FLOOD MITIGATION & RESILIENCE REPORT

Mamaroneck River – SD 969 MOD 2

Prepared for:

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

SLR #142.16511.00020
September 2023

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New York State Office of General Services
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Albany, New York 12242

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ACRONYMS

AOP	Aquatic Organism Passage
BFE	Base Flood Elevation
BIN	Bridge Identification Number
CEA	Critical Environmental Area
CFS	Cubic Feet per Second
CRRA	Community Risk and Resiliency Act
DEC	Department of Environmental Conservation
ECL	Environmental Conservation Law
EFC	Environmental Facilities Corporation
EPA	Environmental Protection Agency
EWP	Emergency Watershed Protection
FEMA	Federal Emergency Management Agency
FIRM	Flood Insurance Rate Map
FIS	Flood Insurance Study
FMA	Flood Mitigation Assistance
FPMS	Floodplain Management Services (program)
GDM	General Design Memorandum
GIGP	Green Innovation Grant Program
GIS	Geographic Information System
GRR	General Reevaluation Report
HEC-HMS	Hydrologic Engineering Center – *Hydrologic Modeling System*
HEC-RAS	Hydrologic Engineering Center – *River Analysis System*
HMGP	Hazard Mitigation Grant Program
HMP	Hazard Mitigation Plan
HRA	High Risk Area
LiDAR	Light Detection and Ranging
MPH	Miles per hour
MTA	Metropolitan Transportation Authority
MWRR	Municipal Waste Reduction and Recycling
NAACC	North Atlantic Aquatic Connectivity Collaborative
NBI	National Bridge Inventory
NFIP	National Flood Insurance Program
NFIRA	National Flood Insurance Reform Act
NLCD	National Land Cover Database
NOAA	National Oceanic and Atmospheric Administration
NRCS	Natural Resources Conservation Service
NWI	National Wetlands Inventory
NYS	New York State
NYSDEC	New York State Department of Environmental Conservation
NYSDOS	New York State Department of State
NYSDOT	New York State Department of Transportation

NYSOGS	New York State Office of General Services
PAS	Planning Advisory Service
PDM	Pre-Disaster Mitigation Program
RCP	Representative Concentration Pathway
RFC	Repetitive Flood Claims
RL	Repetitive Loss
SEQRA	State Environmental Quality Review Act
SFHA	Special Flood Hazard Area
SLR	SLR Engineering, Landscape Architecture, and Land Surveying, P.C.
SRL	Severe Repetitive Loss
STA	Station (river)
USACE	United States Army Corps of Engineers
USGS	United States Geological Survey

SUMMARY

The Mamaroneck River originates in southern Westchester County and drains generally southward, discharging to the East Basin of Mamaroneck Harbor on Long Island Sound. This flood analysis of the Mamaroneck 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 report begins with an overview of the Mamaroneck River watercourse and watershed, summarizes the history of flooding, and identifies a total of seven High Risk Areas within the watershed. An analysis of flood mitigation considerations within each High Risk Area is undertaken. Flood mitigation recommendations are provided, either as specific recommendations for a High Risk Area or as overarching recommendations that apply to the entire watershed or stream corridor. Flood mitigation scenarios such as floodplain enhancement and channel restoration, road closures, replacement of undersized bridges and culverts, strategic property relocations, and other strategies are investigated and recommended where appropriate.

The Mamaroneck River watershed is nearly 80 percent developed, leaving relatively little forest, wetland, and undeveloped floodplain. Repetitive flooding in the more densely developed portions of the watershed is driven primarily by insufficiently sized bridge crossings, undersized stream channel, lack of undeveloped floodplain, and poor channel alignment. In many areas along the Mamaroneck and Sheldrake Rivers, the river channels are encroached by roadways and buildings on both banks, and the river is forced to flow narrowly through a hydraulically undersized channel comprised of vertical walls. Reconstructing of the river channel with adequately sized multistage channel and floodplain is recommended in these areas. Because of tight development on the riverbanks and floodplain, there is very little room available for channel enhancements without disturbing nearby houses and businesses. Therefore, property acquisition followed by channel and floodplain restoration is recommended.

High Risk Area 1 is located within the village of Mamaroneck starting downstream at the East Basin of Mamaroneck Harbor and extending upstream to above the confluence of the Sheldrake River and the Mamaroneck River. This section of the Mamaroneck River is highly urbanized; a mix of residential and commercial buildings are densely positioned along the riverbanks and throughout the river's floodplain. The following recommendations are provided for High Risk Area 1:

- Reconstruction of the Mamaroneck River and Sheldrake River channel with a multistage channel and floodplain bench. Bankfull channel width of 54 feet for Mamaroneck River and 41 feet for Sheldrake River. Realignment of the confluence and rivers to eliminate sharp bends and smooth the transition of flow under the Metropolitan Transportation Authority railroad bridge.

- Replacement of the Station Plaza bridge with a105- to 120-foot-wide structure or to fully span the proposed channel and floodplain areas and not obstruct flood flows.

- Replacement of the Halstead Avenue bridge with a 70-foot-wide structure and elevated low chord by 2 feet to fully span the proposed United States Army Corps of Engineers' (USACE) design channel and not obstruct flood flows.

- Removal or replacement of the Anita Lane utility bridge with a 70-foot-wide, single-span open deck bridge and elevated low chord between 6 to 7 feet above existing.

- Replacement of the Ward Avenue bridge with a 100-foot-wide bridge that spans a proposed 550-foot-long by 75-foot-wide floodplain bench is recommended. At the time of this report, the USACE was in the process of designing a new structure for Ward Avenue.

- Replacement of the Tompkins Avenue bridge with a 115-foot-wide bridge to span the active channel and existing floodplain.

- Removal of either the Ward Avenue or Tompkins Avenue crossing and restoration of the adjoining sections of the channel is also an option since there may be sufficient alternative routes available across the Mamaroneck River.

- It is recommended that floodproofing measures along East Prospect Avenue and East Boston Post Road account for future climatic conditions and that the town/village utilize the information presented in this report to aid in decision making for existing and future development within the lower Mamaroneck River reach. Wherever landowner interest exists, property buyouts are recommended.

High Risk Area 2 includes the Mamaroneck River between Jefferson Avenue and Interstate 95 (I-95) in the village of Mamaroneck. The river flows through an undersized and walled-in channel for most of its course. Dense residential development and a handful of commercial businesses occupy the riverbanks and floodplain. Two bridges span the Mamaroneck River within this section. The following recommendations are provided for High Risk Area 2:

- Flooding here is the result of development on the river's floodplain, which is naturally expected to inundate during a flood. The most cost-effective, long-term flood mitigation solution for flood-prone properties would be managed retreat through voluntary property acquisitions and restoration of the river's floodplain areas.

- There are over 100 properties built on the floodplain on either side of the Mamaroneck River in High Risk Area 2. For this reason, a feasibility study should be conducted to determine the optimal combination of property relocations and floodplain restoration.

- Reconstructing the river channel with a multistage channel with a 54-foot-wide bankfull channel. Property buyouts and floodplain restoration wherever willingness and viability align.

- Removal or replacement of the North Barry Avenue Extension bridge with a 70-foot-wide single-span structure so it no longer obstructs flows. A rigorous hydraulic and hydrologic analysis is recommended when due for replacement to ensure that it is adequately sized to convey flood flows and does not exacerbate flooding.

- Sections of the approach roads to the right (west) of the Hillside Avenue bridge and left (east) of the North Barry Avenue Extension bridge are still expected to be underwater during severe flood events. It is recommended that proper roadway closure signage be implemented when major storm events are forecasted.

- At flood-prone properties where bridge replacements and floodplain restoration improve but do not eliminate flooding issues, individual floodproofing is recommended.

High Risk Area 3 covers the section of the Mamaroneck River from I-95 upstream to the Mamaroneck Reservoir dam. The river at this location defines the boundary between the village of Mamaroneck and the town of Harrison. Crowded residential development along the riverbanks and floodplain, especially on the village of Mamaroneck side, has experienced flooding in the past, including during Tropical Storm Ida in 2021. The following recommendations are provided for High Risk Area 3:

- Flooding here is the result of development on the river's floodplain, which is naturally expected to inundate during a flood. The most cost-effective, long-term flood mitigation solution for flood-prone properties would be managed retreat through voluntary property acquisitions and restoration of the river's floodplain areas.

- Inspection of the I-95 crossing following a major storm and regular removal of debris accumulation at the inlet.

- Removal of Winfield Avenue bridge and restoration of the channel to a bankfull width of 47 feet.

- Individual property flood protection measures should be implemented using predicted future water surface elevations to adequately elevate homes and utilities. It is recommended that all floodproofing measures account for future climatic conditions and that the town/village utilize this information to aid in decision making when it comes to existing and future development within the floodplain.

- A feasibility study is recommended for High Risk Area 3 to find the optimal combination of property relocations and floodplain restoration.

High Risk Area 4 includes approximately 1.1 river miles of the Sheldrake River tributary starting at the confluence with the Mamaroneck River and continuing upstream to where I-95 crosses. The upper portion is moderately developed with a few houses and industrial buildings located on the right overbanks. However, the lower portion of the Sheldrake River becomes encroached by roadways and buildings on both banks and flows narrowly through a hydraulically undersized channel comprised of vertical walls until reaching Columbus Park. The following recommendations are provided for High Risk Area 4:

- Restoration of the channelized Sheldrake River to a width of 41 feet.

- A short-term floodplain bench creation approach that prioritizes minimal disturbance to existing roadways and buildings. Floodplain bench creation would alternate between river-left and river-right, consuming sections of Plaza Avenue, Northup Avenue, Center Avenue, and Waverly Avenue.

- o Floodplain bench #1 along the left bank of the Sheldrake River about 1,160 feet long. The first 916 feet of floodplain is excavated 5 feet below existing ground and measures approximately 20 feet wide. The remaining 245 feet of floodplain bench is excavated 3 feet below existing ground and varies between 25 feet and 50 feet wide.

- o Floodplain bench #2 along the right bank of the Sheldrake River. Excavated about 4 feet below the current ground level approximately 350 feet long and of varying widths between 16 feet and 32 feet. The floodplain bench would consume a portion of a scrapyard and a parking lot along Waverly Avenue to the right (southwest).

- o Floodplain bench #3 along the left bank of the Sheldrake River. Excavated about 5.5 feet below current ground level and approximately 323 feet long by 32 feet wide. Conversion of Plaza Avenue to a single-lane road would be required.

- o Floodplain bench #4 along the right bank of the Sheldrake River. Excavated at approximately 4 feet below existing ground and measuring 460 feet long by 25 feet wide. The floodplain bench would consume a section of Northup Avenue.

- A long-term, more ambitious, riparian corridor creation extending from Columbus Park upstream. This would require acquisition and demolition of flood-prone properties, followed by the establishment of a floodable linear park along the Sheldrake River.

- Replacement of the Waverly Avenue bridge with a new span of at least 50 feet.

- Replacement of the Mamaroneck Avenue bridge with a new span of at least 52 feet.

- Removal of the Center Avenue bridge.

- Removal or reduction of pedestrian bridges across the Sheldrake River.

High Risk Area 5 encompasses the section of the Sheldrake River at the Brookside Drive neighborhood in northern Larchmont. The river flows through a narrow channel with no floodplain for most of this section and is narrowly squeezed between East Brookside Drive and West Brookside Drive. The East Branch Sheldrake River tributary enters the Sheldrake River from the north and is similarly encroached upon by roadways on either bank. The following recommendations are provided for High Risk Area 5:

- Widening the Sheldrake River channel to a bankfull width of 39 feet throughout the 2,500-foot-long project reach. Channel modifications would require converting sections of Brookside Drive East and West to one-way, single-lane roads.

- Replacement of the bridge structures under Forest Avenue, Briarcliff Road, and Hickory Grove Drive East with 40-foot single-span structures.

- Removal of Fernwood Road and Lansdowne Drive crossings over the Sheldrake River.
- Channel profile modifications would further enhance conveyance and should be explored where bedrock in the channel is absent.
- Demolishing the existing East Brook Drive culvert over the East Branch Sheldrake River and installing an adequately sized structure, approximately 24 feet wide, between 260 to 600 feet upstream of the confluence beyond the tailwater influence from the Sheldrake River.
- Rigorous hydraulic and hydrologic analyses are recommended as a component of all culvert replacement designs and should begin at the downstream end of the High Risk Area and proceed upstream.

High Risk Area 6 is located near the headwaters of the Sheldrake River in the town of Scarsdale. The river at this location is very flat and has a contributing watershed area of 0.7 square miles. At the upstream limits of the Sheldrake River is a dam and private pond where the river originates. Reports indicate that Seneca Road, Cayuga Road, and Oneida Road flood often, and residential flooding is also a persistent issue. The following recommendations are provided for High Risk Area 6:

- Replacement of six public crossings with single-span structures of approximately 20 feet and widening the channel to at least 21 feet over roughly 2,000 feet of stream length.
- Modifications to the channel or roadway profile may be required in spots to allow for the installation of a replacement structure with a taller vertical opening.
- Replacement of six private driveway crossings with adequately sized structures to optimize flood reduction benefits resulting from upsizing the public roadway crossings.
- At Catherine Road at station (STA) 346+87 and Canterbury Road at STA 349+48, daylighting of the stream where it is not required to run underground or removal and decommission of the roadway.
- Rigorous hydraulic and hydrologic analyses are recommended as a component of culvert replacement design and should begin at the downstream end of High Risk Area 6 and proceed upstream.

High Risk Area 7 is within the hamlet of Purchase in Harrison along the East Branch Mamaroneck River at Pinehurst Drive. The tributary drains moderately steeply from northeast to southwest through a narrow and confined valley. Sparse residential development and roadways built east of the river, on the valley floor, along Pinehurst Drive have experienced flooding according to Town of Harrison public officials. The following recommendations are provided for High Risk Area 7:

- Creation of a 50-foot-wide, 1,060-foot-long floodplain bench and a 27-foot-wide, 660-foot-long floodplain bench along the right bank. Reconstructing 2,000 feet of channel to a bankfull width dimension of 26 feet.

- Relocation or floodproofing of individual properties along Pinehurst Drive is recommended.

The hydraulics of the Mamaroneck and Sheldrake Rivers are complex. The implementation of flood mitigation projects in one area of the Mamaroneck River watershed has the potential to impact a separate area of the watershed. Strategic prioritization of recommended projects is critical to fully realize the benefits of flood reduction projects and is discussed in this report.

- Implementation of recommended improvements through the lower reach of High Risk Area 1 should occur prior to the rework of the Mamaroneck and Sheldrake River confluence area and replacement of the Halstead Avenue and Station Plaza bridges. High Risk Area 1 recommendations and priority are as follows:
    - Floodproofing or removal of buildings along East Prospect Avenue and East Boston Post Road within the influence of riverine and coastal flooding and anticipated flow surcharge from upstream improvements.
    - Replacement of the Ward Avenue bridge and floodplain bench creation through the structure.
    - Replacement or removal of the Tompkins Avenue bridge.

- Replacement or relocation of the Anita Lane utility bridge should begin with the recommended improvements through the upper reach of High Risk Area 1 (i.e., Mamaroneck River and Sheldrake River realignment and reconstruction, Halstead Avenue and Station Plaza bridge removal or replacements). Anita Lane bridge replacement or removal is required to ensure full flood mitigation benefits of upper High Risk Area 1 project.

- Because of the backwater influence from the Mamaroneck River, implementation of any flood mitigation projects in High Risk Area 4 along the Sheldrake River should occur after employment of the recommendations described for the upper reach of High Risk Area 1.

- Aside from the specific recommendations made above, improvements can be implemented within each High Risk Area without substantially impacting other High Risk Areas.

- As general guidance, implementation of improvement with each High Risk Area should begin at the downstream end of the High Risk Area and proceed upstream. For example, in High Risk Area 6, project implementation should begin with stream crossing replacement at Catherine Road, followed by the stream crossing replacement of the private bridges upstream, followed by the replacement at Mamaroneck Road.

- Voluntary acquisitions and demolition of flood-prone properties is a key component to increasing flood resiliency and should be implemented wherever funding is available and landowner willingness exists.

Several funding sources may be available for the implementation of recommendation flood mitigation scenarios and are discussed in further detail in this report.

The final section of this report includes an analysis of land use regulations in each watershed municipality as well as best practices that each community can review to assess whether they are already in their municipal code or if there is an opportunity to enhance the code to further protect municipal resources, residents, businesses, and the natural environment from unplanned and unwanted impacts from flooding.

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 mitigation alternatives to help guide implementation of mitigation projects.

The Mamaroneck River originates in southern Westchester County at Silver Lake at the border between the town of Harrison and the city of White Plains, New York. The Mamaroneck River drains generally southward through Westchester County into the East Basin Mamaroneck Harbor on Long Island Sound. This report begins with an overview of the watercourses 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, road closures, replacement of undersized bridges and culverts, property relocations, and other strategies are investigated and recommended where appropriate.

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 subject watercourses. Stationing on each watercourse is measured in feet, beginning at station 0+00 and continuing upstream. Stationing on the Mamaroneck River begins at station (STA) 0+00 at the point where the river empties into Long Island Sound. Stationing on the Sheldrake River begins at STA 0+00 at the confluence with the Mamaroneck River.

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 purposes of this 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.

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 Mamaroneck River and its tributaries.

References to channel reconstruction with a “multistage channel” design are made throughout the report. As opposed to different design approaches, such as ditching and channelization of river systems, a multistage channel is designed to accommodate a range of flood flows while maintaining sediment transport competency. These channels are designed to provide flood conveyance, balanced sediment transport, and enhance nutrient filtration through the creation of channel stages that are intentionally sized to accommodate these natural stream functions. Multistage channels include a bankfull channel, floodplain benches, and sometimes a low-flow channel to concentrate water during the drier seasons for aquatic organisms. Correct sizing of a multistage channel is critical for flood flow conveyance, effective sediment transport, and the reduction of stream bank erosion. Equally as important are the restoration efforts post channel construction with native vegetation along the various stages of the channel, which will further promote channel stability and nutrient filtration. The most common form of multistage channel is the two-stage channel, although three- and four-stage channels are options for larger channels and watersheds. Figure 1-1 illustrates an example cross section of a conceptual three-stage channel design.

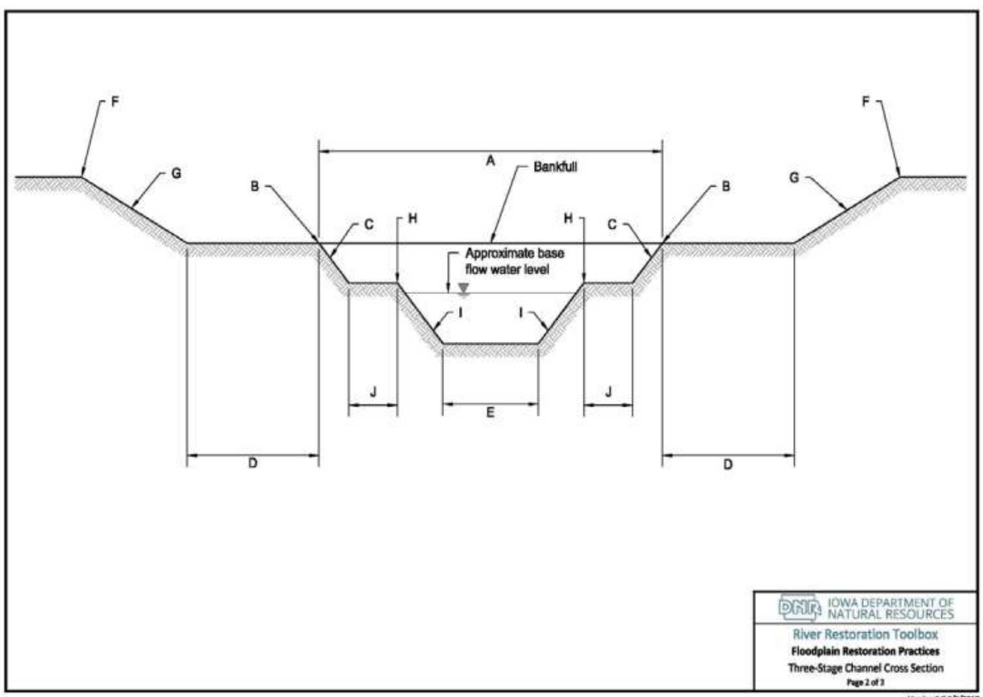


Figure 1-1: Three-stage channel cross section example from Iowa Department of Natural Resource from the River Restoration Toolbox Practice Guide 4 (April 2018)

2. DATA COLLECTION

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

2.1 MAMARONECK RIVER WATERSHED CHARACTERISTICS

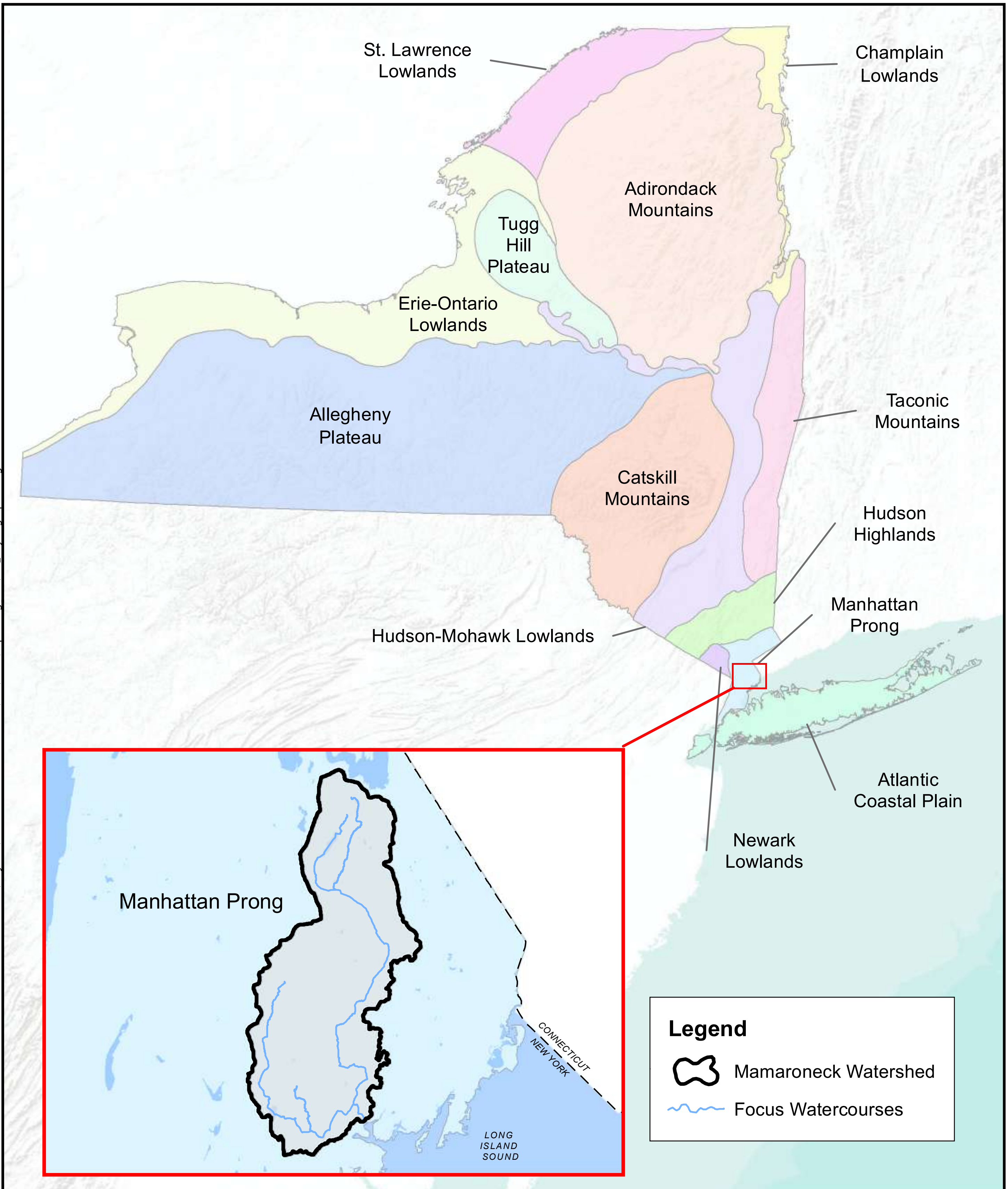
The Mamaroneck River watershed is located in Westchester County, in southeastern New York State, and falls within the physiographic region known as the Manhattan Prong (Figure 2-1). The watershed flows in a generally southerly direction, draining part of the southeastern portions of Westchester County before flowing into Long Island Sound. Approximately half of the town and village of Harrison, town of White Plains, and town and village of Scarsdale is drained by the Mamaroneck River watershed as well as parts of the city of New Rochelle, town of Mamaroneck, and village of Mamaroneck.

The Mamaroneck River watershed is oblong in shape, widening near its outlet to Long Island Sound in New York. When measured at its outlet, the watershed is 22.8 square miles in size. Figure 2-2 is a watershed map. Watershed relief is depicted in Figure 2-3.

The Manhattan Prong is a lowland area with rolling hills and valleys comprised of metamorphic rocks of Early Paleozoic age. The relative age of the following bedrock, with the exception of the Fordham and Yonkers Gneiss, is unknown but speculated to be sometime within the Cambrian and Ordovician Periods (443.8 to 541.0 million years ago). Two separate sections found in the central and southern parts of the watershed are mapped as the Hartland Formation, specifically the Schist and Granulite Member. This member is distinguished by brown to gray schist with garnets interbedded with fine-grained granulites. Mapped in the southern section is the Harrison Gneiss, specifically the Quartz Feldspar Gneiss member. This member is comprised of a medium-grained banded gneiss with large, coarse-grained quartz-feldspar segregations. Mapped in the north central section is the Manhattan Schist. This formation consists of a dark gray to silvery, medium-grained, foliated schist. The most northern area of the Mamaroneck River watershed is an area with tightly folded bedrock comprised of several different formations. Those formations include the Inwood Marble, Fordham Gneiss, and Yonkers Gneiss. The Inwood Marble consists of dolomite marble. The Fordham and Yonkers Gneiss are estimated to be of Precambrian to Middle Proterozoic in age, and both consist of a variety of gneisses.

These rocks and much of southeastern New York rock were tightly folded and metamorphosed primarily during the Taconic Orogeny, a mountain-building event that occurred 450 million years ago. The underlying bedrock influences the topography of the land within the Manhattan Prong, with the metamorphic rocks resistant to erosion making up the hills and the less erosion-resistant rocks creating the valleys.

During the Pleistocene Epoch (11.7 thousand to 2.58 million years ago), New York State was undergoing a period of glaciation. As the glaciers retreated, they deposited mud, sand, and gravel that make the surficial materials seen on land today. Surficial materials underlying the Mamaroneck River watershed consist primarily of glacial till, with areas mapped as exposed bedrock occurring along the northern margins of the watershed as well as small, isolated pockets in the southeast. Two small areas mapped as lacustrine silt and clay and outwash sand and gravel exist in the northern part of the watershed. Multiple small, isolated pockets of kame deposits are located in the central section as well.



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NEW YORK STATE PHYSIOGRAPHIC REGIONS

MAMARONECK RIVER FLOOD & RESILIENCY STUDY
SD 969 MOD 2
WESTCHESTER COUNTY, NEW YORK

N

0 140,000 280,000
Feet

SCALE 1 " = 300,000 '

DATE 5/25/2023

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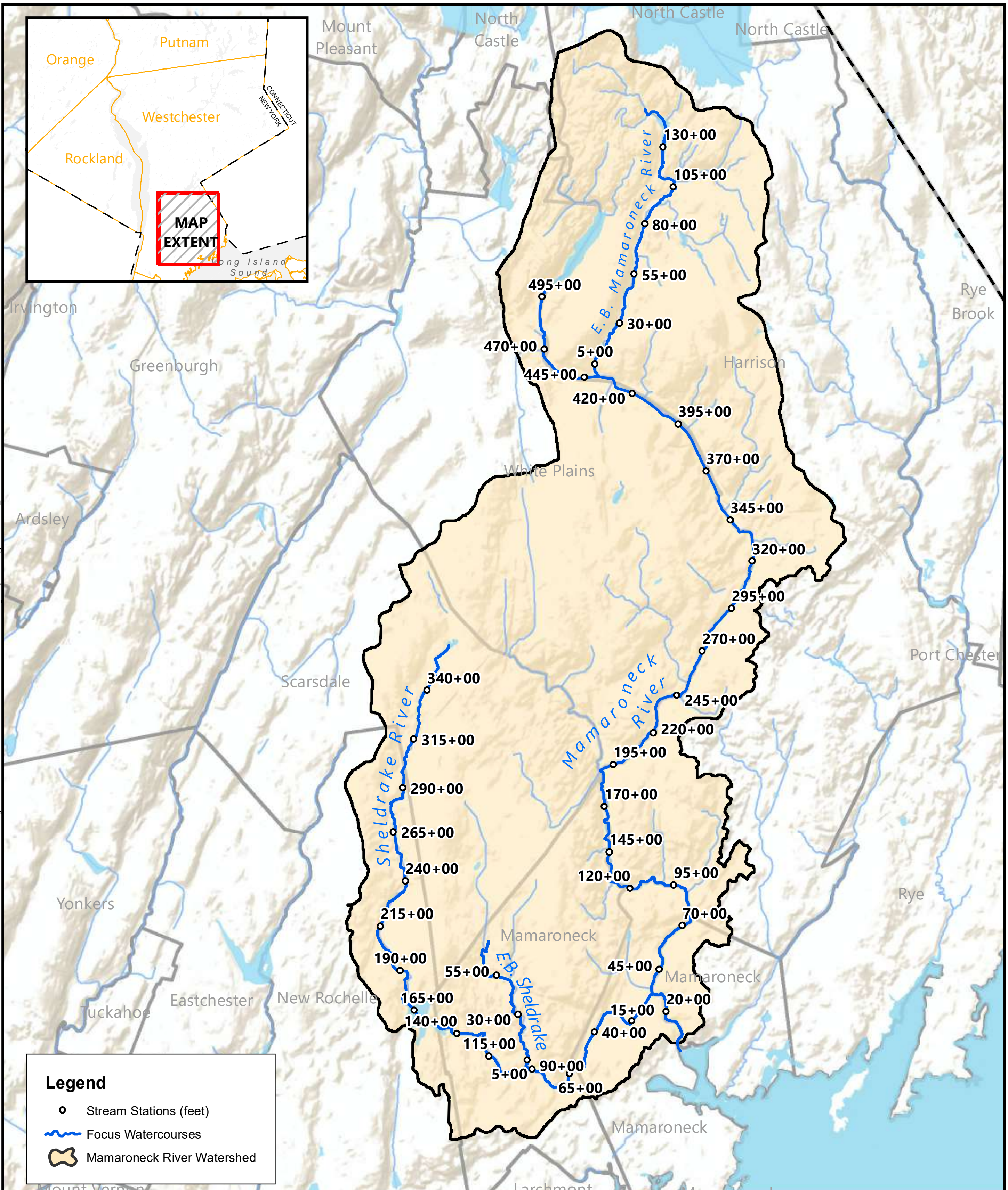
FIG. 2-1



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MAMARONECK RIVER WATERSHED

MAMARONECK RIVER FLOOD & RESILIENCY STUDY
SD 969 MOD 2
WESTCHESTER COUNTY, NEW YORK

N

0 2,500 5,000
Feet

SCALE	1 " = 6,000 '
DATE	8/2/2023
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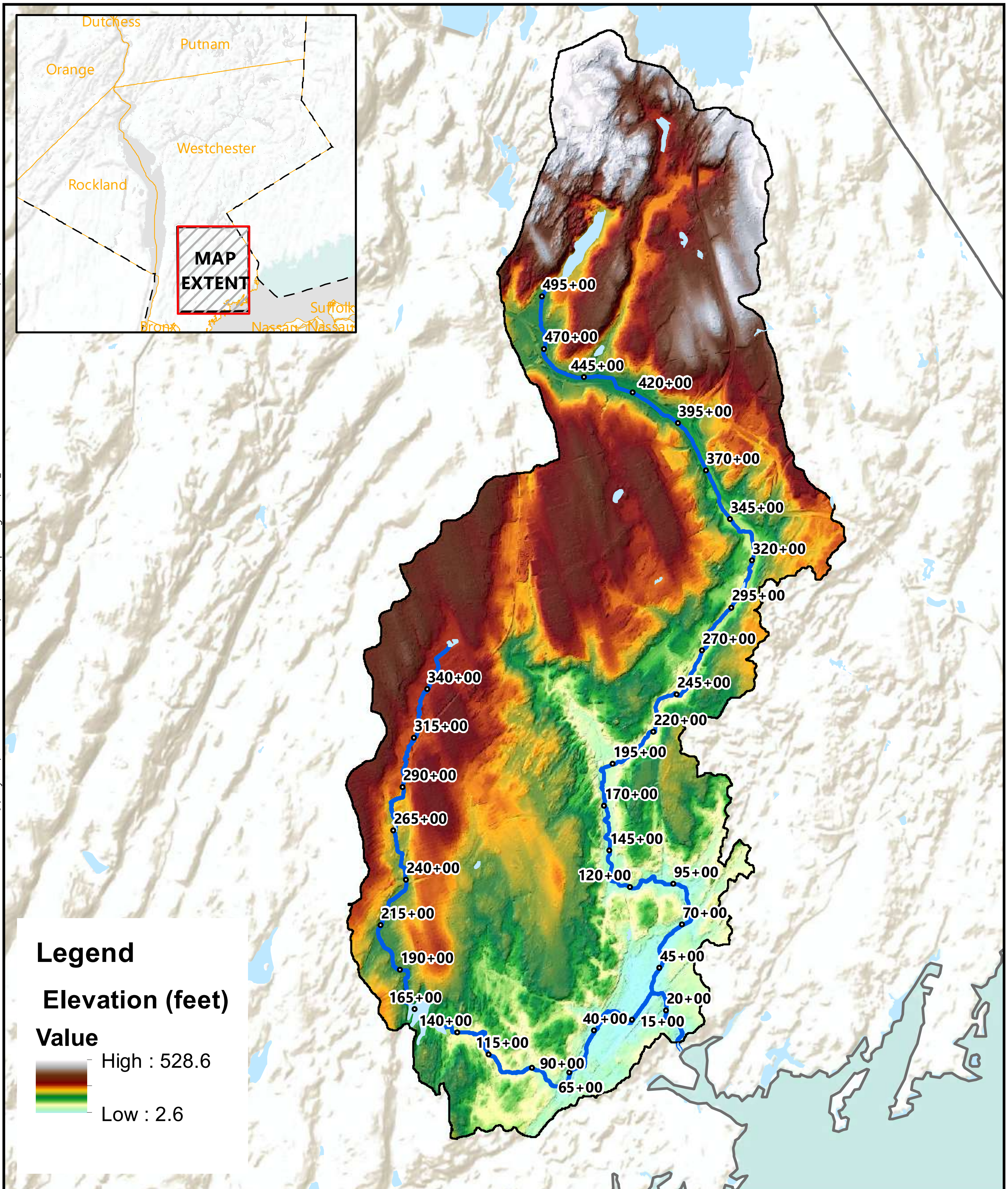
FIG. 2-2



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RELIEF MAP

MAMARONECK RIVER FLOOD & RESILIENCY STUDY
SD 969 MOD 2

WESTCHESTER COUNTY, NEW YORK

N

0 2,500 5,000
Feet

SCALE 1 " = 6,000 '

DATE 5/5/2023

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FIG. 2-3

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 52 percent of the mapped soils in the Mamaroneck River watershed are classified as hydrologic soil group B, indicating a higher infiltration capacity and low tendency for runoff (Figure 2-4). An additional 25 percent consists of B/D or D soil types. The remaining 11 percent consists of soil types C, C/D, and A/D.

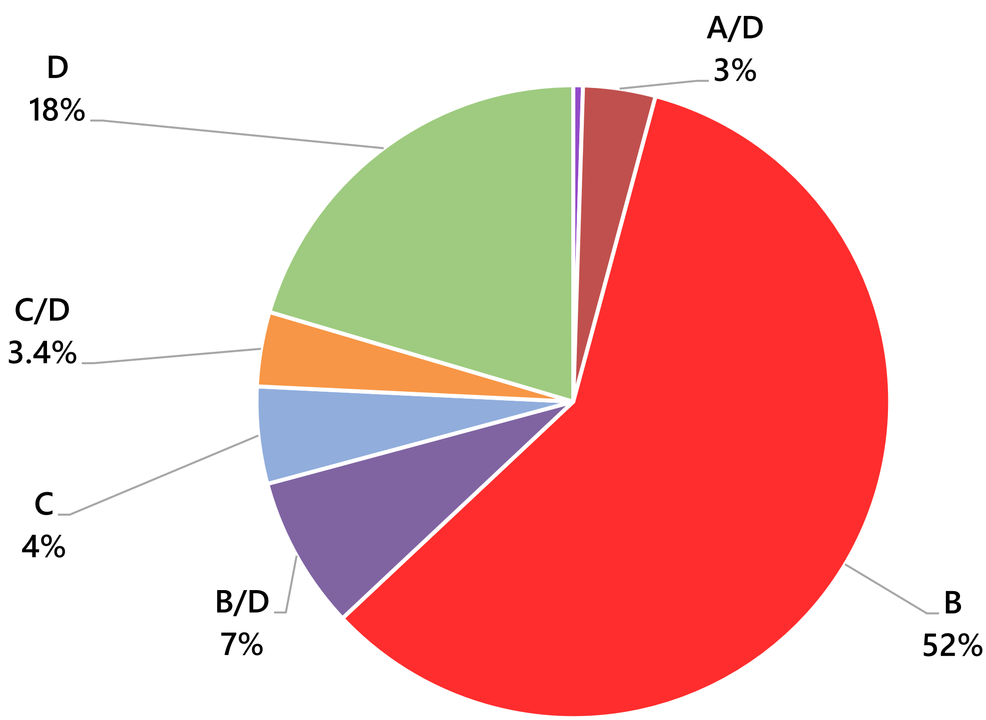

Figure 2-4: Hydrologic Grouping of Soils within the Mamaroneck River Watershed

Land cover is another important factor influencing the runoff characteristics of a watershed. Land cover within the Mamaroneck River watershed can be characterized using the 2016 Multi-Resolution Land Characteristics National Land Cover Database for Southeast New York State and is shown graphically in Figure 2-5. Developed land is the most common land cover, representing 79 percent of the watershed. Forested land consists of deciduous, coniferous, and mixed forest types and makes up 19 percent of the land cover in the watershed. Open water and wetlands combined make up 2 percent of the land cover. The remaining land cover, making up less than 1 percent, consists of barren land.

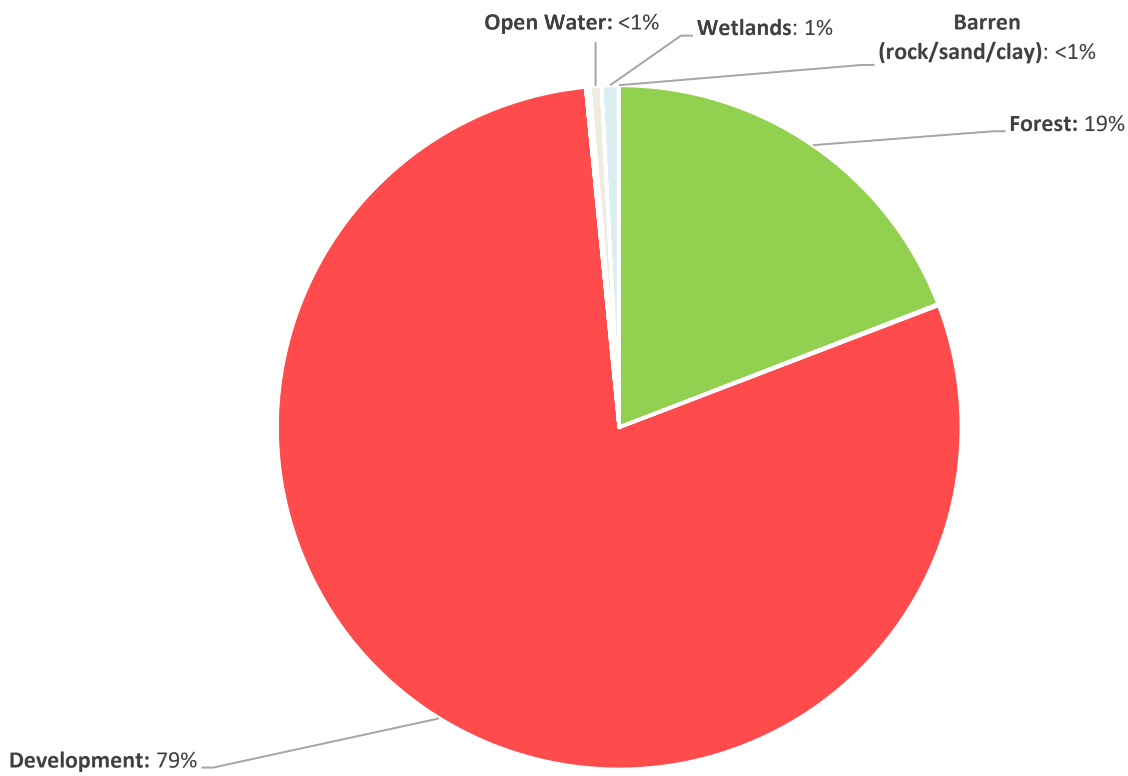

Figure 2-5: Land Cover within the Mamaroneck River Watershed

> 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 also examined using information available from the U.S. Fish & Wildlife Service's National Wetlands Inventory (NWI). The NWI indicates that there are 457 acres of wetlands in the Mamaroneck River watershed, or approximately 3 percent of the watershed. This amount is slightly larger compared with the estimate above based on land cover and includes the following types of wetland habitats: estuarine and marine deep water, freshwater emergent wetland, freshwater forested/shrub wetland, freshwater pond, lake, and riverine. NYSDEC-mapped wetlands in the Mamaroneck River watershed include a 19.7-acre freshwater wetland in the town of Scarsdale east of the intersection between Weaver Street and Hutchinson River Parkway, a 19.8-acre freshwater wetland in the town of White Plains southwest of White Plains High School, a 24.5-acre freshwater wetland around Forest Lake in the town of Harrison, and a 23-acre freshwater wetland south of Forest Lake in the town of Harrison.

2.2 MAMARONECK RIVER WATERCOURSE

The main stem of Mamaroneck River originates at Silver Lake on the border between the town of Harrison and city of White Plains. It flows southward, acting as the town border between the town of Harrison and city of White Plains and the border between the town of Harrison and village of Mamaroneck. The

Mamaroneck River continues to flow southward through the center of the Village of Mamaroneck before joining with the Sheldrake River and eventually empties into Long Island Sound. When measured at the point where it enters Long Island Sound, the Mamaroneck River is approximately 12.6 miles in length. Named tributaries to the main stem of the Mamaroneck River are the East Branch Mamaroneck River, West Branch Mamaroneck River, and the Sheldrake River.

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 Mamaroneck River can be characterized as a third-order stream at its outlet where it discharges to Mamaroneck Harbor. Second-order tributaries include the East Branch Sheldrake River and the lower Sheldrake River. First-order tributaries include the upper reaches of the Sheldrake River and the West Branch Mamaroneck River. Figure 2-6 is a map depicting stream order in the Mamaroneck River watershed.

Characteristics of each order of stream (total length, average slope, and percentage of overall stream network) are summarized in Table 2-1. First- and second-order streams account for most of the overall stream length within the Mamaroneck River watershed (78 percent). First-order streams are generally steeper in slope than the larger second- and third-order streams.

Table 2-1 Stream Order Characteristics in the Mamaroneck River Watershed

STREAM ORDER	TOTAL LENGTH (MILES)	PERCENTAGE OF OVERALL NETWORK LENGTH (%)	AVERAGE SLOPE (%)
1st	27.2	58	2.3
2nd	9.2	20	2.0
3rd	10.5	22	0.4
Total	**46.9**	**100**	

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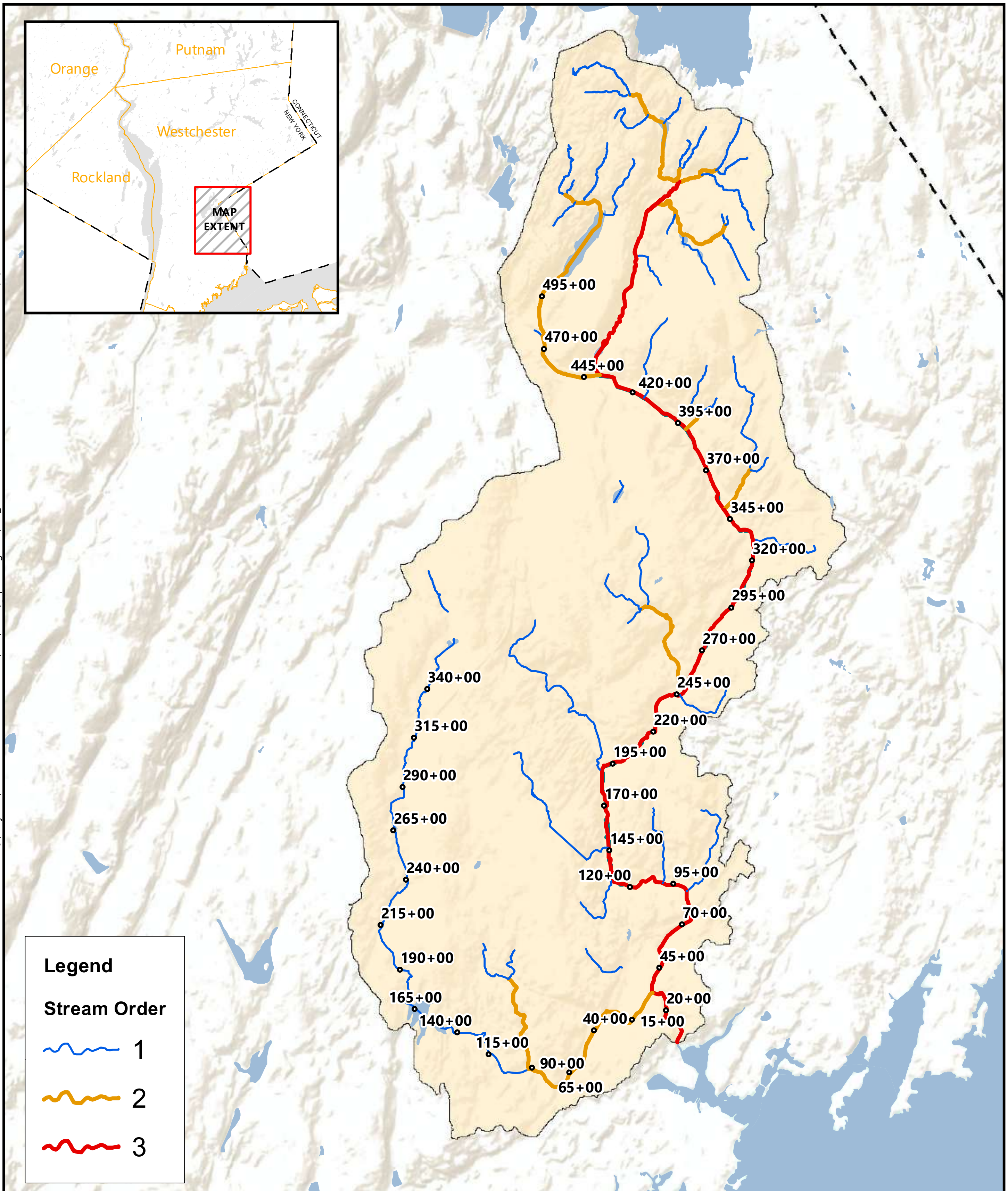

SLR
231 MAIN STREET
SUITE 102
NEW PALTZ, NY 12561
845.633.8153

MAMARONECK RIVER WATERSHED STREAM ORDER
MAMARONECK RIVER FLOOD & RESILIENCY STUDY
SD 969 MOD 2
WESTCHESTER COUNTY, NEW YORK

N

0 2,500 5,000
Feet

SCALE 1 " = 6,000 '
DATE 5/5/2023
6511.0020
PROJ. NO.

FIG. 2-6

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 such as Hydrologic Engineering Center – *River Analysis System* (HEC-RAS). 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; these 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.

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.

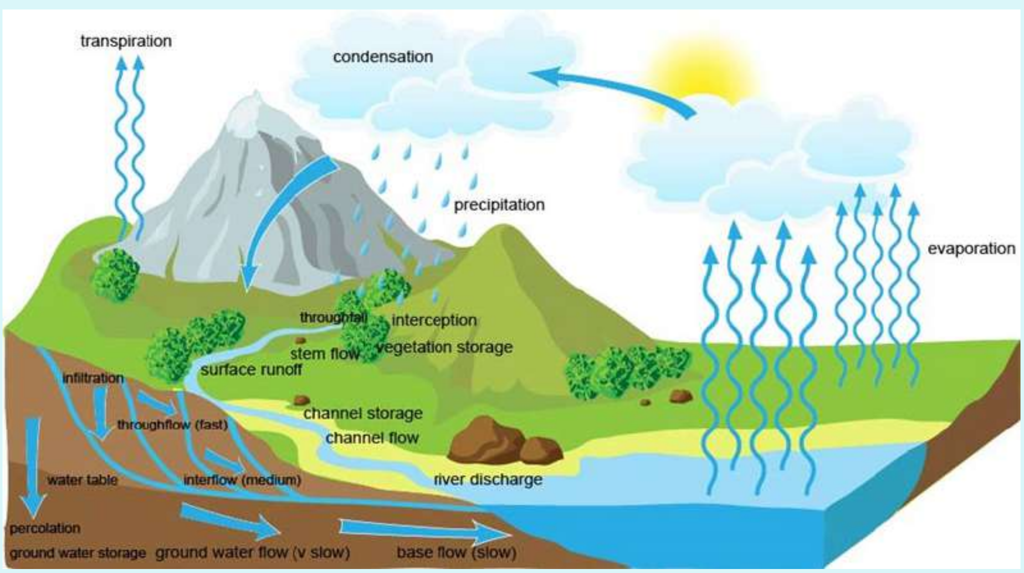

Figure 2-7: Diagram of Simplified Hydrologic Cycle

Estimated flood flows on the Mamaroneck River and its tributaries were taken from the FEMA effective Flood Insurance Study (FIS) for Westchester County (36119CV001A, Effective September 28, 2007). Hydrology for the lower Mamaroneck River was updated for the effective FIS using a Log-Pearson Type III analysis performed on the 45 years of record available at the USGS stream gauge 01301000 on the

Mamaroneck River. Peak discharges were determined at the gauge for the 10-, 50-, 100-, and 500-year storm events. Drainage area transposition was then utilized to determine peak discharges for the selected storm events at the study reach limits and upstream of confluence with tributaries. The exponents used in the drainage area transposition calculation were obtained from WRI 90-4197 (Lumia, 1990).

Hydrology on the East Branch Mamaroneck River was developed using the USACE HEC-1 Flood Hydrograph computer program (USACE, 1991). A Clark hydrograph was used to derive the runoff hydrograph for each subbasin and was calibrated to match the 100-year storm discharges calculated by the rational method. For the Sheldrake River and East Branch Sheldrake River, regional regression equations for peak discharge estimation were used as presented in USGS WRI 84-4350 and then modified by an urban watershed correction as described in USGS *Water Supply Paper 2007* (Sauer, 1983). The FEMA analysis is the most recently completed hydrologic analysis for Westchester County; therefore, those computed peak flows were used for the hydraulic analysis that was conducted using a one-dimensional HEC-RAS model. Peak flood flow values for the study watercourses are presented in Table 2-2.

Table 2-2 Flood Hydrology for Mamaroneck River Watershed Developed for Westchester County FIS

WATERCOURSE	LOCATION	DRAINAGE AREA (SQR. MI.)	PEAK FLOOD DISCHARGE (CFS)			
			10-YEAR	50-YEAR	100-YEAR	500-YEAR
Lower Mamaroneck River	STA 0+00, at mouth	24	2,870	4,210	4,800	6,070
	STA 25+00, at USGS gauge	23.4	2,820	4,140	4,710	5,960
	STA 35+00, upstream of confluence with Sheldrake River	17.1	2,280	3,330	3,800	4,790
Upper Mamaroneck River	STA 465+00, at Westchester Avenue	1.8	655	852	927	1,130
	STA 476+25, at I-287 ramp, approximately 1,700 feet upstream of Westchester Avenue	1.3	353	492	549	716
	STA 502+36, at outflow of Silver Lake	1.0	273	391	438	563
East Branch Mamaroneck River	STA 0+00, at downstream corporate limits	2.76	749	1,042	1,152	1,444
	STA 50+00, at Oakmont Drive	2.44	650	900	1,000	1,300
	STA 79+73, approximately 2,250 feet downstream of Barnes Lane	2.18	571	794	878	1,100
	STA 92+80, immediately upstream of confluence with unnamed tributary at approximately 935 feet downstream of Barnes Lane	1.61	230	360	410	700

WATERCOURSE	LOCATION	DRAINAGE AREA (SQR. MI.)	PEAK FLOOD DISCHARGE (CFS)			
			10-YEAR	50-YEAR	100-YEAR	500-YEAR
East Branch Mamaroneck River	STA 103+23, immediately upstream of confluence with unnamed tributary approximately 100 feet upstream of Barnes Lane	0.95	160	225	285	400
	STA 127+00, outflow from Forest Lake	0.85	135	216	256	366
	STA 150+00, inflow from Forest Lake	0.85	315	437	482	603
Sheldrake River	STA 0+00, upstream of confluence with Mamaroneck River	6.5	1,112	1,564	1,806	2,256
	STA 91+95, upstream of confluence with East Branch Sheldrake River	3.2	515	724	830	1,042
	STA 140+00, upstream of Weaver Street	2.9	440	614	700	862
	STA 238+00, downstream of Hutchinson River Parkway	1.9	360	495	557	669
	STA 302+00, at cross section A (just downstream of Palmer Avenue, at corporate limits with New Rochelle)	1.2	242	323	361	434
	STA 322+65, at cross section I (upstream of Brookby Road)	0.9	182	247	276	325
East Branch Sheldrake River	STA 0+00, immediately upstream of confluence with Sheldrake River	1.9	485	681	776	972

cfs = cubic feet per second

For the study area evaluated using an unsteady two-dimensional hydraulic model, existing conditions hydrologic values calculated by the USACE were utilized. USACE performed a rigorous hydrologic assessment of the Mamaroneck and Sheldrake River watersheds using an updated gauge peak discharge versus frequency analysis and developed hydrographs for the 1-, 2-, 5-, 10-, 25-, 50-, 100-, 200-, and 500-year storm events. Hydrologic modeling was conducted in Hydrologic Engineering Center – *Hydrologic Modeling System* (HEC-HMS) and calibrated to high water marks of the April 2007 flood using an HEC-RAS model. Additional details on the methodology used for the flood frequency analysis by the USACE can be found in Appendix C1-Hydrology of the General Reevaluation Report (GRR) Flood Risk Management Study for the Mamaroneck and Sheldrake Rivers. Overall, the peak discharge amounts computed by the USACE are generally larger than those estimated in the FEMA FIS and assumed to be more conservative and a better approximation of future flow conditions. Table 2-3 compares flows calculated by USACE to those estimated by FEMA for the Westchester County-wide FIS.

Table 2-3 Peak Discharges from 2017 USACE Study and FEMA FIS Computed at the Former Mamaroneck River USGS Gauge near Halstead Road

FLOOD EVENT	PEAK DISCHARGE (CFS)		PERCENT CHANGE
	2007 FEMA FIS	USACE 2017 GRR	
10-Year	2,820	3,370	20%
50-Year	4,140	4,740	15%
100-Year	4,710	5,350	14%
500-Year	5,960	6,860	15%

cfs = cubic feet per second

At the time of this report, a preliminary FIS (36119CV001B) has been available for Westchester County since December 2014 but has not yet been adopted. The flood hydrology for Mamaroneck River and its tributaries reported in the preliminary FIS is unchanged and matches those reported in the effective FIS.

Climate change is causing a trend of wetter winters and drier summers in the region. To account for these changes and the resulting increase in peak flows, the estimated future peak flows were determined using regional regression equations (Lumia et al., 2006) and predicted future runoff, from the "National Climate Change Viewer," a web-based tool developed by the USGS (Alder and Hostetler, 2013). The predicted future runoff shows an increase in the winter months and a decrease in the summer months. To apply this to the change in future peak flows, the average increase in runoff in the winter months was used in the regional regression equations. The results allow for modeling of flood conditions that may occur in future decades, enabling proactive flood mitigation measures.

Runoff data were evaluated for two future scenarios, termed "Representative Concentration Pathways" or RCPs, that provide estimates of the extent to which greenhouse gas concentrations in the atmosphere are likely to change through the 21st century. RCPs are based on 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. The future runoff estimates are based on 20 different climate models, which have been scaled for Westchester County. The runoff values are used in regional regression equations to estimate the change in peak flow for the Mamaroneck River watershed.

Climate is not stationary. It should be noted that increased flows result not just from climate change but also from increased watershed development. It is important to note that flood-prone areas depicted on FIRMS do not account for future flows or sea-level rise.

Flows based on the more moderate greenhouse gas scenario were used in hydraulic models. Proposed replacement stream crossings were assessed based on the 2075 to 2099 projections to account for a culvert life span of approximately 50 years and bridge life span of 75 years or more.

Mean estimated increases for the 50- and 100-year floods based on the climate models are presented in Table 2-4. These are based on regressions for Flood Frequency Region 2 in New York. Current and predicted future flows for Mamaroneck River and its tributaries at various locations along the watercourses are compared in Table 2-5.

Table 2-4 Projected Increases (percent) in Flood Flows in the Mamaroneck River Watershed

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	1.6	2.1	1.6	2.1	4.9	5.4
RCP 8.5	1.8	2.2	3.2	3.7	5.3	5.1

Table 2-5 Current and Projected Future Flood Flows Used in Hydraulic Analyses in the Mamaroneck River Watershed

WATERCOURSE	LOCATION	PEAK FLOOD DISCHARGE (CFS) INCREASE (%)					
		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
Upper Mamaroneck River	STA 0+00, at mouth	4,210	4,800	4,277	4,901	4,416	5,059
	STA 25+00, at USGS gauge	4,140	4,710	4,206	4,809	4,343	4,964
	STA 35+00, upstream of confluence with Sheldrake River	3,330	3,800	3,383	3,880	3,493	4,005
Lower Mamaroneck River	STA 465+00, at Westchester Avenue	852	927	866	946	894	977
	STA 476+25, at I-287 ramp, approximately 1,700 feet upstream of Westchester Avenue	492	549	500	561	516	579
	STA 502+36, at outflow of Silver Lake	391	438	397	447	410	462
East Branch Mamaroneck River	STA 0+00, at downstream corporate limits	1,042	1,152	1,059	1,176	1,093	1,214
	STA 50+00, at Oakmont Drive	900	1,000	914	1,021	944	1,054
	STA 79+73, approximately 2,250 feet downstream of Barnes Lane	794	878	807	896	833	925
	STA 92+80, 9mmediately upstream of confluence with unnamed tributary at approximately 935 feet downstream of Barnes Lane	360	410	366	419	378	432

WATERCOURSE	LOCATION	PEAK FLOOD DISCHARGE (CFS) INCREASE (%)					
		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
East Branch Mamaroneck River	STA 103+23, immediately upstream of confluence with unnamed tributary approximately 100 feet upstream of Barnes Lane	225	285	229	291	236	300
	STA 127+00, outflow from Forest Lake	216	256	219	261	227	270
	STA 150+00, inflow from Forest Lake	437	482	444	492	458	508
Sheldrake River	STA 0+00, upstream of confluence with Mamaroneck River	1,564	1,806	1,589	1,844	1,641	1,904
	STA 91+95, upstream of confluence with East Branch Sheldrake River	724	830	736	847	759	875
	STA 140+00, upstream of Weaver Street	614	700	624	715	644	738
	STA 238+00, downstream of Hutchinson River Parkway	495	557	503	569	519	587
Sheldrake River	STA 302+00, at cross section A (just downstream of Palmer Avenue, at corporate limits with New Rochelle)	323	361	328	369	339	380
	STA 322+65, at cross section I (upstream of Brookby Road)	247	276	251	282	259	291
East Branch Sheldrake River	STA 0+00, immediately upstream of confluence with Sheldrake River	681	776	692	792	714	818

cfs = cubic feet per second

Long Island Sound flood elevation estimates were obtained from the effective FIS for Westchester County, shown in Table 2-6. Projected sea-level rise in the tidal coast was based on New York State Sea-Level Rise Projections (6 NYCRR Part 490) that were developed in accordance with the Community Risk and Resiliency Act to help prepare for the coastal impacts of climate change. Projected increases in sea level for the Long Island Region, where the Mamaroneck River empties, are reproduced below as Table 2-7. These are predicted increases over the baseline of the average elevation measured from 2000 to 2004. Several scenarios are possible, ranging from less to more severe; however, "while there is some uncertainty regarding the precise rate at which sea level will rise, there is relative certainty that global sea level will ultimately rise at least six feet over current levels" (6 NYCRR Part 490). For the purpose of this analysis, Long Island Sound tailwater elevations used in hydraulic modeling of future flood scenarios on the Mamaroneck River were increased by 16 inches over the elevations reported in the current effective FIS. This represents the "medium" sea-level rise scenario for the 2050s time period.

Table 2-6 Stillwater Flood Elevations in Long Island Sound at Town of Mamaroneck as Reported in the Westchester County-Wide FIS

FLOOD EVENT	STILLWATER FLOOD ELEVATION (FEET, NAVD88)
10-Year	8.8
50-Year	10.7
100-Year	11.6
500-Year	13.9

Table 2-7 New York State Sea-Level Rise Projections, Long Island Region (from 6 NYCRR 490)

	PROJECTED SEA-LEVEL RISE (INCHES)				
Projection Scenario	Low	Low-Medium	Medium	High-Medium	High
2020s	2	4	6	8	10
2050s	8	11	16	21	30
2080s	13	18	29	39	58
2100	15	22	34	47	72

2.4 HYDRAULICS

Hydraulic analyses were conducted using the HEC-RAS computer software. This program was developed by the USACE Hydrologic Engineering Center and is the industry standard for riverine flood analysis. The model is used to compute water surface profiles for one- and two-dimensional, steady- and unsteady-state flow conditions. The system can accommodate a full network of channels, a dendritic system, or a single river reach. HEC-RAS is capable of modeling water surface profiles under subcritical, supercritical, and mixed-flow conditions. Water surface profiles are computed from one cross section to the next by solving the one-dimensional energy equation with an iterative procedure called the standard step method. Energy losses are evaluated by friction (Manning's Equation) and the contraction/expansion of flow through the channel. The momentum equation is used in situations where the water surface profile is rapidly varied such as hydraulic jumps, mixed-flow regime calculations, hydraulics of dams and bridges, and evaluating profiles at a river confluence.

2.4.1 EXISTING CONDITIONS MODELING

Effective FEMA HEC-RAS one-dimensional hydraulic models were sought for areas of the Mamaroneck River watershed where they were available, which include the Mamaroneck River (upper and lower reach), East Branch Mamaroneck River, Sheldrake River, and East Branch Sheldrake River. These models were obtained from the NYSDEC Floodplain Management Section, which is gratefully acknowledged. In addition to the effective FEMA hydraulic models, which were created for the purpose of the 2007 FIS, the

USACE developed steady- and unsteady-state one-dimensional models for its study of the Sheldrake and Mamaroneck River basins. USACE HEC-RAS models included 2.5 miles of the Mamaroneck River and approximately 1.0 mile along the Sheldrake River within the village of Mamaroneck and town of Harrison. A total of 176 channel cross sections, 21 bridges, and two dam structures were surveyed in 2010 and added to the HEC-RAS hydraulic model. USACE kindly shared its more recent survey data and hydraulic modeling with SLR Engineering, Landscape Architecture, and Land Surveying, P.C. (SLR), which was used to develop a two-dimensional hydraulic model for this flood study.

