New York State of Opportunity | Department of Environmental Conservation

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FLOOD MITIGATION & RESILIENCE REPORT

Saddle River Watershed SD114

Prepared for:

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

SLR #142.16511.00009

June 2022

SLR

Saddle River Watershed SD114

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New York State Department of Environmental Conservation,
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New York State Office of General Services
Empire State Plaza
Corning Tower, 35th Floor
Albany, New York 12242

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ACRONYMS

BFE	Base Flood Elevation
BIN	Bridge Identification Number
CFS	Cubic Feet per Second
CMP	Corrugated Metal Pipe
CRRA	Community Risk and Resiliency Act
DGEIS	Digital Generic Environmental Impact Statement
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
GEIS	Generic Environmental Impact Statement
GIGP	Green Innovation Grant Program
GIS	Geographic Information System
HEC-HMS	Hydrologic Engineering System – *Hydrologic Modeling System*
HEC-RAS	Hydrologic Engineering Center – *River Analysis System*
HMP	Hazard Mitigation Plan
HMGP	Hazard Mitigation Grant Program
HRA	High Risk Area
LiDAR	Light Detection and Ranging
mph	Miles Per Hour
MWRR	Municipal Waste Reduction and Recycling
NBI	National Bridge Inventory
NFIP	National Flood Insurance Program
NFIRA	National Flood Insurance Reform Act
NOAA	National Oceanic and Atmospheric Administration
NRCS	Natural Resources Conservation Service
NWI	National Wetlands Inventory
NYS	New York State
NYSDEC	New York State Department of Environmental Conservation
NYSDOT	New York State Department of Transportation
NYSOGS	New York State Office of General Services
PDM	Pre-Disaster Mitigation
RCP	Representative Concentration Pathways
RFC	Repetitive Flood Claims
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
SWPPP	Stormwater Pollution Prevention Plan
USACE	United States Army Corps of Engineers
USGS	United States Geological Survey
WSP	Water Supply Paper

SUMMARY

This analysis of the Saddle 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 Saddle River originates in the southern portion of Monsey, in Rockland County, and flows generally southward along the eastern side of Airmont before crossing into New Jersey. It joins the Passiac River in Passiac, New Jersey, and eventually empties in Newark Bay. Tributaries to the Saddle River in the state of New York, which are the focus of this study, include West Branch Saddle River, East Branch Saddle River, and Pine Brook.

Rockland County, including the Saddle River watershed, has an active history of flooding. According to National Oceanic and Atmospheric Administration (NOAA) historical records, 25 hurricane or tropical storm tracks have passed within 65 miles of Rockland County since 1861, with five passing directly through Rockland County.

It is noted in the analysis that Federal Emergency Management Agency (FEMA) hydraulic modeling for East Branch Saddle River and Pine Brook is based on antiquated HEC-2 analyses dating from the 1980s. It is recommended that new FEMA modeling for these watercourses be developed to reflect current hydraulic and hydrologic conditions. The updated hydraulic modeling would reflect changes such as bridge replacements, dams that are no longer present, and updated flood hydrology.

As part of this analysis, flood-prone High-Risk Areas, or HRAs, along West Branch Saddle River, East Branch Saddle River, and Pine Brook are identified, and an analysis of flood mitigation considerations within each HRA is undertaken. Factors with the potential to influence more than one HRA are also evaluated and discussed. An analysis of watershed land use is conducted, and a Flood Resiliency Best Practices Audit is conducted for each community within the watershed.

Flood mitigation scenarios such as dam removal, road closures, replacement of undersized bridges and culverts, and floodproofing measures of individual structures are investigated. Rough-order-of-magnitude cost ranges are provided for the recommended flood mitigation scenarios. A range of potential funding sources is provided.

1. INTRODUCTION

1.1 PROJECT BACKGROUND AND OVERVIEW

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

The Saddle River originates in south-central Rockland County, New York, and drains generally southeast through the county before crossing over the New Jersey state line and flowing into the Passaic River in Passaic, New Jersey. The Passaic River drains into Newark Bay. This report will focus on the portion of the Saddle River watershed located within New York State, including three tributaries to the Saddle River: West Branch Saddle River, East Branch Saddle River, and Pine Brook.

This report begins with an overview of the Saddle River 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 dam removal, road closures, replacement of undersized bridges and culverts, and floodproofing measures of individual structures are investigated and are recommended where appropriate. Rough-order-of-magnitude cost ranges are provided for the recommended flood mitigation scenarios, and potential funding sources are listed.

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 each watercourse. Stationing is measured in feet and begins at station (STA) 0+00, where each watercourse crosses the New Jersey border, and continues upstream. As an example, West Branch Saddle River flows under New York State Thruway I-287 at STA 120+00, a stream distance of 12,000 linear feet upstream of where West Branch Saddle River crosses the New York/New Jersey state line.

This study focuses on the portion of the Saddle River watershed located in New York State, specifically, West Branch Saddle River, East Branch Saddle River, and Pine Brook. Throughout this report, references to the Saddle River tributaries and the Saddle River watershed pertain to the portions located in New York State.

The Federal Emergency Management Agency (FEMA) is an agency of the United States Department of Homeland Security. In order to provide a common standard, FEMA's National Flood Insurance Program

(NFIP) has adopted a baseline probability called the base flood. The base flood has a 1 percent (one in 100) chance of occurring in any given year, and the base flood elevation (BFE) is the level floodwaters are expected to reach in this event. For the purpose of this report, the 1 percent annual chance flood is also referred to as the 100-year flood. Other recurrence probabilities used in this report include the 2-year flood event (50 percent annual chance flood), the 10-year flood event (10 percent annual chance flood), the 25-year flood event (4 percent annual chance flood), the 50-year flood event (2 percent annual chance flood), and the 500-year flood event (0.2 percent annual chance flood).

The Special Flood Hazard Area (SFHA) is the area inundated by flooding during the 100-year flood event. Within the project area, FEMA has developed Flood Insurance Rate Mapping (FIRM), which indicates the location of the SFHA along West Branch Saddle River, East Branch Saddle River, and Pine Brook.

2. DATA COLLECTION

Data were gathered from various sources related to the hydrology and hydraulics of West Branch Saddle River, East Branch Saddle River, and Pine Brook, Saddle River watershed characteristics, recent and historical flooding in the affected communities, and factors that may contribute to flood hazards.

