FLOOD MITIGATION & RESILIENCE REPORT

Great Chazy River - SD119

Prepared for:

New York State Department of Environmental Conservation,
in cooperation with the New York State Office of General Services

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June 2022

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Cover photo: Village of Champlain during breakup ice jam event in 2007. Image provided by Clinton County Department of Emergency Services.

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ACRONYMS

AEP	Annual Exceedance Probability
APA	Adirondack Park Agency
ASDSO	Association of State Dam Safety Officials
BFE	Base Flood Elevation
BIN	Bridge Identification Number
CFS	Cubic Feet per Second
CIP	Cast in Place
CMP	Corrugated Metal Pipe
CR	County Route
CRRA	Community Risk and Resiliency Act
CRREL	Cold Regions Research and Engineering Lab
DEC	Department of Environmental Conservation
DEM	Digital Elevation Model
DHSES	Department of Homeland Security and Emergency Services
ECL	Environmental Conservation Law
EWP	Emergency Watershed Protection
FEMA	Federal Emergency Management Agency
FHMIP	Flood Hazard Mitigation Implementation Program
FIRM	Flood Insurance Rate Map
FIS	Flood Insurance Study
FMA	Flood Mitigation Assistance
FPMS	Floodplain Management Services Program
fps	feet per second
GIS	Geographic Information System
GLFC	Great Lakes Fishery Commission
HEC-RAS	Hydrologic Engineering Center – River Analysis System
HMA	Hazard Mitigation Assistance
HMGP	Hazard Mitigation Grant Program
HMP	Hazard Mitigation Plan
HRA	High Risk Area
HSG	Hydrologic Soil Group
HWM	High Water Mark
I & M	Inspection and Maintenance
LiDAR	Light Detection and Ranging
mph	miles per hour
MWRR	Municipal Waste Reduction and Recycling
NBI	National Bridge Inventory
NERFC	Northeast River Forecast Center
NFIP	National Flood Insurance Program
NFIRA	National Flood Insurance Reform Act
NOAA	National Oceanic and Atmospheric Administration

NRCS	Natural Resources Conservation Service
NWI	National Wetlands Inventory
NWS	National Weather Service
NYS	New York State
NYSDEC	New York State Department of Environmental Conservation
NYSDOT	New York State Department of Transportation
NYSOGS	New York State Office of General Services
PDM	Pre-Disaster Mitigation
RCP	Representative Concentration Pathway
RFC	Repetitive Flood Claims
SFHA	Special Flood Hazard Area
SIR	Scientific Investigations Report
SLR	SLR Engineering, Landscape Architecture, and Land Surveying, P.C.
SRL	Severe Repetitive Loss
STA	station (stream or river)
USACE	United States Army Corps of Engineers
USBR	United States Bureau of Reclamation
US EPA	United States Environmental Protection Agency
USGS	United States Geological Survey
WY	Water Year

SUMMARY

This analysis of the Great Chazy River watershed is being conducted as part of the Resilient New York Program, an initiative of the New York State Department of Environmental Conservation. The Great Chazy River originates above Chazy Lake, north of the town of Saranac, in Clinton County, New York. The Great Chazy River watershed is 304 square miles.

Clinton County has an active history of floods, flash floods, and ice jamming. The county has experienced 16 flash floods or flooding events, including lakeshore flooding, since 2000. Thirteen of those events occurred from 2007 to 2012. Ice jamming issues consistently occur in Perry Mills and Champlain. Ice jams typically occur in the springtime or during mid-winter thaw or rain-on-snow events, with the thaw producing higher flows and breaking up ice deposits. As of 2021, the U.S. Army Engineer Research and Development Center's Cold Regions Research and Engineering Lab Ice Jam database reports 71 ice jam events on the Great Chazy River since 1929, with 40 such events taking place since 1996.

As part of this analysis, flood-prone High Risk Areas, or HRAs, within the Great Chazy watershed are identified, and an analysis of flood mitigation considerations within each HRA is undertaken. Factors with the potential to influence more than one HRA are also evaluated and discussed. Flood and ice jam mitigation scenarios such as floodplain enhancement, dam removal, and replacement of undersized bridges and culverts are investigated and are recommended where appropriate.

1. INTRODUCTION

1.1 PROJECT BACKGROUND AND OVERVIEW

This work is a component of the Resilient New York Program, an initiative of the New York State Department of Environmental Conservation (NYSDEC), contracted through the New York State Office of General Services (NYSOGS). The goal of the Resilient New York Program is to make New York State more resilient to flooding and climate change. Through the program, flood studies are being conducted across the state, resulting in the development of flood and ice jam hazard mitigation alternatives to help guide implementation of mitigation projects.

The Great Chazy River originates above Chazy Lake, north of the town of Saranac, in Clinton County, New York. The Great Chazy River watershed measured at its outlet to King Bay in the town of Champlain is 304 square miles in size. Most of the watershed is located within New York State. A very small portion of the watershed drains from Quebec, Canada. The river drains northeastward into Lake Champlain.

This report begins with an overview of the Great Chazy River watercourse and watershed, summarizes the history of flooding, and identifies High Risk Areas (HRAs) within the watershed. An analysis of flood mitigation considerations within each HRA is undertaken. Flood mitigation recommendations are provided either as HRA-specific recommendations or as overarching recommendations that apply to the entire watershed or stream corridor. Flood mitigation scenarios such as floodplain enhancement and channel restoration, dam removals, road closures, and replacement of undersized bridges and culverts are investigated and are recommended where appropriate.

According to Jamieson and Morris, the word "Chazy" is an adaptation of a French lieutenant named *Chezy,* who was killed by the Iroquois in 1666 near the Chazy River mouth. During the early 1900s, philanthropist and entrepreneur William Henry Miner acquired 13,150 acres of land in Chazy. That is where he built Heart's Delight Farm and various other institutions, including a two-million-dollar school and a wild animal preserve. His enterprise extended upstream as far as Chazy Lake, where he also constructed a still-existing dam in 1926. The Miner Foundation has given at least 700 acres of land to New York State since 1963 and remains an integral part of the region's history.

1.2 TERMINOLOGY

In this report, all references to right bank and left bank refer to "river right" and "river left," meaning the orientation assumes that the reader is standing in the river, looking downstream. Stream stationing is used in the narrative and on maps as an address to identify specific points along the watercourses. Stream Stationing (STA) is measured in feet and begins at STA 0+00 where the Great Chazy River flows into Lake Champlain at its downstream end and continues upstream to the Great Chazy Lake at STA 2500+00. As an example, the US-9 bridge spans the Great Chazy River at STA 298+00. On the North Branch of the Great Chazy River, stationing begins at STA 0+00 where the North Branch flows into the Great Chazy River and continues upstream to the North Branch headwaters at STA 1500+00.

The Federal Emergency Management Agency (FEMA) is an agency of the United States Department of Homeland Security. In order to provide a common standard, FEMA's National Flood Insurance Program (NFIP) has adopted a baseline probability called the base flood. The base flood has a 1 percent (one in 100) chance of occurring in any given year, and the base flood elevation (BFE) is the level floodwaters are expected to reach in this event. For the purpose of this report, the 1 percent annual chance flood is also referred to as the 100-year flood. Other recurrence probabilities used in this report include the 2-year flood event (50 percent annual chance flood), the 10-year flood event (10 percent annual chance flood), the 25-year flood event (4 percent annual chance flood), the 50-year flood event (2 percent annual chance flood), and the 500-year flood event (0.2 percent annual chance flood).

The Special Flood Hazard Area (SFHA) is the area inundated by flooding during the 100-year flood event. Within the project area, FEMA has developed Flood Insurance Rate Mapping (FIRM), which indicates the location of the SFHA along the Great Chazy River and its tributaries.

2. DATA COLLECTION

Data were gathered from various sources related to the hydrology and hydraulics of the Great Chazy River and its tributaries, Great Chazy River watershed characteristics, recent and historical flooding in the affected communities, and factors that may contribute to flood hazards.

2.1 GREAT CHAZY RIVER WATERSHED CHARACTERISTICS

The Great Chazy River watershed is located primarily in Clinton County, in northeastern New York State, and falls within the physiographic regions known as the Adirondack Mountain and Champlain Lowlands (Figure 2-1). The river flows 545 miles in a generally northeasterly direction, draining the northwestern and northeastern portions of Clinton County before flowing into Lake Champlain at King Bay. Much of the area is rural farmland and wooded areas with hamlet and village developed areas. According to the Lake Champlain Non-Point Source Pollution Subwatershed Assessment and Management Plan, the Great Chazy is used for motorboat/sailing (up to the village of Champlain), canoeing/kayaking, fishing, ice fishing, swimming, aesthetic enjoyment, and wildlife viewing. The towns of Altona, Mooers, and Champlain and the village of Champlain all drain into the Great Chazy River. The watershed is oblong in shape, narrowing toward its outlet. When measured at its outlet, the watershed is 304 square miles in size. Figure 2-2 is a watershed map of the Great Chazy River watershed, and Figure 2-3 depicts the watershed's topographic relief.

The Great Chazy watershed is underlain by bedrock that dates from the Lower Ordovician to Upper Cambrian Periods. Most of the bedrock is Potsdam Sandstone, which consists of a well-cemented, pure quartz sandstone that deposited in the Cambrian Period and is sometimes referred to as orthoquartzite. A small northern section of the watershed is underlain by the Theresa Formation, which is composed of calcareous, sandy dolomites with interbedded weak sandstones dating from the Lower Ordovician Period. It is very closely related to the Potsdam Sandstone. Around 38 percent of the watershed is in Adirondack Park. The Adirondack Mountains located in the southwestern portion of the watershed that surrounds Chazy Lake are made of metamorphic rock of the Middle Proterozoic age. The bedrock comprises pyroxene/hornblende granitic gneiss. A major block fault line borders the western side of the Champlain basin, marking the transition between the Adirondack Mountains and the Champlain Lowlands. A 500-foot descent is seen when crossing the fault line. Various other faults are contained throughout the Great Chazy watershed. A radial drainage pattern is observed in the streams that originate in the Adirondack Mountains, indicating the youth of the mountains as the streams have not had the time to find the weaker bedrock and carve valleys there.

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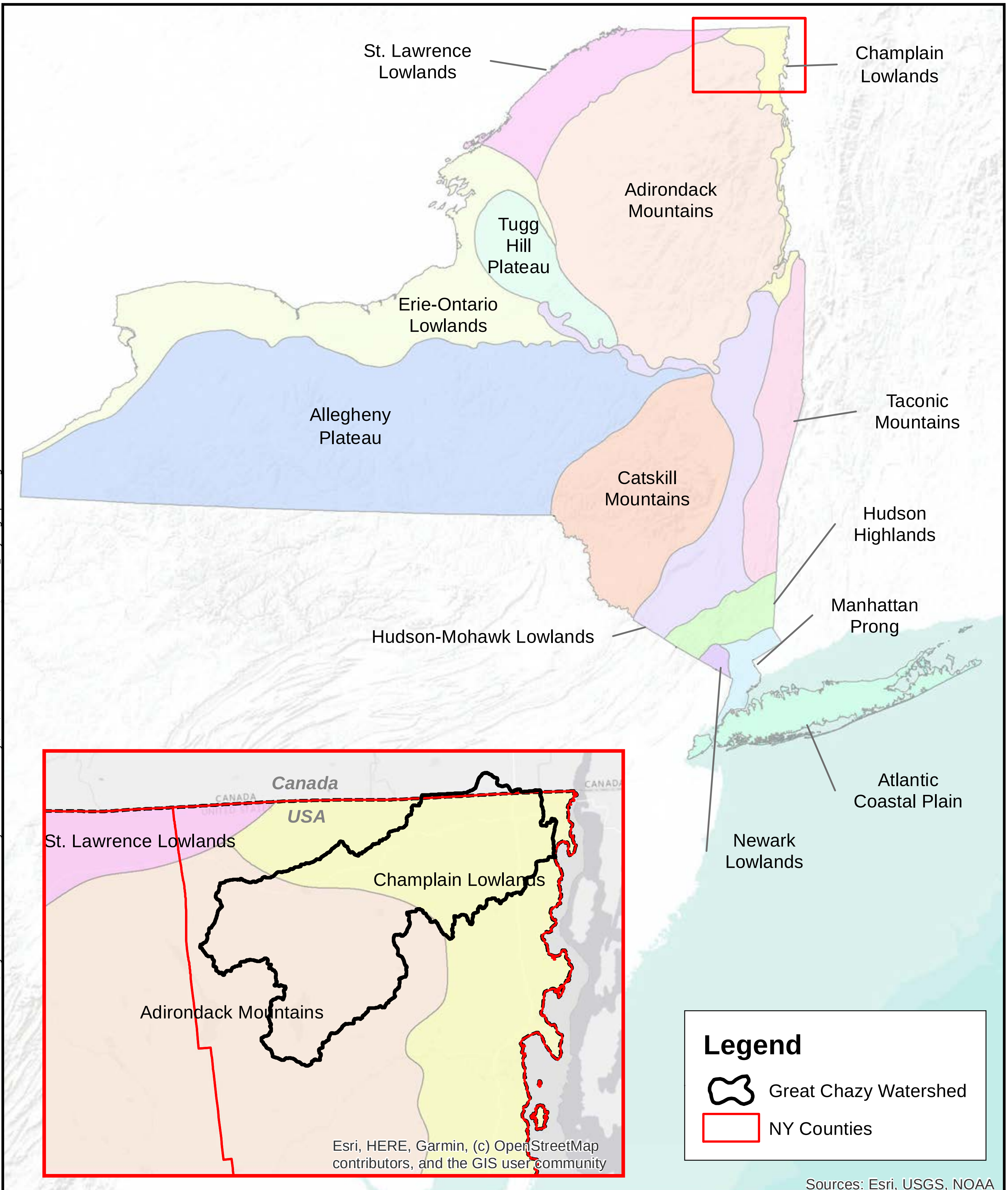

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NYS PHYSIOGRAPHIC REGIONS
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FIG. 2-1

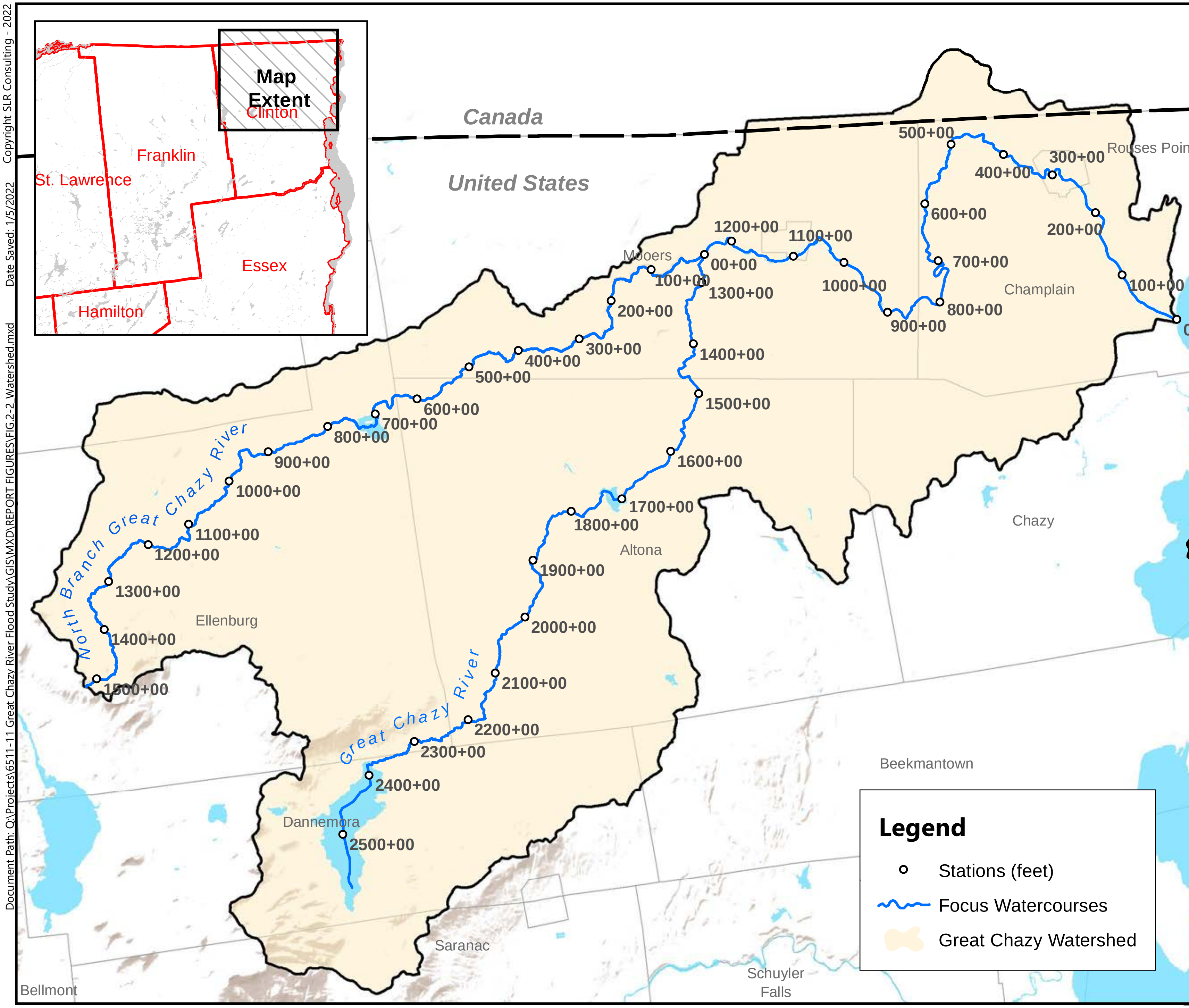

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FIG. 2-2

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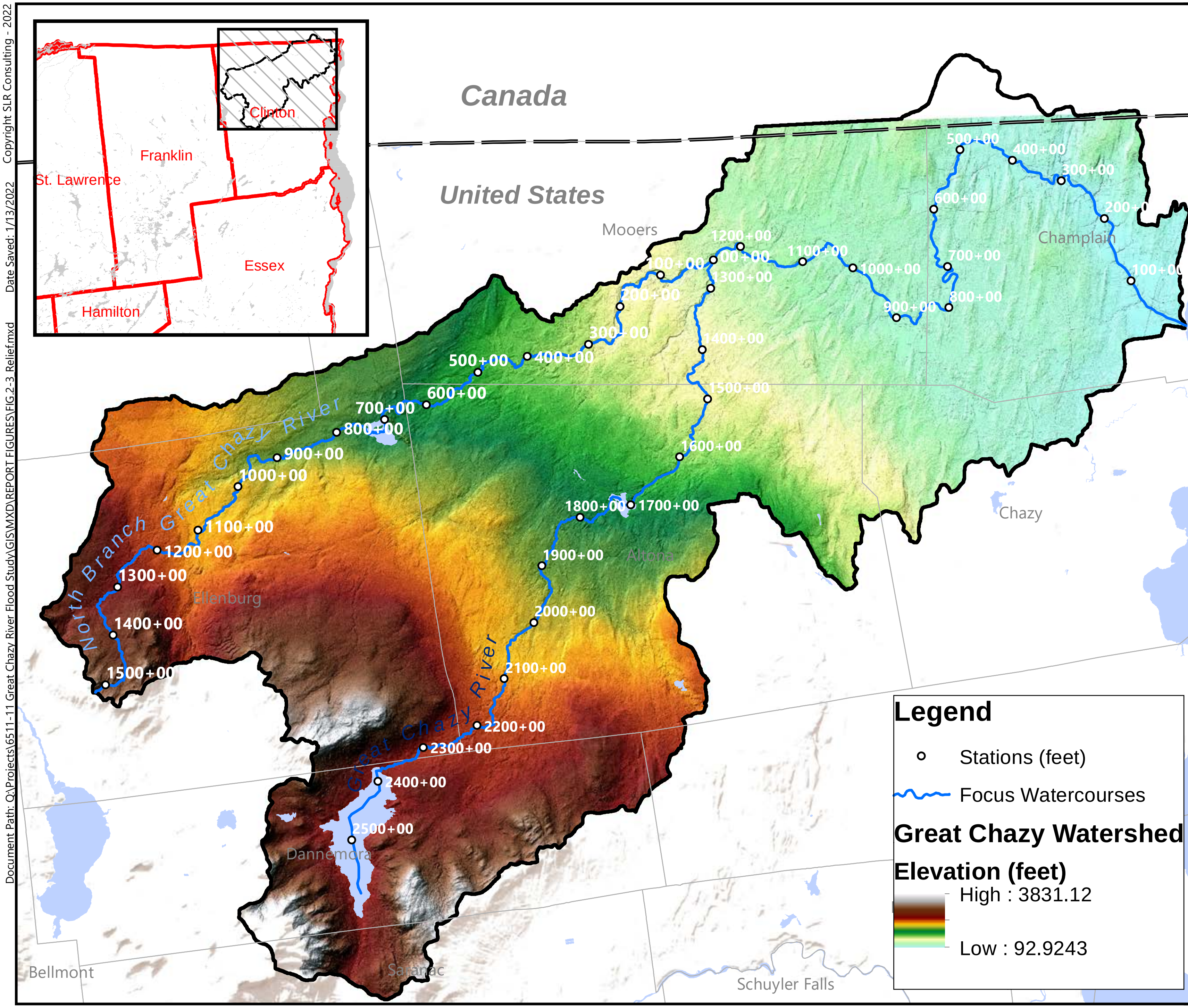

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GREAT CHAZY RIVER WATERSHED RELIEF MAP

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FIG. 2-3

The Adirondack Mountains and Champlain Lowlands went through periods of glaciation during the Pleistocene Epoch. A glacial lake termed Glacial Lake Vermont extended across upper New York, parts of Vermont, and parts of Canada. Clay and silt were deposited in the bottom of the lake, along with sand. The glaciers melted and retreated after some time. Sea level then rose, and a shallow sea deposited sand in the area. Surficial materials underlying the Great Chazy River watershed consist primarily of glacial till, with areas mapped as exposed bedrock or bedrock within 3 to 10 feet below the surface occurring along the southern and western margins of the watershed. Areas mapped as lacustrine silt and clay along with outwash sand and gravel underlie the Great Chazy River valley bottom in the eastern section of the watershed. The sand deposited in glacial lakes and shallow seas makes for rich farmland in the area. The sand and gravel produced by the beaches and deltas form productive aquifers and allow for well-drained sites on which to build cities and towns. However, the marine clay is a poor foundation for structures.

During a rainfall event, the proportion of rainfall that runs off directly into rivers and streams or that infiltrates into the ground is greatly influenced by the composition of soils within a watershed. Soils are assigned a hydrologic soil group identifier, which is a measure of the infiltration capacity of the soil. These are ranked A through D. A hydrologic soil group A soil is often very sandy, with a high infiltration capacity and a low tendency for runoff except in the most intense rainfall events; a D-ranked soil often has a high silt or clay content or is very shallow to bedrock and does not absorb much stormwater, which instead is prone to run off even in small storms. A classification of B/D indicates that when dry the soil exhibits the properties of a B soil, but when saturated, it has the qualities of a D soil. Approximately 42 percent of the mapped soils in the Great Chazy River watershed are classified as hydrologic soil group C, C/D, or D, indicating a low capacity for infiltration and a high tendency for runoff (Figure 2-4). A large portion of the mapped soils are B/D (31 percent), which indicates a tendency for runoff in high-magnitude rainfall events.

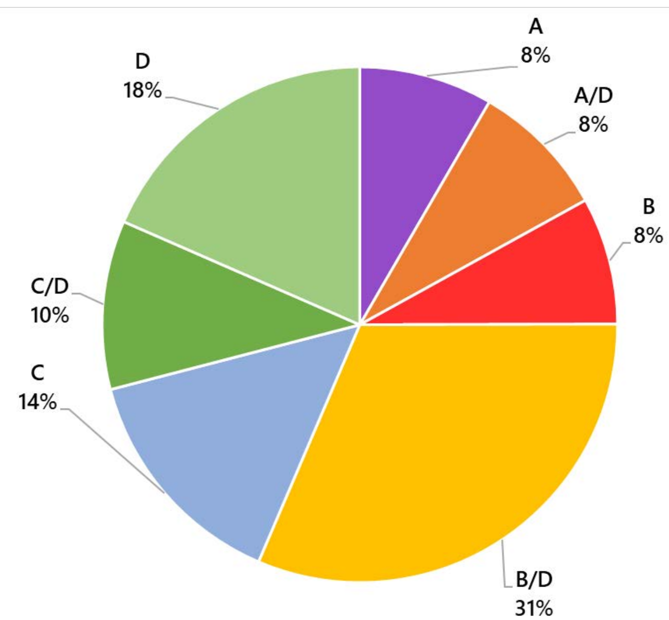


Figure 2-4: Hydrologic Grouping of Soils within the Great Chazy River Watershed

Land cover is another important factor influencing the runoff characteristics of a watershed. Land cover within the Great Chazy River watershed can be characterized using the 2016 Multi-Resolution Land Characteristics National Land Cover Database for Northeast New York State and is shown graphically in Figure 2-5. Forest is the most common land cover, representing 62 percent of the watershed. Forested land consists of deciduous, coniferous, and mixed forest types. Agriculture (crop/pasture) land makes up 17 percent. Open water and wetlands combined make up 13 percent of the land cover. The remaining 8 percent of the land cover consists of development land, grassland and shrubland, and barren land.

Approximately 116 square miles, or 38 percent, of the Great Chazy River watershed is located within Adirondack Park. Adirondack Park is the largest publicly protected area in the contiguous United States and is a mix of public and private land. Land management planning for municipalities located within the Adirondack Park falls under the jurisdiction of the Adirondack Park Agency (APA). Land-use management plans can play an important part in protecting a community and providing resilience against potential hazards like floods and ice jams. The APA developed a management plan for the administration of all state land in the Adirondack Park titled the Adirondack Park State Land Master Plan. The imperative and foremost goal of the master plan is to provide protection and preserve natural resources of the state lands within the park. The APA state land-use classifications are wilderness, primitive, canoe, wild forest, intensive use, historic, and state administrative. In Clinton County, the towns of Ausable, Black Brook, Dannemora, and Saranac are entirely within the Adirondack Park and therefore required to abide by the land use regulations of the APA. Portions of the towns of Peru, Ellenberg, and Altona are within the park and are also subject to APA land use regulations (from Discovery Report, page 25).