Due to the complexity of flooding in and around the Mamaroneck and Sheldrake Rivers confluence area, a two-dimensional hydraulic model was developed using the HEC-RAS software (v.6.3.1). Approximately 2.7 miles of the Mamaroneck River and 1.1 miles of the Sheldrake River channel, including over 600 acres of overbank area. Modeling begins above the Mamaroneck River reservoir dam (STA 143+54) and extends downstream to the outlet at the Long Island Sound (STA 0+00). The section of the Sheldrake River that was included begins downstream of the Lakeside Drive Lake (STA 70+00) and extends downstream to the confluence with the Mamaroneck River (STA 0+00). Two-dimensional modeling can more effectively capture the complex hydrodynamics encountered when the stream spills onto its floodplain. Flows are computed across a two-dimensional network of cells upon a three-dimensional terrain surface. Water surface elevations, flow depths, and velocities are computed at cell nodes and faces based on the St. Venant shallow-water approximations of the Navier-Stokes equations for three-dimensional fluid flow, as numerically discretized by HEC. Boundary drag is computed based on Manning's roughness coefficients applied to the terrain.

Model geometry for the two-dimensional model was based on a combination of surveyed channel cross sections included in USACE modeling, field measurements collected by SLR, and Light Detection and Ranging (LiDAR)-derived topographic mapping from the New York State (NYS) Geographic Information System (GIS) Clearinghouse. A combination of 1-meter and 2-meter grid resolution topographic surfaces collected in 2011 and 2009, respectively, were utilized for the terrain model. Planimetric data from Westchester County was used to add the outline of buildings and insert their approximate heights into the terrain model. Roughness coefficients were applied to the model domain based on field observations, 2016 National Land Cover Database (NLCD) for North America, and 2021 aerial orthophotography.

2.4.2 PROPOSED CONDITIONS MODELING

Several HEC-RAS model geometries were developed to represent proposed conditions to assess flood mitigation alternatives at the identified HRAs on the Mamaroneck River and its tributaries. These involved modifications of the terrain, cross sections, bridge and dams, boundary conditions, surface roughness, or combinations thereof. Flood mitigation alternatives were modeled individually and in combination to assess practical and effective short- and long-term solutions.

2.5 PREVIOUS STUDIES OF MAMARONECK RIVER

Previous efforts to address flooding along the Mamaroneck River have been made and include studies undertaken by the USACE focused on flooding problems in the village of Mamaroneck. A 1989 General Design Memorandum (GDM) Flood Control Project for the Mamaroneck and Sheldrake River Basins in the village of Mamaroneck initially explored flood risk management strategies. The study ultimately recommended channel modifications, constructing retaining walls, replacing six bridges, removing one bridge, and a diversion tunnel from Fenimore Road to the west basin of Mamaroneck Harbor. None of the mitigation actions were constructed.

Following the aftermath of the April 2007 flood, a General Reevaluation Report & Environmental Impact Statement (GRR) of the 1989 study was started and completed in July 2017. The study identified potential structural and nonstructural recommendations that could be implemented, many of which are already underway, to reduce flood damage across the village of Mamaroneck. The 2017 GRR study recommended the following cost-effective flood mitigation actions:

- Over 7,500 linear feet of channel modifications along the Mamaroneck and Sheldrake Rivers, with various channel widths and depths within the village of Mamaroneck.
- Realignment at the confluence of the Mamaroneck and Sheldrake Rivers with a 25-foot-wide by 8-foot-high by 390-foot-long culvert located under the railroad station parking lot.
- Channel modifications would consist of constructing a trapezoidal channel with a natural channel bed and pitched or sloped vegetated banks. Retaining walls would be utilized for the sections of stream where a trapezoidal channel cannot be constructed, typically where buildings, roads, or other features may be affected.
- Removal and replacement of existing retaining walls and utilities along the length of channel, including at Waverly Avenue bridge and Ward Avenue bridge.
- Removal of several small bridges, including Center Avenue bridge, and replacement of two footbridges in Columbus Park.
- Nonstructural recommendations along the Mamaroneck and Sheldrake Rivers, including structure elevations, ringwall levees, and/or floodproofing.

Other known studies conducted on the Mamaroneck River watershed are listed in Table 2-8.

Table 2-8 Summary of Studies Conducted on the Mamaroneck River and Mamaroneck River Watershed

Study	Conducted By	Date
General Design Memorandum Flood Control Project for the Mamaroneck and Sheldrake River Basins in the village of Mamaroneck	USACE	January 1989
General Reevaluation Report & Environmental Impact Statement for the village of Mamaroneck	USACE	July 2017
Village of Mamaroneck Final Local Multi-Hazard Mitigation Plan	Environmental Technology Group, Inc.	May 2012
Westchester County Hazard Mitigation Plan Update	Tetra Tech	July 2015
Village of Mamaroneck Stormwater Management Program	Dolph Rotfeld Engineering, P.C.	2015

2.6 STAKEHOLDER MEETINGS

An important component of the data gathering for this study took place through stakeholder engagement. A series of formal and informal meetings were convened by video conference call. The first meeting was held on September 14, 2022. This meeting was geared toward participating government agencies, county, and municipal representatives and included participation from NYSDEC, OGS, and Westchester County. In addition to the formal video conferences, many one-on-one conversations took place with representatives from the watershed municipalities, government agencies, and the Village of Mamaroneck Flood Mitigation Advisory Committee. A final stakeholder meeting will be coordinated at the close of the study to share findings and recommendations.

2.7 INFRASTRUCTURE

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.*

Several bridge and culvert crossings of the Mamaroneck River and its tributaries 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 2-9. The span of the crossing and estimated bankfull width of the channel is provided for each crossing location. It should be noted that a crossing span that is narrower than the channel's bankfull width indicates that the crossing may be hydraulically undersized and may be prone to scour or contribute to flooding.

Table 2-9 Summary Data for Assessed Bridge and Culvert Crossings of Mamaroneck River and Major Tributaries

RIVER	ROADWAY	RIVER STATION (FEET)	STRUCTURE	NBI BIN* (OWNER)	NUMBER OF SPANS/ BARRELS	SPAN (FEET)	BANKFULL WIDTH (FEET) (REGIONAL REGRESSIONS)	YEAR BUILT
Mamaroneck River (Lower)	East Boston Post Road (Highway One Road)	1+01	Masonry Arch Deck Bridge	1000040 (NYSDOT)	1	43	60	1985
	Tompkins Avenue	9+20	Steel Multi-Beam or Box Girder Bridge	2225120 (Village of Mamaroneck)	1	37	60	1893 (Poor Status)
Mamaroneck River (Lower)	Ward Avenue	18+70	Concrete Arch Deck Bridge	2225110 (Village of Mamaroneck)	1	34	60	1937
	Anita Lane (Utility Bridge)	23+92	Not Listed	Not Listed (Unknown)	2	28	60	Not Listed
	Halstead Avenue	27+53	Steel Multi-Beam or Box Girder Bridge	3348290 (Westchester County)	1	40	60	1910
Mamaroneck River (Lower)	Metro-North Railroad	28+48	Masonry Arch Bridge	Unknown (Metro-North Company)	2	22	60	1887
	Station Plaza	30+74	Prestressed Concrete Box Beam Bridge	2225100 (Village of Mamaroneck)	2	38	60	1987
	Jefferson Avenue	36+10	Prestressed Concrete Tee Beam Bridge	2225080 (Village of Mamaroneck)	1	84	54	2013
	Hillside Avenue	45+50	Concrete Tee Beam Bridge	2225070 (Village of Mamaroneck)	1	32	54	1936 (Poor Status)
	North Barry Avenue Extension	46+46	Concrete Frame Bridge	2225060 (Village of Mamaroneck)	3	16	53	1957
	NYS I-95	75+92	Concrete Frame Bridge	5514709 (NYS Thruway Authority)	3	19	53	1954
	Winfield Avenue (Decommissioned)	108+54	Concrete Tee Beam Bridge	2262310 (Town of Mamaroneck)	1	31	53	1919
Mamaroneck River (Upper)	I-287 Northbound Ramp	476+53	Concrete Culvert	Not Listed (NYSDOT)	2	8	28	2009
	Main Street East	482+09	Stone Arch Culvert	Not Listed (Unknown)	1	10	25	Not Listed

RIVER	ROADWAY	RIVER STATION (FEET)	STRUCTURE	NBI BIN* (OWNER)	NUMBER OF SPANS/ BARRELS	SPAN (FEET)	BANKFULL WIDTH (FEET) (REGIONAL REGRESSIONS)	YEAR BUILT
	Lake Street	501+30	Concrete Box Culvert	Not Listed (Unknown)	1	8	25	Not Listed
East Branch Mamaroneck River	Anderson Hill Road	0+20	Not Listed	Not Listed (Unknown)	2	9	32	Not Listed
	Barnes Lane	102+42	Not Listed	Not Listed (Unknown)	1	5	27	Not Listed
	New Lake Street	111+36	Not Listed	Not Listed (Unknown)	1	4	21	Not Listed
	Old Lake Street	113+97	Not Listed	Not Listed (Unknown)	1	7	21	Not Listed
	Forest Lake Drive	125+94	Not Listed	Not Listed (Unknown)	3	11	20	Not Listed
Sheldrake River	Footbridge	0+20	Wood Bridge	Not Listed (Unknown)	1	22	41	Not Listed
	Footbridge	3+03	Wood Bridge	Not Listed (Unknown)	1	22	41	Not Listed
	Mamaroneck Avenue	6+52	Concrete Arch Deck Bridge	2225090 (Westchester County)	1	20	41	2005
	Waverly Avenue	19+34	Steel Multi-Beam or Box Girder Bridge	2225140 (Town of Mamaroneck)	1	27	41	1931 (Poor Status)
	Center Avenue Pedestrian Bridge	21+77	Concrete Bridge	Unknown (Not Listed)	1	22	40	Not Listed
	Fenimore Road	34+17	Concrete Frame Bridge	2265140 (Town of Mamaroneck)	2	16	40	1956
	Rockland Avenue	52+21	Concrete Culverts	2265260 (Town of Mamaroneck)	2	18	40	1955
	NYS I-95	62+11	Concrete Frame Bridge	5514649 (NYS Thruway Authority)	2	25	39	1956
	Lakeside Drive	74+25	Prestressed Concrete Box Beam Bridge	3348480 (Westchester County)	1	26	39	1925
	Hickory Grove Drive	78+32	Steel Multi-Beam or Box Girder Bridge	2262280 (Town of Mamaroneck)	1	24	39	1939

RIVER	ROADWAY	RIVER STATION (FEET)	STRUCTURE	NBI BIN* (OWNER)	NUMBER OF SPANS/ BARRELS	SPAN (FEET)	BANKFULL WIDTH (FEET) (REGIONAL REGRESSIONS)	YEAR BUILT
Sheldrake River	Fernwood Road	84+78	Not Listed	Not Listed (Unknown)	1	17	39	Not Listed
	Lansdowne Drive	92+50	Not Listed	Not Listed (Unknown)	1	12	38	Not Listed
	Footbridge	99+35	Not Listed	Not Listed (Unknown)	1	17	34	Not Listed
	Briarcliff Road	101+16	Not Listed	Not Listed (Unknown)	1	14	34	Not Listed
	Forest Avenue	105+00	Not Listed	Not Listed (Unknown)	1	11	34	Not Listed
	Rockland Avenue	113+07	Concrete Slab Culvert	2225130 (Village of Larchmont)	1	13	33	1930 (Poor status)
	Leatherstocking Trail Footbridge	116+99	Not Listed	Not Listed (Unknown)	3	22	33	Not Listed
	Bonnie Briar Lane	120+66	Steel Multi-Beam or Box Girder Bridge	2262290 (Town of Mamaroneck)	1	24	33	1950
	Weaver Street	140+00	Concrete Box Culvert	C890057 (NYSDOT)	1	15	33	1995
	Pine Brook Boulevard	170+00	Concrete Arch Bridge	2265470 (City of New Rochelle)	1	25	32	1935
	Pine Brook Boulevard	176+40	Not Listed	Not Listed (Unknown)	1	18	32	1935
	Quaker Ridge Road On Ramp	177+92	Not Listed	Not Listed (Unknown)	1	16	31	Not Listed
	Pine-Quaker Ramp	186+69	Concrete Frame Bridge	2265180 (City of New Rochelle)	1	19	31	1936
	Tulip Lane	201+62	Concrete Pipe Culverts	Not Listed (Unknown)	3	5	31	Not Listed
	Pine Brook Hollow Drive	219+34	Not Listed	Not Listed (Unknown)	1	16	31	Not Listed
	Private Drive	221+80	Not Listed	Not Listed (Unknown)	1	10	30	Not Listed
	Private Drive	223+11	Not Listed	Not Listed (Unknown)	1	9	30	Not Listed

RIVER	ROADWAY	RIVER STATION (FEET)	STRUCTURE	NBI BIN* (OWNER)	NUMBER OF SPANS/ BARRELS	SPAN (FEET)	BANKFULL WIDTH (FEET) (REGIONAL REGRESSIONS)	YEAR BUILT
Sheldrake River	Pinebrook Boulevard	225+00	Concrete Ellipse Pipe Culverts	Not Listed (Unknown)	2	9	30	Not Listed
	Brookwood Road	232+41	Not Listed	Not Listed (Unknown)	1	25	30	Not Listed
	Hutchinson River Parkway	238+84	Corrugated Metal Arch Culverts	C890704 (NYSDOT)	2	7	29	Not Listed
	Hutchinson River Parkway South Ramp	240+86	Concrete Box Culverts	1073610 (NYSDOT)	2	12	29	Not Listed
	Harlan Drive	258+04	Corrugated Metal Pipe Culverts	2265830 (City of New Rochelle)	3	5	28	Not Listed
	Footbridge	263+53	Not Listed	Not Listed (Unknown)	1	15	27	Not Listed
	Private Driveway	279+67	Not Listed	Not Listed (Unknown)	1	5	26	Not Listed
	Private Driveway	280+91	Corrugated Metal Arch Culvert	Not Listed (Unknown)	1	10	26	Not Listed
	Private Driveway	281+64	Corrugated Metal Arch Culvert	Not Listed (Unknown)	1	11	26	Not Listed
	Private Driveway	282+70	Corrugated Metal Arch Culvert	Not Listed (Unknown)	1	11	26	Not Listed
	Wilmot Road	303+29	Concrete Box Culvert	Not Listed (Unknown)	1	10	25	Not Listed
	Heathcote Road	311+18	Concrete Box Culvert	Not Listed (Unknown)	1	13	24	Not Listed
	Brookby Road	322+62	Not Listed	Not Listed (Unknown)	1	12	24	Not Listed
	Catherine Road	332+91	Not Listed	Not Listed (Unknown)	1	10	22	Not Listed
	Catherine Road	338+55	Not Listed	Not Listed (Unknown)	1	10	22	Not Listed
	Private Driveway	339+50	Concrete Ellipse Pipe Culvert	Not Listed (Unknown)	1	7	22	Not Listed
	Private Driveway	340+55	Corrugated Metal Pipe Culvert	Not Listed (Unknown)	1	5	22	Not Listed

RIVER	ROADWAY	RIVER STATION (FEET)	STRUCTURE	NBI BIN* (OWNER)	NUMBER OF SPANS/ BARRELS	SPAN (FEET)	BANKFULL WIDTH (FEET) (REGIONAL REGRESSIONS)	YEAR BUILT
Sheldrake River	Mamaroneck Road	341+67	Corrugated Metal Arch Culvert	Not Listed (Unknown)	1	5	22	Not Listed
	Private Driveway	342+53	Concrete Pipe Culvert	Not Listed (Unknown)	1	5	21	Not Listed
	Private Driveway	343+57	Concrete Pipe Culvert	Not Listed (Unknown)	1	5	21	Not Listed
	Private Driveway	345+37	Concrete Pipe Culvert	Not Listed (Unknown)	1	4	21	Not Listed
	Catherine Road	346+87	Concrete Pipe Culvert	Not Listed (Unknown)	1	4	21	Not Listed
	Private Driveway	348+18	Concrete Pipe Culvert	Not Listed (Unknown)	1	4	21	Not Listed
	Canterbury Road	349+48	Concrete Pipe Culvert	Not Listed (Unknown)	1	4	21	Not Listed
	Cayuga Road	353+65	Concrete Box Culvert	Not Listed (Unknown)	1	5	20	Not Listed
	Oneida Road	361+88	Corrugated Metal Arch Culvert	Not Listed (Unknown)	1	5	18	Not Listed
East Branch Sheldrake River	East Brookside Drive	0+73	Not Listed	Not Listed (Unknown)	1	15	29	Not Listed
	Private Driveway	8+82	Not Listed	Not Listed (Unknown)	1	10	29	Not Listed
	Rockland Avenue	16+44	Not Listed	Not Listed (Unknown)	1	18	29	Not Listed
	Hilltop Road	27+94	Not Listed	Not Listed (Unknown)	1	17	28	Not Listed
	Private Driveway	31+34	Not Listed	Not Listed (Unknown)	1	13	28	Not Listed
East Branch Sheldrake River	Private Driveway	33+54	Not Listed	Not Listed (Unknown)	1	15	28	Not Listed
	York Road	35+00	Ellipse Concrete Culverts	Not Listed (Unknown)	3	6	28	Not Listed
	Private Driveway	36+84	Not Listed	Not Listed (Unknown)	1	18	27	Not Listed

RIVER	ROADWAY	RIVER STATION (FEET)	STRUCTURE	NBI BIN* (OWNER)	NUMBER OF SPANS/ BARRELS	SPAN (FEET)	BANKFULL WIDTH (FEET) (REGIONAL REGRESSIONS)	YEAR BUILT
	Winding Brook Drive	47+02	Not Listed	Not Listed (Unknown)	1	18	27	Not Listed

*NBI BIN = National Bridge Inventory Bridge Identification Number

Based on guidance provided in the New York State Department of Transportation (NYSDOT) *Highway Design Manual* (NYSDOT, 2021) and *Bridge Design Manual* (NYSDOT, 2019), the design criteria for bridges and culverts are listed below. Culverts are classified as any stream crossings with a span of less than 20 feet (measured parallel to the roadway) while bridges have a span of 20 feet or greater. Regardless of past bridge performance and flood history, all replacement stream crossings should be accompanied by a 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 NYSDOT and NYSDEC, as practical. Hydraulic design criteria developed by these agencies are presented below.

- Culverts will be designed to pass the predicted 50-year storm event.
- Bridges will be designed to pass the 50-year storm event with 2 feet of freeboard below the bridge low chord and the 100-year storm event without touching the low chord.
- The structure will not raise the water surface elevations anywhere when compared to existing conditions for both the 50-year and 100-year flood events.
- The proposed bridge's low chord will not be lower than the existing low chord.
- Hydrologic analysis will include an evaluation of future predicted flows. The recommended design-flow multiplier for eastern New York State, which includes the Mamaroneck River watershed, is 120 percent.
- The maximum skew of the bridge pier(s) to the flow shall not exceed 10 degrees.
- Headwater at culverts will be limited to an elevation that:
    - Would not result in damage to upland property,
    - Would not increase the water surface elevation allowed by floodplain regulations, and
    - Would result in a headwater depth-to-culvert height ratio of not greater than 1.0 for culverts with a height greater than 5 feet and not greater than 1.5 for culverts with a height of 5 feet or less.

NYSDEC stream crossing guidelines recommend, where possible, that the following best management guidelines be incorporated:

- Provide a minimum opening width of 1.25 times the bankfull width of the waterway in the vicinity of the crossing.
- Use open-bottom or embedded, closed-bottom structures, which allows for installation of natural streambed material through the length of the structure.
- Match the channel slope through the bridge or culvert to the natural channel slope.
- Install bridges or culverts perpendicularly to the direction of flow of the stream.
- Install new or replacement structures so that no inlet or outlet drop would restrict aquatic organism passage (AOP).

Table 2-10 is a summary of dams on the Mamaroneck River and tributaries according to the NYSDEC inventory of registered dams. Additional dam structures are likely to be present within the Mamaroneck River watershed that are not included in the state's database. Typically, removal of any derelict dams that no longer serve a purpose is advised. Experience with dam removals has shown that removal can be a more cost-effective option than repair, especially since there are several potential funding sources available for dam removals. In addition to flood reductions benefits, there exists many environmental benefits from habitat and aquatic connectivity restoration associated with dam removals.

Table 2-10 Summary Data for Inline Structures on the Mamaroneck River and Tributaries

RIVER	RIVER STATION (FEET)	DESCRIPTION	NYS DAM ID (OWNER)	DAM HEIGHT (FEET)	DAM LENGTH (FEET)
Mamaroneck River	115+89	Mamaroneck Reservoir Dam – Hazard Code C	233-0866 (Village of Mamaroneck)	19	185
	502+36	Silver Lake Dam – Hazard Code B	214-0262 (Westchester County Department of Parks and Recreation)	9	225
Sheldrake River	70+00	Lakeside Drive Dam – Hazard Code A	215-5914 (Town of Mamaroneck)	6	50
	150+00	Larchmont Dam – Hazard Code B	215-0210 (Village of Larchmont)	10	210
	157+60	Larchmont Water Company Dam #2 – Hazard Code C	215-0996 (Village of Larchmont)	31	1000
	265+00	Carpenter Pond Dam – Hazard Code B	215-0222 (City of New Rochelle)	16	156

3. IDENTIFICATION OF FLOOD HAZARDS

3.1 FLOODING HISTORY

Westchester County has historically been impacted by hurricanes, tropical storms, and nor'easters. Hurricanes typically produce flooding in the area by generating heavy rainfall over long periods of time, which saturates the soil, and combined with a period of more intense rainfall, causes runoff volumes that lead to flooding. There have been nine direct hits by hurricanes to NYS between 1900 and 1996. Table 3-1 is a summary of flood events that impacted Westchester County and the Mamaroneck River watershed. The flood history is summarized from the FEMA FIS for Westchester County, the Westchester County Hazard Mitigation Plan (HMP), and National Oceanic and Atmospheric Administration (NOAA) historical records for Westchester County.

According to the USACE, the village of Mamaroneck experienced 23 significant flood events from 1889 to 2017. According to FEMA, approximately $16,230,000 was paid out in insurance claims for flood damage in the village of Mamaroneck between January 1, 1978, and May 31, 2011.

Table 3-1 Westchester County Flood History

DATE	FLOOD EVENT	NOTES
June 1972	Hurricane Agnes	At the Winfield Avenue USGS gauge in Mamaroneck, the flood was computed to be 2,590 cfs. At USGS Gauge No. 01301000, located downstream of Halstead Avenue in the village of Mamaroneck and includes the Sheldrake River, flows were recorded at 3,800 cfs. Around 6 inches of rain fell between June 16 and 19.
September 1975	Hurricane Eloise	This storm caused extensive flooding within the Mamaroneck River watershed. USGS Gauge No. 01301000 recorded a flow of 4,260 cfs. Hurricane Eloise was a record flood in the area. The village of Mamaroneck received 10.84 inches of rain from September 19 to September 27. $19 million in damages were caused.
December 1992	Nor'easter	This nor'easter dropped heavy rains and caused heavy flooding in Westchester County. This storm caused about $1-$2 million in damages and costs. Nineteen people died as a result of this storm.
July 1996	Hurricane Bertha	Hurricane Bertha originally made landfall in North Carolina but had weakened to a tropical storm by the time it reached the New York City area. It passed Long Island, producing torrential rain and strong gusty winds. Torrential rain caused flooding of low-lying and poor-drainage areas, streams, and rivers across the area. The heaviest rain fell in a band to the northwest of Bertha's track over the lower Hudson Valley. Torrential rain caused flooding in Rockland, Orange, Westchester, Nassau, and Suffolk Counties. Westchester County received 3 inches at Ossining.

DATE	FLOOD EVENT	NOTES
October 1996	Nor'easter	This nor'easter dropped approximately 5 inches of rain in southern Westchester County and caused widespread flooding. A total of $3.5 million in damage was caused to Westchester and Suffolk Counties.
August 1999	Severe Thunderstorms	Severe thunderstorms produced heavy rain that caused serious urban flooding in the area. In the village of Mamaroneck, 3 to 5 inches of rain fell over 90 minutes. Streets and basements were flooded. Metro-North service was suspended.
September 1999	Remnants of Hurricane Floyd	Tropical depression by the time it reached Westchester County. Widespread flooding in Rockland, Orange, Putnam, and Westchester Counties; total damage costs estimated at $14.6 million. Damages in Westchester County totaled $6.6 million. Rainfall rates were from 1 to 2 inches per hour for at least 3 consecutive hours across parts of Westchester. Total rainfall at the Westchester County Airport was measured at 6.26 inches.
September 2006	Tropical Storm Ernesto	Tropical Storm Ernesto brought heavy rain and winds to Westchester County. Southern Westchester towns were hit the hardest, including the town of Mamaroneck, White Plains, Scarsdale, and New Rochelle.
October 2005	Unnamed Storm	Periods of heavy rain fell on southern New York from Friday night through Saturday. The heaviest rain fell north of New York City across the lower Hudson Valley. This resulted in significant flooding on some rivers and throughout urban areas. Rainfall amounts in Westchester County ranged from 5.25 inches at Westchester County Airport in White Plains to 6.28 inches at Yorktown Heights.
March 2007	Severe Thunderstorm	A severe thunderstorm dropped around 4 inches of rain in the village of Mamaroneck. More than 85 homes were evacuated near the Mamaroneck River as streets, basements, and garage became flooded.
April 15-16, 2007	Nor'easter	This nor'easter dropped 8.05 inches of rain on Southern Westchester County within a 24-hour period, causing widespread flooding in the area. The village of Mamaroneck was seriously affected, and some people considered this the "worst flooding in half a century."
September 2008	Tropical Storm Hanna	Tropical Storm Hanna dropped heavy rain on Westchester County, with a recorded 4.41 inches of rain at Westchester County Airport.
March 2010	Nor'easter	This nor'easter brought rain and high wind gusts. The winds brought coastal water from the Mamaroneck Harbor flooding onto the land and flooded the Orienta and Harbor Heights sections of the village of Mamaroneck.

DATE	FLOOD EVENT	NOTES
August and September 2011	Tropical Storm Irene and Tropical Storm Lee	Hurricane Irene formed from a tropical wave on August 21, 2011, in the tropical Atlantic Ocean. It moved west-northwestward before becoming a hurricane. Irene struck Puerto Rico as a tropical storm. Hurricane Irene steadily strengthened to reach peak winds of 120 miles per hour (mph) on August 24. Irene then gradually weakened and made landfall on the Outer Banks of North Carolina with winds of 85 mph on August 27. It slowly weakened over land and reemerged into the Atlantic the following day. Later on August 28, Irene was downgraded to a tropical storm and made two additional landfalls, one in New Jersey and another in New York. Irene produced heavy damage over much of New York, totaling $296 million. The storm is ranked as one of the costliest in the history of New York, after Hurricane Agnes in 1972. Much of the damage occurred due to flooding, both from heavy rainfall in inland areas and storm surge in New York City and on Long Island. Tropical storm force winds left at least 3 million residents without electricity in New York and Connecticut. Ten fatalities are directly attributed to the hurricane. $296 million in damages were caused across NYS. Over 7 inches of rainfall fell on the village of Mamaroneck, and approximately 40 percent of the village was flooded. 3,300 homes were affected. The neighborhoods of Washingtonville, First Street, Second Street, and a section of Harbor Heights were flooded heavily. Between 400 and 500 homes in the village of Mamaroneck's low-lying areas and coastal and river flood zones were affected by an evacuation order. A storm surge of 3 feet off the Long Island Sound was recorded during this event.
October 29, 2012	Hurricane Sandy	Hurricane Sandy was the deadliest and most destructive hurricane of the 2012 Atlantic hurricane season as well as the second-costliest hurricane in United States history. It was classified as the 18th named storm, 10th hurricane, and 2nd major hurricane of the year. Hurricane Sandy made landfall in the United States about 8:00 p.m. EDT on October 29, striking near Atlantic City, New Jersey, with winds of 80 mph. A full moon made high tides 20 percent higher than normal and amplified Sandy's storm surge. Hurricane Sandy affected 24 states, including the entire eastern seaboard from Florida to Maine and west across the Appalachian Mountains to Michigan and Wisconsin, with particularly severe damage in New Jersey and New York. Its storm surge hit New York City on October 29, flooding streets, tunnels, and subway lines and cutting power in and around the city. Damage in the United States is estimated at over $100 billion (2013 USD). Record coastal flooding in Lower New York. Hurricane Sandy produced high tides in the coastal areas. Around 60 percent of the community is without power, and 70 roads are closed due to downed trees and wires.

DATE	FLOOD EVENT	NOTES
August through September 2021	Tropical Storm Henri and Tropical Storm Ida	Tropical Storm Henri was the first tropical cyclone to make landfall in Rhode Island since Hurricane Bob in 1991. It proceeded to move west-northwestward, weakening down to a tropical depression while greatly slowing down. On August 23, Henri degenerated into a remnant low over New England, before dissipating the next day over the Atlantic. Despite its relatively weak intensity, the storm brought very heavy rainfall over the Northeastern United States and New England, causing widespread flooding in many areas, including Westchester County. Tropical Storm Henri dropped 6 inches of rain on the city of Rye. Hurricane Ida made landfall near Port Fourchon, Louisiana, and moved through the Northeastern United States as a tropical storm on September 1–2, 2021, dropping large amounts of rainfall across the region before moving out into the Atlantic. Widespread flooding shut down much of the New York City Subway system as well as large portions of the New Jersey Transit, Long Island Railroad, and Metro-North Railroad commuter rail systems and Amtrak intercity services. Extensive and historic flooding occurred in Lower New York. Westchester County received a major disaster declaration.

In addition to the public flood records described above, repetitive loss (RL) property information from May 2019 was obtained for communities within the study watershed and utilized to identify critical flood areas. RL data is a record of insurable buildings for which two or more flood loss claims of more than $1,000 were paid by the NFIP. According to FEMA, there are currently over 122,000 RL properties nationwide. As of May 2019, roughly 259 repetitive loss claims were filed across the Mamaroneck River watershed and are summarized in Table 3-2 by community. Figure 3-1 illustrates an overview map of the project watershed and the concentration of repetitive loss properties as points.

Table 3-2 Repetitive Loss Claims in the Mamaroneck River Watershed as of May 2019

Community	Number of Claims	Percent of Total
Harrison	8	3.1%
Purchase	1	0.4%
Larchmont	29	11.2%
Mamaroneck	179	68.7%
Scarsdale	18	6.9%
White Plains	7	2.7%
New Rochelle	18	6.9%
Total	259	100%

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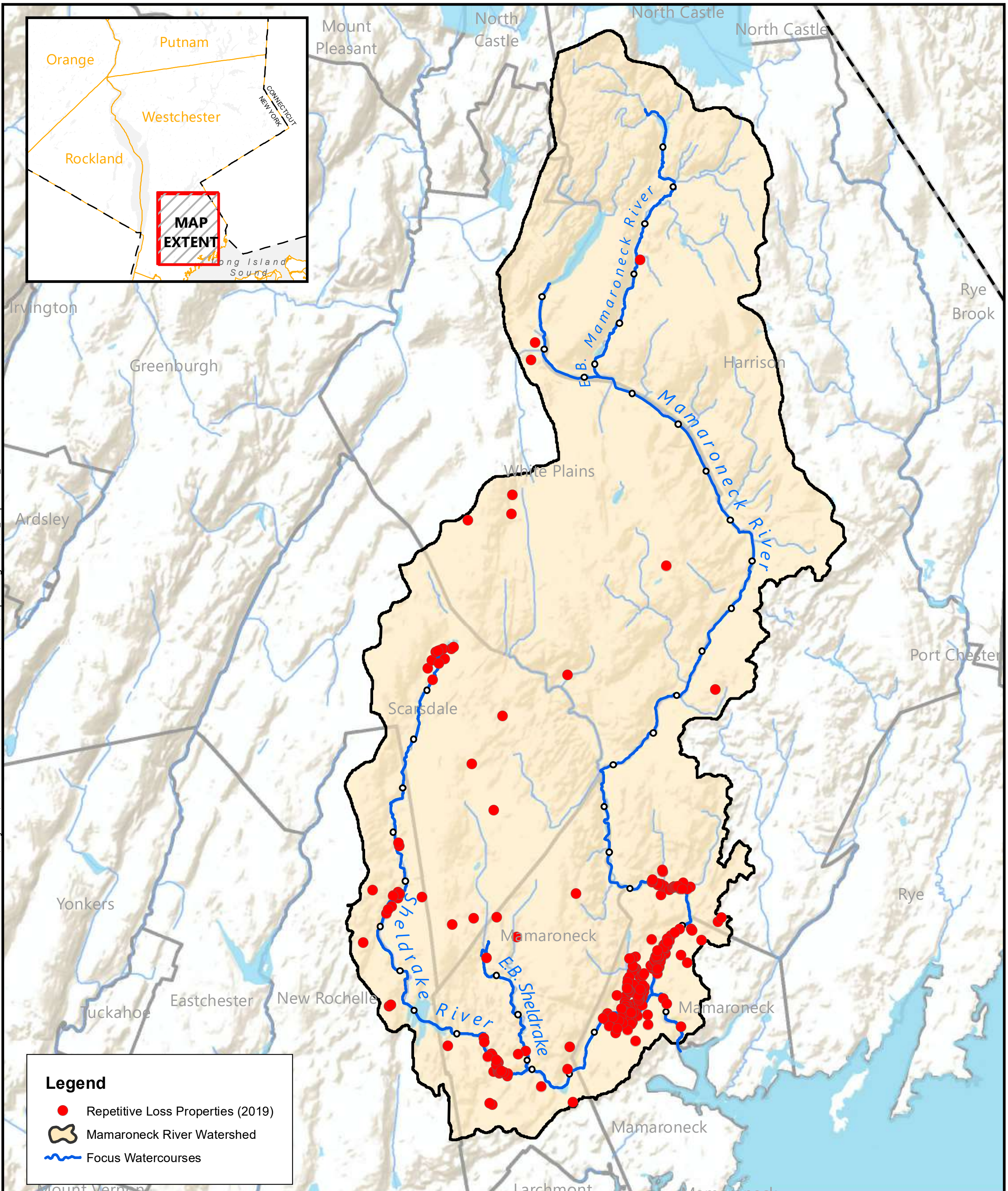

231 MAIN STREET
SUITE 102
NEW PALTZ, NY 12561
845.633.8153

MAMARONECK RIVER WATERSHED REPETITIVE LOSS CLAIMS

MAMARONECK RIVER FLOOD & RESILIENCY STUDY
SD 969 MOD 2
WESTCHESTER COUNTY, NEW YORK

N

0 2,500 5,000
Feet

SCALE 1 " = 6,000 '

DATE 8/2/2023

6511.0020
PROJ. NO.

FIG. 3-1

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.

> 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.

The FIS for Westchester County (36119CV001A) has been effective since September 2007. A preliminary FIS (36119CV001B) has been available since December 2014 but has not yet been implemented. The flood hazard areas delineated by FEMA are mapped for each focus watercourse. Figures 3-1 through 3-5 depict flood hazard mapping along the Mamaroneck River, Figures 3-6 through 3-9 depict flood hazard mapping along the Sheldrake River and East Branch Sheldrake River, and Figures 3-10 through 3-11 show flood hazard mapping for the East Branch Mamaroneck River. Each map displays the Special Flood Hazard Layers delineated by FEMA for each focus watercourse in this report, including the 1 percent annual chance flood hazard layer (100-year flood), 0.2 percent annual chance flood hazard layer (500-year flood), and the floodway hazard layer.

The figures provide an overview of what FEMA data is available on each focus watercourse. 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.

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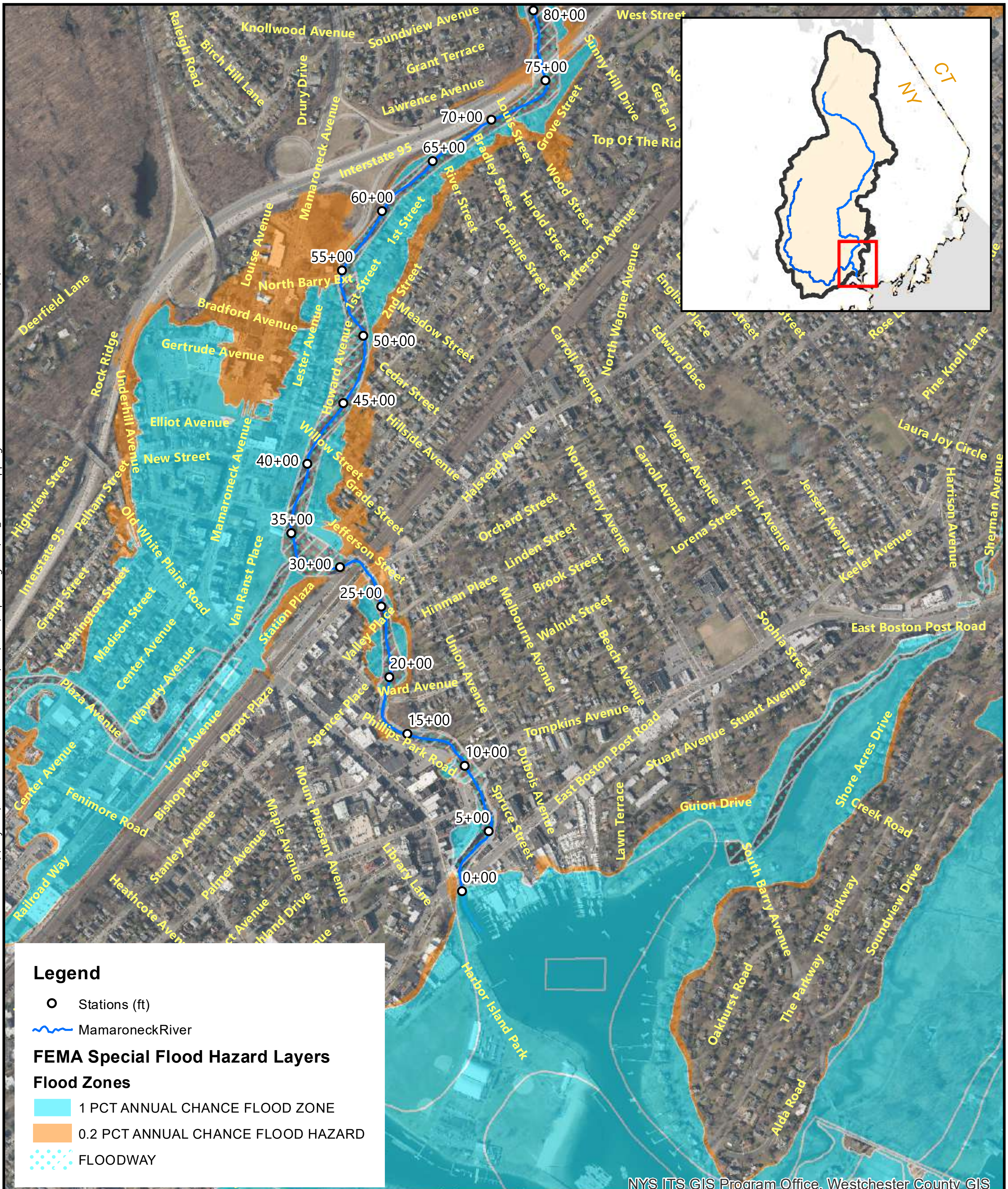
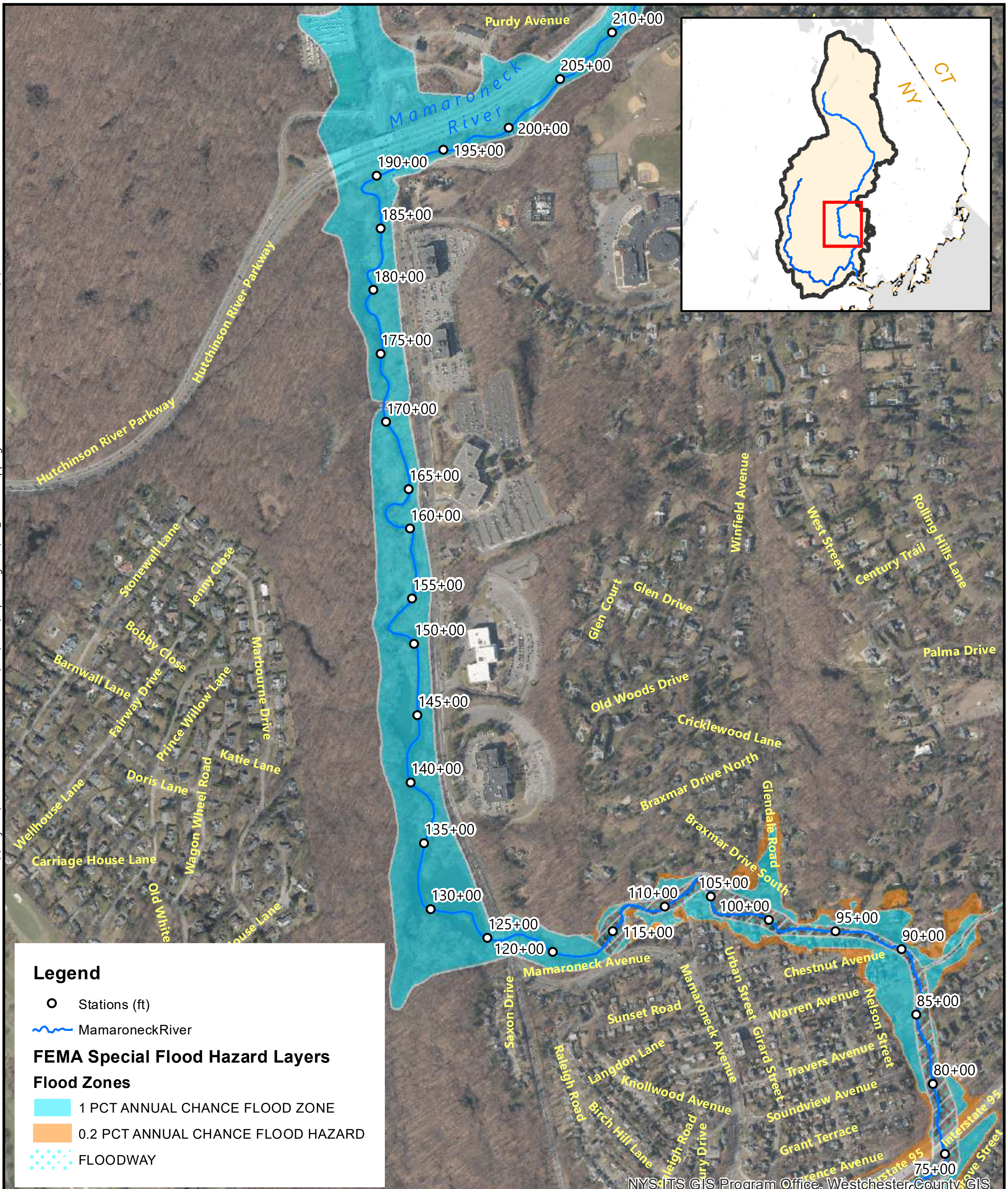


SLR 231 MAIN STREET SUITE 102 NEW PALTZ, NY 12561 845.633.8153	MAMARONECK RIVER: FEMA MAPPING MAMARONECK RIVER WATERSHED FLOOD & RESILIENCY STUDY SD 969 MOD 2 WESTCHESTER COUNTY NEW YORK N 0 500 Feet	SCALE 1 " = 925 ' DATE 12/1/2022 6511.0020 PROJ. NO. **FIG. 3-2**



SLR

231 MAIN STREET
SUITE 102
NEW PALTZ, NY 12561
845.633.8153

MAMARONECK RIVER: FEMA MAPPING

MAMARONECK RIVER WATERSHED FLOOD & RESILIENCY STUDY
SD 969 MOD 2
WESTCHESTER COUNTY
NEW YORK

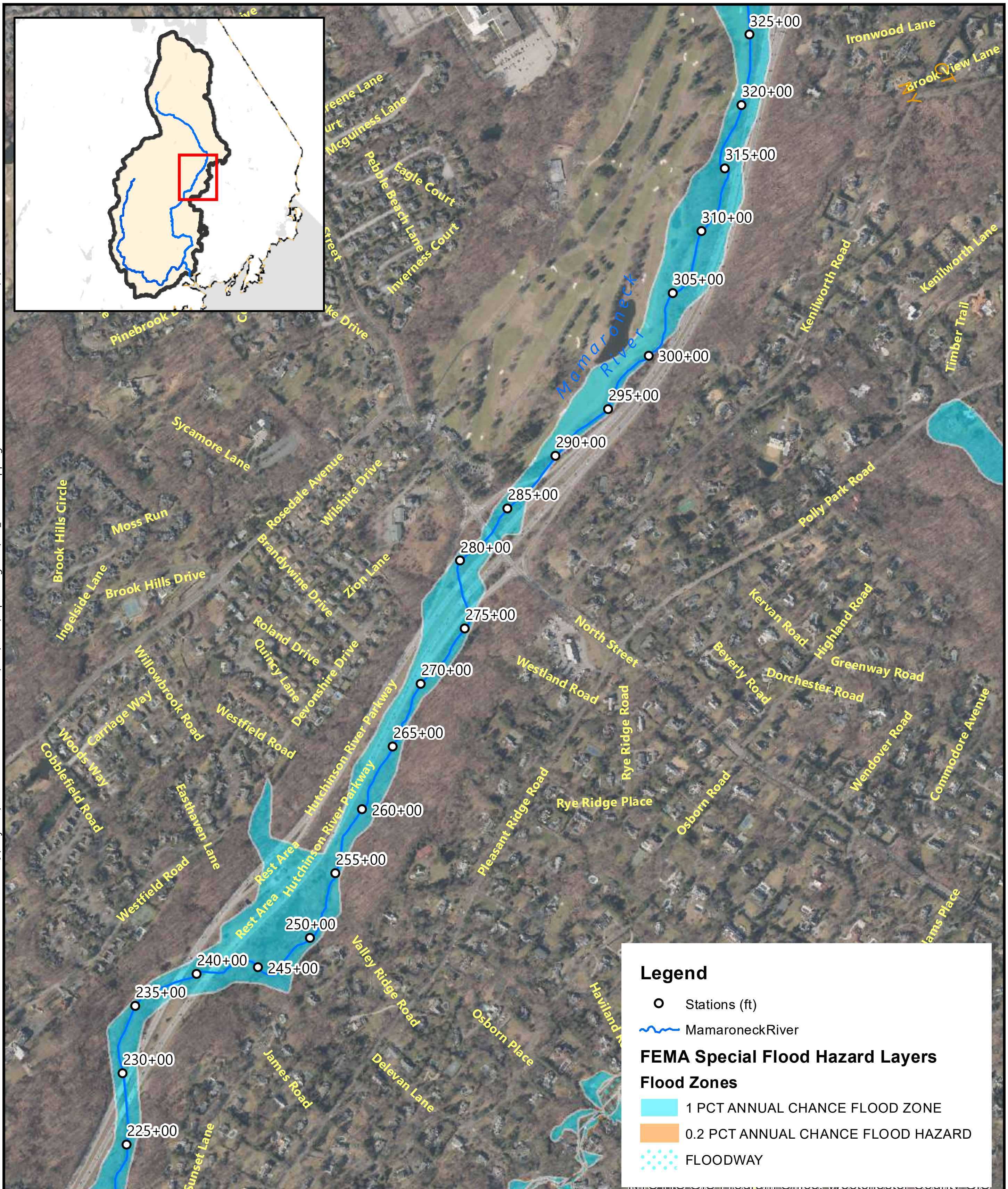
N
0 500
Feet

SCALE 1 " = 925 '

DATE 12/1/2022

6511.0020
PROJ. NO.

FIG. 3-3



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231 MAIN STREET
SUITE 102
NEW PALTZ, NY 12561
845.633.8153

MAMARONECK RIVER: FEMA MAPPING

MAMARONECK RIVER WATERSHED FLOOD & RESILIENCY STUDY

SD 969 MOD 2

WESTCHESTER COUNTY

NEW YORK

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0 500 Feet

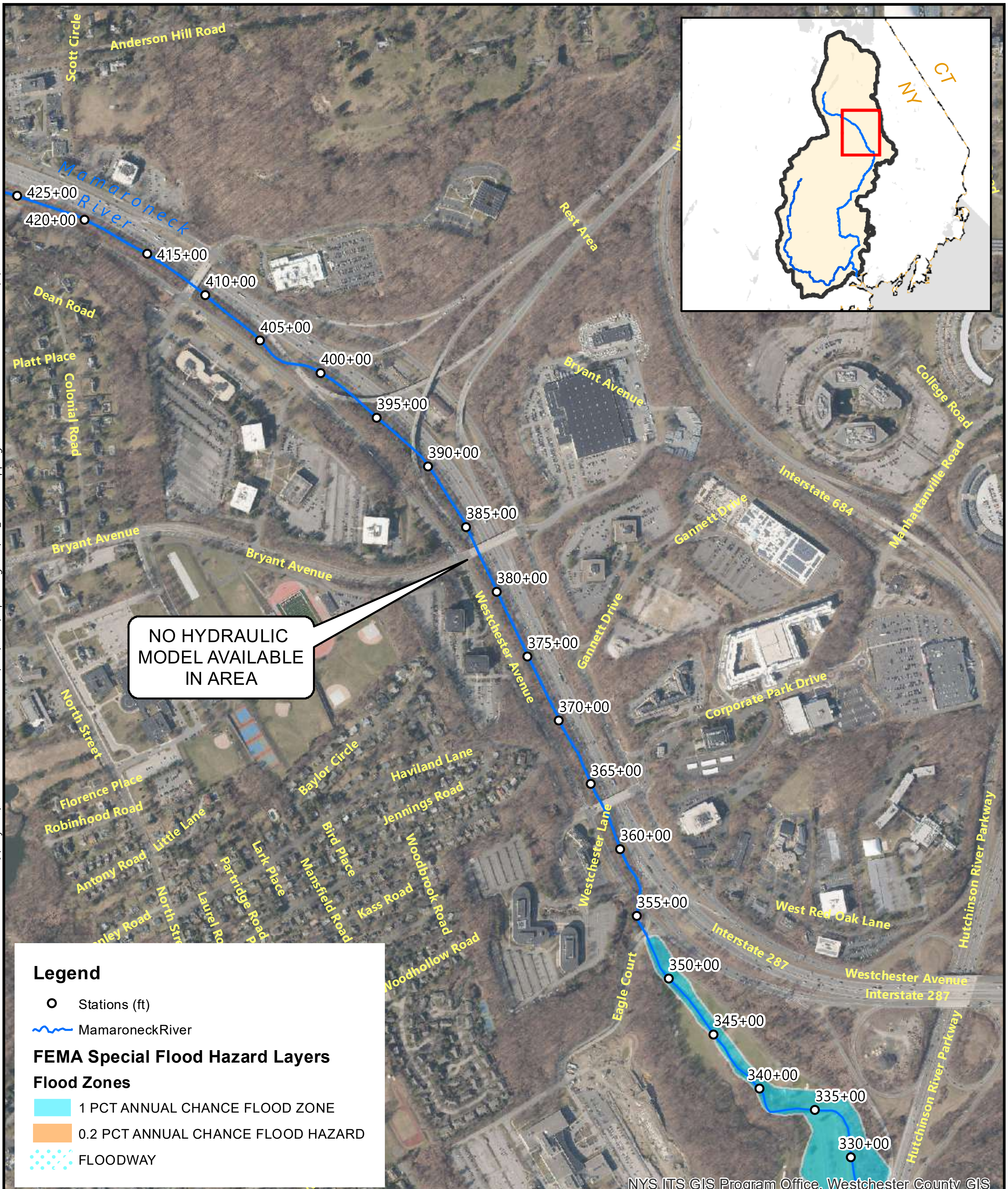
SCALE 1 " = 933 '

DATE 12/1/2022

6511.0020

PROJ. NO.

FIG. 3-4



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

MAMARONECK RIVER: FEMA MAPPING

MAMARONECK RIVER WATERSHED FLOOD & RESILIENCY STUDY
SD 969 MOD 2
WESTCHESTER COUNTY
NEW YORK

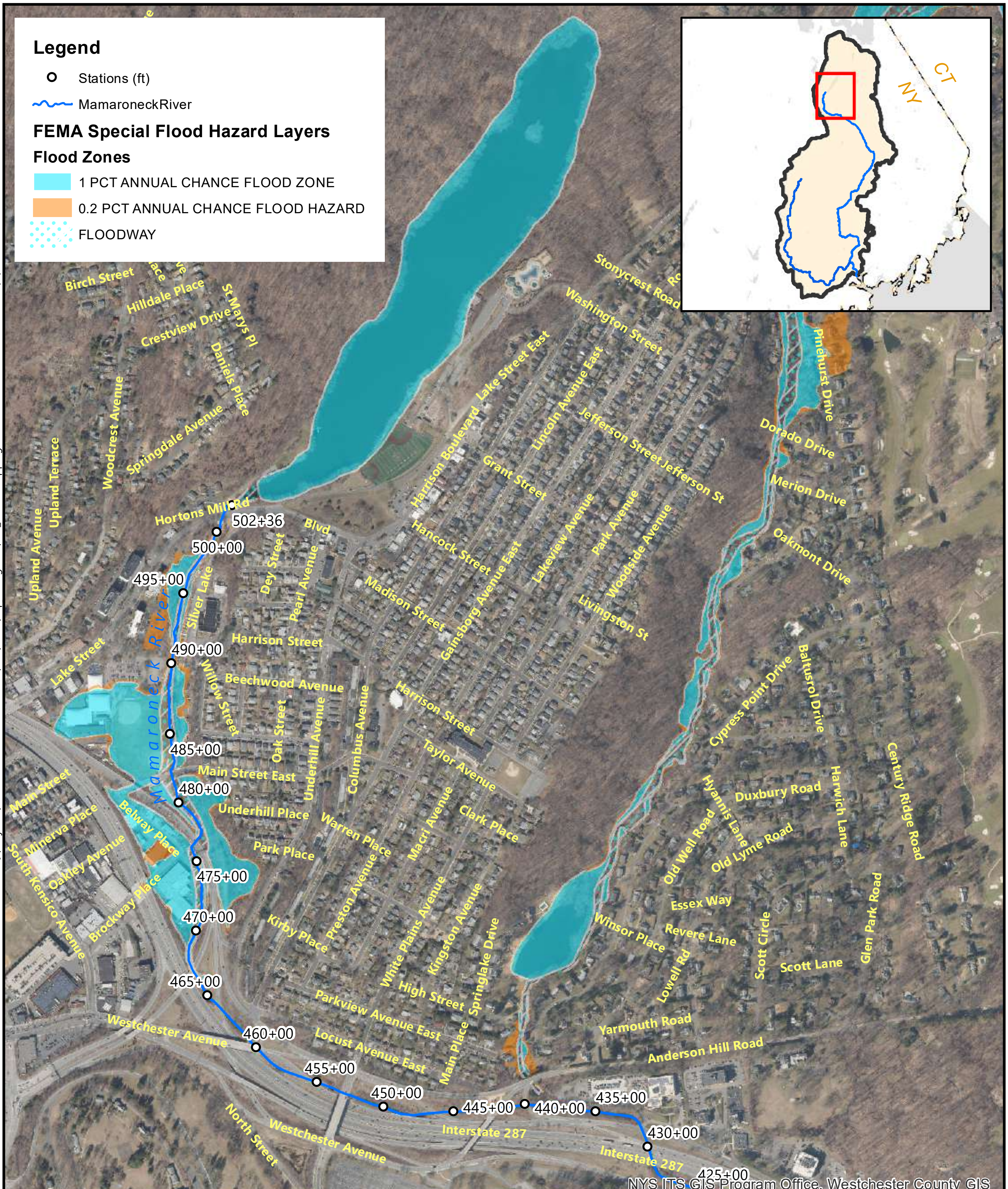
N
0 500
Feet

SCALE 1 " = 933 '

DATE 12/1/2022

6511.0020
PROJ. NO.

FIG. 3-5



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

MAMARONECK RIVER: FEMA MAPPING

MAMARONECK RIVER WATERSHED FLOOD & RESILIENCY STUDY
SD 969 MOD 2
WESTCHESTER COUNTY
NEW YORK

N
0 500
Feet

SCALE	1 " = 933 '
DATE	12/1/2022
PROJ. NO.	6511.0020

FIG. 3-6

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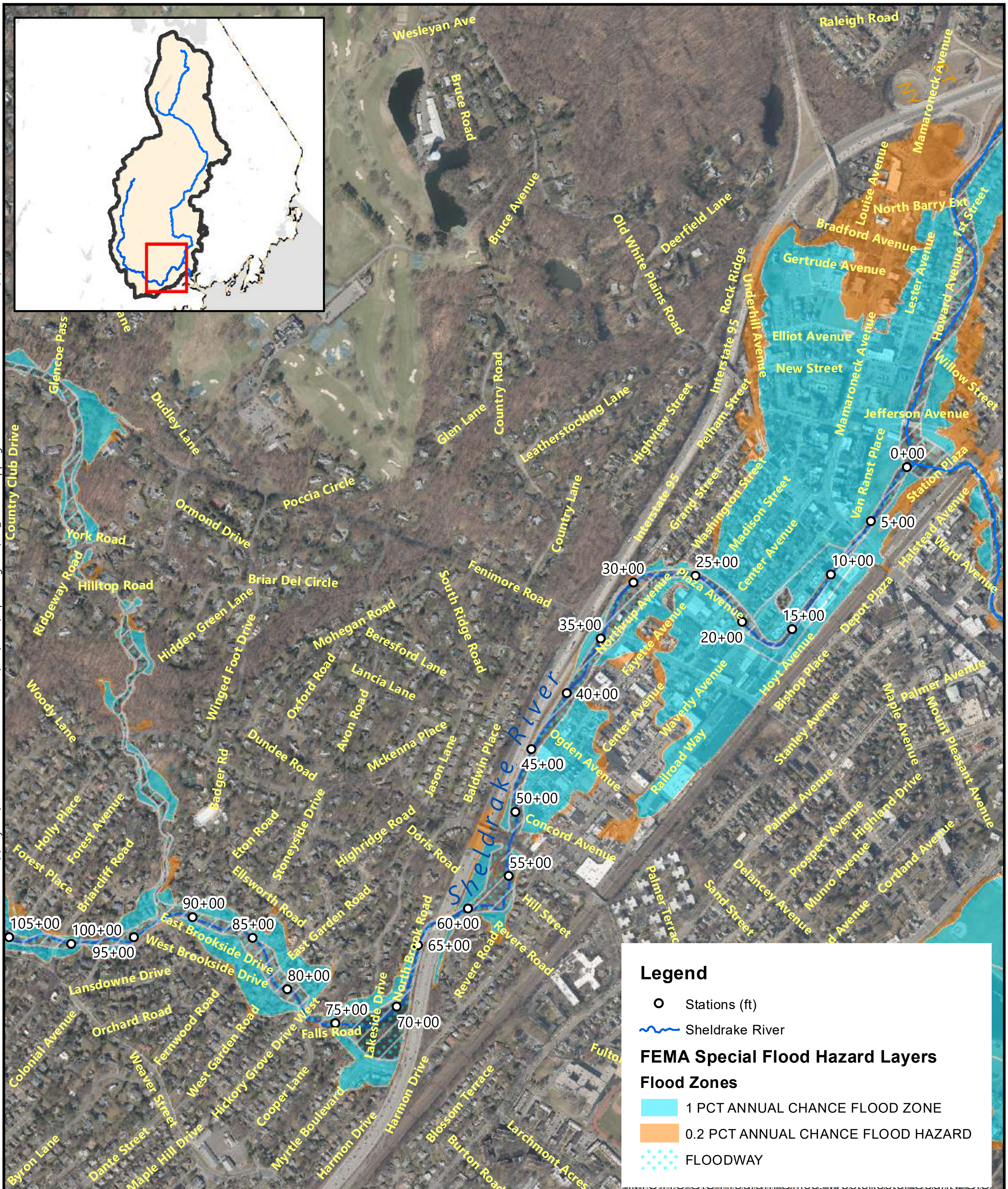

SLR 231 MAIN STREET SUITE 102 NEW PALTZ, NY 12561 845.633.8153	SHELDRAKE RIVER: FEMA MAPPING MAMARONECK RIVER WATERSHED FLOOD & RESILIENCY STUDY SD 969 MOD 2 WESTCHESTER COUNTY NEW YORK N 0 500 1,000 Feet	SCALE 1 " = 1,000 ' DATE 12/2/2022 6511.0020 PROJ. NO. FIG. 3-7

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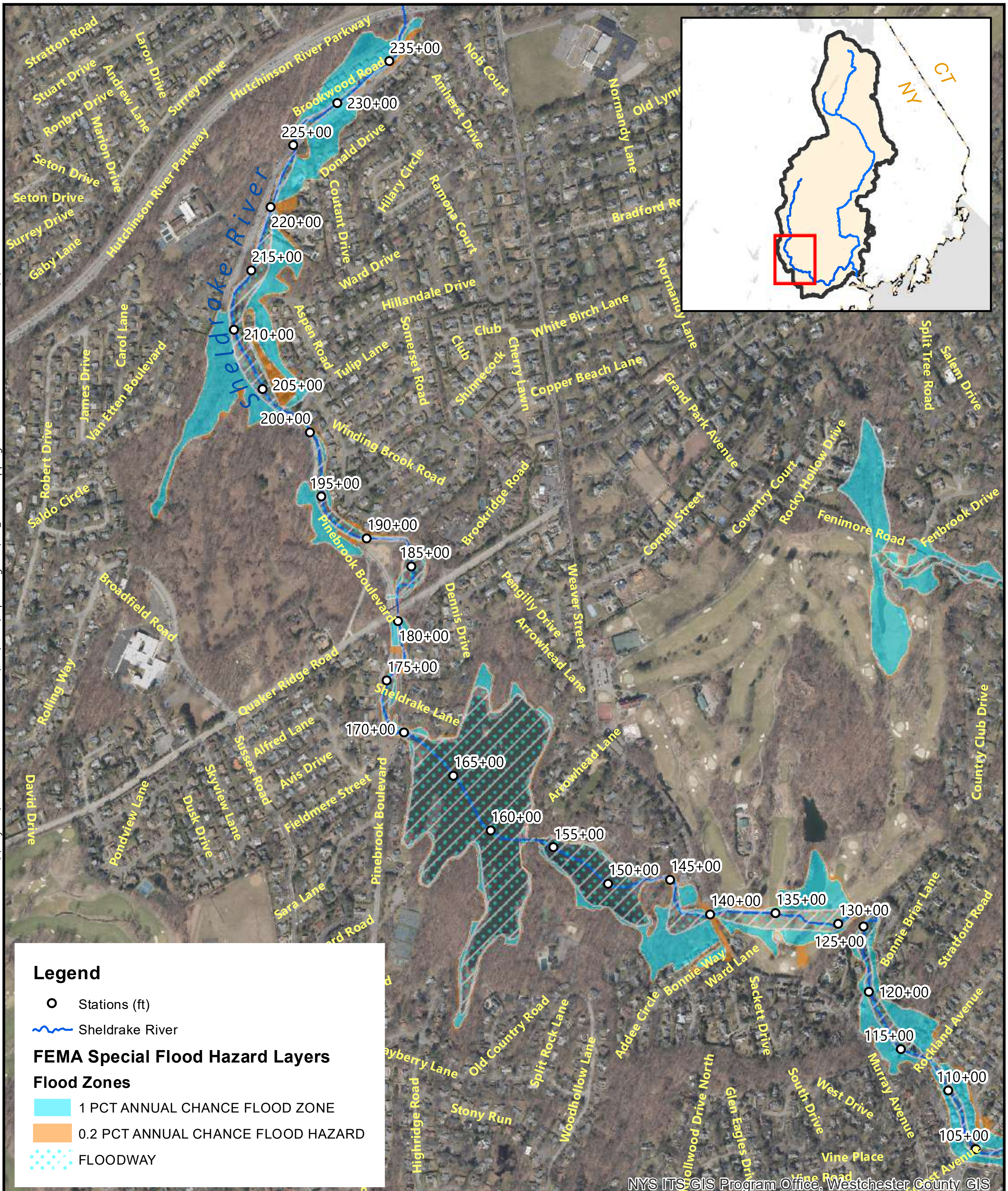