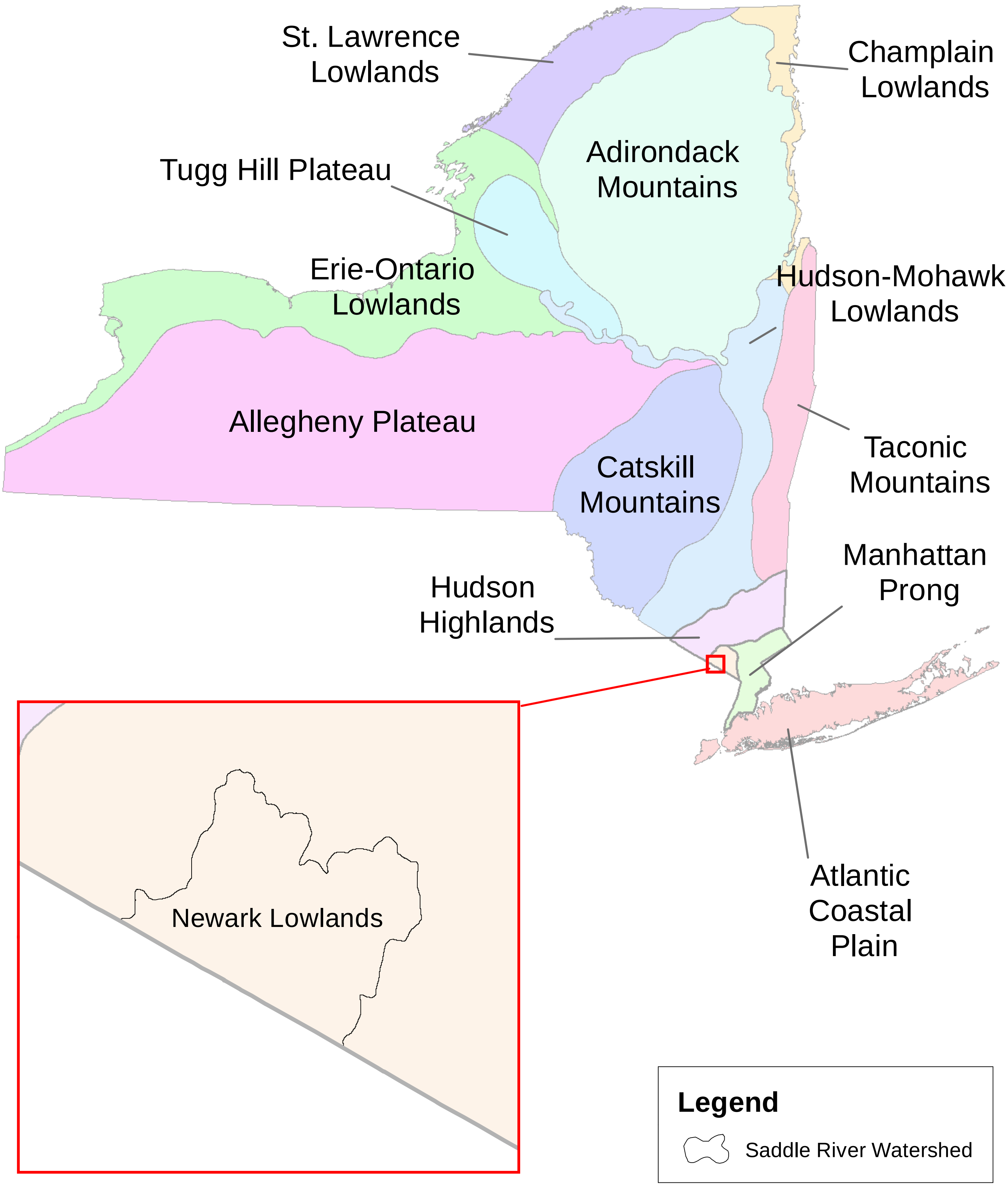
2.1 SADDLE RIVER WATERSHED CHARACTERISTICS

The Saddle River watershed is located in Rockland County, in southeastern New York State. The watershed falls within the physiographic region of New York State known as the Newark Basin or Newark Lowlands (Figure 2-1). The watershed has an irregular, semi-rectangular shape. When measured at its confluence with the Passaic River in New Jersey, the Saddle River watershed is 61 square miles in size.

The main stem of the Saddle River does not flow within New York State, but there are three tributaries that join the Saddle River in New Jersey whose watersheds fall within New York State. The tributaries that fall within New York State are the East Branch Saddle River, West Branch Saddle River, and Pine Brook. At the confluence with the Saddle River within Northern Upper Saddle River, New Jersey, the West Branch Saddle River has a watershed size of 3.6 square miles, the East Branch Saddle River has a watershed size of 2.4 square miles, and Pine Brook has a watershed size of 3.4 square miles. When measured at the New York/New Jersey border, the West Branch Saddle River has a watershed size of 2.4 square miles, the East Branch Saddle River has a watershed size of 2.3 square miles, and Pine Brook watershed has a watershed size of 3.0 square miles. For this study, only the portion of the watershed located in the state of New York is assessed. Figure 2-2 is a Saddle River watershed map. Figure 2-3 is a relief map of the watershed.

The bedrock underlying the Saddle River watershed consists of two formations from the Newark Group. Almost the entirety of the bedrock is mapped as the Brunswick Formation. The Brunswick Formation is Upper Triassic Period in age and consists of reddish-brown shaley mudstone. The mudstone alternates with layers of red-brown sandstone. These rocks gradually merge with the Hammer Creek Formation, which is found in the northwest and southwest corners of the Saddle River watershed. The Hammer Creek Formation is also Upper Triassic Period in age and is a coarse-grained conglomerate, coarse sandstone, and shale. The Newark Lowlands are very flat compared to the land to the west due to the more easily erodible sandstone and shale bedrock. The Newark Lowlands are a gently rolling surface that slopes down to the east.

Surficial materials underlying the Saddle River watershed consist primarily of glacial till, with two small oblong areas of kame deposits. The kame deposits are mapped in the northwest corner of the watershed and in the southeast section.



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NYS PHYSIOGRAPHIC REGIONS

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SD 114
ROCKLAND COUNTY
NEW YORK

N

0 140,000 280,000
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FIG. 2.1

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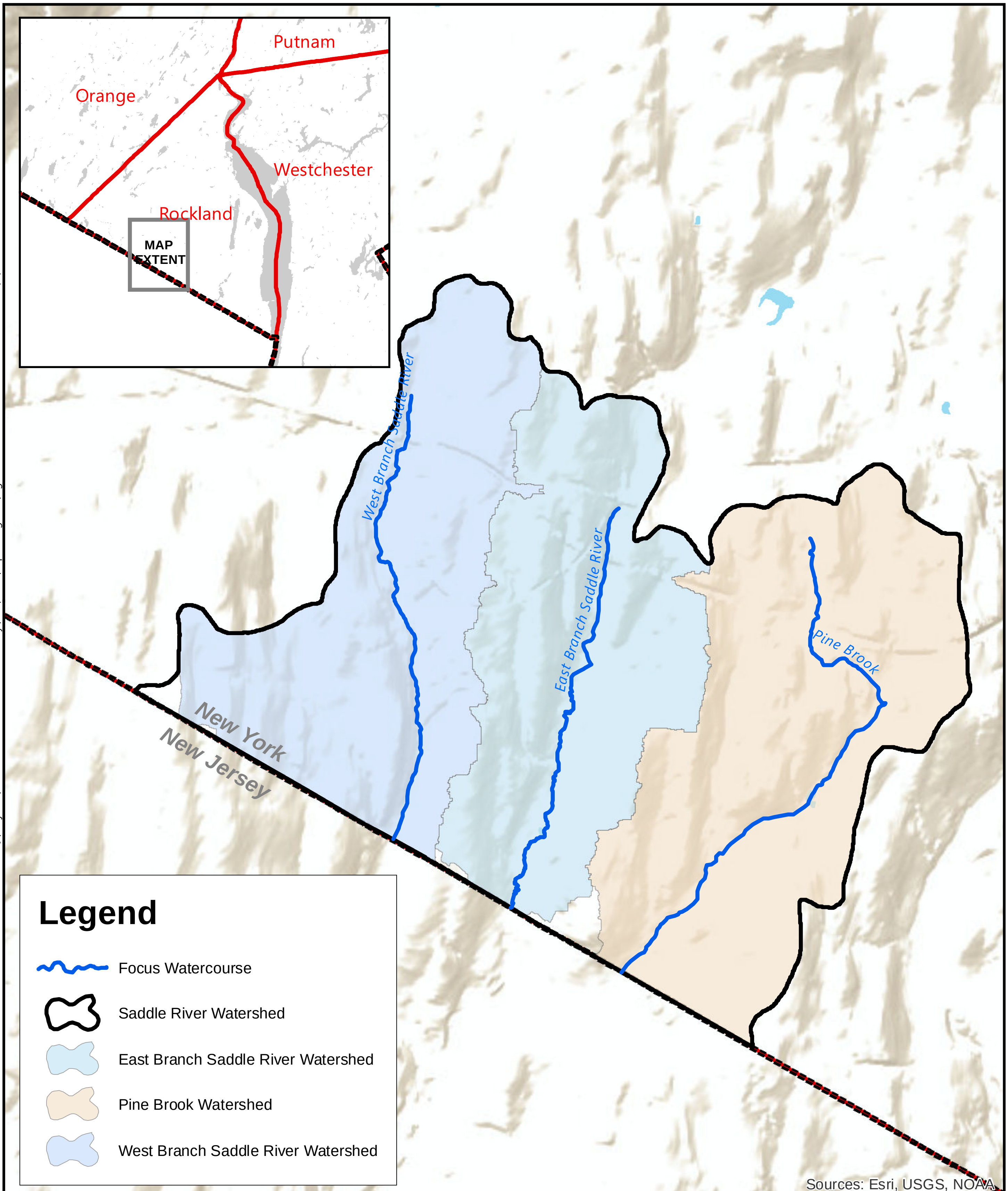

