Environmental Conservation (DEC), 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 Grant Program

The Climate Smart Communities (CSC) Grant Program is a 50/50 matching grant program for municipalities under NYS DEC's New York State Environmental Protection Fund, offered through the CFA by the NYS 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 Program

Through the Emergency Watershed Protection (EWP) Program, the U.S. Department of Agriculture's Natural Resources Conservation Service (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 necessary permits, furnishing the local cost share (25 percent), and performing any necessary operation and maintenance for a ten-year period. Through EWP, the NRCS may pay up to 75 percent of the construction costs of emergency measures, with up to 90 percent 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 Unified Hazard Mitigation Program

The Federal Emergency Management Agency (FEMA) Unified Hazard Mitigation (HMA) Program, offered by the New York State Division of Homeland Security and Emergency Services (DHSES), provides funding for creating/updating hazard mitigation plans and implementing hazard mitigation projects. The HMA 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 Pre-Disaster Mitigation (PDM) Program and the Flood Mitigation Assistance (FMA) Program.

Pre-Disaster Mitigation (PDM) Program

The Pre-Disaster Mitigation (PDM) Grant Program provides resources to reduce overall risk to the population and structures from future hazard events, while also reducing reliance on federal funding from future disasters. Federal funding is available for up to 75 percent of eligible activity costs. The PDM project funding categories include Advance Assistance (up to $200,000 total of federal share funding), Resilient Infrastructure (up to $10 million total of federal share funding), and Projects (up to $4 million per project).

Flood Mitigation Assistance (FMA) Program

The Flood Mitigation Assistance Program (FMA) provides resources to reduce or eliminate long-term risk of flood damage to structures insured under the National Flood Insurance Program (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 percent of the eligible activity costs. FEMA may contribute up to 100 percent federal cost share for severe repetitive loss (SRL) properties, and up to 90 percent cost share for repetitive loss (RL) 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 & Conclusion

Summary

Donner Creek has caused notable flooding issues within the Town of Lockport, for at least the last 15 years. The main areas of flooding concern are the residential neighborhoods along Locust Street south of Hamm Road and between Hamm Road and Sherman Drive, as well as the commercial area near the intersection of South Transit and Robinson Roads. Feedback collected in the community meeting indicated that siltation and vegetation within the channel, as well as undersized structures were the main causes of flooding. In response to these flooding issues, the State of New York in conjunction with the Town and City of Lockport and Niagara County are studying, addressing and recommending potential flood mitigation projects for Donner Creek as part of the Resilient NY Initiative.

This study included an analysis of available data and new hydraulic models to evaluate the causes of flooding along Donner Creek. Field observations of the channel substrate indicated that sedimentation of the channel is occurring. The effective flood profile and the corrected base condition hydraulic model indicate that significant water surface rises occur across many of the structures, indicating that the structures are undersized for the computed discharges. Hydrologic and hydraulic data was used to model potential mitigation measures, which have the potential to reduce computed water surface elevations within high flood risk areas along Donner Creek, and reduce potential flood related damages to properties along the creek. Constructing multiple flood mitigation measures together would increase the overall flood reduction potential along Donner Creek.

Based on the hydraulic modeling discussed in this report, the mitigation measures that are expected to provide the greatest reductions in computed water surface elevations were the modifications to the South Transit Road and Locust Street bridges. While the Locust Street bridge modification alternative is the least costly, its impacts on flood damages would be relatively limited to the area just upstream of the bridge. However, combining the modification to the Locust Street bridge with one or more flood benches would have the greatest impact on structure flooding, and extend the stream distance over which water surface elevations would be reduced. Table 16 provides a summary of the flood mitigation alternatives evaluated in this study.

In addition to reducing water surface elevations, the construction of flood benches would help to reduce the sediment load within flood waters and limit future sedimentation of the channel. However, regulatory constraints regarding the identified wetland area to the west of Locust Street may limit the potential extent of the flood bench mitigation measure.