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SHELDRAKE RIVER: FEMA MAPPING

MAMARONECK RIVER WATERSHED FLOOD & RESILIENCY STUDY
SD 969 MOD 2
WESTCHESTER COUNTY
NEW YORK

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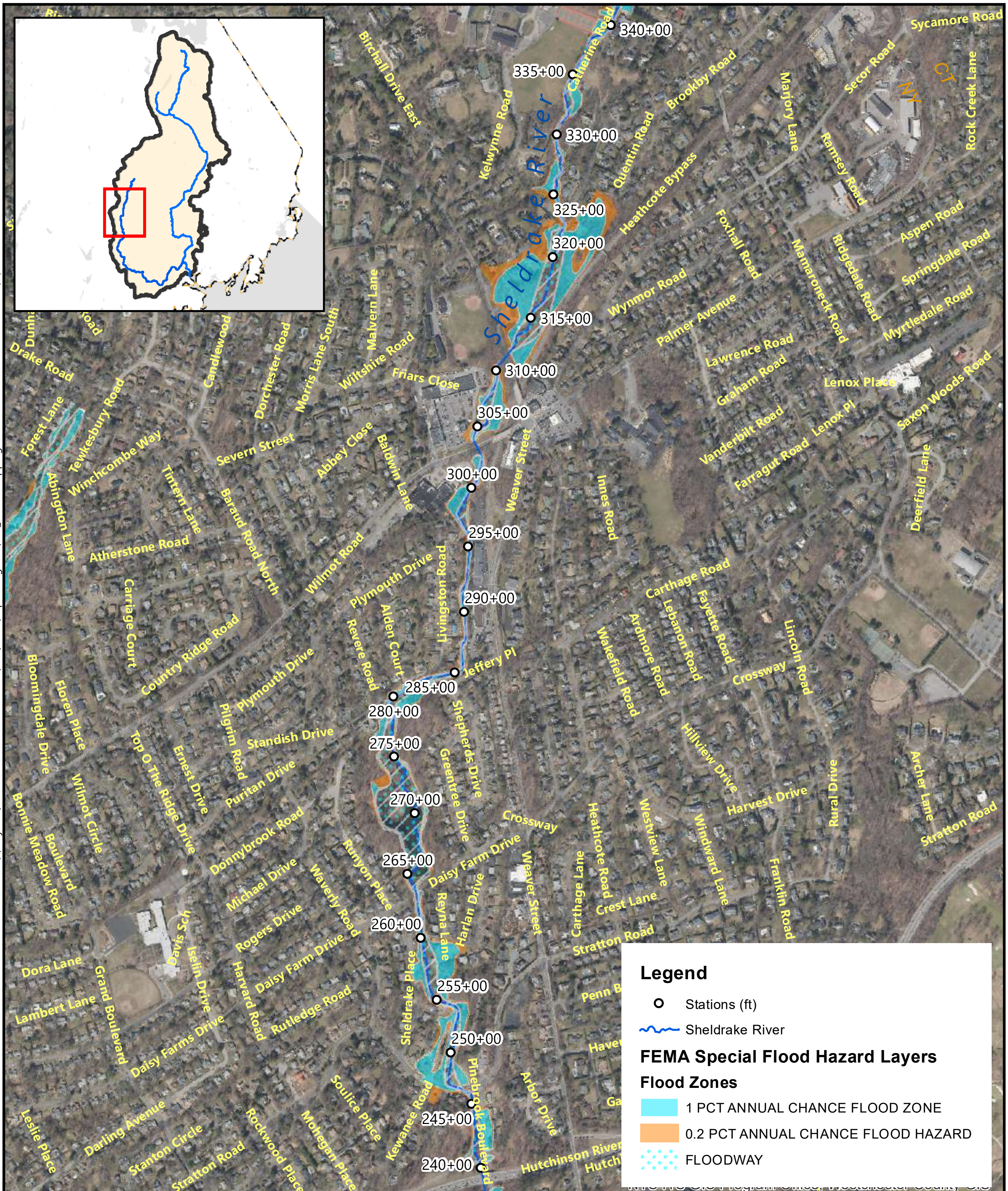
FIG. 3-8



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SHELDRAKE RIVER: FEMA MAPPING

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FIG. 3-9

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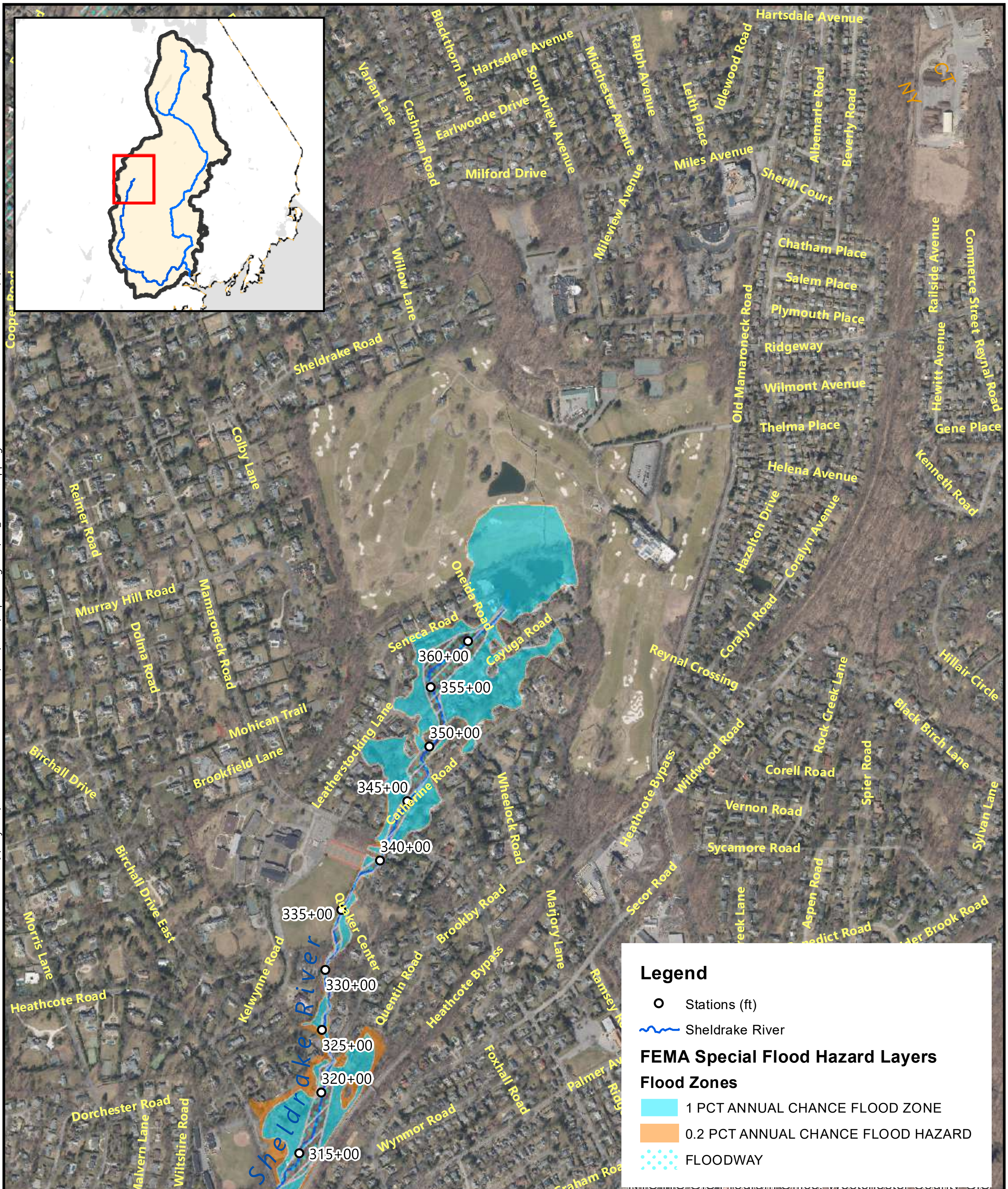

SHELDRAKE RIVER: FEMA MAPPING

MAMARONECK RIVER WATERSHED FLOOD & RESILIENCY STUDY
SD 969 MOD 2
WESTCHESTER COUNTY
NEW YORK

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FIG. 3-10

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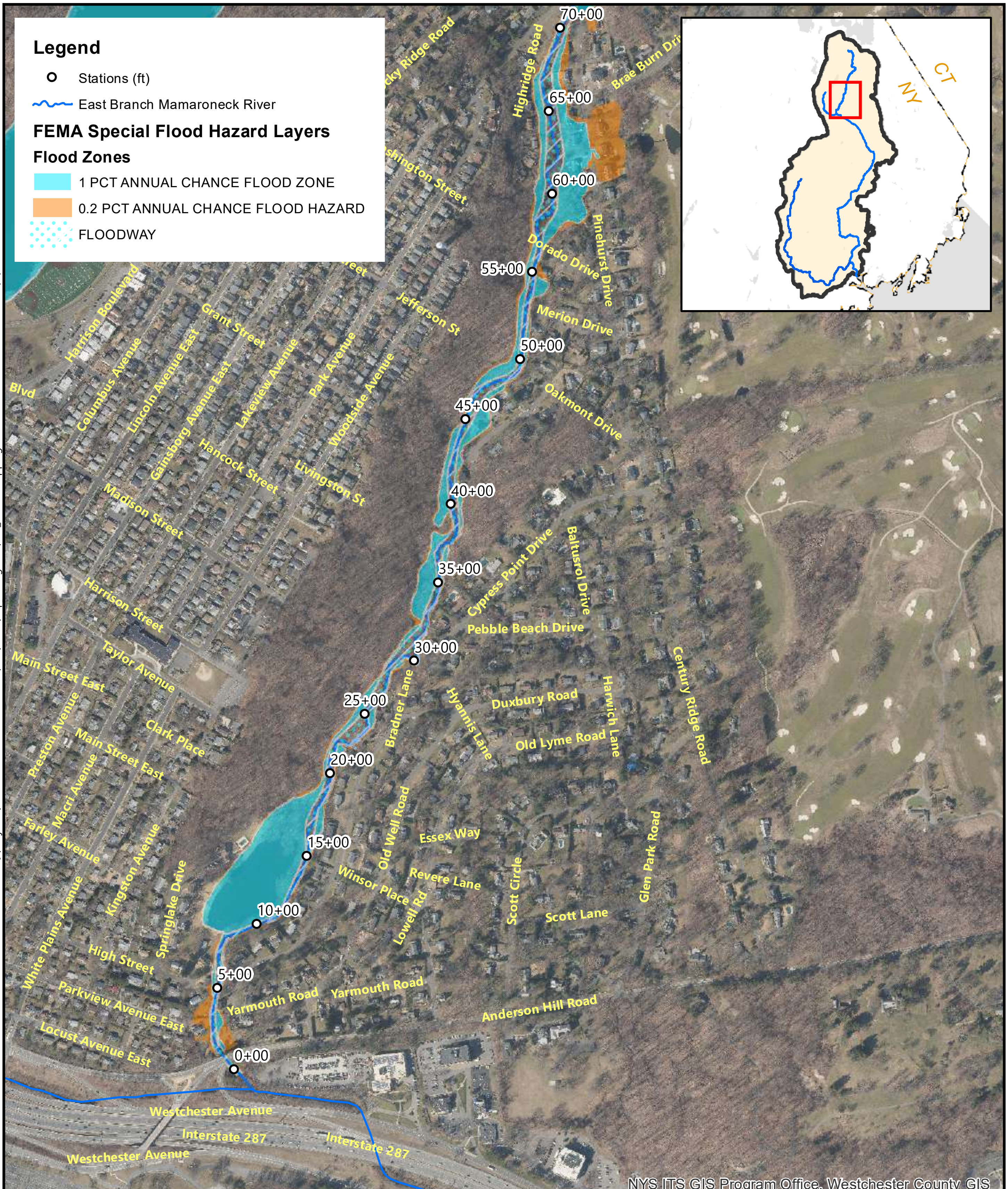
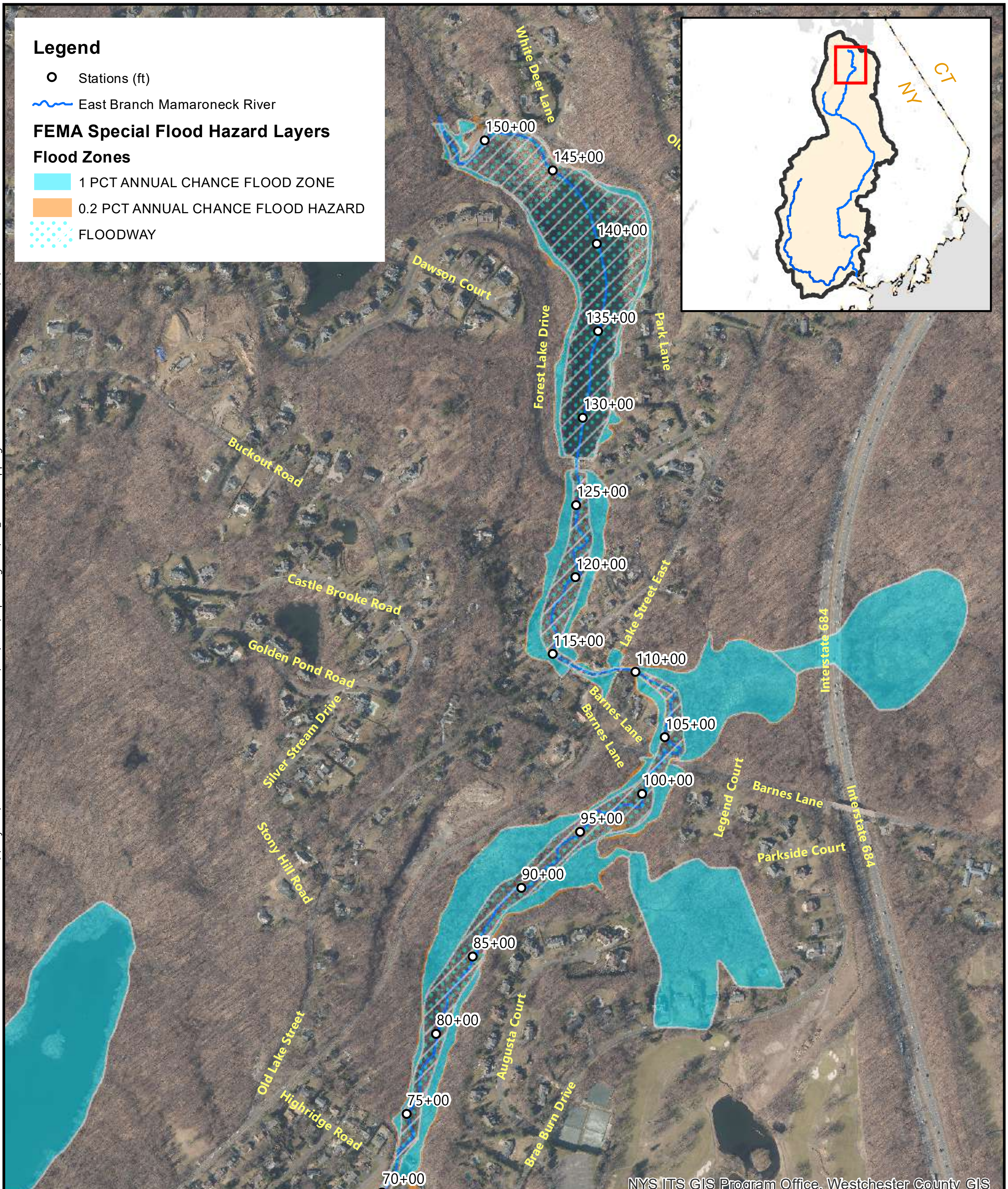


SLR 231 MAIN STREET SUITE 102 NEW PALTZ, NY 12561 845.633.8153	FEMA MAPPING: EAST BRANCH MAMARONECK RIVER MAMARONECK RIVER WATERSHED FLOOD & RESILIENCY STUDY SD 969 MOD 2 WESTCHESTER COUNTY NEW YORK N 0 500 Feet	SCALE 1 " = 750 ' DATE 12/2/2022 6511.0020 PROJ. NO. **FIG.** 3-11



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FEMA MAPPING: EAST BRANCH MAMARONECK RIVER

MAMARONECK RIVER WATERSHED FLOOD & RESILIENCY STUDY
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FIG. 3-12

4. FLOOD MITIGATION ANALYSIS

In this section, flood-prone areas within the Mamaroneck River watershed are identified, and an analysis of flood mitigation considerations within each HRA is undertaken. HRAs were identified based on a variety of sources, including comments received during stakeholder meetings; conversations with municipal officials, emergency responders, landowners, and business owners; and through review of FEMA FISs and FIRMs, County Hazard Mitigation Plans, previous flood studies, online sources, and other documents. Factors with the potential to influence more than one HRA are also evaluated and discussed. Figure 4-1 shows the locations of all HRAs within the Mamaroneck River watershed.

NYS has announced the release of a draft criteria developed by the Climate Justice Working Group for identifying disadvantaged communities. The draft criteria will guide the equitable implementation of New York's Climate Leadership and Community Protection Act. Pursuant to the Climate Act's disadvantaged community provisions, the draft includes an interactive map and a list of communities that criteria would cover directing programs and projects to reduced air pollution and climate-altering greenhouse gas emissions, provide economic development opportunities, and target clean energy and energy efficiency investments. Portions of HRA 1, HRA 2, and HRA 4 have been identified as disadvantaged communities. The map can be viewed at the following link:

https://www.nyserda.ny.gov/ny/disadvantaged-communities

Much of HRA 1 and HRA 4 within the village of Mamaroneck have also been designated as a Potential Environmental Justice Area. Potential Environmental Justice Areas are U.S. Census block groups of 250 to 500 households each that, in the Census, had populations that met or exceeded at least one of the following statistical thresholds:

1. At least 52.42 percent of the population in an urban area reported themselves to be members of minority groups; or
2. At least 26.28 percent of the population in a rural area reported themselves to be members of minority groups; or
3. At least 22.82 percent of the population in an urban or rural area had household incomes below the federal poverty level.

The federal poverty level and urban/rural designations for census block groups are established by the U.S. Census Bureau. The thresholds are determined by a statistical analysis of the 2014-2018 American Community Survey data, which is the most recent data available as of the time of the analysis in 2020. See NYSDEC Commissioner Policy 29 on Environmental Justice and Permitting (CP-29) for more information. The following link provides a map to Potential Environmental Justice Areas throughout NYS:

https://www.arcgis.com/home/webmap/viewer.html?url=https://services6.arcgis.com/DZHaqZm9cxOD4CWM/ArcGIS/rest/services/Potential_Environmental_Justice_Area__PEJA__Communities/FeatureServer&source=sd.

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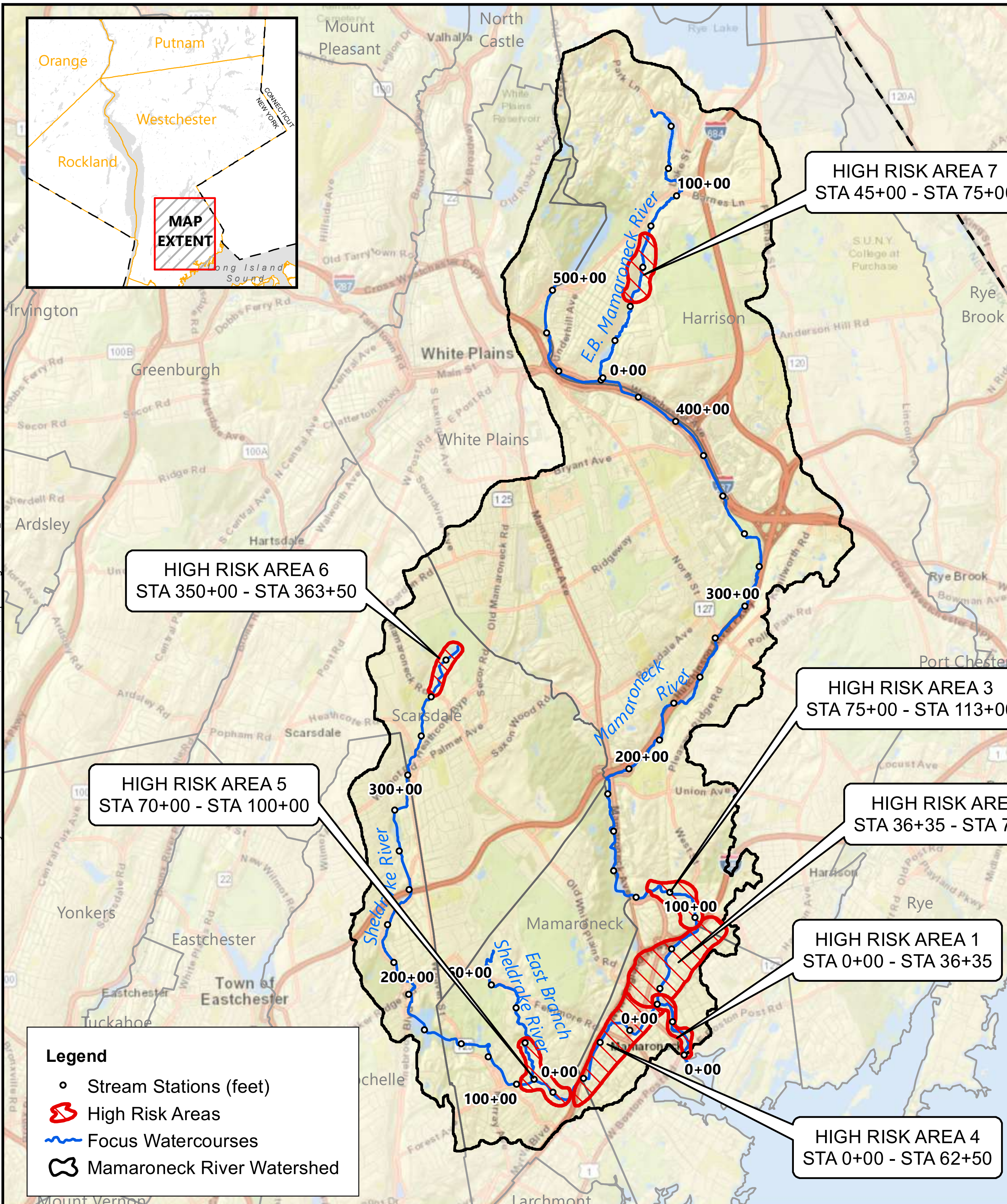

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MAMARONECK RIVER WATERSHED HIGH RISK AREAS

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SD 969 MOD 2
WESTCHESTER COUNTY, NEW YORK

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FIG. 4-1

4.1 HIGH RISK AREA 1 – MAMARONECK RIVER AT VILLAGE OF MAMARONECK

HRA 1 is located within the village of Mamaroneck starting downstream at the East Basin of Mamaroneck Harbor at STA 0+00 and extending upstream to STA 36+35, above the Sheldrake River and the Mamaroneck River confluence. This section of the Mamaroneck River is highly urbanized; a mix of residential and commercial buildings are densely positioned along the riverbanks and throughout the river's floodplain. At the harbor, the Mamaroneck wastewater treatment plant, private and public marinas, and parks span the shoreline. Historically, residents and businesses within HRA 1 have been plagued by riverine flooding from the Mamaroneck River, tidal flooding at Mamaroneck Harbor, or a combination of both. Most recently, the remnants from Tropical Storm Ida in September 2021 devastated the village and amounted to over $100 million in flood damages, according to reports from village officials (Figure 4-2). HRA 1 accounted for roughly 2 percent, or roughly three structures, of repetitive loss claims filed in the town of Mamaroneck as of 2019. Although a small percentage of RL properties are present within the selected boundaries of HRA 1, the issues identified at HRA 1 influence flooding at HRA 2 and HRA 4, which collectively account for most of the claims in the town of Mamaroneck. Therefore, RL within specific HRAs is not fully indicative of the full scope of flooding but rather meant to represent repetitive loss properties solely within the demarcated HRAs. Critical facilities within HRA 1 include the Mamaroneck wastewater treatment plant, the Mamaroneck Volunteers Firehouse, and several medical service centers. Portions of HRA 1 fall within a census block that has been designated as a Disadvantaged Community, and a portion is also mapped within a Potential Environmental Justice Area.

Figure 4-2: Photo from aerial drone taken after the remnants of Tropical Storm Ida swept through the area (provided by the village of Mamaroneck). Receding water levels on the Mamaroneck River and Sheldrake River are shown. The area below the confluence where the Mamaroneck River flows under Station Plaza Road, MTA railroad, and Halstead Avenue is circled in red.

Approximately 0.75 river miles of the Mamaroneck River mainstem were assessed for HRA 1, which can be broken down into two separate reaches according to the dominant forces that control flooding:

2) The upper Mamaroneck River corridor from STA 18+66 to STA 36+35, where an inadequately sized channel, lack of floodplain, poor channel alignment, and inadequately sized bridges contribute to widespread flooding at the village of Mamaroneck.

3) The lower Mamaroneck River from STA 0+00 to STA 18+66, which is subjected to riverine flooding from the Mamaroneck River mainstem and influenced by tidal conditions, storm surge events, and sea-level rise at the harbor.

In the analysis of HRA 1, it was determined that improvements at the upper reach of the Mamaroneck River are likely to influence the severity of flooding downstream at the lower reach. For this reason, the following sections in the report will be discussed from upstream to downstream. Section 4.1.1 discusses existing and proposed conditions at the Mamaroneck River upper reach while 4.1.2 discusses the lower stretch of the Mamaroneck River. Final findings and recommendations and project prioritization considerations for all HRAs are detailed in Section 5.13 of this report.

Portions of HRA 1 had been previously assessed by the USACE in a 2017 study conducted for the Mamaroneck and Sheldrake River basins. The study identified potential structural and nonstructural recommendations that could be implemented to reduce flood damage across the village of Mamaroneck and included the following within HRA 1:

- Channel modifications along the Mamaroneck River from the confluence area to just downstream of the Tompkins Avenue bridge. Proposed channel bottom width of 45 feet and construction of retaining walls.

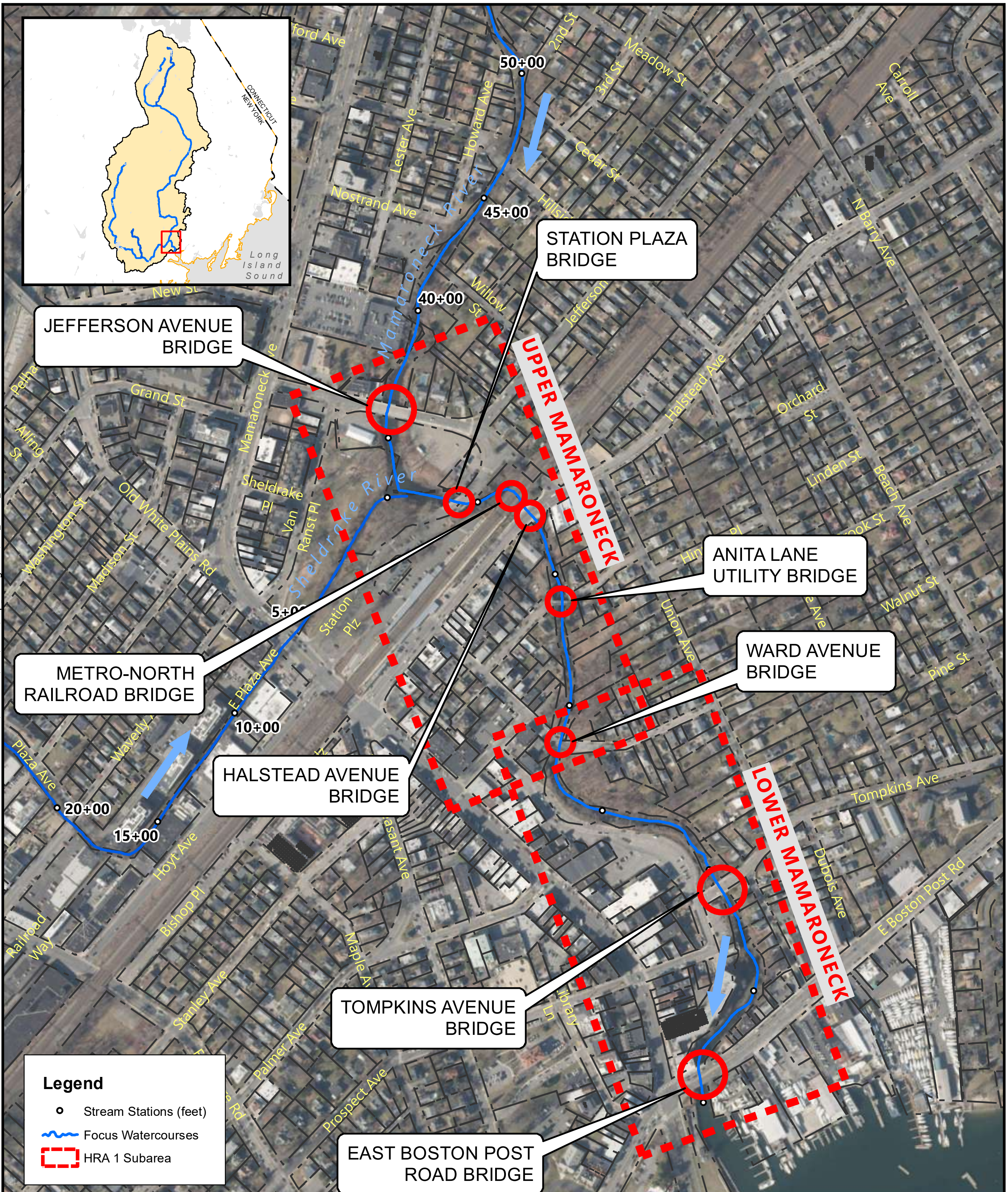
- Realignment at the confluence of the Mamaroneck and Sheldrake Rivers with a 25-foot-wide by 8-foot-high by 390-foot-long culvert located under the railroad station parking lot.

- Channel modifications would consist of constructing a trapezoidal channel with a natural channel bed and pitched or sloped vegetated banks. Retaining walls would be utilized for the sections of stream where a trapezoidal channel cannot be constructed, typically where buildings, roads, or other features may be affected.

- Removal and replacement of existing retaining walls and utilities along the length of channel at Ward Avenue bridge.

- Nonstructural recommendations along the Mamaroneck and Sheldrake Rivers, including structure elevations, ringwall levees, and/or floodproofing.

Recommendations provided by the USACE were considered but not evaluated in greater detail for this study. Figure 4-3 illustrates an overview map of HRA 1 and the extents of the upper and lower subareas.



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HIGH RISK AREA 1 OVERVIEW

MAMARONECK RIVER FLOOD & RESILIENCY STUDY
SD 969 MOD 2
WESTCHESTER COUNTY, NEW YORK

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FIG. 4-3

4.1.1 MAMARONECK RIVER UPPER REACH (STA 18+66 TO STA 36+35)

Flooding in and around the upper reach of HRA 1 is highly dynamic and complex in the vicinity of the confluence of the Mamaroneck and Sheldrake Rivers. Five bridges span the Mamaroneck River in the upper reach of HRA 1: Anita Lane utility bridge (STA 23+92), the Halstead Avenue bridge (STA 27+53), the Metro-North (Metropolitan Transportation Authority [MTA]) Railroad bridge (STA 28+48), the Station Plaza bridge (STA 30+74), and the Jefferson Avenue bridge (STA 36+10). All existing structures were incorporated into the HEC-RAS two-dimensional model developed for this study.

Existing conditions modeling indicates that under unobstructed flow conditions, most of the bridges impede flood conveyance to some degree. The group of bridges around the MTA railroad crossing are particularly of concern. According to the hydraulic model, the Station Plaza and Halstead Avenue bridges are shown to increase upstream water surface elevations by 1.0 feet and 3.3 feet in the modeled 10-year and 100-year storms, respectively. The MTA bridge and railroad embankments are shown being a moderate constriction; however, the model indicates that its hydraulic performance is significantly reduced by the Halstead Avenue bridge immediately downstream. The influence from these structures is shown extending upstream for approximately 4,400 river feet from approximately STA 30+00 to STA 74+00 before fully diminishing.

The twin-arch masonry stone bridge at Anita Lane that carries a utility pipe across the Mamaroneck River is also shown to be constrictive in the hydraulic model (Figure 4-4). The existing structure is shown increasing upstream water surface elevations by a foot during the 10-year flood event and upwards of a foot in the 100-year storm, extending for approximately 300 feet upstream.

The upstream-most crossing within HRA 1 is Jefferson Avenue, which is carried by a single-span open deck bridge replaced in 2013. In the hydraulic model, the bridge can convey the more frequent, lower magnitude floods without creating a backwater. However, around a 50-year storm event, the structure becomes drowned by the tailwater created at the confluence of the Mamaroneck River and Sheldrake River.

Figure 4-4: Removal of storage crate at the Anita Lane crossing after Tropical Storm Ida (picture courtesy of the village of Mamaroneck). This crossing is an impediment to flow across all modeled storm events and influences the hydraulic performance of upstream bridges.

For proposed conditions, improvements at and around the MTA bridge were evaluated to enhance flood flow conveyance and mitigate flooding at the village of Mamaroneck. One alternative considered realignment of the Mamaroneck River and Sheldrake River confluence to eliminate any sharp bends and smooth the transition of flow under the MTA railroad bridge. This entails reconstruction of the Mamaroneck River channel between STA 28+84 to STA 36+08 and the Sheldrake River channel between STA 0+00 at the confluence to approximately STA 1+80. Reconstruction of the confluence area with a multistage channel with bankfull channel dimensions of 54 feet wide on the Mamaroneck River and 41 feet wide for the Sheldrake River, both with an incorporated low-flow channel, was evaluated. Floodplain benches vary in dimensions and would essentially be established over the existing sections of channel that are recommended to be realigned, designed to be inundated during the 10-year storm event, and pitched at a 2 percent slope to tie back to existing ground. The public parking lot on the river-left overbank on Jefferson Avenue/Station Plaza would be lowered by 3 to 5 feet and converted into a floodable parking area with appropriate signage or preferably a floodable park. Rework of the channel would require removal or replacement of Station Plaza bridge to fully span the proposed channel and floodplain areas and not obstruct flood flows. During the analysis of proposed mitigation actions, it was determined that removal or replacement of the Halstead Avenue and Anita Lane bridges would be critical to gain the full benefits of the flood mitigation work around the confluence area. A concept map showing recommended improvements for the upper reach of HRA 1 is illustrated in Figure 4-5.

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SLR 231 MAIN STREET SUITE 102 NEW PALTZ, NY 12561 845.633.8153	HRA 1 UPPER REACH: CONCEPT PLAN LAYOUT MAMARONECK RIVER FLOOD & RESILIENCY STUDY SD 969 MOD 2 WESTCHESTER COUNTY, NEW YORK N 0 300 Feet	SCALE 1 " = 300 ' DATE 9/8/2023 6511.0020 PROJ. NO. **FIG. 4-5**

Implementing the recommendations at and around the confluence area and replacing the Station Plaza and Halstead Avenue bridges alone would produce reductions in upstream water surface elevations of 0.8 feet in the 10-year storm and 2 feet in the 100-year storm. However, due to the modest impounding effect created by the existing structures, upstream improvements would produce an increase in peak flows downstream and intensify flooding. Under proposed conditions, the structure at Anita Lane is shown to become more constrictive and increases flooding upstream by as much as 1.2 feet in the 100-year storm. Removal or relocation of the utility bridge would be imperative to fully realize the flood mitigation benefits from the enhancements upstream. According to the model, removing the Anita Lane crossing would further reduce water surface elevations through and above the MTA bridge by an additional 0.8 feet in the 100-year storm.

Station Plaza (if replaced) would need to span the proposed realignment and floodplain configuration to not constrict flood flows and reduce the benefits of the recommended channel rework. Given the low and flat topography, a large bridge span will be necessary to achieve this. A single-span open deck bridge that spans between 105 and 120 feet would be appropriate. Replacement of the bridge with an adequate structure of this scale may be uneconomical, especially considering that there are other routes available for vehicles to cross the stream. Therefore, its replacement is a lower priority than the bridges under Halstead Avenue and Anita Lane.

Halstead Avenue bridge (if replaced) would need to span the design channel proposed by USACE for this reach of the Mamaroneck River (from STA 33+20 to STA 18+30). The USACE 2017 report proposed a channel bottom width of 45 feet for this stretch of the river. Increasing the bridge span to 70 feet or as necessary to not constrict flood flow conveyance and elevating the bridge low chord by 2 feet is recommended.

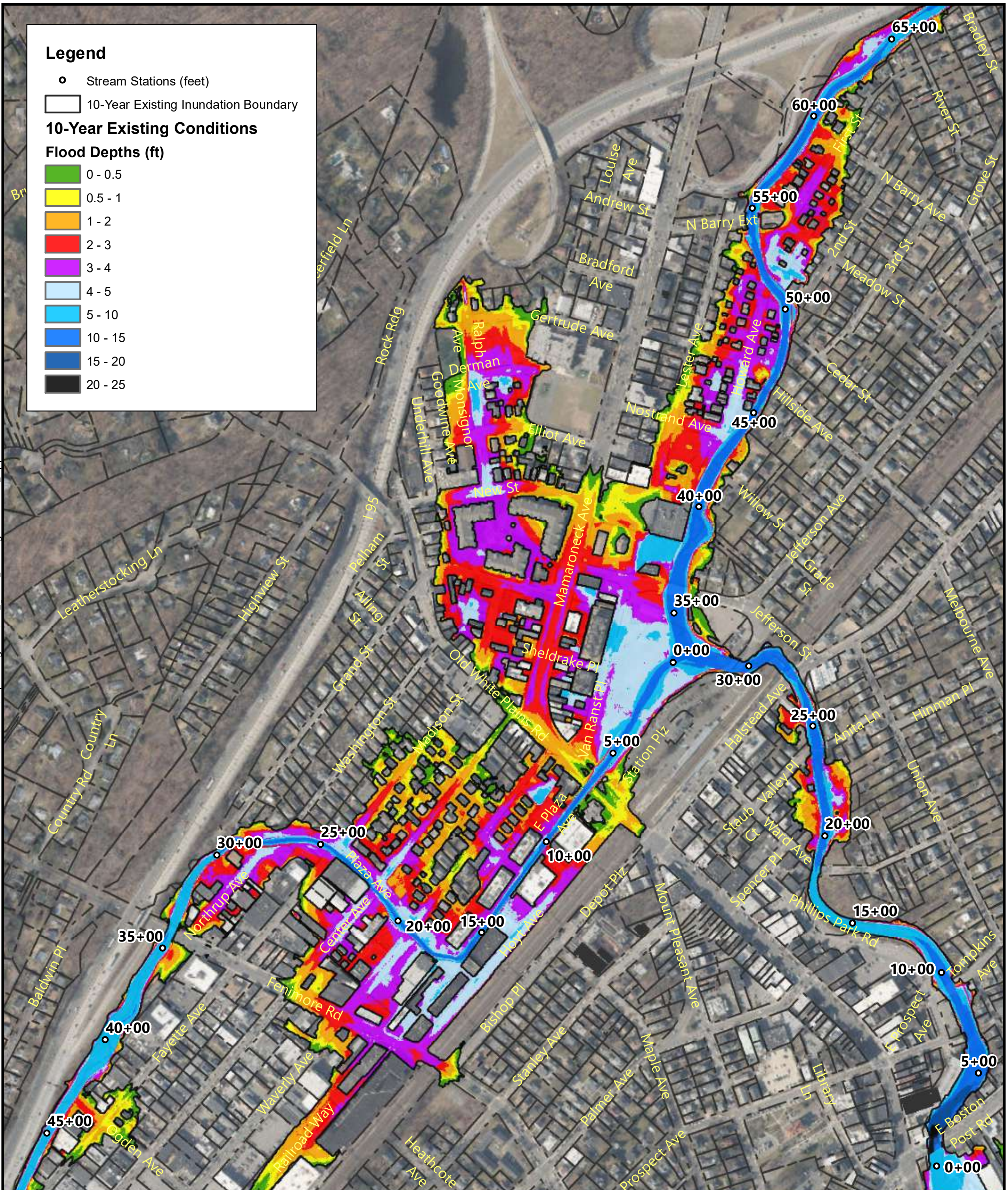
Removal of Anita Lane and relocation of the utility line under carried by the structure is highly recommended. Alternatively, replacing the structure with a bridge that spans the USACE's proposed design channel to not obstruct flood flows should be considered. Replacement of the twin-span stone arch bridges with a single-span open deck structure that spans 70 feet and elevating the bridge low chord by between 6 to 7 feet above existing is recommended.

Flood reductions under the modeled 10-year flood event are illustrated in Figure 4-6 (existing conditions) and Figure 4-7 (with proposed flood mitigation measures implemented). Flood reductions during the 50-year flood event are illustrated in Figure 4-8 (existing conditions) and Figure 4-9 (proposed conditions). Flood reductions during the 100-year flood event are illustrated in Figure 4-10 (existing conditions) and Figure 4-11 (proposed conditions).

As illustrated in the flood depth mapping, under proposed conditions, flood depths would be substantially reduced, but flooding would not be eliminated across the village. The inundation extents during the 100-year storm are modestly reduced at the fringes when compared to existing conditions and are estimated that over a dozen homes would be removed from the extents of the mapped base flood or 100-year storm under proposed conditions. Furthermore, according to the two-dimensional hydraulic model, realignment of the confluence area combined with bridge replacements would also enable upstream flood depths to recede faster back into the channel approximately 9 hours earlier than an existing conditions 100-year storm. By allowing water to drain out of the inundated area faster, emergency forces can be mobilized sooner into the affected areas after the peak of a major flood event.

Roughly 118 buildings are estimated to be removed from the 100-year floodplain within the village of Mamaroneck. However, over 500 buildings on the floodplain would still be mapped partially or fully within the proposed conditions 100-year floodplain. These buildings would need to be evaluated for feasibility of floodproofing, elevation, or relocation on a case-by-case basis. Individual flood protection measures are detailed in Section 5.11 of this report.

The recommended improvements for HRA 1 at the upper reaches of the Mamaroneck River were shown to increase discharge amounts at the lower reach between 5 and 15 percent, depending on the magnitude of the flood event. The increase in discharge would further overwhelm the structures spanning the Mamaroneck River and would make flooding worse in certain areas. Recommendations for offsetting the impacts from upstream flood conveyance improvements along the lower stretch of the Mamaroneck River are detailed in Section 4.1.2.



UPPER HRA 1: 10-YEAR EXISTING CONDITIONS FLOOD DEPTHS

MAMARONECK RIVER FLOOD & RESILIENCY STUDY
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WESTCHESTER COUNTY, NEW YORK

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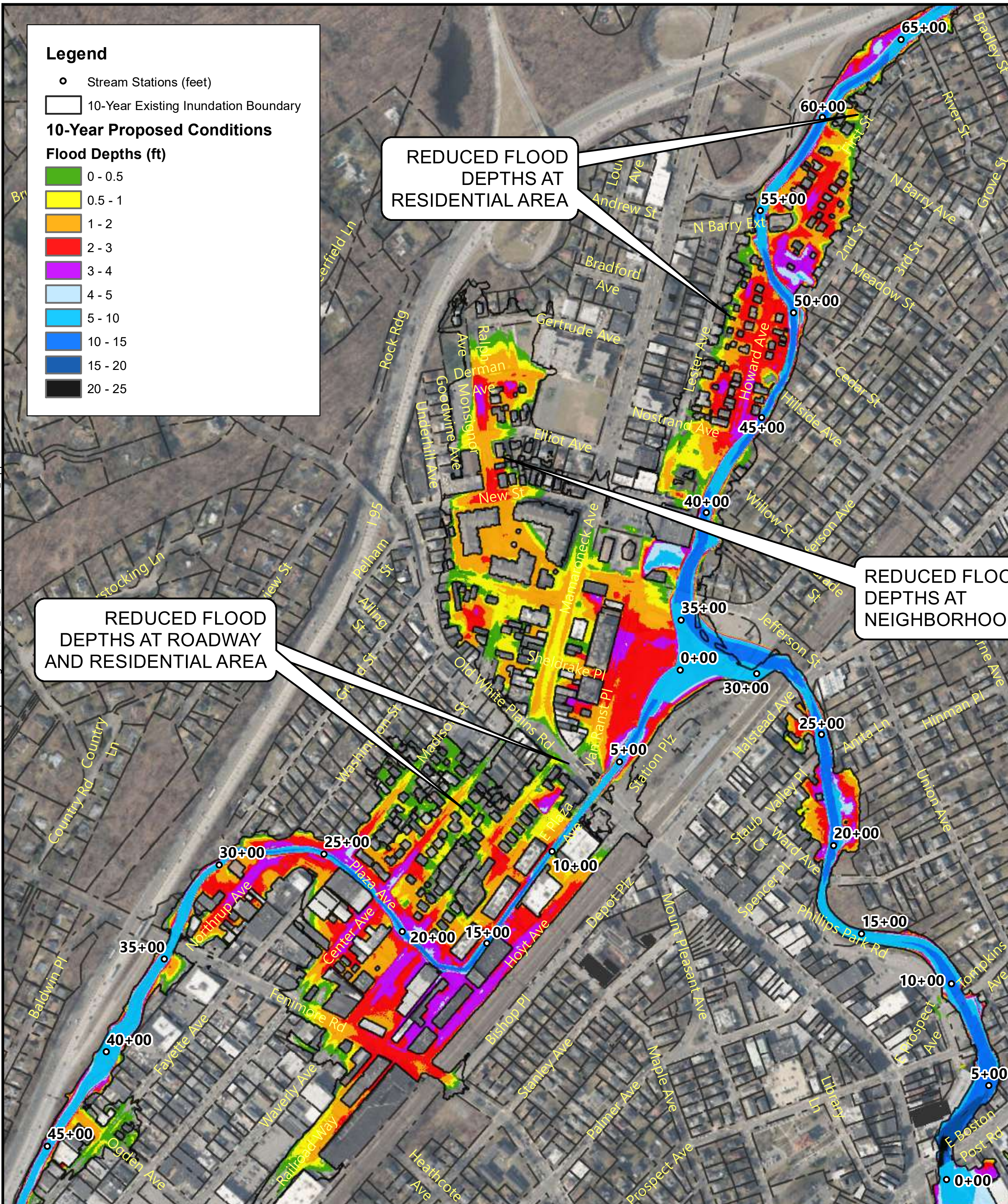
FIG. 4-6



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UPPER HRA 1: 10-YEAR PROPOSED CONDITIONS FLOOD DEPTHS

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WESTCHESTER COUNTY, NEW YORK

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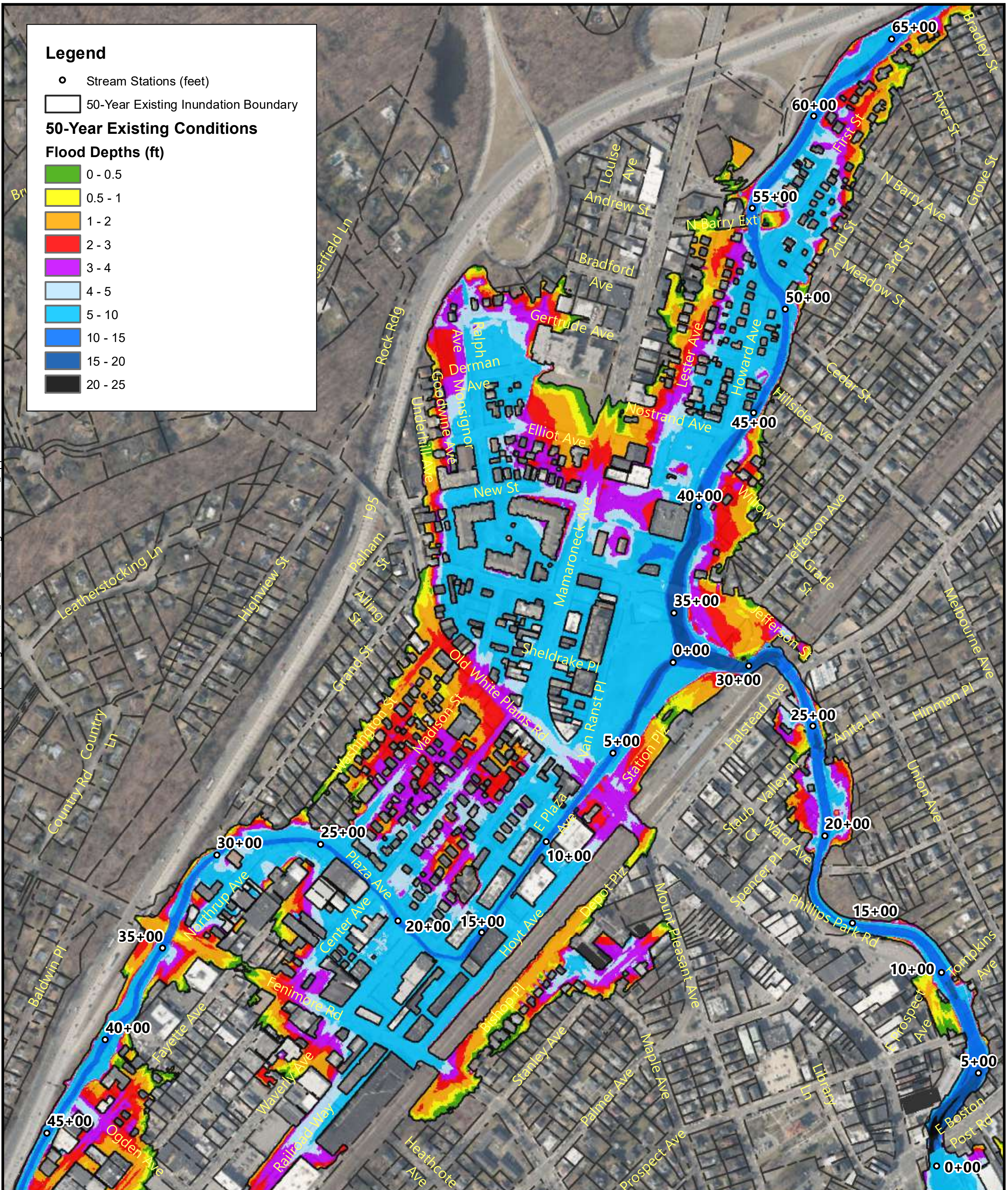
FIG. 4-7



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UPPER HRA 1: 50-YEAR EXISTING CONDITIONS FLOOD DEPTHS

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FIG. 4-8

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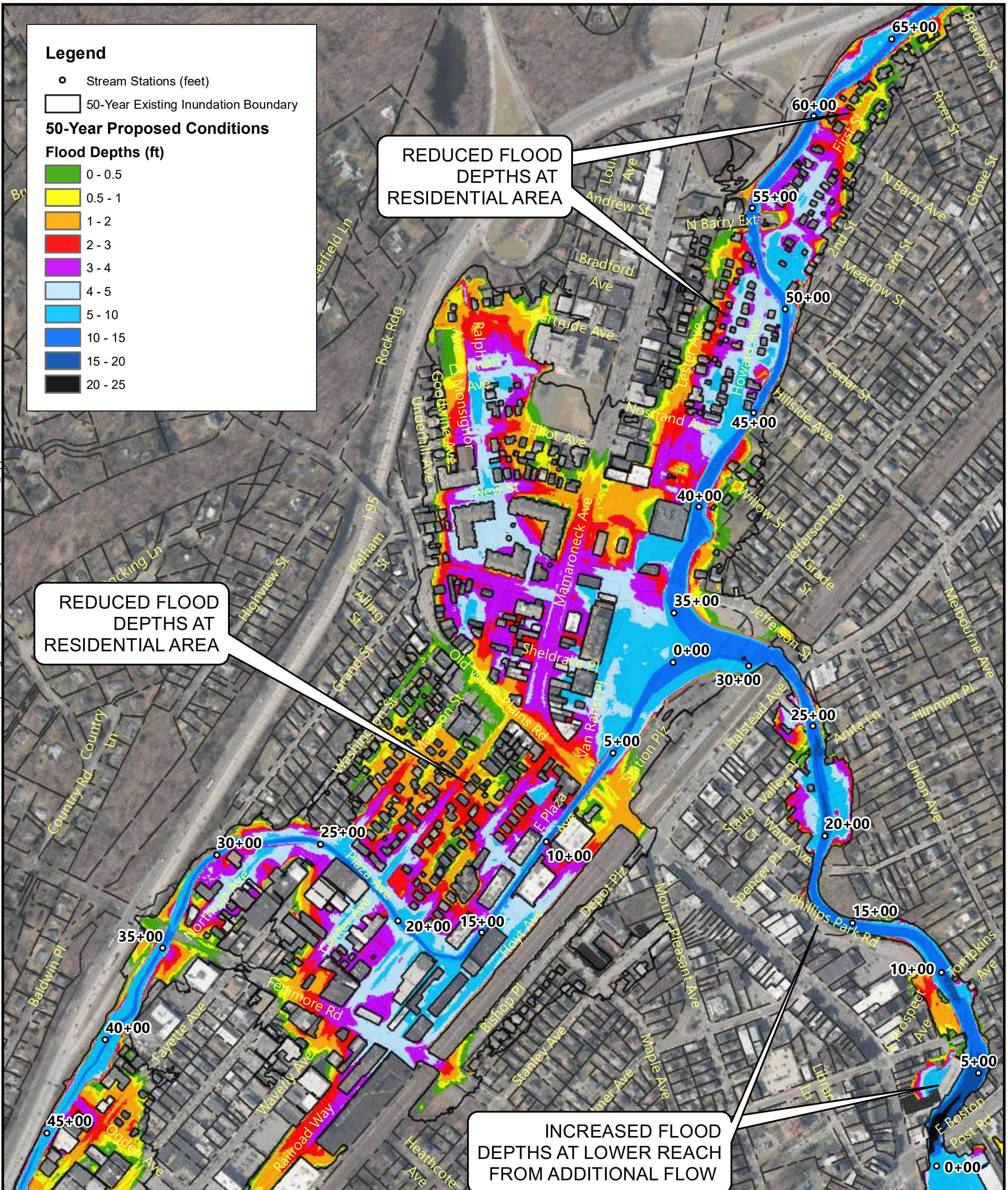

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UPPER HRA 1: 50-YEAR PROPOSED CONDITIONS FLOOD DEPTHS
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FIG. 4-9

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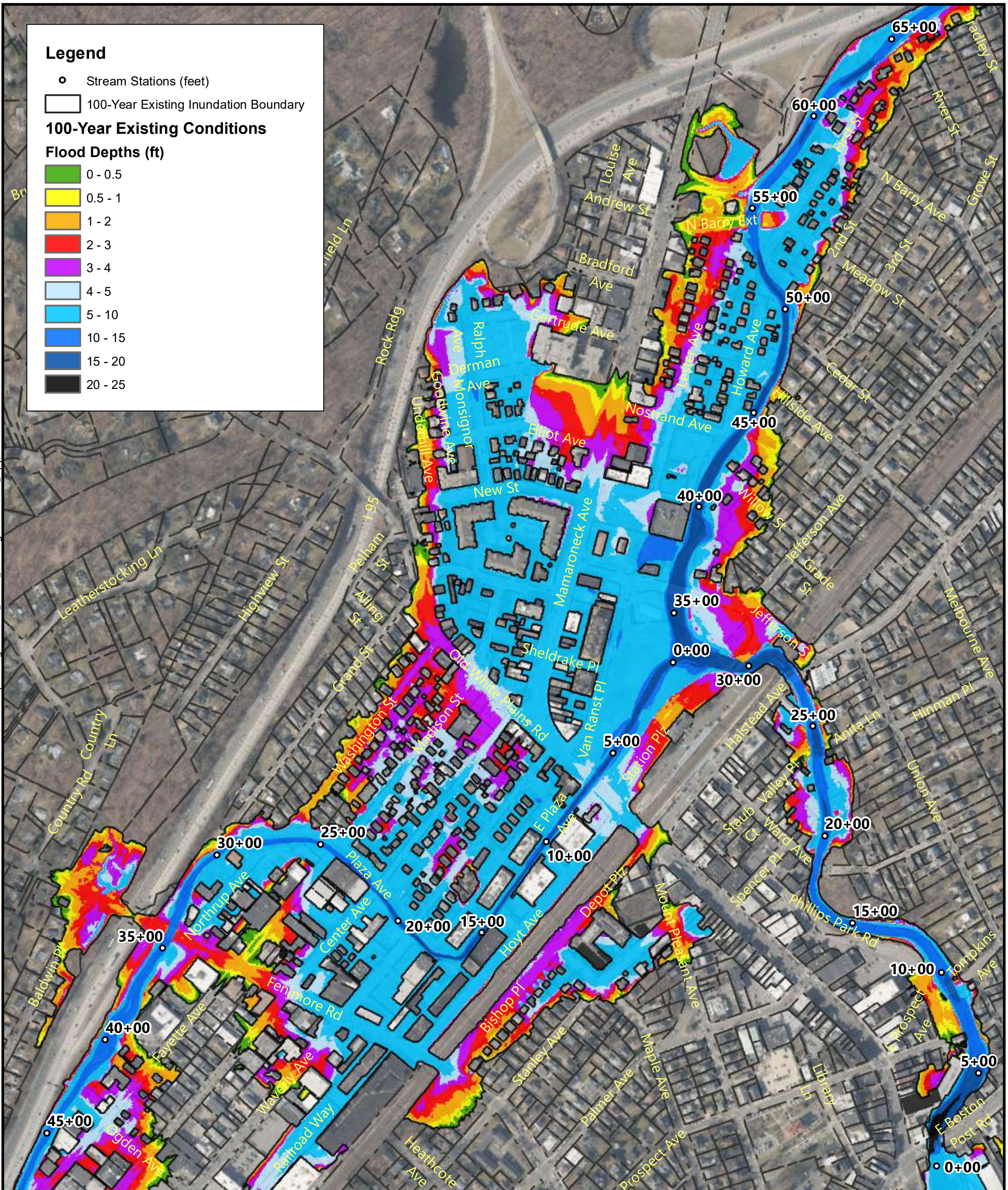

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UPPER HRA 1: 100-YEAR EXISTING CONDITIONS FLOOD DEPTHS

MAMARONECK RIVER FLOOD & RESILIENCY STUDY
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FIG. 4-10

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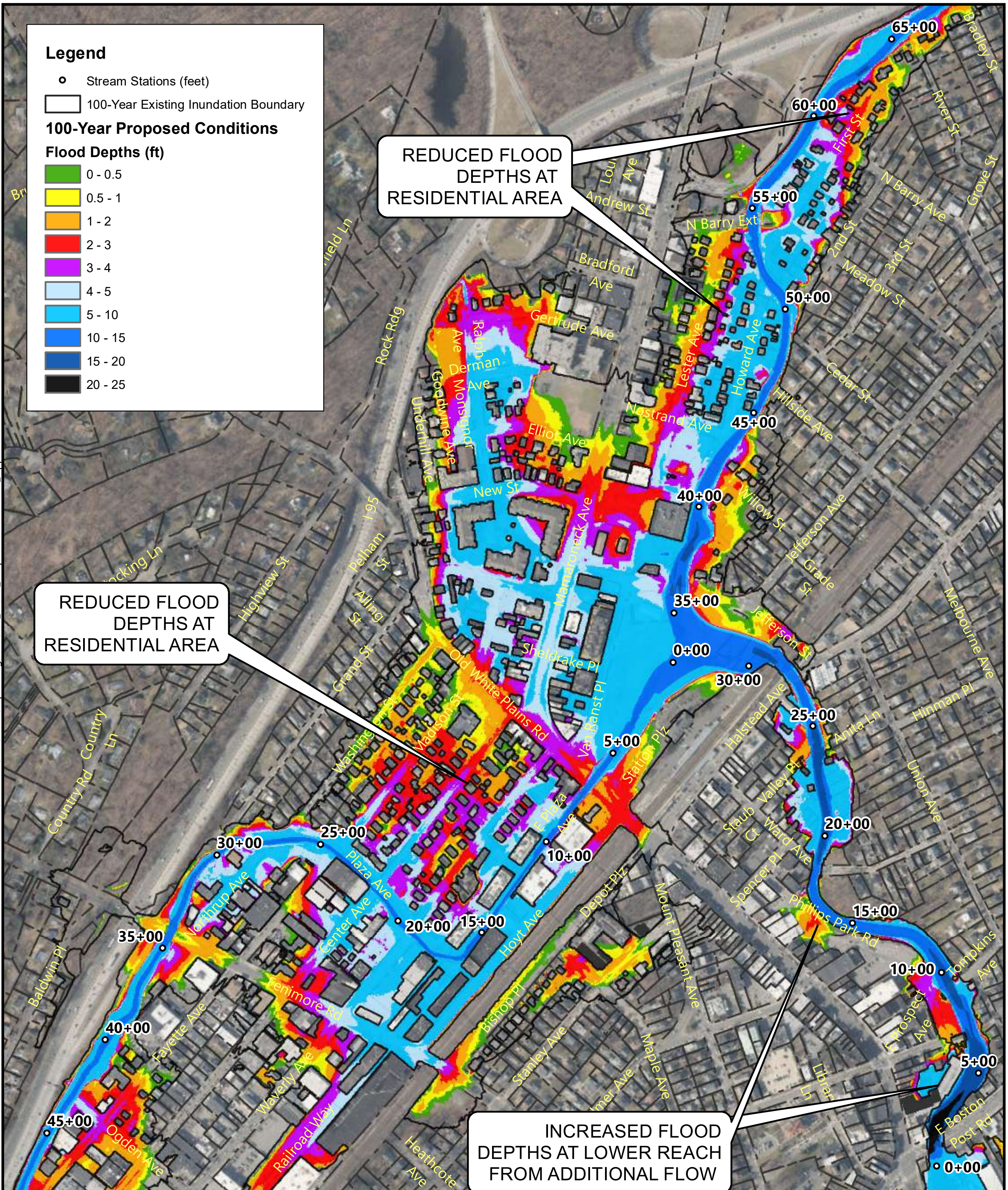

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UPPER HRA 1: 100-YEAR PROPOSED CONDITIONS FLOOD DEPTHS
MAMARONECK RIVER FLOOD & RESILIENCY STUDY
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FIG. 4-11

4.1.2 MAMARONECK RIVER LOWER REACH (STA 0+00 TO STA 18+66)

The lower reach of the Mamaroneck River within HRA 1 is steeper in gradient and more confined between vertical channel walls in comparison to the upstream section. Most of the development is concentrated near the Mamaroneck Harbor mouth where commercial and residential buildings form the riverbanks. In addition to being subjected to riverine flooding from the Mamaroneck River, the lower stretch can be influenced by sea levels at Mamaroneck Harbor, which may exacerbate flooding when high tides or storm surges coincide with high flow events on the Mamaroneck River. Three bridges span the Mamaroneck River at this location: East Boston Post Road bridge (STA 1+01), Tompkins Avenue bridge (STA 9+20), and Ward Avenue bridge (STA 18+70). The existing structures were incorporated into the HEC-RAS two-dimensional model developed for this study, and flooding along the Mamaroneck River was assessed under various tailwater conditions at Mamaroneck Harbor (Figure 4-12).

Figure 4-12: Looking upstream along the entrance to Harbor Island Park where the Mamaroneck River outlets onto the East Basin of Mamaroneck Harbor. Photo taken after the remnants from Tropical Storm Ida passed through, courtesy of the Larchmont-Mamaroneck Patch.