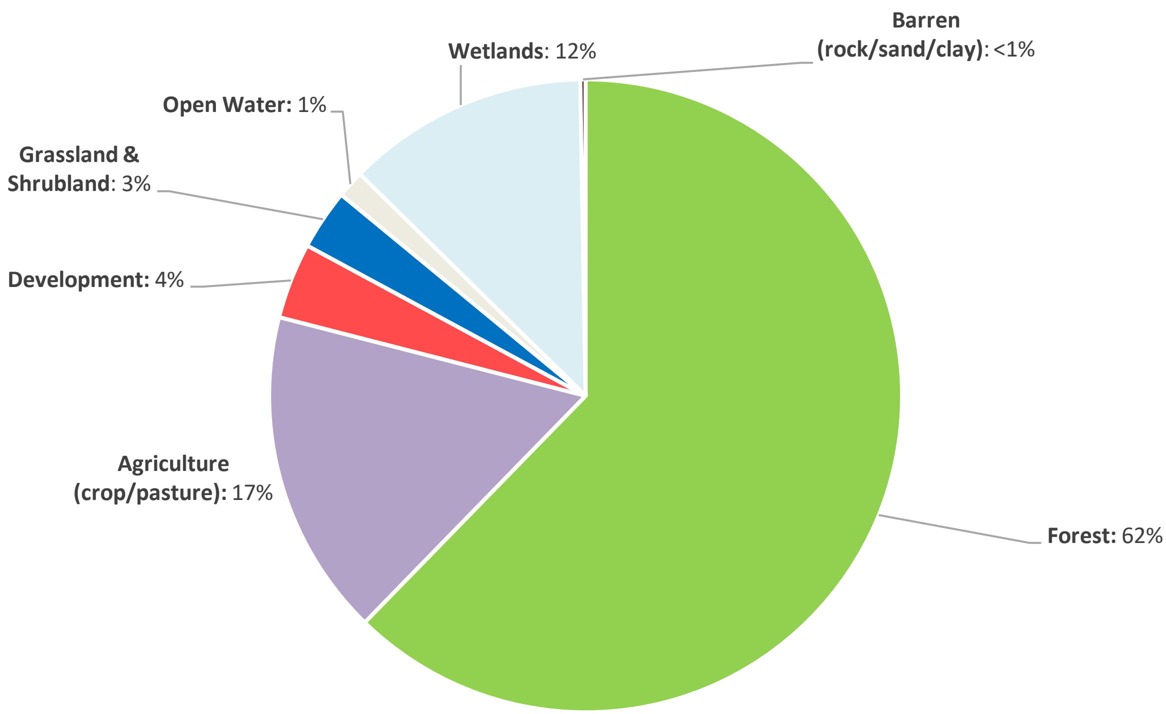


Figure 2-5: Land Cover within the Great Chazy River Watershed

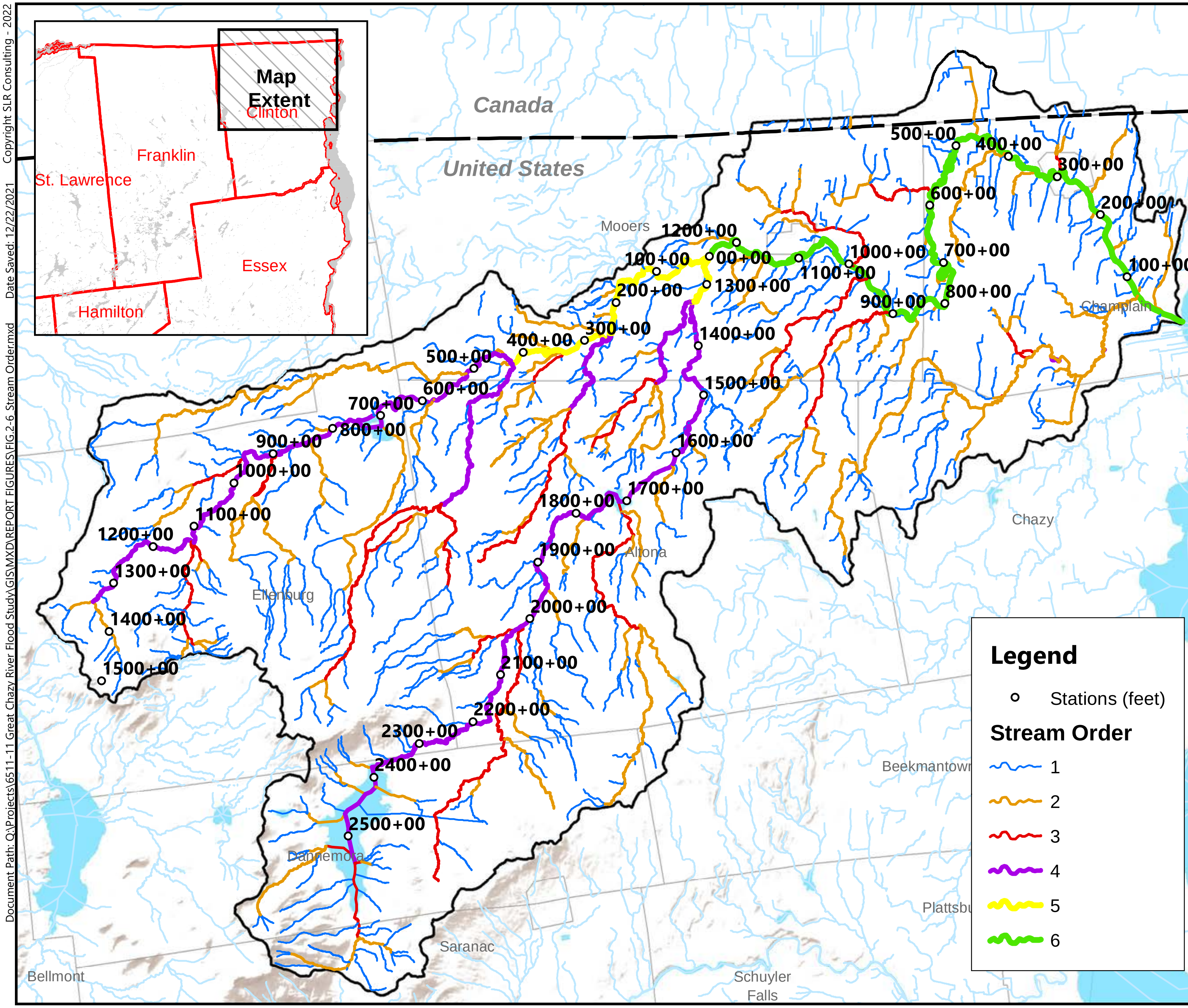
It is estimated that since colonial times approximately 50 to 60 percent of the wetlands in the state of New York have been lost through draining, filling, and other types of alteration.

Wetland cover was examined using information available from the U.S. Fish & Wildlife Service's National Wetlands Inventory (NWI). The NWI indicates that there are 24,343 acres of wetlands in the Great Chazy River watershed, or approximately 12 percent of the watershed. This amount is consistent with the estimates above based on land cover and includes the following types of wetland habitats: freshwater forest/shrub wetland, freshwater emergent wetland, freshwater pond, lake (reservoirs), and riverine wetland. Some of this acreage can be attributed to large waterbodies in the watershed, which include the Chazy Lake, Miner Lake, Lake Roxanne, and Bradley Pond. Wetlands play an important role in flood mitigation by storing water and attenuating peak flows. It is estimated that since colonial times approximately 50 to 60 percent of the wetlands in the state of New York have been lost through draining, filling, and other types of alteration.

2.2 THE GREAT CHAZY WATERCOURSE

The Great Chazy River's main stem originates at Chazy Lake and flows in a northeastern direction for nearly 50 miles. The channel has an average slope of 38 feet per mile, which translates to a 0.7-percent slope. Named tributaries to the main stem include the North Branch Great Chazy River, Corbeau Creek, Park Brook, Witherspoon Brook, Sperry Brook, Bullis Brook, Cold Springs Brook, and Stillwater Brook.

Stream order provides a measure of the relative size of streams by assigning a numeric order to each stream in a stream network. The smallest tributaries are designated as first-order streams, and the designation increases as tributaries join. The main stem of the Great Chazy River can be characterized as a sixth-order stream at its outlet where it discharges to King Bay and as a fourth-order stream for most of its length. Larger tributaries such as the North Branch of the Great Chazy River are fifth order. Fourth-order streams include Corbeau Creek and Park Brook. Third-order streams include Bullis Brook and Sperry Brook. Second-order stream examples include Brandy Brook and Deer Pond Brook. Many of the first-order streams are unnamed. Figure 2-6 is a map depicting stream order in the Great Chazy River watershed.



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GREAT CHAZY RIVER WATERSHED STREAM ORDER

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FIG. 2-6

Characteristics of each order of stream (total length, average slope, and percentage of overall stream network) are summarized in Table 2-1. In the Great Chazy River watershed, first- and second-order streams account for most of the overall stream length (77 percent), and first-order streams are steeper in slope than higher order streams.

Table 2-1: Stream Order Characteristics in the NYS Portion of the Great Chazy River Watershed

Stream Order	Total Length (miles)	Percentage of Overall Network Length (%)	Average Slope (%)
1st	425.1	56%	2.28
2nd	162.2	21%	1.94
3rd	76.0	10%	1.28
4th	55.1	7%	0.92
5th	10.7	1%	1.44
6th	27.4	4%	0.33
Total	**756.5**	**100%**	

2.3 HYDROLOGY

Hydrologic studies are conducted to understand historical, current, and potential future river flow rates, which are a critical input for hydraulic modeling software. These often include statistical techniques to estimate the probability of a certain flow rate occurring within a certain period of time based on data from the past. Data are collected and maintained by the United States Geological Survey (USGS) at thousands of stream gauging stations around the country. For the streams without gauges, the USGS has developed region-specific regression equations that estimate flows based on watershed characteristics, such as drainage area and annual precipitation, as well as various techniques to account for the presence of nearby stream gauges or to improve analyses of gauges with limited records. These are based on the same watershed characteristics as gauged streams in that region so are certainly informative although not as accurate or reliable as a gauge due to the intricacies of each unique basin.

For the purposes of this flood study, we are primarily concerned with the more severe flood flows although hydrologic analyses may be conducted for the purposes of estimating low flows, high flows, or anywhere in between. The commonly termed "100-Year Flood" refers to the flow rate that is predicted to have a 1 percent, or 1 in 100, chance of occurring in any year. A "25-Year Flood" has a 1 in 25 chance of occurring (4 percent) every year. It is important to note that referring to a specific discharge as an "X-Year Flood" is a common and convenient way to express a statistical probability but can be misleading because it has no bearing whatsoever on when or how often such a flow actually occurs.

A simplified diagram of the hydrologic cycle is presented in Figure 2-7.

Along with the location, duration, and intensity of a storm, the flooding that may result from a rainfall event can vary widely depending on the unique hydrology of each basin. Characteristics of local topography, soils, vegetation cover and type, bedrock geology, land use and cover, river hydraulics and floodplain storage, ponding, wetland, and reservoir storage, combined with antecedent conditions in the watershed such as snowpack or soil saturation, can impact the timing, duration, and severity of flooding.

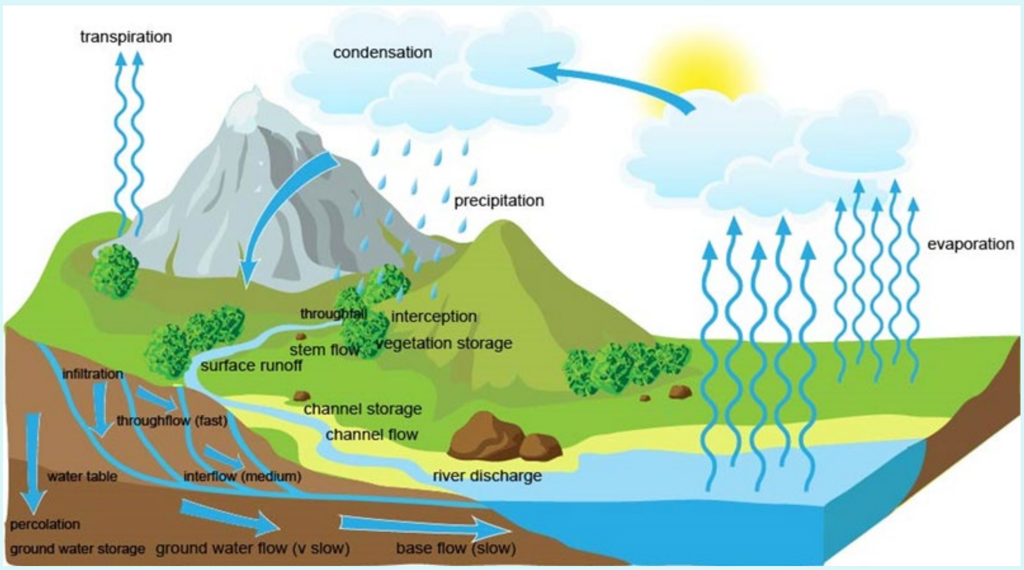
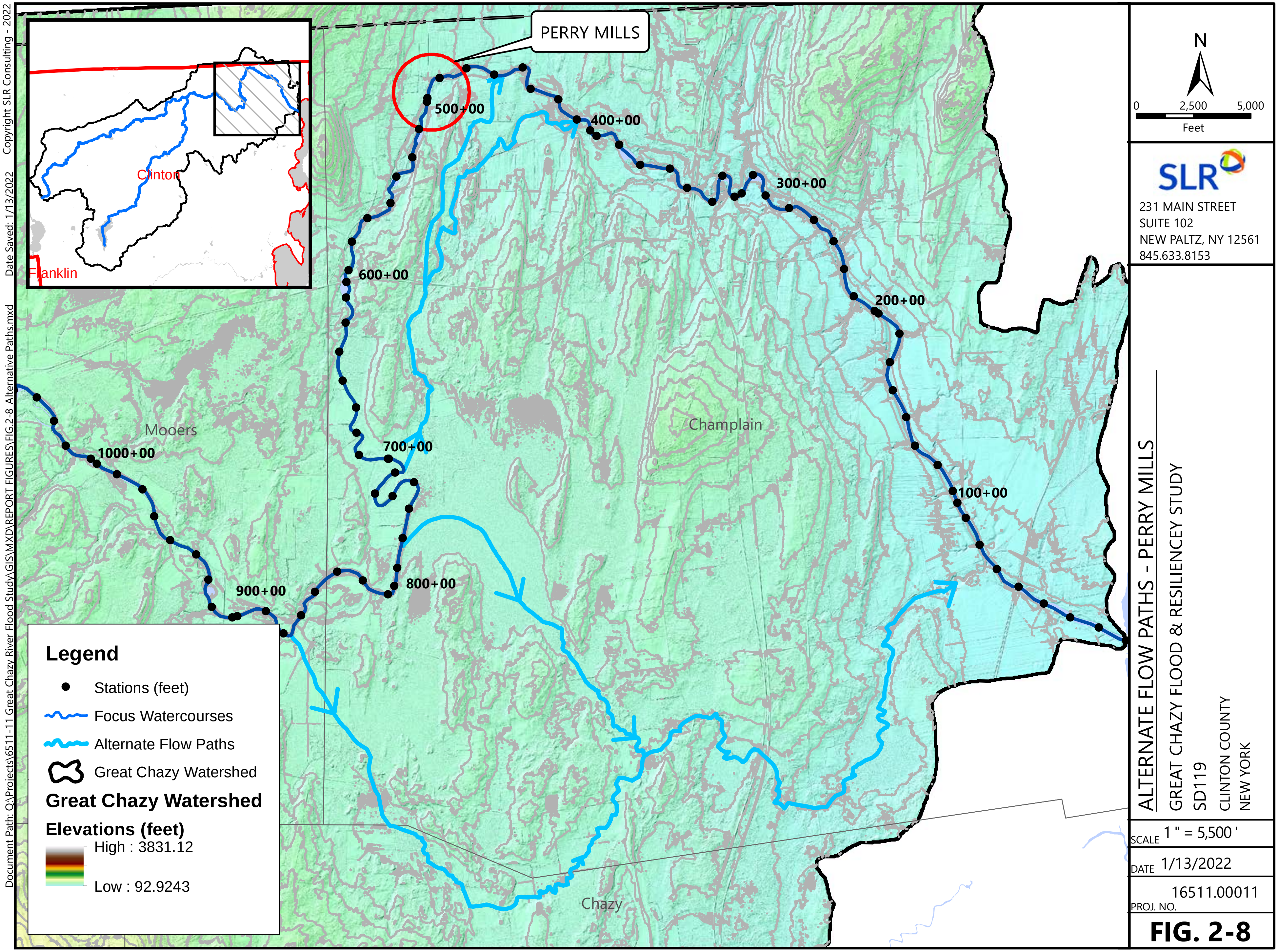


Figure 2-7: Diagram of Simplified Hydrologic Cycle

The USGS operates a stream flow gauging station on the Great Chazy River at Perry Mills (04271500), which has been in service since 1928 although limited data were recorded between 1968 and 1990. A critical aspect of this gauge's location is the fact that according to the remarks associated with this station, "at flows greater than about 2,000 [cfs], significant undetermined amounts of flow bypass the [gauge]." Analysis of Light Detection and Ranging (LiDAR)-derived topographic mapping reveals multiple flow paths that circumvent the gauge to the east and south, as depicted in Figure 2-8. Thus, while stage and discharge measurements are expected to be representative of conditions at this site, it is understood that this is not an accurate reflection of the total watershed's discharge in flow events that exceed the aforementioned 2,000 cubic feet per second (cfs) threshold. As points of reference, according to regional regression equations developed for New York State, the estimated 1.25-year recurrence interval (80 percent Annual Exceedance Probability [AEP]) flood produces 2,550 cfs at this location on the Great Chazy River (USGS SIR 2006-5112), with an estimated bankfull discharge of 5,350 cfs (USGS Scientific Investigations Report [SIR] 2009-5144).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ALTERNATE FLOW PATHS - PERRY MILLS
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A USGS Bulletin 17B analysis of the annual peak stream flow recorded at this station was performed, but the results are not considered appropriate or reliable for techniques used to extrapolate gauge analyses to elsewhere in the watershed, such as drainage-area-based transfer equations. Consultation with representatives of the National Weather Service's Northeast River Forecast Center has revealed that considerable effort has been expended in order to calibrate their river stage-discharge rating curves to account for the flows that bypass the stream gauge for more accurate projections of flooding in the village of Champlain.

Hydrology developed for FEMA for detailed and approximate methods models implements the drainage-area only regression equations for Hydrologic Region 1 in New York, as reported in USGS SIR 2006-5112. These produce greater flood flows than are computed based on the gauge record although this is not unexpected because the gauge does not capture the entire watershed's runoff. Modeled flooding in parts of HRA 1, including the village of Champlain, is therefore considered conservative as model hydrology assumes all discharge follows the primary channel rather than flanking to the south as discussed above. Flood flows at selected locations in identified HRAs are presented below in Table 2-2 along with projected future flood discharges.

Table 2-2: Peak Flow Hydrology for Great Chazy River

Location		Drainage Area (square miles)	Peak Flood Discharge (cfs)			
			10-Year	50-Year	100-Year	500-Year
Great Chazy River	STA 0+00; at confluence with Lake Champlain	300	9,898	13,729	15,588	19,760
	STA 300+00; Village of Champlain	260	8,825	12,271	13,944	17,703
	STA 500+00; Perry Mills	248	8,743	12,159	13,818	17,546
	STA 1100+00; Hamlet of Mooers	202	8,102	11,312	12,870	16,379
	STA 1630+00; Devils' Den Road, Altona	78	3,467	4,856	5,526	7,042
North Branch	STA 680+00; HRA 4, Ellenburg Depot	46	2,361	3,430	3,950	5,150
	STA 1080+00; HRA 4, Ellenburg Center	33	2,000	2,930	3,380	4,420

Stillwater flood elevations on Lake Champlain are based on statistical analysis of the USGS stage gauge at Rouses Point, New York (4295000), as reported in the 2020 Preliminary Flood Insurance Study (FIS) for Clinton County (36019CV000B). These elevations are summarized in Table 2-3.

Table 2-3 : Stillwater Flood Elevations on Lake Champlain for 1929 and 1988 Vertical Datums; May 2011 Record High Elevation Presented for Reference

Event	Lake Elevation (feet)	
	NGVD 29	NAVD 88
10-Year	101.43	101.0
25-Year	102.03	101.6
50-Year	102.43	102.0
100-Year	102.83	102.4
May 2011 Record High Elevation	103.2	102.77
500-Year	103.53	103.1

The web-based tool, "Application of Flood Regressions and Climate Change Scenarios to Explore Estimates of Future Peak Flows," developed by the USGS (Burns et al., 2015a,b) was used to obtain estimates for changes in peak-flood flows under a range of projected climate change scenarios at different periods in the future. This tool is currently only available for New York State and was used to assess flooding conditions that may occur in future decades, enabling proactive flood mitigation measures. These may include restricting development in areas that are not currently regulated floodplains but are reasonably expected to be in the future based on climate change projections or identifying bridges and culverts that currently perform well but may become hydraulically inadequate in the future.

Precipitation data were evaluated for two future scenarios, termed "Representative Concentration Pathways" (RCPs), 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. RCP 4.5 is considered a midrange-emissions scenario, and RCP 8.5 is a high-emissions scenario. Resulting precipitation and runoff estimates are based on five different climate models and are input into the USGS *StreamStats* program, a web-based implementation of regional hydrologic regression equations. Percent increases over *StreamStats* regression estimates based on current climatic data, as computed for Great Chazy River watershed, were applied to corresponding design flood flows in the FEMA hydraulic model at the 25 flow-change points along the modeled reaches of river. The flows based on the more moderate greenhouse gas scenario were used in the model. Proposed replacement stream crossings were assessed based on the flood flows the structure would be expected to encounter over its design lifetime. When modeling culverts, the 2050-2074 projections were employed as a 50-year design life is typical for such structures; the 2075-2099 projections were used for bridges, which are often in service for 75 to 100 years or more. Mean estimated increases at the Great Chazy River's confluence with Lake Champlain based on the five climate models are presented in Table 2-4. These are based on regressions for Flood Frequency Region 1 in New York. Projected 50- and 100-year future flows at identified HRAs are presented in Table 2-5.

Table 2-4: Projected Increases in Flood Flows on the Great Chazy River at Confluence with Lake Champlain

Mean Change in Discharge (%)	2025-2049		2050-2074		2075-2099	
Greenhouse Gas Scenario	50-Year Flood	100-Year Flood	50-Year Flood	100-Year Flood	50-Year Flood	100-Year Flood
RCP 4.5	1	1	5	5	4	4
RCP 8.5	6	6	6	6	11	11

Table 2-5: Current and Projected Future Flows Used in Hydraulic Analyses at Selected Locations on Great Chazy River

Location		Peak Flood Discharge (cfs)					
		Current		Projected Future (RCP 4.5, 2050-2074)		Projected Future (RCP 4.5, 2075-2099)	
		50-Year	100-Year	50-Year	100-Year	50-Year	100-Year
Great Chazy River	STA 0+00; HRA 1, at confluence with Lake Champlain	13,729	15,588	14,415 (+5%)	16,367 (+5%)	14,278 (+4%)	16,212 (+4%)
Great Chazy River	STA 300+00; HRA 1, Village of Champlain	12,271	13,944	13,007 (+6%)	14,641 (+5%)	12,762 (+4%)	14,502 (+4%)
Great Chazy River	STA 500+00; HRA 2, Perry Mills	12,159	13,818	13,132 (+8%)	14,785 (+7%)	12,889 (+6%)	14,647 (+6%)
Great Chazy River	STA 1100+00; HRA 3, Hamlet of Mooers	11,312	12,870	12,669 (+12%)	14,414 (+12%)	12,556 (+11%)	14,157 (+10%)
Great Chazy River	STA 1630+00; HRA 4, Devils Den Road, Altona	4,856	5,526	5,682 (+17%)	6,410 (+16%)	5,584 (+15%)	6,355 (+15%)
North Branch	STA 680+00; HRA 5, Ellenburg Depot	3,430	3,950	3,704 (+8%)	4,266 (+8%)	3,670 (+7%)	4,227 (+7%)
North Branch	STA 1080+00; HRA 5, Ellenburg Center	2,930	3,380	3,311 (+13%)	3,819 (+13%)	3,106 (+6%)	3,583 (+6%)

2.4 HYDRAULICS

One-dimensional *Hydrologic Engineering Center – River Analysis System* (HEC-RAS) hydraulic modeling of the Great Chazy River developed by FEMA between 2018 and 2019 was obtained from NYSDEC. The lower reaches of the river, downstream of Interstate 87, were modeled by detailed methods. Approximate methods were used upstream, meaning that assumptions are made about channel geometry, and hydraulic structures such as bridges, culverts, and dams are not surveyed for faithful representation in the model. Within identified flood-prone areas, these features' geometries were field measured by SLR Engineering, Landscape Architecture, and Land Surveying, P.C. (SLR) staff and incorporated into the model. The upstream and downstream models were composited into a single complete model of the watercourse and upgraded from HEC-RAS v.5.0.5 to v.6.1 for subsequent analyses.

2.5 PLANNING DOCUMENTS

This assessment utilized existing conditions data and information that was generally publicly available online to identify issues, opportunities, and needs that may be relevant to flood resiliency planning efforts. Sources used for this assessment include the following:

- Floodplain and Flood Hazard Areas utilizing Clinton County Geographic Information System (GIS) and New York State (NYS) GIS Clearinghouse data
- Google Maps (visual review of existing conditions)
- NYS Property Type Classification Codes – Assessors' Manual (NYS Department of Taxation and Finance)
- Town of Altona, New York, Zoning
- Town of Champlain, New York, Zoning
- Town of Chazy, New York, Zoning
- Town of Mooers, New York, Zoning
- Adirondack Park State Land Master Plan
- Clinton County Multi-Jurisdictional Hazard Mitigation Plan
- Clinton County GIS land use and parcel data
- The Lake Champlain Non-Point Source Pollution Subwatershed Assessment and Management Plan LC Nonpoint Source Pollution Subwatershed Assessment and Management Plan Final.pdf (lclgrpb.org)

Relevant planning and zoning information for each identified HRA is located in the respective sections.

For the entire watershed, the Lake Champlain Non-Point Source Pollution Subwatershed Assessment and Management Plan recommends the creation of a Great Chazy River watershed management plan. It also recommends livestock exclusion fencing and a riparian buffer program to deal with phosphorus loading concerns. The plan also recommends the implementation of an agricultural waste storage system in the Town of Champlain and an agricultural riparian buffer program in the Town of Champlain.

2.6 STAKEHOLDER MEETINGS

An important component of the data gathering for this study took place through stakeholder engagement. Three formal stakeholder meetings have been convened by video conference call. The first meeting was held on June 21, 2021, and included NYSDEC Region 5 staff. A second meeting was held on July 29, 2021, and a third on the evening of August 2, 2021, with participation from members of watershed groups, various agencies, and municipalities. In addition to the formal video meetings, many one-on-one conversations took place with representatives from the watershed municipalities and groups.

2.7 INFRASTRUCTURE

Several bridge crossings of the Great Chazy River are contained within identified HRAs and in certain cases may contribute to flooding in these locations. These structures and summary details are listed below in Table 2-6. A number of additional structures span the river but were not assessed in detail generally because they were adequately sized, relatively new, or did not significantly increase the flood hazard in surrounding developed areas.

Table 2-6: Bridge Summary Data (limited to bridges in Identified HRAs)

	Roadway	River Station (feet)	Structure Description	NBI BIN* (Owner)	Year Built	Total Span (feet) (Number of Spans)	Rise Above Streambed (feet)	Bankfull Width (feet) (Regional Regressions)
Great Chazy River	Canadian Pacific Railroad	54+00		Not Listed (CP RR)		120 (1)	23	170
	NY-9B/Lake Street	73+00	Steel thru-truss	1006270 (State)	1930	110 (1)	24	170
	US-11	235+00	Steel multibeam	1009080 (State)	1961	184 (2)	20	165
	Elm Street	279+00	Steel girder and floorbeam	3363310 (County)	1937	100 (1)	20	162
	US-9	298+00	Steel thru-truss	1006060 (State)	1932	120 (1)	14	162
	I-87 N	340+00	Steel multibeam	1034152 (State)	1960	270 (3)		161
	I-87 S	341+00	Steel multibeam	1034151 (State)	1960	270 (3)		161
	Dubois Road	346+20	Steel thru-truss	3336200 (County)	1991	120 (1)	14	161
	Creek Road	491+00	Steel multibeam	3336210 (County)	1961	95 (1)	14	158
	CR-34/East Street (out of service)	1084+00	Steel Whipple truss	3336250 (County)	1888 (Rehab. 1960, Aban. 1983)	182 (1)	21	147
	NY-22	1089+00	Steel multibeam	1017310 (State)	1983	145 (1)		147
	Tappin Road	1155+00	Steel multibeam	3336260 (County)	2021	125 (1)		

	Roadway	River Station (feet)	Structure Description	NBI BIN* (Owner)	Year Built	Total Span (feet) (Number of Spans)	Rise Above Streambed (feet)	Bankfull Width (feet) (Regional Regressions)
	Devil's Den Road	1628+00	Twin cast-in-place (CIP) concrete box	3336320 (County)	1965	37 (2)	13	104
North Branch Great Chazy River	Canaan Road	633+80	Multibox beam	3370270 (County)	2006	130 (2)		86
	NY-11	641+00	Concrete	1009010 (State)	1948	50 (1)		86
	Lake Roxanne Road	674+50	Steel multibeam	3336590 (County)	1951	37 (1)		86
	Cold Spring Road	774+30	Prestressed concrete box beam	3336590 (County)	1997	89 (1)		80
	Military Turnpike/ NY-11 Junction	841+20	Prestressed concrete stringer	3336640 (State)	1988	33 (1)		76

*National Bridge Inventory Bridge Identification Number

Regardless of past bridge performance and flooding history, all replacement stream crossings should be accompanied by rigorous, up-to-date hydrologic and hydraulic analyses and incorporate the most current future flood projections and all applicable design standards and guidance set forth by New York State Department of Transportation (NYSDOT) and NYSDEC, as practical. Hydraulic design criteria developed by these agencies are presented below and in Table 2-7.