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SADDLE RIVER WATERSHED MAP

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SD 114
ROCKLAND COUNTY
NEW YORK

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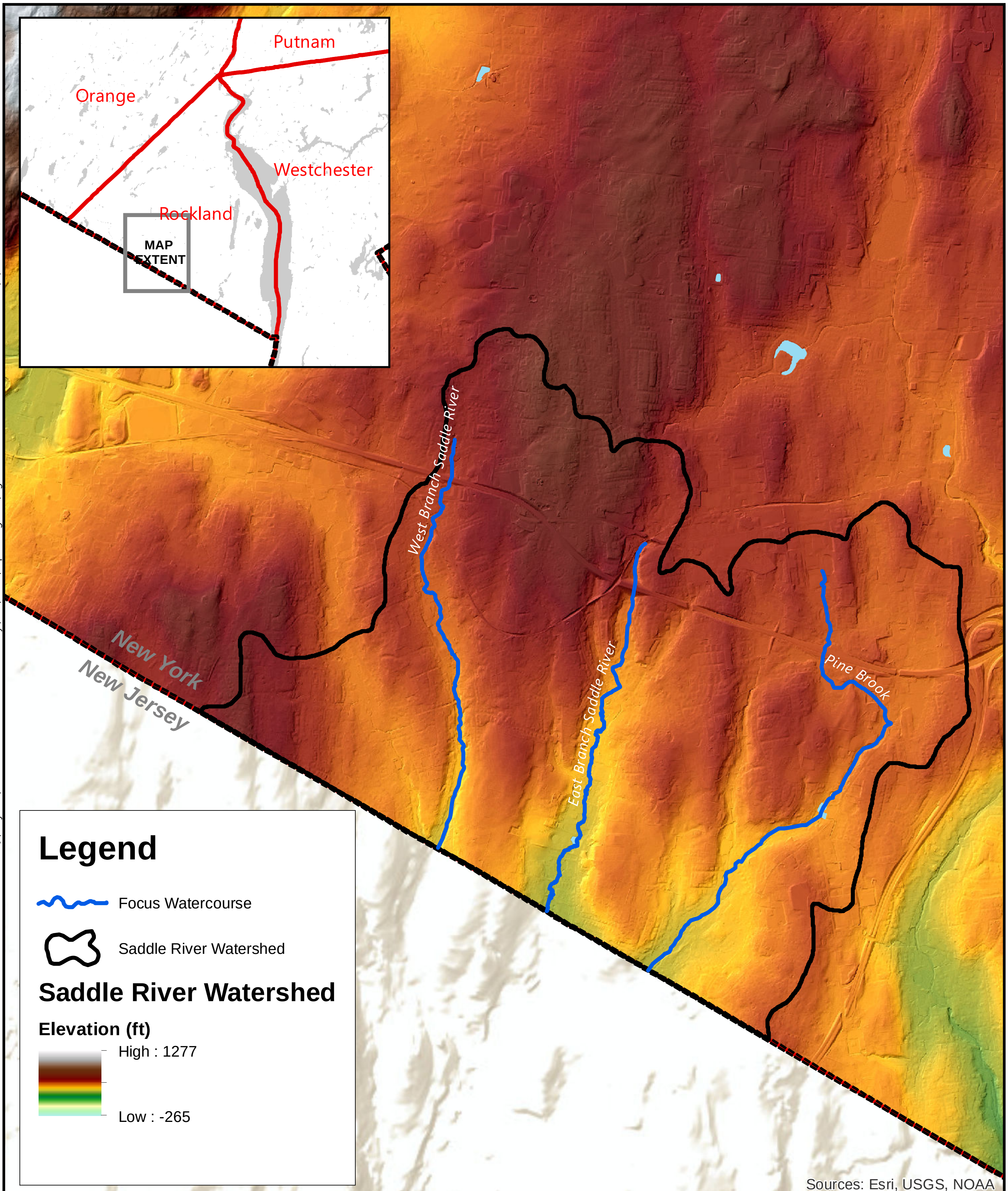
FIG. 2-2



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SADDLE RIVER WATERSHED RELIEF MAP

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ROCKLAND COUNTY
NEW YORK

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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. Figure 2-4 depicts the hydrologic soil groups present in the Saddle River watershed. The hydrologic soil group C is most prevalent, followed by the hydrologic soil group B. Combined, these two hydrologic soil groups make up 96 percent of the watershed.

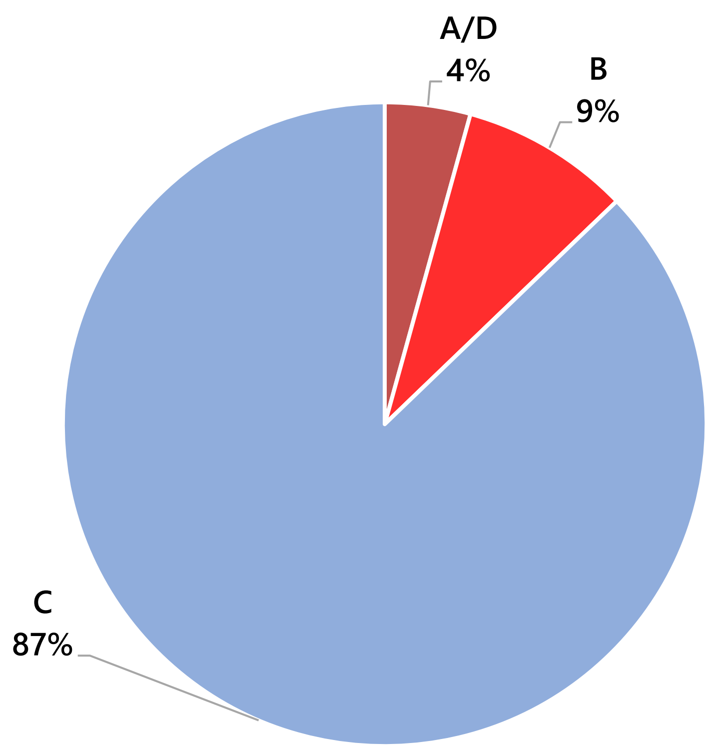

Figure 2-4: Hydrologic Grouping of Soils within the Saddle River Watershed

Land cover is another important factor influencing the runoff characteristics of a watershed. Rockland County is located a dozen miles north-northwest of New York City and is part of the New York Metropolitan Area. Land cover within the Ramapo 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 67 percent of the watershed. Forested land consists of deciduous, coniferous, and mixed forest types and makes up

28 percent of the land cover in the watershed. Open water and wetlands combined make up 4 percent of the land cover. The remaining 3 percent of the land cover consists of agricultural land and barren land.