East Boston Post Road is carried by single-span masonry arch deck bridge approximately 43 feet wide by 20 feet high. At the time of this study, the structure was undergoing repairs, and a new structure was being built underneath to allow the bridge to withstand all vehicular loads. It was stated by NYSDOT officials that the structural improvements would have minimal to no actual change to the bridge opening dimensions. The hydraulic model indicates that the bridge is hydraulicly adequate to convey all modeled storm events without overtopping the roadway. The structure is moderately constrictive, pressuring higher-magnitude flows such as the 50-year flood and slightly increasing velocities at the outlet under normal tidal conditions.

An open deck concrete bridge built in 1893 carries Tompkins Avenue over the Mamaroneck River (Figure 4-13). The crossing is roughly 37 feet wide by 16 feet high. At the time of this report, the village and town of Mamaroneck were looking to replace the bridge which has been temporarily closed off due to structural concerns. The existing structure is shown conveying all modeled storm events except for the 100-year storm where the model predicts floodwaters to flank over the river-right approach road. The Tompkins Avenue bridge is moderately constrictive to flood flows in part due to the bridge abutments and wingwalls, which do not fully span the river channel and floodplain.

Figure 4-13: Looking upstream at Tompkins Avenue bridge. Passage across the bridge has been closed off due to structural concerns. A utility line is seen suspended underneath the bridge deck at the inlet.

Ward Avenue is currently carried by a concrete arch deck bridge spanning 34 feet wide by 16 feet high. The village-owned structure is slated for replacement according to town of Mamaroneck officials as per the recommendations from the USACE 2017 study. USACE is also undertaking the design of the replacement bridge for Ward Avenue. The crossing is situated atop a narrow and confined section of the Mamaroneck River, with no floodplain connectivity to alleviate flood flows and reduced instream velocities (Figure 4-14). The existing bridge structure is shown conveying all modeled flood events, including the 100-year storm with sufficient freeboard. However, according to the hydraulic model, the bridge abutments and roadway embankments contract river flows. Flow velocities at and downstream of the bridge can reach upwards of 10 feet per second, or 50 percent higher than anywhere else along the lower river reach, during the 100-year flood event.

Figure 4-14: Standing on top of Ward Avenue looking downstream at a narrow and confined Mamaroneck River channel.

As stated, the lower reach of the Mamaroneck River is influenced by water surface elevations, or the downstream boundary condition, at Mamaroneck Harbor. Hydraulic analyses were conducted under a range of flood flow conditions on the Mamaroneck River and under a range of tidal conditions at the harbor. The analyses indicate that there is a moderate influence on riverine flooding due to high tide or coastal surge at the harbor. When peak flows on the Mamaroneck River coincide with a 100-year future stillwater flood at the harbor, a worst-case scenario, the impact to water surface elevations extends upstream to about the Ward Avenue bridge (from STA 0+00 to STA 18+70). Increased flood depths range between 0.5 to 1.0 feet compared to a high-tide boundary condition at the harbor. Riverine flooding is expected to worsen between East Boston Post Road and Tompkins Avenue under a sea-level rise scenario. Flooding along the coastline of the East Basin is expected to worsen as well; however, analysis of flooding along the coast was not evaluated in this study.

Replacement or removal of the Tompkins Avenue and Ward Avenue bridges is recommended for the lower Mamaroneck River reach to mitigate flooding. Replacement of Tompkins Avenue with a 115-foot-wide bridge to span the active channel and existing floodplain is recommended. At Ward Avenue, which is scheduled for replacement, a 100-foot-wide open deck bridge that spans a proposed 550-foot-long by roughly 75-foot-wide floodplain bench (from STA 15+00 to STA 23+01) is recommended. Removal of either crossing and restoration of the adjoining sections of the channel is also an option since there may be sufficient alternative routes available across the Mamaroneck River within the extents of HRA 1. Recommendations at Tompkins Avenue and Ward Avenue were determined assuming improvements at the upper reach of the Mamaroneck River and the influence of increased flows through the lower reach. The recommendations at these crossings are necessary to not only improve existing flooding but to offset additional flooding expected from upstream improvements as discussed in Section 4.1.1. Project prioritization considerations and recommended sequence of project implementation are discussed in greater detail in Section 5.13 of this report.

At East Boston Post Road, due to the hydraulic adequacy and the recent structural improvements to the bridge, no further recommendations are proposed. Because of the highly developed overbanks directly upstream of East Boston Post Road, there is little to no room available to alleviate flooding without converting occupied space into floodplain. Instead, floodproofing methods and property relocations are recommended along East Prospect Avenue and East Boston Post Road where flooding is expected to worsen from anticipated sea-level rise combined with coastal surge and flooding along the Mamaroneck River with upstream improvements. Individual property flood protection measures are discussed in Section 5.11.

Recommendations for the lower section of HRA 1 are depicted in Figure 4-15. Maps showing modeled flooding depths and extents within HRA 1 under existing 10-, 50-, and 100-year flood events on the Mamaroneck River combined with the 10-year flood event on the Mamaroneck Harbor are depicted in Figures 4-16, 4-18, and 4-20, respectively. Maps showing modeled flooding depths and extents within HRA 1 with proposed improvements along the upper and lower Mamaroneck River reaches for the 10-, 50-, and 100-year flood events combined with the 10-year flood event on the Mamaroneck Harbor are depicted in Figures 4-17, 4-19, and 4-21, respectively. Furthermore, for planning purposes at the Mamaroneck River outlet to the harbor, flooding extents under various tailwater conditions are illustrated in Figure 4-22 and include flooding under the following scenarios:

- Existing 100-year flood event on the Mamaroneck River with existing 100-year storm surge at the Mamaroneck Harbor
- Existing 100-year flood event on the Mamaroneck River with existing 100-year storm surge at the Mamaroneck Harbor plus 16” sea-level-rise
- Proposed conditions 100-year flood event on the Mamaroneck River with existing 100-year storm surge at the Mamaroneck Harbor
- Proposed conditions 100-year flood event on the Mamaroneck River with existing 100-year storm surge at the Mamaroneck Harbor plus 16” sea-level-rise

It is recommended that all floodproofing measures account for future climatic conditions and that the town/village utilize the information above to aid in decision making when it comes to existing and future development within the lower Mamaroneck River reach.

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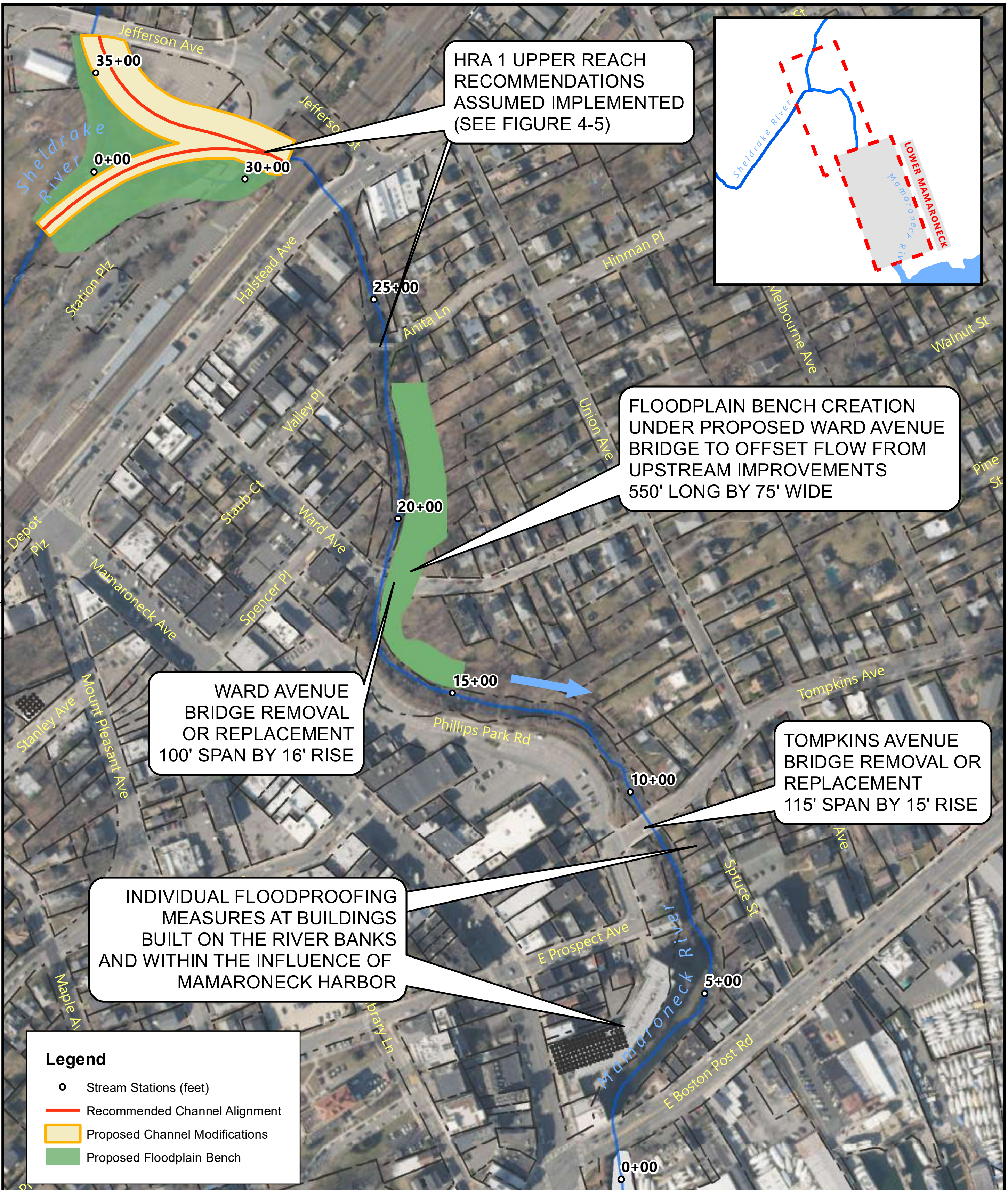

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HRA 1 LOWER REACH: CONCEPT PLAN LAYOUT

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FIG. 4-15

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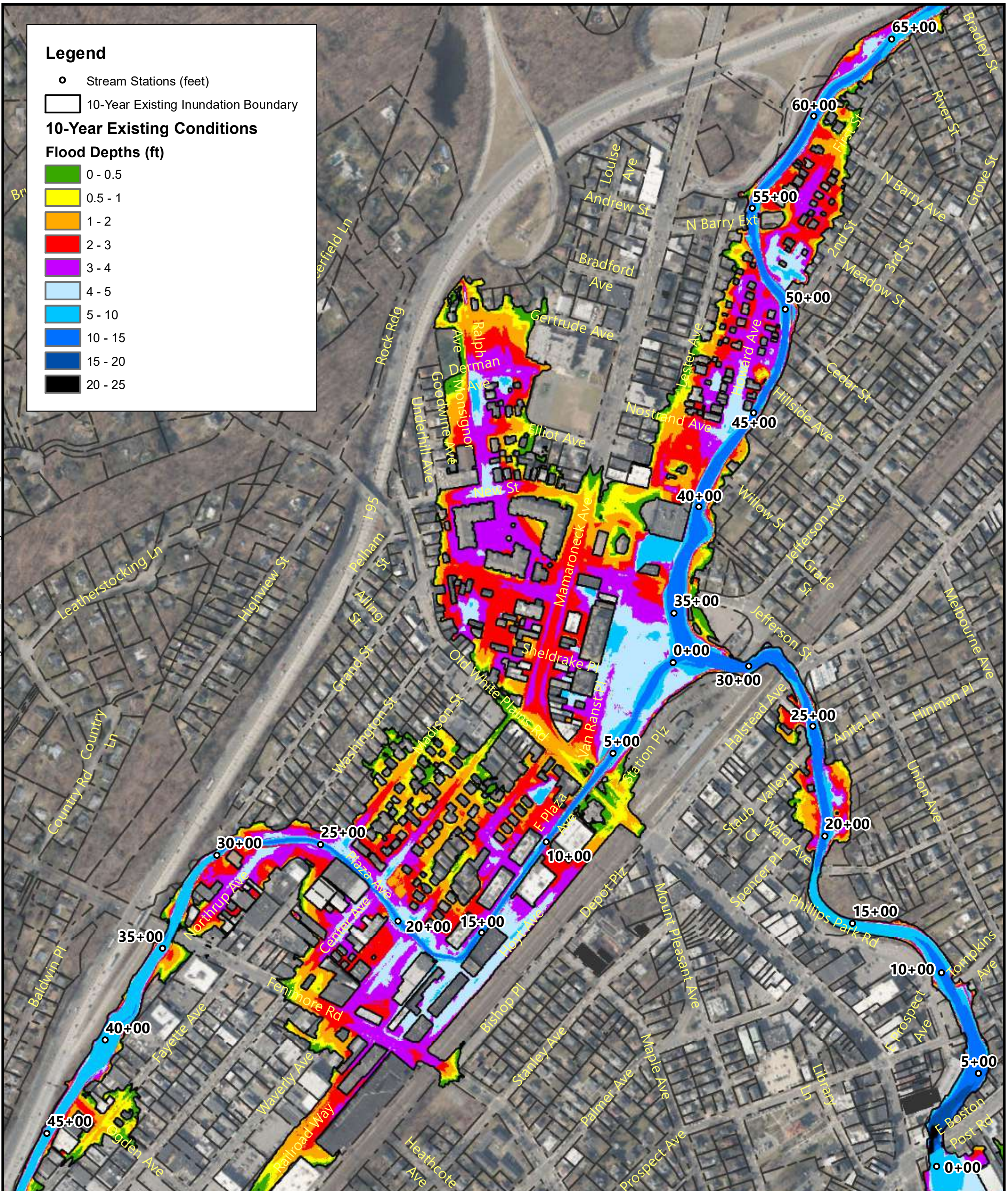

LOWER HRA 1: 10-YEAR EXISTING CONDITIONS FLOOD DEPTHS

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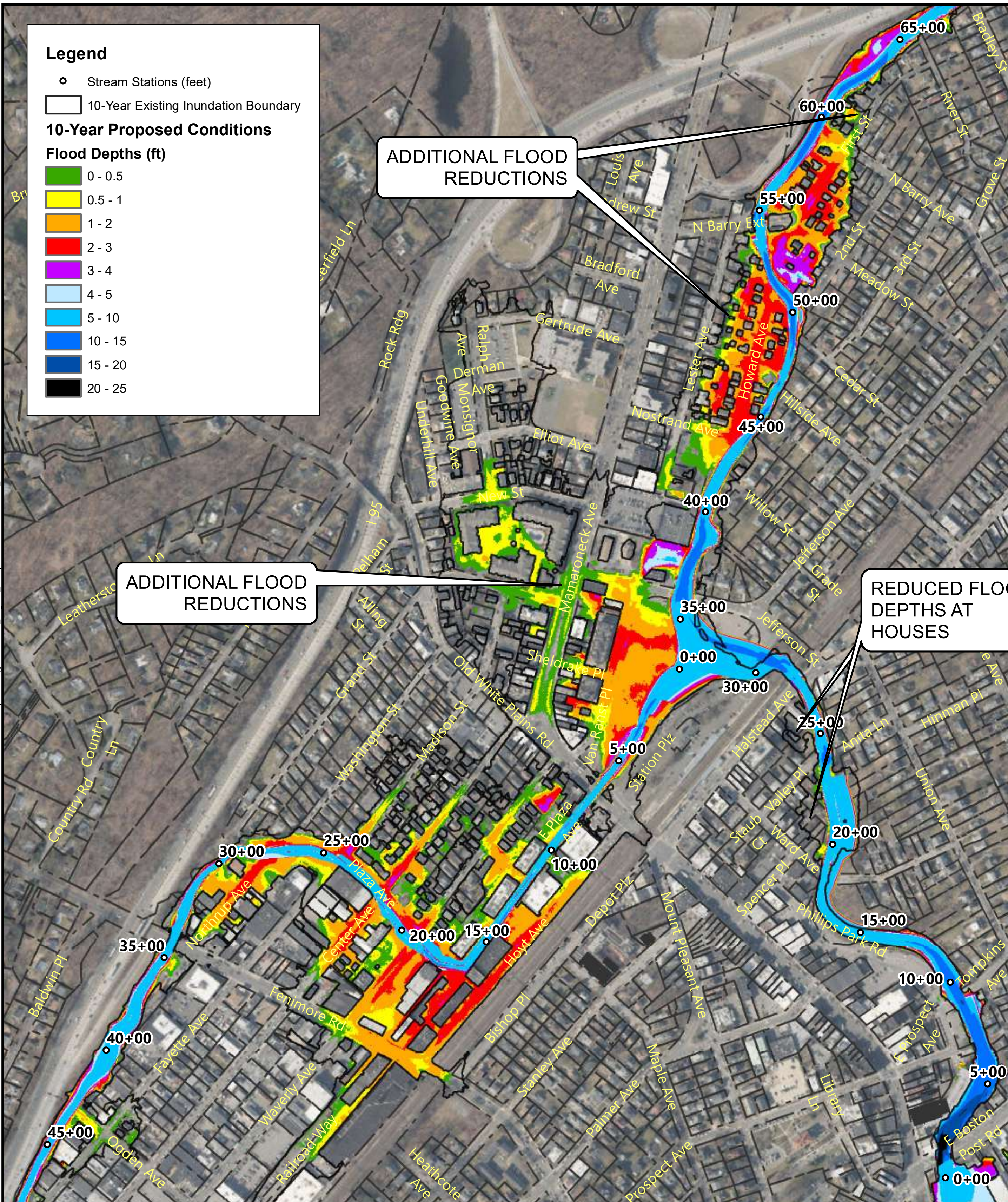
FIG. 4-16



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LOWER HRA 1: 10-YEAR PROPOSED CONDITIONS FLOOD DEPTHS

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FIG. 4-17

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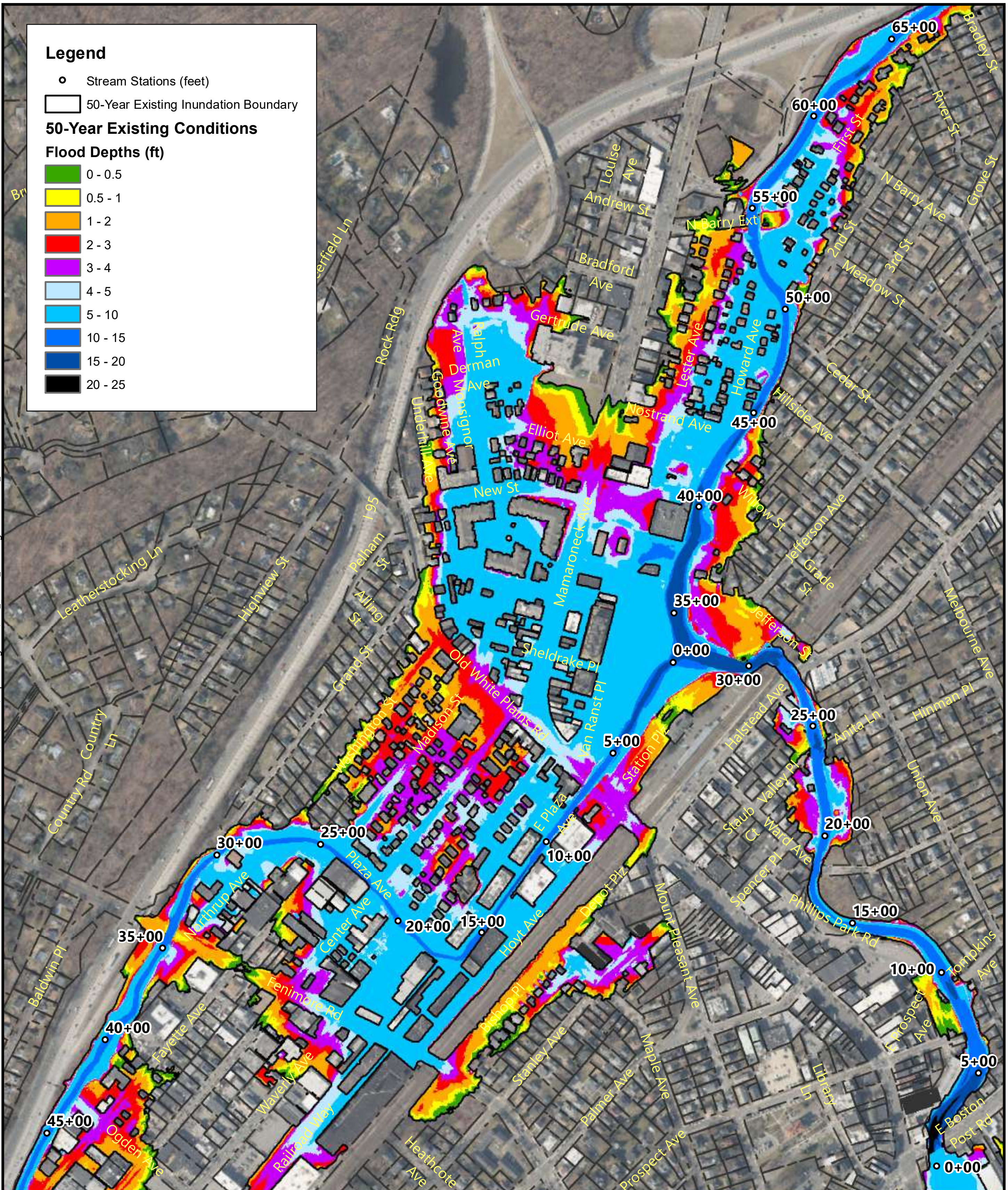

LOWER HRA 1: 50-YEAR EXISTING CONDITIONS FLOOD DEPTHS

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FIG. 4-18

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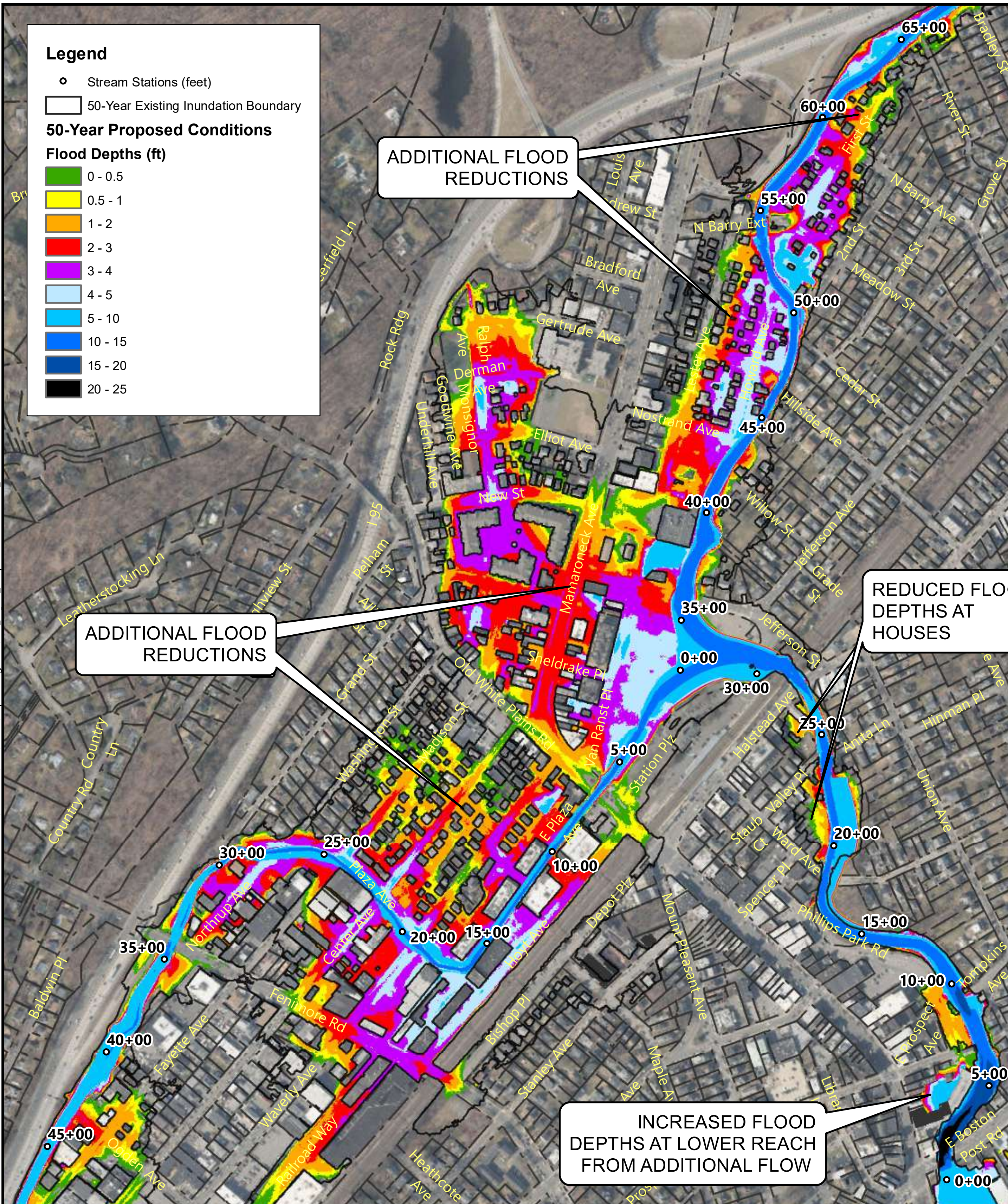

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LOWER HRA 1: 50-YEAR PROPOSED CONDITIONS FLOOD DEPTHS

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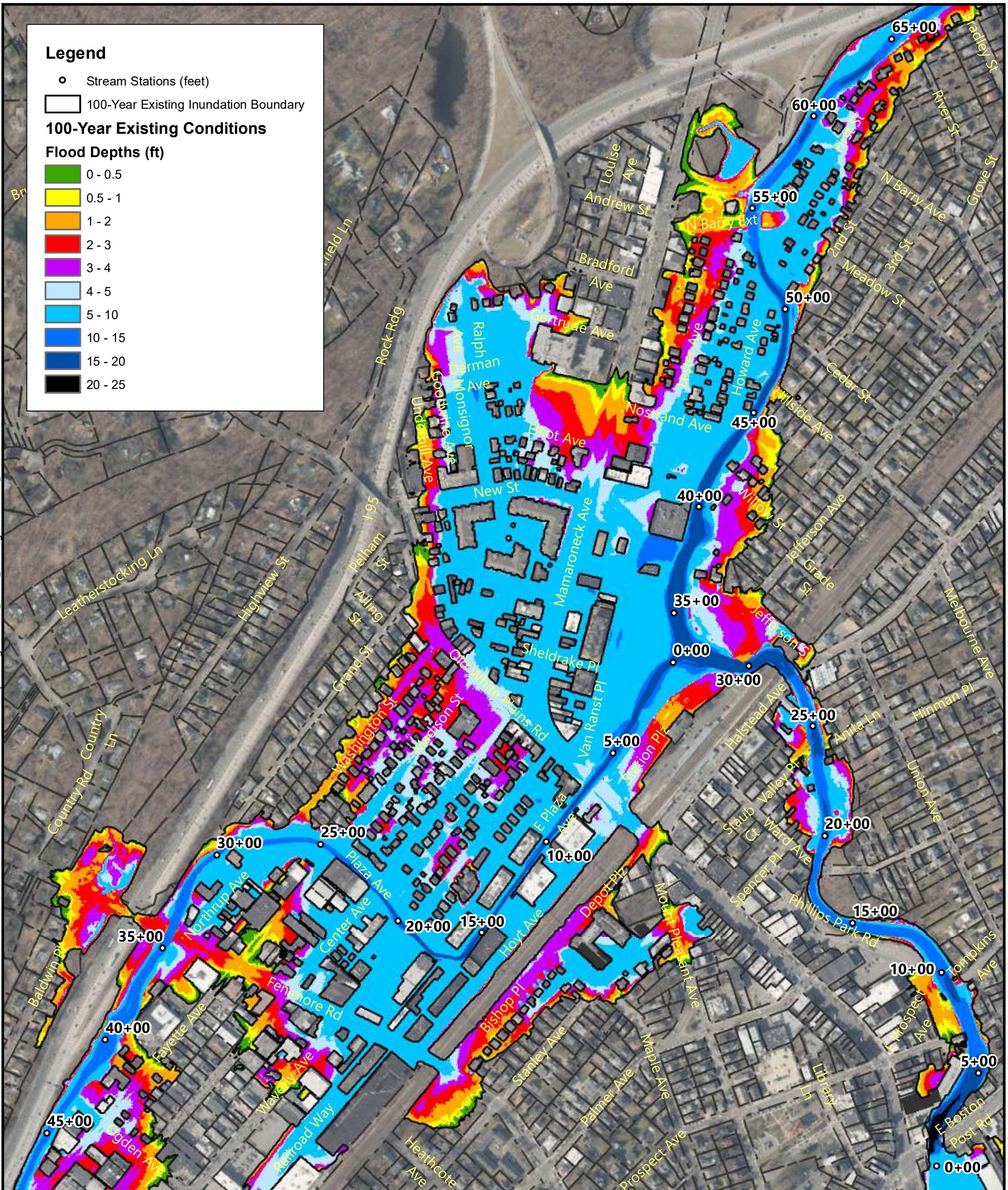
FIG. 4-19



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LOWER HRA 1: 100-YEAR EXISTING CONDITIONS FLOOD DEPTHS

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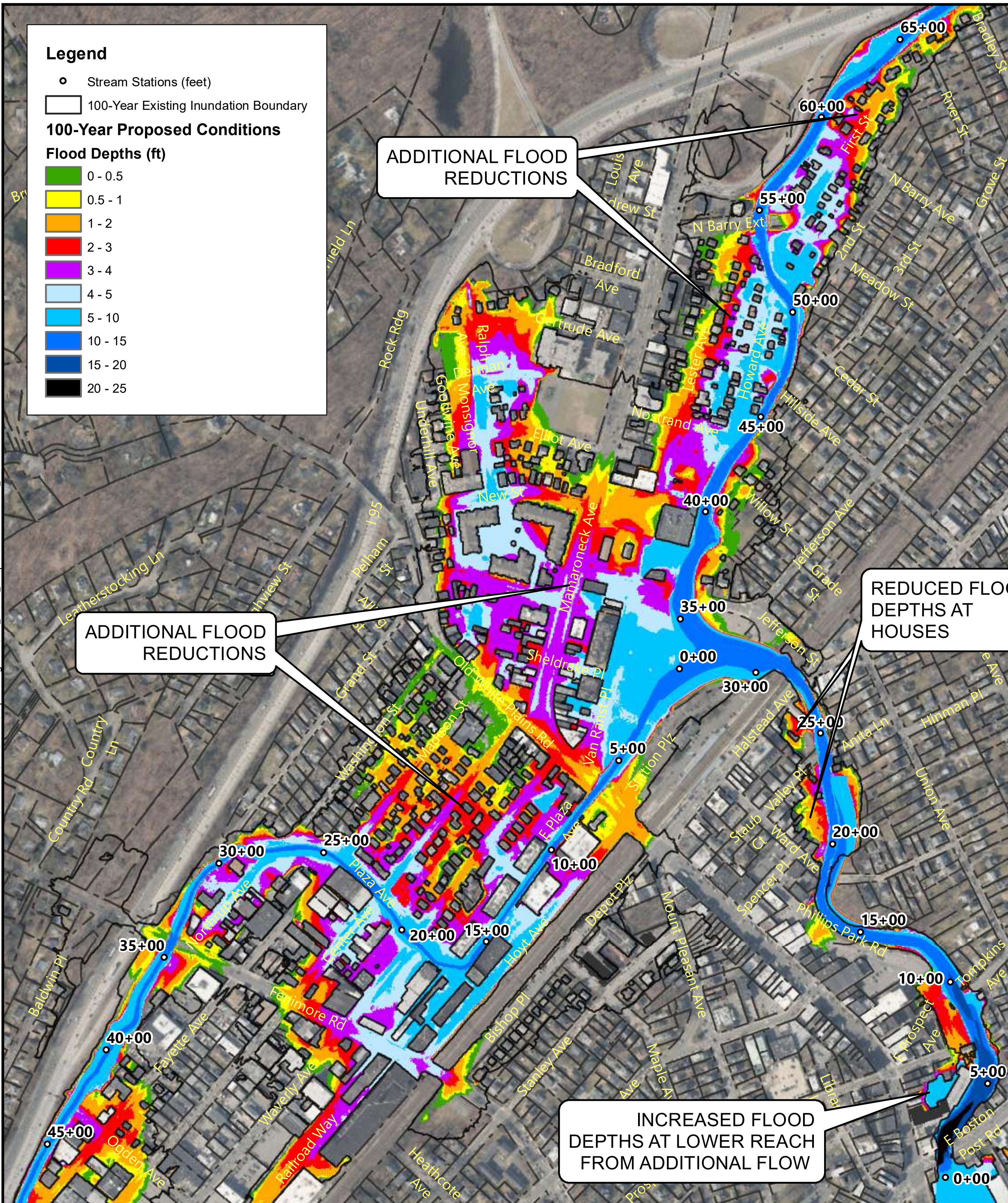
FIG. 4-20



LOWER HRA 1: 100-YEAR PROPOSED CONDITIONS FLOOD DEPTHS

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FIG. 4-21

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LOWER HRA 1: FLOODING NEAR HARBOR FOR VARIOUS SCENARIOS

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FIG. 4-22

4.2 HIGH RISK AREA 2 – MAMARONECK RIVER BETWEEN JEFFERSON AVENUE AND I-95 IN THE VILLAGE OF MAMARONECK

HRA 2 includes the section of the Mamaroneck River runs from Jefferson Avenue upstream to I-95 in the village of Mamaroneck, from STA 36+35 upstream to STA 75+00. The river flows through an undersized and walled-in channel for most of its course (Figure 4-23). Dense residential development and a handful of commercial businesses occupy the riverbanks and floodplain. Two bridges span the Mamaroneck River within HRA 2: Hillside Avenue (STA 45+50) and North Barry Avenue Extension (STA 46+46). Critical facilities within HRA 2 include the Emergency Medical Service building and other medical offices. There are also several anchor businesses within the extents of HRA 2, including gas stations and hardware stores. HRA 2 accounted for 95RL claims or over half of all that occurred in the town of Mamaroneck as of 2019. Most of these properties are located along Lester Avenue, Howard Avenue, and First Street. HRA 2 falls within two census blocks that have been designated as a Disadvantaged Community. A map of HRA 2 is illustrated in Figure 4-24.

Figure 4-23: Looking upstream of Hillside Avenue bridge. Sections of the Mamaroneck River within HRA 2 have been walled-in as depicted in this photo, consequently cutting off floodplain access and connectivity, which can affect channel stability and flood conveyance. The presence of undersized bridges further exacerbates flooding by constricting flows and raising upstream water surface elevations.

SLR 231 MAIN STREET SUITE 102 NEW PALTZ, NY 12561 845.633.8153	HIGH RISK AREA 2 OVERVIEW MAMARONECK RIVER FLOOD & RESILIENCY STUDY SD 969 MOD 2 WESTCHESTER COUNTY, NEW YORK N 0 360 Feet	SCALE 1 " = 350 ' DATE 5/30/2023 6511.0020 PROJ. NO. **FIG. 4-24**

It is worth noting that the severity of flooding at HRA 2 is strongly influenced by downstream conditions at HRA 1. Employing the improvements recommended for HRA 1 would also reduce water surface elevations throughout HRA 2 across all modeled storm events. Recommendations for project prioritization are discussed in Section 5.13 of this report. Equally important are the past efforts to mitigate flooding along the Mamaroneck River. The 2017 study performed by the USACE included potential structural and nonstructural actions to mitigate flooding along the reach of the Mamaroneck River that falls within HRA 2. Recommendations from the USACE study were considered but not evaluated in this study. A summary of the USACE recommendations follows.

- Approximately 2,400 feet of channel work along the Mamaroneck River extending from the confluence to Hillside Avenue (distance 1,050 feet and width 40 feet) and from Hillside Avenue bridge to upstream of North Barry Avenue Extension (distance 1,350 feet and width 30 feet).

- Channel modifications would consist of constructing a trapezoidal channel with a natural channel bed and pitched or sloped vegetated banks. Retaining walls would be utilized for the sections of stream where a trapezoidal channel cannot be constructed, typically where buildings, roads, or other features may be affected.

- Nonstructural recommendations along the Mamaroneck River, including structure elevations, ringwall levees, and/or floodproofing.

The structure carrying Hillside Avenue is a precast concrete arch bridge that was replaced in 2021. The new bridge spans 38 feet wide, or 7 feet wider than the previous structure, and has a vertical opening of approximately 11 feet. The bridge is shown perched to the surrounding terrain and therefore is susceptible to flanking to its right (west), inundating the approach roadway with upwards of 3 feet of water in the existing 10-year storm event and 7 feet in the 100-year storm event.

North Barry Avenue Extension is carried by a three-span concrete frame bridge over the Mamaroneck River. The full span of the bridge is approximately 57 feet wide and has a 12-foot-high opening. The structure is similarly perched to the ground river-left (east) of the crossing (Figure 4-25). In the hydraulic model, floodwaters are shown spilling over the banks upstream of the bridge and bypassing the structure starting at the 10-year storm event, flooding homes and the intersection with Meadow Street under 3 feet of water. Flood depths upwards of 7 feet can be expected during a 100-year storm event along the river-left overbank.

As previously noted, flooding across HRA 2 is affected by the downstream tailwater conditions at HRA 1. For an alternatives analysis of HRA 2, it was assumed that flood mitigation projects would be completed downstream beforehand. This will allow for flood reductions projects along HRA 2 to take opportunity of and further expand on the flood reduction benefits expected from the recommended improvements at HRA 1.

Figure 4-25: Looking towards North Barry Avenue Extension bridge from the east. The Mamaroneck Emergency Medical Service building (a critical facility) is seen in the background, upstream of the bridge inlet on the right overbank.

Hydraulic modeling indicates that flooding is predominantly driven by the undersized river channel and development on the floodplain. Regional regression equations estimate a bankfull channel width of 54 feet for the Mamaroneck River within HRA 2. The existing channel top width changes between 61 feet and 30 feet throughout the study reach. The river's narrowest sections are in the vicinity of the Hillside Avenue bridge between STA 40+00 to STA 50+00. The presence of bridges is also problematic, although because water exits the channel and bypasses the structures, they are not fully responsible for widespread flooding.

Reconstructing the river channel from STA 37+90 to STA 65+00 with an adequately sized multistage channel and floodplain restoration is recommended. Because of tight development on the riverbanks and floodplain, there is very little room available for channel enhancements without disturbing nearby houses and businesses. Therefore, wherever landowner interest exists, property acquisition followed by channel and floodplain restoration is recommended. Channel restoration would include excavation of a properly sized multistage channel and floodplain, installation of grade control structures and/or scour protection measures along the restored channel to prevent channel incision and protect upstream infrastructure, and installation of native plantings. Floodplain restoration would at a minimum include removal of buildings and impervious cover, lowering of the floodplain to inundate at a desired flood event, and creation of a proper riparian buffer zone comprised of native vegetation.

A conceptual channel reconstruction and floodplain restoration configuration for HRA 2 is depicted in Figure 4-26. This plan calls for roughly 2,700 river feet of channel reconstruction to bankfull width dimensions of 54 feet and relocation of approximately 100 properties mapped within the 100-year flood extent and restoration of the floodplain. Conceptual floodplain bench restoration alternative investigated in this report, and as depicted in Figure 4-26, measures approximately 300 feet wide from STA 50+00 upstream to STA 64+10 on river-left and approximately 400 feet wide from STA 38+22 to STA 54+00 on river-right. Floodplain bench excavation depths would range between 5 to 6 feet below existing ground.

In addition, replacement or removal of the North Barry Avenue Extension bridge is recommended so it no longer obstructs flows. Replacement of the North Barry Avenue bridge with a single-span open deck structure that spans 70 feet is recommended. Although, because of the low-lying nature of the surrounding area, replacement of the bridge alone is not guaranteed to eliminate flanking of the bridge and roadway overtopping during a flood event. Since the Hillside Avenue bridge was recently replaced, no further recommendations besides routine inspection and monitoring of the structure are recommended. Sections of the approach roads to the right (west) of the Hillside Avenue bridge and left (east) of the North Barry Avenue Extension bridge are still expected to be under water during severe flood events. It is recommended that proper roadway closure signage be implemented when major storm events are forecasted for the area to deter passage over inundated roadways.

Floodproofing, elevation, or relocation of buildings may still be required and is highly dependent on the final layout and dimensions of any floodplain bench creation that takes place within HRA 2. For the scenario depicted in Figure 4-26, which aims to remove flood-prone buildings from the floodplain and restore it, no structures would require floodproofing, elevation, or relocation. Individual flood protection measures are detailed in Section 5.11 of this report.

Flood reductions under the modeled 10-year flood event are illustrated in Figure 4-27 (existing conditions) and Figure 4-28 (with proposed flood mitigation measures implemented). Flood reductions during the 100-year flood event are illustrated in Figure 4-29 (existing conditions) and Figure 4-30 (proposed conditions).

A rigorous hydraulic and hydrologic analysis is recommended for the North Barry Avenue Extension bridge when due for routine replacement to ensure that it is adequately sized to convey flood flows and does not exacerbate flooding. Feasibility studies should be conducted to find the optimal combination of property relocations and floodplain bench restoration within HRA 2. Potential funding sources for property relocation are listed in Section 5.14 of this report. For flood-prone homes where flooding is expected to persist after implementing flood mitigation actions, floodproofing of individual homes and businesses may be appropriate.

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HRA 2: CONCEPT PLAN

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WESTCHESTER COUNTY, NEW YORK

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FIG. 4-26

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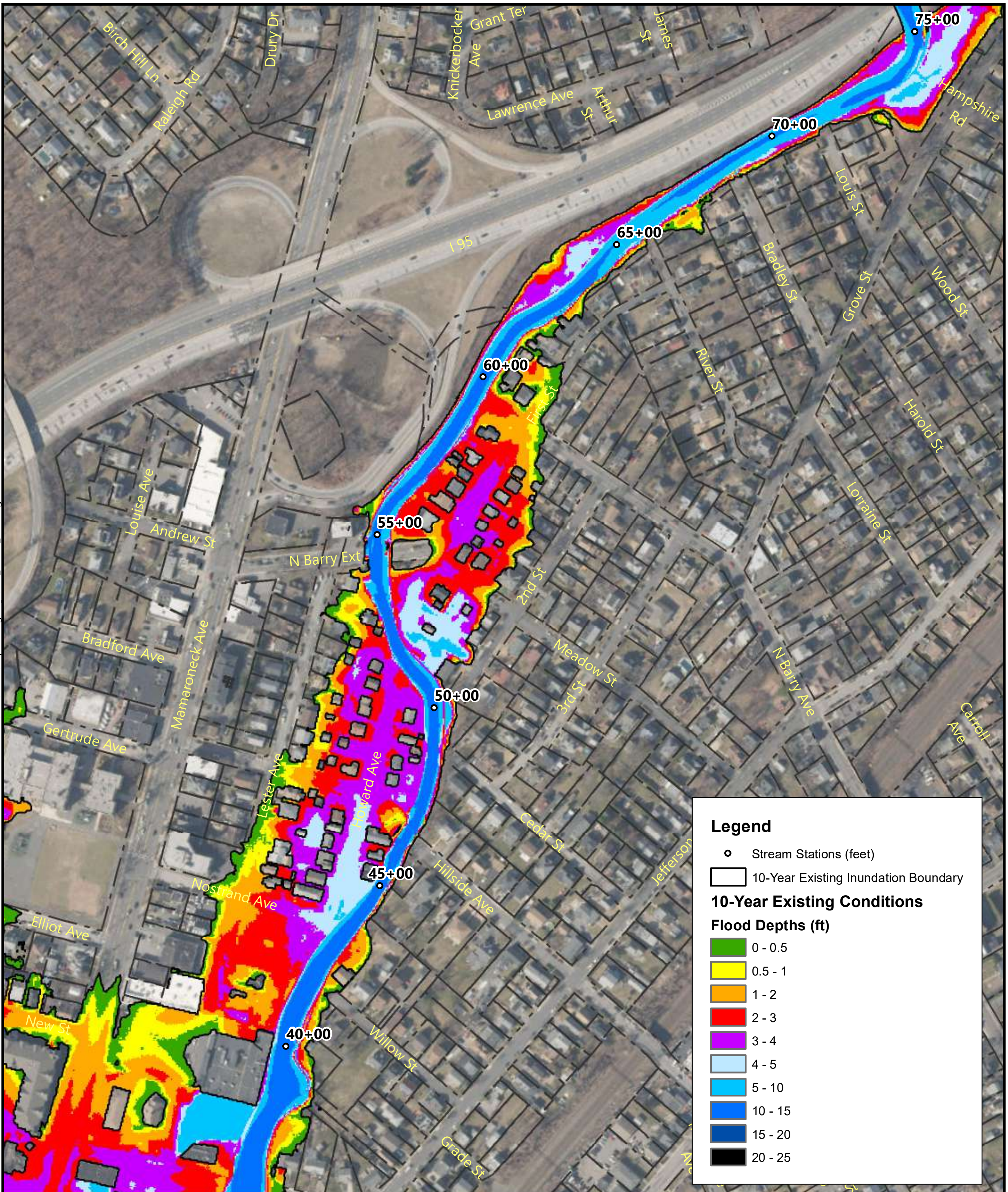

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HRA 2: 10-YEAR EXISTING CONDITIONS FLOOD DEPTHS

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FIG. 4-27

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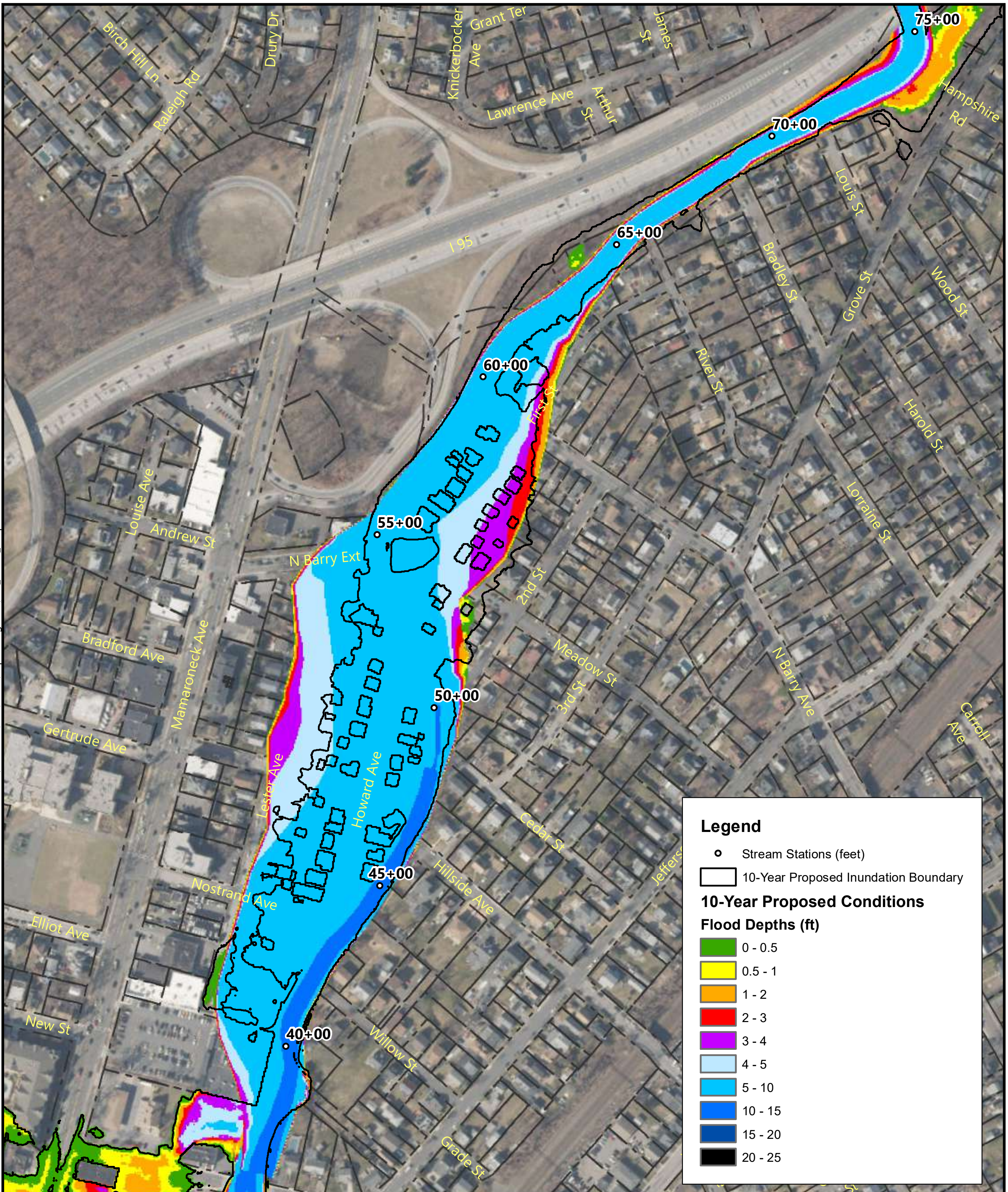

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HRA 2: 10-YEAR PROPOSED CONDITIONS FLOOD DEPTHS

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FIG. 4-28

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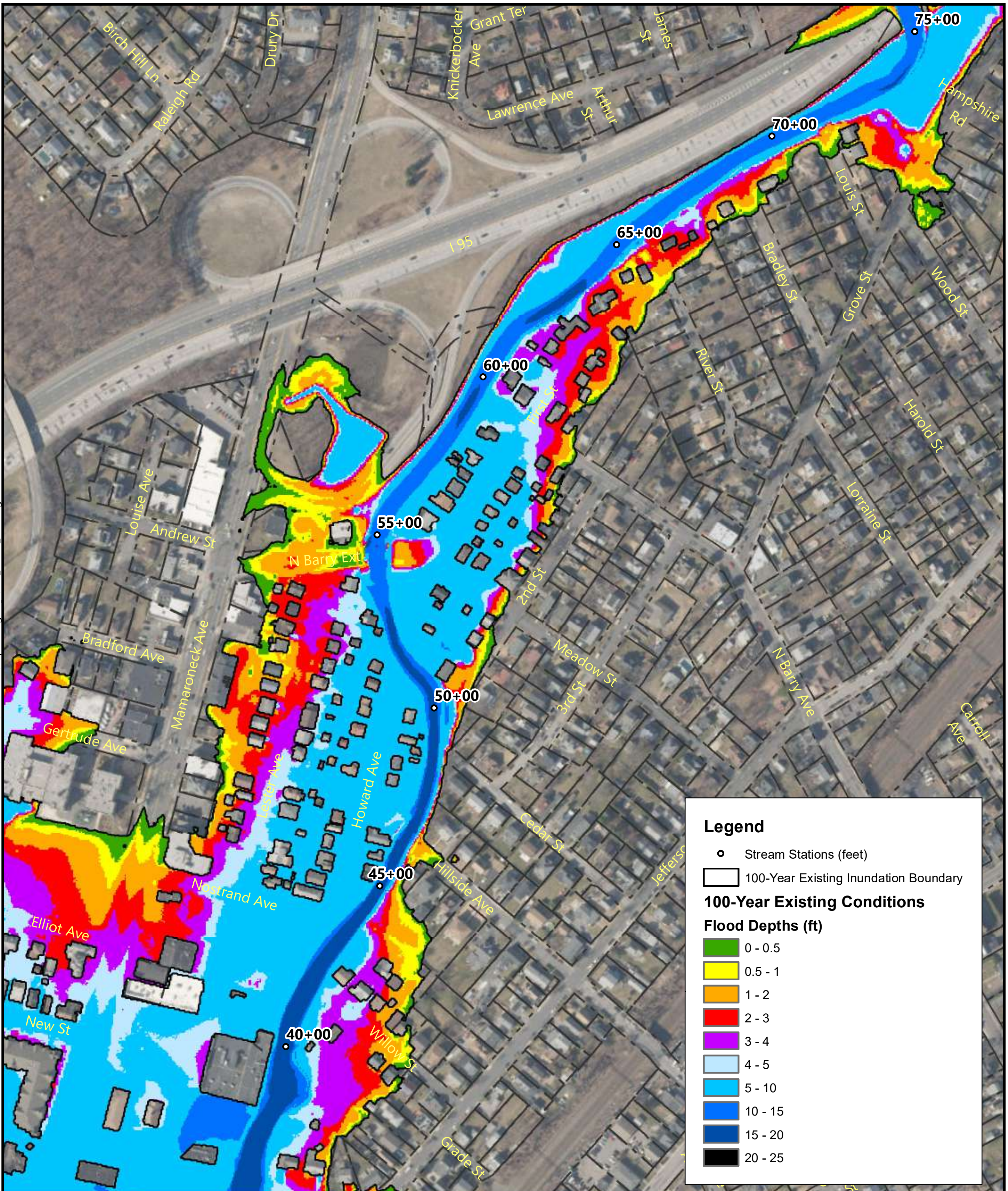

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HRA 2: 100-YEAR EXISTING CONDITIONS FLOOD DEPTHS

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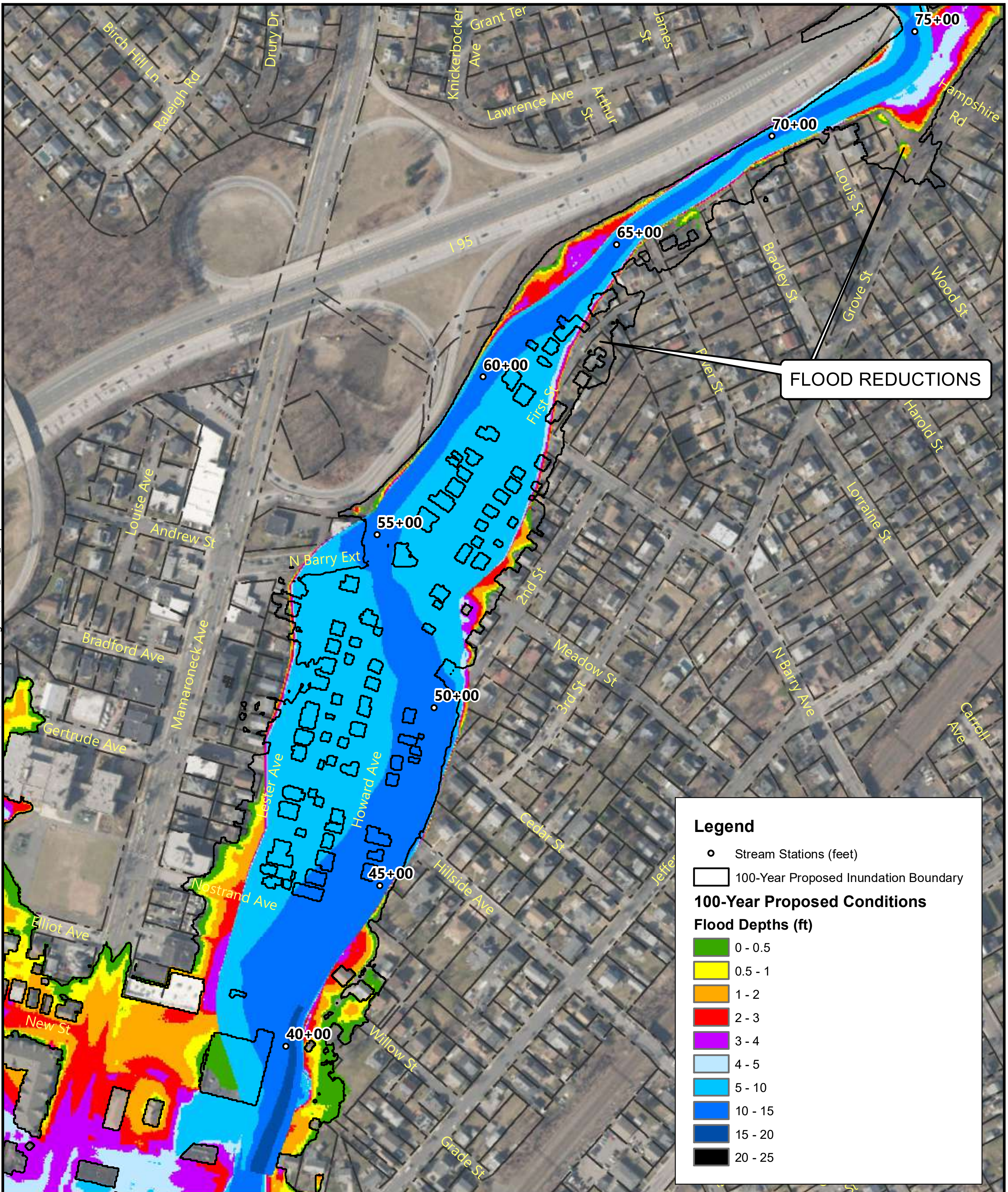
FIG. 4-29



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HRA 2: 100-YEAR PROPOSED CONDITIONS FLOOD DEPTHS
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FIG. 4-30

4.3 HIGH RISK AREA 3 – MAMARONECK RIVER UPSTREAM I-95 IN THE VILLAGE OF MAMARONECK AND TOWN OF HARRISON

HRA 3 covers the section of the Mamaroneck River from I-95 upstream to the Mamaroneck Reservoir dam near STA 117+05. The river at this location defines the jurisdictional boundary between the village of Mamaroneck to the west and the town of Harrison to the east. Crowded residential development along the riverbanks and floodplain, especially on the village of Mamaroneck side, has experienced flooding in the past, including during Tropical Storm Ida in 2021 (Figure 4-31). HRA 3 accounted for 19 structures or about 11 percent of all repetitive loss claims filed in the town of Mamaroneck, and 4 structures or 50 percent of claims in the town of Harrison for 2019. The portion of HRA 3 within the village of Mamaroneck falls within a census block that has been designated as a Disadvantage Community.

Three in-stream structures cross the Mamaroneck River within the extents of HRA 3. At the downstream limits, NYS I-95 is carried over the river at STA 75+92 by a three-span concrete frame bridge that measures 60 feet wide by 11.5 feet high. Spanning the Mamaroneck River at STA 108+54 is the Winfield Avenue bridge which, at the time of this report, had been formally closed to vehicular passage. The concrete open deck bridge measures approximately 23 feet wide by 7 feet high. Lastly, the Mamaroneck Reservoir dam at STA 115+89 (NYS ID 233-0866) is approximately 19 feet high and has a length of 185 feet. It is a hazard class "C," or high hazard, dam built in 1928 and is owned by the Westchester Joint Waterworks. The structure formerly served to impound the village's drinking water reservoir, but after switching over to NYC drinking water, the structure remained to provide limited flood control. A part of HRA 3 was previously studied by USACE in 2017 and included an assessment of these structures over the Mamaroneck River. Select nonstructural solutions were ultimately recommended for homes in the 100-year floodplain. An overview map of HRA 3 is shown in Figure 4-32.

Figure 4-31: Piles of damaged personal belongings from homes along Warren Avenue following flooding produced by the remnants of Hurricane Ida

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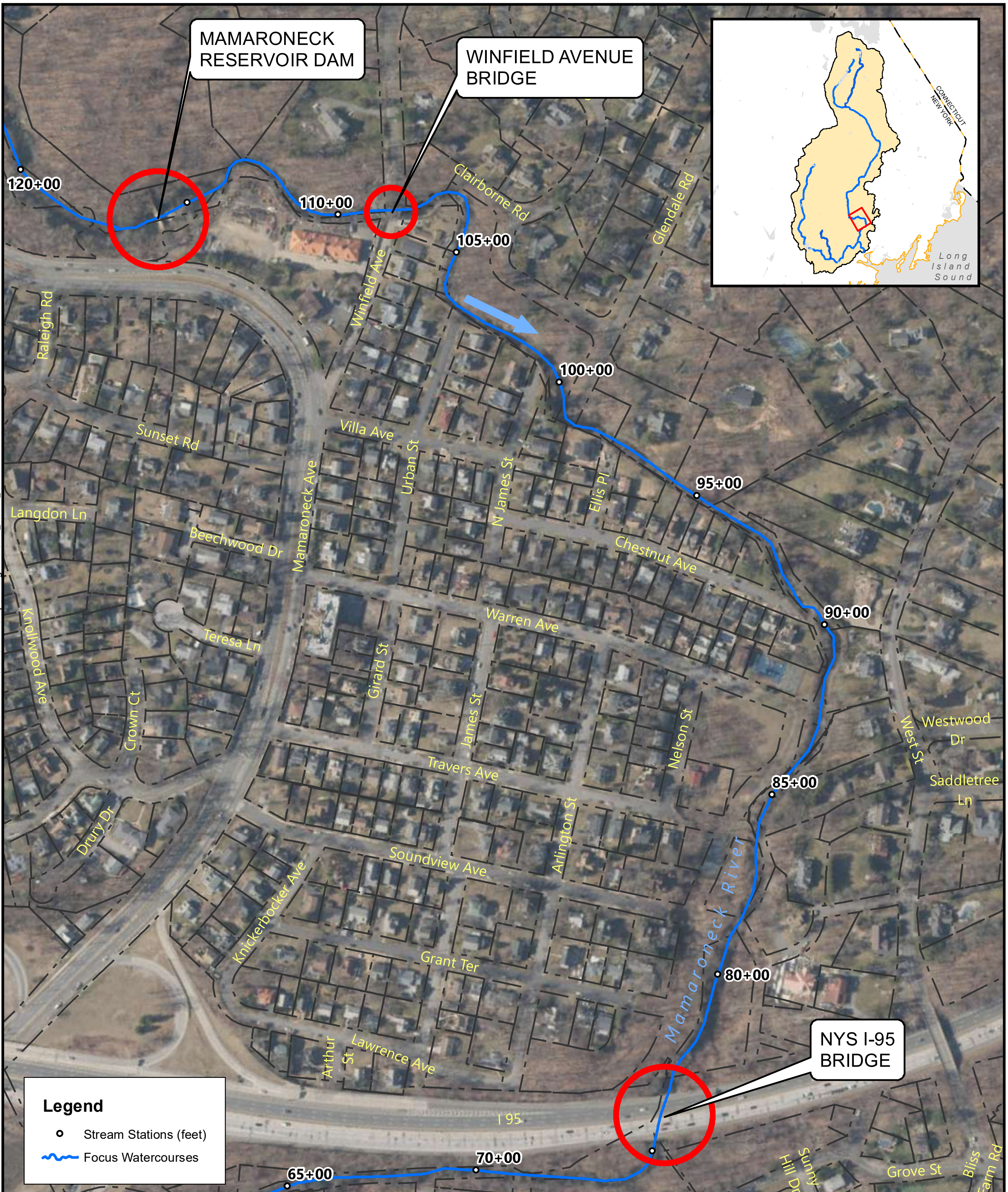

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HIGH RISK AREA 3 OVERVIEW

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FIG. 4-32

In the hydraulic model, I-95 is shown conveying all modeled peak storm events without overtopping the road, which is situated 15 feet above the concrete bridge low chord. The highway embankment and the bridge conduit transect the Mamaroneck River corridor and create a minor backwater effect. Increases in water surface elevations from the crossing are shown to range between 0.2 feet and 1.0 foot in the 10-year and 100-year storm events, respectively, at the upstream bridge face under unobstructed flow conditions. This backwater influence extends upstream for about half a mile before fully diminishing (STA 108+50). A debris jam analysis conducted at this bridge indicated that flooding is rather sensitive to obstructions at the bridge inlet. According to the model, a 20 percent reduction in hydraulic opening area is anticipated to increase upstream water surface elevations by 0.4 feet in the 10-year storm and 1.1 feet in the 100-year storm when compared to unobstructed conditions. A 100-year storm event coupled with 20 percent blockage of the I-95 bridge inlet would worsen flooding at homes adjacent to the river on Warrant Avenue, Chestnut Avenue, Ellis Plane, North James Street, and Urban Street.

The decommissioned Winfield Avenue bridge (Figure 4-33) is shown to have a capacity of less than the existing 10-year storm event before overtopping of the roadway occurs. According to the hydraulic model, in the lower-magnitude storm events, the undersized bridge and adjoining sections of channel can be highly constrictive to flows and produce a backwater. This backwater flanks around the bridge parapet and is likely to worsen flooding at a pair of homes situated on the downstream river-right floodplain. During less frequent, larger magnitude storm events, the influence of the bridge becomes negligible, and widespread flooding of homes on the floodplain is due to excess discharge amounts.