In 2014, the Community Risk and Resiliency Act (CRRA) was signed into law to build New York's resilience to rising sea levels and extreme flooding. The Climate Leadership and Community Protection Act made modifications to the CRRA, expanding the scope of climate hazards and projects for consideration. These modifications became effective January 1, 2020. NYSDEC has provided guidelines for requirements under CRRA, which are summarized in a publication entitled *New York State Flood Risk Management Guidance for Implementation of the Community Risk and Resiliency Act.*

NYSDOT Hydraulic Design Criteria for Bridges

- **The proposed structure shall not raise the water surface elevations anywhere when compared to the existing conditions for both the 50- and 100-Year flows.**
- **The proposed low chord shall not be lower than the existing low chord.**
- **A minimum of 2.0 feet of freeboard for the projected 50-Year flood is required for the proposed structure. The freeboard shall be measured at the lowest point of the superstructure between the two edges of the bottom angle for all structures.**
- **The projected 100-Year flow shall pass below the proposed low chord without touching it.**
- **The maximum skew of the pier(s) to the flow shall not exceed 10 degrees.**
- **For the purposes of resilient design, current peak flow estimates shall be increased by 10% in DEC Regions 4, 5, and 6, plus Cayuga, Onandoga, Seneca, and Tompkins Counties; in Regions 1, 2, 7, 8, 9, 10, and 11, plus Cortland and Oswego Counties, peak flows shall be increased by 20%.**

Reproduced from Section 3.2.3.1 of 2019 NYSDOT *Bridge Manual*.

Table 2-7: Design Flood Frequencies for Drainage Structures and Channels, Reproduced from Table 8-2 in 2018 NYSDOT *Highway Design Manual Revision 91*.

HIGHWAY FUNCTIONAL CLASSIFICATION	DESIGN FLOOD FREQUENCY (YEARS)[1,3]		
	Culverts[2]	Storm Drainage Systems	Ditches[4]
Interstates and Freeways	50	10[5]	25
Principal Arterials	50	10[5]	25
Minor Arterials, Collectors, Local	50[6]	5[7]	10

1. The values in this table are typical. The selected value for a project should be based upon an assessment of the likely damage to the highway and adjacent landowners from a given flow and the costs of the drainage facility. Note: 100-year requirements must be checked if the proposed highway is in an established regulatory floodway or floodplain.
2. The check flow, used to assess the performance of the facility, should be the 100-year storm event.
3. Relocated natural channels should have the same flow characteristics (geometrics and slope) as the existing channel and should be provided with a lining having roughness characteristics similar to the existing channel.
4. Including lining material
5. As per 23CFR650A, and Table 1-1 of HDS 2, a 50-year frequency shall be used for design at the following locations where no overflow relief is available:

   a. sag vertical curves connecting negative and positive grades.
   b. other locations such as underpasses, depressed roadways, etc.

6. A design flood frequency of 10 or 25 years is acceptable if documented in the Design Approval Document, and when identified after design approval, in the drainage report. A design flood frequency of 10 or 25 years should be used in the design of driveway culverts and similar structures.
7. Use a 25-year frequency at the following locations where no overflow relief is available:
   a. sag vertical curves connecting negative and positive grades.
   b. other locations such as underpasses, depressed roadways, etc.

NYSDEC Stream Crossing Standards

- **Bridges and bottomless arches are preferred and should be used whenever possible.**
- **Box and pipe culverts, if used, must be:**
    - Embedded into the streambed to at least 20 percent of the culvert height at the downstream end.
    - Used only on streambeds with slopes no steeper than 3 percent.
    - Installed level.
- **The crossing opening should be at least 1.25 times the width of the stream channel bed. This width is measured bank-to-bank at the ordinary high water level or edges of terrestrial, rooted vegetation.**
    - An average of three measurements, at the project location and up- and downstream, should be used to determine the channel bed width.
- **At low flows, water depths and velocities should be the same as they are in natural areas up- and downstream of the crossing.**
- **Natural substrate should be used within the crossing, and it should match the up- and downstream substrates. It should resist displacement during floods and should be designed so that the appropriate material is maintained during normal flows.**

3. IDENTIFICATION OF FLOOD AND ICE JAM HAZARDS

3.1 FLOODING AND ICE JAM HISTORY

Clinton County has an active history of floods, flash floods, and ice jamming. According to the National Oceanic and Atmospheric Administration (NOAA) historical records summarized in the FEMA Discovery Report for the Lake Champlain Watershed, Clinton County has experienced 16 flash floods or flooding events, including lakeshore flooding, since 2000. Thirteen of those events occurred from 2007-2012. Clinton County's Hazard Mitigation Plan (HMP) states that ice jamming issues consistently occur in Perry Mills and the town of Champlain. Ice jams typically occur in the springtime or during mid-winter thaw or rain-on-snow events, with the thaw producing higher flows and breaking up ice deposits. The broken-up ice can accumulate at obstructions or flow contractions such as undersized bridges and cause significant additional flooding and damage. Clinton County has experienced 15 ice jam events between 2004 and 2011. As of Water Year (WY) 2021, the U.S. Army Engineer Research and Development Center's Cold Regions Research and Engineering Lab (CRREL) Ice Jam database reports 71 ice jam events on the Great Chazy River since 1929, with 40 such events taking place since 1996. Flood and ice jam events in Clinton County and on the Great Chazy River are summarized in Table 3-1.

Table 3-1: The Great Chazy River Flood History

Event Type	Areas(s) Affected	Date	Notes
Flood/Ice Jam	Champlain	1/19/1996	Warm temperatures combined with high amounts of rainfall caused flash floods throughout the county. Around 7" of rain fell in 12 hours. A State of Emergency was declared, and Governor Pataki proclaimed Clinton County a disaster area. Extensive flooding made hundreds of miles of roads unpassable, and infrastructure was considerably damaged. No deaths were reported, and approximately $4,000,000 in property damages were incurred during this event.
Flash Flood	Countywide	11/09/1996	Heavy rain resulted in flash floods, consequently damaging numerous roads and bridges. Some bridges were washed out. Several rivers crossed record level thresholds. Property damage totaled approximately $23,000,000.
Flash Flood	Countywide	6/27/1998	Wet soil conditions led to rapid rise in rivers and streams. Numerous roads were flooded and washed out. Property damage totaled $2,500,000.
Flash Flood/Ice Jam	Countywide	2/27/2000	Warm temperatures caused large amounts of snowmelt and runoff. A cold front stalled across New England on 2/28/2000, dropping steady amounts of rain on the area as well. These factors combined resulted in ice jams on the Great Chazy River in Perry Mills and the town/village of Champlain. The river gage for the Great Chazy River at Perry Mills was around 3' above flood stage. Houses and roads were flooded in the village of Champlain. Route 9 was closed. The flood caused an estimated $75,000 worth of property damage.

Flood	Countywide	6/12/2002	2" to 4" of rain fell on Clinton County due to a stalled frontal boundary. A few roads were closed. Property damage totaled $20,000.
Flood/Ice Jams	Champlain	3/07/2004	Ice jams created blockages and caused flooding along the Great Chazy River due to combined rainfall and mild temperatures. A few roads were closed, and property damage totaled $20,000.
Flood/Ice Jams	Champlain	3/16/2007	Ice jams caused by snowmelt and rainfall resulted in flooding along the Great Chazy River. Some residents were evacuated from their homes. Property damage totaled $25,000.
Flash Flood	Dannemora, Mooers	7/28/2007	Several thunderstorms traveled through the region on 8/17/2007, resulting in heavy rainfall. On 7/28/2007, a weak upper low-pressure system drifted across a warm, moist, and unstable airmass across northern New York. Localized rainfall amounts were greater than 3", which produced flash floods. Roads were washed out, and basements were flooded. Approximately $45,000 in property damages occurred.
Flood/Flash Flood	Altona, Harrigan Corners, Ellenburg	8/04/2010	Extensive rainfall totaling more than 5" fell over the northern Adirondacks for 2 days. Extreme flash flooding made multiple roads impassable and also resulted in widespread damage to those roads. Homes, a motel, general store, and two seasonal RV parks were flooded. In one RV park in Ellenburg, three people were trapped by the flash flood and required rescue. No injuries or deaths occurred. The flash flood caused approximately $750,000 in property damages.
Flash Flood	Countywide	8/28/2011	Tropical Storm Irene traveled through Clinton County on 8/28/2011, and caused extensive damage to the region. An estimated 2" to 4" of rain fell on Champlain Valley, and an estimated 4" to 7" of rain fell on the Adirondacks in southern Clinton County. Flash flooding was widespread throughout the region. Winds were greater than 60 miles per hour (mph) and downed trees, resulting impacted power lines. Agricultural fields were flooded, causing around $1,000,000 in crop damages. In the town of Altona, two fatalities occurred due to a flash flood on the Great Chazy River. Flood stage begins at 9' on the Great Chazy River at Perry Mills, and the gage there recorded a crest of 9.5'. Many other evacuations and rescues happened all over the county as emergency responders were called to assist individuals. Damages to roads and homes throughout the county totaled around $9,500,000.
Flood	Altona, Beekmantown	6/29/2013	Heavy rainfall in the higher terrain of central Clinton County caused flooding of Route 190, the Military Turnpike, closing it from Duley Road to Seymour Road. Flooding also occurred on General Leroy Manor Road, Route 734, and roads in Rand Hill. Property damage totaled $175,000.
Flood	Champlain, Saranac	4/15/2014	Heavy rainfall and snowmelt combined to produce flooding in the Saranac and Great Chazy Rivers. Local roads were flooded along both rivers. Property damaged totaled $250,000.

Ice jamming in Perry Mills or the village of Champlain is recorded in the United States Army Corps of Engineers (USACE) CRREL ice jam database as having occurred at least once per year in 21 of the past 25 years, at times causing significant damage to infrastructure and property. In the village, this can be influenced by thicker ice that forms in the Lake Champlain backwaters, which normally extend approximately to the Elm Street bridge but can reach several hundred feet upstream of it. A gas transmission line crosses the Great Chazy River on the US-9 bridge, and Clinton County Department of Emergency Services reports that this line is valved on both sides of the bridge and that it is shut down during ice breakup events. Heavy machinery is also stationed on either side of this bridge to aid ice passage. At Perry Mills, thick, solid ice that forms in the Whiteside Dam impoundment can collect ice upstream, affecting the Creek Road bridge.

> Ice jamming in Perry Mills or the village of Champlain has occurred at least once per year in 21 of the past 25 years, at times causing significant damage to infrastructure and property.

3.2 FEMA MAPPING

As part of the NFIP, FEMA produces FIRMs that demarcate the regulatory floodplain boundaries. As part of a FIS, the extents of the 100-year and 500-year floods are computed or estimated, as well as the regulatory floodway, if one is established. The area inundated during the 100-year flood event is also known as the SFHA. In addition to establishing flood insurance rates for the NFIP, the SFHA and other regulatory flood zones are used to enforce local flood damage prevention codes related to development in floodplains.

The current FIS for Clinton County (36019CV000A) has been effective since September 2007. Effective FIRM panels for the Great Chazy River were produced based on hydraulic modeling completed between 1977 and 2001, depending on the pre-countywide FIS municipal jurisdiction. The effective flood hazard areas delineated by FEMA are mapped in Figures 3-1 through 3-18. A revised Preliminary FIS dated August 2021 has been produced (36019CV001B), which incorporates both detailed and approximate methods hydraulic modeling completed as recently as 2018. Residents are encouraged to consult the most recent products available from the FEMA Flood Map Service Center (https://msc.fema.gov/portal/home) for a more complete understanding of the flood hazards that currently exist.

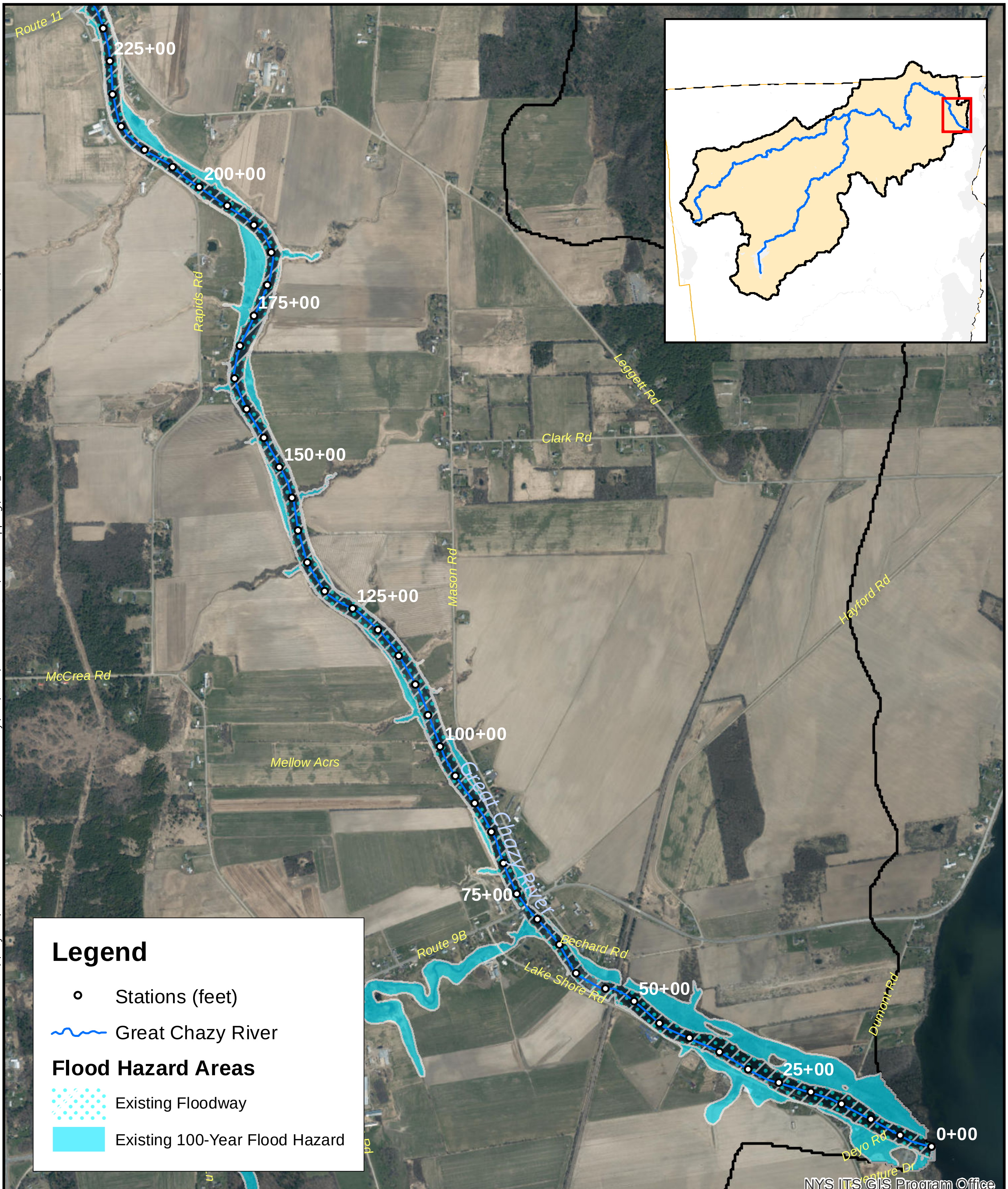
> Over the period of a standard 30-year mortgage, a property located within the SFHA will have a 26 percent chance of experiencing a 100-year flood event. Structures falling within the SFHA may be at an even greater risk of flooding because if a house is low enough it may be subject to flooding during the 25-year or 10-year flood events. During the period of a 30-year mortgage, the chance of being hit by a 25-year flood event is 71 percent, and the chance of being hit by a 10-year flood event is 96 percent, which is a near certainty.

A local Flood Damage Prevention Permit is required to be obtained from the local Floodplain Administrator in communities where floodplain development will occur. This includes construction of buildings, excavation, drilling, paving, installation of generators, aboveground and underground tanks, and storage of materials and equipment. The local floodplain permit should not be issued until all other local, state, or federal permits have been obtained. The NYSDEC is available to assist any community with permitting needs, as requested.

Local floodplain permits are not required of New York State agencies; however, they must develop projects according to 6 NYCRR Part 502. New York State agencies that provide funding for projects must also conduct a Part 502 review.

Several stretches of the Great Chazy River contain mapped FEMA floodways. This is a high hazard area of the floodplain where the community must (according to 44 CFR Part 60.3 (d)(3)) “prohibit encroachments, including fill, new construction, substantial improvements, and other development within the adopted regulatory floodway unless it has been demonstrated through hydrologic and hydraulic analyses performed in accordance with standard engineering practices that the proposed encroachment would not result in any increase in flood levels within the community during the occurrence of the base flood discharge." Any projects within these areas are required to demonstrate no net rise. It should be noted that these reviews will increase the overall project budget.

Should the floodplain extent be reduced or increased because of the projects, communities should request a Letter of Map Revision (LOMR) be submitted to FEMA, especially if structures are removed from the floodplain. Costs for this FEMA application should be considered as part of any grant application submitted since it will increase costs.



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SLR
231 MAIN STREET
SUITE 102
NEW PALTZ, NY 12561
845.633.8153

GREAT CHAZY RIVER - FEMA MAPPING

GREAT CHAZY FLOOD & RESILIENCY STUDY
SD119
CLINTON COUNTY
NEW YORK

SCALE 1 " = 2,000 '

DATE 1/19/2022

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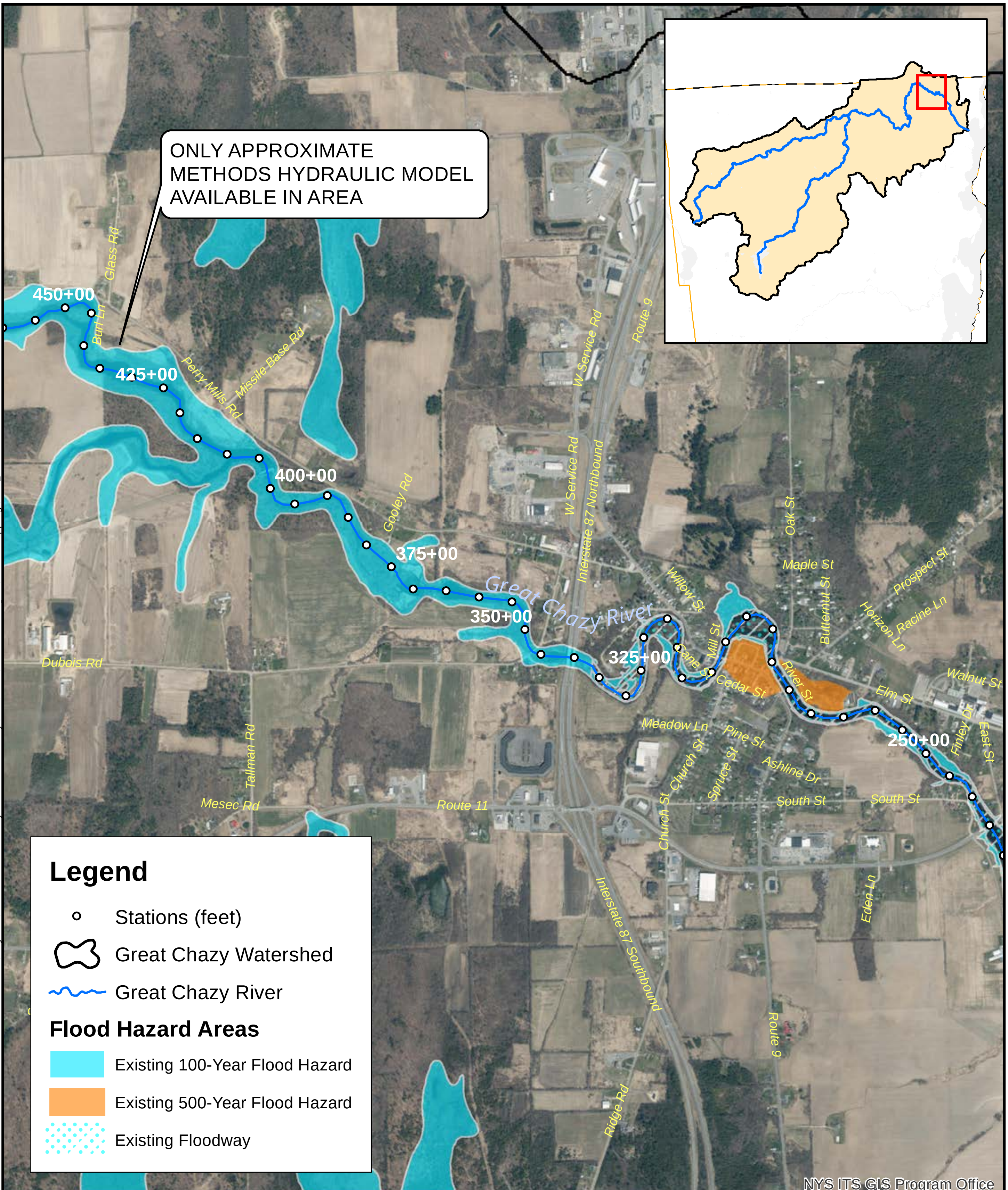
FIG. 3-1



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231 MAIN STREET
SUITE 102
NEW PALTZ, NY 12561
845.633.8153

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GREAT CHAZY FLOOD & RESILIENCY STUDY
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CLINTON COUNTY
NEW YORK

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FIG. 3-2

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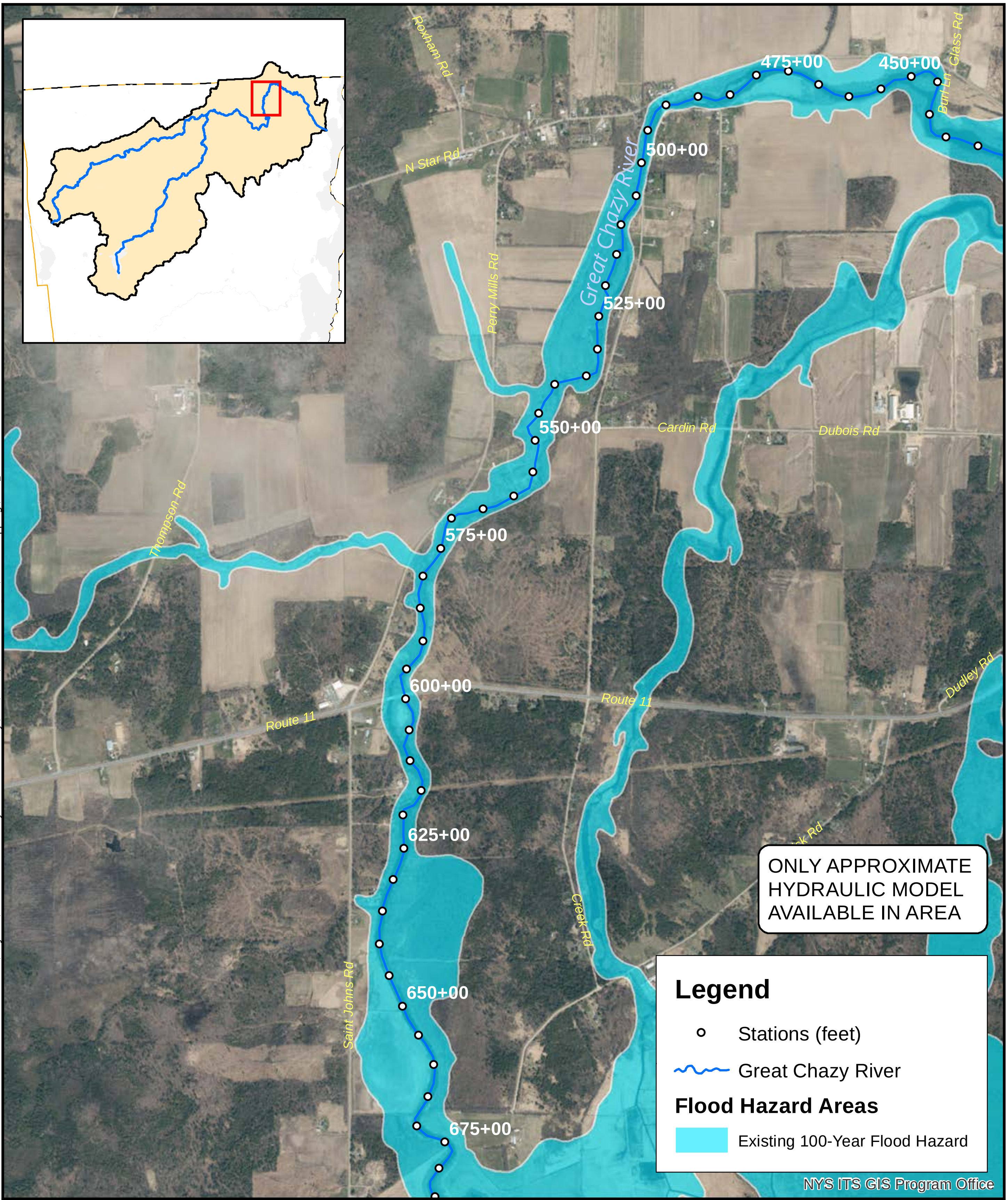

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CLINTON COUNTY
NEW YORK

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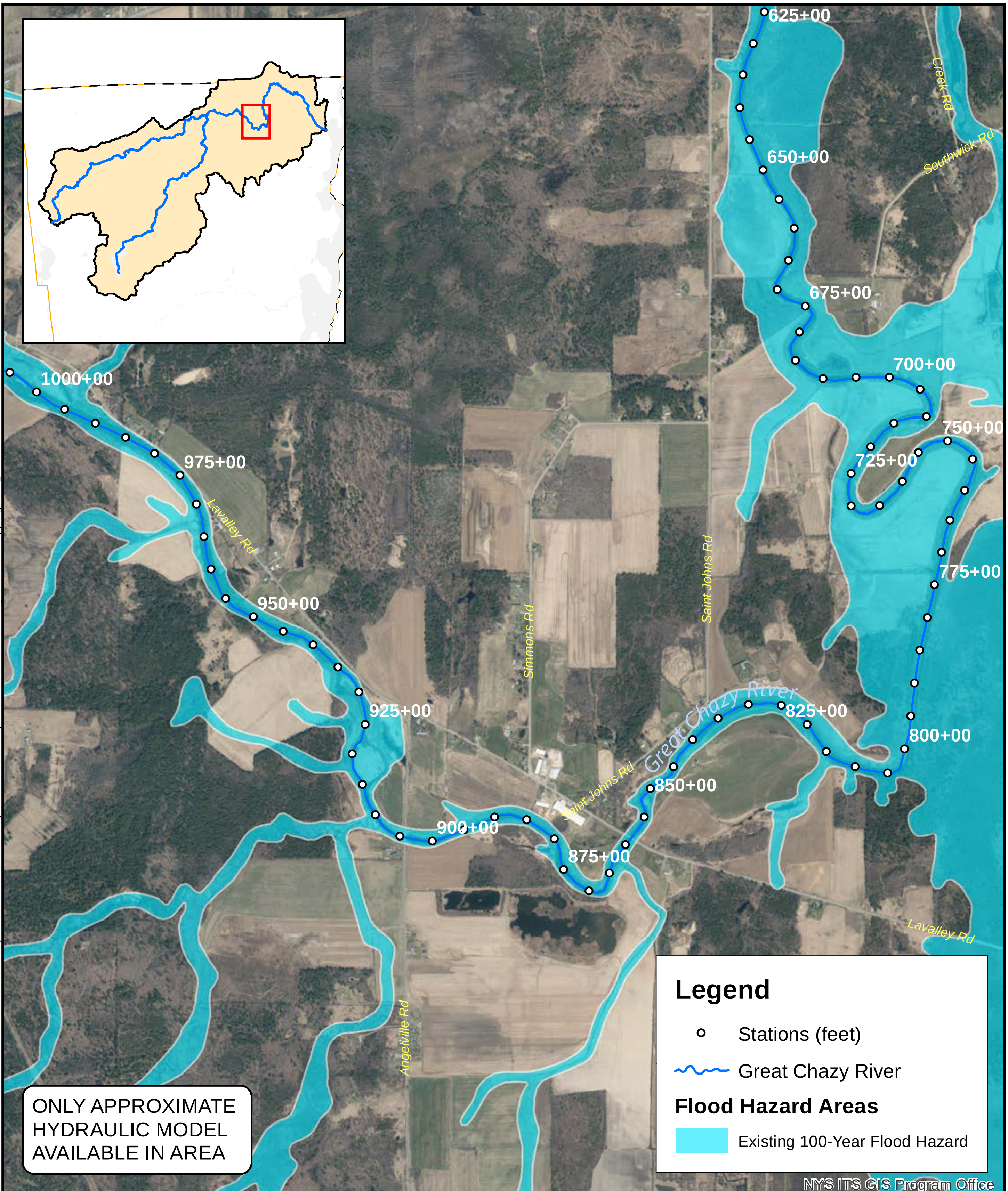
FIG. 3-3