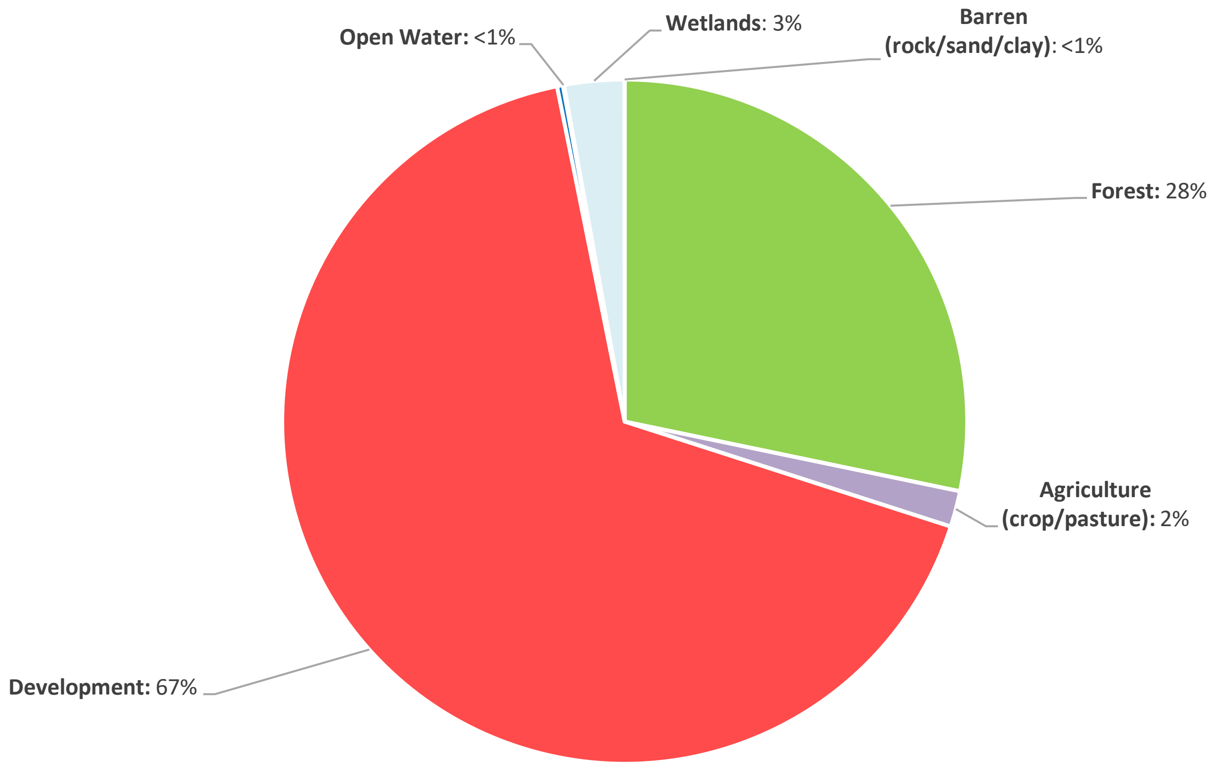

Figure 2-5: Land Cover within the Saddle River Watershed

> 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 104 acres of wetlands in the Saddle River watershed, or approximately 2.0 percent of the watershed. This includes the following types of wetland habitats: freshwater forest/shrub wetland, freshwater emergent wetland, freshwater lakes and ponds, and riverine wetland.

There is one NYSDEC-mapped wetland within the Saddle River watershed: a 21.6-acre wetland near the headwaters of Pine Brook, just south of the New York State Thruway and east of Hungry Hollow Road. Wetlands play an important role in flood mitigation by storing water and attenuating peak flows. It is estimated that since colonial times approximately 50 to 60 percent of the wetlands in the state of New York have been lost through draining, filling, and other types of alteration.

The Saddle River watershed has few waterbodies. The West Branch Saddle River has two impoundments near the New Jersey state line: Allabough Pond (4 acres) and Mountain Lake (5 acres). Farther upstream on the West Branch are Island Lake (1 acre) and an impoundment along Cherry Lane (2.4 acres). Water bodies on the East Branch Saddle River include Lulinski Lake (1 acre) and the pond at St. Patrick's Cathedral Cemetery (1 acre). Pine Brook has a series of impoundments in its upper reaches, upstream of Schoolhouse Road.

2.2 SADDLE RIVER WATERCOURSE

The East Branch Saddle River originates in the southeast corner of the hamlet of Monsey, in the town of Ramapo, and drains southward through the village of Airmont before crossing over the New Jersey border. Pine Brook originates in the southwest corner of the Village of Spring Valley and flows southward before crossing the New Jersey State border. The West Branch Saddle River originates in the southern part of the hamlet of Viola, town of Ramapo, and flows southward into the village of Airmont before crossing the New Jersey state border.

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 East Branch Saddle River can be characterized as a second-order stream where it crosses the New Jersey border. West Branch Saddle River and Pine Brook are also second-order streams. Figure 2-6 is a map depicting stream order in the Saddle 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 all the stream length within the Saddle River watershed in New York.

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

Stream Order	Total Length (miles)	Percentage of Overall Network Length (%)	Average Slope (%)
1st	9.6	68	2.2
2nd	4.6	32	2.1
Total	**14.2**	**100**	

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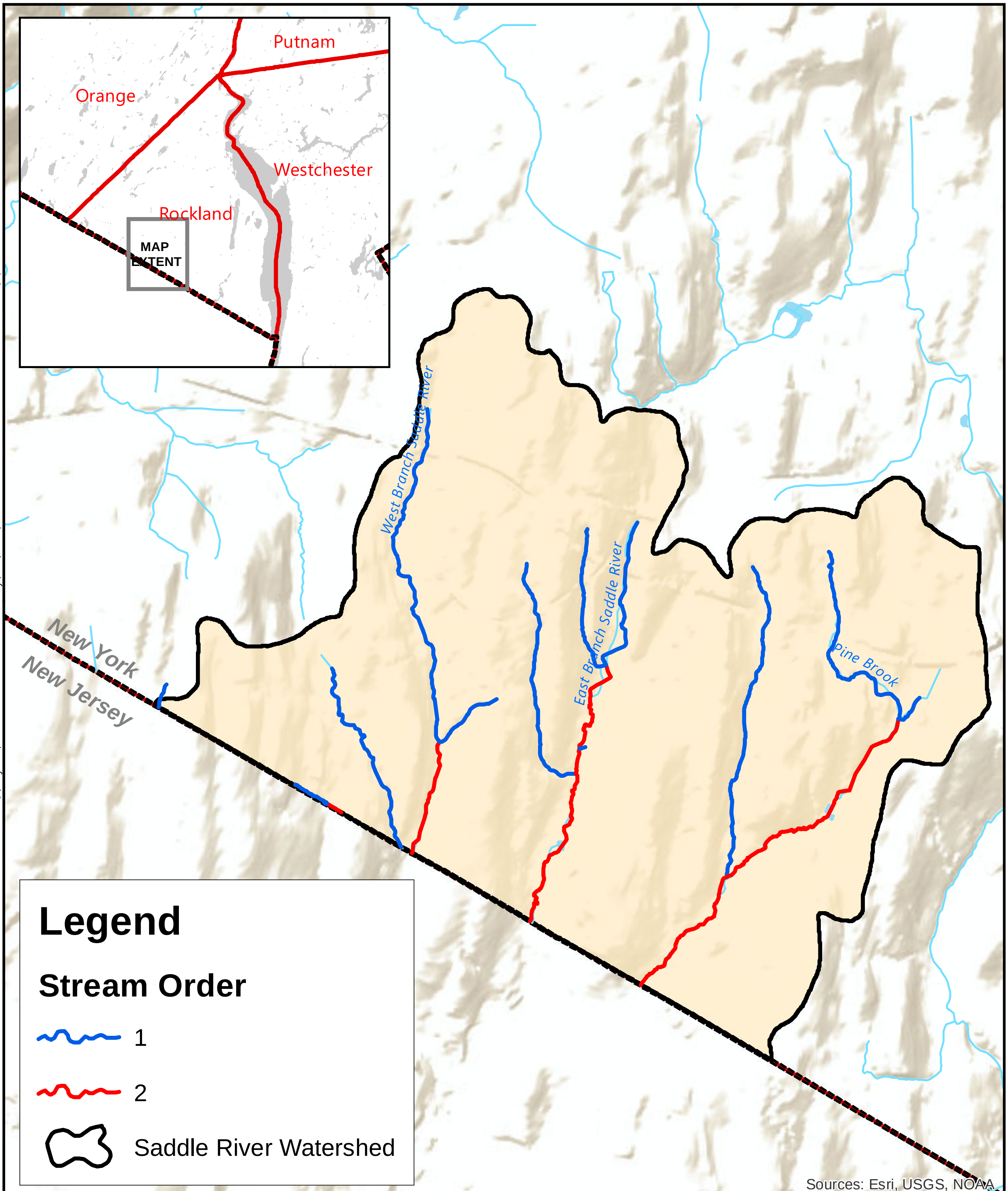