Figure 4-33: Winfield Avenue bridge outlet (photo courtesy of the Town of Harrison). The bridge and channel are both undersized and shown to contribute to localized flooding during small flood events.

The Mamaroneck Reservoir dam was incorporated into the hydraulic model as it currently stands and was shown to have a very small attenuating effect on flood storm events. The USACE conducted a detailed study of the structure and evaluated various alternatives to determine if retrofitting the dam would be viable for flood risk management. Their evaluation indicated that significant modifications to the existing dam would be required to have any meaningful attenuation of peak flows. In the USACE report, it was stated that the cost of raising the dam and all other associated expenses to realize the project would not be cost effective. SLR's findings aligned with USACE's results and recommendations.

Flooding within HRA 3 is the result of development on the river's floodplain, which is naturally expected to inundate during a flood. The most cost-effective, long-term flood mitigation solution for flood-prone properties would be managed retreat through voluntary property acquisitions and restoration of the river's floodplain areas. Intermediate flood mitigation solutions such as inspection of the I-95 crossing following a major storm and regular removal of debris accumulation at the inlet is recommended. Removal of the Winfield Avenue bridge and restoration of the channel to bankfull dimensions of 47 feet wide is recommended for short-term flood relief at homes on Winfield Avenue. A conceptual map for HRA 3 is illustrated in Figure 4-34.

Figure 4-35 is provided for planning purposes and depicts the extents of the existing 10-year flood event and the projected future 100-year flood event under existing conditions. Over two dozen properties are mapped partially or fully within the inundation extents of the future 100-year floodplain. In the village of Mamaroneck, flood-prone properties are located mainly along Warren Avenue, Chestnut Avenue, Ellis Place, Urban Street, and Winfield Avenue. In the town of Harrison, properties along Glendale Road and West Street are prone to flooding. It is recommended that all floodproofing measures account for future climatic conditions and that the town/village utilize this information to aid in decision making when it comes to existing and future development within the floodplain. A feasibility study is recommended for HRA 3 to find the optimal combination of property relocations and floodplain restoration. Individual property flood protection measures are discussed in Section 5.10 and should be implemented using predicted future water surface elevations to adequately elevate homes and utilities. Potential funding sources for property relocation are listed in Section 5.14 of this report.

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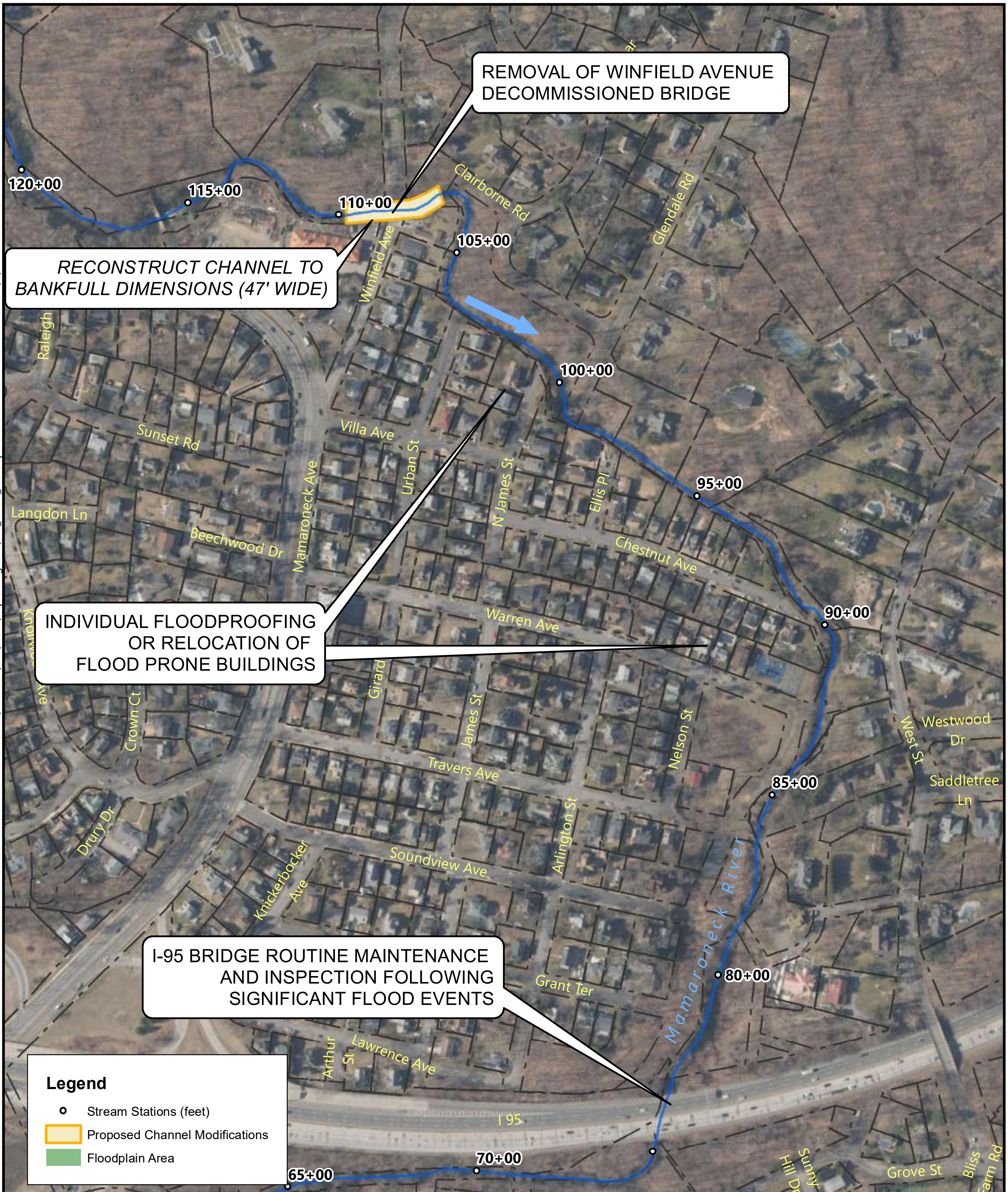

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HRA 3: CONCEPT PLAN
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FIG. 4-34

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HRA 3: MODEL FLOOD INNUNDATION EXTENTS

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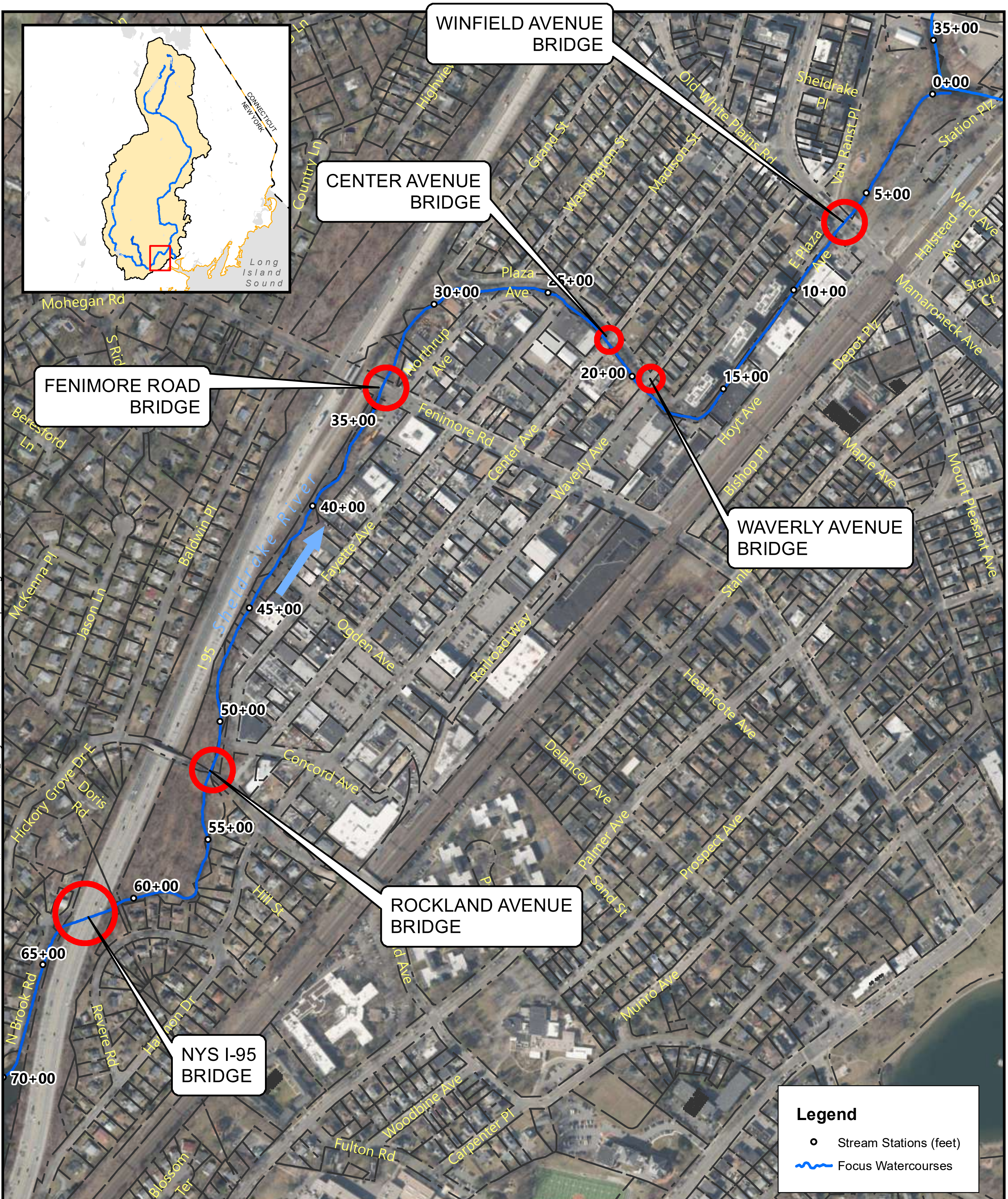
FIG. 4-35

4.4 HIGH RISK AREA 4 – SHELDRAKE RIVER IN THE VILLAGE OF MAMARONECK

HRA 4 includes approximately 1.1 river miles of the Sheldrake River tributary starting downstream at STA 0+00, the confluence with the Mamaroneck River, and continuing upstream to STA 62+50 where I-95 crosses. The upper 3,300 feet of the subject watercourse is moderately developed with a few houses and industrial buildings located on the river-right overbanks. However, starting at STA 30+00, the Sheldrake River becomes encroached by roadways and buildings on both banks and flows narrowly through a hydraulically undersized channel comprised of vertical walls until reaching Columbus Park at STA 5+00. The Sheldrake River corridor within HRA 4 was also analyzed by the USACE in its 2017 basin study, which noted the undersized channel and structures.

Flooding around HRA 4 occurs frequently at industrial, commercial, and residential development on the floodplain and is widespread due to the low-lying nature of the topography (Figure 4-36). Inadequately sized bridges and an undersized channel drive flooding through this reach but are also influenced by flood stage conditions downstream at the Mamaroneck River confluence. HRA 4 accounted for about one third of all repetitive loss claims filed, or 57 structures, in the town of Mamaroneck in 2019. Critical facilities within the extents of HRA 4 include the village of Mamaroneck Department of Public Works building. Anchor businesses include a series of gasoline stations and grocery and supply stores. HRA 4 falls within a census block that has been designated as a Disadvantaged Community and is also mapped inside of two Potential Environmental Justice Areas. An overview map of HRA 4 is shown in Figure 4-37.

Figure 4-36: Photo from aerial drone taken after the remnants of Tropical Storm Ida swept through the area (provided by the village of Mamaroneck). A flooded Sheldrake River is seen at the center of the photo following the line of trees. The Waverly Avenue bridge (circled red) along with other roadways are shown under water. Several residential and commercial buildings on the floodplain along the Sheldrake River are shown inundated.



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HIGH RISK AREA 4 OVERVIEW
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FIG. 4-37

As previously stated, the stretch of the Sheldrake River encompassed in HRA 4 had been previously assessed by the USACE in the 2017 Mamaroneck and Sheldrake Rivers basin study. The study identified potential structural and nonstructural recommendations that could be implemented to reduce flood damage across the village of Mamaroneck and included the following within HRA 4:

- Roughly 3,470 feet of channel deepening and widening along the Sheldrake River, rectangular channel where needed. Channel bottom width of 20 feet from the confluence to Mamaroneck Avenue bridge. Channel bottom width of 30 feet from Mamaroneck Avenue to Fenimore Road bridge, rectangular to semitrapezoidal channel (Figure 4-38).

- Channel modifications would consist of constructing a trapezoidal channel with a natural channel bed and pitched or sloped vegetated banks. Retaining walls would be utilized for the sections of stream where a trapezoidal channel cannot be constructed, typically where buildings, roads, or other features may be affected.

- Removal and replacement of existing retaining walls and utilities along the length of channel, including at Waverly Avenue bridge

- Removal of several small bridges, including Center Avenue bridge, and replacement of two footbridges in Columbus Park.

- Nonstructural recommendations along the Sheldrake River, including structure elevations, ringwall levees, and/or floodproofing.

The recommendations provided by the USACE were considered but not evaluated in greater detail for this study.

Figure 4-38: Sheldrake River looking upstream near STA 28+71 towards Fenimore Road bridge. USACE proposed 8-foot concrete retaining walls along the Sheldrake River from STA 16+67 to STA 33+91.

Six public crossings span over the Sheldrake River in HRA 4, many of which are undersized and create a backwater that exacerbates flooding. The structures evaluated in this study include Mamaroneck Avenue (STA 6+52), Waverly Avenue (STA 19+34), Center Avenue (STA 21+77), Fenimore Road (STA 34+19), Rockland Avenue (STA 52+21), and I-95 (STA 62+11). In addition, two public footbridges cross the Sheldrake River at STA 0+20 and STA 3+03 in Columbus Park. However, these structures are insignificant obstructions during large-magnitude flood events on either the Sheldrake River or the Mamaroneck River and therefore were not assessed in detail. Through outreach and stakeholder engagement, it was learned that the Center Avenue bridge is a pedestrian bridge that is projected to be removed and that Waverly Avenue (Figure 4-39) will be replaced in 2023 both in accordance with USACE 2017 recommendations. All existing structures were incorporated into the HEC-RAS two-dimensional model developed for this study.

Figure 4-39: Looking at the Waverly Avenue bridge outlet. The town-owned bridge will be replaced with a structure that spans 6 feet wider than existing.

Hydraulic modeling suggests that flooding along the Sheldrake River is controlled by the undersized channel and bridges during lower-magnitude, more frequent flood events but switches over to a tailwater control during larger-magnitude, less frequent floods. For instance, under existing conditions, water is expected to break over the Sheldrake River's banks between STA 18+48 to STA 32+60 early during a 10-year event due to insufficient channel and bridge conveyance capacity. Under a 100-year flood event, backwaters generated by the Mamaroneck River during a coincident peak flood event travel up the Sheldrake River for almost a mile, essentially drowning out the area, and results in 1.5 to 3.0 feet of additional upstream flood depths. Because of the backwater influence from the Mamaroneck River, implementation of any flood mitigation projects along the Sheldrake River should occur after employing the recommendations described for HRA 1 downstream. Prioritization of projects, discussed in greater detail in Section 5.13 of this report, is critical to fully realize the benefits of flood reduction projects within HRA 4.

For the analysis of proposed flood mitigation alternatives within HRA 4, implementation of downstream improvements at HRA 1 was assumed. One flood mitigation alternative investigated restoring the channelized Sheldrake River from STA 5+00 to STA 30+00 to at least bankfull dimensions, or a width of 41 feet. Channel restoration would entail excavation of a properly sized multistage channel and floodplain, installation of grade control structures and/or scour protection measures along the restored channel to prevent channel incision and protect upstream infrastructure, and installation of native plantings. Because of the tightly developed overbanks along this stretch of the Sheldrake River, two different approaches to channel restoration were considered:

1. A short-term floodplain bench creation approach that prioritizes minimal disturbance to existing roadways and buildings. Floodplain bench creation would alternate between river-left and river-right, consuming sections of Plaza Avenue, Northup Avenue, Center Avenue, and Waverly Avenue. The floodplain bench configuration modeled in this study is illustrated in Figure 4-40 and summarized below.

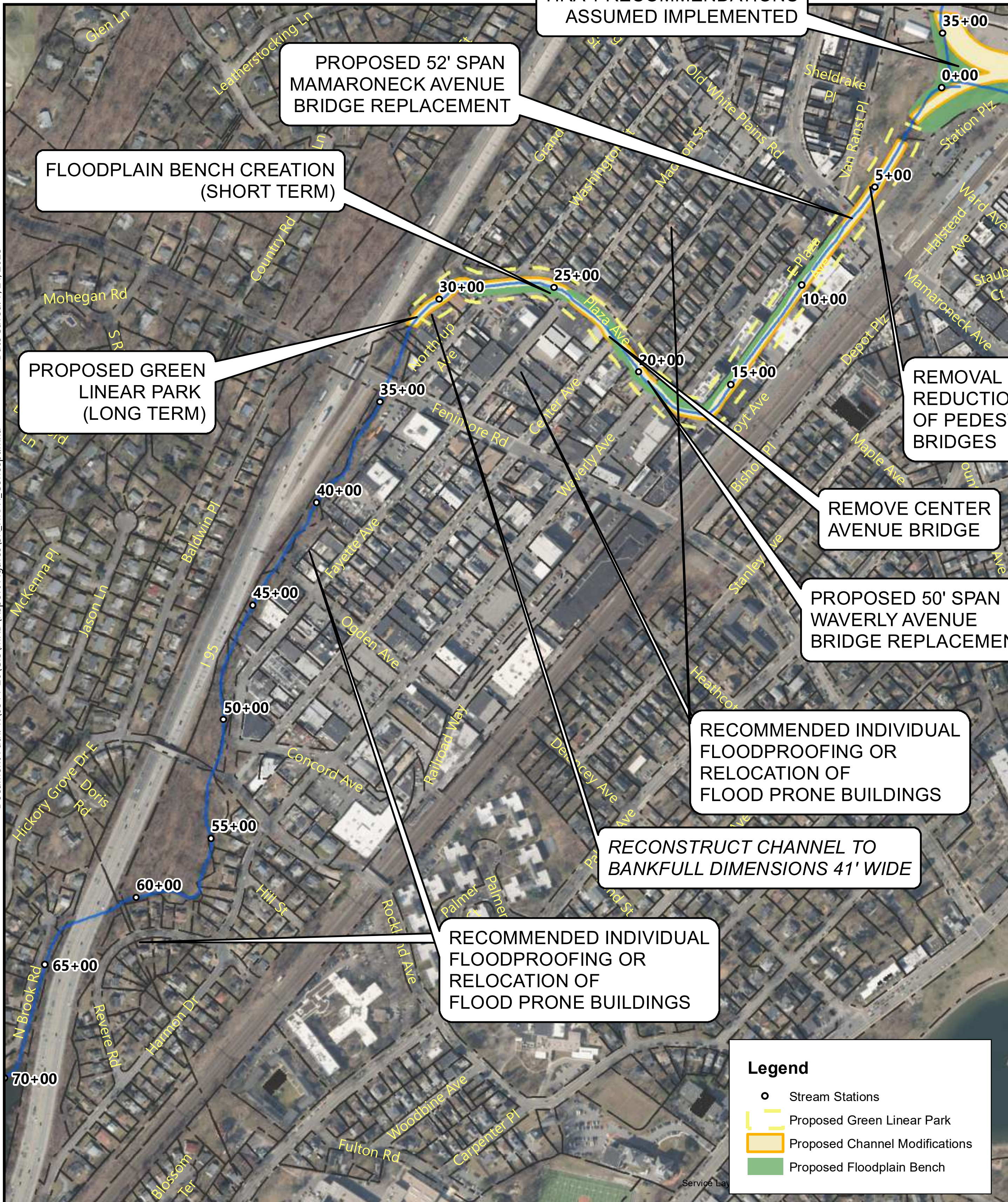
    a. Floodplain bench #1 from STA 7+00 to STA 19+15 along the left bank of the Sheldrake River about 1,160 feet long. The first 916 feet of floodplain is excavated 5 feet below existing ground and measures approximately 20 feet wide. The remaining 245 feet of floodplain bench is excavated 3 feet below existing ground and varies between 25 feet and 50 feet wide.

    b. Floodplain bench #2 from STA 18+28 to STA 21+88 along the right bank of the Sheldrake River. Excavated about 4 feet below the current ground level approximately 350 feet long and of varying widths between 16 feet and 32 feet. The floodplain bench would consume a portion of a scrapyard and a parking lot along Waverly Avenue to the right (southwest).

    c. Floodplain bench #3 from STA 21+36 to STA 24+45 along the left bank of the Sheldrake River. Excavated about 5.5 feet below current ground level and approximately 323 feet long by 32 feet wide. Conversion of Plaza Avenue to a single-lane road would be required.

    d. Floodplain bench #4 from STA 24+05 to STA 29+00 along the right bank of the Sheldrake River. Excavated at approximately 4 feet below existing ground and measuring 460 feet long by 25 feet wide. The floodplain bench would consume a section of Northup Avenue.

2. A long-term, more ambitious riparian corridor creation extending from Columbus Park upstream to STA 30+00. This initiative would require gradual acquisition and demolition of flood-prone properties, followed by the establishment of a floodable linear park along the Sheldrake River. During times of normal flow, the area could be used by residents and visitors as a scenic park and linear trail, featuring walking and biking trails, lunch tables, food trucks, and other features. During high flows, the park would be designed to function as a floodplain, conveying excess flows while reducing flooding along the Sheldrake River. The approximate project footprint for this alternative is depicted by the yellow dashed outline on Figure 4-40.



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HRA 4: CONCEPT PLAN

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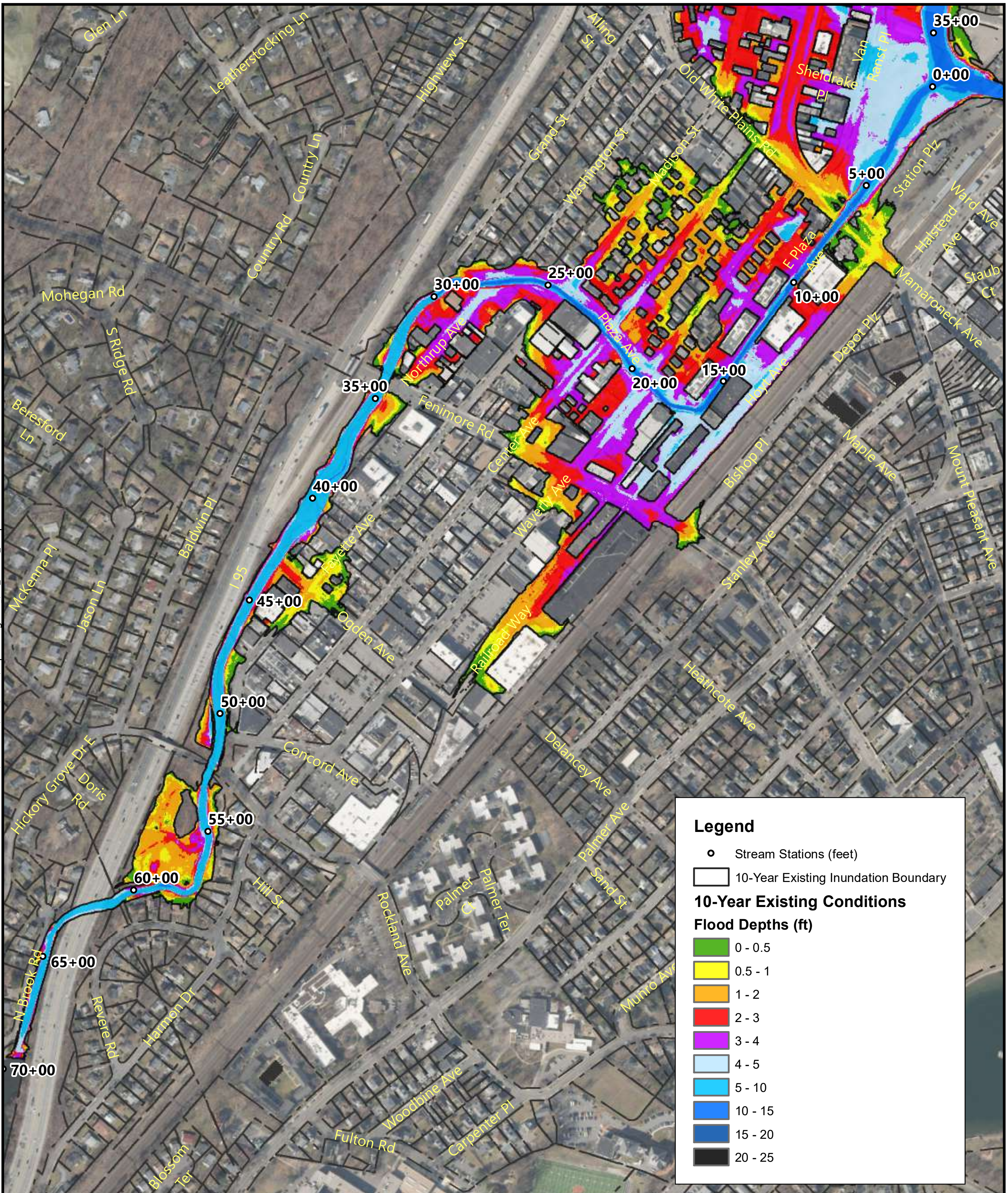
FIG. 4-40

For either scenario, increasing the Waverly Avenue and Mamaroneck Avenue bridges to 50 feet and 52 feet, respectively, or with hydraulically unobtrusive replacements to span the new channel and floodplain would be required. Removal of the Center Avenue bridge is also recommended, as being planned by the village. Implementing the recommendations with minimal disturbance can reduce flooding depths by up to about 3.7 feet at the confluence and 1.7 feet upstream near Rockland Avenue in the projected future 100-year flood event. This is recommended at a minimum, although the more ambitious alternative could further reduce upstream flooding and improve infrastructure resilience. Establishing a riparian corridor could further reduce flood depths in the vicinity by an additional 0.5 feet in the existing and future 100-year storm events. Under these scenarios, flooding would be drastically reduced but not eliminated. Wherever flooding is expected to persist, individual property flood protection measures are recommended especially for homes and businesses within the proposed conditions 100-year floodplain along Old White Plains Road/Mamaroneck Avenue, Plaza Avenue, Waverly Avenue, Center Avenue, Madison Street, Washington Street, Northup Avenue, Fayette Avenue, and Ogden Avenue. Individual flood protection measures may include floodproofing, elevation of the structure, or relocation, depending on the building type, use, and projected frequency and depth of flooding.

The bridges carrying Fenimore Road, Rockland Avenue, and I-95 were determined to be hydraulically adequate and capable of conveying the existing and future 100-year storms with minimal backwater. The Fenimore Road and Rockland Avenue bridges were shown to be within the influence of the Mamaroneck River backwater, and their hydraulic performance would marginally improve under proposed conditions. No further action aside from routine inspection and maintenance are being recommended for these bridges. When due for routine replacement, a rigorous hydraulic and hydrologic analysis is recommended as a component of all bridge designs and should begin at the downstream end of the HRA and proceed upstream. Removal or reduction of pedestrian bridges across the Sheldrake River is recommended. Although structures such as these are minor impediments to flood flow, they are susceptible to snagging woody debris during a flood, which can worsen flooding conditions.

Figure 4-41 shows modeled flooding depths in the Sheldrake River section of HRA 4 under existing conditions in the 10-year flood event. Figure 4-42 shows the 10-year food event under proposed conditions, which includes the recommended replacement of bridges and floodplain benches alternative. Figures 4-43 and 4-44 depict existing and proposed conditions, respectively, during the 100-year flood event.



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HRA 4: 10-YEAR EXISTING CONDITIONS FLOOD DEPTHS

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FIG. 4-41

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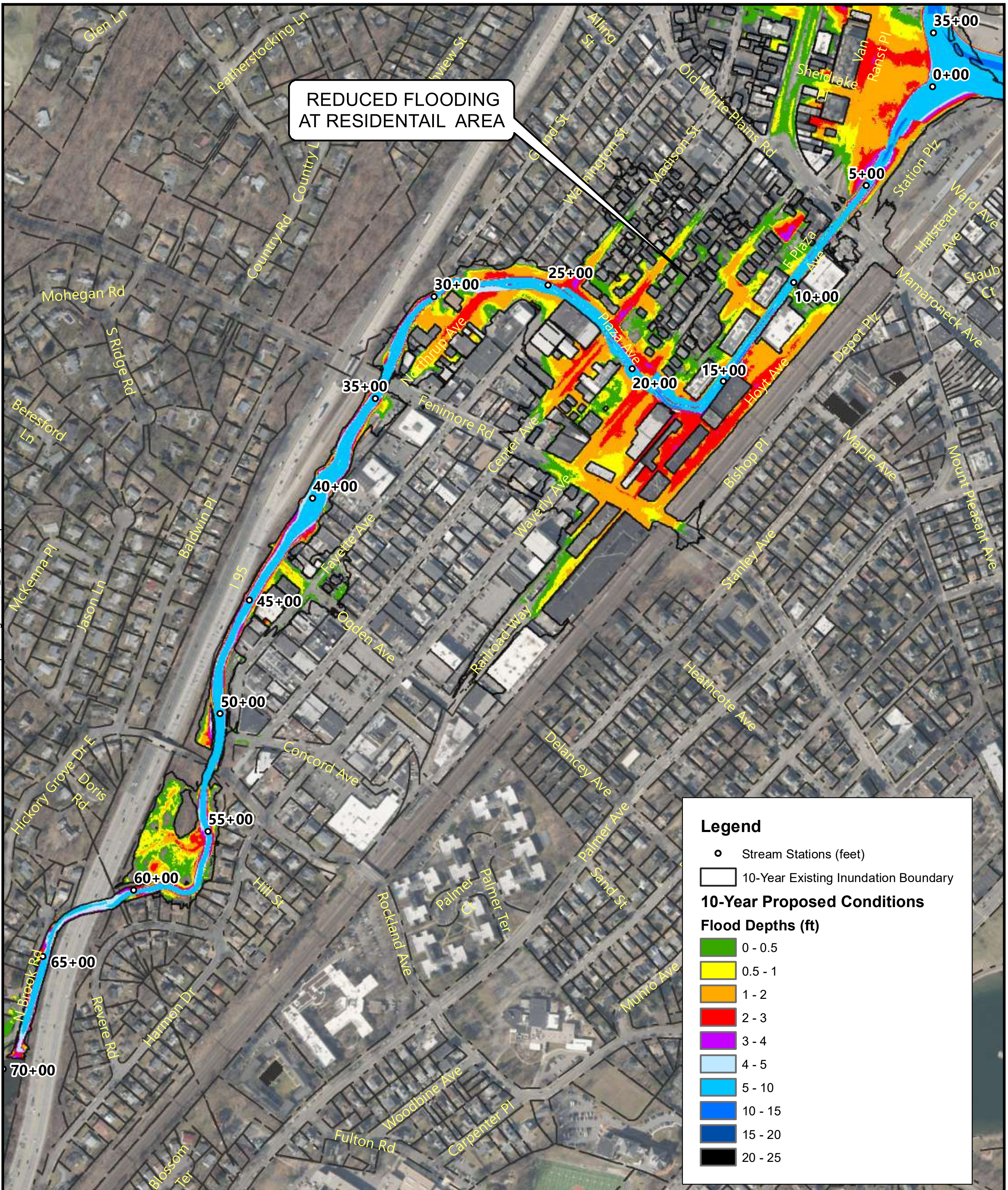

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HRA 4: 10-YEAR PROPOSED CONDITIONS FLOOD DEPTHS

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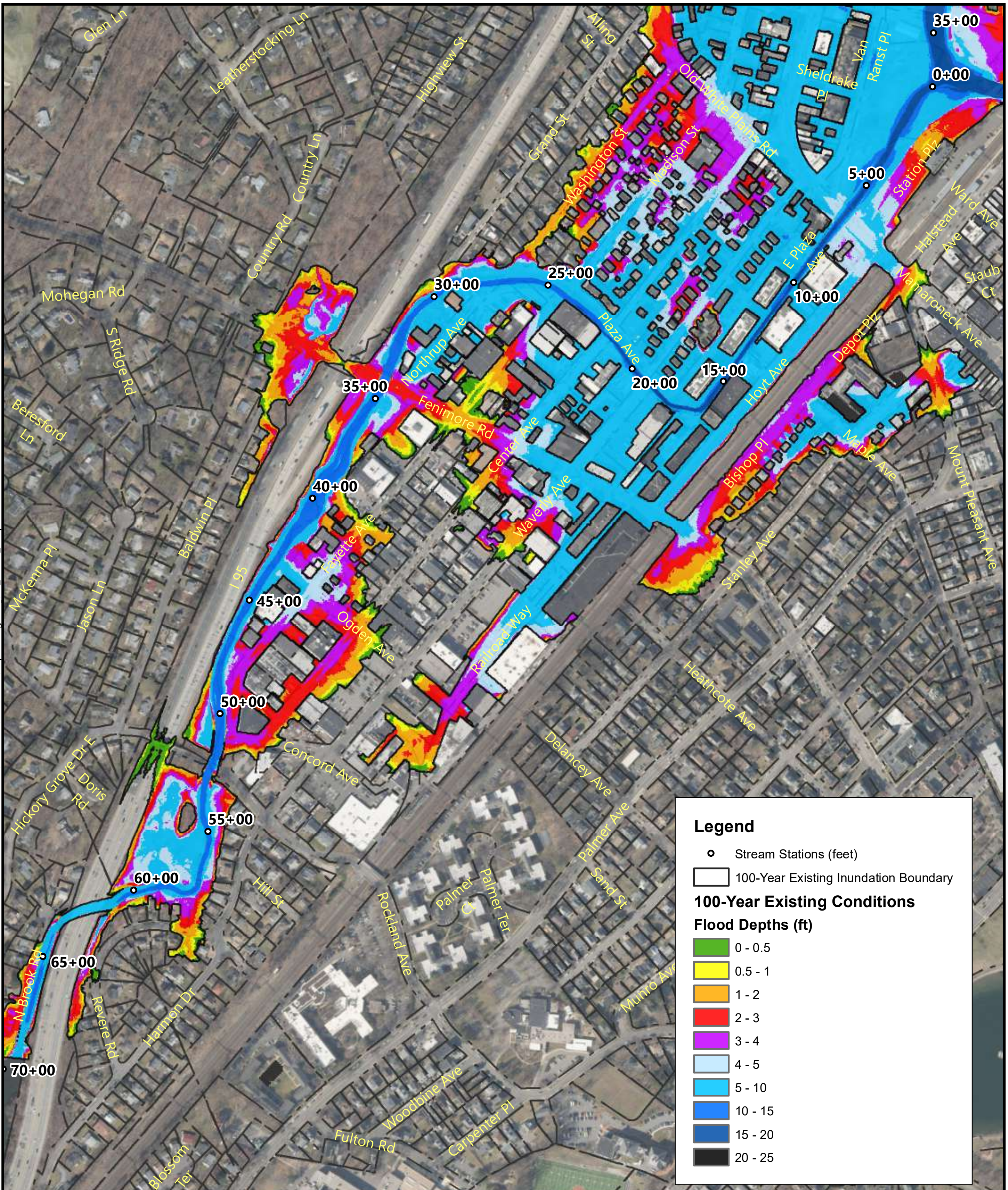
FIG. 4-42



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HRA 4: 100-YEAR EXISTING CONDITIONS FLOOD DEPTHS

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FIG. 4-43

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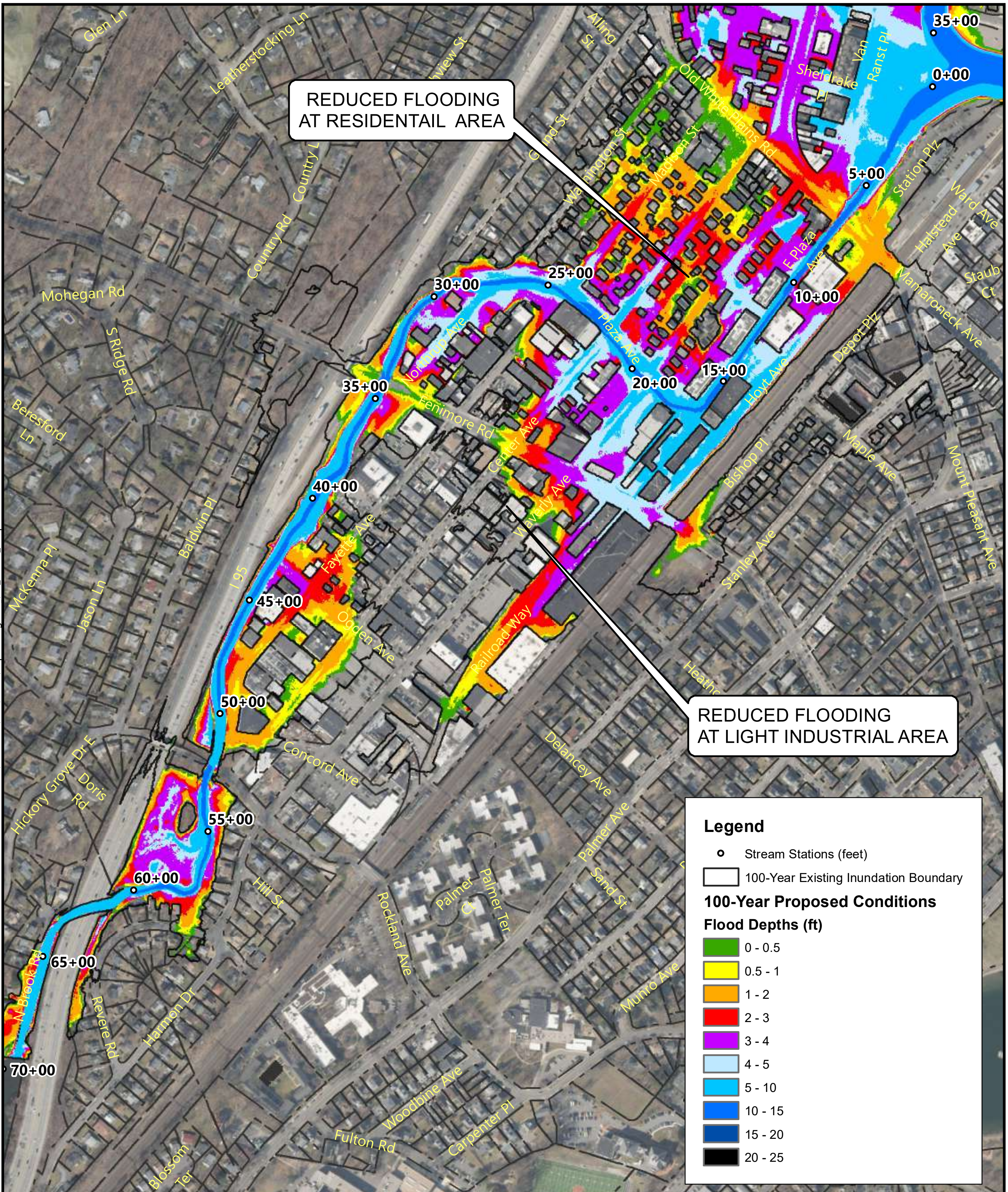

HRA 4: 100-YEAR PROPOSED CONDITIONS FLOOD DEPTHS

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FIG. 4-44

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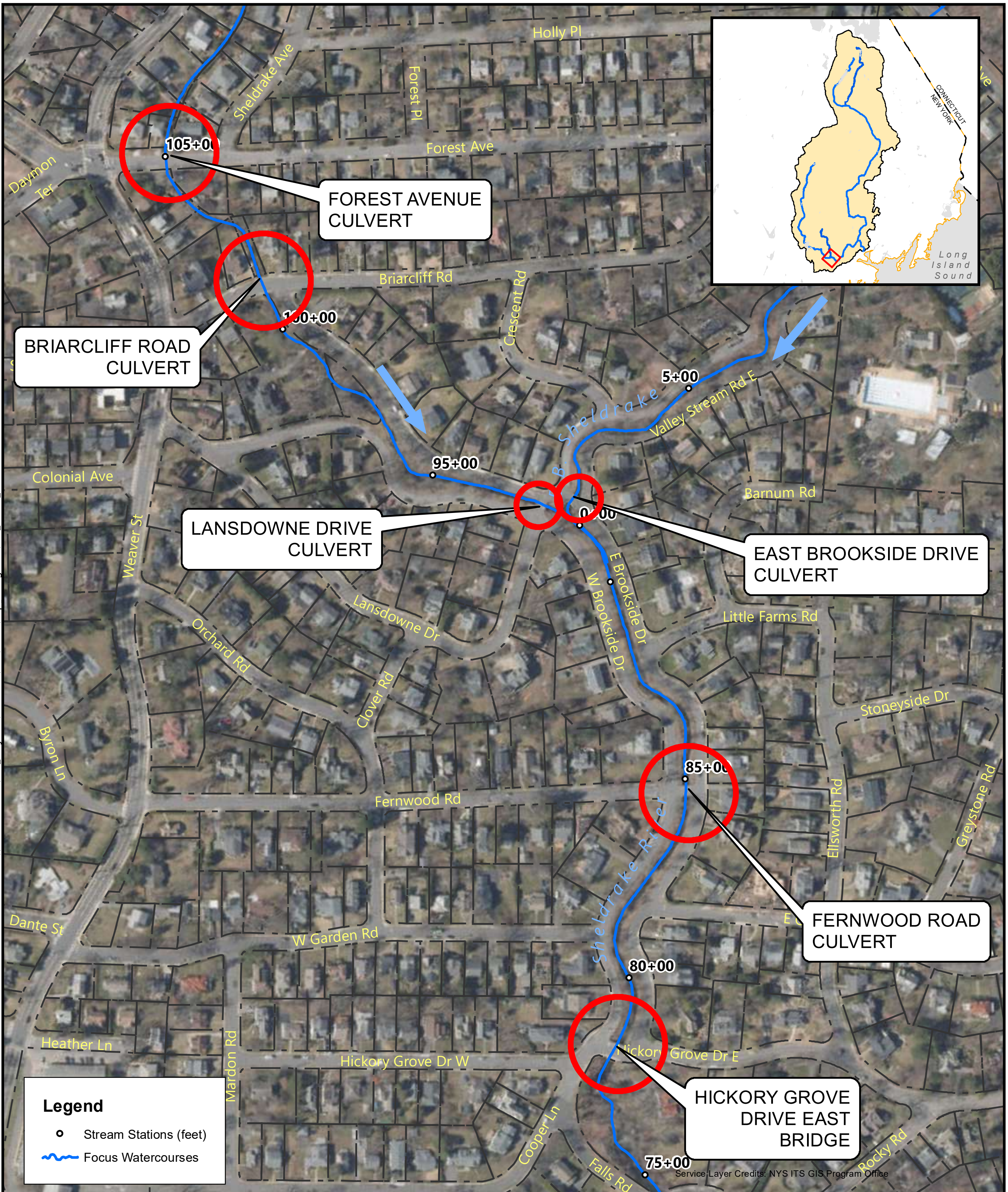
4.5 HIGH RISK AREA 5 – SHELDRAKE RIVER AT BROOKSIDE DRIVE NEIGHBORHOOD

HRA 5 encompasses the section of the Sheldrake River at the Brookside Drive neighborhood between STA 70+00 and STA 100+00 in northern Larchmont. The river flows through a trapezoidal channel with no floodplain for most of this section and is narrowly squeezed between East Brookside Drive and West Brookside Drive (Figure 4-45). The East Branch Sheldrake River tributary enters the Sheldrake River from the north near STA 91+95 and is similarly encroached upon by roadways on either bank. Six public stream crossings were assessed for HRA 5, four culverts and a bridge over the Sheldrake River and one culvert over the East Branch Sheldrake River tributary. An overview map of HRA 5 is shown in Figure 4-46. Anecdotal reports from the public indicate that homes along East Brookside Drive and West Brookside Drive experience frequent flooding in their basements and first floors when the Sheldrake River spills over its banks. Vehicles parked alongside the river were reported to have been swept away by the flood currents in the past. HRA 5 accounted for roughly 28 percent, or eight structures, of all repetitive loss claims filed in the village of Larchmont in 2019. Claimed losses occurred on Valley Stream Road East, East Garden Road, Briarcliff Road, Forest Avenue, and Weaver Street.

Figure 4-45: Looking upstream of the Hickory Grove Drive East bridge over the Sheldrake River at STA 78+50. The river flows through a uniform trapezoidal channel for most of its length within HRA 5.

Roadways over the Sheldrake River within the extents of HRA 5 include Hickory Grove Drive East (STA 78+32), Fernwood Road (STA 84+78), Lansdowne Drive (STA 92+50), Briarcliff Road (STA 101+16), and Forest Avenue (STA 105+00). All structures are comprised of open-bottom concrete decks of varying spans. A private footbridge spans the Sheldrake River at STA 99+31. East Brookside Drive is carried over the East Branch Sheldrake River by an open-bottom concrete deck structure at STA 0+73.



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HIGH RISK AREA 5 OVERVIEW

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FIG. 4-46

According to the hydraulic model, all crossings spanning the Sheldrake River and its tributary are severely undersized and contribute to flooding. Moreover, in the hydraulic model, the existing channel is shown lacking the hydraulic capacity to convey flood flows and is also responsible for flooding.

Widening the Sheldrake River channel to a bankfull width of 39 feet throughout the 2,500-foot-long project reach would result in substantial reductions in flooding. Channel modifications would require converting sections of Brookside Drive East and West to one-way, single-lane roads. Replacement of the bridge structures under Forest Avenue, Briarcliff Road, and Hickory Grove Drive East with 40-foot single-span structures would be necessary to convey the 100-year future flood with freeboard. Removal of Fernwood Road and Lansdowne Drive over the Sheldrake River is recommended. Additionally, channel profile modifications would further enhance conveyance and should be explored where bedrock in the channel is absent. A concept map showing these improvements is shown in Figure 4-47. A summary of the hydraulic findings and the recommended proposed replacement structures, evaluated under current and future hydrologic conditions, is listed in Table 4-1. For this analysis, it was assumed that the private driveway bridge at STA 99+31 would be removed and relocated off West Brookside Drive within the same property bounds.

The East Brook Drive culvert over the East Branch Sheldrake River is located near the confluence with the Sheldrake River, and the structure's hydraulics are controlled by the flood levels at the mainstem. Implementing the channel rework and structural improvements described prior along the Sheldrake River will reduce water surface elevations near the Brookside Drive East culvert, but the current structure is still shown overtopping in the 10-year flood event. Replacing the culvert with a 40-foot-span bridge will pass the modeled 10-year flood event; however, the structure is drowned out by the Sheldrake River tailwater conditions during the 50-year and 100-year flood events. To convey the desired design flood, substantial rework of the channel and roadway profile, in addition to a large bridge structure, would be necessary and would be highly uneconomical. Demolishing the existing culvert and installing an adequately sized structure between 260 to 600 feet upstream of the confluence, beyond the tailwater influence from the Sheldrake River, should be considered. Replacement of the East Brook Drive culvert with a 24-foot-wide structure is suggested. Rigorous hydraulic and hydrologic analyses are recommended as a component of all culvert replacement designs and should begin at the downstream end of the HRA and proceed upstream.

Flood reductions under the 10-year flood event are illustrated in Figure 4-48 (existing conditions) and Figure 4-49 (with proposed improvements implemented at all crossings). Flood reductions during the 50-year flood event are illustrated in Figure 4-50 (existing conditions) and Figure 4-51 (proposed conditions). Flood reductions during the 100-year flood event are illustrated in Figure 4-52 (existing conditions) and Figure 4-53 (proposed conditions). All proposed conditions flood depth mapping along the East Branch Sheldrake River assumes removal of the East Brookside Drive culvert. According to the resultant flood depth mapping, under proposed conditions, approximately 38 buildings would be partially or fully removed from the mapped inundation extents of the base flood or 100-year flood event.

Table 4-1 Summary of Hydraulic Analysis for HRA 5

STREAM CROSSING (STREAM STATION)	EXISTING STRUCTURE DESCRIPTION	EXISTING FLOOD CAPACITY	MODELED REPLACEMENT STRUCTURE	REPLACEMENT STRUCTURE FLOOD CAPACITY	
				Current Hydrology	Projected Future Flows to Account for Climate Change
Hickory Grove Drive East (STA 78+32)	24’-span by 7’-rise open-bottom bridge	10-Year	40’-span open deck bridge	500-Year	100-Year
Fernwood Road (STA 84+78)	17’-span by 6’-rise open-bottom culvert	<10-Year	Removal	--	--
Lansdowne Drive (STA 92+50)	12’-span by 4.5’-rise open-bottom culvert	<10-Year	Removal	--	--
Private Footbridge (STA 99+31)	16’-span by 5’-rise open-bottom culvert	10-Year	Removal and relocation off West Brookside Drive	--	--
Briarcliff Road (STA 101+16)	14’-span by 5’-rise open-bottom culvert	<10-Year	40’-span open deck bridge	500-Year	100-Year
Forest Avenue (STA 150+00)	11’-span by 4’-rise open-bottom culvert	<10-Year	40’-span open deck bridge	500-Year	100-Year
East Brookside Drive (STA 0+73 – East Branch Sheldrake River)	15’-span by 5’-rise open-bottom culvert	<10-Year	Removal and relocation – 24’ suggested span	--	--

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HRA 5: CONCEPT PLAN

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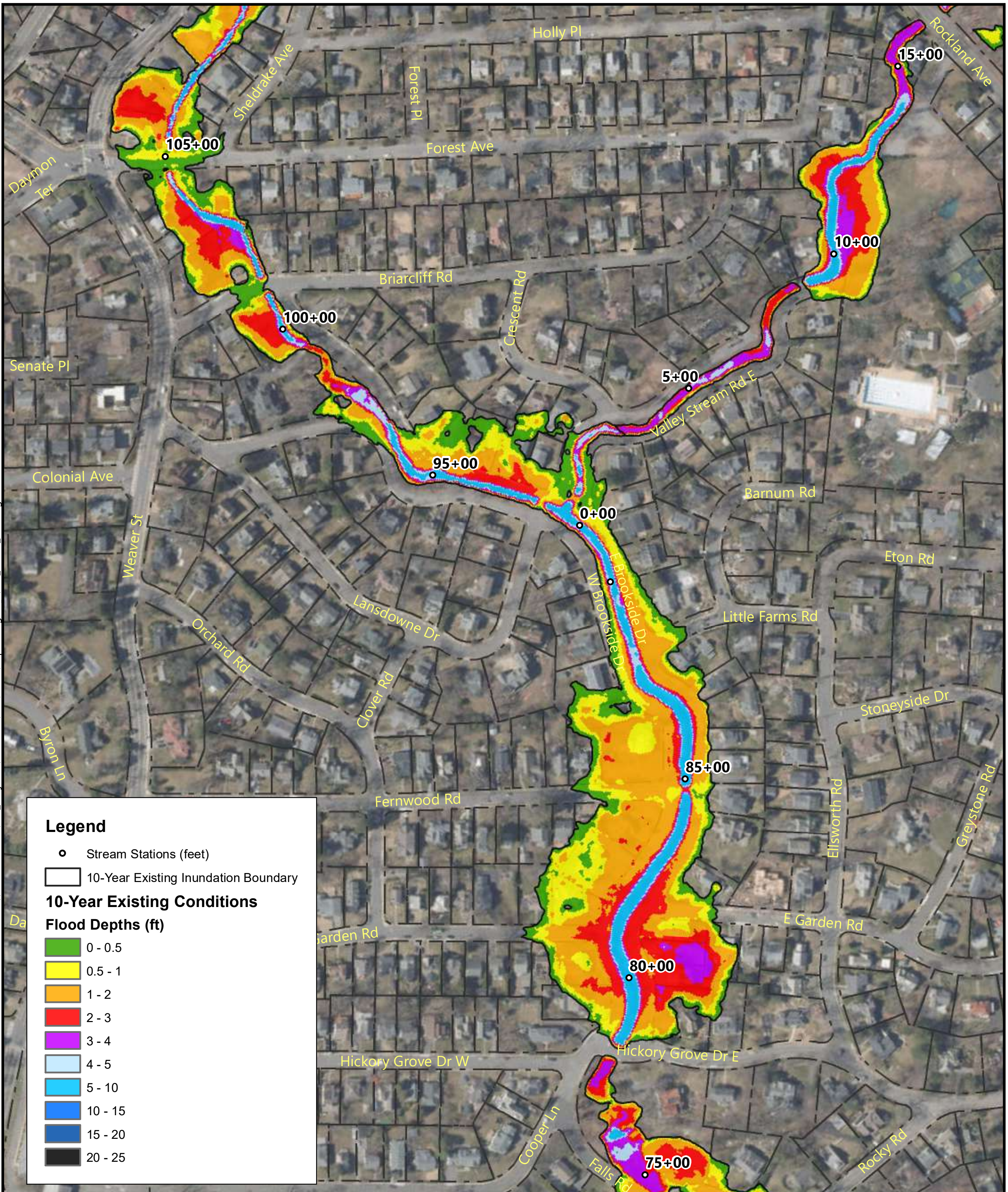
FIG. 4-47



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HRA 5: 10-YEAR EXISTING CONDITIONS FLOOD DEPTHS

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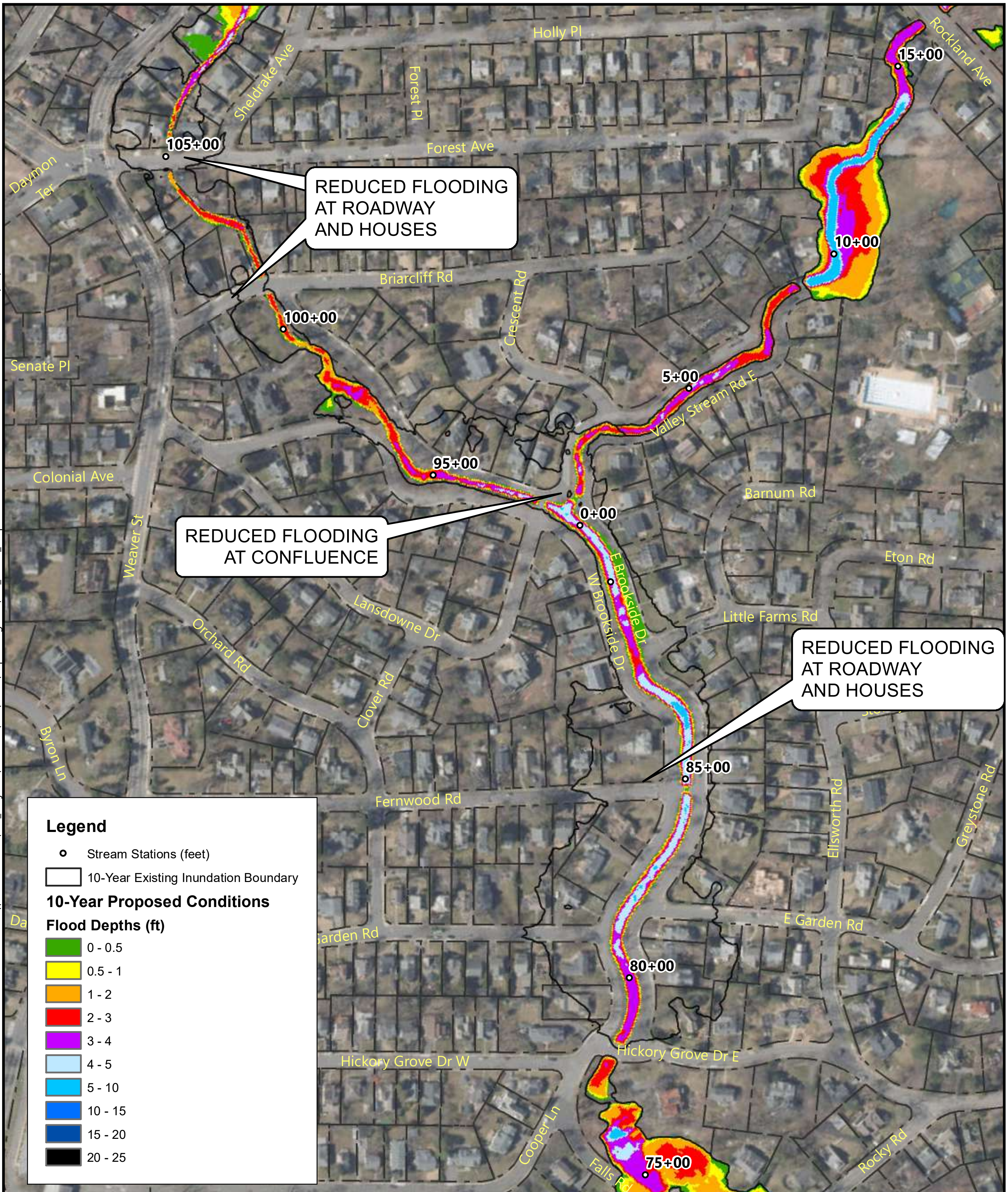
FIG. 4-48



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HRA 5: 10-YEAR PROPOSED CONDITIONS FLOOD DEPTHS

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FIG. 4-49

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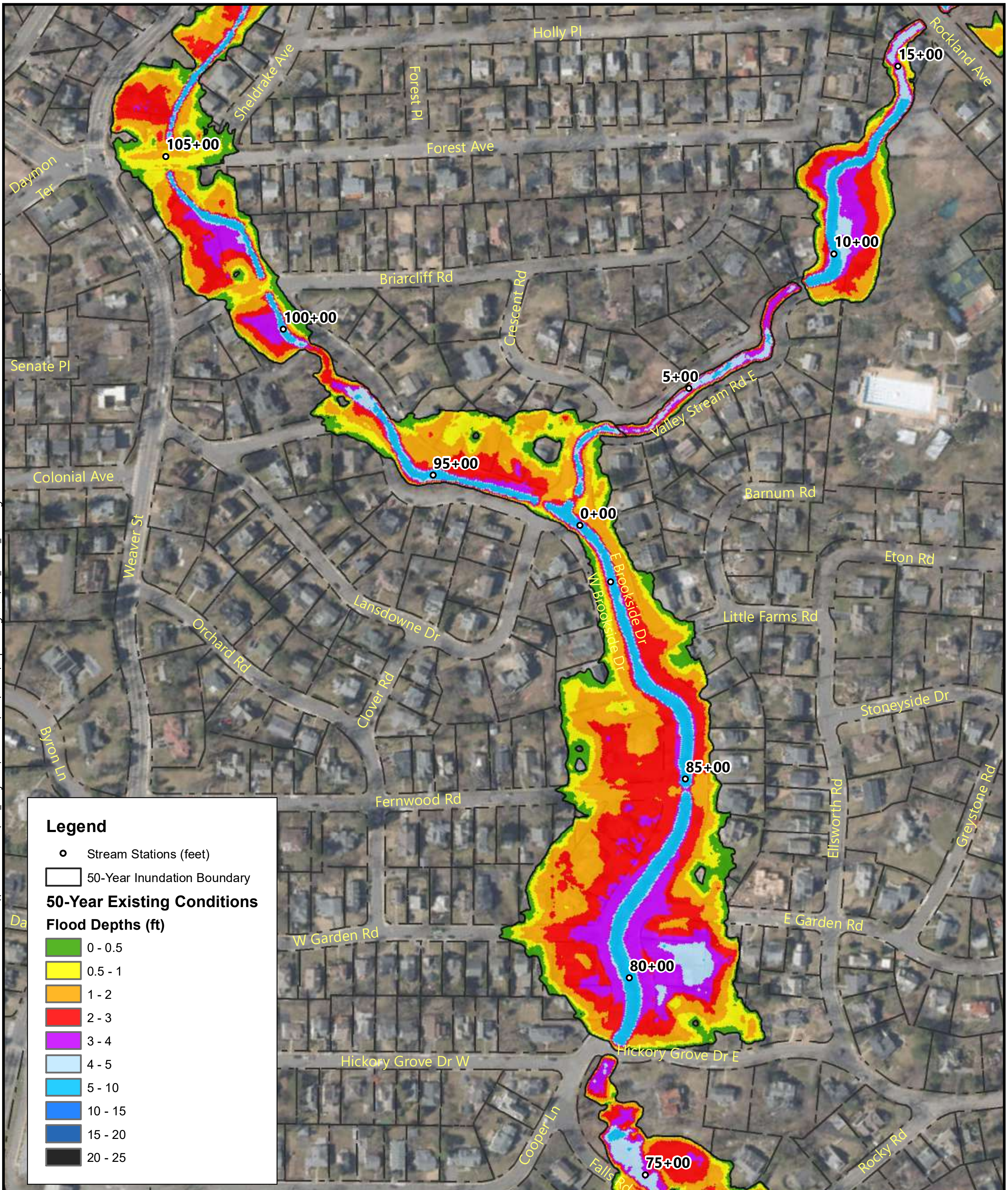

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HRA 5: 50-YEAR EXISTING CONDITIONS FLOOD DEPTHS

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FIG. 4-50

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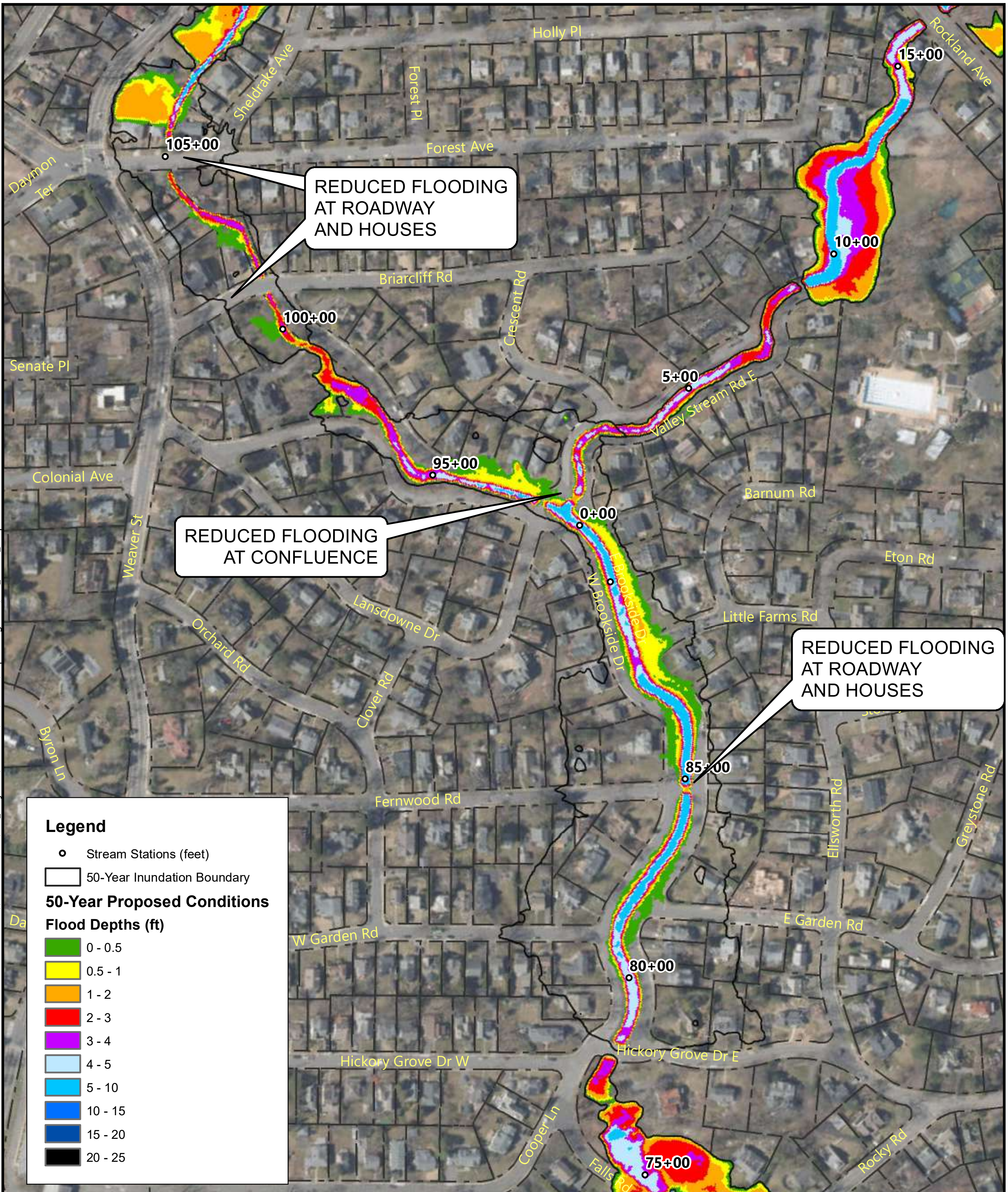