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SD119

CLINTON COUNTY
NEW YORK

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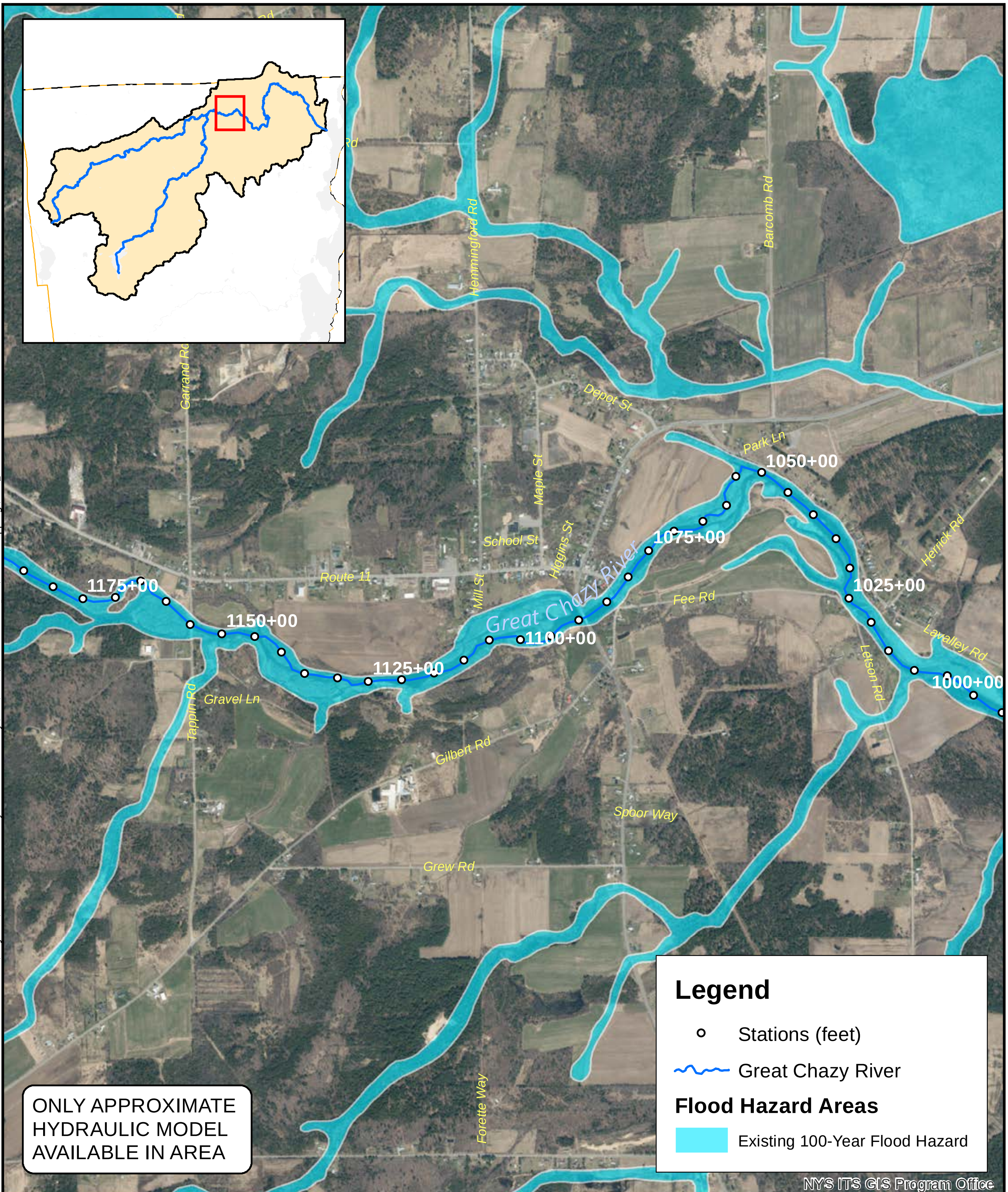
FIG. 3-4



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231 MAIN STREET
SUITE 102
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GREAT CHAZY RIVER - FEMA MAPPING
GREAT CHAZY FLOOD & RESILIENCY STUDY
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CLINTON COUNTY
NEW YORK

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SCALE 1 " = 2,000 '
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FIG. 3-5

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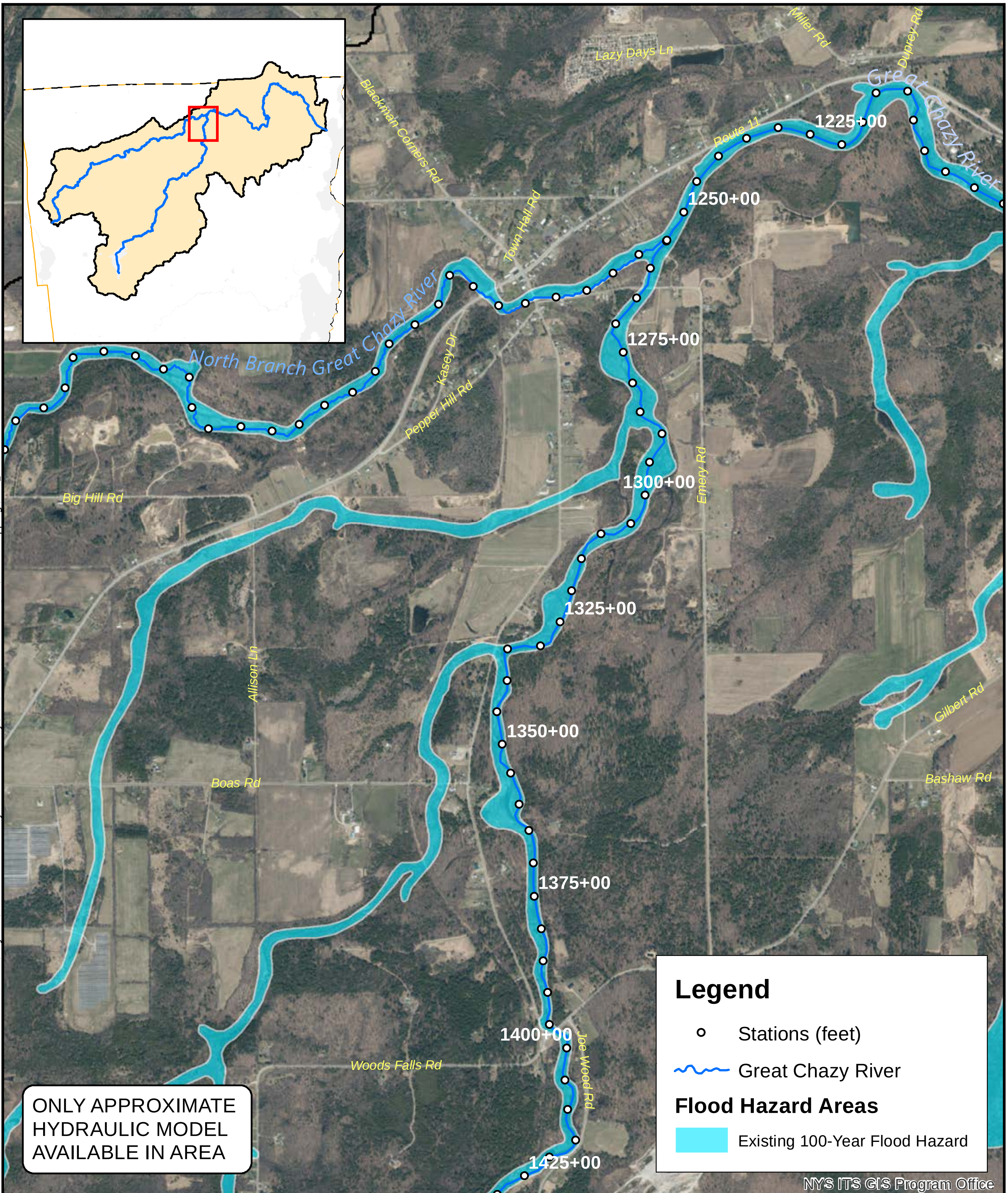

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231 MAIN STREET
SUITE 102
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845.633.8153

GREAT CHAZY RIVER - FEMA MAPPING

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NEW YORK

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FIG. 3-6

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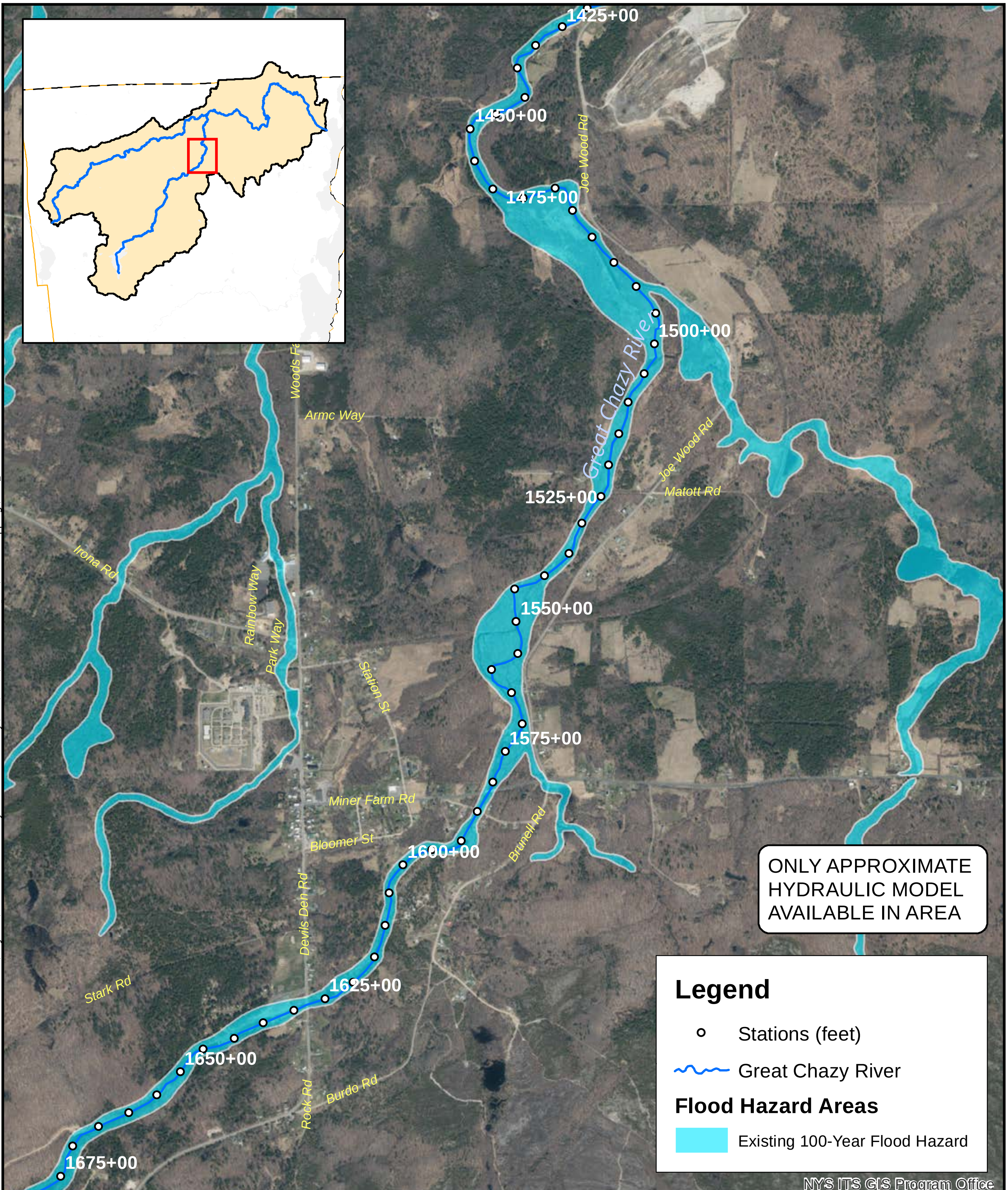

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GREAT CHAZY RIVER - FEMA MAPPING

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SD119
CLINTON COUNTY
NEW YORK

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Feet

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FIG. 3-7

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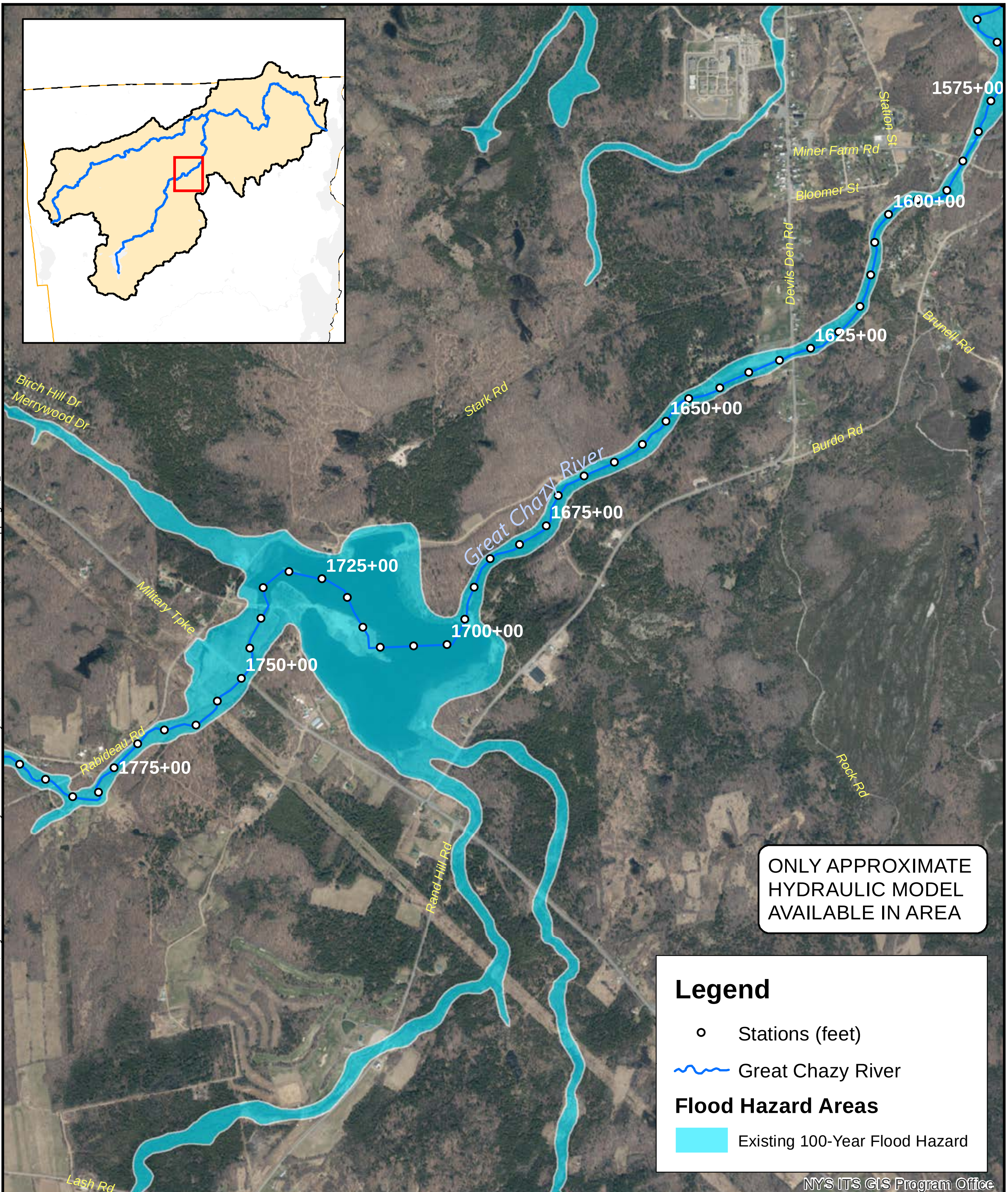

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FIG. 3-8

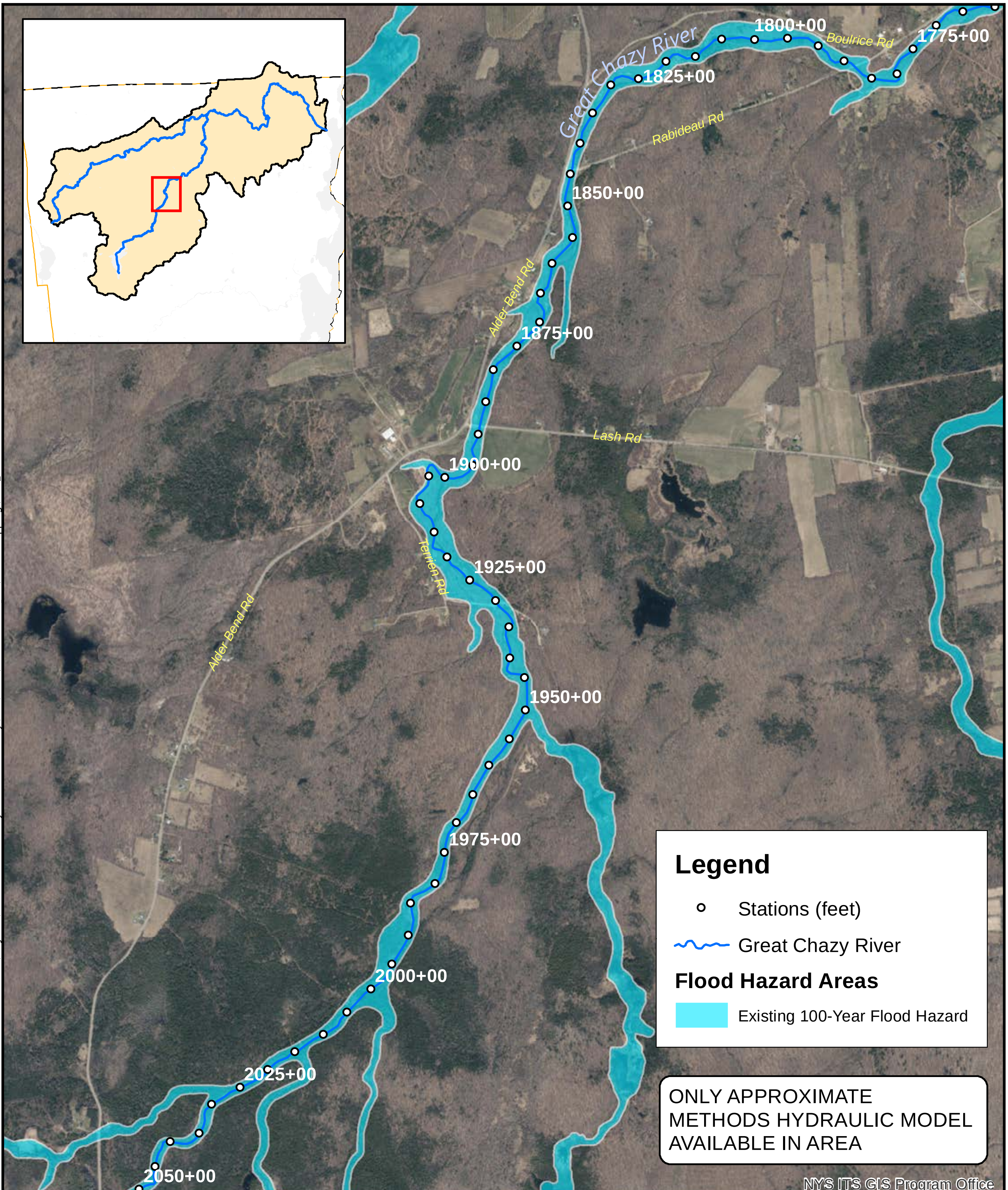

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FIG. 3-9

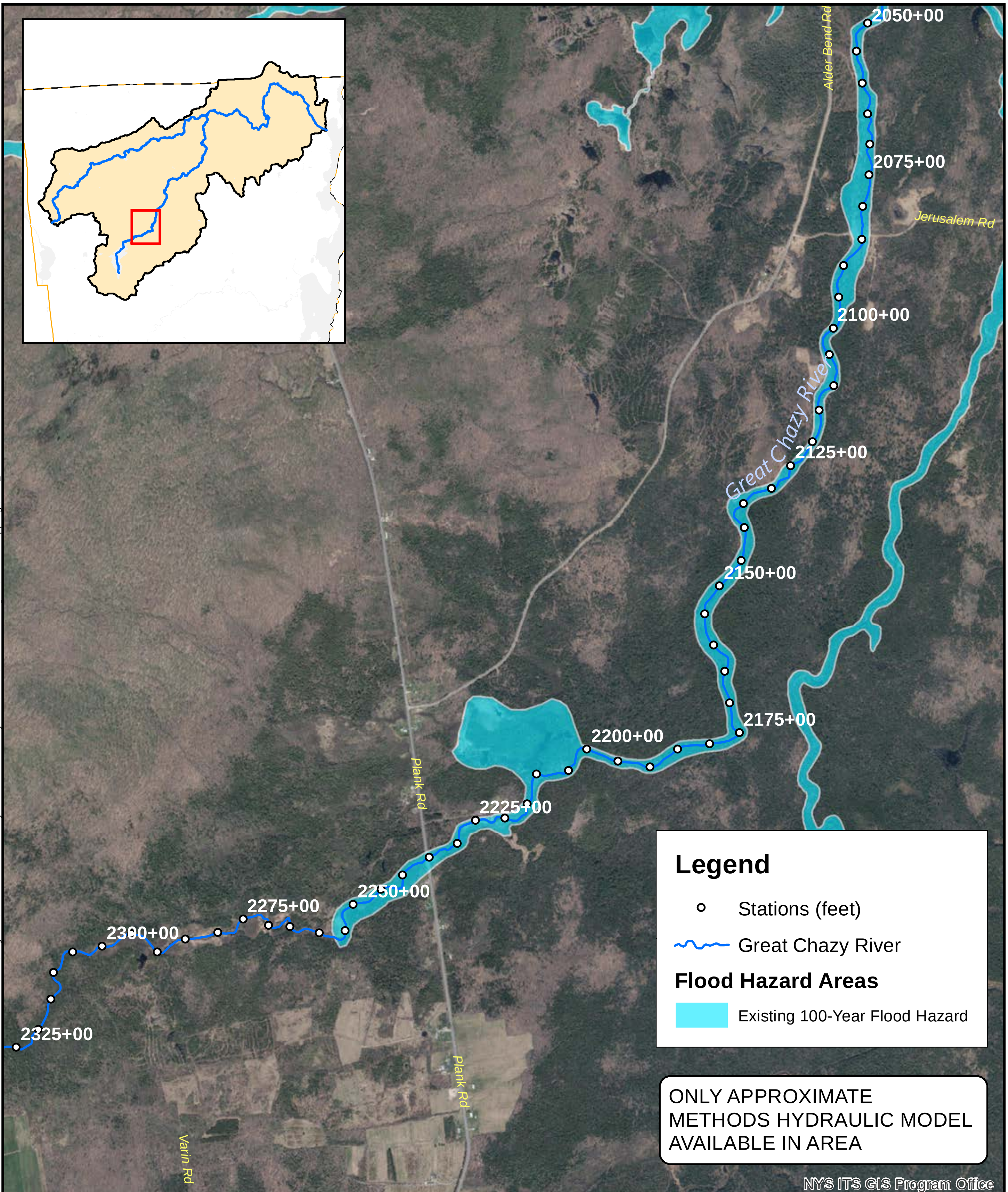

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FIG. 3-10

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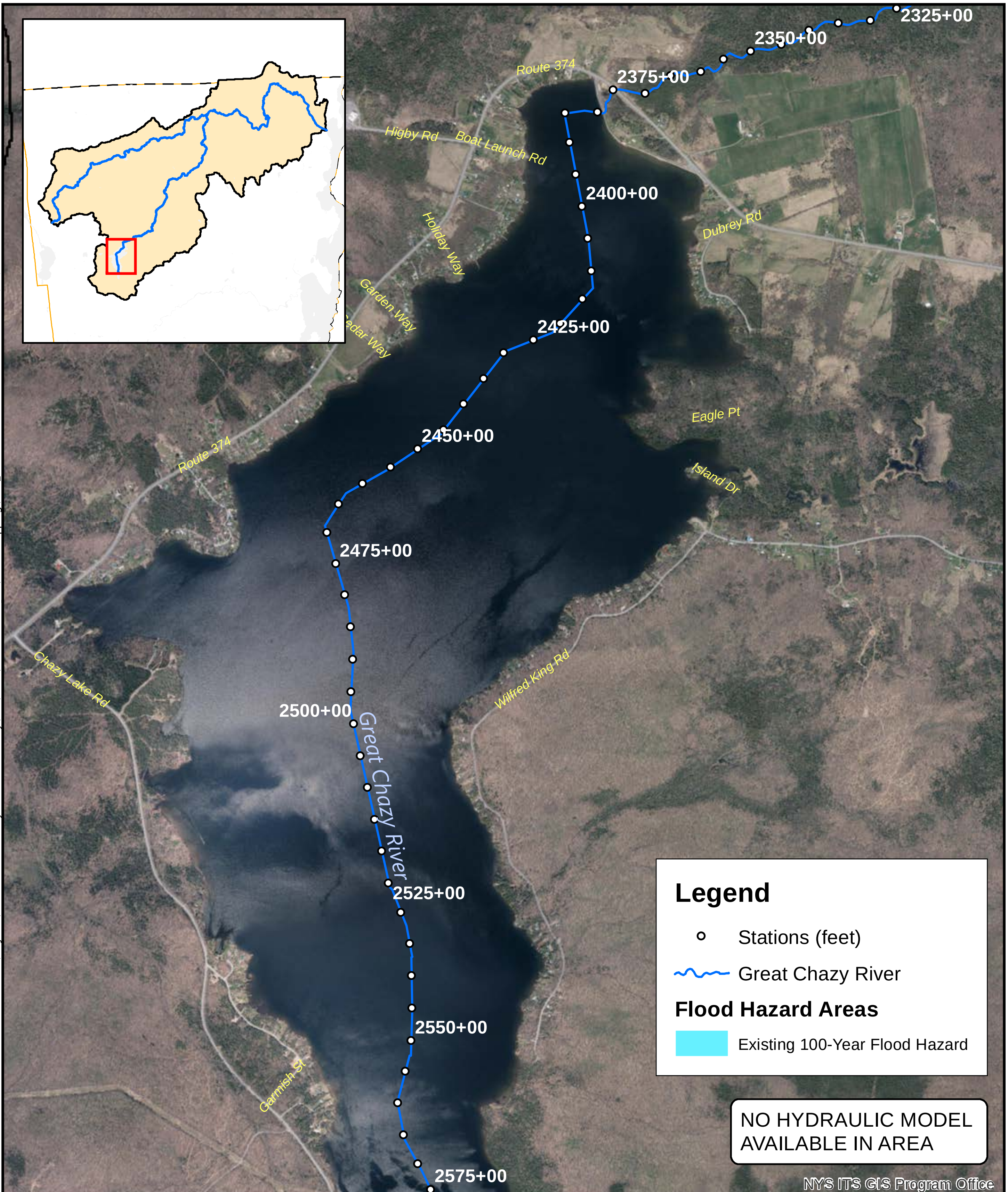

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GREAT CHAZY RIVER - FEMA MAPPING