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STREAM ORDER

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ROCKLAND COUNTY
NEW YORK

N

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Feet

SCALE 1 " = 3,500 '

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FIG. 2-7

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 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.

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.

Flood hydrology for the West Branch Saddle River, East Branch Saddle River, and Pine Brook were all collected from the effective Flood Insurance Study (FIS) for Rockland County (36087CV001A), effective date March 3, 2014. For the West Branch Saddle River, peak discharge estimates reported in the FIS were computed using 2006 New York regression equations. The USGS WSP 2207 urban regression adjustment was used to determine peak discharges where the contributing drainage basins were greater than 1 square mile. The Rational Method was used for peak flows in smaller basins. At the Route 87-287 culvert, Modified Puls routing was performed using Hydrologic Engineering System – *Hydrologic Modeling System* (HEC-HMS). For the East Branch Saddle River, the FIS reports that Modified Puls routing analysis was performed utilizing the HEC-1 computer program. On Pine Brook, the FIS reports that hydrologic analysis was determined using the computational method described in *Special Report 38*. To account for future development within the town, permeability indices were selected based upon the assumption of full development within existing zoning regulations.

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.

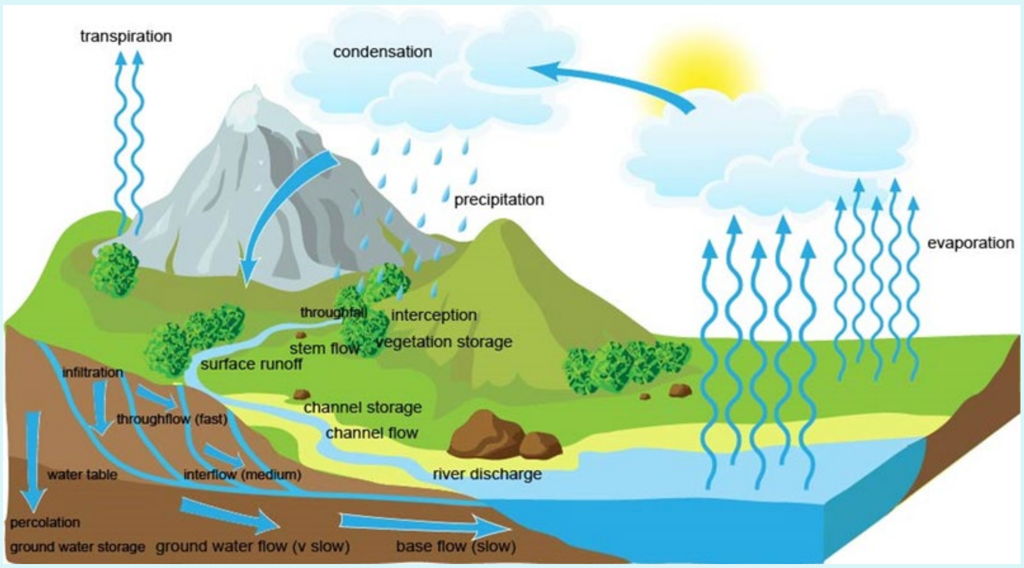

Figure 2-7: Diagram of Simplified Hydrologic Cycle

Table 2-2 Flood Hydrology on West Branch Saddle River Developed for the Rockland County FIS

Station	Location	Drainage Area (sq. mi.)	Peak Flood Discharge (cfs)			
			10-Year	50-Year	100-Year	500-Year
00+00	At Town of Ramapo corporate limits	1.58	428	699	843	1,219
33+89	Approximately 1,220 feet downstream of Beaver Hollow Lane	1.38	394	642	773	1,112
70+44	Approximately 1,097 feet upstream of Christmas Hill Road	0.93	292	412	464	607
98+87	Approximately 950 feet upstream of East Blossom Road	0.68	248	314	338	401
119+03	Approximately 120 feet downstream of Interstate Routes 87 and 287	0.55	163	202	213	249
220+00	Upstream of culvert entrance of Interstate Routes 87 and 287	0.55	180	249	272	357

Table 2-3 Flood Hydrology on East Branch Saddle River Developed for the Rockland County FIS

Station	Location	Drainage Area (sq. mi.)	Peak Flood Discharge (cfs)			
			10-Year	50-Year	100-Year	500-Year
00+00	At Town of Ramapo corporate limits	2.29	710	1,090	1,300	1,860
46+80	Approximately 554 feet upstream of South Monsey Road	1.38	480	730	870	1,230
75+80	Approximately 425 feet downstream of Regina Road	0.68	450	560	620	740
89+50	Approximately 950 feet upstream of Regina Road	0.57	280	310	340	380
110+00	Approximately 320 feet downstream of Interstate Routes 87 and 287	0.3	240	250	260	280

Table 2-4 Flood Hydrology on Pine Brook Developed for the Rockland County FIS

Station	Location	Drainage Area (sq. mi.)	Peak Flood Discharge (cfs)			
			10-Year	50-Year	100-Year	500-Year
00+00	At Borough of Upper Saddle River, NJ - Village of Chestnut Ridge Corporate Limits	2.86	690	1070	1290	1,860
21+80	Approximately 370 feet downstream of Pine Brook Road	2.15	550	860	1030	1,490
39+00	Upstream of confluence with Hungry Hollow Brook	1.5	360	570	690	1,000
67+80	Approximately 100 feet downstream of driveway opposite School House Road	1.28	320	500	610	880
87+60	Approximately 771 feet from Lakeside School Dam	1.03	270	420	510	740
110+50	Approximately 1,581 feet from Lakeside School Dam	0.38	150	190	220	280
123+60	Approximately 1,640 feet downstream from New York State Thruway	0.33	100	120	140	180
140+00	Approximately 100 feet downstream from New York State Thruway	0.16	54	58	63	80

The web-based tool "Application of Flood Regressions and Climate Change Scenarios to Explore Estimates of Future Peak Flows" developed by the USGS (Burns, et al., 2015a,b) was used to obtain estimates for changes to peak flood flows under a range of projected climate change scenarios at different periods in the future (Tables 2-5, 2-6, and 2-7). This tool was used to assess flooding conditions that may occur in future decades, enabling proactive flood mitigation measures. These may include restricting development in areas that are not currently regulated floodplains but are reasonably expected to be in the future based on climate change projections or identifying bridges and culverts that currently perform well but may become hydraulically inadequate in the future.