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HRA 5: 50-YEAR PROPOSED CONDITIONS FLOOD DEPTHS
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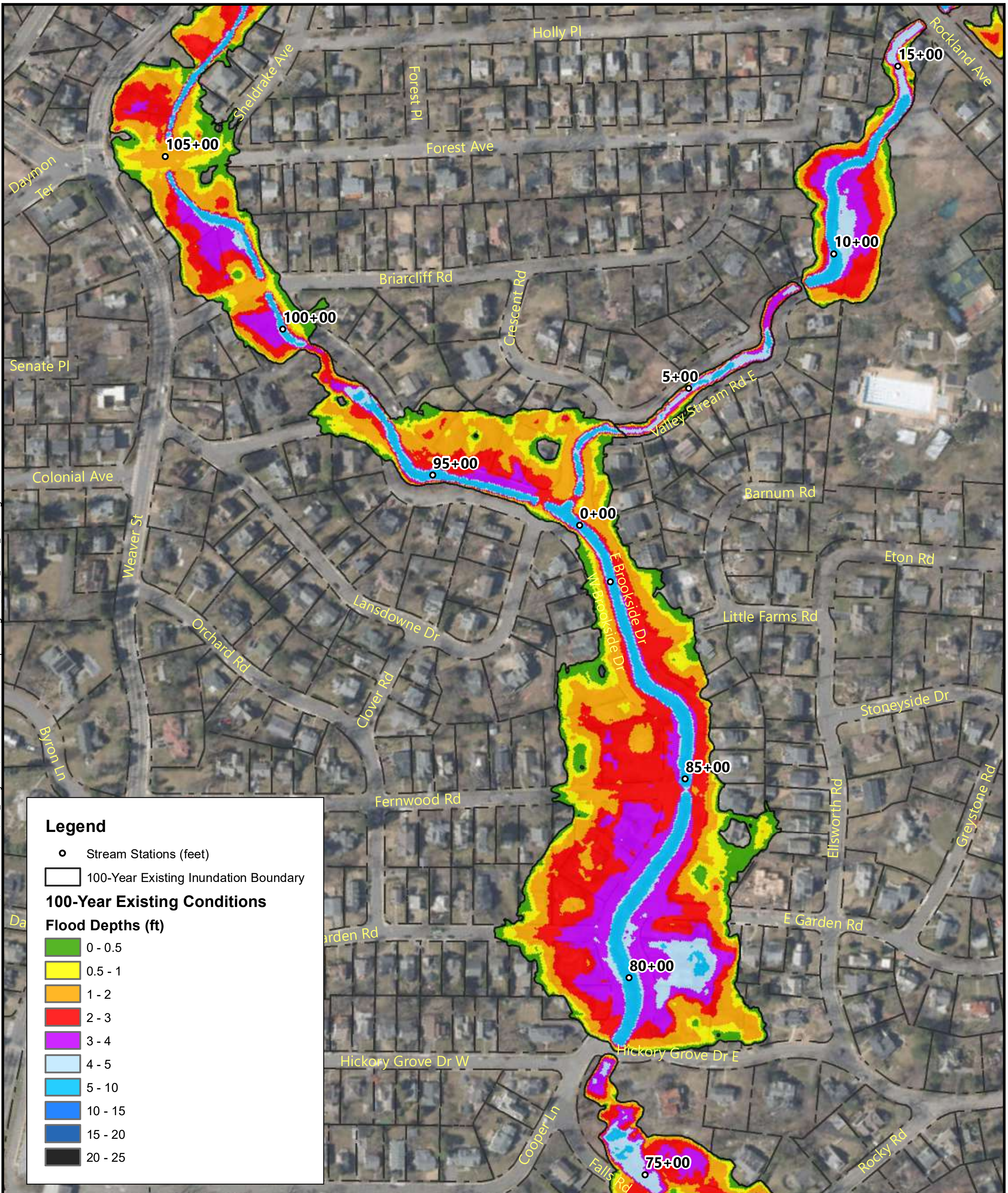
FIG. 4-51



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HRA 5: 100-YEAR EXISTING CONDITIONS FLOOD DEPTHS

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FIG. 4-52

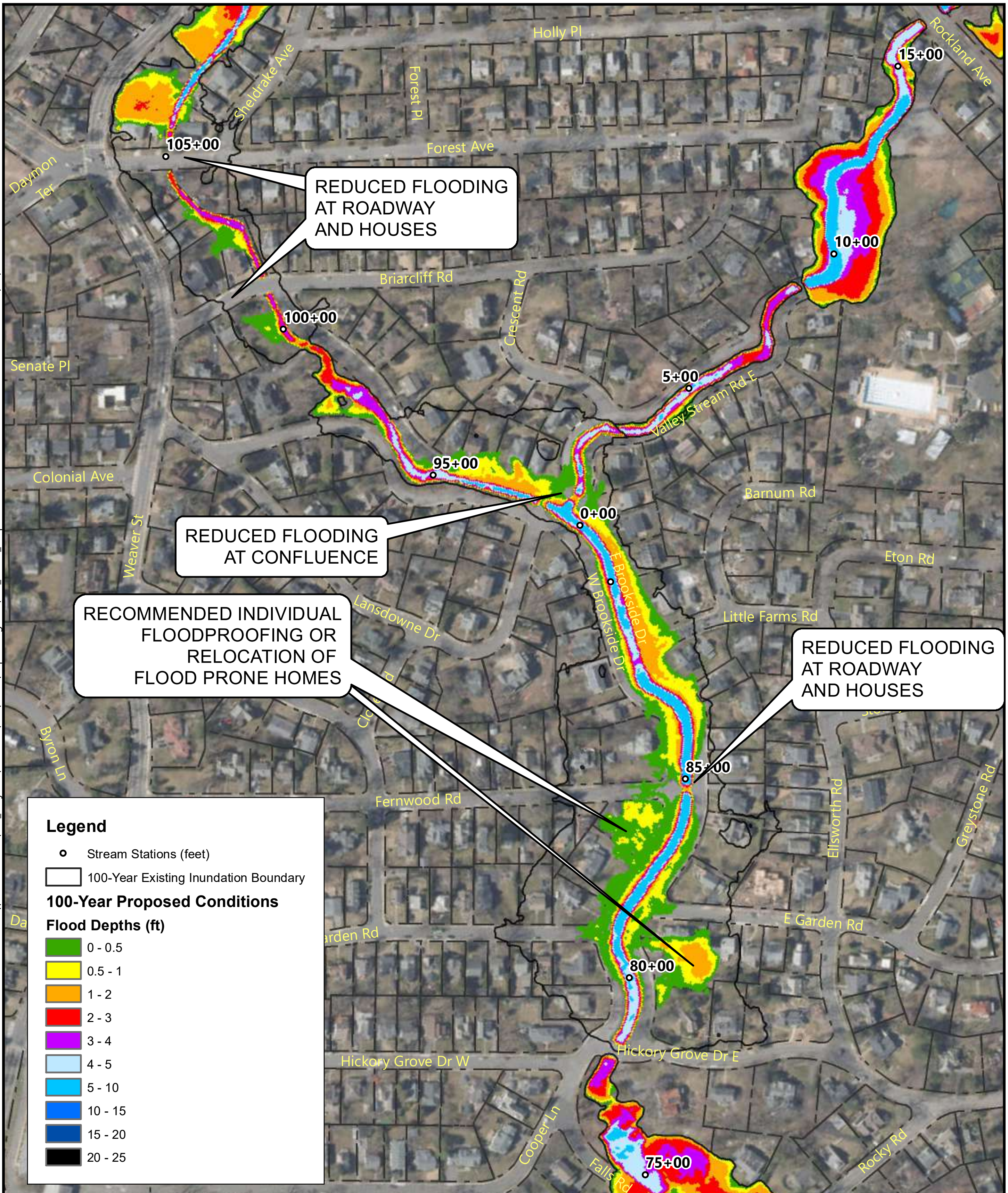

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FIG. 4-53

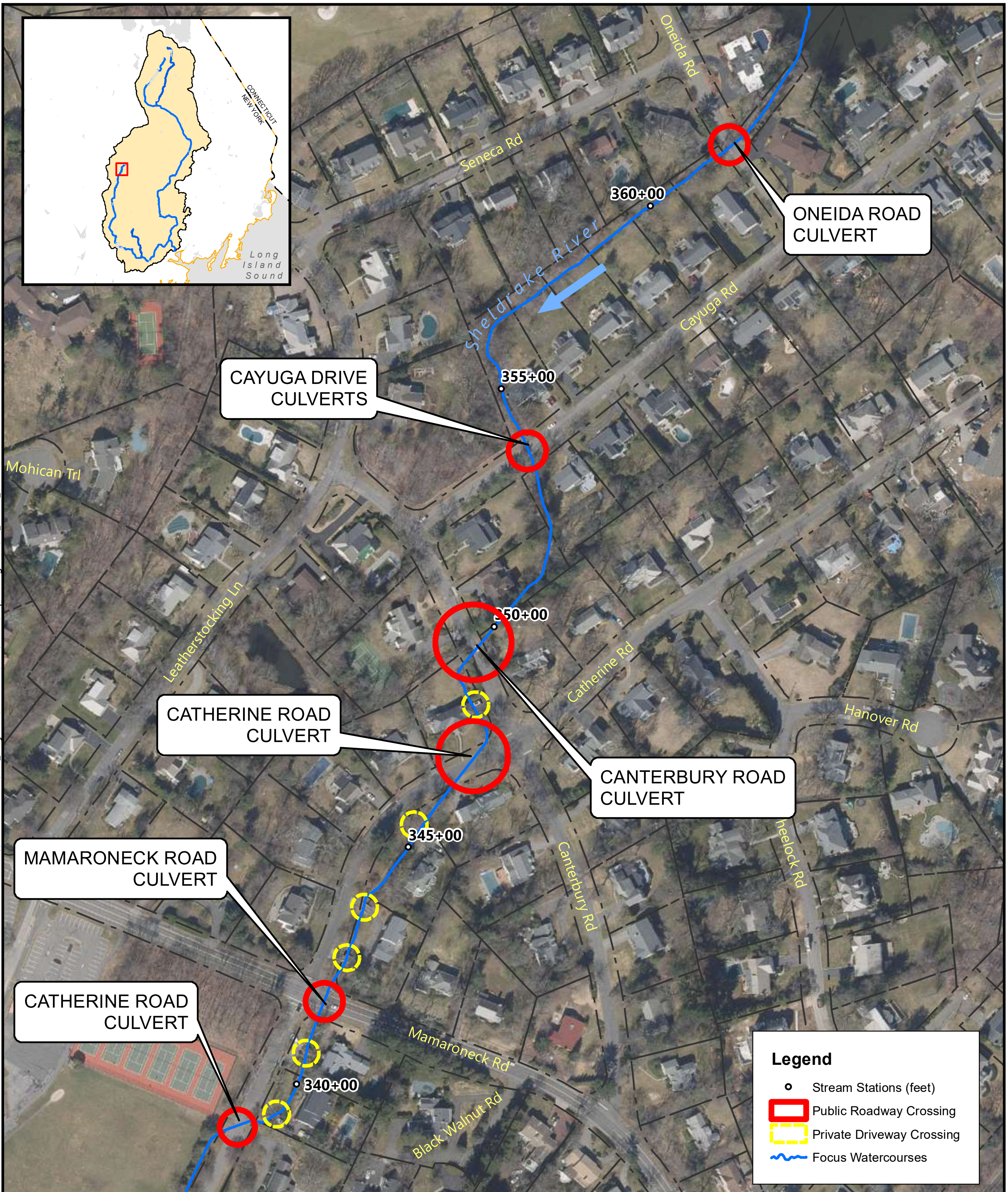
4.6 HIGH RISK AREA 6 – SHELDRAKE RIVER HEADWATERS

HRA 6 is located near the headwaters of the Sheldrake River and extends roughly from STA 340+00 upstream to STA 365+00 in the town of Scarsdale. The river at this location is very flat, with a slope of about one tenth of a percent or about 7 feet per mile and has a contributing watershed area of 0.7 square miles. At the upstream limits of the Sheldrake River (STA 365+00) is an unregistered dam and private pond where the river originates. Public reports indicate that residential flooding is a persistent issue along Seneca Road, Cayuga Road, and Oneida Road. Repetitive loss records indicate that 11 properties along these roads, as well as Catherine Road and Leatherstocking Road, account for about 61 percent of all claims made in Scarsdale in 2019.

The Sheldrake River is spanned by 12 structures, six private driveways (Figure 4-54) and six public roadways (Figure 4-55), within the extents of HRA 6. Privately owned driveway crossings over the Sheldrake River are predominantly comprised of single-pipe culverts of varying materials, with a diameter ranging from 4 to 7 feet. The structure under Catherine Road (STA 338+55) is an open-bottom concrete culvert that spans 10 feet wide by approximately 3 feet high. Carrying Mamaroneck Road at STA 341+67 is a 5-foot-wide by 3-foot-high corrugated metal arch culvert. The structures under Catherine Road (STA 346+87) and Canterbury Road (STA 349+48) are both 4-foot-diameter corrugated metal pipes that measure 115 feet and 180 feet long, respectively. Cayuga Road (STA 353+65) is carried by a concrete box culvert that measures approximately 6 feet wide by 3 feet high. The upstream-most structure under Oneida Road (STA 361+88) is an arch corrugated metal culvert approximately 5 feet wide by 3 feet high. In the hydraulic model, all 12 structures within HRA 6 have a capacity of less than the modeled 10-year flood event and drastically obstruct flood flows, leading to widespread flooding. An overview map of HRA 6 is depicted in Figure 4-56.

Figure 4-54: A 4-foot-diameter concrete private driveway culvert near STA 318+18 (looking upstream)

Figure 4-55: Public crossings of varying types over the Sheldrake River. (Top Left) Catherine Road crossing looking upstream, exposed iron pipe runs across the bridge outlet. (Top Right) Mamaroneck Road culvert inlet with stacked stone abutments and headwall. (Bottom Left) Catherine Road culvert inlet immediately downstream of private driveway crossing illustrated in Figure 4-54. (Bottom Right) Oneida culvert outlet looking upstream.



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HIGH RISK AREA 6 OVERVIEW

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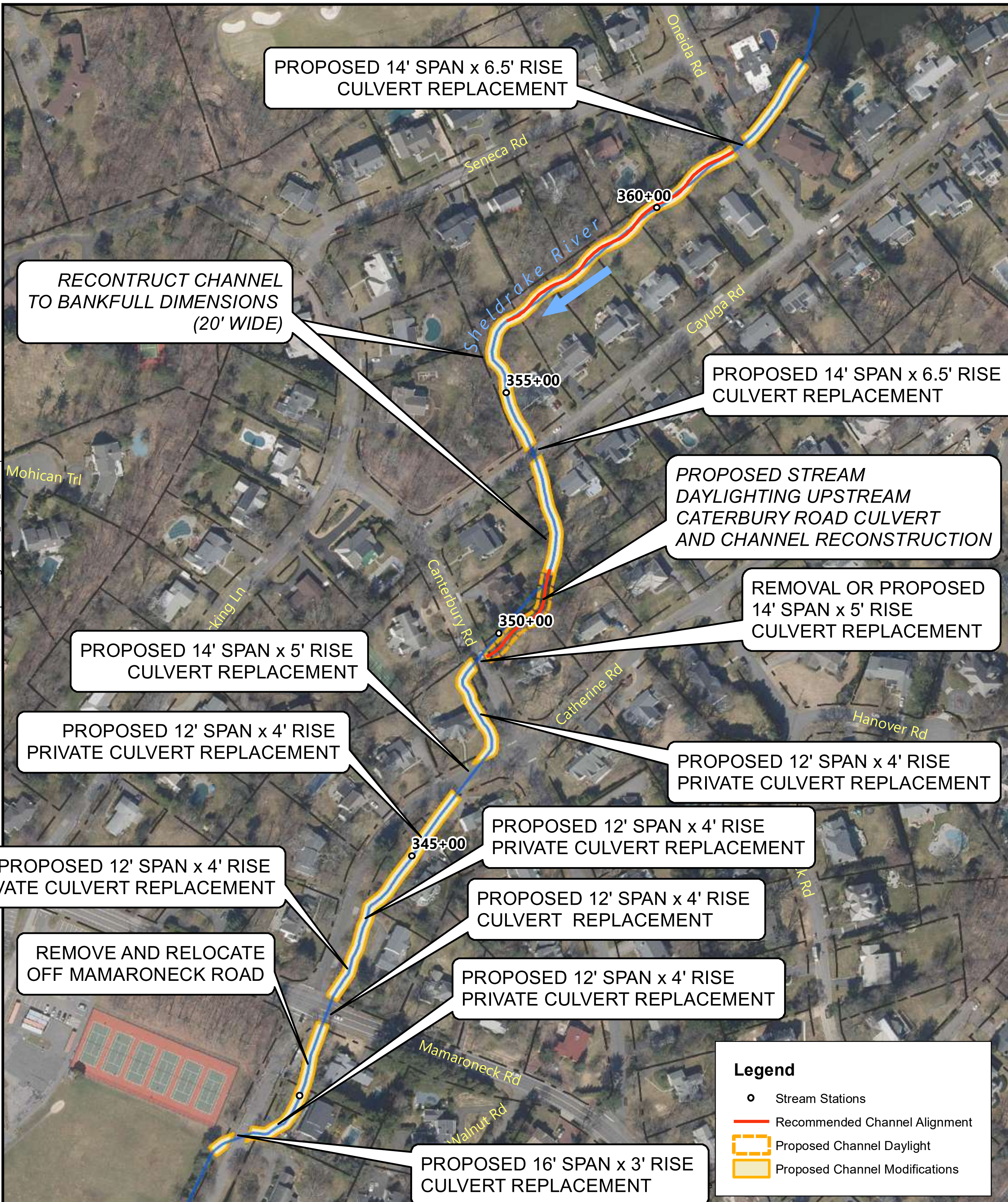
FIG. 4-56

Replacement of all public crossings with single-span structures of varying widths between 10 and 16 feet and widening the channel to a bankfull width of 21 feet over roughly 2,000 feet of stream length would result in substantial reductions in flooding. Modifications to the channel or roadway profile may be required in spots to allow for the installation of a replacement structure with a taller vertical opening. Additionally, replacement of the six private driveway crossings with adequately sized structures will be necessary to optimize flood reduction benefits resulting from upsizing the public roadway crossings. Recommendations for private driveway relocations were determined using 2017 satellite imagery and tax parcel information for Westchester County where property entrances could avoid going over the Sheldrake River. A concept map showing recommended improvements is shown in Figure 4-57.

Given the length of the culverts under Catherine Road at STA 346+87 and Canterbury Road at STA 349+48, daylight of the stream where it is not required to run underground or removal and decommission of the roadway is recommended. Daylighting the structure would include, at minimum, physically uncovering the culvert, removing it, and restoring the channel. Channel restoration would include excavation of a properly sized, multistage channel and floodplain, installation of grade control structures and/or scour protection measures along the restored channel to prevent channel incision and protect upstream infrastructure, and installation of native plantings.

A summary of the hydraulic findings and the recommended proposed replacement structures, evaluated under current and future hydrologic conditions, is listed in Table 4-2. Flood reductions under the 10-year flood event are illustrated in Figure 4-58 (existing conditions) and Figure 4-59 (with proposed improvement implemented at all crossings). Flood reductions during the 50-year flood event are illustrated in Figure 4-60 (existing conditions) and Figure 4-61 (proposed conditions). Flood reductions during the 100-year flood event are illustrated in Figure 4-62 (existing conditions) and Figure 4-63 (proposed conditions). It is estimated that over a dozen homes would be removed from the extents of the mapped base flood or 100-year storm under proposed conditions. However, to fully realize the flood reduction benefits at HRA 6, it is imperative that all private driveway culverts, all of which are currently hydraulically undersized, be modified in such a way that they would not restrict flows and hinder the hydraulic performance of the proposed public structures. Figure 4-64 illustrates the resulting flood depths from the proposed improvements at the public crossings only, without addressing the undersized private driveway structures, for the 100-year flood event.

Rigorous hydraulic and hydrologic analyses are recommended as a component of culvert replacement design and should begin at the downstream end of the HRA and proceed upstream. Due to the flat nature of the stream at this location, the cumulative influence from an undersized private driveway has significant ramifications on the conveyance of any stream crossing located upstream. The final hydraulics and competency of any proposed public roadway crossing to convey a design flood will be entirely dependent on removal, relocation, or replacement of existing private driveway structures. In addition, further analysis is needed to evaluate the downstream impact of upsizing culverts in cases where the culverts impound water during flood events.



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HRA 6: CONCEPT PLAN

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FIG. 4-57

Table 4-2 Summary of Hydraulic Analysis for HRA 6

STREAM CROSSING (STREAM STATION)	EXISTING STRUCTURE DESCRIPTION	EXISTING FLOOD CAPACITY	MODELED REPLACEMENT STRUCTURE	REPLACEMENT STRUCTURE FLOOD CAPACITY	
				Current Hydrology	Projected Future Flows to Account for Climate Change
Catherine Road (STA 338+55)	10’-span by 2’-rise open-bottom culvert	<10-Year	16’-span by 3’-rise concrete box culvert (elevate roadway)	100-Year	100-Year
Private Driveway (STA 339+50)	7’-span by 4’-rise concrete ellipse culvert	<10-Year	12’-span by 4’-rise concrete box culvert	100-Year	50-Year
Private Driveway (STA 340+55)	5’-diameter corrugated metal pipe culvert	<10-Year	Remove and relocate off Mamaroneck Road	--	--
Mamaroneck Road (STA 341+67)	5’-span by 3’-rise corrugated metal arch culvert	<10-Year	12’-span by 4’-rise concrete box culvert	100-Year	100-Year
Private Driveway (STA 342+53)	4.5’-diameter concrete pipe culvert	<10-Year	12’-span by 4’-rise concrete box culvert	100-Year	100-Year
Private Driveway (STA 343+57)	4.5’-diameter concrete pipe culvert	<10-Year	10’-span by 4’-rise concrete box culvert	50-Year	50-Year
Private Driveway (STA 345+37)	4’-diameter concrete pipe culvert	<10-Year	12’-span by 4’-rise concrete box culvert	100-Year	100-Year
Catherine Road (STA 346+87)	115’-long, 4’-diameter corrugated metal pipe culvert	<10-Year	14’-span by 5’-rise concrete box culvert	100-Year	100-Year
Private Driveway (STA 348+18)	4’-diameter concrete pipe culvert	<10-Year	12’-span by 4’-rise concrete box culvert	100-Year	50-Year
Canterbury Road (STA 349+48)	180’-long, 4’-diameter corrugated metal pipe culvert	<10-Year	Removal or 40’-long, 14’-span by 5’-rise concrete box culvert	100-Year	100-Year
Cayuga Road (STA 353+65)	6’-span by 3’-rise concrete box culvert	<10-Year	14’-span by 6.5’-rise concrete box culvert (elevate roadway)	50-Year	50-Year
Oneida Road (STA 361+88)	5’ span by 3’ rise corrugated metal arch culvert	<10-Year	14’ span by 6.5’ rise concrete box culvert (elevate roadway)	100-Year	50-Year

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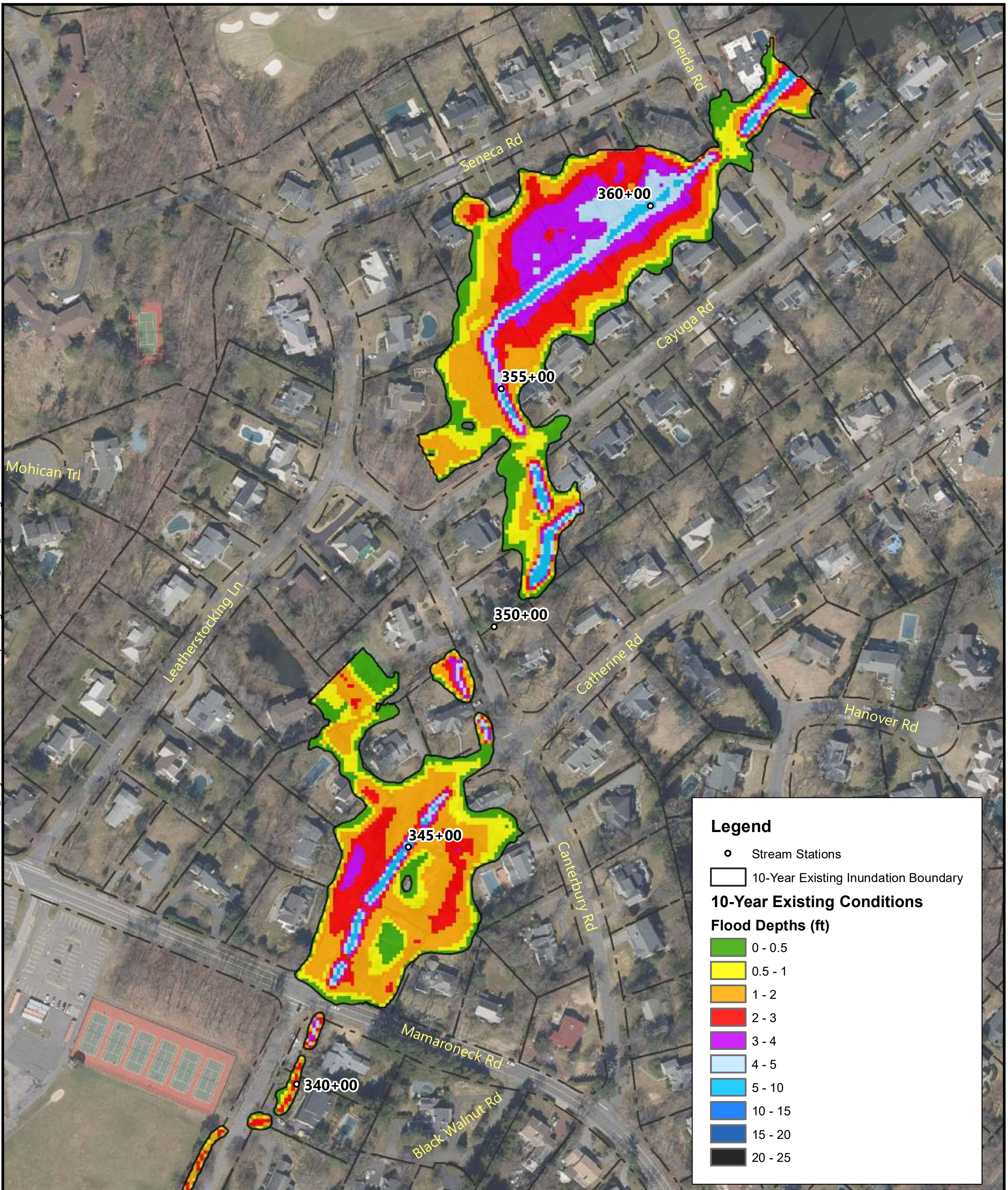

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HRA 6: 50-YEAR EXISTING CONDITIONS FLOOD DEPTHS

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FIG. 4-58

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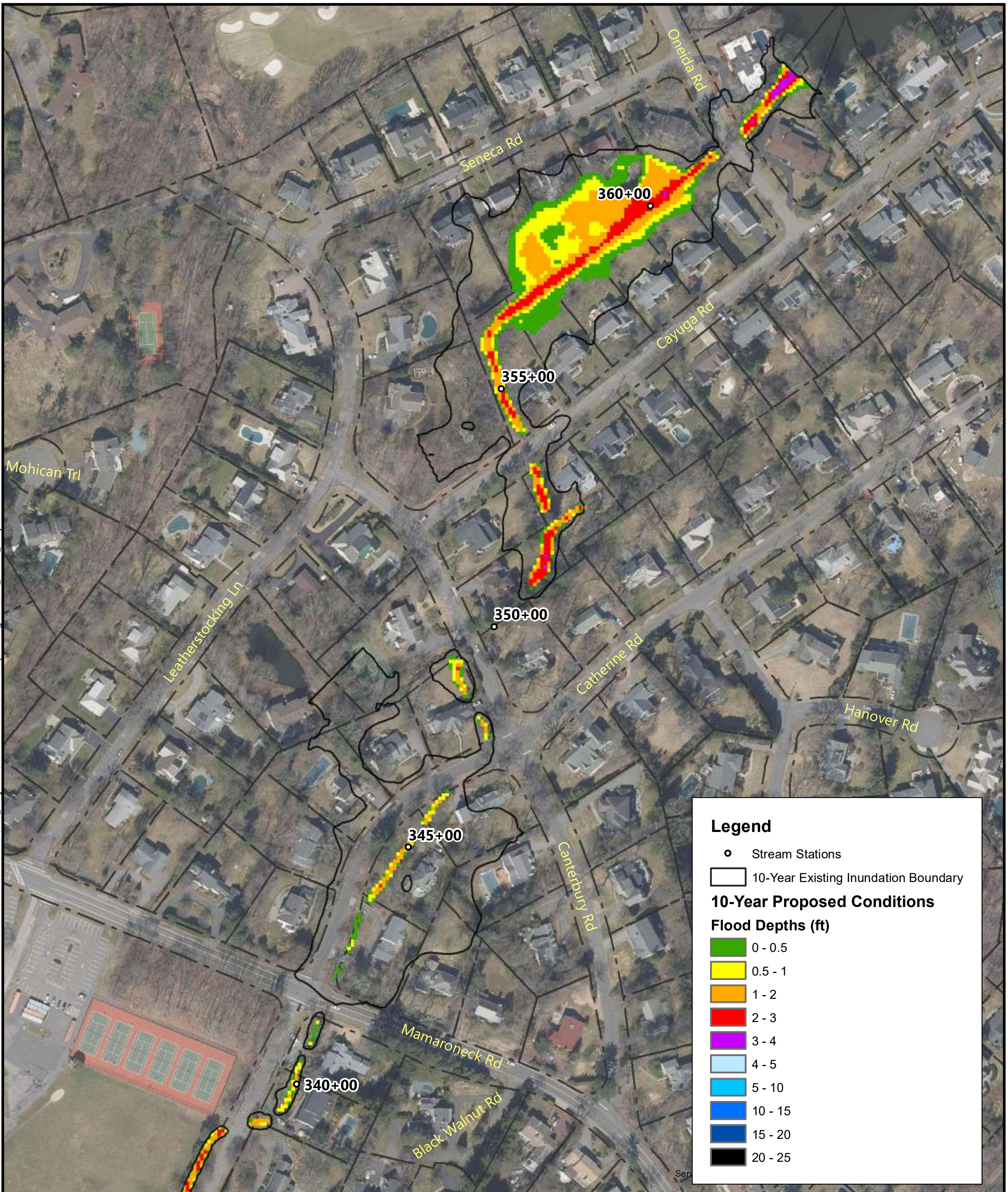

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HRA 6: 10-YEAR PROPOSED CONDITIONS FLOOD DEPTHS

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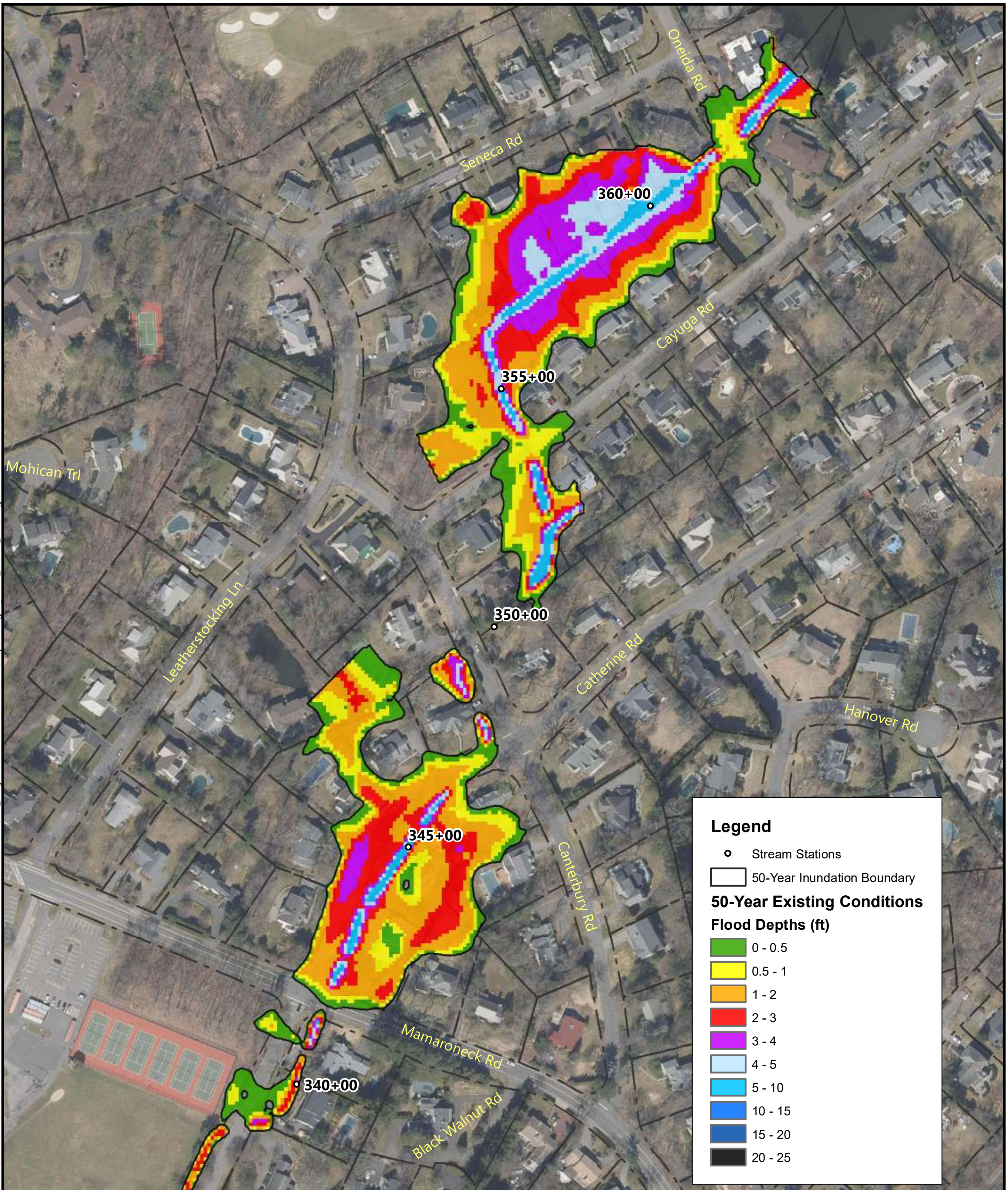
FIG. 4-59



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HRA 6: 50-YEAR EXISTING CONDITIONS FLOOD DEPTHS

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FIG. 4-60

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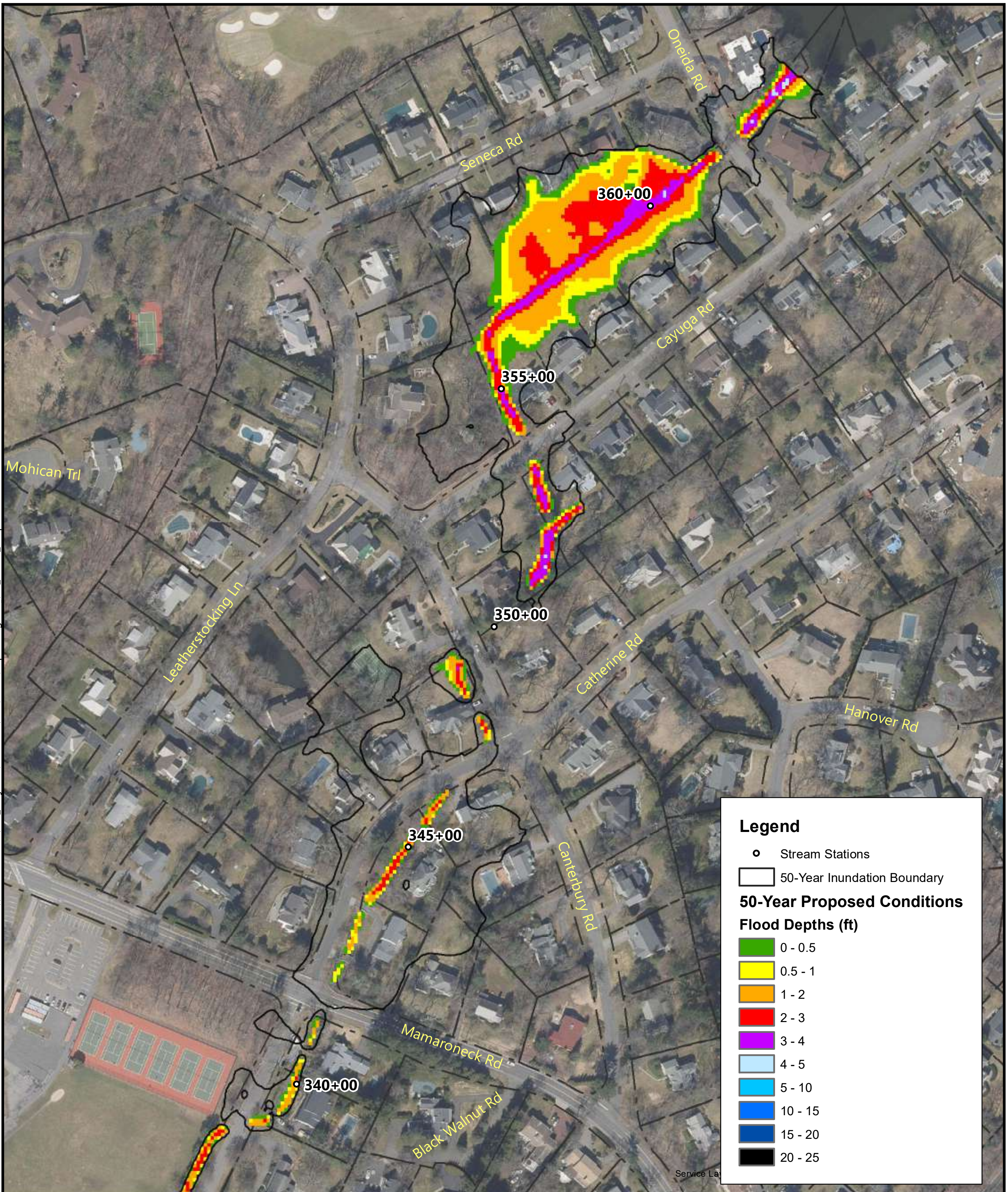

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HRA 6: 50-YEAR PROPOSED CONDITIONS FLOOD DEPTHS

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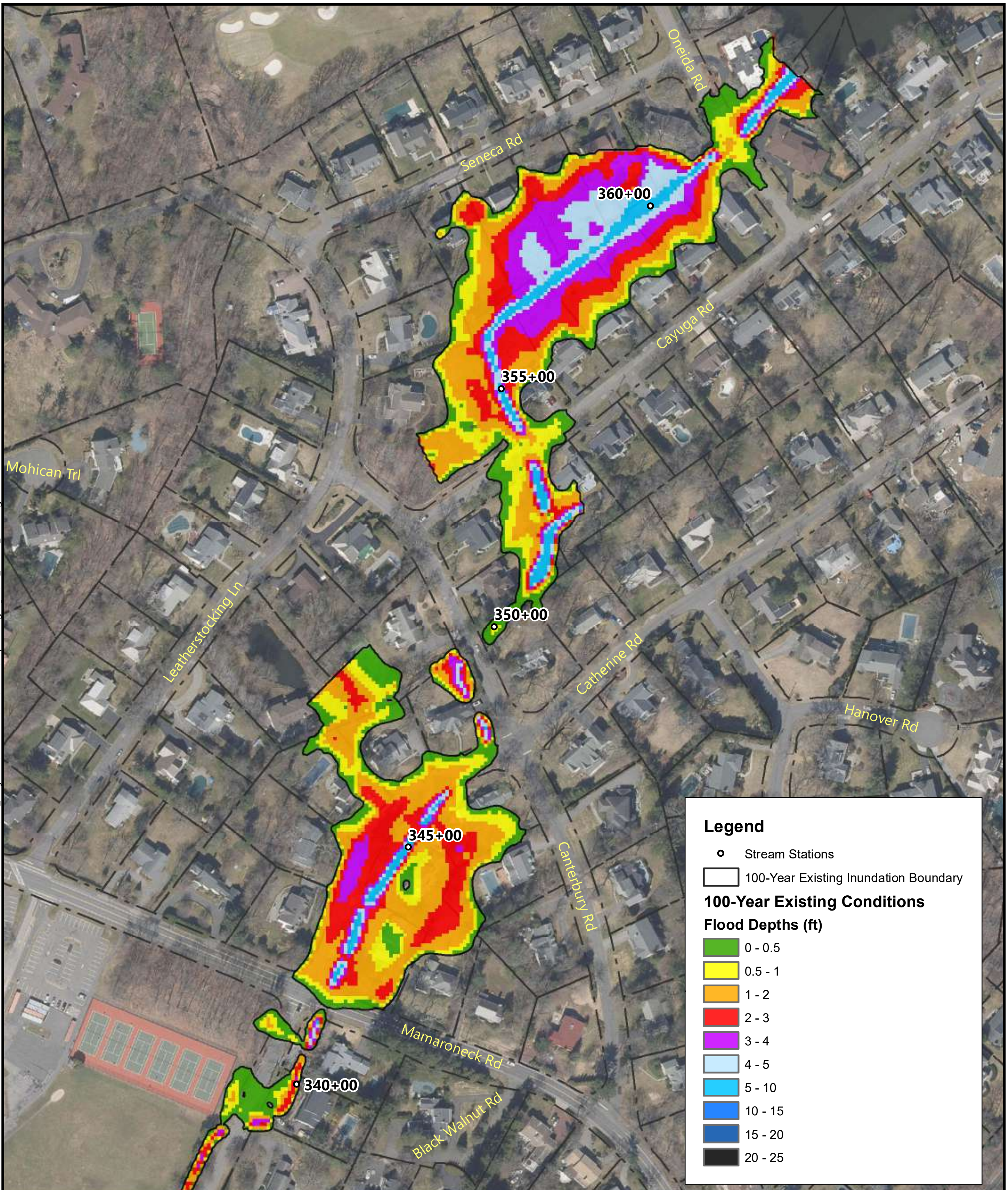
FIG. 4-61



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HRA 6: 100-YEAR EXISTING CONDITIONS FLOOD DEPTHS

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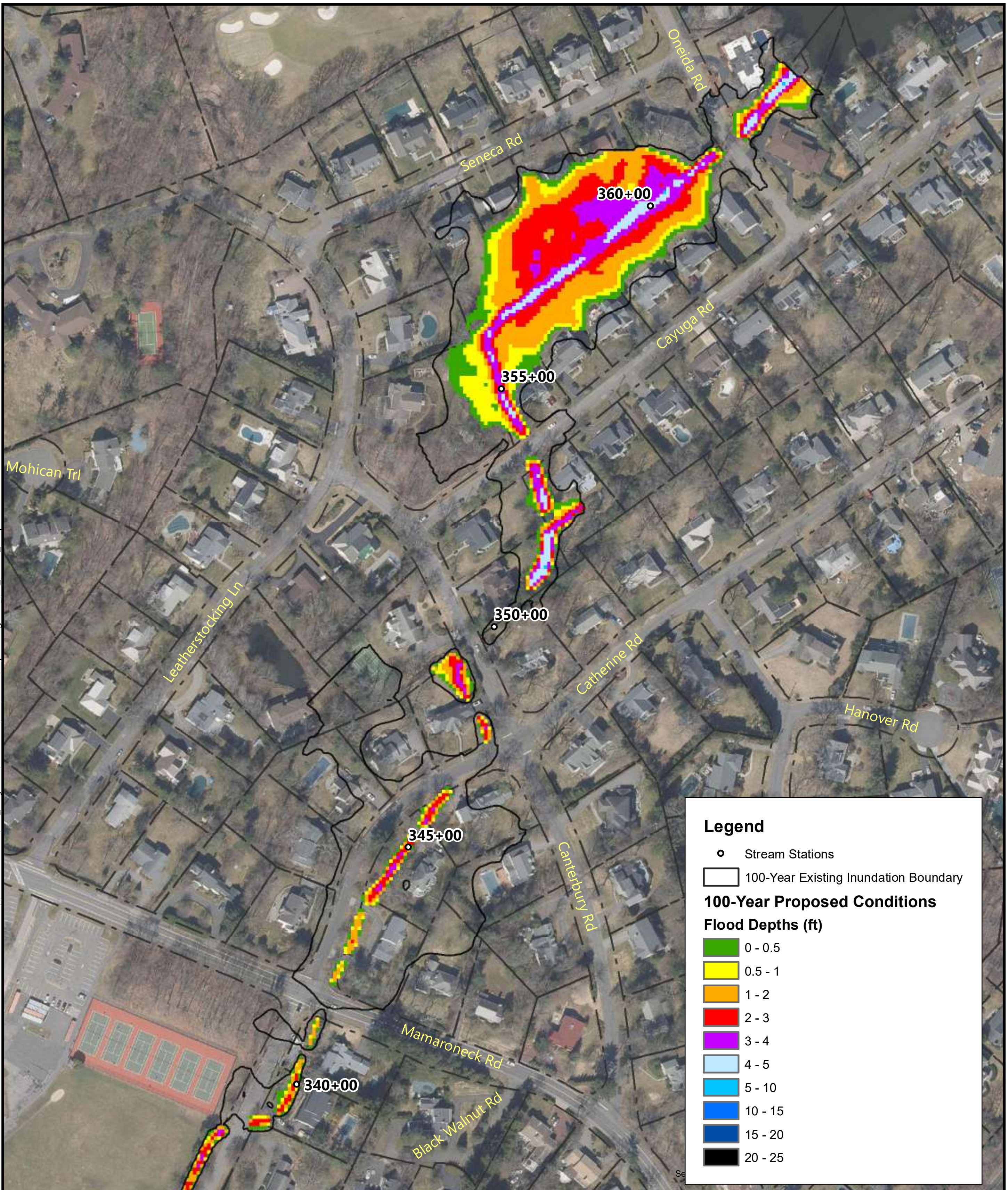

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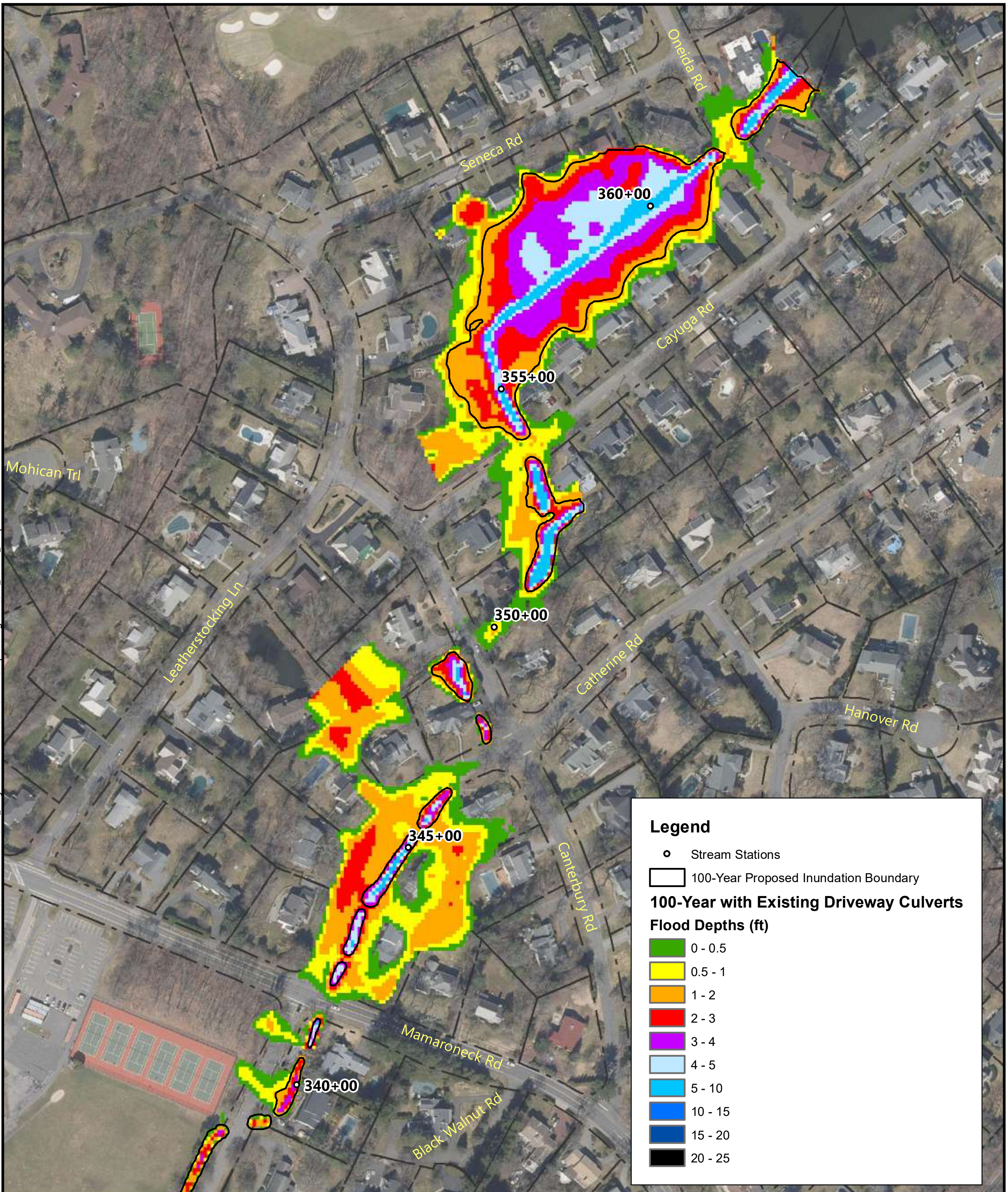
FIG. 4-63



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PROPOSED PUBLIC STRUCTURES WITH EXISTING PRIVATE CROSSINGS

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FIG. 4-64

4.7 HIGH RISK AREA 7 – EAST BRANCH MAMARONECK RIVER AT PINEHURST DRIVE

HRA 7 is within the hamlet of Purchase in the village and town of Harrison along the East Branch Mamaroneck River at Pinehurst Drive, from STA 45+00 to STA 75+00. The tributary drains moderately steeply from northeast to southwest through a narrow and confined valley. Sparse residential development and roadways built east of the river, on the valley floor, along Pinehurst Drive have experienced flooding according to town of Harrison public officials. There are no stream crossings over the East Branch Mamaroneck River within the extents of HRA 7. A single repetitive loss claim was made along Pinehurst Drive in 2019, the only claim made in Purchase within the Mamaroneck River watershed.

In the hydraulic model, the backside of a few homes on the river-left overbank near STA 60+00 are shown inundating beginning at the existing 10-year storm event. Flood depths at some of the homes are estimated to reach upwards of 4 feet and 6 feet during the existing 10-year and 100-year storm events, respectively. The stream gradient between STA 48+45 and STA 70+00 is less than half a percent, or 10.5 feet per mile, and runs against the toe of a steep hillslope to the west with homes abutting east of the stream. Comparing historical topographic maps of HRA 7 from the 1940s and 1960s, it becomes apparent that homes along Pinehurst Drive were built on top of a former wetland, which naturally inundates and stores water during a flood (Figure 4-65). Figure 4-66 shows an overview map of HRA 7.

Figure 4-65: USGS historical topographic maps of HRA 7 from 1944 (left) and 1960 (right); STA 60+00 is circled in red. Homes along Pinehurst Drive were built on and around a wetland.

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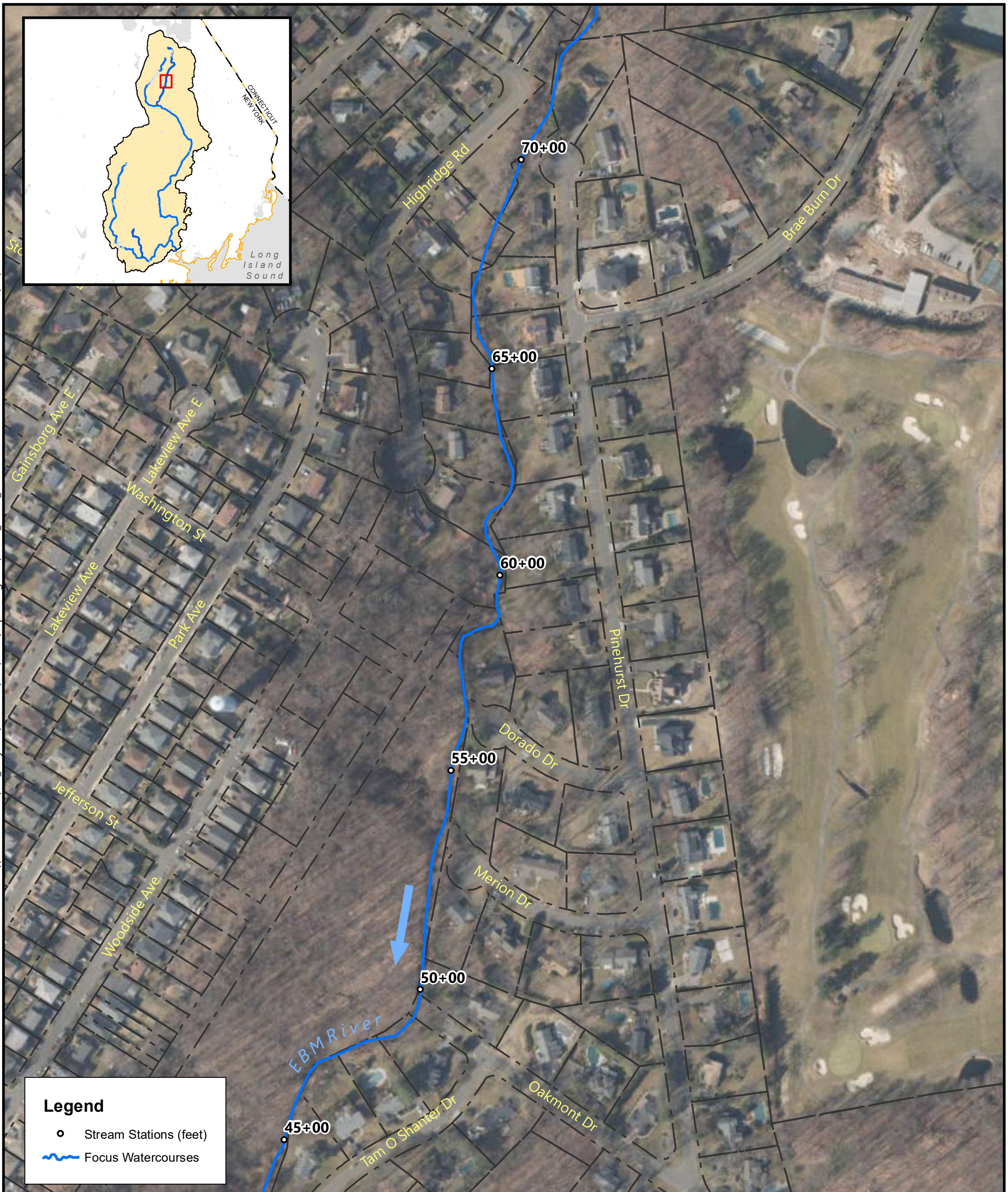

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HIGH RISK AREA 7 OVERVIEW

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FIG. 4-66

Stream channel restoration efforts to reverse the anthropogenic alterations to the wetland area and floodplain bench creation wherever feasible would improve flooding conditions at homes along Pinehurst Drive. One alternative considered reconstructing 2,000 feet of channel to a bankfull width dimension of 26 feet and floodplain bench creation as depicted in Figure 4-67. A 50-foot-wide floodplain bench along the river-right bank from STA 52+37 to STA 58+65 and 27-foot-wide floodplain bench from STA 63+00 to STA 72+00 was added to the hydraulic model. Adjustments to the channel profile to a more natural slope would also improve conveyance where the channel flows at a positive gradient.

Under proposed conditions, reduction in flood depths at the neighborhood would range from 1.2 to 1.5 feet across all modeled storm events. A detailed engineering analysis is recommended for all stream channel restoration and floodplain creation measures and should consider optimization of riverine functions such as sediment transport and aquatic organism passage. Recommended mitigation actions will reduce but not eliminate flooding of homes along Pinehurst Drive, and individual landowner floodproofing measures may be necessary to reduce future flood damage. Individual property flood protection measures are discussed in Section 5.11 of this report. Where interest exists, relocation outside of the floodplain is recommended. Potential funding sources for property relocation are listed in Section 5.14 of this report.

Flood reductions under the 10-year flood event are illustrated in Figure 4-68 (existing conditions) and Figure 4-69 (with proposed channel and floodplain bench improvements). Flood reductions during the 100-year flood event are illustrated in Figure 4-70 (existing conditions) and Figure 4-71 (proposed conditions).