Table 16. Summary of Flood Mitigation Alternatives

Alternative No.	Description	Maximum Reduction in Water Surface Elevation (ft)		ROM Cost (U.S. Dollars)
		Current Flows	Predicted Future Flows	
1	Create Flood Bench to East of Locust Street	0 - 0.2	0 - 0.2	$.6 million
2	Modify Locust Street Bridge	0.4 - 1.5	0.5 - 1.5	$1.1 million
3	Modify Locust Street Bridge and Create Flood Bench to East of Locust Street	0.4 - 1.5	0.5 - 1.5	$1.7 million
4	Create Flood Bench to West of Locust Street	0.2 - 0.4	0.2 - 0.4	$2.5 million
5	Create Flood Bench to West of Locust Street and Modify Locust Street Bridge	0.6 - 1.8	0.6 - 1.7	$3.6 million
6	Modify Hamm Road Bridge	Not Modeled		
7	Modify Robinson Road Bridge	Not Modeled		
8	Modify South Transit Road Bridge	0.3 - 0.9	0.3 - 0.9	$3.3 million
9	Channel Maintenance	0.1 - 0.3	0.1 - 0.3	$200 thousand
10	Add Upstream Detention Basins	0 - 0.1	0 - 0.1	$1.5 million
11	Flood Early Warning Detection System	N/A		$100 thousand
12	Flood Buyouts / Property Acquisition	N/A		Variable (case-by-case)
13	Debris Maintenance around Bridges /Culverts	N/A		$20 thousand (not including annual operational costs)

Conclusion

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

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

2. Obtain stakeholder and public input to assess the feasibility and public support of each mitigation strategy presented in this report.

3. Identify any additional mitigation strategies based on stakeholder and public input.

4. Complete additional data collection and modeling efforts to assess the effectiveness of the proposed flood mitigation strategies.

5. Develop a list of final flood mitigation strategies based on the additional data collection and modeling results.

6. Select a final flood mitigation strategy or series of strategies to be completed for Donner Creek based on feasibility, permitting, effectiveness, and available funding.

REFERENCES

Alder, J. R., & Hostetler, S. W. (2017). *USGS National Climate Change Viewer.* Retrieved from US Geological Survey: https://www2.usgs.gov/landresources/lcs/nccv/viewer.asp

Burns, D. A., Smith, M. J., & Freehafer, D. A. (2015). *Development of Flood Regressions and Climate Change.* Retrieved from U.S. Geological Survey: http://dx.doi.org/10.3133/ofr20151235

Federal Emergency Management Agency. (1981). *Flood Insurance Study: Town of Lockport, NY.* Federal Emergency Management Agency.

Federal Emergency Management Agency. (2010). *Flood Insurance Study: Niagara County, NY.* Federal Emergency Management Agency.

Lumia, R. (1991). *Regionalization of Flood Discharges for Rural, Unregulated Streams in New York, Excluding Long Island.* Albany, NY: U.S. Geological Survey.

Lumia, R., Freehafer, D. A., & Smith, M. J. (2006). *Magnitude and Frequency of Floods in New York.* Retrieved from United States Geologic Survey: https://pubs.usgs.gov/sir/2006/5112/

Mulvihill, C. I., Baldigo, B. P., Miller, S. J., DeKoskie, D., & DuBois, J. (2009). *Bankfull Discharge and Channel Characteristics of Streams in New York State.* Retrieved from United States Geological Survey.

National Weather Service Hydrometeorological Design Studies Center. (2017). *NOAA Atlas 14 Point Precipitation Frequency Estimates.* Retrieved from NOAA's National Weather Service: https://hdsc.nws.noaa.gov/hdsc/pfds/pfds_map_cont.html?bkmrk=pa

New York Sate Governor's Press Office. (2018, November 5). *Governor Cuomo Announces $3 Million for Studies to Reduce Community Flood Risk.* Retrieved from New York Sate Governor's Press Office: https://www.governor.ny.gov/news/governor-cuomo-announces-3-million-studies-reduce-community-flood-risk

New York State Department of Environmental Conservation. (2018). *DRAFT New York State.* Retrieved from New York State Department of Environmental Conservation: https://www.dec.ny.gov/docs/administration_pdf/frmgpublic.pdf