Table 2-5 Projected Percent Increases in Flood Flows for East Branch Saddle River at Town of Ramapo Limit

	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	6	6	9	9	7	7
RCP 8.5	5	6	7	7	12	12

Table 2-6 Projected Percent Increases in Flood Flows for Pine Brook at Village of Chestnut Ridge Limit

	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	7	7	10	10	9	8
RCP 8.5	7	7	8	8	13	13

Table 2-7 Projected Percent Increases in Flood Flows for West Branch Saddle River at Town of Ramapo Limit

	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	6	6	9	9	8	8
RCP 8.5	6	6	8	8	12	13

Precipitation data were evaluated for two future scenarios, termed "Representative Concentration Pathways" (RCP), that provide estimates of the extent to which greenhouse gas concentrations in the atmosphere are likely to change through the 21st century. RCP refers to potential future emissions trajectories of greenhouse gases such as carbon dioxide. RCP 4.5 is considered a midrange-emissions scenario, and RCP 8.5 is a high-range emissions scenario. Resulting precipitation and runoff estimates are based on five different climate models and are input into the USGS *StreamStats* program, a web-based implementation of regional hydrologic regression equations. Percent increases over *StreamStats* regression estimates based on current climatic data, as computed for the Saddle River watershed, were applied to corresponding design flood flows used in hydraulic modeling of the stream and its tributaries. The flows based on the more moderate greenhouse gas scenario were used in the model. Proposed replacement stream crossings were assessed based on the flood flows the structure would be expected to encounter over its design lifetime. When modeling culverts, the 2050 through 2074 projections were employed as a 50-year design life, which is typical for such structures; the 2075 through 2099 projections were used for bridges, which are often in service for 75 to 100 years or more. Mean estimated increase of 10 percent is applied to the 50- and 100-year floods for both the 2050 through 2074 and 2075 through 2099 projections based on regressions for Flood Frequency Region 3 in New York and the five climate models. Current and predicted future flows for the West Branch Saddle River, East Branch Saddle River, and Pine Brook are compared in Tables 2-8, 2-9, and 2-10, respectively.

Table 2-8 Current and Projected Future Design Flood Flows Used in Hydraulic Analyses on West Branch Saddle River

Station	Location	Peak Flood Discharge (cfs)			
		Current		Projected Future (10% increase)	
		50-Year	100-Year	50-Year	100-Year
00+00	At Town of Ramapo corporate limits	699	843	769	927
33+89	Approximately 1,220 feet downstream of Beaver Hollow Lane	642	773	706	850
70+44	Approximately 1,097 feet upstream of Christmas Hill Road	412	464	453	510
98+87	Approximately 950 feet upstream of East Blossom Road	314	338	345	372
119+03	Approximately 120 feet downstream of Interstate Routes 87 and 287	202	213	222	234
220+00	Upstream of culvert entrance of Interstate Routes 87 and 287	249	272	274	299.2

Table 2-9 Current and Projected Future Design Flood Flows Used in Hydraulic Analyses on East Branch Saddle River

Station	Location	Peak Flood Discharge (cfs)			
		Current		Projected Future (10% increase)	
		50-Year	100-Year	50-Year	100-Year
00+00	At Town of Ramapo corporate limits	1,090	1,300	1,199	1,430
46+80	Approximately 554 feet upstream of South Monsey Road	730	870	803	957
75+80	Approximately 425 feet downstream of Regina Road	560	620	616	682
89+50	Approximately 950 feet upstream of Regina Road	310	340	341	374
110+00	Approximately 320 feet downstream of Interstate Routes 87 and 287	250	260	275	286

Table 2-10 Current and Projected Future Design Flood Flows Used in Hydraulic Analyses on Pine Brook

Station	Location	Peak Flood Discharge (cfs)			
		Current		Projected Future (10% increase)	
		50-Year	100-Year	50-Year	100-Year
00+00	At Borough of Upper Saddle River, NJ - Village of Chestnut Ridge Corporate Limits	1070	1290	1,177	1,419
21+80	Approximately 370 feet downstream of Pine Brook Road	860	1030	946	1,133
39+00	Upstream of confluence with Hungry Hollow Brook	570	690	627	759
67+80	Approximately 100 feet downstream of driveway opposite School House Road	500	610	550	671
87+60	Approximately 771 feet from Lakeside School Dam	420	510	462	561
110+50	Approximately 1,581 feet from Lakeside School Dam	190	220	209	242
123+60	Approximately 1,640 feet downstream from New York State Thruway	120	140	132	154
140+00	Approximately 100 feet downstream from New York State Thruway	58	63	64	69

2.4 HYDRAULICS

To develop hydraulic modeling to assess flood mitigation alternatives, effective FEMA HEC-RAS hydraulic models were sought for the areas of the Saddle River watershed where they are available, which is limited to the West Branch Saddle River in Rockland County, New York. This model was obtained from NYSDEC.

Hydraulic analyses on West Branch Saddle River were conducted using the HEC-RAS computer software. This program was developed by the United States Army Corps of Engineers (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 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.

Model geometry was based on a combination of surveyed channel cross sections included in effective FEMA modeling, field measurements by SLR, and Light Detection and Ranging (LiDAR)-derived topographic mapping from the New York State (NYS) Geographic Information System (GIS) Clearinghouse.

Roughness coefficients were applied to the model domain based on field observations and aerial orthophotography.

The East Branch Saddle River and Pine Brook were last modeled in the 1980s using the antiquated HEC-2 software. To evaluate stream crossings on the East Branch Saddle River and Pine Brook, the HY-8 culvert hydraulics software was used. This program uses several input parameters to perform hydraulic calculations for structures but with limited contextual data relative to the surrounding stream. For this reason, these models are relatively simple and useful for approximate sizing of culverts but are not substitutes for complete hydraulic analyses of proposed culvert upgrades, especially if projects are expected to impact flow dynamics beyond their immediate vicinity.

For HY-8 models, culvert geometry, including dimensions of the hydraulic opening, barrel material, slope, and inlet configuration, as well as roadway embankment characteristics and stream channel profile and cross sections, were measured in the field. Culvert capacity and potential roadway overtopping can then be assessed.

2.5 STAKEHOLDER MEETINGS

An important component of the data gathering for this study took place through stakeholder engagement. Two formal stakeholder meetings were convened by video conference call. The first meeting was held on the evening of October 4, 2021. This meeting was geared toward participation by members of watershed groups. The second meeting was a daytime meeting held on October 6, 2021, with participation by government agencies, county, and municipal staff and included participation from NYSDEC, OGS, and Rockland County. Throughout the study, there were one-on-one conversations and calls with highway departments, fire departments, emergency responders, landowners, and other groups.