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FIG. 3-11

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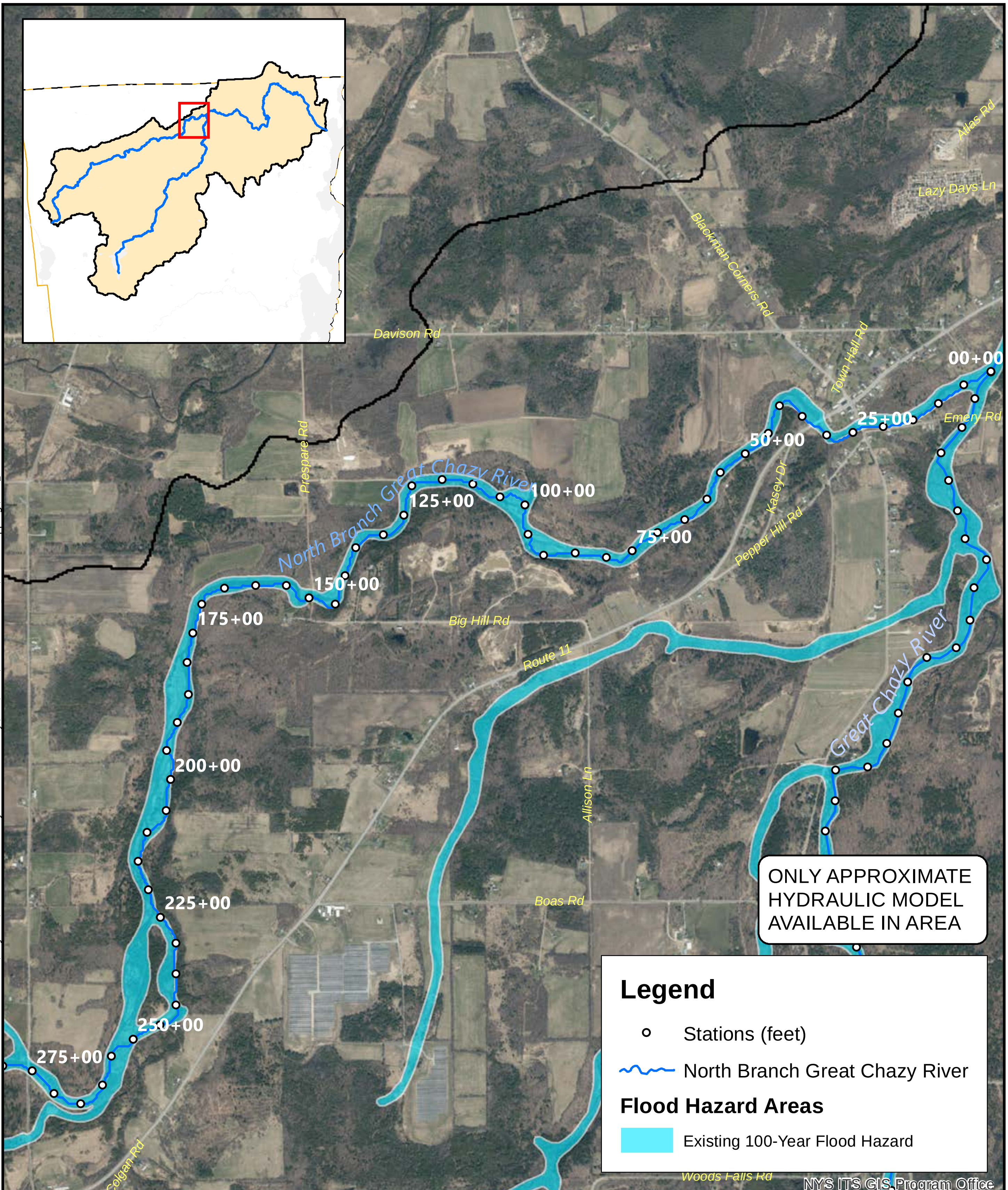

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NORTH BRANCH GREAT CHAZY RIVER - FEMA MAPPING

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FIG. 3-12

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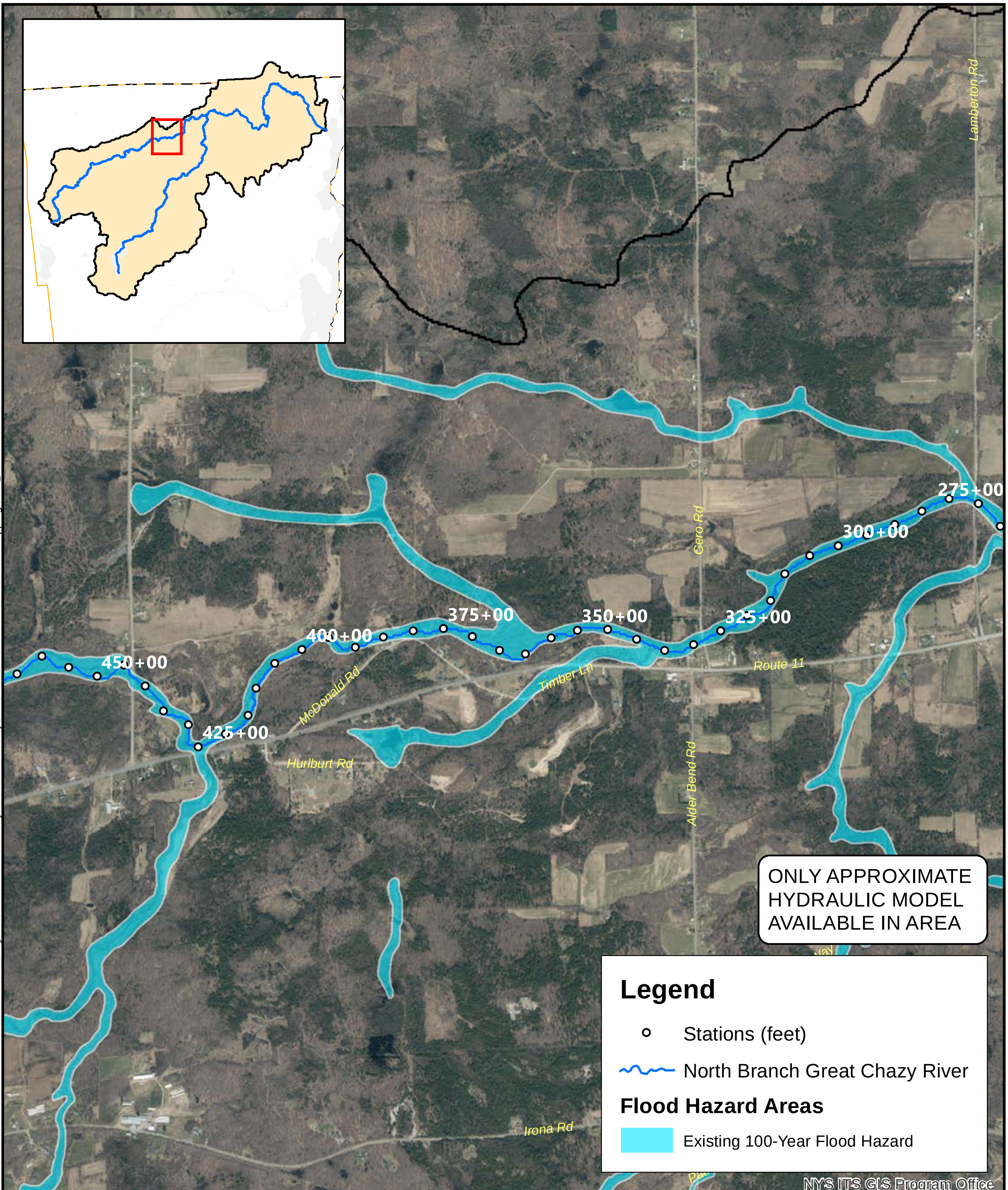

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FIG. 3-13

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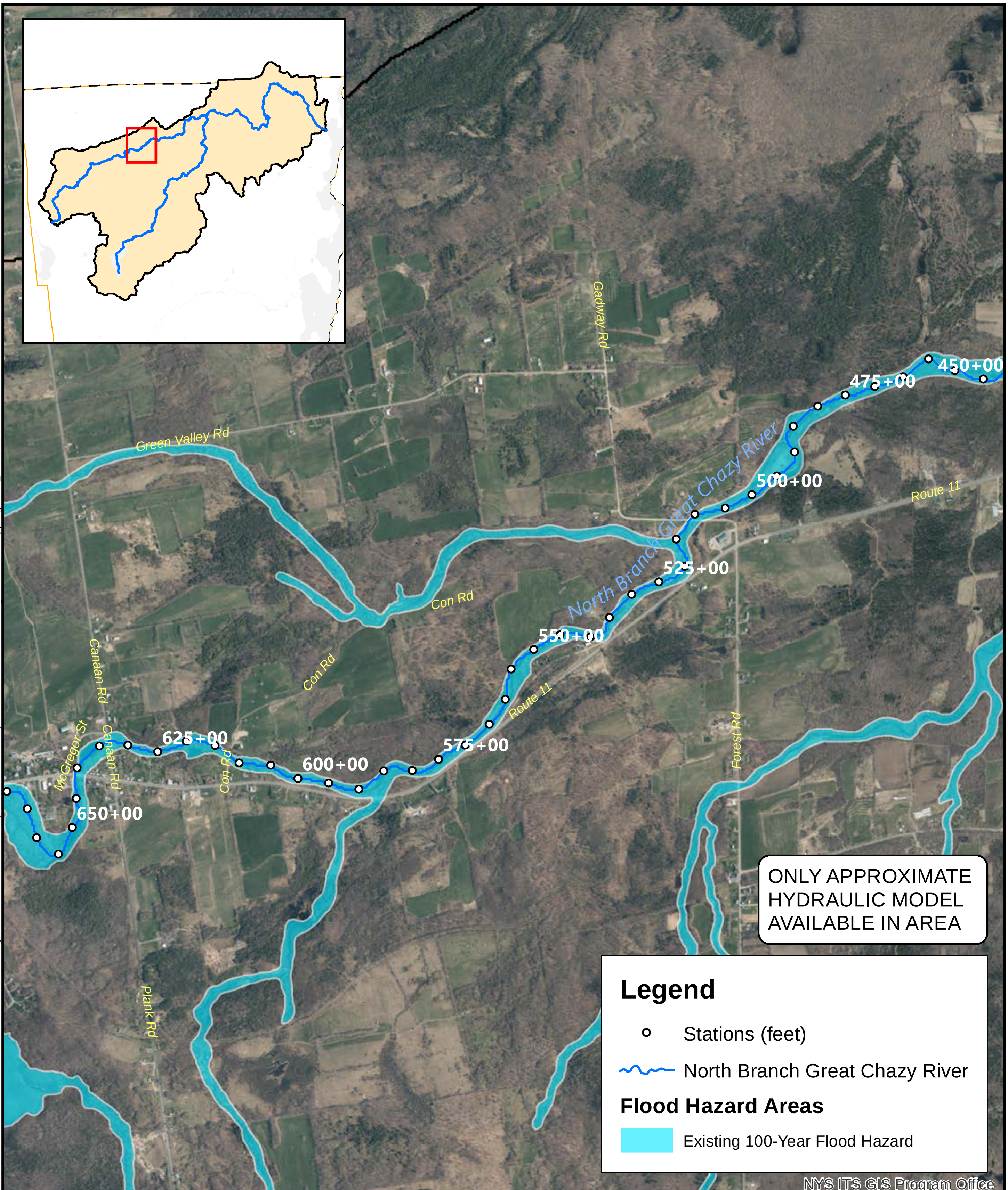

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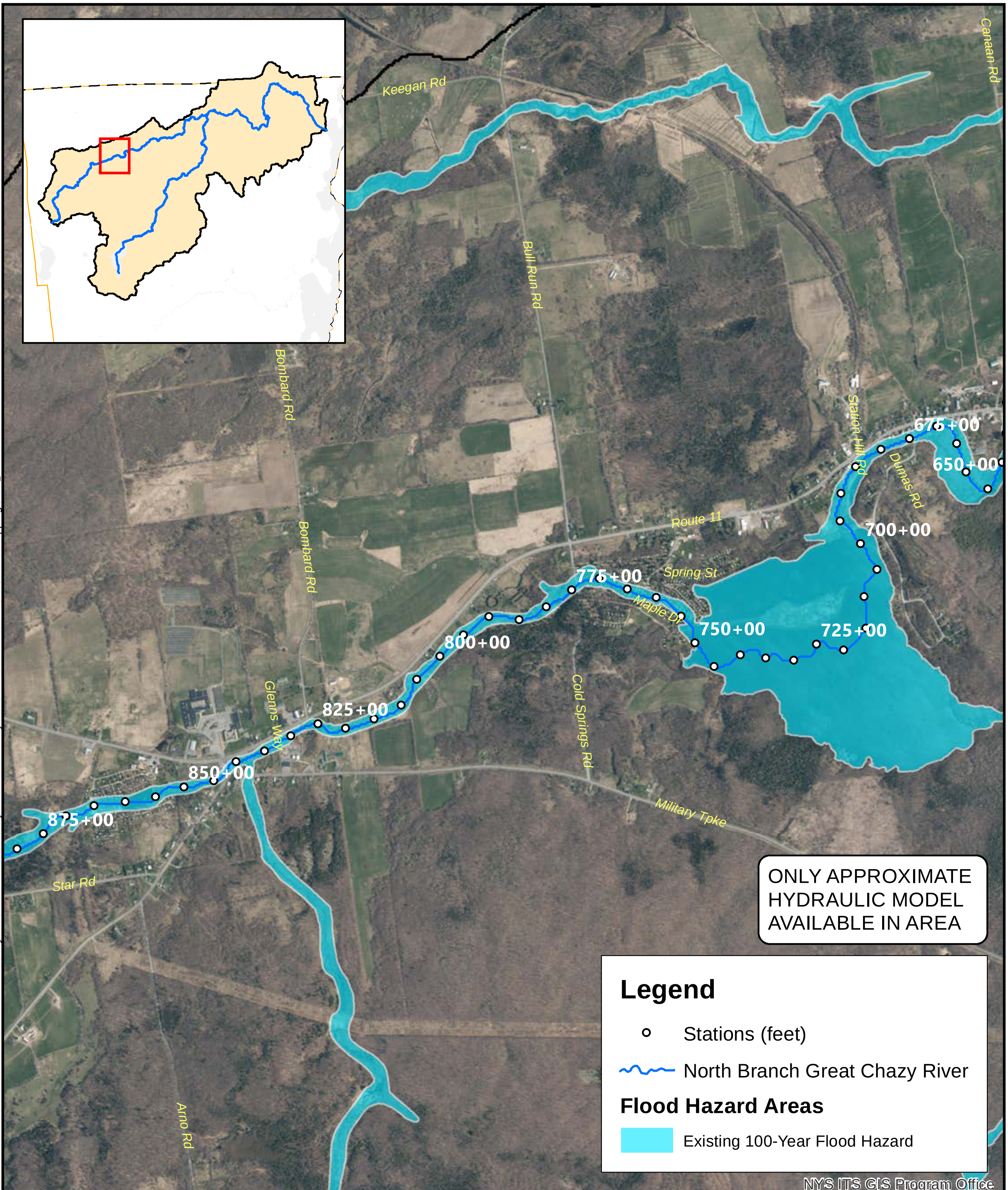
FIG. 3-14



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NORTH BRANCH GREAT CHAZY RIVER - FEMA MAPPING

GREAT CHAZY FLOOD & RESILIENCY STUDY

SD119

CLINTON COUNTY

NEW YORK

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FIG. 3-15

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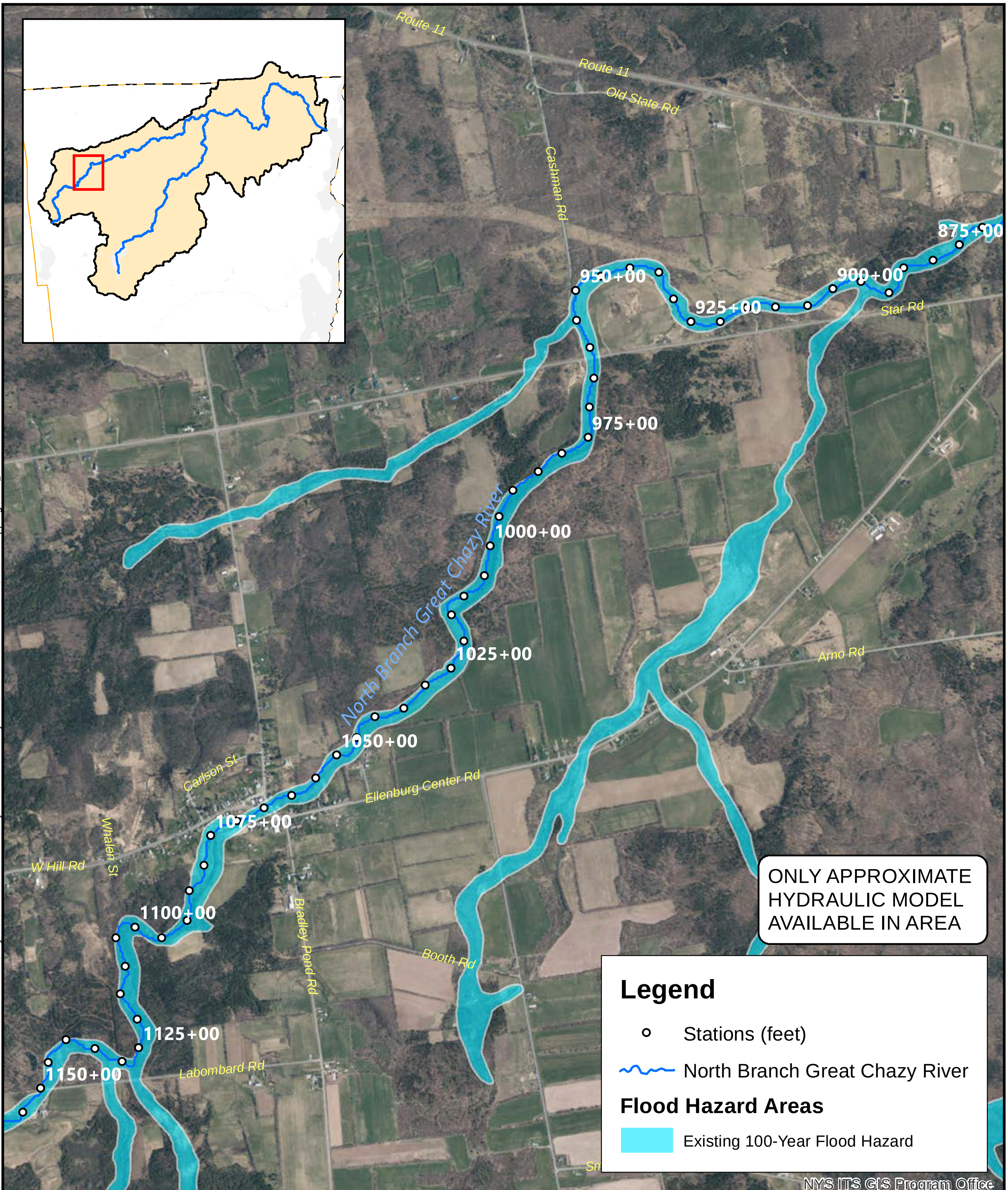

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NORTH BRANCH GREAT CHAZY RIVER - FEMA MAPPING
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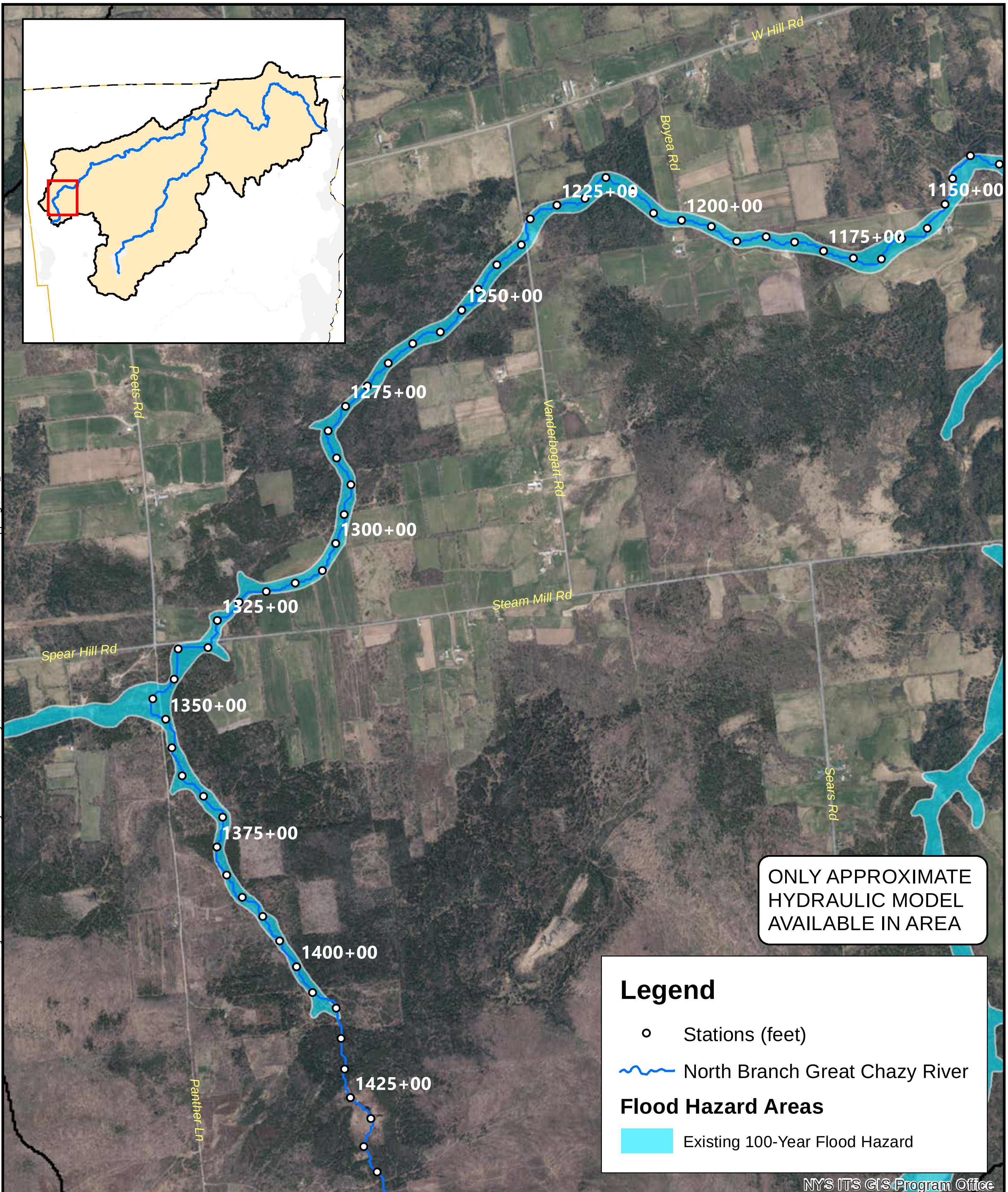
FIG. 3-16



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NORTH BRANCH GREAT CHAZY RIVER - FEMA MAPPING

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FIG. 3-17

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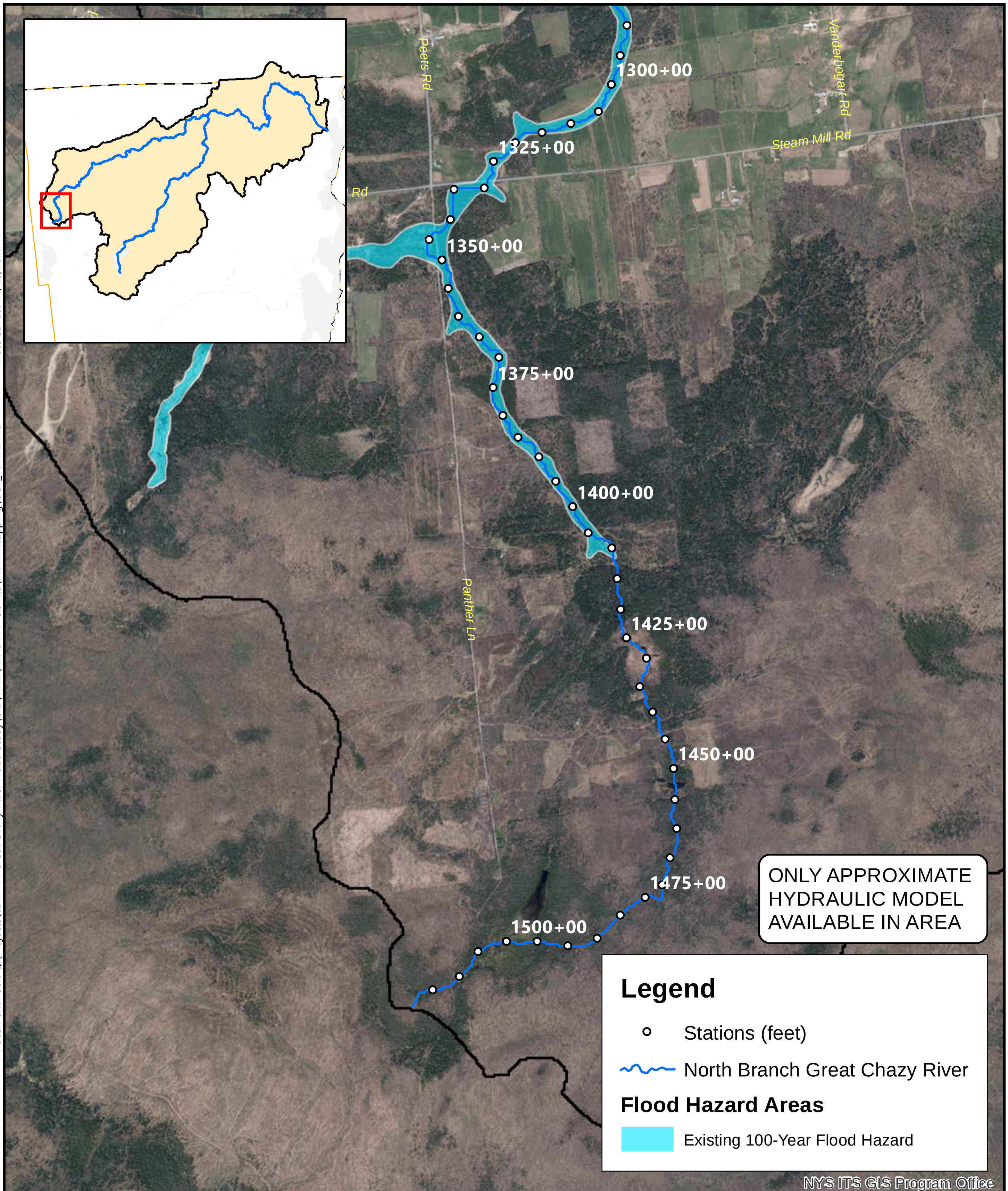

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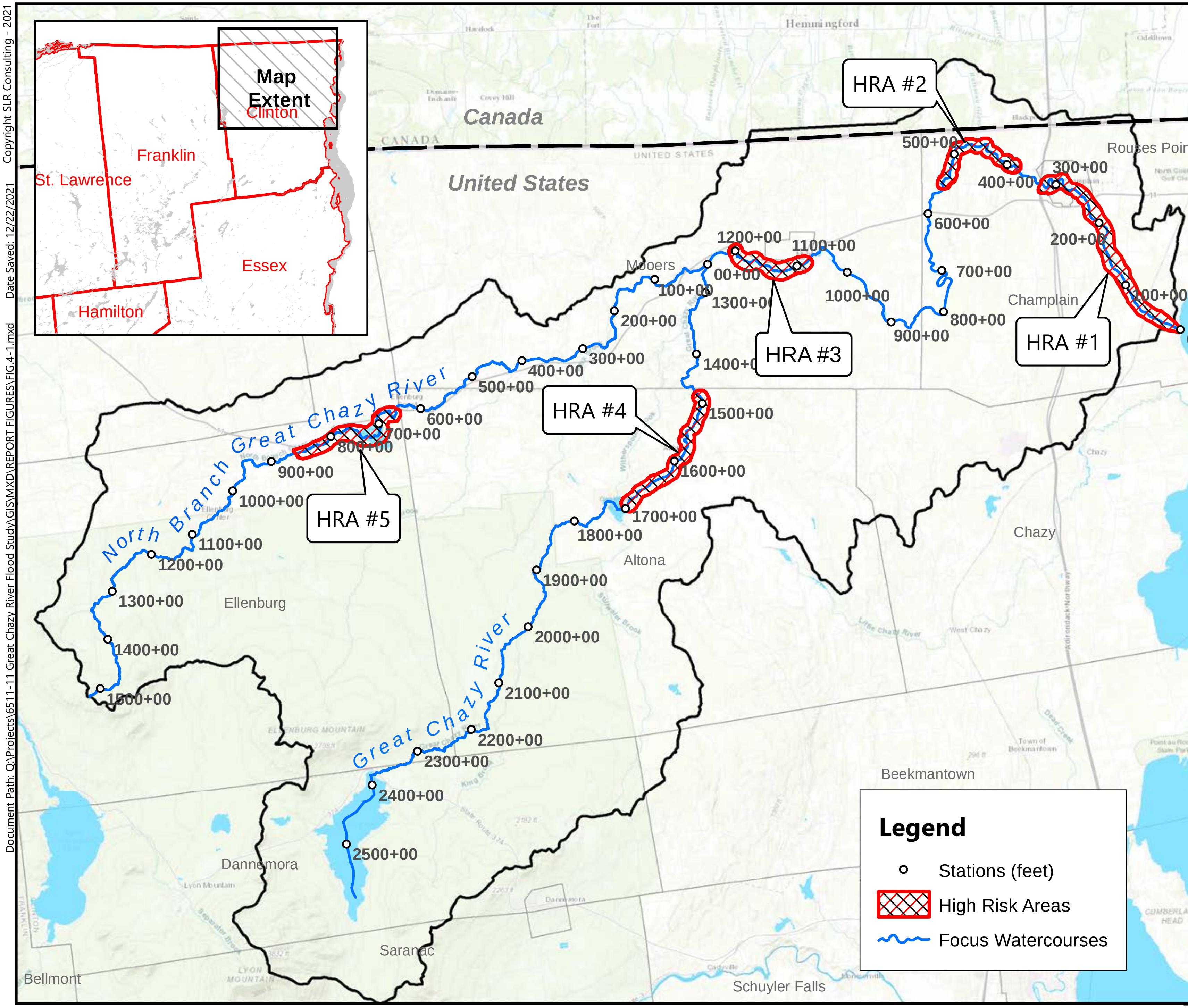
FIG. 3-18

4. FLOOD MITIGATION ANALYSIS

In this section, flood-prone areas within the Great Chazy River watershed are identified, and an analysis of flood mitigation considerations within each HRA is undertaken. HRAs were identified based on comments received during stakeholder meetings; conversations with municipal officials, emergency responders, landowners, and agencies; and through review of FEMA FISs and FIRMs, County Hazard Mitigation Plans, and other documents. Factors with the potential to influence more than one HRA are also evaluated and discussed. This section also includes analysis and discussion of dams and other structures within the Great Chazy watershed, including those that do not fall within the HRAs.