New York State Department of Transportation. (2019). *Bridge Point Location & Attributes.* Retrieved from New York State Department of Transportation: http://gis.ny.gov/

NYS Department of Tax and Finance's Office of Real Property Tax Services. (2019, 07 31). *Niagara 2018 Tax Parcel Centroid Points.* Retrieved from NYS GIS Clearinghouse: http://gis.ny.gov/

Parveen, R., Kumar, U., & Singh, V. K. (2012). Geomorphometric Characterization of Upper South Koel Basin, Jharkhand: A Remote Sensing & GIS Approach. *Journal of Water Resource and Protection*, 1042-1050.

Prohaska, T. (2007, October 31). Donner Creek Flooding Issue Given Airing. *Buffalo News*.

Ries, K. G., Newson, J. K., Smith, M. J., Steeves, P. A., Haluska, T. L., Kolb, K. R., . . . Vraga, H. W. (2017). *StreamStats, version 4.3.8: U.S. Geological Survey Fact Sheet 2017–3046.* Retrieved from United States Department of Interior: https://streamstats.usgs.gov/ss/

Robinson, D., & Prohaska, T. (2008, May 29). Donner Creek Flood Control Plan Jeered. *Buffalo News*.

Rosenzweig, C., Solecki, W., DeGaetano, A., O'Grady, M., Hassol, S., & Grabhorn, P. (Eds.). (2011). *Responding to Climate Change in New York State: The ClimAID Integrated Assessment for Effective Climate Change Adaptation.* Retrieved from New York State Energy Research and Development Authority: https://www.nyserda.ny.gov/About/Publications/Research%20and%20Development%20Technical%20Reports/Environmental%20Research%20and%20Development%20Technical%20Reports/Response%20to%20Climate%20Change%20in%20New%20York

Rosgen, D. L., & Silvey, H. L. (1996). *Applied River Morphology, 2nd Edition.* Fort Collins, CO: Wildland Hydrology Books.

RS Means: Gordian, Inc. (2019). *RSMeans CostWorks 2019*. Retrieved from RSMeans Data Online: https://www.rsmeans.com/products/online.aspx

Sauer, V. B., Thomas, W. O., Stricker, V. S., & Wilson, K. V. (1983). *Flood Characteristics of Urban Watersheds in the United States.* Alexandria, VA: Unites States Geological Survey.

Siders, A. R. (2013). Anatomy of a Buyout Program - New Yor Post-Superstorm Sandy. *16th Annual Conference on Litigating Takings Challenges to Land Use and Environmental Regulations.* New York, NY: Vermont Law School.

Taylor, K. E., Stouffer, R. J., & Meehl, G. A. (2011). An Overview of CMIP5 and the Experiment Design. *Bulletin of the American Meteorological Society*, 485-498.

Town of Lockport. (2014). *Town of Lockport Comprehensive Plan.*

U.S. Geological Survey. (2019). *Multi-Resolution Land Characteristics Consortium.* Retrieved from National Land Cover Database: https://www.mrlc.gov/

United States Army Corps of Engineers. (2016). *Buffalo Creek - Lexington Green CAP 205, Report No. P2#443918.* United States Army Corps of Engineers, Buffalo District.

United States Army Corps of Engineers. (2016). *HEC-RAS River Analysis System User's Manual, Version 5.0.* Davis, CA: United States Army Corps of Engineers Hydrologic Engineering Center.

Waikar, M. L., & Nilawar, A. P. (2014). Morphometric Analysis of a Drainage Basin Using Geographical Information System: A Case study. *International Journal of Multidisciplinary and Current Research*, 179-184.