2.6 INFRASTRUCTURE

Several bridge and culvert crossings of the Saddle River watershed are contained within identified HRAs and, in certain cases, may be hydraulically undersized and contribute to flooding in these locations. These structures and summary details are listed below in Table 2-11. 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 2-11 Summary Data for Assessed Bridge and Culvert Crossings of East Branch Saddle River, West Branch Saddle River, and Pine Brook

River	Station	Roadway	Structure	NBI BIN* (Owner)	Number of Spans/ Barrels	Span (ft)	Bankfull Width (ft) (Regional Regressions)
West Branch Saddle River	46+00	Beaver Hollow Lane	Twin Concrete Pipe Culverts	Unlisted	2	5.2	25.8
	59+50	Christmas Hill Road	Arch CMP Culvert	Unlisted	1	17	25.2
	88+80	East Blossom Road	Twin Arch CMP Culverts	Unlisted	2	5.5	22.2
	104+00	Conrail Railroad	Arch Concrete Culvert	N/A (Railroad)	1	7.5	21.2
	113+05	Route 59/Nyack Turnpike	Single Box Culvert	C860034 (NYSDOT)	1	11	20.2
	120+00	I-287	Single Pipe Culvert	Unlisted	1	4	19.9
	129+25	Olympia Lane	Single Concrete Pipe Culvert	Unlisted	1	6	16.2
East Branch Saddle River	12+80	Hillside Avenue	Concrete Box Culvert	2224150 (County)	1	22.8	29.8
	20+00	Gates of Zion Cemetery driveway	Twin Arch Pipes	Unlisted	2	10	29
	25+00	Ascension Cemetery driveway	Twin Concrete Arches	Unlisted	2	10	28.9
	41+30	South Monsey Road	Concrete Box Culvert	Unlisted	1	8	28.1
	80+00	Regina Road	Concrete Box Culvert	Unlisted	1	10.5	21.7
Pine Brook	25+50	Pine Brook Road	Concrete Box Culvert	Unlisted	1	12	30.3

*NBI BIN = National Bridge Inventory Bridge Identification Number
CMP = Corrugated metal pipe

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*.

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.

- 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, which includes the Saddle River watershed, is 20 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 state that, where possible, the following best management guidelines should be incorporated:

- Provide a minimum opening width of 1.25 times the width of the stream channel bed 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.

Several dams span the Saddle River tributaries. Known dams are listed in Table 2-12.

Table 2-12 Summary of Dams of East Branch Saddle River, West Branch Saddle River, and Pine Brook

River	Station	Name	Height
West Branch Saddle River	62+00	200 Cherry Lane Dam	12 ft
	74+60	Island Lake Dam	10 ft
	78+00	Unnamed	8 ft
East Branch Saddle River	4+50	Unnamed	Breached
	22+00	St. Patrick Cathedral Cemetery Dam	10 to 17 ft
	44+50	Unnamed	Breached

3. IDENTIFICATION OF FLOOD HAZARDS

3.1 FLOODING HISTORY

Rockland County has an active history of hurricanes and tropical storms. According to NOAA historical records summarized in the FEMA FIS for Rockland County, 25 hurricane or tropical storm tracks have passed within 65 miles of Rockland County since 1861, including four Category 1 hurricanes, two Category 2 hurricanes, and 19 tropical storms. Of the 25 recorded storm events, five passed directly through Rockland County. Table 3-1 is a summary of flood events that impacted Rockland County and the Saddle River watershed. The flood history is summarized from the FEMA FIS for Rockland County, the Rockland County Multi-Jurisdictional Hazard Mitigation Plan, and NOAA historical storm records.

Table 3-1 Saddle River Watershed Flood History

Date	Flood Event	Notes
1863 to 1915	Four unnamed tropical storms	
1972	Tropical Storm Agnes	Tropical Storm Agnes first developed in the northwest Caribbean Sea on June 11. By the night of June 15, Agnes transitioned into a tropical depression as it moved northward into the Gulf of Mexico. When the storm hit the Florida panhandle, it had reached its peak intensity as a hurricane on June 18. Hurricane Agnes weakened as it moved northward up through North Carolina and Virginia but quickly regained its strength as it merged with another storm system over Pennsylvania. The states of Pennsylvania, Virginia, and New York received large amounts of rain. Rainfall amounts ranged from 6 to 12 inches. Almost $13 billion in damages were estimated to be caused by Hurricane Agnes nationwide.
September 1975	Hurricane Eloise	Rockland County was included in areas eligible for both Individual and Public Assistance under Disaster Declaration DR-0487, following the impacts of the remnants of Hurricane Eloise. Heavy rainfall caused riverine flooding and an estimated $300 million in damage across the northeastern United States.
1988	Tropical Depression	
December 21, 1992	Nor'easter	This nor'easter, which caused widespread flooding and damage to commercial and residential properties, utilities, roads, and other infrastructure, resulted in Disaster Declaration 0974, under which Rockland County became eligible for both Public and Individual Assistance.

Date	Flood Event	Notes
July 13, 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. The Mahwah River at Suffern in Rockland County rose above its 4-foot flood stage from 11:30 a.m. EST on July 13 through 10:15 a.m. on July 14. The crest stage was 5.75 feet at 1:15 p.m. on July 13. The Saw Mill River in Westchester County also flooded. Rainfall amounts recorded in Rockland County ranged from 3.25 inches at West Nyack to 4.65 inches at Pomona.
September 1999	Remnants of Hurricane Floyd	Tropical Depression by the time it reached Rockland County. Widespread flooding in Rockland, Orange, Putnam, and Westchester Counties; total damage costs estimated at $14.6 million. Rainfall amounts from 3.16 inches at Nanuet to 3.31 inches at New City.
September 2004	Hurricane Ivan	Tropical Depression by the time it reached Rockland County.
April 15-16, 2007	Nor'easter	A nor'easter occurred during Sunday and Monday, April 15 and 16, which brought heavy rain and high winds that caused widespread and significant river, stream, and urban flooding of low-lying and poor-drainage areas. Rockland County was among the counties eligible for Individual and Public Assistance under the resulting Federal Disaster Declaration DR-1692. Costs to repair disaster damages to roads and drainage structures in Rockland County were estimated at $5,000,000.
September 2008	Tropical Storm Hanna	Tropical Depression by the time it reached Rockland County.
August 21, 2011	Tropical Storm Irene	Hurricane Irene formed from a tropical wave on August 21, 2011, in the tropical Atlantic Ocean. It moved west-northwestward, and 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 re-emerged 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 across New York State, 7.52 inches of rainfall recorded at Tappan, New York.

Date	Flood Event	Notes
October 29, 2012	Superstorm 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. Classified as the eighteenth named storm, tenth hurricane, and second major hurricane of the year, Hurricane Sandy made landfall in the United States about 8 p.m. EDT 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 US is estimated at over $100 billion (2013 USD). Record coastal flooding in Lower New York. Towns of Stony Point and Piermont sustained major damage. In the village of Piermont, approximately 300 individuals were evacuated from homes and businesses.
August through October, 2021	Tropical Storm Henri, Tropical Storm Ida, and October Nor'easter	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 Rockland County. Record-breaking rainfall of 1.94 inches fell in just 1 hour in Central Park, the wettest hour on record for New York City. 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. An October 2021 Nor'easter, which eventually became Tropical Storm Wanda, was an erratic nor'easter and tropical cyclone that struck the East Coast of the United States, causing widespread flooding in parts of New York and New Jersey.

There are no active USGS stream gauges in the Saddle River watershed in New York. In New Jersey, an active USGS stream gauge (01390450) on the Saddle River in the Borough of Upper Saddle River has collected annual peak flow data since 1966, which provides a useful view of flood events. The gauge is located approximately 100 feet downstream from Lake Street and 1.3 miles downstream from the confluence of Pine Brook with the Saddle River. Figure 3-1 is a hydrograph showing annual peak flows recorded. Flood recurrence information from the FEMA FIS showing the magnitude of the 10-, 50-, and 100-year flood events has been superimposed on the hydrograph. One event stands out: the September 1999 Hurricane Floyd. This event exceeded the 100-year flood at 6,290 cubic feet per second (cfs) in Upper Saddle River. Tropical Storm Ida, which occurred in September 2021, exceeded the 10-year flood event.