Figure 4-1 shows the locations of HRAs within the Great Chazy River watershed.



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GREAT CHAZY RIVER WATERSHED - HIGH RISK AREAS

GREAT CHAZY FLOOD & RESILIENCEY STUDY

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CLINTON COUNTY
NEW YORK

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FIG. 4-1

4.1 HIGH RISK AREA 1 – VILLAGE OF CHAMPLAIN

HRA 1, depicted in Figures 4-2A and 4-2B, is located in the town of Champlain and includes the village of Champlain, extending downstream to Lake Champlain at STA 0+00 and upstream to Interstate 87 at STA 340+00. The village of Champlain and surrounding area are located along the banks of the Great Chazy River just a few miles west of Lake Champlain and northwest of the mouth of the Great Chazy River. The village encompasses both banks of the Great Chazy River as it meanders through the center of the village. The village has a mix of residential and nonresidential uses scattered throughout the heart of the village with most nonresidential uses located along the eastern and northern edges of the village.

The following land use types are found within the study area shown in the map below and relocation map: Tax Classification Codes 100 – Agricultural, 200 – Residential, 300 – Vacant Land, 400 – Commercial, 500 – Recreation and Entertainment, 600 – Community Services, and 800 – Public Services. Flood-prone areas include municipal properties, residences, commercial properties, agriculture, and vacant land. The village wastewater treatment plant is located in the floodplain.

As of 2019, NYS Department of Homeland Security and Emergency Services (DHSES) records indicate that five properties in HRA 1 have incurred repetitive losses due to flooding; this figure excludes several recent buyouts. Five bridges span the Great Chazy River within HRA 1. Listed from downstream to upstream these include the Canadian Pacific Railway bridge at STA 54+00, the NY State-owned Lake Street/NY-9B bridge at STA 73+00, the NY State-owned US-11 bridge at STA 235+00, the county-owned Elm Street bridge at STA 279+00, and the NY State-owned US-9 bridge at STA 298+00. Of these, the Elm Street and US-9 bridges were assessed for potential flood and ice jam mitigation and were surveyed as part of the detailed hydraulic model developed by FEMA for the Great Chazy River downstream of the I-87 crossing.

Flooding in the village of Champlain is highly influenced by Lake Champlain, which is about 5 miles downstream. The elevation of Lake Champlain fluctuates, with a record low recorded at the Rouses Point USGS gauge (04295000) of 92.9 feet NGVD29 (92.47 feet NAVD88) in October 1941 and a record high of 103.2 feet NGVD29 (102.77 feet NAVD88) in May 2011, which caused widespread flooding that persisted for several weeks. Monthly median lake levels for this gauge's period of record from WY1939 – WY2020 range from 94.7 feet NGVD29 (94.3 feet NAVD88) in October up to 98.2 feet NGVD29 (97.8 feet NAVD88) in April. Stillwater inundation mapping for Lake Champlain for stages from 100.0 feet to 106.0 feet (NGVD29) has been rigorously produced by USGS as part of Scientific Investigations Report (SIR) 2018-5169 and mapped in Figures 4-3A and 4-3B. The approximate extent of Lake Champlain's backwater on the Great Chazy River at various lake levels is presented in Table 4-1 and annotated in Figure 4-3A.

Table 4-1: Lake Champlain Tailwater Influences (stillwater flood elevations from 2020 Preliminary FIS for Clinton County)

Lake level (ft)		Notes	Approximate extent of tailwater on Great Chazy River (STA)
NGVD 29	NAVD 88		
92.9	92.47	October 1941 record low elevation	284+00
94.7	94.3	October median elevation	290+00
98.2	97.8	April median elevation	298+00
101.43	101.0	10-Year stillwater flood elevation	299+50
102.03	101.6	25-Year stillwater flood elevation	300+25
102.43	102.0	50-Year stillwater flood elevation	300+80
102.83	102.4	100-Year stillwater flood elevation	301+60
103.2	102.77	May 2011 record high elevation	301+90
103.53	103.1	500-Year stillwater flood elevation	302+40

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HRA #1 - VILLAGE OF CHAMPLAIN TO LAKE CHAMPLAIN
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SD119
CLINTON COUNTY
NEW YORK

SCALE 1 " = 3,000 '
DATE 12/21/2021
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FIG. 4-2A

N

0 400
Feet

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HRA #1 - VILLAGE OF CHAMPLAIN
GREAT CHAZY RIVER FLOOD & ICE JAM STUDY
SD119
CLINTON COUNTY
NEW YORK

SCALE 1 " = 400 '

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FIG. 4-2B

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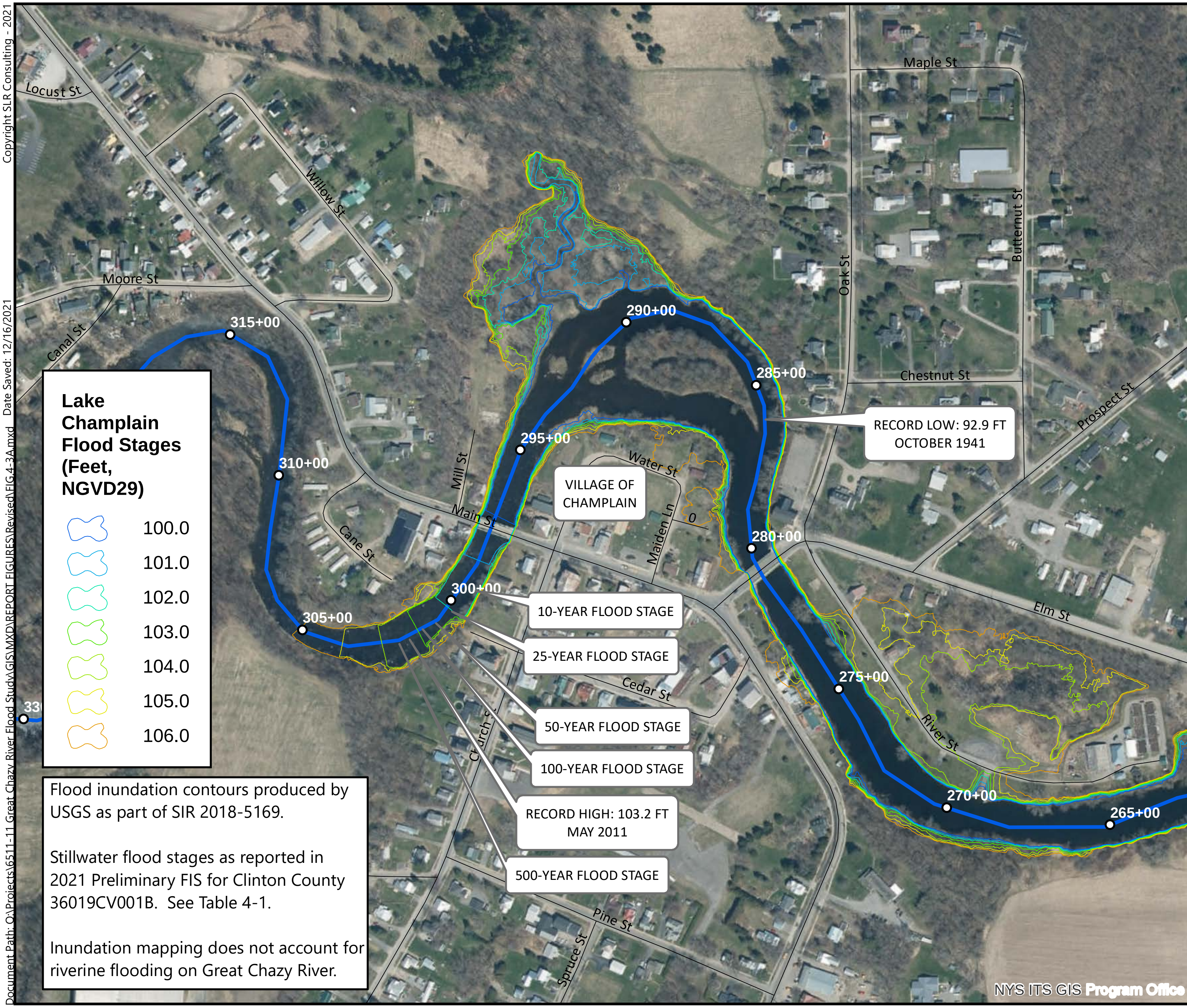

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HRA #1 - LAKE CHAMPLAIN STILLWATER FLOODING
GREAT CHAZY RIVER FLOOD & ICE JAM STUDY
SD119
CLINTON COUNTY
NEW YORK

SCALE 1 " = 400 '
DATE 12/16/2021
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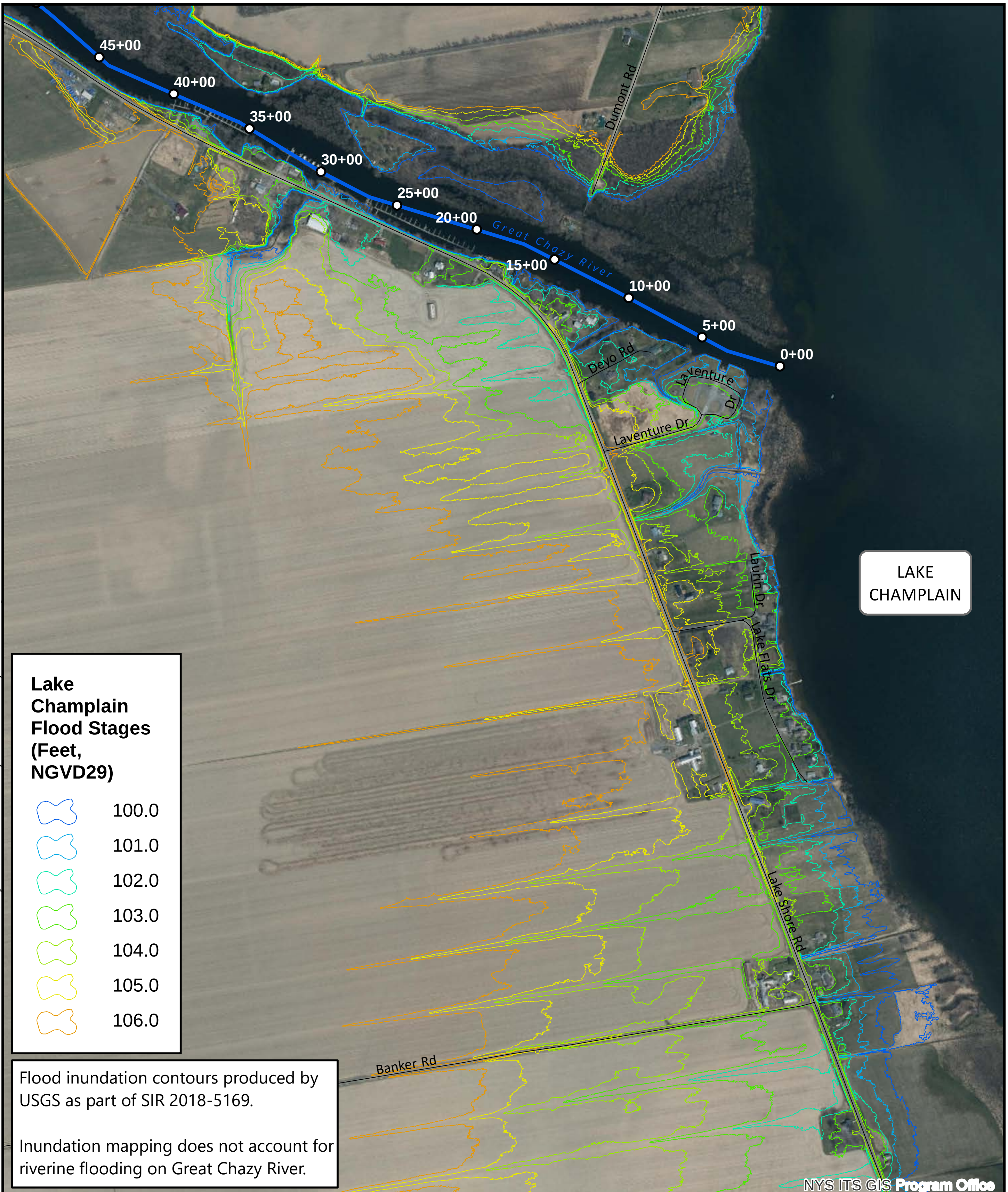
FIG. 4-3A



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HRA #1 - LAKE CHAMPLAIN STILLWATER FLOODING

GREAT CHAZY RIVER FLOOD & ICE JAM STUDY
SD119
CLINTON COUNTY
NEW YORK

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FIG. 4-3B

Flooding within HRA 1 was simulated in the hydraulic model developed for this study. Near the Great Chazy River's confluence with Lake Champlain, the river is spanned by a Canadian Pacific (CP) railway bridge at STA 54+00 and the NY-9B (Lake Street) bridge at STA 73+00, shown in Figure 4-2A. Riverine flooding can be heavily influenced by the tailwater of Lake Champlain, depending on its stage; for example, with the lake at 98 feet (NAVD88), floodwater elevations between these two bridges in the 100-year flood are comparable to those modeled in the 10-year flood with the lake at its 10-year stage of 101 feet (NAVD88). Natural conditions modeling indicates that in the 100-year flood with Lake Champlain at its 100-year stage, the CP railway bridge generates up to about 0.5 feet of additional backwater flooding depths while the Lake Street bridge causes up to about 0.7 feet of additional upstream flooding, with comparable results for the projected future 100-year flood. With the lake at 98 feet (NAVD88), CP railway bridge backwaters are up to about 0.7 feet, with Lake Street bridge up to about 0.9 feet. In the 10-year scenario, these backwaters are about 0.25 feet at both bridges. When due for replacement, 200-foot spans are recommended for both bridges along with updated detailed hydrologic and hydraulic analyses. Approximately 20 properties are affected by these bridges' backwaters; however, many of these appear to be within the river's natural floodplain. Therefore, while bridge upgrades are projected to reduce flooding severity, none of the impacted properties are modeled as being entirely removed from the flood-prone areas as a result of the proposed replacement spans; relocation may be a more appropriate mitigation strategy for these properties.

Within the village of Champlain, more than 40 structures are located within the 100-year floodplain. There have been several property buyouts along the Great Chazy River's right bank on Maiden Lane, Church Street, and Water Street between the US-9 and Elm Street bridges in the village of Champlain, one of the most flood-prone areas within the village, as well as along River Street downstream of the Elm Street bridge on the left bank. Hydraulic modeling of clear water flooding demonstrates that nearly this entire area is prone to flooding in the 25-year discharge. Several properties are located within this area, and some of the buyout properties are currently occupied by a public park and community gardens.

Analysis in HRA 1 focused on a two-pronged strategy to mitigate damages resulting from flooding and ice jamming. This strategy includes replacement of bridges that are hydraulically undersized and/or prone to ice jamming and creation of floodplain benches and ice raft deposition areas along the riverbanks. Buyouts and relocations of flood-prone properties are required in order to make space available for this strategy to be implemented.

Within the village of Champlain, the Great Chazy River is spanned by the US-9/Main Street bridge at STA 298+00 (NBI BIN: 1006060) and the Elm Street bridge at STA 279+00 (NBI BIN: 3363310), shown in Figures 4-3C and 4-3D, respectively. Hydraulic modeling demonstrates that the US-9 bridge is undersized for flood flows although with development on both overbanks there currently is no space to meaningfully increase the structure's span. If voluntary buyouts and relocations of remaining flood-prone properties can be secured, it would facilitate creation of a floodplain and ice rafting area along the right bank, as well as replacement of the current 100-foot US-9 Bridge span with a 180-foot span, both of which are recommended.

The Samuel de Champlain Museum is located immediately adjacent to the river just upstream of the Elm Street bridge, and the stone masonry building's wall comprises the river's left bank at this location. This historic structure dates to 1880 and has significant cultural value for the local community and the

Champlain Valley region in both the United States and Canada. As such, proposed flood mitigation measures seek to leave the building undisturbed. There is minimally developed land just upstream and downstream of the Elm Street bridge on the Great Chazy's right bank, opposite the de Champlain Museum. The upstream area is privately owned while the downstream area contains the Paquette Park with a gazebo and several memorials. If ownership of or easement upon a portion of the upstream parcel can be acquired, it is recommended to relocate Paquette Park to the north end of River Street Park on the opposite riverbank, just downstream and across Elm Street from the de Champlain Museum. This would facilitate replacement of the existing 100-foot Elm Street bridge with a 185-foot span and construction of a floodplain bench and ice raft deposition area along the right bank. It would then be recommended to reclaim additional floodplain downstream of the proposed Paquette Park relocation site on the left bank, between the Great Chazy and River Street. This area is currently River Street Park, which would be restored at this location but at a lower elevation.

As shown in Figure 4-4, an approximately 100-foot-wide floodplain bench along about 1,700 feet of the Great Chazy River's right bank was modeled between STA 275+50 and STA 302+00. This essentially represents the area between the existing stream bank and Church Street/Water Street. At the downstream end, the floodplain transitions to the left bank along River Street, where it continues to approximately STA 268+00, upstream of the village's wastewater treatment plant. Under this scenario, overbank elevations were reduced by approximately 6 feet. The proposed replacement Elm Street and US-9 bridges were incorporated into this scenario as well. As shown in Figures 4-5 and 4-6, flood mitigation benefits under proposed conditions are limited during high-magnitude clear water flood scenarios. The primary benefits of the proposed floodplain reclamation and bridge replacements are realized during the frequent ice jamming events that occur in the village.

The flood mitigation benefits of the proposed floodplain and bridge replacements are limited by the tailwater control of Lake Champlain and the Great Chazy River's shallow slope between the village of Champlain and the lake. With Lake Champlain at a modest level of 98 feet (NAVD88), up to 0.7 feet of reduction in the 100-year flood elevation is modeled in the village, which is reduced to 0.5 feet if the lake is at its 100-year flood stage of 102.4 feet (NAVD88). Summary results are presented in Tables 4-2 and 4-3. Without the bridge replacements, the proposed floodplain along Water Street has minimal benefit due to the bridges' restriction of flow. During ice jamming events, these floodplain areas and increased bridge spans provide more meaningful benefits, discussed later in this section.

Figure 4-3C: Elm Street bridge over Great Chazy River, looking upstream from the left (north) bank. Samuel de Champlain Museum is visible at right.

Figure 4-3D: US-9 bridge crossing of Great Chazy River; view from the left bank looking east toward the downtown of the Village of Champlain. Flow is right to left in image.

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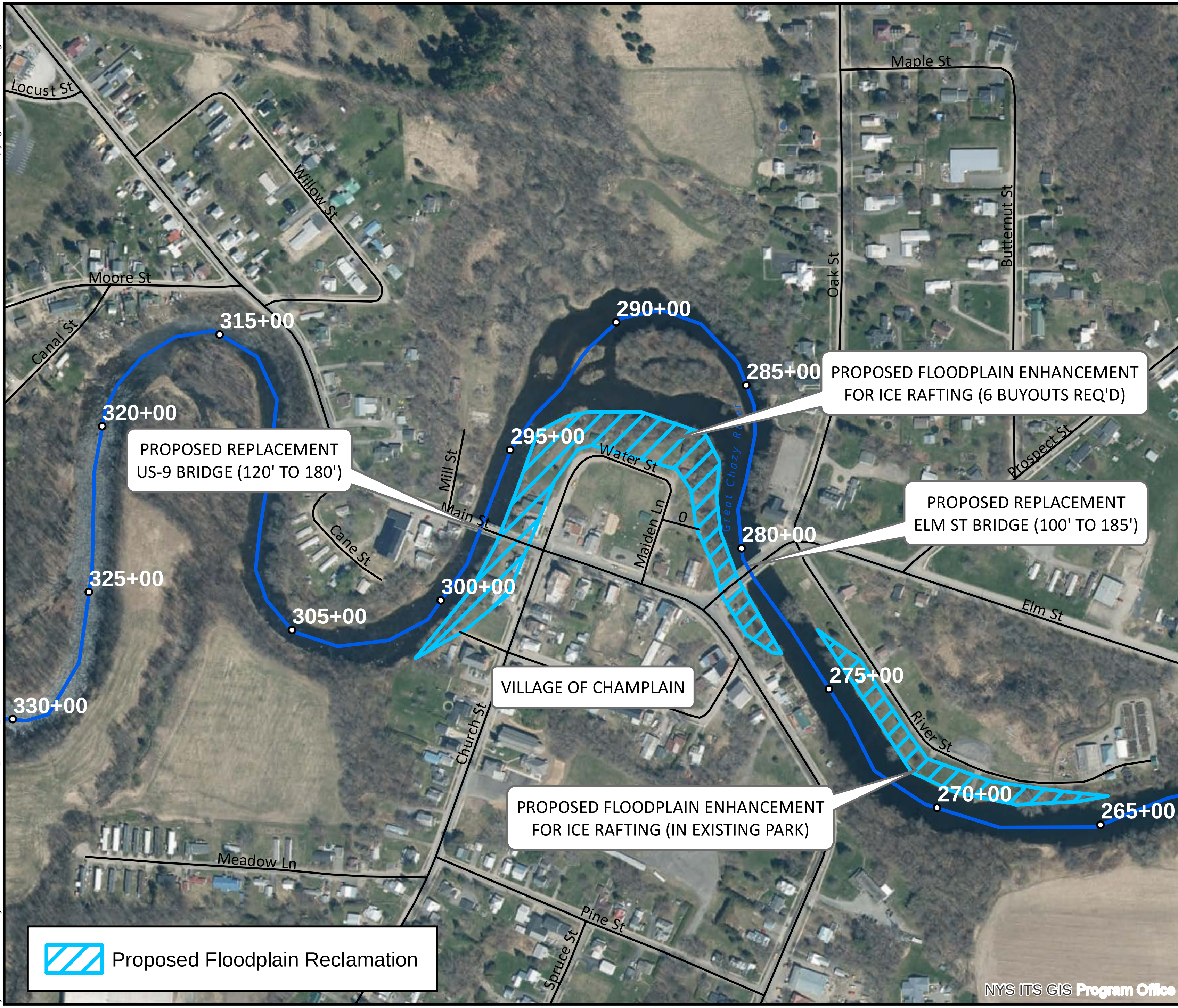
-11 Great Chazy River Flood Study\GIS\MXD\REPORT FIGURES_Revised_2021-12-21\FIG.4-4.mxd



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HRA #1 - PROPOSED CONCEPT LAYOUT
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FIG. 4-4

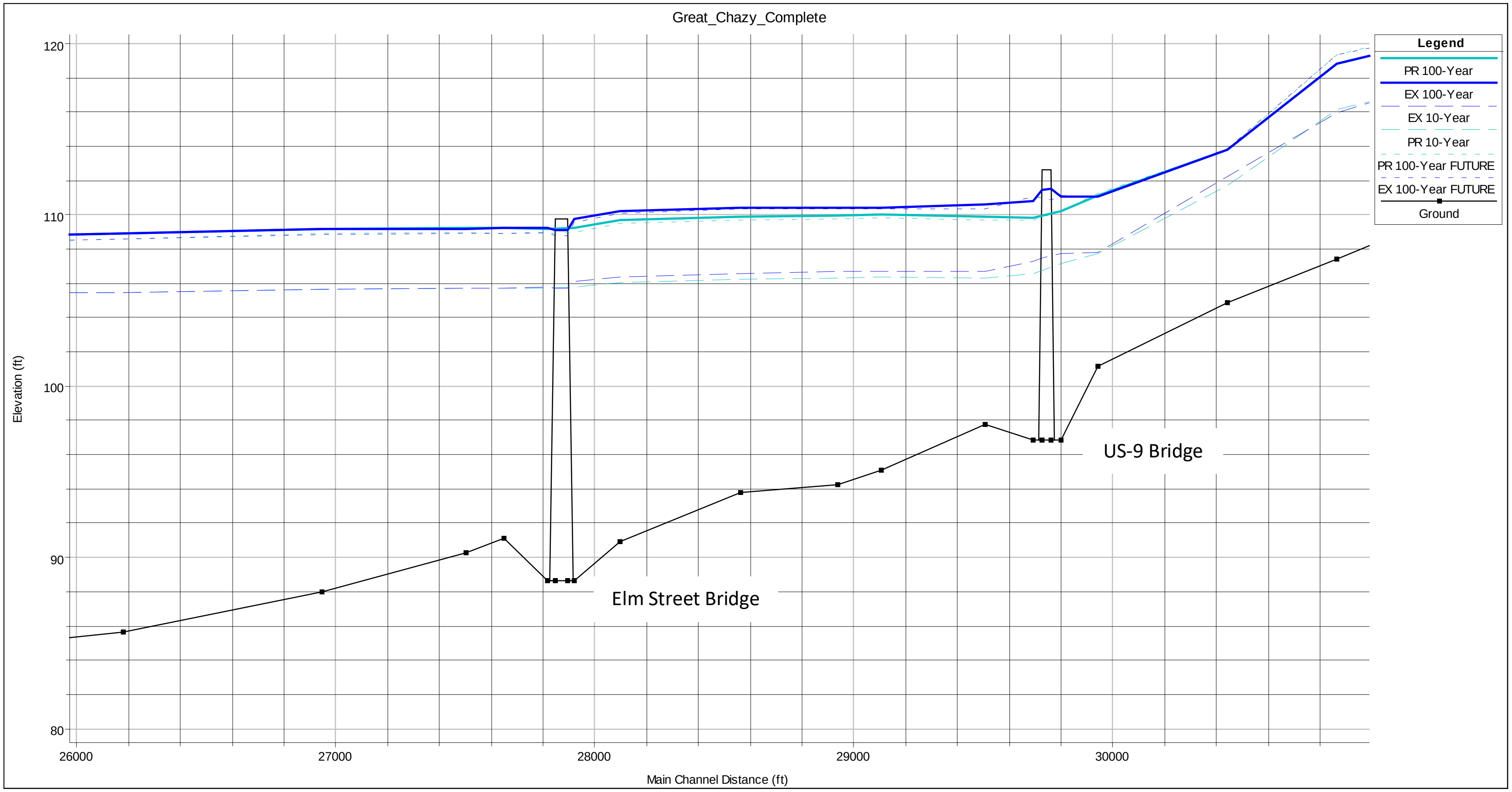

Figure 4-5: Flood Profiles under Existing and Proposed Clear Water Flood Conditions in the Village of Champlain with Lake Champlain at Corresponding Flood Stages