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HRA 7: CONCEPT PLAN

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FIG. 4-67

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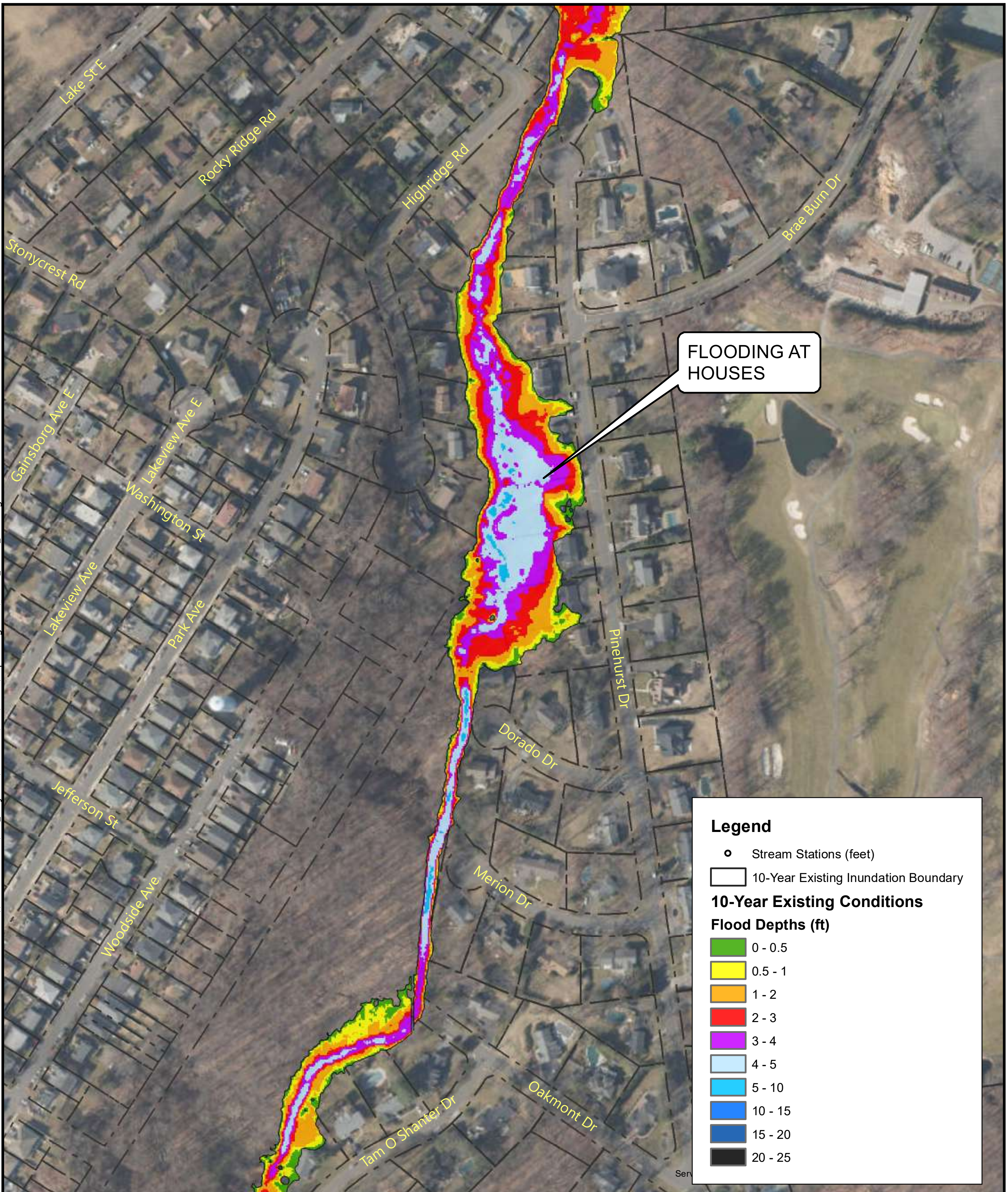

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HRA 7: 10-YEAR EXISTING CONDITIONS FLOOD DEPTHS

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FIG. 4-68

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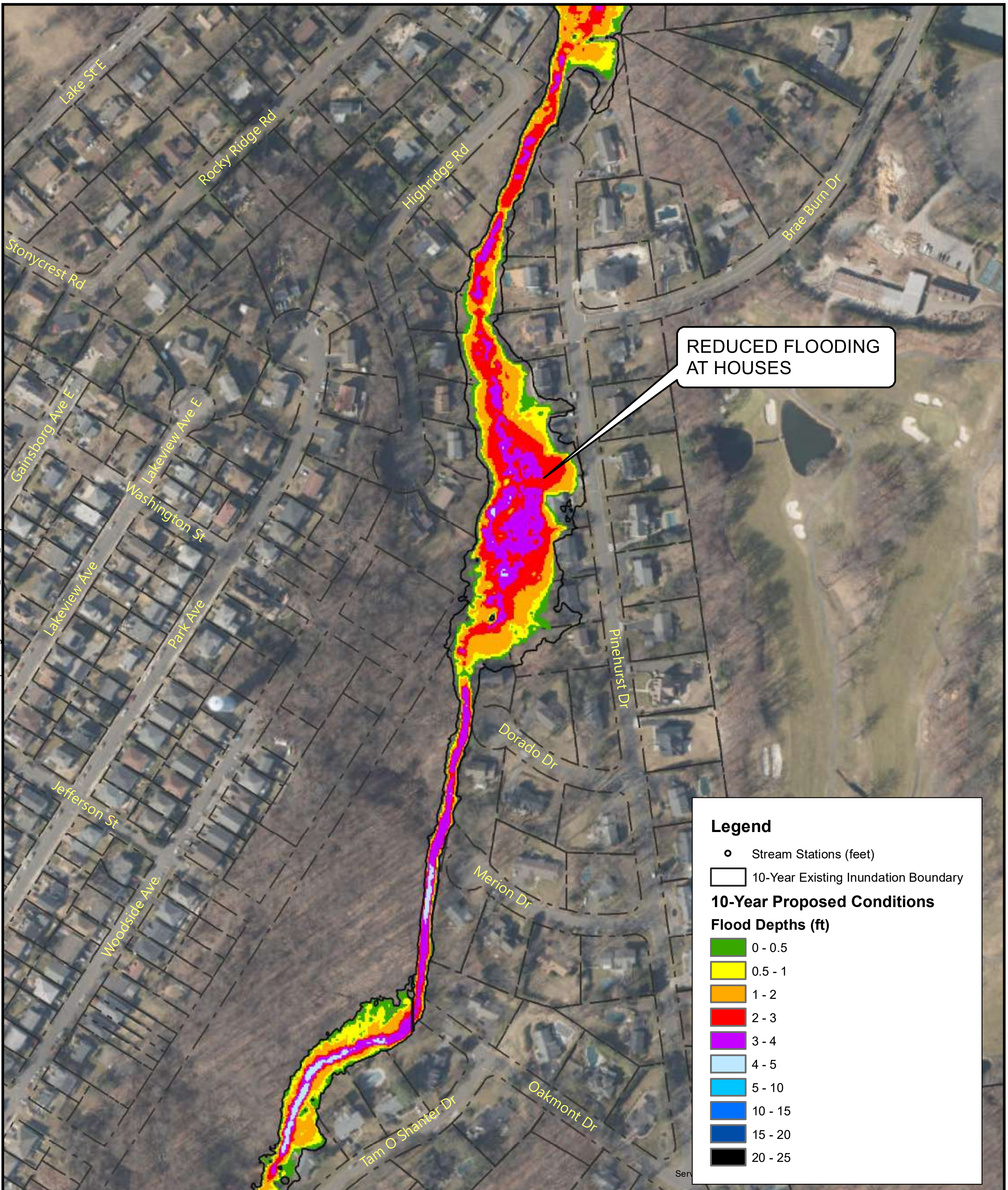

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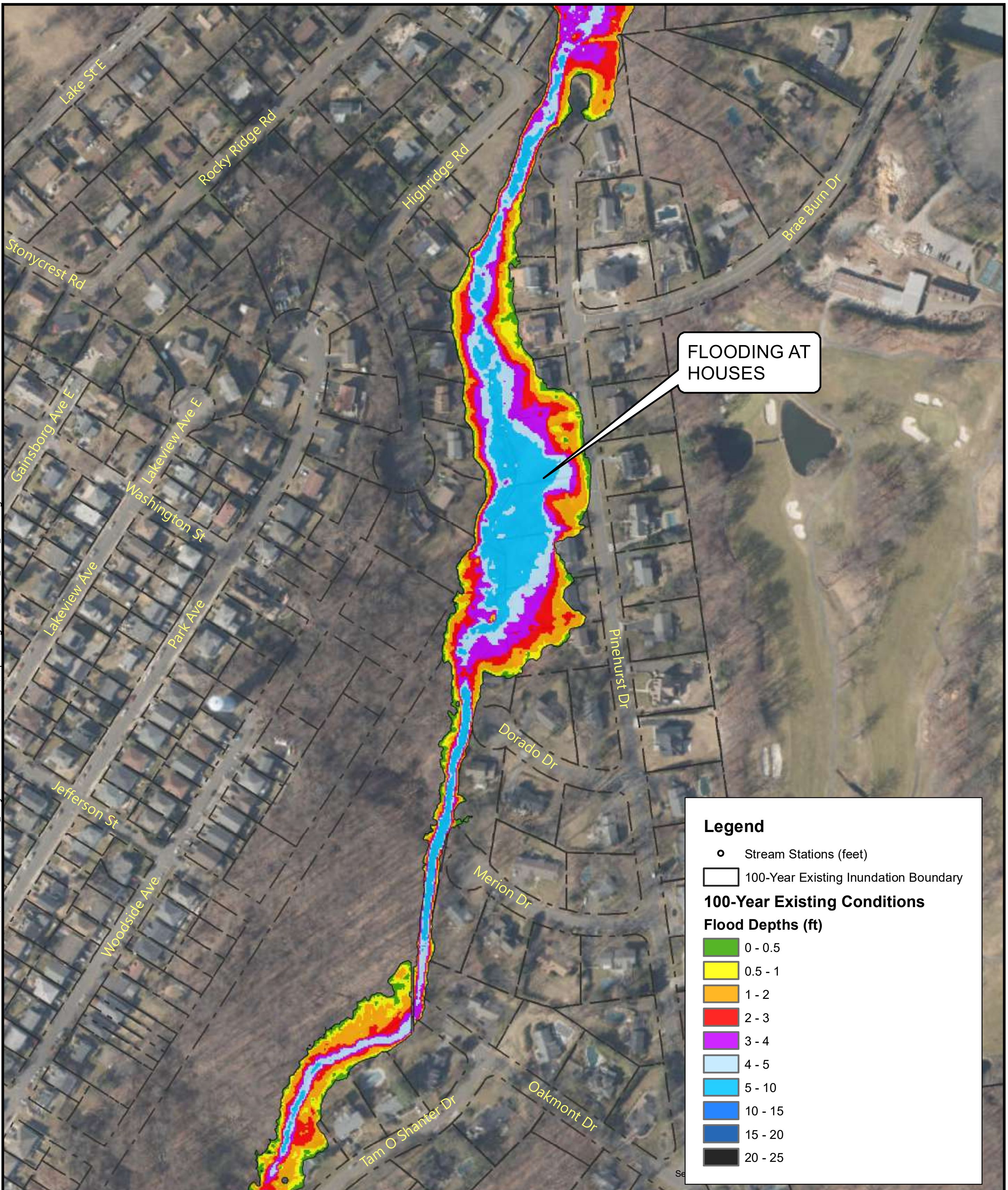
FIG. 4-69



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HRA 7: 100-YEAR EXISTING CONDITIONS FLOOD DEPTHS

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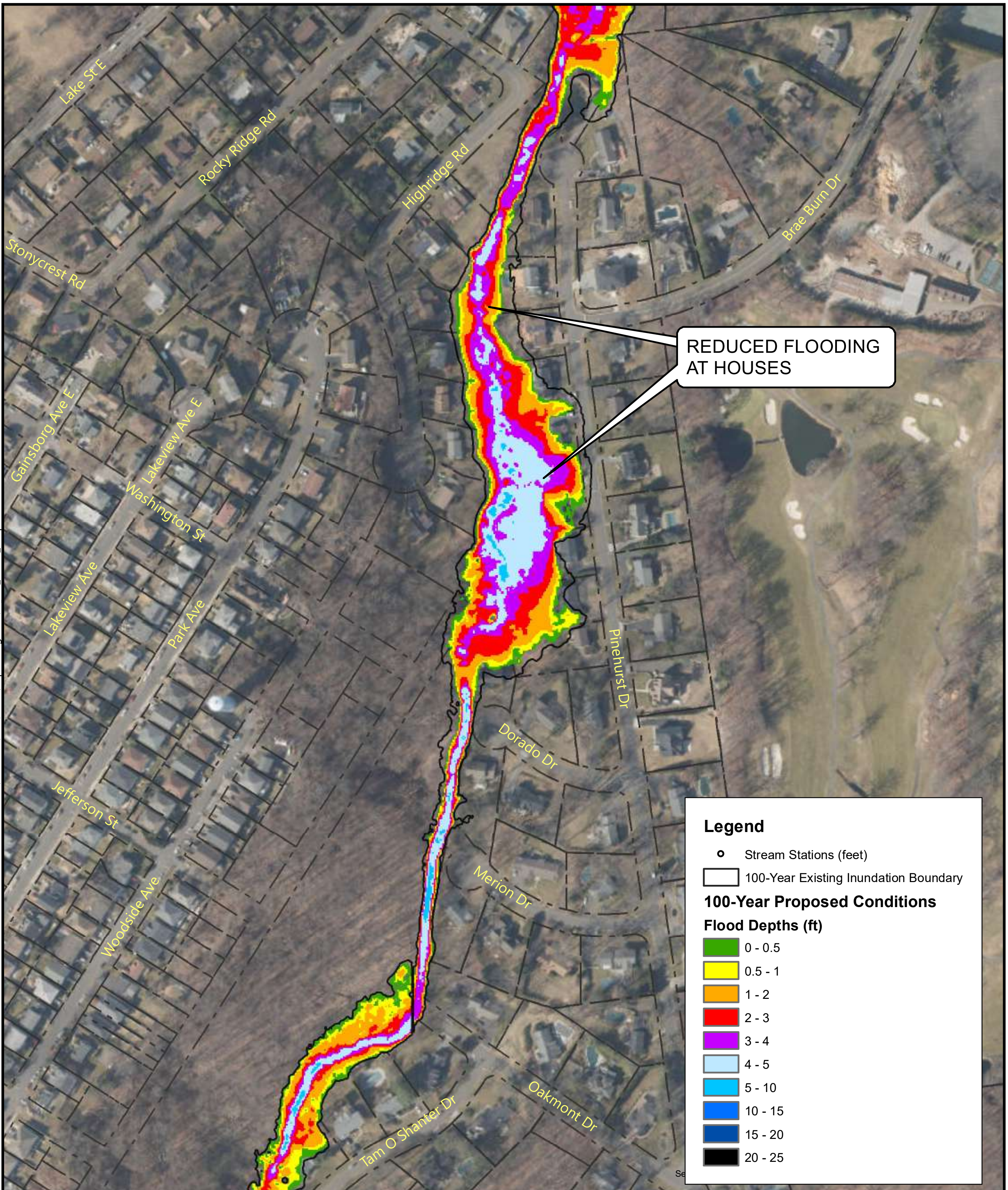
FIG. 4-70



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SLR

231 MAIN STREET
SUITE 102
NEW PALTZ, NY 12561
845.633.8153

HRA 7: 100-YEAR PROPOSED CONDITIONS FLOOD DEPTHS

MAMARONECK RIVER FLOOD & RESILIENCY STUDY
SD 969 MOD 2
WESTCHESTER COUNTY, NEW YORK

N

0 300 Feet

SCALE 1 " = 300 '

DATE 5/31/2023

6511.0020
PROJ. NO.

FIG. 4-71

4.8 MAMARONECK RIVER AND SHELDRAKE RIVER DREDGING ANALYSIS

A river dredging analysis was conducted using HEC-RAS two-dimensional modeling and in accordance with the specifications described in the Village of Mamaroneck's "River Maintenance Plan for Sheldrake River, Mamaroneck River, & Beaver Swamp Brook" plans. According to the plans, channel dredging would consist of excavating a maximum depth of 4 feet below existing grade and creating 3:1 side slopes for the channel bottom to tie into existing banks. No details were provided for dredging under existing bridges and culverts; therefore, for this analysis, it was assumed that dredging would not take place under existing structures. Four sites across the Sheldrake and Mamaroneck Rivers were selected and are described in greater detail below. Dredge area 1 and area 2 on the Mamaroneck River fall within the extents of HRA 3 and HRA 2, respectively. Dredge areas 1 and 2 on the Sheldrake River are both within the extents of HRA 4.

- Mamaroneck River Area 1: Extends from upstream Warren Avenue (STA 90+00) downstream through I-9 and around bend (STA 72+35)
    - Proposed dredge area: ± 61,150 SF
    - Proposed dredge volume: ± 9,064 CY
    - Proposed dredge length: ± 1,614 LF
- Mamaroneck River Area 2: From North Barry Avenue Extension bridge (STA 54+30) downstream to Hillside Avenue bridge (STA 46+70)
    - Proposed dredge area: ± 22,792 SF
    - Proposed dredge volume: ± 3,380 CY
    - Proposed dredge length: ± 754 LF
- Sheldrake River Area 1: From Fenimore Road bridge (STA 34+00) to Plaza Avenue (STA 28+80)
    - Proposed dredge area: +/- 12,485 SF
    - Proposed dredge volume: +/- 1,850 CY
    - Proposed dredge area length: 400 LF
- Sheldrake River Area 2: From Rockland Avenue bridge (STA 52+00) to Fenimore Road bridge (STA 34+50)
    - Proposed dredge area: ± 44,415 SF
    - Proposed dredge volume: ± 6,580 CY
    - Proposed dredge area length: 1,740 LF

According to the hydraulic model, implementing the dredge scenarios described above under existing conditions would have zero flood reduction benefits across all modeled storm events. These results are in part due to the insignificant volume storage and conveyance that would be created through the dredging in relation to the large volume of water expected during a flood. Likewise, many of the dredge areas are located upstream of undersized stream crossings or sections of channel that control the depth of water and backwater through the dredged areas. Furthermore, under HRA-specific proposed conditions as recommended and described in the sections prior, the dredging efforts would add no additional benefits. Historically, channel dredging is not advisable due to the increased likelihood of promoting channel instability that can create an onset of wall failures and headcuts along the disturbed reaches. Therefore, as opposed to dredging the Mamaroneck and Sheldrake Rivers, funds should be allocated toward long-term solutions to flooding, which include a combination of property buyouts, adequately sized channel and floodplain restoration efforts, and bridge replacements.

5. RECOMMENDATIONS

This report identifies HRAs within the Mamaroneck River watershed. 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, road closures, and replacement of undersized bridges and culverts are investigated and are recommended where appropriate. Recommendations for project prioritization are discussed in Section 5.13.

5.1 HRA 1 RECOMMENDATIONS

The following recommendations are provided for HRA 1:

- Realignment of the Mamaroneck River and Sheldrake River confluence to eliminate sharp bends and smooth the transition of flow under the MTA railroad bridge. Reconstruction of the Mamaroneck River channel from STA 28+84 to STA 36+08 and the Sheldrake River channel between STA 0+00 to approximately STA 1+80. Reconstruction of the confluence area with a multistage channel to bankfull channel dimensions of 54 feet wide on the Mamaroneck River and 41 feet wide for the Sheldrake River, both with an incorporated low-flow channel. Floodplain benches over existing channels, sloped at 2 percent slope towards existing ground, and lowering of parking lot for floodable space.

- Replacement of the Station Plaza bridge to fully span the proposed channel and floodplain areas and not obstruct flood flows. A single-span open deck replacement bridge between 105 to 120 feet wide might be necessary to not impede flows.

- Replacement of the Halstead Avenue bridge to fully span the proposed USACE channel for this stream reach and not obstruct flood flows. A 70-foot-wide bridge span and elevating the bridge low chord by 2 feet may be appropriate.

- Removal of either the Station Plaza or Halstead Avenue crossing and restoration of the adjoining sections of the channel is also an option since there may be sufficient alternative routes available across the Mamaroneck River.

- Removal or replacement of the Anita Lane utility bridge with a 70-foot-wide single-span open deck bridge and elevated low chord between 6 to 7 feet above existing.

- Replacement of the Tompkins Avenue bridge with a 115-foot-wide bridge to span the active channel and existing floodplain.

- Replacement of the Ward Avenue bridge with a 100-foot-wide bridge that spans a proposed 550-foot-long (STA 15+00 to STA 23+01) by a 75-foot-wide floodplain bench is recommended.

- Removal of either the Ward Avenue or Tompkins Avenue crossing and restoration of the adjoining sections of the channel is also an option since there may be sufficient alternative routes available across the Mamaroneck River.

- It is recommended that floodproofing measures account for future climatic conditions and that the town/village utilize the information presented in this report to aid in decision making for existing and future development within the lower Mamaroneck River reach.

5.2 HRA 2 RECOMMENDATIONS

The following recommendations are provided for HRA 2:

- Feasibility studies should be conducted to find the optimal combination of property relocations and floodplain bench creation and restoration within HRA 2.

- Reconstructing the river channel from STA 37+90 to STA 65+00 with a multistage channel, 54-foot-wide bankfull channel, with floodplain benches.

- Replacement or removal of the North Barry Avenue Extension bridge so it no longer obstructs flows. A rigorous hydraulic and hydrologic analysis is recommended when due for replacement to ensure that it is adequately sized to convey flood flows and does not exacerbate flooding. Replacement with a single-span open deck bridge that spans 70 feet wide.

- Sections of the approach roads to the right (west) of the Hillside Avenue bridge and left (east) of the North Barry Avenue Extension bridge are still expected to be under water during severe flood events. It is recommended that proper roadway closure signage be implemented when major storm events are forecasted.

- At flood-prone properties where bridge replacements and floodplain restoration improve but do not eliminate flooding issues, individual floodproofing is recommended.

5.3 HRA 3 RECOMMENDATIONS

The following recommendations are provided for HRA 3:

- Flooding within HRA 3 is the result of development on the river’s floodplain, which is naturally expected to inundate during a flood. The most cost-effective, long-term flood mitigation solution for flood-prone properties would be managed retreat through voluntary property acquisitions and restoration of the river’s floodplain areas.

- Inspection of the I-95 crossing following a major storm and regular removal of debris accumulation at the inlet.

- Removal of Winfield Avenue bridge and restoration of the channel to a bankfull width of 47 feet.

- Individual property flood protection measures should be implemented using predicted future water surface elevations to adequately elevate homes and utilities. It is recommended that all floodproofing measures account for future climatic conditions and that the town/village utilize this information to aid in decision making when it comes to existing and future development within the floodplain.

- A feasibility study is recommended for HRA 3 to find the optimal combination of property relocations and floodplain restoration.

5.4 HRA 4 RECOMMENDATIONS

The following recommendations are provided for HRA 4:

- Restoration of the channelized Sheldrake River from STA 5+00 to STA 30+00 to a width of 41 feet.

- A short-term floodplain bench creation approach that prioritizes minimal disturbance to existing roadways and buildings. Floodplain bench creation would alternate between river-left and river-right, consuming sections of Plaza Avenue, Northup Avenue, Center Avenue, and Waverly Avenue.

    - Floodplain bench #1 from STA 7+00 to STA 19+15 along the left bank of the Sheldrake River about 1,160 feet long. The first 916 feet of floodplain is excavated 5 feet below existing ground and measures approximately 20 feet wide. The remaining 245 feet of floodplain bench is excavated 3 feet below existing ground and varies between 25 feet and 50 feet wide.

    - Floodplain bench #2 from STA 18+28 to STA 21+88 along the right bank of the Sheldrake River. Excavated about 4 feet below the current ground level approximately 350 feet long and of varying widths between 16 feet and 32 feet. The floodplain bench would consume a portion of a scrapyard and a parking lot along Waverly Avenue to the right (southwest).

    - Floodplain bench #3 from STA 21+36 to STA 24+45 along the left bank of the Sheldrake River. Excavated about 5.5 feet below current ground level and approximately 323 feet long by 32 feet wide. Conversion of Plaza Avenue to a single-lane road would be required.

    - Floodplain bench #4 from STA 24+05 to STA 29+00 along the right bank of the Sheldrake River. Excavated at approximately 4 feet below existing ground and measuring 460 feet long by 25 feet wide. The floodplain bench would consume a section of Northup Avenue.

- A long-term, more ambitious riparian corridor creation extending from Columbus Park upstream to STA 30+00. This would require acquisition and demolition of flood-prone properties, followed by the establishment of a floodable linear park along the Sheldrake River.

- Replacement of the Waverly Avenue bridge with a new span of at least 50 feet.

- Replacement of the Mamaroneck Avenue bridge with a new span of at least 52 feet.

- Removal of the Center Avenue bridge.
- Removal or reduction of pedestrian bridges across the Sheldrake River.

5.5 HRA 5 RECOMMENDATIONS

The following recommendations are provided for HRA 5:

- Widening the Sheldrake River channel to a bankfull width of 39 feet throughout the 2,500-foot-long project reach. Channel modifications would require converting sections of Brookside Drive East and West to one-way, single-lane roads.
- Replacement of the bridge structures under Forest Avenue, Briarcliff Road, and Hickory Grove Drive East with 40-foot single-span structures.
- Removal of Fernwood Road and Lansdowne Drive crossings over the Sheldrake River.
- Channel profile modifications would further enhance conveyance and should be explored where bedrock in the channel is absent.
- Demolishing the existing East Brook Drive culvert over the East Branch Sheldrake River and installing an adequately sized structure, approximately 24 feet wide, between 260 to 600 feet upstream of the confluence or beyond the tailwater influence from the Sheldrake River.
- Rigorous hydraulic and hydrologic analyses are recommended as a component of all culvert replacement designs and should begin at the downstream end of the HRA and proceed upstream.

5.6 HRA 6 RECOMMENDATIONS

The following recommendations are provided for HRA 7:

- Replacement of six public crossings with single-span structures between 10 and 16 feet wide and widening the channel to a bankfull width 21 feet over roughly 2,000 feet of stream length.
- Modifications to the channel or roadway profile may be required in spots to allow for the installation of a replacement structure with a taller vertical opening.
- Replacement of six private driveway crossings with adequately sized structures to optimize flood reduction benefits resulting from upsizing the public roadway crossings.
- At Catherine Road at STA 346+87 and Canterbury Road at STA 349+48, daylighting of the stream where it is not required to run underground or removal and decommission of the roadway.
- Rigorous hydraulic and hydrologic analyses are recommended as a component of culvert replacement design and should begin at the downstream end of HRA 7 and proceed upstream.

5.7 HRA 7 RECOMMENDATIONS

The following recommendations are provided for HRA 6:

- Creation of a 50-foot-wide floodplain bench from STA 52+37 to STA 58+65 and 27-foot-wide floodplain bench from STA 63+00 to STA 72+00 along the right bank. Reconstructing 2,000 feet of channel to a bankfull width dimension of 26 feet.

- Relocation or floodproofing of individual properties along Pinehurst Drive is recommended.

5.8 REPLACEMENT OF UNDERSIZED STREAM CROSSINGS

Hydraulically undersized stream crossings contribute to flooding and washout of roadways. In addition to the recommendations for the replacement of stream crossings within the HRAs described above, it is recommended that undersized stream crossings elsewhere in the Mamaroneck River watershed be identified and prioritized for replacement. Guidance for this prioritization should be based on capacity modeling, structural condition, and severity to aquatic organism passage. The North Atlantic Aquatic Connectivity Collaborative (NAACC) is a network of individuals from agencies and organizations focused on improving aquatic connectivity across the northeast. A select number of culverts have been evaluated in New York State and assigned a crossing score according to aquatic and wildlife passability and structural condition. Their data center may contain information about a particular road-stream crossing in Westchester County and can aid in culvert replacement prioritization. The NAACC data center can be accessed at the following link: https://naacc.org/naacc_data_center_home.cfm. Where multiple stream crossings are slated for replacement along a stretch of river, it is recommended that replacements begin at the downstream end and progress sequentially in an upstream direction.

5.9 INSTALLATION AND MONITORING OF STREAM GAUGE

USGS gauge (01301000) at Mamaroneck was installed in the early 1940s and decommissioned in 1999. The gauge was located 113 feet downstream from the bridge on Halstead Avenue or 700 feet downstream from the Sheldrake River. There are currently no active stream gauges on the Mamaroneck River or Sheldrake River, making statistical analysis difficult. Stream gauges provide valuable data that can be used in future hydrologic analyses and to improve flood monitoring and forecasting. Recommissioning of the former gauge or installation of a permanent new stream gauge is recommended.

5.10 DAM MODIFICATIONS

It is recommended that certain dams within the Mamaroneck River watershed that have a compelling active use but also contribute to flooding of nearby property and infrastructure explore the feasibility of increasing spillway capacity to better accommodate flood flows or other modifications that may mitigate flooding.

Archaic, unnecessary, breached, or abandoned dams should be considered for removal as a cost-effective and ecological long-term flood mitigation solution.

All dams should be regularly inspected and maintained in sound conditions in accordance with 6 NYCRR Part 673 and Environmental Conservation Law (ECL) § 15-0507.

5.11 INDIVIDUAL PROPERTY FLOOD PROTECTION

A variety of measures are available to protect existing public and private properties from flood damage. While broader mitigation efforts are most desirable, they often take time and money to implement. On a case-by-case basis where structures are at risk, individual floodproofing should be explored. Property owners within FEMA-delineated floodplains should also be encouraged to purchase flood insurance under the NFIP and to make claims when damage occurs. Potential measures for property protection include the following:

Elevation of the structure – Home elevation involves the removal of the building structure from the basement and elevating it on piers to a height such that the first floor is located at least 2 feet above the level of the 100-year flood event. The basement area is abandoned and filled to be no higher than the existing grade. All utilities and appliances located within the basement must be relocated to the first-floor level or installed from basement joists or similar mechanism.

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

Dry floodproofing of the structure to keep floodwaters from entering – Dry floodproofing refers to the act of making areas below the flood level watertight and is typically implemented for commercial buildings that would be unoccupied during a flood event. Walls may be coated with compound or plastic sheathing. Openings such as windows and vents can be either permanently closed or covered with removable shields. Flood protection should extend only 2 to 3 feet above the top of the concrete foundation because building walls and floors cannot withstand the pressure of deeper water.

Wet floodproofing of the structure to allow floodwaters to pass through the lower area of the structure unimpeded – Wet floodproofing refers to intentionally letting floodwater into a building to equalize interior and exterior water pressures. Wet floodproofing should only be used as a last resort. If considered, furniture and electrical appliances should be moved away or elevated above the 100-year flood elevation.

Performing other home improvements to mitigate damage from flooding – The following measures can be undertaken to protect home utilities and belongings:

- Relocate valuable belongings above the 100-year flood elevation to reduce the amount of damage caused during a flood event.

- Relocate or elevate water heaters, heating systems, washers, and dryers to a higher floor or to at least 12 inches above the BFE (if the ceiling permits). A wooden platform of pressure-treated wood can serve as the base.
- Anchor the fuel tank to the wall or floor with noncorrosive metal strapping and lag bolts.
- Install a backflow valve to prevent sewer backup into the home.
- Install a floating floor drain plug at the lowest point of the lowest finished floor.
- Elevate the electrical box or relocate it to a higher floor and elevate electric outlets.

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

5.12 ROAD CLOSURES

Approximately 75 percent of all flood fatalities occur in vehicles. Shallow water flowing across a flooded roadway can be deceptively swift and wash a vehicle off the road. Water over a roadway can conceal a washed-out section of roadway or bridge. When a roadway is flooded, travelers should not take the chance of attempting to cross the flooded area. It is not possible to tell if a flooded road is safe to cross just by looking at it.

One way to reduce the risks associated with the flooding of roadways is their closure during flooding events, which requires effective signage, road closure barriers, and consideration of alternative routes.

According to FEMA modeling and anecdotal reporting, flood-prone roads exist within the Mamaroneck River watershed. In some cases, small, unnamed tributaries and even roadside drainage ditches can cause washouts or other significant damage to roadways, culverts, and bridges. Drainage issues and flooding of smaller tributary streams are generally not reflected in FEMA modeling, so local public works and highway departments are often the best resource for identifying priority areas and repetitively damaged infrastructure.

5.13 PRIORITIZATION OF PROJECTS

The hydraulics of the Mamaroneck River are complex. The implementation of flood mitigation projects in one area of the Mamaroneck River has the potential to impact a separate area of the watershed. Therefore, the following recommendations are provided for the prioritization of projects. Recommendations herein are intended to plan for the downstream impacts from upstream improvements but also synergize the flood mitigation benefits of downstream improvements on upstream projects.

- Implementation of recommended improvements through the lower reach of HRA 1 should occur prior to the rework of the Mamaroneck and Sheldrake Rivers confluence area and replacement or removal of the Halstead Avenue and Station Plaza bridges. HRA 1 recommendations and priority are as follows:
    - Floodproofing, elevation, or relocation of buildings along East Prospect Avenue and East Boston Post Road within the influence of riverine and coastal flooding and anticipated flow surcharge from upstream improvements.
    - Replacement of the Ward Avenue bridge and floodplain bench creation through structure.
    - Replacement or removal of the Tompkins Avenue bridge.

- Replacement or relocation of the Anita Lane utility bridge should begin with the recommended improvements at the upper reach of HRA 1 (i.e., Mamaroneck River and Sheldrake River realignment and reconstruction, Halstead Avenue and Station Plaza bridge removal or replacements). Anita Lane bridge replacement or removal required to ensure full flood mitigation benefits of upper HRA 1 project.

- Because of the backwater influence from the Mamaroneck River, implementation of any flood mitigation projects in HRA 4 along the Sheldrake River should occur after employment of the recommendations described for the upper reach of HRA 1.

- Aside from the specific recommendations made above, improvements can be implemented within each HRA without substantially impacting other HRAs.

- As general guidance, implementation of improvement with each HRA should begin at the downstream end of the HRA and proceed upstream. For example, in HRA 6, project implementation should begin with stream crossing replacement at Catherine Road, followed by the stream crossing replacement of the private bridges upstream, followed by the replacement at Mamaroneck Road.

- Voluntary acquisitions and demolition of flood-prone properties is a key component to increasing flood resiliency and should be implemented wherever funding is available and landowner willingness exists.

5.14 ROUGH ORDER OF MAGNITUDE COST RANGE OF KEY RECOMMENDATIONS

To assist with prioritization of the above recommendations, Table 5-1 provides an estimated cost range for key recommendations. Due to the conceptual nature of recommended actions and significant amount of data required to produce a reasonable rough order of magnitude cost, it is not feasible to further quantify the costs of all actions. Costs of land acquisition or easements are not included.

Table 5-1 Cost Range of Recommended Actions

Recommendation	< $100k	$100k - $500k	$500k - $1M	$1M - $5M	$5M - $10M	>$10M
HRA 1 - Reconstruction of the Mamaroneck River channel and realignment of the confluence to eliminate sharp bends					X	
HRA 1 - Replacement of the Station Plaza bridge					X	
HRA 1 - Replacement of the Halstead Avenue bridge					X	
HRA 1 - Removal or replacement of the Anita Lane utility bridge				X		
HRA 1 - Replacement of the Tompkins Avenue bridge					X	
HRA 1 - Replacement of the Ward Avenue bridge					X	
HRA 2 - Reconstructing the river with a multistage channel and floodplain					X	
HRA 2 - Replacement or removal of the North Barry Avenue Extension bridge				X		
HRA 3 - Removal of Winfield Avenue bridge and restoration of the channel				X		
HRA 4 - Channel restoration and floodplain bench creation that prioritizes minimal disturbance to existing roadways and buildings					X	
HRA 4 - Riparian corridor creation extending from Columbus Park upstream to STA 30+00, requiring acquisition and demolition of flood-prone properties and establishment of floodable linear park						X
HRA 4 - Replacement of the Waverly Avenue bridge				X		
HRA 4 - Replacement of the Mamaroneck Avenue bridge				X		
HRA 4 - Removal of the Center Avenue bridge		X				
HRA 4 - Removal or reduction of pedestrian bridges across the Sheldrake River		X				
HRA 5 - Widening the Sheldrake River channel to 39 feet throughout the 2,500-foot-long project reach				X		

Recommendation	< $100k	$100k - $500k	$500k - $1M	$1M - $5M	$5M - $10M	>$10M
HRA 5 - Replacement of the bridge structures under Forest Avenue, Briarcliff Road, and Hickory Grove Drive East				X		
HRA 5 - Removal of Fernwood Road and Lansdowne Drive crossings over the Sheldrake River			X			
HRA 5 - Demolishing the East Brook Drive culvert and installing a new structure between 260 to 600 feet upstream				X		
HRA 6 - Replacement of six public crossings with structures of approximately 20 feet and widening the channel to 21 feet over 2,000 feet of stream length				X		
HRA 6 - Replacement of six private driveway crossings with adequately sized structures				X		
HRA 6 - Daylighting of the stream or removal and decommission of the roadway at Catherine Road and Canterbury Road			X			
HRA 7 - Creation of floodplain bench and reconstructing 2,000 feet of channel			X			

5.15 FUNDING SOURCES

Several funding sources may be available for the implementation of recommendations made in this report. These and other potential funding sources are discussed in further detail below. Note that these may evolve over time as grants expire or are introduced.

New York State and Federal Funding Opportunities Overview (May 2023)

NYSDEC has prepared a document with potential federal and state funding sources that could be of interest to eligible municipalities, not-for-profit organizations, and other partners for climate change, environmental justice, and other natural resource protection projects. Example funding sources are provided and intended to complement or be leveraged to enhance Bond Act funds to further achieve beneficial environmental impacts across New York. The funding document can be accessed at the following weblink: https://www.dec.ny.gov/docs/administration_pdf/bondactinfodoc.pdf

Emergency Watershed Protection Program (EWP)

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

FEMA Pre-Disaster Mitigation (PDM) Program

The PDM program was authorized by Part 203 of the Robert T. Stafford Disaster Assistance and Emergency Relief Act (Stafford Act), 42 U.S.C. 5133. The PDM program provides funds to states, territories, tribal governments, communities, and universities for hazard mitigation planning and implementation of mitigation projects prior to disasters, providing an opportunity to reduce the nation's disaster losses through PDM planning and the implementation of feasible, effective, and cost-efficient mitigation measures. Funding of pre-disaster plans and projects is meant to reduce overall risks to populations and facilities. The PDM program is subject to the availability of appropriation funding as well as any program-specific directive or restriction made with respect to such funds.
https://www.fema.gov/pre-disaster-mitigation-grant-program

FEMA Hazard Mitigation Grant Program (HMGP)

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

The HMGP is one of the FEMA programs with the greatest possible fit to potential projects recommended in this report. However, it is available only in the months subsequent to a federal disaster declaration in the State of New York. Because the state administers the HMGP directly, application cycles will need to be closely monitored after disasters are declared in New York.
https://www.fema.gov/hazard-mitigation-grant-program

FEMA Flood Mitigation Assistance (FMA) Program

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

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

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

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

NYS Department of State

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

NYS Department of Environmental Conservation – Municipal Waste Reduction and Recycling (MWRR) Program

The NYS Department of Environmental Conservation (DEC) administers MWRR funding to local government entities for waste reduction and recycling projects. The overall goal of this funding program is to assist municipalities in expanding or improving local waste reduction and recycling programs and to increase participation in those programs.

The MWRR state assistance program can help fund the costs of the following:

- Capital Investment in Facilities and Equipment

Eligible projects are expected to enhance municipal capacity to collect, aggregate, sort, and process recyclable materials. Recycling equipment includes structures, machinery, or devices providing for the environmentally sound recovery of recyclables, including source separation equipment and recyclables recovery equipment.

U.S. Army Corps of Engineers (USACE)

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

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

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

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

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

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

Emergency Watershed Protection (EWP) Program Buyouts

For voluntary property buyouts, it is suggested that municipalities within the subject watershed consider applying to the Emergency Watershed Protection (EWP) Program administered by the U.S. Department of Agriculture's Natural Resources Conservation Service (NRCS). The program provides technical and financial assistance to help local communities relieve imminent threats to life and property caused by floods and other natural disasters.. EWP buyout funds can be applied to flood-prone properties wherever structural flood mitigation projects reduce but do not eliminate flooding.
Emergency Watershed Protection (EWP) Program Buyouts | Natural Resources Conservation Service (usda.gov)

New York State Grants

All New York State grants are now announced on the NYS Grants Gateway. The Grants Gateway is designed to allow grant applicants to browse all NYS agency anticipated and available grant opportunities, providing a one-stop location that streamlines the way grants are administered by the State of New York.
https://grantsmanagement.ny.gov/

Environmental Facilities Corporation

The Environmental Facilities Corporation (EFC) helps local governments and eligible organizations undertake water infrastructure projects. EFC provides grants and financing to help ensure projects are affordable while safeguarding essential water resources. EFC administers state and federal grants as well as interest-free and low-cost financing to help minimize the tax burden for communities.
https://efc.ny.gov

The EFC's Green Innovation Grant Program (GIGP) supports projects across New York State that utilize unique Environmental Protection Agency (EPA)-designated green stormwater infrastructure design and creates cutting-edge green technologies. Competitive grants are awarded annually to projects that improve water quality and mitigate the effects of climate change through the implementation of one or more of the following green practices: Green Stormwater Infrastructure, Energy Efficiency, and Water Efficiency.
https://efc.ny.gov/gigp

Bridge NY Program

The Bridge NY program, administered by NYSDOT, is open to all municipal owners of bridges and culverts. Projects are awarded through a competitive process and support all phases of project development. Projects selected for funding are evaluated based on the resiliency of the structure, including such factors as hydraulic vulnerability and structural resiliency; the significance and importance of the bridge, including traffic volumes, detour considerations, number and types of businesses served, and impacts on commerce; and the current bridge and culvert structural conditions.
https://www.dot.ny.gov/BRIDGENY.

Private Foundations

Private entities such as foundations are potential funding sources in many communities. Communities will need to identify the foundations that are potentially appropriate for some of the actions proposed in this report.

In addition to the funding sources listed above, other resources are available for technical assistance, planning, and information. While the following sources do not provide direct funding, they offer other services that may be useful for proposed flood mitigation projects.

Land Trust and Conservation Groups

These groups play an important role in the protection of watersheds, including forests, open space, aquatic ecosystems, and water resources.

Communities will need to work closely with potential funders to ensure that the best combinations of funds are secured for the proposed alternatives and for the property-specific mitigation such as floodproofing, elevations, and relocations. It will be advantageous for the communities to identify combinations of funding sources in order to reduce their own requirement to provide matching funds.

6. LAND USE ANALYSIS

6.1 LAND USE AND ZONING REVIEW AND ANALYSIS

Potential changes to land use, particularly development proposals in close proximity to a water body or within a riparian buffer, can bring about issues and consequences both for the impact on those developments should a flood occur but also as a contributor to the flooding problem itself. In New York State, land use is controlled at the municipal level through zoning, subdivision, and other related regulations, including wetlands and floodplain ordinances.

In Westchester County, there has been a significant amount of work conducted by the state, county, and local municipalities, typically following a flood event, which creates an immediate need to respond to the disaster as well as an understanding that situations surrounding such disasters need to be assessed and plans developed to mitigate likely future repeat events.

This analysis reviewed publicly available project-relevant documents found online to identify recommendations and opportunities identified for communities to address issues related to flooding through land use and zoning. This analysis also provides best practice recommendations that communities in Westchester County within the Mamaroneck watershed can review and discuss implementing, if not already in the municipal code.

- All Westchester County communities within the Mamaroneck watershed have a flood damage prevention ordinance or similar standards to address flood damage prevention. The standards adopted can vary from community to community, but they all provide construction standards for actions within flood hazard areas.

https://planning.westchestergov.com/images/stories/reports/patternsforwestchester.pdf
https://planning.westchestergov.com/images/stories/pdfs/2025ContextPolicies.pdf

The current regulations, most recently adopted/revised in 2007 by all Mamaroneck watershed communities, go a long way toward addressing potential issues and concerns related to flooding and land use planning.

Below are summaries of relevant recommendations from other county-wide documents addressing flooding and sustainability that may be useful to consider when assessing potential changes to existing zoning, subdivision, and other regulations that could impact flood-related conditions:

- All Westchester County communities are under the "umbrella" of the 1996 "Patterns for Westchester" Plan Update. Additionally, there is Westchester's 2025's "Context for County and Municipal Planning and Policies to Guide County Planning." All communities fall within the following recommendations from the Plan:

    - Natural Resources and the Environment Section – Encourages municipalities to implement best management practices; designate critical environmental areas; enact wetland, tree preservation, and steep slope protection ordinances; and encourage preservation of lands and conservation easements to protect wetland and riparian systems.

- Cleaner, Greener Communities Mid-Hudson Regional Sustainability Plan (Mid-Hudson Planning Consortium*)* 2013

    - This plan was developed to "…set realistic yet ambitious objectives for the long term sustainable development of the Region, each of which is supported by initiatives and projects that can be implemented in the short-, medium-, and long-term. The plan lists 218 project ideas, some of which are directed toward Westchester County specifically, but none of those projects are flood or land use/zoning focused. That said, there are Mid-Hudson-wide recommended projects related to flooding that are relevant, including the following:

        - Project 63 – Install porous pavement in municipalities.
        - Project 188 – Increases in the extent of riparian buffers.
        - Project 203 – Watershed remediation. This project will help identify and target funds to specific vulnerable locations to protect roads and other facilities from flooding.
        - Project 212 – Get municipalities involved in green infrastructure. Enable more green infrastructure projects by removing cost and knowledge barriers.

https://www.orangecountygov.com/DocumentCenter/View/1469/Mid-Hudson-Regional-Sustainability-Plan-PDF

    - The Greenprint for a Sustainable Future, the Westchester County Greenway Compact Plan (2004) includes a policy related to preserving and protecting the county's natural resources, including water bodies, wetlands, and coastal zones. https://planning.westchestergov.com/greenway-compact-plan/sustainable-future-greenprint
    - The 2021 Westchester County Hazard Mitigation Plan's mission is to "protect and enhance the health, safety, property, environment, and economy of the communities within Westchester County and to increase resilience by partnering and planning to identify and reduce future vulnerability to natural and other emerging hazards in an equitable, proactive, and efficient manner." All communities within the Mamaroneck watershed have Jurisdictional Annexes in the Plan detailing information about their community as well as recommendations for projects to be undertaken to mitigate different types of hazards, including flooding. https://planning.westchestergov.com/hazard-mitigation-planning

6.2 MUNICIPAL ASSESSMENTS

The following section details individual recommendations for each community being assessed within the Mamaroneck River watershed. Following these writeups are best practices that each community can review to assess whether they are already in their municipal code or if there is an opportunity to enhance the code to further protect municipal resources, residents, businesses, and the natural environment from unplanned and unwanted impacts from flooding.

6.2.1 VILLAGE AND TOWN OF HARRISON

Zoning & Other Code(s) Analysis

https://ecode360.com/8314019

The town/village of Harrison has a "Floodplain Damage Prevention" code (Chapter 146). The code has standards related to elevation and flood-resistant construction. The town/village also has a "Stormwater Management and Erosion and Sediment Control" code (Chapter 267) and a Subdivision of Land code, which regulates flooding-related issues (Chapter 275). The town/village also has freshwater wetlands regulations (Chapter 149).

Other Land Use documents reviewed:

- Westchester County HMP – Town of Harrison Annex - The Annex document does not reference high-level issues or concerns related to the Mamaroneck River watershed, but there are specific recommendations related to mitigation measures for properties prone to flooding and an overall recommendation for the town/village to update its flood maps, among other recommendations. Specific recommendations are made to implement flood mitigation measures along the Mamaroneck River between Barnes Lane and Anderson Hill Road. There is also a recommendation to remove the Mamaroneck Reservoir dam. The Annex document can be found here: https://planning.westchestergov.com/hazard-mitigation-planning

- The Town/Village of Harrison Comprehensive Plan (2013) – The Plan discusses water quality concerns and watershed protection. A portion of the Mamaroneck River Basin is noted as a Critical Environmental Area. https://www.harrison-ny.gov/sites/g/files/vyhlif671/f/file/file/adopted_master_plan_2013.pdf

6.2.2 TOWN OF NORTH CASTLE

Zoning & Other Code(s) Analysis

https://ecode360.com/36929254

The town of North Castle has a "Flood Damage Prevention" code (Chapter 177). The code has standards related to elevation and flood-resistant construction. The town also has a "Stormwater Management" code (Chapter 267), which regulates certain acts that are permitted or prohibited within a stream or watercourse. The town also has Wetlands and Watercourse Protection regulations (Chapter 340).

The town code requires the Planning Board to review water supply and sewerage systems to minimize or eliminate flood damage and provide adequate drainage. The code also states that no more than 25 percent of the minimum lot area under water or defined as wetland can be used to satisfy the minimum lot area.

Other Land Use documents reviewed:

- Westchester County HMP – Town of North Castle Annex: The Annex document does not reference high-level issues or concerns related to the Mamaroneck River watershed, nor specific recommendations, but does discuss general mitigation measures for properties prone to flooding, among other recommendations. The Annex document can be found here: https://planning.westchestergov.com/hazard-mitigation-planning

- The Town of North Castle Comprehensive Plan (2018) – This plan does not discuss the Mamaroneck watershed but discusses other watershed plans and planning efforts and participation in the Northern Westchester Watershed Committee. https://www.northcastleny.com/sites/g/files/vyhlif3581/f/uploads/2018_comprehensive_plan_amended_2_6-12-19-compressed.pdf

6.2.3 CITY OF WHITE PLAINS

Zoning & Other Code(s) Analysis

https://library.municode.com/ny/white_plains/codes/code_of_ordinances?nodeId=TITVIIPUWO_CH7-10FLDAPR

The City of White Plains has a Flood Damage Prevention Code (Chapter 7-10) to "promote public health, safety, and general welfare, and to minimize public and private losses due to flood conditions in specific areas…" The code has standards regulating uses related to water or erosion hazards; the protection of facilities against flood damage at the time of initial construction; controls for alteration of natural floodplains, stream channels, and natural protective floodwater barriers; the filling, grading, dredging, or other development that may increase erosion or flood damage, construction of flood barriers which will unnaturally divert floodwaters or which may increase flood hazards to other lands; and to qualify and maintain properties for participation in the National Flood Insurance Program. The City has a Stormwater Management and Erosion and Sediment Control code (Chapter 3-6) and a Subdivision of Land Code (Chapter 9-4), which both address flooding-related issues. The City also has Standards and Regulations to Protect and Preserve Environmentally Sensitive Sites and Features (Chapter 3-5), which includes wetlands and water resources such as watercourses, ponds, lakes, reservoirs, retention basins, and watersheds.

Other Land Use documents reviewed:

- 2006 Revision to the 1997 Comprehensive Plan – The 2006 Comprehensive Plan Update Strategies for the Environment included a recommendation that the City continue to work with other agencies and local governments within the Mamaroneck and Bronx River watersheds to undertake watershed planning and management activities. The City entered into intermunicipal agreements with other affected communities in both the Bronx River and Mamaroneck River watersheds.

- Westchester County HMP – City of White Plains Annex - The Annex document references the Mamaroneck River and West Branch of Mamaroneck Avenue as a specific area of concern based on resident responses to the Westchester County Hazard Mitigation Citizen Survey. The Annex also recommends discontinuing the 2015 HMP recommendation to partner with neighboring communities' flood gauges on the Mamaroneck River. The Annex document containing details on the findings can be found here: https://planning.westchestergov.com/hazard-mitigation-planning

6.2.4 TOWN/VILLAGE OF SCARSDALE

Zoning & Other Code(s) Analysis

https://ecode360.com/6439798

The town/village of Scarsdale has a Flood Damage Prevention code (Chapter 167). The code has standards and regulations for elevation of structures and flood-resistant construction. The town/village also has a "Stormwater Management and Erosion and Sediment Control" code (Chapter 254) and a Subdivision of Land Code, which regulates flooding-related issues (Chapter A319).

Other Land Use documents reviewed:

- 1994 Comprehensive Plan – The Landscapes and Open Spaces section of the Plan had a short writeup on the protection of natural resources. This element stated that residents want assurances that local streams, wetlands, and floodplains are protected from encroachment and degradation through the enforcement of current regulations. The Plan recommendations section notes that codes need to be reviewed and updated to protect natural resources, an action that was taken since the Plan was drafted. It also notes that large areas of sensitive lands could be considered for designation as a Critical Environmental Area (CEA), which requires a heightened level of scrutiny under State Environmental Quality Review Act (SEQRA) if development is proposed on designated lands.

- Westchester County HMP – Town/Village of Scarsdale Annex – The Annex document does not reference high-level issues or concerns related to the Mamaroneck River watershed, nor specific recommendations, but does discuss general mitigation measures for properties prone to flooding, among other recommendations. The Annex did state that the village does not keep a list of properties that have been damaged by flooding; however, FEMA maintains a list of repetitive loss properties, and the village has a copy of the document. The Annex document can be found here: https://planning.westchestergov.com/hazard-mitigation-planning

6.2.5 TOWN OF MAMARONECK

Zoning & Other Code(s) Analysis

https://ecode360.com/9160708

The town of Mamaroneck has a Flood Damage Prevention code (Chapter 110). The code has standards and regulations for elevation of structures and flood-resistant construction. The town also has a "Stormwater Management and Erosion and Sediment Control" code (Chapter 95) and a Subdivision of Land Code which regulates flooding-related issues (Chapter 190). The town also has a Wetlands and Watercourses code which is intended to preserve, protect, and conserve tidal and freshwater wetlands and watercourses and ensure "no net loss" of wetlands and watercourse areas (Chapter 114).

Other Land Use documents reviewed:

- Comprehensive Plan – The town is currently working on updating their Comprehensive Plan – *Together Our Mamaroneck* (T.O.M.). Their website states that the plan will create a blueprint for a more environmentally, equitable, and economically sound unincorporated area of the town of Mamaroneck. An Existing Conditions Assessment was posted online. Three CEAs have been designated. The Larchmont Reservoir Sheldrake Leatherstocking CEA and Westchester County – County and State Park Lands (Saxon Woods Park) CEA are at least partially, if not entirely, located within the Mamaroneck River watershed.

- Westchester County HMP – Town of Mamaroneck Annex – The Annex document does not reference high-level issues or concerns related to the Mamaroneck River watershed, nor specific recommendations, but does discuss general mitigation measures for properties prone to flooding, among other recommendations. The document noted that frequent flooding events have resulted in damages to residential properties. The town has 62 repetitive loss properties, but others may be impacted by flooding. The Annex document containing details on the findings can be found here: https://planning.westchestergov.com/hazard-mitigation-planning

6.2.6 VILLAGE OF MAMARONECK

Zoning & Other Code(s) Analysis

https://ecode360.com/7712654

The village of Mamaroneck has a Flood Damage Prevention code (Chapter 186). The code has standards and regulations for elevation of structures and flood-resistant construction. The village of Mamaroneck also has a "Stormwater Management and Erosion and Sediment Control" code (Chapter 294) and a

Subdivision of Land Code, which regulates flooding-related issues (Chapter A348). The village also has Freshwater Wetlands regulations (Chapter 192).

Other Land Use documents reviewed:

- Comprehensive Plan – The village is currently working on updating its Comprehensive Plan, and an updated plan has been drafted. The Plan notes that the USACE Flood Risk Management Project for the Sheldrake and Mamaroneck Rivers is the foundation upon which other flood-reduction measures are being considered and implemented by the village (Chapter 5 Environmental Protection, Open Space & Flood Resiliency). The Plan notes that in 2022, the village appropriated funds to undertake emergency dredging and desiltation of the Mamaroneck River, among others. The Plan provides a few Environmental Protection, Open Space & Resilience recommendations, including related to flooding, including (5-2) conducting a mitigation study for areas not improved by the USACE projects, (5-11) invest in early warning and tracking systems by installing gauges in the Mamaroneck River (among others) to monitor water levels.

- Westchester County HMP – Town of Mamaroneck Annex – The Annex document contains several references to the Mamaroneck River. It notes that the Anita Lane/Valley Place sewer bridge causes poor hydraulic flow in the river. It also notes that the Sheldrake and Mamaroneck Rivers experience flooding and that the USACE has completed a flood mitigation study of the area. However, there are areas of the village that flood that were not covered by the study. These areas are in the vicinity of the Beaver Swamp Brook subdrainage basin and areas with insufficient stormwater sewer infrastructure. A "Road to Nowhere" in Harrison on the opposite side of the Mamaroneck River creates a block and secondary river that causes additional flooding on Chestnut Avenue and other streets in the area. Howard Avenue along the Mamaroneck River needs to be addressed. The Annex document containing details on the findings can be found here: https://planning.westchestergov.com/hazard-mitigation-planning

6.2.7 CITY OF NEW ROCHELLE

Zoning & Other Code(s) Analysis

https://ecode360.com/6729498

The city of New Rochelle has a Flood Damage Prevention code (Article IV). The code has standards and regulations for elevation of structures and flood-resistant construction. The city also has a "Use of Best Management Practices to Prevent, Control, and Reduce Stormwater Pollutants" section of the code (Section 215-12) and a Land Development Code, which regulates flooding-related issues (Chapter A361).

Other Land Use documents reviewed:

- 2016 Comprehensive Plan – The Comprehensive Plan does not reference the Mamaroneck River watershed. Within the Land Use and Zoning Recommendations, a key concept is listed as implementing zoning changes to promote sustainability. Concept 4.14 calls for reviewing the city's Flood Damage Prevention Regulations adequacy in light of sea-level rise projections.

Within the Public Facilities and Utilities Recommendations, a key concept is listed as incorporating resiliency planning into New Rochelle's utility systems. Recommendation 7.16: Reduce impervious surfaces, the Plan calls for reducing the incidence and severity of local flooding by controlling stormwater runoff, expanding permeable surface coverage, repairing existing infrastructure, and utilizing new green infrastructure models. It also calls for examining local building and zoning codes, with the goal or removing potential impediments to and creating incentives and/or requirements for the use of permeable surfaces. There is also a recommendation to establish and enforce lot coverage maximums and to impose fees for noncompliance.

- Westchester County HMP – City of New Rochelle Annex - The Annex document does not reference high-level issues or concerns related to the Mamaroneck River watershed, nor specific recommendations, but does discuss general mitigation measures for properties prone to flooding, among other recommendations. The document noted that there are 286 repetitive loss properties, but other properties may be impacted as well. The Annex document containing details on the findings can be found here: https://planning.westchestergov.com/hazard-mitigation-planning

6.3 BEST PRACTICES RECOMMENDATIONS

Flood Resiliency Best Practices - Code Audit Checklist

A Flood Resiliency Best Practices Code Audit Checklist has been created for each of the communities (see below). The preliminary review undertaken for this effort provides summary information on some of the more common resiliency code elements found in communities in the Hudson River Valley. This effort is intended to be a starting point for communities to determine whether or not additional best practices should be added to the municipal code. The code should be further reviewed and assessed for potential incorporation of additional laws, where applicable and feasible.

Best Practice Resources

Communities within the Mamaroneck River watershed have in many cases undertaken the implementation of many positive regulatory actions to help mitigate the impacts of flooding within their communities. Land use planning is an action that is always searching for answers to existing problems and concerns as well as those that are anticipated in the future. Consideration of additional potential best practices to enhance the protection of property, riparian buffers, rivers, tributaries, and other water bodies is essential to continuing the work already undertaken and maximize its impact now and into the future.

As noted in the Planning Advisory Service (PAS) reports, the "…zoning code can be used to enable local elevation and mitigate its impacts through design standards and bulk regulations. Design standards can help to encourage a continuity of local character and give developers and homeowners a menu of potential options that can mitigate increased height, exposed piers and piles, and open spaces beneath the structure. The zoning and building code can be used to add additional freeboard above the FEMA Base Flood Elevation to account for sea-level rise, and retain and expand existing architectural design elements for raised structures." Overlays can be used to protect areas without needing to adjust the underlying zoning.

Below are a few resources that could assist in drafting new best practices code language:

- https://dos.ny.gov/model-local-laws-increase-resilience
- https://www1.nyc.gov/assets/planning/download/pdf/plans-studies/flood-resiliency-update/zoning-for-flood-resiliency.pdf
- https://planning-org-uploaded-media.s3.amazonaws.com/publication/download_pdf/Zoning-Practice-2018-06.pdf
- https://planning-org-uploaded-media.s3.amazonaws.com/document/Zoning-Practice-2016-03.pdf

As a component of this flood analysis, a Flood Resiliency Best Practices Audit was conducted for each watershed community. A map with the boundaries of the Mamaroneck River watershed and the towns and villages that fall within it is depicted in Figure 6-1. Results of the audit are presented in the following tables:

Table 6-1: Village and Town of Harrison
Table 6-2: Town of North Castle
Table 6-3: City of White Plains
Table 6-4: Village/Town of Scarsdale
Table 6-5: Town of Mamaroneck
Table 6-6: Village of Mamaroneck
Table 6-7: City of New Rochelle

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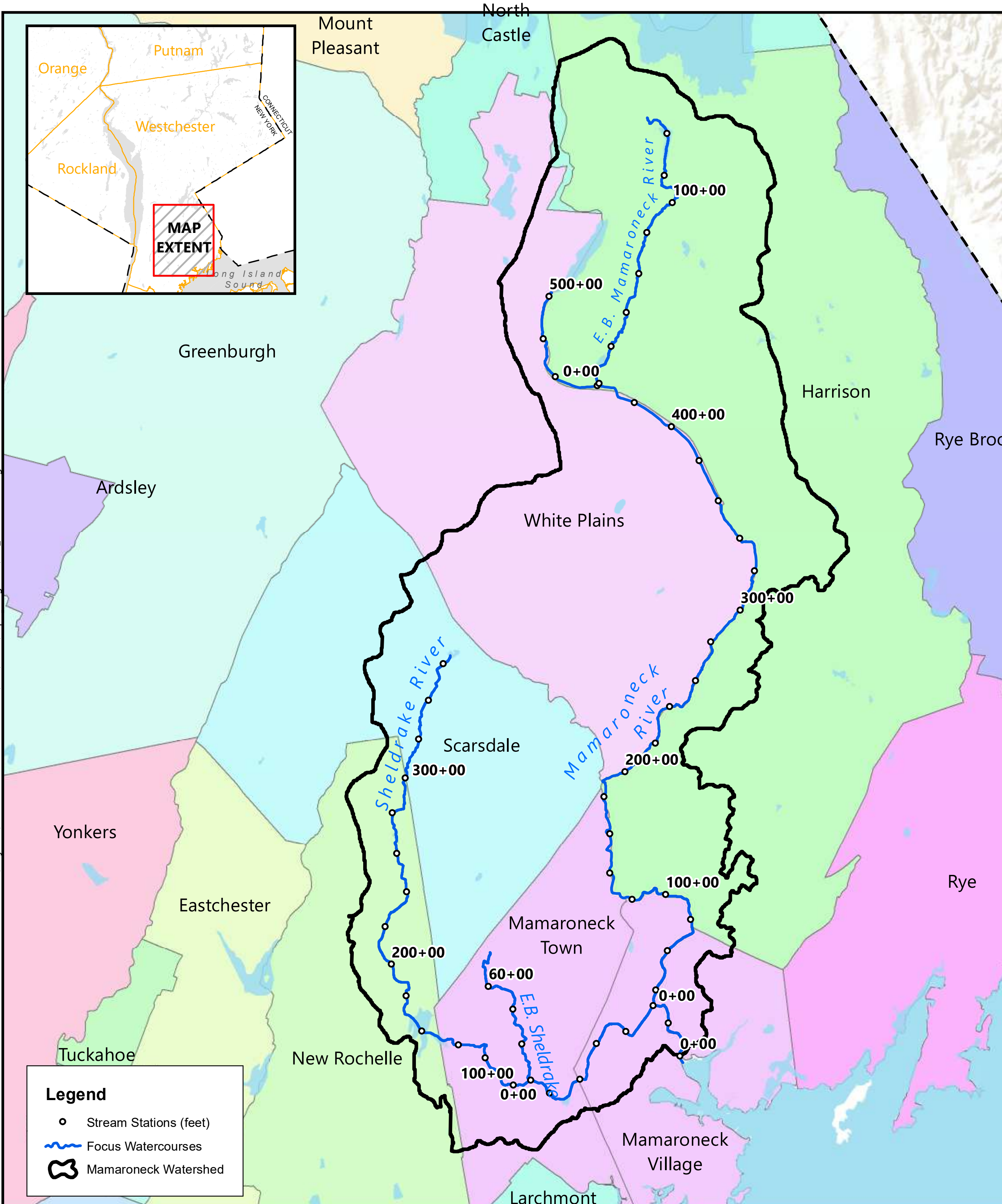

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MAMARONECK RIVER WATERSHED TOWNS & VILLAGES

MAMARONECK RIVER FLOOD & RESILIENCY STUDY
SD 969 MOD 2
WESTCHESTER COUNTY, NEW YORK

N

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Feet

SCALE 1 " = 6,000 '

DATE 5/26/2023

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FIG. 6-1

Table 6-1: Flood Resiliency Best Practices Code Audit Checklist				
Town of Harrison, NY Preliminary Audit	***In Existing Code***	***Consider for Implementation***	***N/A***	***Notes***
Zoning Code Ordinance Best Practices				
Elevation Design & Screening				
Require design interventions to screen and mitigate elevation impacts on the streetscape for elevated buildings.	☐	☐	☐	
Use hedges and fencing to separate private and public realms. Screen on-site parking located beneath a structure with foundation plantings and vegetative screening. Screen piers and columns that have been used to raise structures.	☐	☐	☐	
Building entries must face the street on which the building fronts, and walkways should provide direct access from the sidewalk to the front door.	☐	☐	☐	
Building fronts, entry porches and similar features must use materials, colors and proportions appropriate for the local architectural context. Large and multi-family building should use treatments similar to ensure local architectural consistency.	☐	☐	☐	
Guidelines for specific design elements such as canopies, galleries, and local significant materials, colors and design strategies to mitigate height and size perceptions are encouraged.	☐	☐	☐	
Bulk & Area Requirements				
Ensure that uses below the building Base Flood Elevation are restricted to access, parking and storage.	☑	☐	☐	The Flood Damage Prevention Code defines the lowest floor as being the lowest enclosed area (including basement or cellar), however an unfinished or flood resistant enclosure, usable solely for parking, access or storage in an area other than a basement area is not considered a buildings lowest floor provided that such enclosure is not in violation of the non-elevation design requirements of the law.
Permit relief from height limits where possible for developers and property owners who wish to go above the Design Flood Elevation.	☐	☐	☐	
Enact new height limits where possible that are based on the new local design flood elevation (one to two feet over the BFE) where side and rear yard relief is possible.	☐	☐	☐	
Given the increased height of buildings due to elevation, turrets, towers and cupolas, ensure total building height does not exceed maximum height(s) desired, but also ensure that maximum building height requirements allow for building elevations without the need for a variance.	☐	☐	☐	
Require an additional 3’ of freeboard above the base flood elevation for buildings within the Special Flood Hazard Area and 18” of freeboard in the “shaded X” area, which includes buildings between the 100-year and 500-year floodplains. All new single family detached dwellings outside of defined flood hazard areas need to be elevated 16-24”. This approach acknowledges the likelihood of more extreme flooding inside of and more extensive flooding outside of the FEMA-defined flood hazard area (based on historic flooding and not sea-level rise).	☑	☐	☐	The code includes residential and nonresidential structure elevation standards. Standards are included that require the lowest habitable flood elevated to between 2' and 3' above base flood level or highest adjacent grade in certain zones as well as requirements for drainage paths in other zones for residential structures. There are many additional design and engineering standards that also apply. Non-residential standards require elevation to or above two feet above the base flood elevation or floodproofing below two feet below the base flood level or be completely floodproofed, depending on the zone.
Permit reduced side or rear yards relative to overall height to allow squatter and more proportional buildings.	☐	☐	☐	
Require riparian and/or floodplain buffers - See also Subdivision Regulations.	☐	☐	☐	
Utilize net density calculations that exclude wetland and floodplain areas in a developable area.	☐	☐	☐	
Establish a maximum percentage of impermeable surface coverage on a lot which limits the density of development and addressing stormwater runoff.	☐	☐	☐	

Table 6-1: Flood Resiliency Best Practices Code Audit Checklist				
Town of Harrison, NY Preliminary Audit	***In Existing Code***	***Consider for Implementation***	***N/A***	***Notes***
Other Code Revisions				
Coastal Resilience Overlays could be applied to areas with the highest flood risk. These areas require higher elevations of the first floor, limit parking and hard pavement, and require additional landscaping and open space.	☑	☐	☐	
Upland Resilience Overlays could be applied to lower-risk areas capable of accommodating growth. New construction within an Upland Resilience Overlay is also permitted to reduce its own resilience requirements in exchange for placing conservation easements on higher-risk properties.	☑	☐	☐	
Neighborhood Resilience Overlays could be applied to lower-risk areas, and are intended for more typical cases. They allow for customized design standards that are appropriate to the local context.	☑	☐	☐	No structure in an area of special flood hazard is permitted without a floodplain development permit and compliance with the code. Encroachments have different regulations depending on their location. For encroachments, assessments and/or a technical evaluation is conducted and the Town applies to FEMA for conditional Firm and floodway revision. Approval is required before construction or improvements can begin. For streams with a regulatory floodway, the code requires that whenever any portion of a floodplain is authorized for development, the volume of space occupied by the authorized fill or structure below the BFE shall be compensated for and balanced by a hydraulically equivalent volume of excavation taken from below the base flood elevation at or adjacent to the development site.
Permit property owners to reallocate lost floor area from the ground floor and sub-grade spaces to elsewhere in the structure.	☐	☐	☐	
Ensure that well heads are above the BFE.	☑	☐	☐	The Code requires water supply systems to minimize or eliminate infiltration of floodwaters into the system.
Add flood resistant construction (flood-proofing) standards such as ensuring buildings are watertight, utilities and sanitary facilities are above the BFE, enclosed within the building's watertight walls, or made watertight and resistance. Standards should also ensure that the building's structural components are also flood resistant.	☑	☐	☐	The Code requires anchoring of new structures and substantial improvements as well as the use of materials, utility equipment, and methods and practices that are resistant to flood damage and that minimize flood damage. New and replacement utilities must located at or above BFE. Water supply systems must minimize or eliminate infiltration of floodwaters into the system. On-site waste disposal systems must be located to avoid impairment to them, or contamination from them, during flood events.
Prohibit new development unless effect on flooding is minimal or zero.	☑	☐	☐	Code prohibits development encroachment if increases base flood by >1 foot (see encroachment notes above).The Code requires notification to adjacent communities and the NYSDEC prior to permitting any alteration or relocation of a watercourse, including a determination that the permit holder has provided for maintenance within the altered or relocated portion of said watercourse so that the flood carrying capacity is not diminished.
Prohibit substantial improvements to nonconforming uses or structures in flood prone areas.	☐	☐	☐	
Consider acquisition of flood-prone lands, particularly where they include vital riparian areas and/or could provide a public benefit such as a park or passive open space.	☐	☐	☐	
Subdivision Ordinance Best Practices				
Subdivision Ordinance				
Conservation subdivision (cluster development) to encourage development be built in suitable areas of development that protects important natural features.	☐	☐	☐	