Wendel Duchscherer. (2008). *Donner Creek Watershed Analysis.*

Appendix A. Summary of Data and Reports Collected

Year	Data Type	Document Title	Author	Publisher
1981	Report	Flood Insurance Study: Town of Lockport, NY	Federal Emergency Management Agency	Federal Emergency Management Agency
2007	Article	Donner Creek Flooding Issue Given Airing	Prohaska, T.	Buffalo News
2008	Article	Donner Creek Flood Control Plan Jeered	Robinson, D., & Prohaska, T.	Buffalo News
2008	Report	Donner Creek Watershed Analysis	Wendel Duchscherer	Town of Lockport
2010	Report	Flood Insurance Study: Niagara County, NY	Federal Emergency Management Agency	Federal Emergency Management Agency
2011	Article	Responding to Climate Change in New York State: The ClimAID Integrated Assessment for Effective Climate Change Adaptation	Rosenzweig, C., Solecki, W., DeGaetano, A., O'Grady, M., Hassol, S., & Grabhorn, P.	New York State Energy Research and Development Authority
2014	Report	Town of Lockport Comprehensive Plan		Town of Lockport
2015	Report	Development of Flood Regressions and Climate Change	Burns, D. A., Smith, M. J., & Freehafer, D. A.	U.S. Geological Survey
2016	Report	HEC-RAS River Analysis System User's Manual, Version 5		United States Army Corps of Engineers
2017	Data	USGS National Climate Change Viewer	Alder, J. R., & Hostetler, S. W.	U.S. Geological Survey
2017	Data	NOAA Atlas 14 Point Precipitation Frequency Estimates	National Weather Service Hydrometeorological	NOAA's National Weather Service

Year	Data Type	Document Title	Author	Publisher
			Design Studies Center	
2017	Data	StreamStats, version 4	Ries, K. G., Newson, J. K., Smith, M. J., Steeves, Steeves, P. A., Haluska, T. L., Vraga, H. W.	U.S. Geological Survey
2018	Report	DRAFT New York State Flood Risk Management Guidance for Implementation of the Community Risk and Resiliency Act		New York State Department of Environmental Conservation
2018	Data	Niagara 2018 Tax Parcel Centroid Points		NYS Department of Tax and Finance's Office of Real Property Tax Services
2019	Report	Preliminary Flood Insurance Study (FIS): Niagara County, NY	Federal Emergency Management Agency	Federal Emergency Management Agency
2019	Data	Bridge Point Location & Attributes		New York State Department of Transportation
2019	Data	City/Town Boundaries, County Boundaries		New York State Office of Information Technology Services
2019	Data	Dams, Hydrography		New York State Department of Environmental Conservation
2019	Data	RSMeans CostWorks 2019. RSMeans Data Online.		Gordian, Inc.
2019	Data	Multi-Resolution Land Characteristics Consortium National Land Cover Database		U.S. Geological Survey

Appendix B. Agency and Stakeholder Meeting Attendees List

Attendees	Affiliation
Thomas Lowe	Alexander, Village of
William Wagner	Alexander, Village of
Tim Lucey	Amherst, Town of
Paul Rubins	Amherst, Town of
Jeff Szatkowski	Amherst, Town of
Jim Zymanek	Amherst, Town of
Tom Lichtenthal	Batavia, Town of
Steve Mountain	Batavia, Town of
Katherine Winkler	Buffalo Niagara Waterkeeper
James Dussing	Clarence, Town of
Paul Englert	Clarence, Town of
Gregory Butcher	Erie County
Mark Gaston	Erie County
Joanna Panawiewicz	Erie County
J.T. Glass	Erie County
Molly Cassatt	Genesee County
Derik Kae	Genesee County
Bradley Mudrzynski	Genesee County
Damian Gomez	Gomez & Sullivan
Erin Redding	Gomez & Sullivan
Charvi Gupta	Highland Planning
Jen Topa	Highland Planning
Susan Hopkins	Highland Planning
Gary Baehr	Newstead, Town of
Norman Allen	Niagara County
Scott Collins	Niagara County
Stephany Antonov	NYSDEC
David Clarke	NYSDEC
Ted Myers	NYSDEC
Kerrie O'keeffe	NYSDEC
Thomas R. Snow Jr.	NYSDEC
Chad Staniszewski	NYSDEC
Ryan Tomko	NYSDEC
Kadir Goz	OBG
James Sparks	Royalton, Town of