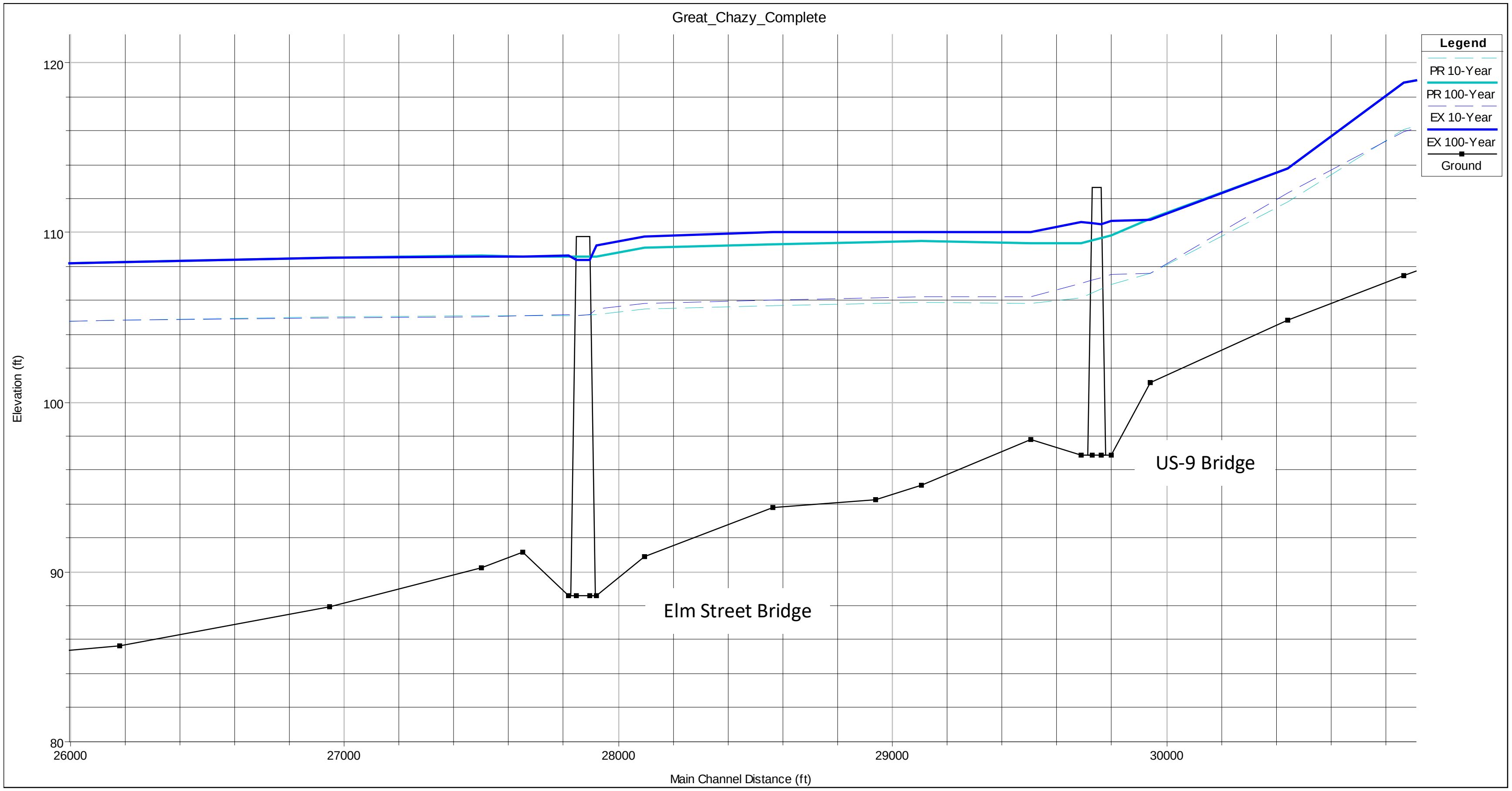

Figure 4-6: Flood Profiles under Existing and Proposed Clear Water Flood Conditions in the Village of Champlain with Lake Champlain at Median April Stage

Table 4-2: Modeled Clear Water Floodwater Surface Elevations at the US-11 and Elm Street Bridges in the Village of Champlain with Lake Champlain at Corresponding Flood Stages

FLOOD (YEAR)	WATER SURFACE ELEVATION (FEET NAVD88)			
	US-11 Bridge		Elm Street Bridge	
	Existing	Proposed	Existing	Proposed
10	107.74	107.16	106.09	105.78
25	109.07	108.41	107.55	107.18
50	109.84	109.29	108.35	108.16
100	111.09	110.25	109.73	109.22
100 +	111.12	110.19	109.57	108.95
500	112.71	112.44	111.93	111.90

Table 4-3: Modeled Clear Water Floodwater Surface Elevations at the US-11 and Elm Street Bridges in the Village of Champlain with Lake Champlain at Median April Stage

FLOOD (YEAR)	WATER SURFACE ELEVATION (FEET NAVD88)			
	US-11 Bridge		Elm Street Bridge	
	Existing	Proposed	Existing	Proposed
10	107.50	106.94	105.52	105.17
25	108.76	108.09	106.97	106.56
50	109.65	108.94	107.99	107.54
100	110.70	109.86	109.24	108.60
100 +	111.12	110.19	109.57	108.95
500	112.40	111.89	111.27	111.23

Voluntary relocation of affected flood-prone property owners in the proposed floodplain reclamation area depicted in Figure 4-4 is recommended, thus facilitating recommended floodplain enhancements and bridge replacements along this reach, which are expected to be most beneficial during ice jamming events. Depending on the ultimate extent of floodplain reclamation, the park and gardens may remain as is or simply be set at a lower elevation where they would remain accessible other than during significant floods and ice-rafting events.

When ice formed and accumulated upstream, including behind Whiteside Dam, is released, it moves downstream toward the village of Champlain. The US-9 and Elm Street bridges are undersized and prone to jamming, which can be exacerbated by both the excess ice generated behind the dam upstream, the Great Chazy River's sinuous path through the downtown area, as well as accumulation at the thick, solid layer of ice that forms in Lake Champlain's tailwater. This is demonstrated in aerial photographs collected by the Clinton County Department of Emergency Services in March 2007, shown in Figures 4-7, 4-8, and 4-9.

Figure 4-7: Ice buildup in the village of Champlain. Note US-9 bridge at center left is closed, and ice rafts had deposited in developed overbank areas. Orientation is northwest, with flow left to right in image. Image is provided by Clinton County Department of Emergency Services.

Figure 4-8: Ice jamming in village of Champlain; view is to the east, looking downstream toward Lake Champlain. Elm Street bridge is in center. Breakup ice accumulates at Lake Champlain tailwater ice at center right of image. Image is provided by Clinton County Department of Emergency Services.

Figure 4-9: Solid ice formed in Lake Champlain's tailwater extends down the Great Chazy River from the village of Champlain to the lake. View is to the southeast, looking downstream. Canadian Pacific railroad bridge is in image center; CR-22 parallels the river on the right. Image is provided by Clinton County Department of Emergency Services.

Wide-river ice jamming and dynamic-bridge ice jamming were simulated in the HEC-RAS hydraulic model developed for this study. Based on input parameters gleaned from descriptions and photographs of past ice jams, flooding was simulated under the conditions described above. In the village of Champlain, 10-year flood depths increase by about 8 feet throughout the developed area, with development of a 6-foot-thick ice jam extending from the Lake Champlain tailwater ice to upstream past the US-9 bridge, which is simulated as being overtopped by ice floes along with the Elm Street bridge.

Ice jamming more commonly occurs with lesser discharges associated with midwinter or early spring freshets, often producing closer to a bankfull or 2-year-magnitude flood in terms of water discharge alone. Modeled ice jamming under bankfull flow conditions, with Lake Champlain at a typical late winter-early spring stage of 98 feet (NAVD88), results in increased flooding depths of between 5 and 8 feet in the village of Champlain, commensurate with the clear-water 10-year flood at the Elm Street bridge and greater than the 50-year flood at the US-9 bridge. This overtops Main Street/US-9 between the two crossings, and floodwaters and ice rafting impact more than 20 properties in the village, primarily along Maiden Lane and Cane, Cedar, Church, Main, and Water Streets, that would be unaffected by this discharge under clear water conditions, as shown in Figures 4-11 and 4-12.

With the proposed Elm Street and US-9 bridges and floodplain enhancements described above, the consequences of ice jam events can be significantly mitigated due to alleviation of the bridge constrictions and provision of overbank relief for ice rafting. In the scenario described above, an ice-affected bankfull flow with Lake Champlain at EL 98 feet (NAVD88), flooding depths in the village of Champlain are reduced by up to 6.9 feet compared to the same ice jam under existing conditions, shown in Figures 4-10, 4-11, and 4-12 and Table 4-4. In an ice-affected 10-year flood with the lake at this same level, ice and water depths in the village are reduced by up to 4.4 feet.

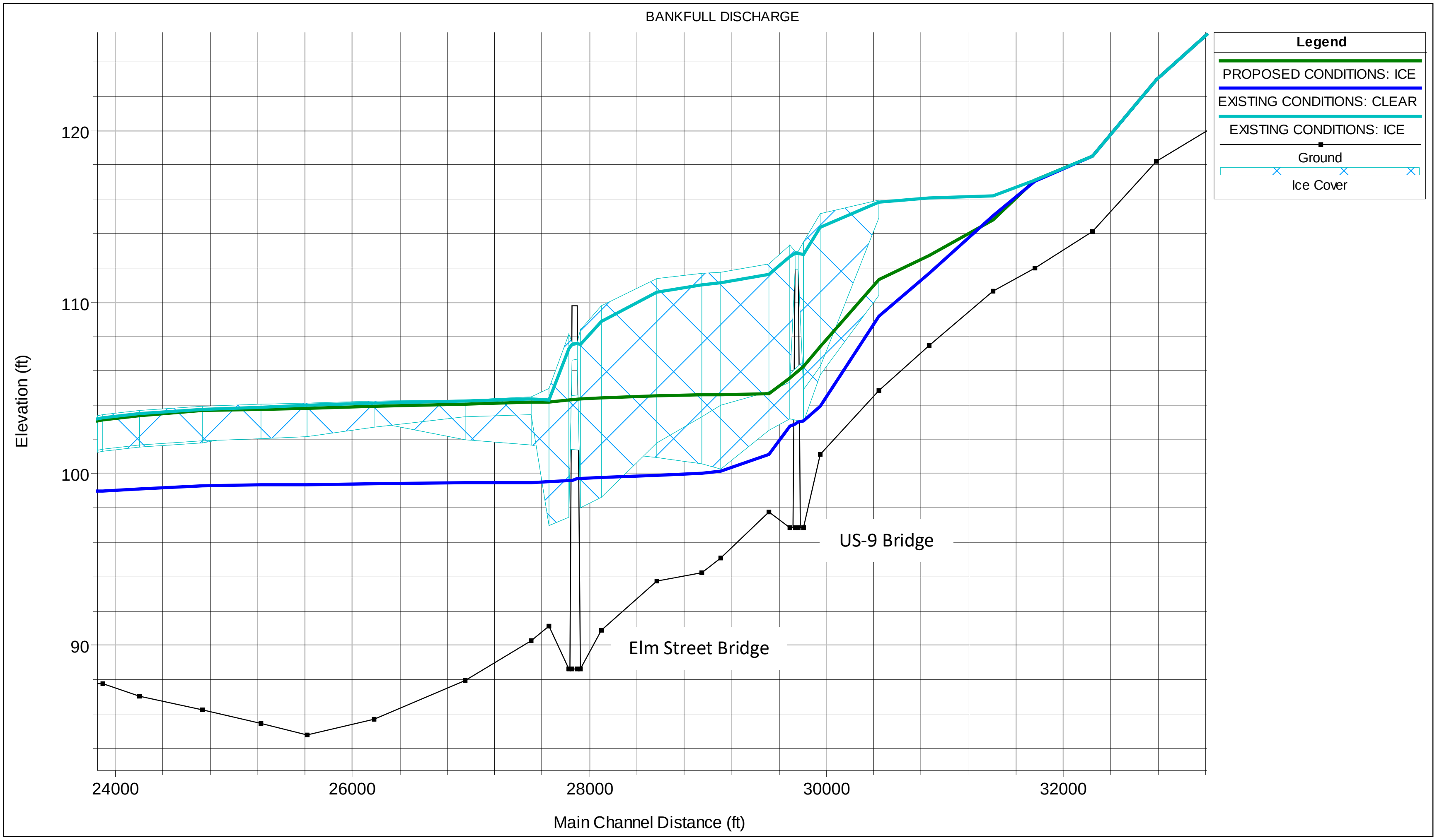

Figure 4-10: Profile of modeled bankfull flow through the Village of Champlain under ice jamming scenarios comparing existing and proposed conditions. Clear water bankfull flow is shown for reference.

Table 4-4: Simulated Ice and Water Elevations at the US-11 and Elm Street Bridges under Ice Jam Conditions and Lake Champlain at April Median Stage

ICE-AFFECTED FLOW EVENT	ICE & WATER SURFACE ELEVATION (FEET NAVD88)			
	US-11 Bridge		Elm Street Bridge	
	Existing	Proposed	Existing	Proposed
Bankfull	112.79	106.26	107.51	104.35
10-Year Flood	117.53	112.77	114.12	112.54

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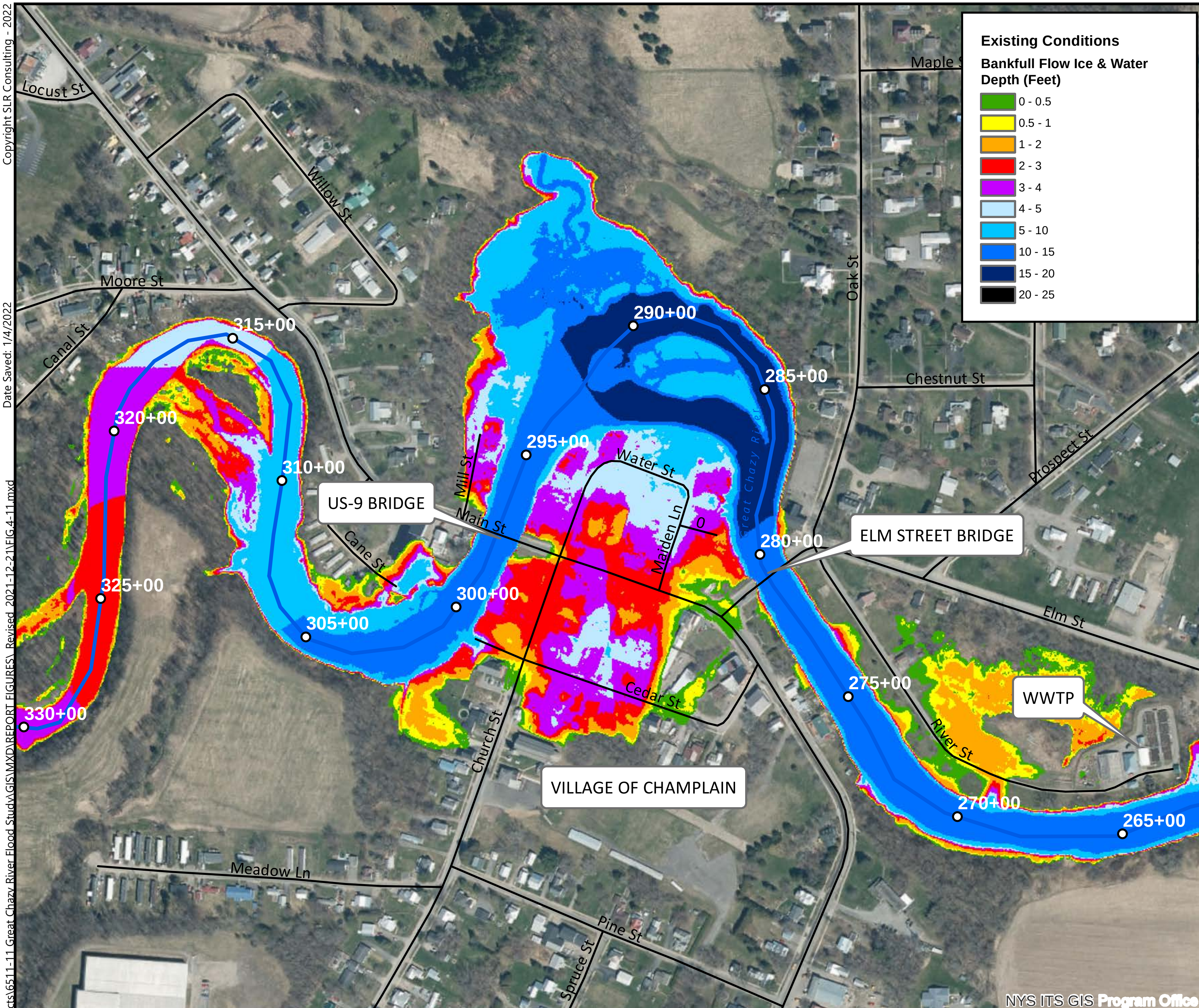

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HRA #1 - EXISTING CONDITIONS ICE JAM - BANKFULL FLOW

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NEW YORK

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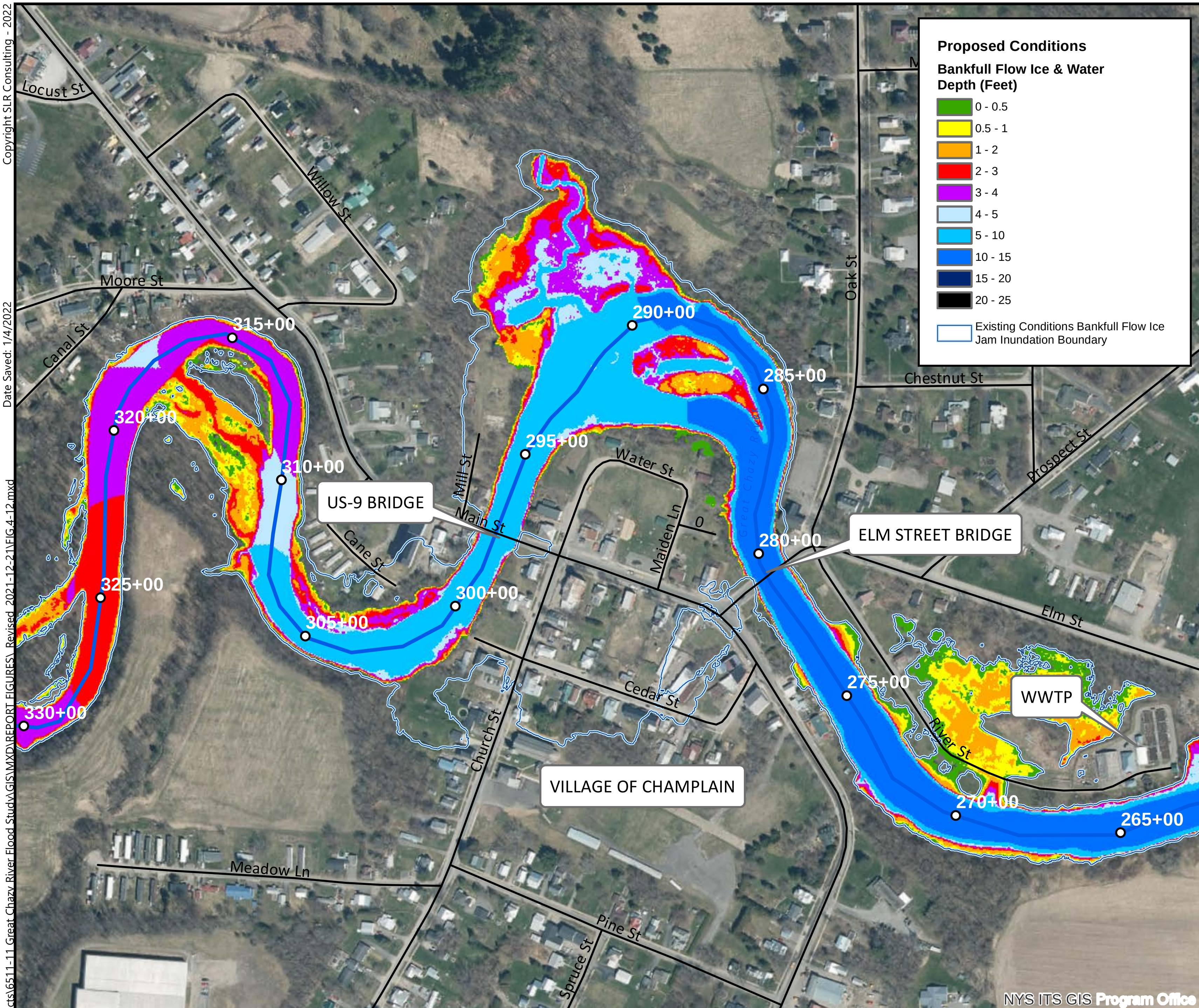
FIG. 4-11



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SUITE 102
NEW PALTZ, NY 12561
845.633.8153

HRA #1 - PROPOSED CONDITIONS ICE JAM - BANKFULL FLOW

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FIG. 4-12

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Potential relocations of flood-prone properties within HRA 1 unrelated to proposed flood and ice jam mitigation projects were also explored. Approximately 90 residential and/or mixed-use properties were identified as potentially needing to be relocated. These properties are not necessarily fully within a floodplain area – many parcels are only partially within a floodplain or adjacent to the edge of a floodplain.

A high-level conceptual relocation "Master Plan" of potential relocation areas for homes and businesses in HRA 1 is presented in Figure 4-13. The relocation master plan identifies potential areas where relocation generally seems to make sense for residential, retail/commercial, industrial, and other land uses identified as having a potential to flood.

In the village of Champlain, a total of 90 residential or mixed-use properties were identified as potentially needing to be relocated. Eight potential relocation sites were identified totaling 46.5 acres. Based on the analysis criteria utilized to calculate lot buildout, these parcels could provide relocation sites for several businesses, including businesses in an existing industrial park, as well as 91 or more residential lots at a density generally consistent with the densities in the areas of each relocation site, utilizing existing cleared land area only. The detailed breakdown for each site is as follows:

The number of properties identified as potentially needing to be relocated was based on a review of Clinton County, NY GIS data. In total, approximately 90 residential and/or mixed-use properties were identified as potentially needing to be relocated.

1) 1 parcel consisting of ~4.9 acres. Nonresidential infill potential. Access to Locust Street just off Route 9. One or more businesses, depending on density and site design, could likely be developed. The site is largely cleared. The parcel is classified as Warehouse.
2) 1 parcel consisting of ~10.5 acres. Nonresidential or residential infill potential – likely medium density residential (~1-acre minimum lot size). Access to Route 11 and South Street. Several businesses or approximately eight residential lots (~1-acre minimum lot size), depending on density and site design, could likely be developed. The site is largely cleared and vacant beyond the existing shopping center. The parcel is classified as area/neighborhood shopping center.
3) 1 parcel consisting of ~14 acres. Residential development potential - likely medium density (~1-acre minimum lot size). Access to Route 11. Eleven or more residential lots, depending on density and site design, could likely be developed. The site is largely cleared. The parcel is classified as rural residential although within the property line shown there is no development.
4) 1 parcel consisting of ~15 acres. Residential development potential – likely medium density (1-acre minimum lot size). Access to Route 11. Twelve or more residential lots, depending on the density and site design, could likely be developed. The parcel is largely cleared. The parcel is classified as rural vacant > 10 acres.
5) 1 parcel consisting of ~47 acres. Residential development potential – likely medium density (1-acre minimum lot size). Access to Prospect Street via Horizon Lane. Thirty-five or more residential lots, depending on the density and site design, could likely be developed. The parcel is classified as rural vacant >10 acres but appears to be farmed and largely cleared. Also appears that road infrastructure has been constructed for future development of the parcel.
6) Several parcels consisting of ~96 acres. Nonresidential development potential. Access to Lawrence Paquette Industrial Drive. This area is an industrial park owned by the Development Corporation and provides shovel-ready sites for appropriate uses. The undeveloped portions of the parcel(s) are classified as vacant industrial.
7) 1 parcel consisting of ~46 acres. Residential development potential – likely medium density (1-acre minimum lot size). Access to Prospect Street. Development potential exists on the approximately 1/3 of the site that is generally cleared. Fifteen or more residential lots, depending on the density, site design, and any potential lot clearing to provide more buildable land, could likely be developed. The parcel is classified as abandoned agriculture.
8) 1 parcel consisting of ~13 acres. Residential development potential – likely medium density (1-acre minimum lot size). Access to Oak Street. Ten or more residential lots, depending on the density and site design, could likely be developed. The parcel is classified as abandoned agriculture.

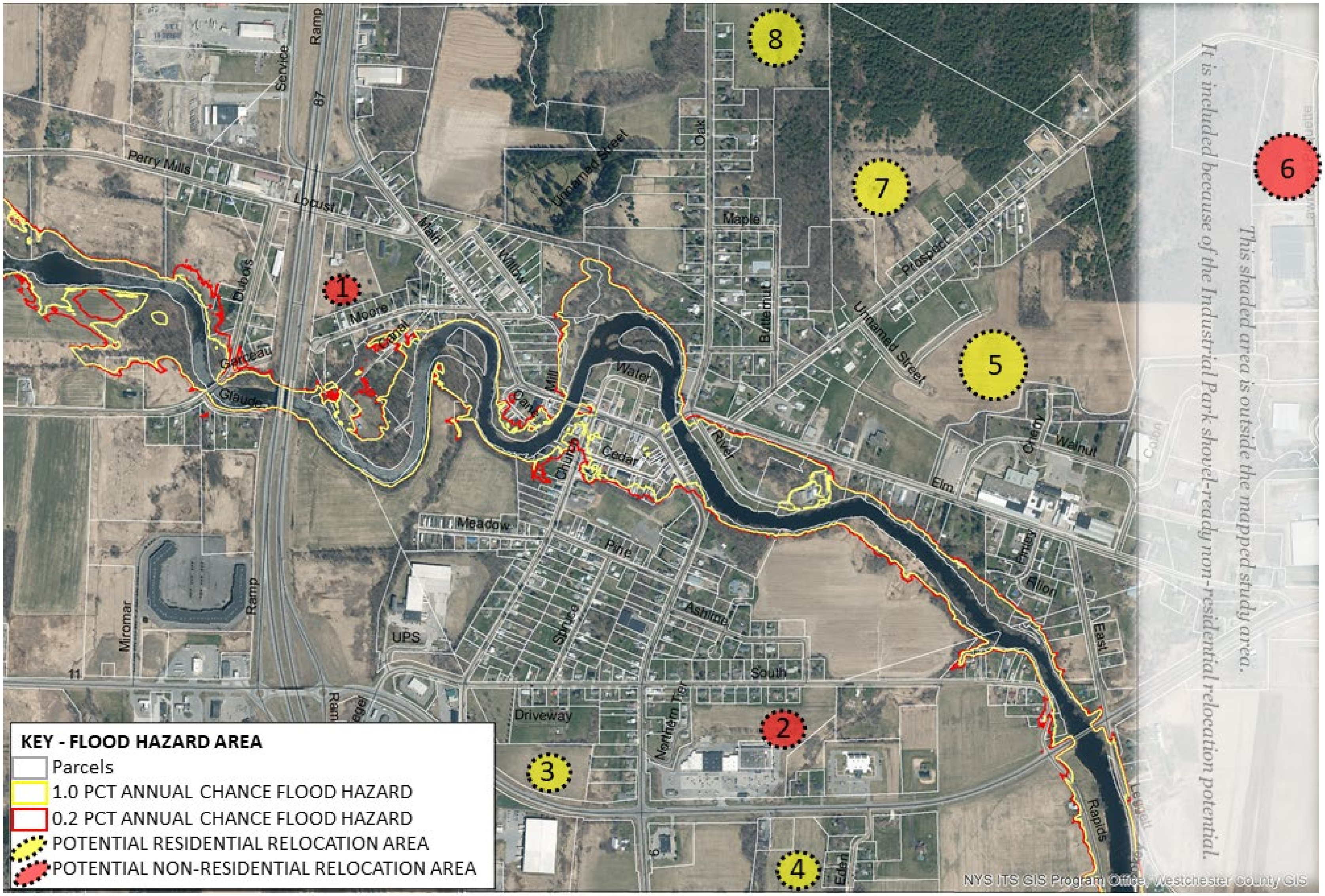


Figure 4-13 Conceptual relocation mapping for HRA 1. **See inset on previous page for details.**

The Clinton County Multi-Jurisdictional Hazard Mitigation Plan notes that there was a comprehensive land use plan in the 1990s that needs to be updated along with the zoning map. The village has two structures in the 500-year floodplain (the fire station and the drinking water and wastewater treatment plant). The village also has eight repetitive loss properties. There are 496 structures within the potential loss category. There are 41 structures in the SFHA (13 with property class code 200-Residential, 1 with property class code 300-Vacant Lands, and 27 with a property class code 400-Commercial). The HMP notes the following mitigation projects related to flooding: cleaning ditches of debris and establishing a maintenance plan in the village and buyout of homes along Main Street and River Street.