Table 6-1: Flood Resiliency Best Practices Code Audit Checklist				
Town of Harrison, NY Preliminary Audit	***In Existing Code***	***Consider for Implementation***	***N/A***	***Notes***
Prohibit subdivisions in floodprone areas.	☑	☐	☐	The subdivision code includes general standards which discuss land subdivision being used safely without danger from flood. The Floodplain Management code requires subdivisions to be consistent with the need to minimize flood damage, utilities and facilities must be located and constructed to minimize flood damage, and adequate drainage needs to be provided to reduce exposure to flood damage. Subdivision regulations require preservation, to the extent feasible, of the natural terrain and natural drainage pattern.
Require and maximize the width of riparian buffers. Provide riparian buffer requirements for the following:	☐	☐	☐	
Stream stabilization - A few dozen feet to a few hundred feet.	☐	☐	☐	
Water quality protection – A few dozen to a few hundred feet (a longer distance if sediment removal is desired)	☐	☐	☐	
Flood attenuation – A few dozen to several hundred feet	☐	☐	☐	
Riparian & wildlife habitat – A few dozen feet up to a mile, though the average minimum is approximately 100’ to several hundred or a few thousand feet.	☐	☐	☐	
Protection of cold water fisheries – A few dozen feet to a few hundred feet	☐	☐	☐	
Prohibit development immediately adjacent to streams, rivers, lakes, wetlands and other water bodies.	☐	☐	☐	
Inventory riparian areas as part of the subdivision process and preserve unimpaired riparian areas in natural conditions.	☐	☐	☐	
Require restoration of impaired riparian zones as a condition of subdivision approval.	☐	☐	☐	
Restrict potentially problematic uses (Hazardous materials uses, for example)	☐	☐	☐	
Dedicate land for public facilities and services.	☐	☐	☐	
Require adequate access where evacuation may be necessary or where emergency vehicle access may be required.	☐	☐	☐	
Ensure utilities such as electric, natural gas, water and wastewater are hardened. Require electrical components to be mounted above flood levels. Major utility equipment should be considered a critical facility and be required to be located outside of the 500 year floodplain.	☐	☐	☐	
Consider the long-term needs of the community when discussing the potential for a homeowner’s association to operate and/or maintain an area prone to flooding.	☐	☐	☐	
Require flood hazard information to be provided on a subdivision plat. Require the 100-year floodplain elevation to be shown on all subdivision plats. Information such as finished building pad elevation or proposed lowest finished floor elevation can also be detailed.	☐	☐	☐	
Any property with a floodplain should be required to show such information on the plan.	☐	☐	☐	
Require conservation easements around flood-prone areas or floodplains.	☐	☐	☐	
Require green infrastructure or low-impact development techniques, where feasible	☑	☐	☐	The code includes Stormwater Management regulations which discuss flooding.
Each proposed lot must have a designated buildable site above the special flood hazard area (SFHA) as shown on the most current Flood Insurance Rate Map.	☐	☐	☐	

<u>Code Sections Reviewed:</u>

Flood Damage Prevention - Chapter 146

Subdivision of Land - Chapter 204

Stormwater Management and Erosion and Sediment Control - Chapter 130

Table 6-2: Flood Resiliency Best Practices Code Audit Checklist				
Town of North Castle, NY Preliminary Audit	***In Existing Code***	***Consider for Implementation***	***N/A***	***Notes***
Zoning Code Ordinance Best Practices				
Elevation Design & Screening				
Require design interventions to screen and mitigate elevation impacts on the streetscape for elevated buildings.	☐	☐	☐	
Use hedges and fencing to separate private and public realms. Screen on-site parking located beneath a structure with foundation plantings and vegetative screening. Screen piers and columns that have been used to raise structures.	☐	☐	☐	
Building entries must face the street on which the building fronts, and walkways should provide direct access from the sidewalk to the front door.	☐	☐	☐	
Building fronts, entry porches and similar features must use materials, colors and proportions appropriate for the local architectural context. Large and multi-family building should use treatments similar to ensure local architectural consistency.	☐	☐	☐	
Guidelines for specific design elements such as canopies, galleries, and local significant materials, colors and design strategies to mitigate height and size perceptions are encouraged.	☐	☐	☐	
Bulk & Area Requirements				
Ensure that uses below the building Base Flood Elevation are restricted to access, parking and storage.	☑	☐	☐	The Flood Damage Prevention Code defines the lowest floor as being the lowest enclosed area (including basement or cellar), however an unfinished or flood resistant enclosure, usable solely for parking, access or storage in an area other than a basement area is not considered a buildings lowest floor provided that such enclosure is not in violation of the non-elevation design requirements of the law.
Permit relief from height limits where possible for developers and property owners who wish to go above the Design Flood Elevation.	☐	☐	☐	
Enact new height limits where possible that are based on the new local design flood elevation (one to two feet over the BFE) where side and rear yard relief is possible.	☐	☐	☐	
Given the increased height of buildings due to elevation, turrets, towers and cupolas, ensure total building height does not exceed maximum height(s) desired, but also ensure that maximum building height requirements allow for building elevations without the need for a variance.	☐	☐	☐	
Require an additional 3' of freeboard above the base flood elevation for buildings within the Special Flood Hazard Area and 18" of freeboard in the "shaded X" area, which includes buildings between the 100-year and 500-year floodplains. All new single family detached dwellings outside of defined flood hazard areas need to be elevated 16-24". This approach acknowledges the likelihood of more extreme flooding inside of and more extensive flooding outside of the FEMA-defined flood hazard area (based on historic flooding and not sea-level rise).	☑	☐	☐	The code includes residential and non-residential structure elevation standards. Standards are included that require between 2' and 3' above base flood level or highest adjacent grade in certain zones as well as requirements for drainage paths in other zones for residential structures.
Permit reduced side or rear yards relative to overall height to allow squatter and more proportional buildings.	☐	☐	☐	
Require riparian and/or floodplain buffers - See also Subdivision Regulations.	☐	☐	☐	
Utilize net density calculations that exclude wetland and floodplain areas in a developable area.	☐	☐	☐	
Establish a maximum percentage of impermeable surface coverage on a lot which limits the density of development and addressing stormwater runoff.	☐	☐	☐	

Table 6-2: Flood Resiliency Best Practices Code Audit Checklist				
Town of North Castle, NY Preliminary Audit	***In Existing Code***	***Consider for Implementation***	***N/A***	***Notes***
Other Code Revisions				
Coastal Resilience Overlays could be applied to areas with the highest flood risk. These areas require higher elevations of the first floor, limit parking and hard pavement, and require additional landscaping and open space.	☑	☐	☐	
Upland Resilience Overlays could be applied to lower-risk areas capable of accommodating growth. New construction within an Upland Resilience Overlay is also permitted to reduce its own resilience requirements in exchange for placing conservation easements on higher-risk properties.	☑	☐	☐	Within special flood hazard areas, construction or improvements are prohibited without a valid floodplain development permit. For encroachments, assessments and/or a technical evaluation is conducted and the Town applies to FEMA for conditional FIRM and floodway revision. Approval is required before construction or improvements can begin.
Neighborhood Resilience Overlays could be applied to lower-risk areas, and are intended for more typical cases. They allow for customized design standards that are appropriate to the local context.	☑	☐	☐	
Permit property owners to reallocate lost floor area from the ground floor and sub-grade spaces to elsewhere in the structure.	☐	☐	☐	
Ensure that well heads are above the BFE.	☑	☐	☐	The Code requires water supply systems to minimize or eliminate infiltration of floodwaters into the system.
Add flood resistant construction (flood-proofing) standards such as ensuring buildings are watertight, utilities and sanitary facilities are above the BFE, enclosed within the building's watertight walls, or made watertight and resistance. Standards should also ensure that the building's structural components are also flood resistant.	☑	☐	☐	The Code requires anchoring of new structures and substantial improvements as well as the use of materials, utility equipment, and methods and practices that are resistant to flood damage and that minimize flood damage. Utilities must be to or above BFE. Water supply systems must minimize or eliminate infiltration of floodwaters into the system. On-site waste disposal systems must be located to avoid impairment to them, or contamination from them, during flood events.
Prohibit new development unless effect on flooding is minimal or zero.	☑	☐	☐	Code prohibits development encroachment if increases base flood by >1 foot (see encroachment note above). The code requires details of any watercourse alteration or relocation. The Code requires notification to adjacent communities and the NYSDEC prior to permitting any alteration or relocation of a watercourse, including a determination that the permit holder has provided for maintenance within the altered or relocated portion of said watercourse so that the flood carrying capacity is not diminished. For the purposes of subdivisions or development proposals, no more than 25% of the minimum lot area required may be satisfied by land which is under water or defined as a wetland.
Prohibit substantial improvements to nonconforming uses or structures in flood prone areas.	☐	☐	☐	
Consider acquisition of flood-prone lands, particularly where they include vital riparian areas and/or could provide a public benefit such as a park or passive open space.	☐	☐	☐	

Table 6-2: Flood Resiliency Best Practices Code Audit Checklist				
Town of North Castle, NY Preliminary Audit	***In Existing Code***	***Consider for Implementation***	***N/A***	***Notes***
Subdivision Ordinance Best Practices				
Subdivision Ordinance				
Conservation subdivision (cluster development) to encourage development be built in suitable areas of development that protects important natural features.	☑	☐	☐	The Town has Conservation Subdivision regulations.
Prohibit subdivisions in floodprone areas.	☑	☐	☐	The subdivision code includes general standards which discuss land subdivision being used safely without danger from flood. The Flood Damage Prevention Ordinance requires subdivisions to be consistent with the need to minimize flood damage, utilities and facilities must be located and constructed to minimize flood damage, and adequate drainage needs to be provided to reduce exposure to flood damage. The Subdivision code requires the Planning Board to review subdivision proposals and new developments to ensure all are elevated and constructed to minimize or eliminate flood damage and that adequate drainage is provided so as to reduce exposure to flood hazards. The Planning Board shall also review water supply and sewage systems to minimize or eliminate flood damage and provide adequate drainage. The code states that no more than 25% of the minimum lot area required may be satisfied by land which is under water or defined as a wetland. When no based flood elevation data are available from other sources, the permit applicant for a subdivision or other development shall provide the data for projects greater than 5 acres or 50 lots in Zone A.
Require and maximize the width of riparian buffers. Provide riparian buffer requirements for the following:	☐	☐	☐	
Stream stabilization - A few dozen feet to a few hundred feet.	☐	☐	☐	
Water quality protection – A few dozen to a few hundred feet (a longer distance if sediment removal is desired)	☐	☐	☐	
Flood attenuation – A few dozen to several hundred feet	☐	☐	☐	
Riparian & wildlife habitat – A few dozen feet up to a mile, though the average minimum is approximately 100' to several hundred or a few thousand feet.	☐	☐	☐	
Protection of cold water fisheries – A few dozen feet to a few hundred feet	☐	☐	☐	
Prohibit development immediately adjacent to streams, rivers, lakes, wetlands and other water bodies.	☐	☐	☐	
Inventory riparian areas as part of the subdivision process and preserve unimpaired riparian areas in natural conditions.	☐	☐	☐	
Require restoration of impaired riparian zones as a condition of subdivision approval.	☐	☐	☐	
Restrict potentially problematic uses (Hazardous materials uses, for example)	☐	☐	☐	
Dedicate land for public facilities and services.	☐	☐	☐	
Require adequate access where evacuation may be necessary or where emergency vehicle access may be required.	☐	☐	☐	
Ensure utilities such as electric, natural gas, water and wastewater are hardened. Require electrical components to be mounted above flood levels. Major utility equipment should be considered a critical facility and be required to be located outside of the 500 year floodplain.	☐	☐	☐	

Table 6-2: Flood Resiliency Best Practices Code Audit Checklist				
Town of North Castle, NY Preliminary Audit	***In Existing Code***	***Consider for Implementation***	***N/A***	***Notes***
Consider the long-term needs of the community when discussing the potential for a homeowner's association to operate and/or maintain an area prone to flooding.	☐	☐	☐	
Require flood hazard information to be provided on a subdivision plat. Require the 100-year floodplain elevation to be shown on all subdivision plats. Information such as finished building pad elevation or proposed lowest finished floor elevation can also be detailed.	☐	☐	☐	
Any property with a floodplain should be required to show such information on the plan.	☐	☐	☐	
Require conservation easements around flood-prone areas or floodplains.	☐	☐	☐	
Require green infrastructure or low-impact development techniques, where feasible	☑	☐	☐	The code includes Stormwater Management regulations which discuss flooding.
Each proposed lot must have a designated buildable site above the special flood hazard area (SFHA) as shown on the most current Flood Insurance Rate Map.	☐	☐	☐	

Code Sections Reviewed:

Flood Damage Prevention - Chapter 177

Subdivision of Land - Chapter 275

Stormwater Management - Chapter 267

Table 6-3: Flood Resiliency Best Practices Code Audit Checklist				
City of White Plains, NY Preliminary Audit	***In Existing Code***	***Consider for Implementation***	***N/A***	***Notes***
Zoning Code Ordinance Best Practices				
Elevation Design & Screening				
Require design interventions to screen and mitigate elevation impacts on the streetscape for elevated buildings.	☐	☐	☐	
Use hedges and fencing to separate private and public realms. Screen on-site parking located beneath a structure with foundation plantings and vegetative screening. Screen piers and columns that have been used to raise structures.	☐	☐	☐	
Building entries must face the street on which the building fronts, and walkways should provide direct access from the sidewalk to the front door.	☐	☐	☐	
Building fronts, entry porches and similar features must use materials, colors and proportions appropriate for the local architectural context. Large and multi-family building should use treatments similar to ensure local architectural consistency.	☐	☐	☐	
Guidelines for specific design elements such as canopies, galleries, and local significant materials, colors and design strategies to mitigate height and size perceptions are encouraged.	☐	☐	☐	
Bulk & Area Requirements				
Ensure that uses below the building Base Flood Elevation are restricted to access, parking and storage.	☑	☐	☐	The Flood Damage Prevention Code defines the lowest floor as being the lowest enclosed area (including basement or cellar), however an unfinished or flood resistant enclosure, usable solely for parking, access or storage in an area other than a basement area is not considered a buildings lowest floor provided that such enclosure is not in violation of the non-elevation requirements of the law. In several Zones, substantially improved structures shall have fully enclosed areas below the lowest floor that are usable solely for parking of vehicles, building access or storage in an area other than a basement and which are subject to flooding, designed to automatically equalize hydrostatic flood forces.
Permit relief from height limits where possible for developers and property owners who wish to go above the Design Flood Elevation.	☐	☐	☐	
Enact new height limits where possible that are based on the new local design flood elevation (one to two feet over the BFE) where side and rear yard relief is possible.	☐	☐	☐	
Given the increased height of buildings due to elevation, turrets, towers and cupolas, ensure total building height does not exceed maximum height(s) desired, but also ensure that maximum building height requirements allow for building elevations without the need for a variance.	☐	☐	☐	
Require an additional 3’ of freeboard above the base flood elevation for buildings within the Special Flood Hazard Area and 18” of freeboard in the “shaded X” area, which includes buildings between the 100-year and 500-year floodplains. All new single family detached dwellings outside of defined flood hazard areas need to be elevated 16-24”. This approach acknowledges the likelihood of more extreme flooding inside of and more extensive flooding outside of the FEMA-defined flood hazard area (based on historic flooding and not sea-level rise).	☑	☐	☐	The Flood Damage Prevention Code includes residential structure elevation standards. Standards are included that require between 2' and 3' above base flood level or highest adjacent grade in certain zones. There are also requirements for drainage paths to guide flood waters around and away from proposed structures on slopes. There are many additional design and engineering standards that also apply. Non-residential standards for areas outside the coastal high-hazard areas, require elevation to or above two feet above the base flood elevation or be floodproofed below two feet above the base flood level with walls substantially impermeable to the passage of water with all components located below the base flood level being capable of resisting hydrostatic and hydrodynamic loads and the effects of buoyancy.
Permit reduced side or rear yards relative to overall height to allow squatter and more proportional buildings.	☐	☐	☐	
Require riparian and/or floodplain buffers - See also Subdivision Regulations.	☐	☐	☐	

Table 6-3: Flood Resiliency Best Practices Code Audit Checklist				
City of White Plains, NY Preliminary Audit	*In Existing Code*	*Consider for Implementation*	*N/A*	Notes
Utilize net density calculations that exclude wetland and floodplain areas in a developable area.	☐	☐	☐	
Establish a maximum percentage of impermeable surface coverage on a lot which limits the density of development and addressing stormwater runoff.	☐	☐	☐	
Other Code Revisions				
Coastal Resilience Overlays could be applied to areas with the highest flood risk. These areas require higher elevations of the first floor, limit parking and hard pavement, and require additional landscaping and open space.	☑	☐	☐	Within the Flood Damage Prevention Code General Provisions, construction or development can not be undertaken without a flood development permit. For encroachments, assessments and/or a technical evaluation is conducted and the City applies to FEMA for conditional FIRM and floodway revision. Approval is required before construction or improvements can begin.
Upland Resilience Overlays could be applied to lower-risk areas capable of accommodating growth. New construction within an Upland Resilience Overlay is also permitted to reduce its own resilience requirements in exchange for placing conservation easements on higher-risk properties.	☑	☐	☐	
Neighborhood Resilience Overlays could be applied to lower-risk areas, and are intended for more typical cases. They allow for customized design standards that are appropriate to the local context.	☑	☐	☐	
Permit property owners to reallocate lost floor area from the ground floor and sub-grade spaces to elsewhere in the structure.	☐	☐	☐	
Ensure that well heads are above the BFE.	☑	☐	☐	The Flood Damage Prevention Code requires water supply systems to minimize or eliminate infiltration of floodwaters into the system.
Add flood resistant construction (flood-proofing) standards such as ensuring buildings are watertight, utilities and sanitary facilities are above the BFE, enclosed within the building's watertight walls, or made watertight and resistance. Standards should also ensure that the building's structural components are also flood resistant.	☑	☐	☐	The Flood Damage Prevention Code requires anchoring of new structures and substantial improvements in areas of special flood hazard to prevent flotation, collapse, or lateral movement during the base flood. Manufactured homes have requirements to be securely anchored to an adequately anchored foundation system to resist flotation, collapse and lateral movement. Construction materials and methods for new construction and substantial improvements to structures shall be constructed with materials and utility equipment resistant to flood damage and that minimize flood damage. New and replacement utilities must be to or above BFE. Water supply systems must minimize or eliminate infiltration of floodwaters into the system. New and replacement sanitary sewage systems shall be designed to minimize or eliminate infiltration of flood waters. On-site waste disposal systems must be located to avoid impairment to them, or contamination from them, during flooding.
Prohibit new development unless effect on flooding is minimal or zero.	☑	☐	☐	Code prohibits development encroachment if it increases base flood by >1 foot (see encroachment note above). The code requires notification to adjacent communities and the NYSDEC prior to permitting any alteration or relocation of a watercourse, including a determination that the permit holder has provided for maintenance within the altered or relocated portion of said watercourse so that the flood carrying capacity is not diminished.
Prohibit substantial improvements to nonconforming uses or structures in flood prone areas.	☐	☐	☐	
Consider acquisition of flood-prone lands, particularly where they include vital riparian areas and/or could provide a public benefit such as a park or passive open space.	☐	☐	☐	
Subdivision Ordinance Best Practices				
Subdivision Ordinance				
Conservation subdivision (cluster development) to encourage development be built in suitable areas of development that protects important natural features.	☑	☐	☐	The City Zoning Code permits "Conservation Development" to encourage flexibility of design and development of land in such a manner to preserve its natural and scenic qualities…[and] reduce flood hazards.

Table 6-3: Flood Resiliency Best Practices Code Audit Checklist

City of White Plains, NY Preliminary Audit	*In Existing Code*	*Consider for Implementation*	*N/A*	*Notes*
Prohibit subdivisions in floodprone areas.	☑	☐	☐	The Subdivision Code includes general standards which discuss land subdivision being used safely without danger from flood. The Flood Damage Prevention Ordinance requires subdivisions to be consistent with the need to minimize flood damage, utilities and facilities must be located and constructed to minimize flood damage, and adequate drainage needs to be provided to reduce exposure to flood damage. In Zone A, when no base flood elevation data are available from other sources, the permit applicant for a subdivision or other proposed development (including manufactured home and recreational vehicle parks and subdivisions) shall provide the data for projects greater than 5 acres or 50 lots.
Require and maximize the width of riparian buffers. Provide riparian buffer requirements for the following:	☐	☐	☐	
Stream stabilization - A few dozen feet to a few hundred feet.	☐	☐	☐	
Water quality protection – A few dozen to a few hundred feet (a longer distance if sediment removal is desired)	☐	☐	☐	
Flood attenuation – A few dozen to several hundred feet	☐	☐	☐	
Riparian & wildlife habitat – A few dozen feet up to a mile, though the average minimum is approximately 100' to several hundred or a few thousand feet.	☐	☐	☐	
Protection of cold water fisheries – A few dozen feet to a few hundred feet	☐	☐	☐	
Prohibit development immediately adjacent to streams, rivers, lakes, wetlands and other water bodies.	☐	☐	☐	
Inventory riparian areas as part of the subdivision process and preserve unimpaired riparian areas in natural conditions.	☐	☐	☐	
Require restoration of impaired riparian zones as a condition of subdivision approval.	☐	☐	☐	
Restrict potentially problematic uses (Hazardous materials uses, for example)	☐	☐	☐	
Dedicate land for public facilities and services.	☐	☐	☐	
Require adequate access where evacuation may be necessary or where emergency vehicle access may be required.	☐	☐	☐	
Ensure utilities such as electric, natural gas, water and wastewater are hardened. Require electrical components to be mounted above flood levels. Major utility equipment should be considered a critical facility and be required to be located outside of the 500 year floodplain.	☐	☐	☐	
Consider the long-term needs of the community when discussing the potential for a homeowner's association to operate and/or maintain an area prone to flooding.	☐	☐	☐	
Require flood hazard information to be provided on a subdivision plat. Require the 100-year floodplain elevation to be shown on all subdivision plats. Information such as finished building pad elevation or proposed lowest finished floor elevation can also be detailed.	☐	☐	☐	
Any property with a floodplain should be required to show such information on the plan.	☐	☐	☐	
Require conservation easements around flood-prone areas or floodplains.	☐	☐	☐	
Require green infrastructure or low-impact development techniques, where feasible	☑	☐	☐	The code includes Stormwater Management regulations which discuss flooding.
Each proposed lot must have a designated buildable site above the special flood hazard area (SFHA) as shown on the most current Flood Insurance Rate Map.	☐	☐	☐	

Code Sections Reviewed:

Flood Damage Prevention - Chapter 7-10

Subdivision of Land - Chapter 9-4

Stormwater Management - Chapter 3-6

Standards and Regulations to Protect and Preserve Environmentally Sensitive Sites and Features - Chapter 3-5

Table 6-4: Flood Resiliency Best Practices Code Audit Checklist

Town/Village of Scarsdale, NY Preliminary Audit	*In Existing Code*	*Consider for Implementation*	*N/A*	*Notes*
Zoning Code Ordinance Best Practices				
Elevation Design & Screening				
Require design interventions to screen and mitigate elevation impacts on the streetscape for elevated buildings.	☐	☐	☐	
Use hedges and fencing to separate private and public realms. Screen on-site parking located beneath a structure with foundation plantings and vegetative screening. Screen piers and columns that have been used to raise structures.	☐	☐	☐	
Building entries must face the street on which the building fronts, and walkways should provide direct access from the sidewalk to the front door.	☐	☐	☐	
Building fronts, entry porches and similar features must use materials, colors and proportions appropriate for the local architectural context. Large and multi-family building should use treatments similar to ensure local architectural consistency.	☐	☐	☐	
Guidelines for specific design elements such as canopies, galleries, and local significant materials, colors and design strategies to mitigate height and size perceptions are encouraged.	☐	☐	☐	
Bulk & Area Requirements				
Ensure that uses below the building Base Flood Elevation are restricted to access, parking and storage.	☑	☐	☐	The Flood Damage Prevention Code defines the lowest floor as being the lowest enclosed area (including basement or cellar), however an unfinished or flood resistant enclosure, usable solely for parking, access or storage in an area other than a basement area is not considered a buildings lowest floor provided that such enclosure is not in violation of the non-elevation design requirements of the law. In several Zones, substantially improved structures shall have fully enclosed areas below the lowest floor that are usable solely for parking of vehicles, building access or storage in an area other than a basement and which are subject to flooding, designed to automatically equalize hydrostatic flood forces.
Permit relief from height limits where possible for developers and property owners who wish to go above the Design Flood Elevation.	☐	☐	☐	
Enact new height limits where possible that are based on the new local design flood elevation (one to two feet over the BFE) where side and rear yard relief is possible.	☐	☐	☐	
Given the increased height of buildings due to elevation, turrets, towers and cupolas, ensure total building height does not exceed maximum height(s) desired, but also ensure that maximum building height requirements allow for building elevations without the need for a variance.	☐	☐	☐	
Require an additional 3' of freeboard above the base flood elevation for buildings within the Special Flood Hazard Area and 18" of freeboard in the "shaded X" area, which includes buildings between the 100-year and 500-year floodplains. All new single family detached dwellings outside of defined flood hazard areas need to be elevated 16-24". This approach acknowledges the likelihood of more extreme flooding inside of and more extensive flooding outside of the FEMA-defined flood hazard area (based on historic flooding and not sea-level rise).	☑	☐	☐	The code includes residential structure elevation standards. Standards are included that require between 2' and 3' above base flood level or highest adjacent grade in certain zones outside the coastal high-hazard areas, as well as requirements for drainage paths in other zones for residential structures. Non-residential standards for new construction and substantial improvements require elevation to or above two feet above the base flood elevation and floodproofing below two feet above the base flood level with walls substantially impermeable to the passage of water.
Permit reduced side or rear yards relative to overall height to allow squatter and more proportional buildings.	☐	☐	☐	
Require riparian and/or floodplain buffers - See also Subdivision Regulations.	☐	☐	☐	
Utilize net density calculations that exclude wetland and floodplain areas in a developable area.	☐	☐	☐	
Establish a maximum percentage of impermeable surface coverage on a lot which limits the density of development and addressing stormwater runoff.	☐	☐	☐	

Table 6-4: Flood Resiliency Best Practices Code Audit Checklist				
Town/Village of Scarsdale, NY Preliminary Audit	***In Existing Code***	***Consider for Implementation***	***N/A***	***Notes***
Other Code Revisions				
Coastal Resilience Overlays could be applied to areas with the highest flood risk. These areas require higher elevations of the first floor, limit parking and hard pavement, and require additional landscaping and open space.	☑	☐	☐	
Upland Resilience Overlays could be applied to lower-risk areas capable of accommodating growth. New construction within an Upland Resilience Overlay is also permitted to reduce its own resilience requirements in exchange for placing conservation easements on higher-risk properties.	☑	☐	☐	Within the Flood Damage Prevention Code, construction or improvements can not be undertaken without full compliance with the Flood Damage Prevention Chapter. For encroachments, assessments and/or a technical evaluation is conducted and the Village applies to FEMA for conditional FIRM and floodway revision. Approval is required before construction or improvements can begin.
Neighborhood Resilience Overlays could be applied to lower-risk areas, and are intended for more typical cases. They allow for customized design standards that are appropriate to the local context.	☑	☐	☐	
Permit property owners to reallocate lost floor area from the ground floor and sub-grade spaces to elsewhere in the structure.	☐	☐	☐	
Ensure that well heads are above the BFE.	☑	☐	☐	The Code requires water supply systems to minimize or eliminate infiltration of floodwaters into the system.
Add flood resistant construction (flood-proofing) standards such as ensuring buildings are watertight, utilities and sanitary facilities are above the BFE, enclosed within the building's watertight walls, or made watertight and resistance. Standards should also ensure that the building's structural components are also flood resistant.	☑	☐	☐	The Flood Damage Prevention Code requires anchoring of new structures and substantial improvements in areas of special flood hazard to prevent flotation, collapse, or lateral movement during the base flood. It also requires the use of materials, utility equipment, and methods and practices that are resistant to flood damage and that minimize flood damage. Utilities must be to or above freeboard (two feet above the base flood level) in some zones. Water supply systems must minimize or eliminate infiltration of floodwaters into the system. On-site waste disposal systems must be located to avoid impairment to them or contamination from them during during flooding.
Prohibit new development unless effect on flooding is minimal or zero.	☑	☐	☐	Code prohibits development encroachment if it increases base flood by >1 foot (see encroachment note above). The Code requires notification to adjacent communities and the NYSDEC prior to permitting any alteration or relocation of a watercourse, including a determination that the permit holder has provided for maintenance within the altered or relocated portion of said watercourse so that the flood carrying capacity is not diminished.
Prohibit substantial improvements to nonconforming uses or structures in flood prone areas.	☐	☐	☐	
Consider acquisition of flood-prone lands, particularly where they include vital riparian areas and/or could provide a public benefit such as a park or passive open space.	☐	☐	☐	
Subdivision Ordinance Best Practices				
Subdivision Ordinance				
Conservation subdivision (cluster development) to encourage development be built in suitable areas of development that protects important natural features.	☐	☐	☐	

Table 6-4: Flood Resiliency Best Practices Code Audit Checklist				
Town/Village of Scarsdale, NY Preliminary Audit	***In Existing Code***	***Consider for Implementation***	***N/A***	***Notes***
Prohibit subdivisions in floodprone areas.	☑	☐	☐	The subdivision code includes general standards which discuss land subdivision being used safely without danger from flood. The Flood Damage Prevention Ordinance requires subdivisions to be consistent with the need to minimize flood damage, utilities and facilities must be located and constructed to minimize flood damage, and adequate drainage needs to be provided to reduce exposure to flood damage. When no base flood elevation data are available from other sources, the permit applicant for a subdivision or other development shall provide the data for projects greater than 5 acres or 50 lots in Zone A.
Require and maximize the width of riparian buffers. Provide riparian buffer requirements for the following:	☐	☐	☐	
Stream stabilization - A few dozen feet to a few hundred feet.	☐	☐	☐	
Water quality protection – A few dozen to a few hundred feet (a longer distance if sediment removal is desired)	☐	☐	☐	
Flood attenuation – A few dozen to several hundred feet	☐	☐	☐	
Riparian & wildlife habitat – A few dozen feet up to a mile, though the average minimum is approximately 100’ to several hundred or a few thousand feet.	☐	☐	☐	
Protection of cold water fisheries – A few dozen feet to a few hundred feet	☐	☐	☐	
Prohibit development immediately adjacent to streams, rivers, lakes, wetlands and other water bodies.	☐	☐	☐	
Inventory riparian areas as part of the subdivision process and preserve unimpaired riparian areas in natural conditions.	☐	☐	☐	
Require restoration of impaired riparian zones as a condition of subdivision approval.	☐	☐	☐	
Restrict potentially problematic uses (Hazardous materials uses, for example)	☐	☐	☐	
Dedicate land for public facilities and services.	☐	☐	☐	
Require adequate access where evacuation may be necessary or where emergency vehicle access may be required.	☐	☐	☐	
Ensure utilities such as electric, natural gas, water and wastewater are hardened. Require electrical components to be mounted above flood levels. Major utility equipment should be considered a critical facility and be required to be located outside of the 500 year floodplain.	☐	☐	☐	
Consider the long-term needs of the community when discussing the potential for a homeowner’s association to operate and/or maintain an area prone to flooding.	☐	☐	☐	
Require flood hazard information to be provided on a subdivision plat. Require the 100-year floodplain elevation to be shown on all subdivision plats. Information such as finished building pad elevation or proposed lowest finished floor elevation can also be detailed.	☐	☐	☐	
Any property with a floodplain should be required to show such information on the plan.	☐	☐	☐	
Require conservation easements around flood-prone areas or floodplains.	☐	☐	☐	
Require green infrastructure or low-impact development techniques, where feasible	☑	☐	☐	The code includes Stormwater Management regulations which discuss flooding.
Each proposed lot must have a designated buildable site above the special flood hazard area (SFHA) as shown on the most current Flood Insurance Rate Map.	☐	☐	☐	

<u>Code Sections Reviewed:</u>

Flood Damage Prevention - Chapter 167

Subdivision of Land - Chapter A319

Stormwater Management - Chapter 254

Table 6-5: Flood Resiliency Best Practices Code Audit Checklist				
Mamaroneck Town, NY Preliminary Audit	***In Existing Code***	***Consider for Implementation***	***N/A***	***Notes***
Zoning Code Ordinance Best Practices				
Elevation Design & Screening				
Require design interventions to screen and mitigate elevation impacts on the streetscape for elevated buildings.	☐	☐	☐	
Use hedges and fencing to separate private and public realms. Screen on-site parking located beneath a structure with foundation plantings and vegetative screening. Screen piers and columns that have been used to raise structures.	☐	☐	☐	
Building entries must face the street on which the building fronts, and walkways should provide direct access from the sidewalk to the front door.	☐	☐	☐	
Building fronts, entry porches and similar features must use materials, colors and proportions appropriate for the local architectural context. Large and multi-family building should use treatments similar to ensure local architectural consistency.	☐	☐	☐	
Guidelines for specific design elements such as canopies, galleries, and local significant materials, colors and design strategies to mitigate height and size perceptions are encouraged.	☐	☐	☐	
Bulk & Area Requirements				
Ensure that uses below the building Base Flood Elevation are restricted to access, parking and storage.	☑	☐	☐	The Flood Damage Prevention Code defines the lowest floor as being the lowest enclosed area (including basement or cellar), however an unfinished or flood resistant enclosure, usable solely for parking, access or storage in an area other than a basement area is not considered a buildings lowest floor provided that such enclosure is not in violation of the non-elevation design requirements of the law. In several Zones, new and substantially improved structures shall have fully enclosed areas below the lowest floor that are usable solely for parking of vehicles, building access or storage in an area other than a basement and which are subject to flooding, designed to automatically equalize hydrostatic flood forces.
Permit relief from height limits where possible for developers and property owners who wish to go above the Design Flood Elevation.	☐	☐	☐	
Enact new height limits where possible that are based on the new local design flood elevation (one to two feet over the BFE) where side and rear yard relief is possible.	☐	☐	☐	
Given the increased height of buildings due to elevation, turrets, towers and cupolas, ensure total building height does not exceed maximum height(s) desired, but also ensure that maximum building height requirements allow for building elevations without the need for a variance.	☐	☐	☐	

Table 6-5: Flood Resiliency Best Practices Code Audit Checklist				
Mamaroneck Town, NY Preliminary Audit	**In Existing Code**	**Consider for Implementation**	**N/A**	**Notes**
Require an additional 3’ of freeboard above the base flood elevation for buildings within the Special Flood Hazard Area and 18” of freeboard in the “shaded X” area, which includes buildings between the 100-year and 500-year floodplains. All new single family detached dwellings outside of defined flood hazard areas need to be elevated 16-24”. This approach acknowledges the likelihood of more extreme flooding inside of and more extensive flooding outside of the FEMA-defined flood hazard area (based on historic flooding and not sea-level rise).	☑	☐	☐	The code includes residential structure elevation standards. Standards are included that require between 2' and 3' above base flood level or highest adjacent grade in certain zones outside the coastal high-hazard areas, as well as requirements for drainage paths in other zones for residential structures. Within coastal high-hazard areas, new construction and substantial improvements shall be elevated on pilings, columns or shear walls such that the lowest horizontal structural member supporting the lowest elevated floor is elevated to or above two feet above base flood level so as to not impede the flow of water. There are many additional design and engineering standards that also apply. Non-residential standards for areas outside the coastal high-hazard areas, require elevation to or above two feet above the base flood elevation or be floodproofed below two feet above the base flood level or be completely floodproofed, with adequate drainage paths and other requirements to be met. Nonresidential structures in coastal high hazard areas require the bottom of the lowest member of the lowest floor to be elevated to or above the base flood elevation. Floodproofing of structures is specifically listed as not being an allowable alternative to elevating the lowest floor in certain zones.
Permit reduced side or rear yards relative to overall height to allow squatter and more proportional buildings.	☐	☐	☐	
Require riparian and/or floodplain buffers - See also Subdivision Regulations.	☐	☐	☐	
Utilize net density calculations that exclude wetland and floodplain areas in a developable area.	☐	☐	☐	
Establish a maximum percentage of impermeable surface coverage on a lot which limits the density of development and addressing stormwater runoff.	☐	☐	☐	
Other Code Revisions				
Coastal Resilience Overlays could be applied to areas with the highest flood risk. These areas require higher elevations of the first floor, limit parking and hard pavement, and require additional landscaping and open space.	☑	☐	☐	
Upland Resilience Overlays could be applied to lower-risk areas capable of accommodating growth. New construction within an Upland Resilience Overlay is also permitted to reduce its own resilience requirements in exchange for placing conservation easements on higher-risk properties.	☑	☐	☐	Within the Flood Damage Prevention Code, construction or improvements can not be undertaken without full compliance with the Flood Damage Prevention Chapter. For encroachments, assessments and/or a technical evaluation is conducted and the Village applies to FEMA for conditional FIRM and floodway revision. Approval is required before construction or improvements can begin.
Neighborhood Resilience Overlays could be applied to lower-risk areas, and are intended for more typical cases. They allow for customized design standards that are appropriate to the local context.	☑	☐	☐	
Permit property owners to reallocate lost floor area from the ground floor and sub-grade spaces to elsewhere in the structure.	☐	☐	☐	
Ensure that well heads are above the BFE.	☑	☐	☐	The Code requires water supply systems to minimize or eliminate infiltration of floodwaters into the system.
Add flood resistant construction (flood-proofing) standards such as ensuring buildings are watertight, utilities and sanitary facilities are above the BFE, enclosed within the building’s watertight walls, or made watertight and resistance. Standards should also ensure that the building’s structural components are also flood resistant.	☑	☐	☐	The Code requires anchoring of new structures and substantial improvements as well as the use of materials, utility equipment, and methods and practices that are resistant to flood damage and that minimize flood damage. Utilities must be to or above BFE, unless (for electrical) properly conforming to building code for location of systems in wet locations. Water supply systems must minimize or eliminate infiltration of floodwaters. On-site waste disposal systems must be located to avoid impairment to them, or contamination from them, during flooding.

Table 6-5: Flood Resiliency Best Practices Code Audit Checklist				
Mamaroneck Town, NY Preliminary Audit	***In Existing Code***	***Consider for Implementation***	***N/A***	***Notes***
Prohibit new development unless effect on flooding is minimal or zero.	☑	☐	☐	Coastal high-hazard areas are required to place all new construction and manufactured homes on site 180 days or longer, landward of the reach of high tide. Code prohibits development encroachment if it increases base flood by >1 foot (see encroachment note above).The Code requires notification to adjacent communities and the NYSDEC prior to permitting any alteration or relocation of a watercourse, including a determination that the permit holder has provided for maintenance within the altered or relocated portion of said watercourse so that the flood carrying capacity is not diminished.
Prohibit substantial improvements to nonconforming uses or structures in flood prone areas.	☐	☐	☐	
Consider acquisition of flood-prone lands, particularly where they include vital riparian areas and/or could provide a public benefit such as a park or passive open space.	☐	☐	☐	
Subdivision Ordinance Best Practices				
Subdivision Ordinance				
Conservation subdivision (cluster development) to encourage development be built in suitable areas of development that protects important natural features.	☐	☐	☐	
Prohibit subdivisions in floodprone areas.	☑	☐	☐	The subdivision code includes general standards which discuss land subdivision being used safely without danger from flood. The Flood Damage Prevention Ordinance requires subdivisions to be consistent with the need to minimize flood damage, utilities and facilities must be located and constructed to minimize flood damage, and adequate drainage needs to be provided to reduce exposure to flood damage. When no base flood elevation data are available from other sources, the permit applicant for a subdivision or other development shall provide the data for projects greater than 5 acres or 50 lots in Zone A.
Require and maximize the width of riparian buffers. Provide riparian buffer requirements for the following:	☐	☐	☐	
Stream stabilization - A few dozen feet to a few hundred feet.	☐	☐	☐	
Water quality protection – A few dozen to a few hundred feet (a longer distance if sediment removal is desired)	☐	☐	☐	
Flood attenuation – A few dozen to several hundred feet	☐	☐	☐	
Riparian & wildlife habitat – A few dozen feet up to a mile, though the average minimum is approximately 100' to several hundred or a few thousand feet.	☐	☐	☐	
Protection of cold water fisheries – A few dozen feet to a few hundred feet	☐	☐	☐	
Prohibit development immediately adjacent to streams, rivers, lakes, wetlands and other water bodies.	☐	☐	☐	
Inventory riparian areas as part of the subdivision process and preserve unimpaired riparian areas in natural conditions.	☐	☐	☐	
Require restoration of impaired riparian zones as a condition of subdivision approval.	☐	☐	☐	
Restrict potentially problematic uses (Hazardous materials uses, for example)	☐	☐	☐	
Dedicate land for public facilities and services.	☐	☐	☐	
Require adequate access where evacuation may be necessary or where emergency vehicle access may be required.	☐	☐	☐	
Ensure utilities such as electric, natural gas, water and wastewater are hardened. Require electrical components to be mounted above flood levels. Major utility equipment should be considered a critical facility and be required to be located outside of the 500 year floodplain.	☐	☐	☐	

Table 6-5: Flood Resiliency Best Practices Code Audit Checklist				
Mamaroneck Town, NY Preliminary Audit	***In Existing Code***	***Consider for Implementation***	***N/A***	***Notes***
Consider the long-term needs of the community when discussing the potential for a homeowner's association to operate and/or maintain an area prone to flooding.	☐	☐	☐	
Require flood hazard information to be provided on a subdivision plat. Require the 100-year floodplain elevation to be shown on all subdivision plats. Information such as finished building pad elevation or proposed lowest finished floor elevation can also be detailed.	☐	☐	☐	
Any property with a floodplain should be required to show such information on the plan.	☐	☐	☐	
Require conservation easements around flood-prone areas or floodplains.	☐	☐	☐	
Require green infrastructure or low-impact development techniques, where feasible	☑	☐	☐	The code includes Stormwater Management regulations which discuss flooding.
Each proposed lot must have a designated buildable site above the special flood hazard area (SFHA) as shown on the most current Flood Insurance Rate Map.	☐	☐	☐	

Code Sections Reviewed:

Flood Damage Prevention - Chapter 110

Subdivision of Land - Chapter 190

Stormwater Management - Chapter 95

Table 6-6: Flood Resiliency Best Practices Code Audit Checklist				
Mamaroneck Village, NY Preliminary Audit	***In Existing Code***	***Consider for Implementation***	***N/A***	***Notes***
Zoning Code Ordinance Best Practices				
Elevation Design & Screening				
Require design interventions to screen and mitigate elevation impacts on the streetscape for elevated buildings.	☐	☐	☐	
Use hedges and fencing to separate private and public realms. Screen on-site parking located beneath a structure with foundation plantings and vegetative screening. Screen piers and columns that have been used to raise structures.	☐	☐	☐	
Building entries must face the street on which the building fronts, and walkways should provide direct access from the sidewalk to the front door.	☐	☐	☐	
Building fronts, entry porches and similar features must use materials, colors and proportions appropriate for the local architectural context. Large and multi-family building should use treatments similar to ensure local architectural consistency.	☐	☐	☐	
Guidelines for specific design elements such as canopies, galleries, and local significant materials, colors and design strategies to mitigate height and size perceptions are encouraged.	☐	☐	☐	
Bulk & Area Requirements				
Ensure that uses below the building Base Flood Elevation are restricted to access, parking and storage.	☑	☐	☐	The Flood Damage Prevention Code defines the lowest floor as being the lowest enclosed area (including basement or cellar), however an unfinished or flood resistant enclosure, usable solely for parking, access or storage in an area other than a basement area is not considered a buildings lowest floor provided that such enclosure is not in violation of the non-elevation design requirements of the law. In several Zones, new and substantially improved structures shall have fully enclosed areas below the lowest floor that are usable solely for parking of vehicles, building access or storage in an area other than a basement and which are subject to flooding, designed to automatically equalize hydrostatic flood forces.
Permit relief from height limits where possible for developers and property owners who wish to go above the Design Flood Elevation.	☐	☐	☐	
Enact new height limits where possible that are based on the new local design flood elevation (one to two feet over the BFE) where side and rear yard relief is possible.	☐	☐	☐	
Given the increased height of buildings due to elevation, turrets, towers and cupolas, ensure total building height does not exceed maximum height(s) desired, but also ensure that maximum building height requirements allow for building elevations without the need for a variance.	☐	☐	☐	

Table 6-6: Flood Resiliency Best Practices Code Audit Checklist				
Mamaroneck Village, NY Preliminary Audit	***In Existing Code***	***Consider for Implementation***	***N/A***	**Notes**
Require an additional 3’ of freeboard above the base flood elevation for buildings within the Special Flood Hazard Area and 18” of freeboard in the “shaded X” area, which includes buildings between the 100-year and 500-year floodplains. All new single family detached dwellings outside of defined flood hazard areas need to be elevated 16-24”. This approach acknowledges the likelihood of more extreme flooding inside of and more extensive flooding outside of the FEMA-defined flood hazard area (based on historic flooding and not sea-level rise).	☑	☐	☐	The code includes residential structure elevation standards. Standards are included that require between 2' and 3' above base flood level or highest adjacent grade in certain zones outside the coastal high-hazard areas, as well as requirements for drainage paths in other zones for residential structures. Within coastal high-hazard areas, new construction and substantial improvements shall be elevated on pilings, columns or shear walls such that the lowest horizontal structural member supporting the lowest elevated floor is elevated to or above two feet above base flood level so as to not impede the flow of water. There are many additional design and engineering standards that also apply. Non-residential standards for areas outside the coastal high-hazard areas, require elevation to or above two feet above the BFE and floodproofed below two feet above BFE with walls substantially impermeable to the passage of water. Nonresidential structures in coastal high hazard areas require the bottom of the lowest member of the lowest floor to be elevated to or above the BFE. Floodproofing of structures is specifically listed as not being an allowable alternative to elevating the lowest floor in certain zones.
Permit reduced side or rear yards relative to overall height to allow squatter and more proportional buildings.	☐	☐	☐	
Require riparian and/or floodplain buffers - See also Subdivision Regulations.	☐	☐	☐	
Utilize net density calculations that exclude wetland and floodplain areas in a developable area.	☐	☐	☐	
Establish a maximum percentage of impermeable surface coverage on a lot which limits the density of development and addressing stormwater runoff.	☐	☐	☐	
Other Code Revisions				
Coastal Resilience Overlays could be applied to areas with the highest flood risk. These areas require higher elevations of the first floor, limit parking and hard pavement, and require additional landscaping and open space.	☑	☐	☐	
Upland Resilience Overlays could be applied to lower-risk areas capable of accommodating growth. New construction within an Upland Resilience Overlay is also permitted to reduce its own resilience requirements in exchange for placing conservation easements on higher-risk properties.	☑	☐	☐	Within the Flood Damage Prevention Code, construction or improvements can not be undertaken without full compliance with the Flood Damage Prevention Chapter. For encroachments, assessments and/or a technical evaluation is conducted and the Village applies to FEMA for conditional FIRM and floodway revision. Approval is required before construction or improvements can begin.
Neighborhood Resilience Overlays could be applied to lower-risk areas, and are intended for more typical cases. They allow for customized design standards that are appropriate to the local context.	☑	☐	☐	
Permit property owners to reallocate lost floor area from the ground floor and sub-grade spaces to elsewhere in the structure.	☐	☐	☐	
Ensure that well heads are above the BFE.	☑	☐	☐	The Code requires water supply systems to minimize or eliminate infiltration of floodwaters into the system.
Add flood resistant construction (flood-proofing) standards such as ensuring buildings are watertight, utilities and sanitary facilities are above the BFE, enclosed within the building’s watertight walls, or made watertight and resistance. Standards should also ensure that the building’s structural components are also flood resistant.	☑	☐	☐	The Code requires anchoring of new structures and substantial improvements as well as the use of materials, utility equipment, and methods and practices that are resistant to flood damage and that minimize flood damage. Utilities must be to or above BFE, unless (for electrical) properly conforming to building code for location of systems in wet locations. Water supply systems must minimize or eliminate infiltration of floodwaters. New and replacement sanitary sewer systems shall be designed to minimize or eliminate infiltration of flood waters. On-site waste disposal systems must be located to avoid impairment to them, or contamination from them, during flood events.

Table 6-6: Flood Resiliency Best Practices Code Audit Checklist				
Mamaroneck Village, NY Preliminary Audit	***In Existing Code***	***Consider for Implementation***	***N/A***	***Notes***
Prohibit new development unless effect on flooding is minimal or zero.	☑	☐	☐	Coastal high-hazard areas are required to place all new construction and manufactured homes on site 180 days or longer, landward of the reach of high tide. Code prohibits development encroachment if it increases base flood by >1 foot (see encroachment note above). The Code requires notification to adjacent communities and the NYSDEC prior to permitting any alteration or relocation of a watercourse, including a determination that the permit holder has provided for maintenance within the altered or relocated portion of said watercourse so that the flood carrying capacity is not diminished.
Prohibit substantial improvements to nonconforming uses or structures in flood prone areas.	☐	☐	☐	
Consider acquisition of flood-prone lands, particularly where they include vital riparian areas and/or could provide a public benefit such as a park or passive open space.	☐	☐	☐	
Subdivision Ordinance Best Practices				
Subdivision Ordinance				
Conservation subdivision (cluster development) to encourage development be built in suitable areas of development that protects important natural features.	☐	☐	☐	
Prohibit subdivisions in floodprone areas.	☑	☐	☐	The subdivision code includes general standards which discuss land subdivision being used safely without danger from flood. The Flood Damage Prevention Ordinance requires subdivisions to be consistent with the need to minimize flood damage, utilities and facilities must be located and constructed to minimize flood damage, and adequate drainage needs to be provided to reduce exposure to flood damage. When no base flood elevation data are available from other sources, the permit applicant for a subdivision or other development shall provide the data for projects greater than 5 acres or 50 lots in Zone A.
Require and maximize the width of riparian buffers. Provide riparian buffer requirements for the following:	☐	☐	☐	
Stream stabilization - A few dozen feet to a few hundred feet.	☐	☐	☐	
Water quality protection – A few dozen to a few hundred feet (a longer distance if sediment removal is desired)	☐	☐	☐	
Flood attenuation – A few dozen to several hundred feet	☐	☐	☐	
Riparian & wildlife habitat – A few dozen feet up to a mile, though the average minimum is approximately 100' to several hundred or a few thousand feet.	☐	☐	☐	
Protection of cold water fisheries – A few dozen feet to a few hundred feet	☐	☐	☐	
Prohibit development immediately adjacent to streams, rivers, lakes, wetlands and other water bodies.	☐	☐	☐	
Inventory riparian areas as part of the subdivision process and preserve unimpaired riparian areas in natural conditions.	☐	☐	☐	
Require restoration of impaired riparian zones as a condition of subdivision approval.	☐	☐	☐	
Restrict potentially problematic uses (Hazardous materials uses, for example)	☐	☐	☐	
Dedicate land for public facilities and services.	☐	☐	☐	
Require adequate access where evacuation may be necessary or where emergency vehicle access may be required.	☐	☐	☐	
Ensure utilities such as electric, natural gas, water and wastewater are hardened. Require electrical components to be mounted above flood levels. Major utility equipment should be considered a critical facility and be required to be located outside of the 500 year floodplain.	☐	☐	☐	

Table 6-6: Flood Resiliency Best Practices Code Audit Checklist Mamaroneck Village, NY Preliminary Audit	In Existing Code	Consider for Implementation	N/A	Notes
Consider the long-term needs of the community when discussing the potential for a homeowner's association to operate and/or maintain an area prone to flooding.	☐	☐	☐	
Require flood hazard information to be provided on a subdivision plat. Require the 100-year floodplain elevation to be shown on all subdivision plats. Information such as finished building pad elevation or proposed lowest finished floor elevation can also be detailed.	☐	☐	☐	
Any property with a floodplain should be required to show such information on the plan.	☐	☐	☐	
Require conservation easements around flood-prone areas or floodplains.	☐	☐	☐	
Require green infrastructure or low-impact development techniques, where feasible	☑	☐	☐	The code includes Stormwater Management regulations which discuss flooding.
Each proposed lot must have a designated buildable site above the special flood hazard area (SFHA) as shown on the most current Flood Insurance Rate Map.	☐	☐	☐	

Code Sections Reviewed:

Flood Damage Prevention - Chapter 186

Subdivision of Land - Chapter A348

Stormwater Management - Chapter 294

Table 6-7: Flood Resiliency Best Practices Code Audit Checklist				
City of New Rochelle, NY Preliminary Audit	*In Existing Code*	*Consider for Implementation*	*N/A*	*Notes*
Zoning Code Ordinance Best Practices				
Elevation Design & Screening				
Require design interventions to screen and mitigate elevation impacts on the streetscape for elevated buildings.	☐	☐	☐	
Use hedges and fencing to separate private and public realms. Screen on-site parking located beneath a structure with foundation plantings and vegetative screening. Screen piers and columns that have been used to raise structures.	☐	☐	☐	
Building entries must face the street on which the building fronts, and walkways should provide direct access from the sidewalk to the front door.	☐	☐	☐	
Building fronts, entry porches and similar features must use materials, colors and proportions appropriate for the local architectural context. Large and multi-family building should use treatments similar to ensure local architectural consistency.	☐	☐	☐	
Guidelines for specific design elements such as canopies, galleries, and local significant materials, colors and design strategies to mitigate height and size perceptions are encouraged.	☐	☐	☐	
Bulk & Area Requirements				
Ensure that uses below the building Base Flood Elevation are restricted to access, parking and storage.	☑	☐	☐	The Flood Damage Prevention Code defines the lowest floor as being the lowest enclosed area (including basement or cellar), however an unfinished or flood resistant enclosure, usable solely for parking, access or storage in an area other than a basement area is not considered a buildings lowest floor provided that such enclosure is not in violation of the non-elevation design requirements of the law. In several Zones, new and substantially improved structures shall have fully enclosed areas below the lowest floor that are usable solely for parking of vehicles, building access or storage in an area other than a basement and which are subject to flooding, designed to automatically equalize hydrostatic flood forces.
Permit relief from height limits where possible for developers and property owners who wish to go above the Design Flood Elevation.	☐	☐	☐	
Enact new height limits where possible that are based on the new local design flood elevation (one to two feet over the BFE) where side and rear yard relief is possible.	☐	☐	☐	
Given the increased height of buildings due to elevation, turrets, towers and cupolas, ensure total building height does not exceed maximum height(s) desired, but also ensure that maximum building height requirements allow for building elevations without the need for a variance.	☐	☐	☐	

Table 6-7: Flood Resiliency Best Practices Code Audit Checklist				
City of New Rochelle, NY Preliminary Audit	***In Existing Code***	***Consider for Implementation***	***N/A***	***Notes***
Require an additional 3' of freeboard above the base flood elevation for buildings within the Special Flood Hazard Area and 18" of freeboard in the "shaded X" area, which includes buildings between the 100-year and 500-year floodplains. All new single family detached dwellings outside of defined flood hazard areas need to be elevated 16-24". This approach acknowledges the likelihood of more extreme flooding inside of and more extensive flooding outside of the FEMA-defined flood hazard area (based on historic flooding and not sea-level rise).	☑	☐	☐	The code includes residential structure elevation standards. Standards are included that require between 2' and 3' above base flood level or highest adjacent grade in certain zones outside the coastal high-hazard areas, as well as requirements for drainage paths in other zones for residential structures. Within coastal high-hazard areas, new construction and substantial improvements shall be elevated on pilings, columns or shear walls such that the lowest horizontal structural member supporting the lowest elevated floor is elevated to or above two feet above base flood level so as to not impede the flow of water. There are many additional design and engineering standards that also apply. Non-residential standards for areas outside the coastal high-hazard areas, require elevation to or above two feet above the base flood elevation or be floodproofed below two feet above the base flood level with walls substantially impermeable to the passage of water. Nonresidential structures in coastal high hazard areas require the bottom of the lowest member of the lowest floor to be elevated to or above the base flood elevation. Floodproofing of structures is specifically listed as not being an allowable alternative to elevating the lowest floor in certain zones.
Permit reduced side or rear yards relative to overall height to allow squatter and more proportional buildings.	☐	☐	☐	
Require riparian and/or floodplain buffers - See also Subdivision Regulations.	☐	☐	☐	
Utilize net density calculations that exclude wetland and floodplain areas in a developable area.	☐	☐	☐	
Establish a maximum percentage of impermeable surface coverage on a lot which limits the density of development and addressing stormwater runoff.	☐	☐	☐	
Other Code Revisions				
Coastal Resilience Overlays could be applied to areas with the highest flood risk. These areas require higher elevations of the first floor, limit parking and hard pavement, and require additional landscaping and open space.	☑	☐	☐	Within the Flood Damage Prevention Code, construction or improvements can not be undertaken without full compliance with the Flood Damage Prevention Chapter. For encroachments, assessments and/or a technical evaluation is conducted and the Village applies to FEMA for conditional FIRM and floodway revision. Approval is required before construction or improvements can begin.
Upland Resilience Overlays could be applied to lower-risk areas capable of accommodating growth. New construction within an Upland Resilience Overlay is also permitted to reduce its own resilience requirements in exchange for placing conservation easements on higher-risk properties.	☑	☐	☐	
Neighborhood Resilience Overlays could be applied to lower-risk areas, and are intended for more typical cases. They allow for customized design standards that are appropriate to the local context.	☑	☐	☐	
Permit property owners to reallocate lost floor area from the ground floor and sub-grade spaces to elsewhere in the structure.	☐	☐	☐	
Ensure that well heads are above the BFE.	☑	☐	☐	The Code requires water supply systems to minimize or eliminate infiltration of floodwaters into the system.

Table 6-7: Flood Resiliency Best Practices Code Audit Checklist

City of New Rochelle, NY Preliminary Audit	*In Existing Code*	*Consider for Implementation*	*N/A*	*Notes*
Add flood resistant construction (flood-proofing) standards such as ensuring buildings are watertight, utilities and sanitary facilities are above the BFE, enclosed within the building’s watertight walls, or made watertight and resistance. Standards should also ensure that the building’s structural components are also flood resistant.	☑	☐	☐	The Code requires anchoring of new structures and substantial improvements as well as the use of materials, utility equipment, and methods and practices that are resistant to flood damage and that minimize flood damage. Utilities must be two feet above the base flood elevation or one foot above the highest flood level of record, whichever is higher. Electrical utilities shall be elevated two feet above the BFE unless they conform to building code for location of systems in wet locations. Water supply systems must minimize or eliminate infiltration of floodwaters. New and replacement sanitary sewage systems shall be designed to minimize or eliminate infiltration of floodwaters. On-site waste disposal systems must be located to avoid impairment to them, or contamination from them, during flooding.
Prohibit new development unless effect on flooding is minimal or zero.	☑	☐	☐	Coastal high-hazard areas are required to place all new construction and manufactured homes on site 180 days or longer, landward of the reach of high tide. Code prohibits development encroachment if it increases base flood by >1 foot (see encroachment note above). The Code requires notification to adjacent communities and the NYSDEC prior to permitting any alteration or relocation of a watercourse, including a determination that the permit holder has provided for maintenance within the altered or relocated portion of said watercourse so that the flood carrying capacity is not diminished.
Prohibit substantial improvements to nonconforming uses or structures in flood prone areas.	☐	☐	☐	
Consider acquisition of flood-prone lands, particularly where they include vital riparian areas and/or could provide a public benefit such as a park or passive open space.	☐	☐	☐	
Subdivision Ordinance Best Practices				
Subdivision Ordinance				
Conservation subdivision (cluster development) to encourage development be built in suitable areas of development that protects important natural features.	☐	☐	☐	
Prohibit subdivisions in floodprone areas.	☐ ✓	☐	☐	The Flood Damage Prevention Ordinance requires subdivisions to be consistent with the need to minimize flood damage, utilities and facilities must be located and constructed to minimize flood damage, and adequate drainage needs to be provided to reduce exposure to flood damage. When no base flood elevation data are available from other sources, the permit applicant for a subdivision or other development shall provide the data for projects greater than 5 acres or 50 lots in Zone A.

Table 6-7: Flood Resiliency Best Practices Code Audit Checklist City of New Rochelle, NY Preliminary Audit	In Existing Code	Consider for Implementation	N/A	Notes
Require and maximize the width of riparian buffers. Provide riparian buffer requirements for the following:	☐	☐	☐	
Stream stabilization - A few dozen feet to a few hundred feet.	☐	☐	☐	
Water quality protection – A few dozen to a few hundred feet (a longer distance if sediment removal is desired)	☐	☐	☐	
Flood attenuation – A few dozen to several hundred feet	☐	☐	☐	
Riparian & wildlife habitat – A few dozen feet up to a mile, though the average minimum is approximately 100' to several hundred or a few thousand feet.	☐	☐	☐	
Protection of cold water fisheries – A few dozen feet to a few hundred feet	☐	☐	☐	
Prohibit development immediately adjacent to streams, rivers, lakes, wetlands and other water bodies.	☐	☐	☐	
Inventory riparian areas as part of the subdivision process and preserve unimpaired riparian areas in natural conditions.	☐	☐	☐	
Require restoration of impaired riparian zones as a condition of subdivision approval.	☐	☐	☐	
Restrict potentially problematic uses (Hazardous materials uses, for example)	☐	☐	☐	
Dedicate land for public facilities and services.	☐	☐	☐	
Require adequate access where evacuation may be necessary or where emergency vehicle access may be required.	☐	☐	☐	
Ensure utilities such as electric, natural gas, water and wastewater are hardened. Require electrical components to be mounted above flood levels. Major utility equipment should be considered a critical facility and be required to be located outside of the 500 year floodplain.	☐	☐	☐	
Consider the long-term needs of the community when discussing the potential for a homeowner's association to operate and/or maintain an area prone to flooding.	☐	☐	☐	
Require flood hazard information to be provided on a subdivision plat. Require the 100-year floodplain elevation to be shown on all subdivision plats. Information such as finished building pad elevation or proposed lowest finished floor elevation can also be detailed.	☐	☐	☐	
Any property with a floodplain should be required to show such information on the plan.	☐	☐	☐	
Require conservation easements around flood-prone areas or floodplains.	☐	☐	☐	
Require green infrastructure or low-impact development techniques, where feasible	☑	☐	☐	The code includes Stormwater Management regulations which discuss flooding.
Each proposed lot must have a designated buildable site above the special flood hazard area (SFHA) as shown on the most current Flood Insurance Rate Map.	☐	☐	☐	

Code Sections Reviewed:

Flood Damage Prevention - Article IV

Use of Best Management Practices to Prevent, Control, and Reduce Stormwater Pollutants - Section 215-12

Land Development Code - Chapter A361

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