Appendix C. Field Data Collection Forms

U.S. Department of Agriculture
Natural Resources Conservation Service

Stream Channel Classification (Level II)

Wisconsin Job Sheet 811

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.
Mean Depth (d_{bkf}):	________ ft.	________ ft.	________ ft.	0.00 ft.
Bankfull X-Section Area (A_{bkf}):	________ sq. ft.	________ sq. ft.	________ sq. ft.	0.00 sq. ft.
Width / Depth Ratio (W_{bkf}/d_{bkf}):	________ ft.	________ ft.	________ ft.	0.00 ft.
Maximum Depth (d_{mbkf}):	________ ft.	________ ft.	________ ft.	0.00 ft.
Width of Flood-Prone Area (W_{fpa}):	________ ft.	________ ft.	________ ft.	0.00 ft.
Entrenchment Ratio (ER):	________ ft.	________ ft.	________ ft.	0.00 ft.

Bankfull Width: *Width of the stream channel, at bankfull stage elevation, in a riffle section.*

Mean Depth: *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: *Area of the stream channel cross section, at bankfull stage elevation, in a riffle section.*

Width / Depth Ratio: *Bankfull width divided by bankfull mean depth, in a riffle section.*

Maximum Depth: *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: *Twice maximum depth, or (2 x d_{mbkf}) = the stage/elevation at which flood-prone area width is determined (riffle section).*

Entrenchment Ratio: *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 #	Particle Count 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				

GOMEZ AND SULLIVAN ENGINEERS

Resilient New York

Date:

Field crew:

Stream:

Road crossing:

Structure data: ☐ Bridge

Height at edge[1]: _____
Height at deepest point: _____
Piers _____
Span between piers: _____

Width at top of opening: _____
Bank slope: Rise: _____ Run: _____
Pier shape: round triangle square
Width of piers: _____

☐ Culvert (see data below)

Length in direction of flow:

Manning value: Top: Bottom:

Deck thickness:

Height of rail:

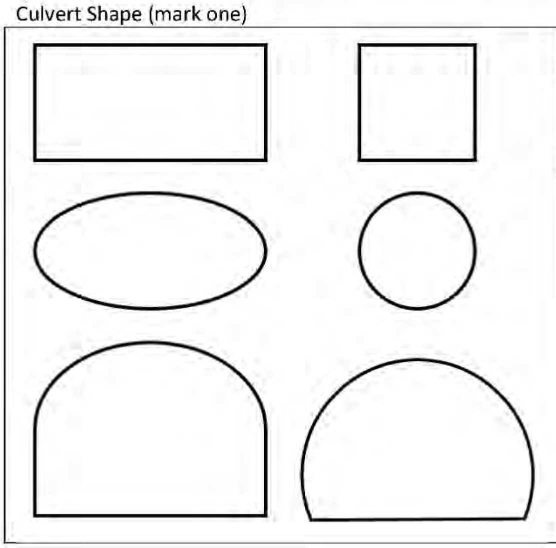
Type of rail:

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

P:\2065 - Resilient NY Initiative\Field Data Collections\Field_Template.docx

Appendix D. Photo Log

List of Additional Field Photos

Photo C-1. *Upstream face of Beattie Ave bridge crossing Donner Creek (2/17/2020)*

Photo C-2. *Downstream face of Beattie Ave bridge crossing Donner Creek (2/17/2020)*

Photo C-3. *Upstream Face of Hamm Road bridge over Donner Creek (2/17/2020)*

Photo C-4. *Downstream Face of Hamm Road bridge over Donner Creek (2/17/2020)*

Photo C-5. *Upstream Face of Locust Street bridge over Donner Creek (2/17/2020)*

Photo C-6. *Downstream Face of Locust Street bridge over Donner Creek (2/17/2020)*

Photo C-7. *Upstream face of Transit Road bridge crossing Tonawanda Creek (9/19/2019)*

Photo C-8. *Upstream face of Transit Road bridge crossing at Donner Brook (9/19/2019)*