The Town of Champlain has two structures in the 500-year floodplain (the fire station and the drinking water and wastewater treatment plant). The town also has 14 repetitive loss properties. There are 1,283 structures within the potential loss category. There are 60 structures in the SFHA (52 with property class code 200-Residential, 6 with property class code 300-Vacant Lands, and 2 with a property class code 500-Recreation/Entertainment). There is one mitigation project listed in the HMP related to flooding: a stormwater drainage project and installation of drainage on Spruce Street.

Town of Champlain, New York, Zoning: Town of Champlain, New York, Table of Contents (ecode360.com)

The Town of Champlain Zoning Law includes 13 zones: Residential, Residential – Manufactured Homes, Small Lot Residential, Conservation, Heavy Industrial, Industrial/Commercial 1, Industrial/Commercial 2, Industrial/Commercial 3, Industrial/Commercial 4, Light Industrial, Commercial 1, Commercial 2, and Lake Area Commercial. The town has a watercourse protection provision that applies to the Great Chazy River. This section requires that structures be set back at least 50 feet from the mean high water mark of the river, not more than 30 percent of trees in excess of 6 inches diameter at breast height can be removed within 35 feet of the mean high water mark, and no vegetation can be removed within 6 feet of the mean high water mark with the exception of a 30-foot-wide clear area for each lot. There is an exception for removal of diseased or rotten vegetation. Cluster development is permitted, and open areas are encouraged to include environmentally sensitive features (such as providing buffers for streams and wetlands). There is a specific article on the control of biosludge and waste, which states that "land application of biosolids, sewage sludge, or human-waste-derived products shall not encroach within 100 feet of any floodplain."

Other codes in the town include a Flood Damage Prevention Ordinance (Chapter 80), which has standards related to elevation and flood-resistant construction. The town also has a Subdivision of Land code (Chapter 111).

4.2 HIGH RISK AREA 2 – PERRY MILLS AND WHITESIDE DAM

HRA 2, depicted in Figure 4-14, is located in the town of Champlain and runs from STA 385+00 below the Whiteside Dam up to the abandoned railroad crossing upstream of the partly breached dam at Perry Mills at STA 550+00. The county-owned Creek Road bridge at STA 491+00 spans the river within HRA 2 and was measured in the field for inclusion in the existing approximate methods hydraulic model.

The Hamlet of Perry Mills is a small predominantly residential area at a sharp bend in the Great Chazy River where it jogs from a north-south orientation to a more east-west orientation. Perry Mills has several properties located along the river but is mostly an area of agricultural and undeveloped land. The hamlet is located approximately ½ mile from the U.S.-Canada border. Flood-prone areas include residences, mixed-use residential land, agriculture, and vacant land. No critical facilities were identified in the floodplain.

The following land use types are found within the study area: Tax Classification Codes 100 – Agricultural, 200 – Residential, 300 – Vacant Land, 400 – Commercial, 600 – Community Services, 800 – Public Services, and 900 – Wild, Forested, Conservation Lands and Public Parks.

The "Whiteside Dam," located at STA 403+00, is a Class A, Low Hazard concrete gravity dam constructed in 1914 and presently owned by NYSDEC Region 5, which maintains the structure as a sea lamprey barrier (NYSDEC ID: 235-0064; Federal ID: NY13994). This dam is also colloquially known as the “Frog Farm Dam.” It was last inspected in 2013, with an Engineering Assessment completed the same year.

Hydraulic modeling demonstrates that the Whiteside Dam generates a backwater that reaches more than 7,000 feet upstream, to within roughly 800 feet of the Creek Road bridge in Perry Mills. This is anecdotally confirmed by several indices of an aggradational environment that were observed at the head of the impoundment, such as gravel bars; islands and anabranching; and a broad, shallow channel. As a result, this location is highly prone to ice accumulation while the large, long impoundment is itself a significant source of ice generation. During clear water flood conditions, the structure's backwater contributes to flooding of CR-17 and nearby homes, shown in Figures 4-15 through 4-18.

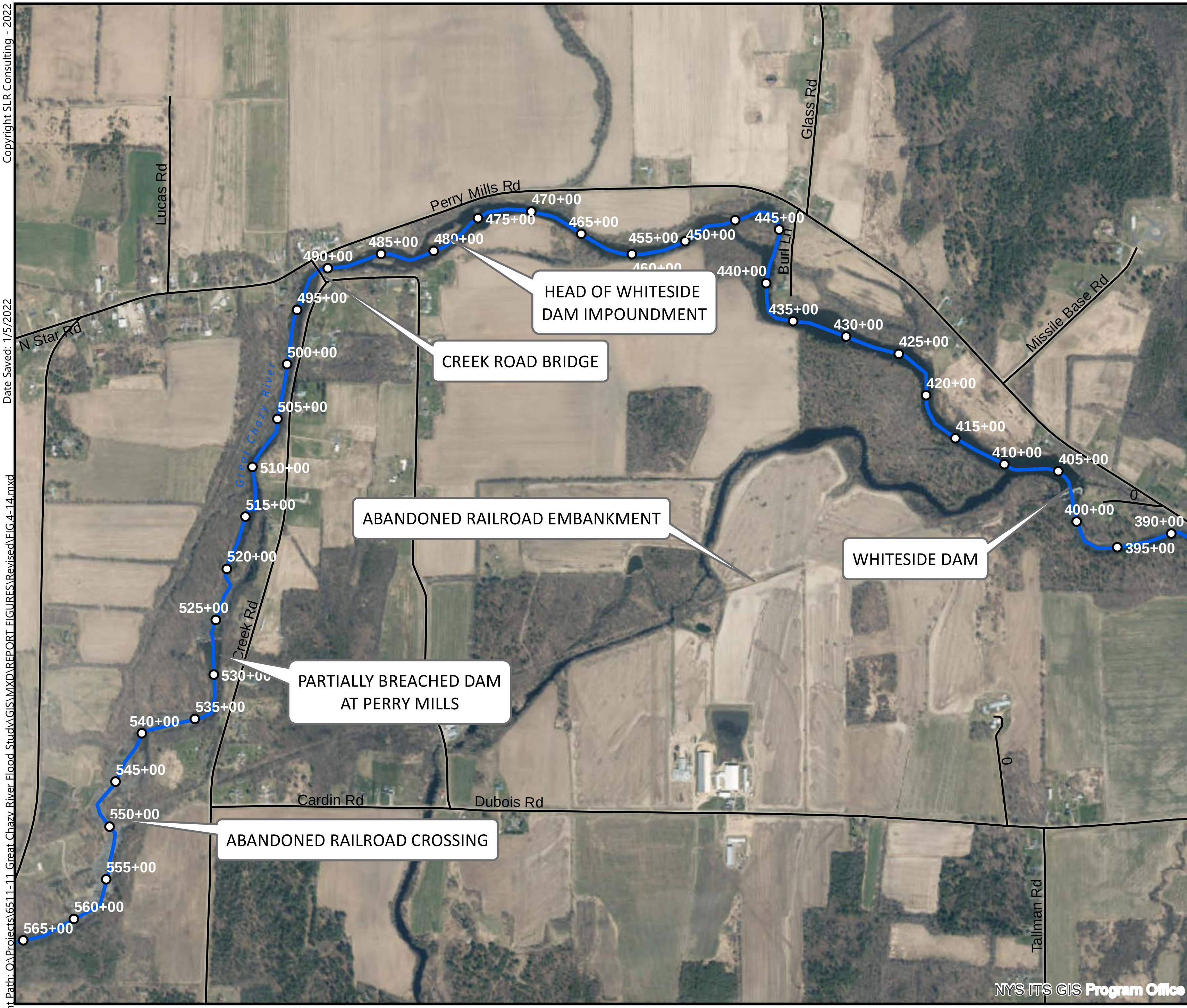
An abandoned railroad embankment serves as a de facto extension of the Whiteside Dam across the broad floodplain on its right overbank, shown in Figures 4-19 and 4-20. This 5- to 6-foot-tall berm extends westward from the main dam section for approximately 1,250 feet before terminating in the adjacent agricultural field. Hydraulic modeling indicates that this berm is susceptible to flanking in the 10-year flood, as can be seen in Figure 4-15, and is modeled as overtopping beginning in the 25-year flood. Flanking and overtopping flows can damage such an embankment if it has not been designed or retrofit to withstand these conditions, posing a hazard to downstream life safety, property, and infrastructure. 2020 aerial imagery shown in Figure 4-20 indicates that this embankment is overgrown, and it does not appear to be documented in the NYSDEC dam inventory. The database lists the Whiteside Dam as being 279 feet long with a 250-foot-long dike; however, this presumably references the railroad embankment on the left (east) overbank where it extends across an old headrace channel for approximately this length, visible in Figure 4-20. Inspection of the railroad embankment on the right (west) overbank and a detailed assessment of its function as a component of the Whiteside Dam is recommended, followed by repair, retrofit, or maintenance of this feature, as appropriate. Note that this should be considered in the context of the flow bifurcation experienced just upstream in flood events, as discussed in Section 2.3, which may significantly influence the hydrologic conditions experienced at the dam.

Removal of the Whiteside Dam is recommended to alleviate backwater flooding and mitigate ice jamming. However, there are important ecological benefits of restricting invasive sea lamprey migration. It is believed that the dam's 9-foot-tall spillway crest height is more than is necessary to accomplish this goal. Replacement of the large aging dam with a purpose-built lamprey barrier is recommended; a hydraulic drop of 2.2 feet (Katopodis et al. 1994), or 1.5 feet if overhanging (GLFC 2014, Reinhardt et al. 2009), is sufficient. Exclusion may also be achieved by flow velocities over 13 feet per second (fps) (Hanson 1980). By these metrics, it is possible that the natural bedrock falls at this location may be adequate in itself. Sea lamprey barrier criteria are discussed further in Section 4.6.1 of this report.

Farther upstream, the abandoned railway crossed the Great Chazy River again at STA 550+00. The raised approach embankment on the right (east) bank is between 10 and 15 feet tall and protrudes over 300 feet into the river's active floodplain. This can be seen in Figures 4-21 and 4-22. Removal of this section of embankment is recommended, along with restoration of the adjacent channel and floodplain to restore functional connectivity of natural geomorphic processes and reduce the potential for ice accumulation at this contraction. Removal of this embankment may be considered a lower priority as hydraulic modeling does not indicate the potential for significant flood hazard reduction at nearby infrastructure or property.

Hydraulic modeling demonstrates that the Creek Road bridge is undersized for flood flows. The bridge has about 1.4 feet of freeboard in the 10-year flood, but flanking flows on the right overbank are over 3 feet deep. In the 25-year flood and greater, the bridge pressurizes; about 5 feet of additional backwater flooding occurs in the 100-year flood, with flanking flows up to 9 feet deep. When due for replacement, detailed hydrologic and hydraulic analyses are recommended. The most current regulations and guidance from NYSDOT and NYSDEC regarding stream crossing geometry and hydraulic performance should be applied, as well as updated assessments of projected future flows. A 135-foot bankfull width was measured at this location; a minimum 170-foot span bridge is recommended to meet the 1.25 times bankfull width standard set forth by NYSDEC.

Roughly 3,500 feet upstream of the Creek Road bridge in Perry Mills, at STA 527+00, an abandoned and partially breached dam is present, which once served as the headworks for the former sawmill located about half a mile downstream, with a headrace channel paralleling the river on its left overbank. Based on comparison between aerial imagery acquired in 2020 and 1964 (while the sawmill was operational and the dam was still intact), it appears that roughly one-third to one-half of the structure remains, projecting about 180 feet into the channel from the right abutment; this is shown in Figures 4-21 and 4-22. This dam is not in the NYSDEC's current dam inventory database (February 2021 Revision), and its inclusion is recommended. This location is considered prone to ice accumulation due to the sharp changes in flow direction and confinement of flows to the breached section that result. Removal of this structure's remnants and restoration of the adjacent stream channel and banks are recommended.



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231 MAIN STREET
SUITE 102
NEW PALTZ, NY 12561
845.633.8153

HIGH RISK AREA #2 - PERRY MILLS
GREAT CHAZY RIVER FLOOD & ICE JAM STUDY
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FIG. 4-14

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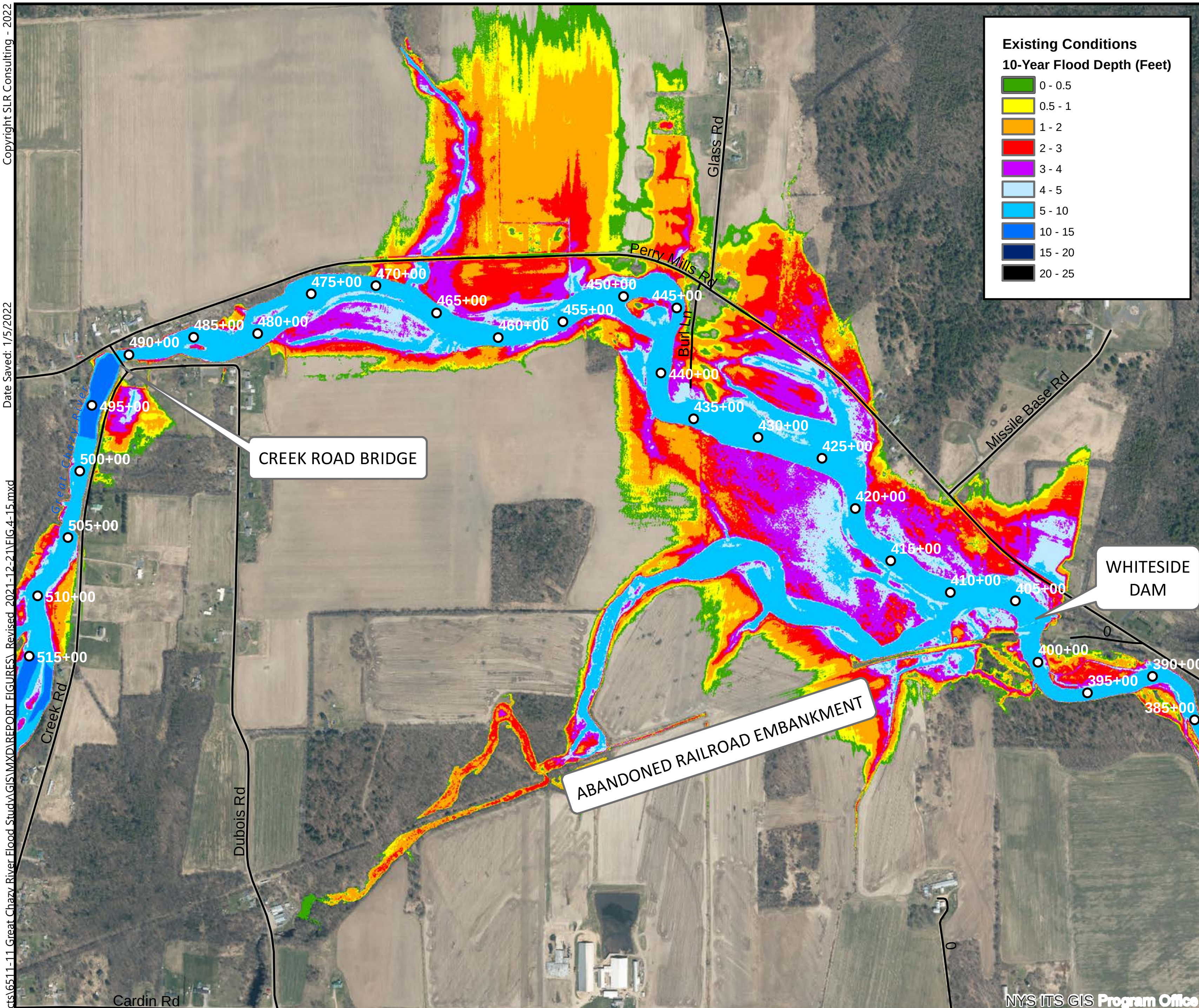

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SLR
231 MAIN STREET
SUITE 102
NEW PALTZ, NY 12561
845.633.8153

HRA #2 - 10-YEAR FLOOD AT PERRY MILLS

GREAT CHAZY RIVER FLOOD & ICE JAM STUDY

SD119

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FIG. 4-15

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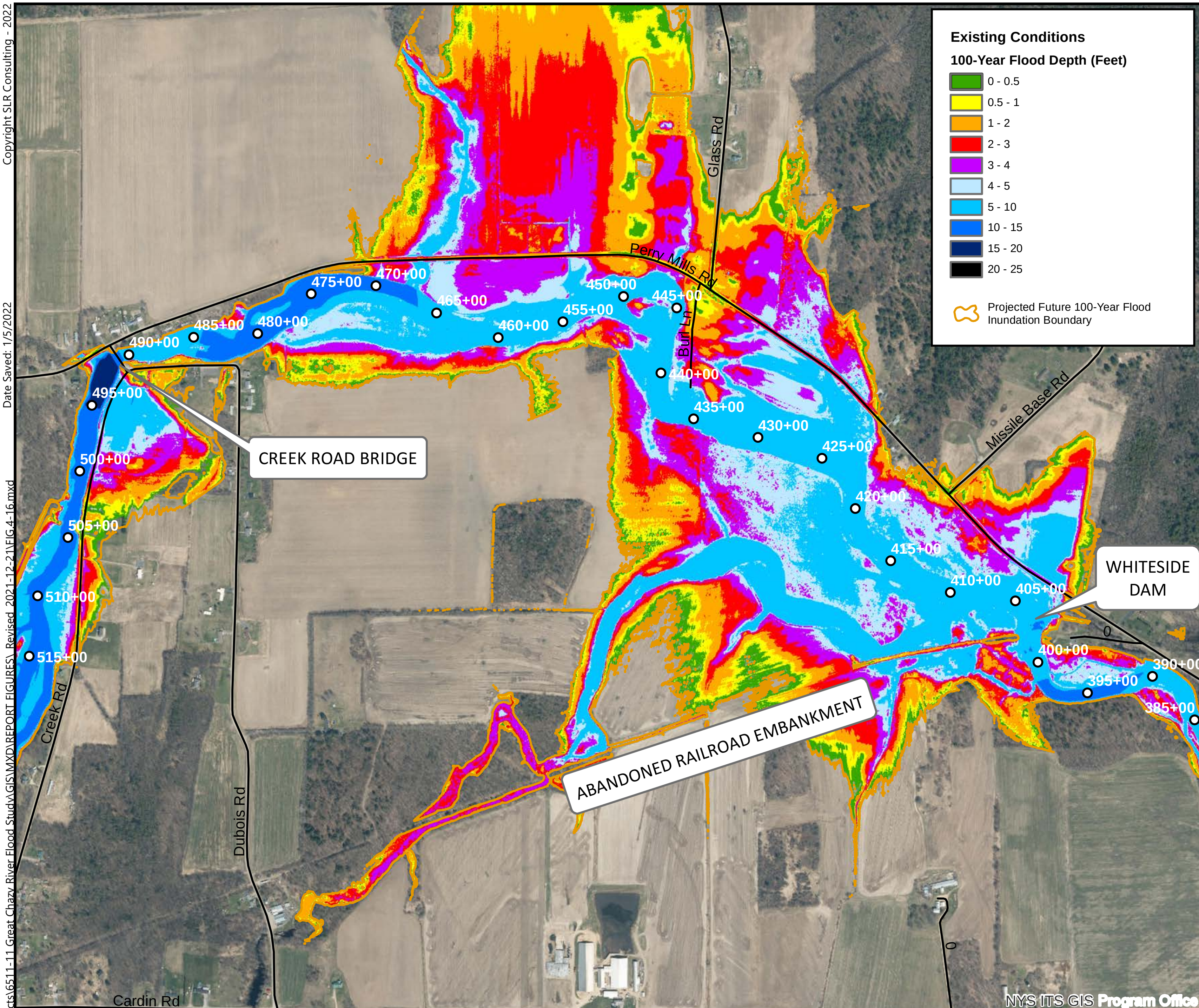

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231 MAIN STREET
SUITE 102
NEW PALTZ, NY 12561
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HRA #1 - 100-YEAR FLOOD AT PERRY MILLS

GREAT CHAZY RIVER FLOOD & ICE JAM STUDY

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NEW YORK

SCALE 1 " = 1,000 '

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FIG. 4-16

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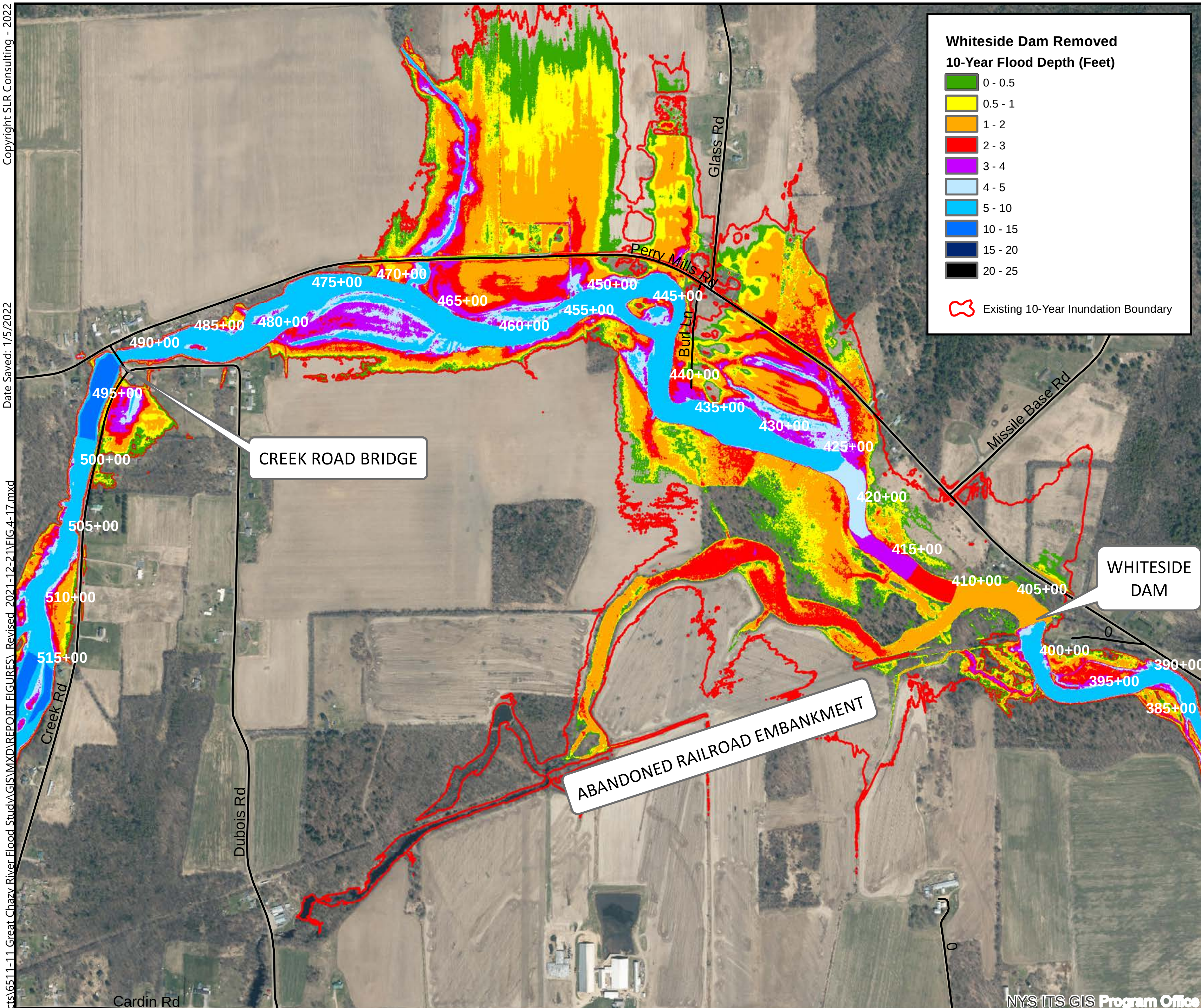

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NEW PALTZ, NY 12561
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HRA #1 - 10-YEAR FLOOD - WHITESIDE DAM REMOVED
GREAT CHAZY RIVER FLOOD & ICE JAM STUDY
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FIG. 4-17

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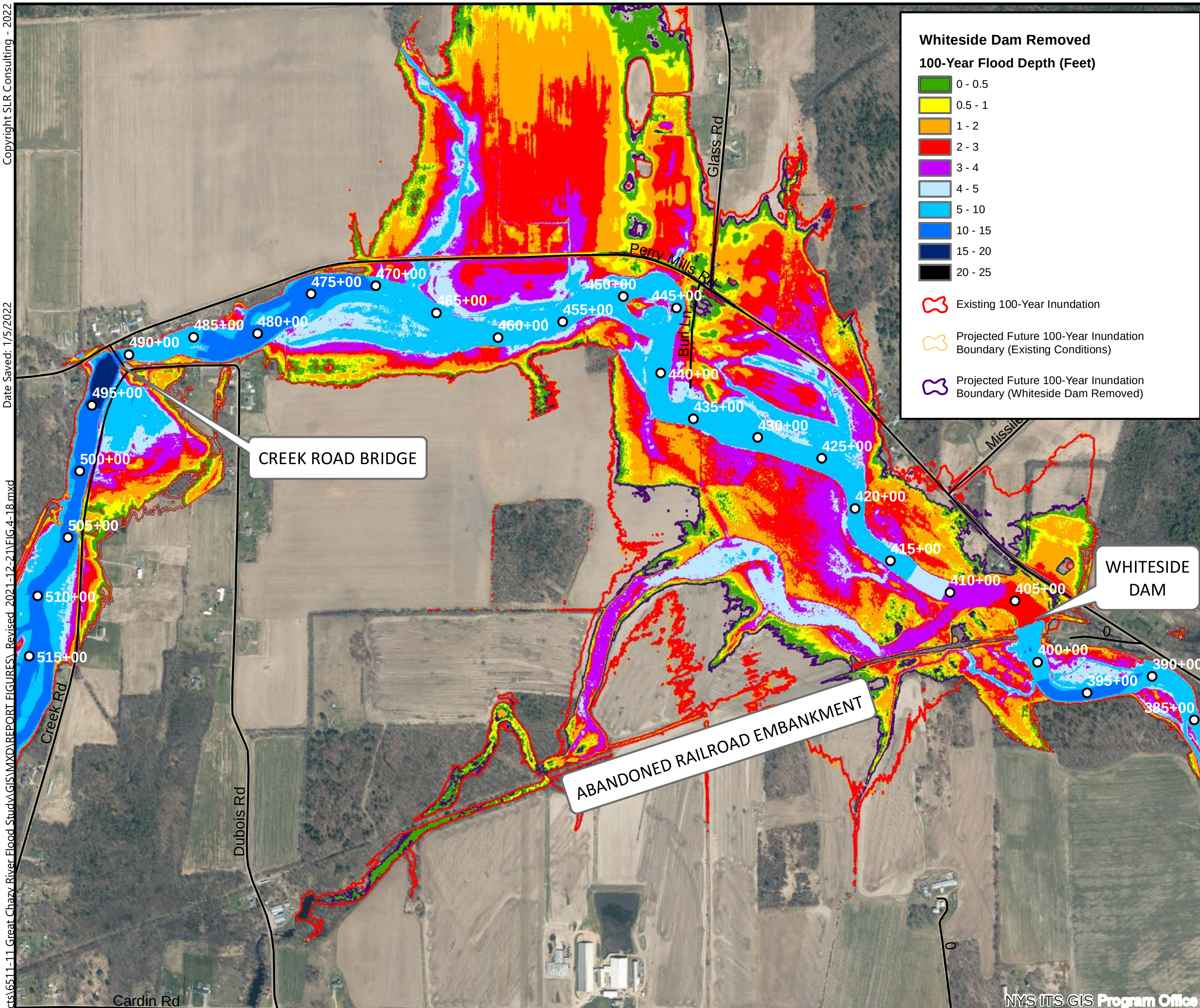

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HRA #1 - 100-YEAR FLOOD - WHITESIDE DAM REMOVED
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FIG. 4-18

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