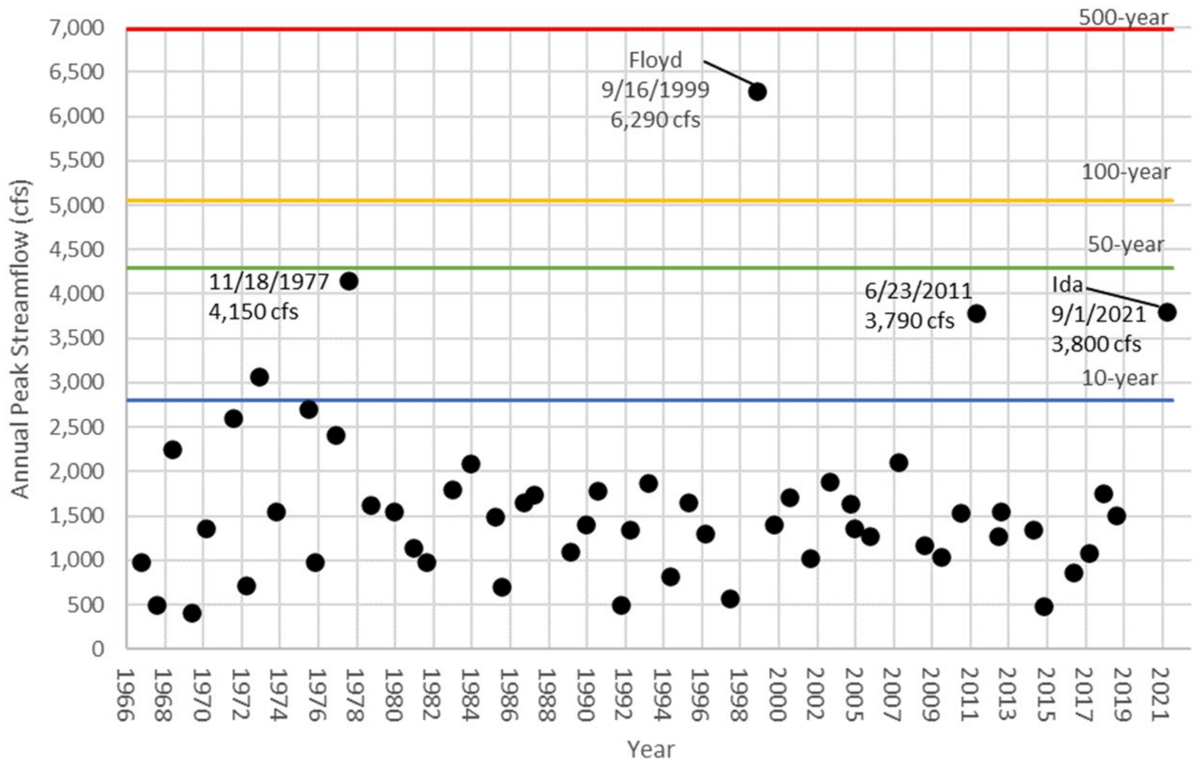

Figure 3-1: Hydrograph of Annual Peak Flow on the Saddle River at Upper Saddle River, New Jersey 1966 – 2021

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 Rockland County (36087CV001A) has been effective since March 2014. The flood hazard areas delineated by FEMA are mapped for each focus watercourse. Figures 3-2 through 3-4 depict flood hazard mapping along the West Branch Saddle River. Figures 3-5 through 3-7 depict mapping along the East Branch Saddle River. Figures 3-8 through 3-10 depict mapping along Pine Brook. Each map displays the Special Flood Hazard Layers delineated by FEMA for each focus watercourse in this report, including the 1.0 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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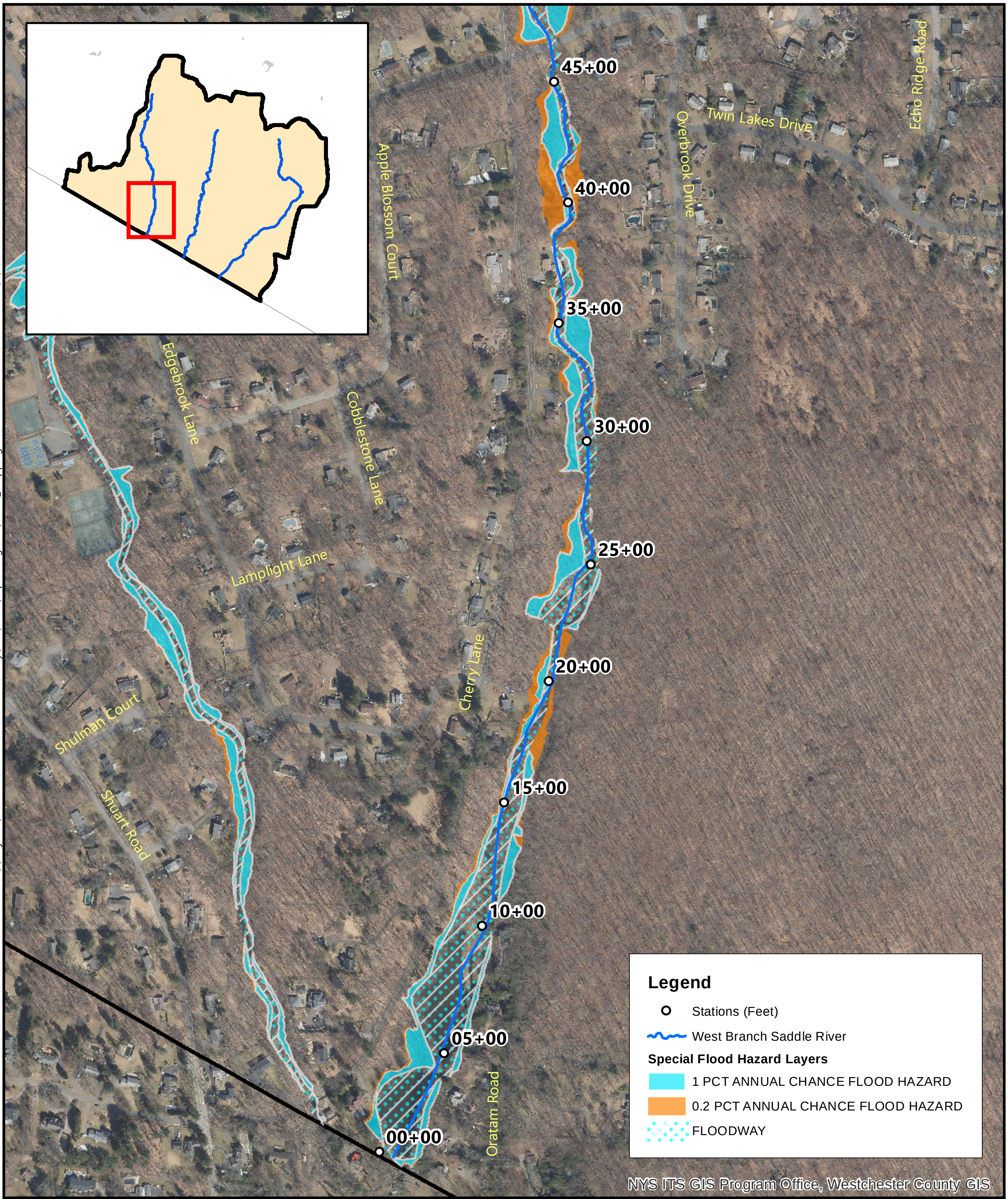

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231 MAIN STREET
SUITE 102
NEW PALTZ, NY 12561
845.633.8153

FEMA MAPPING - WEST BRANCH SADDLE RIVER

SADDLE RIVER FLOOD & RESILIENCE STUDY

SD 114

ROCKLAND COUNTY
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FIG. 3-2

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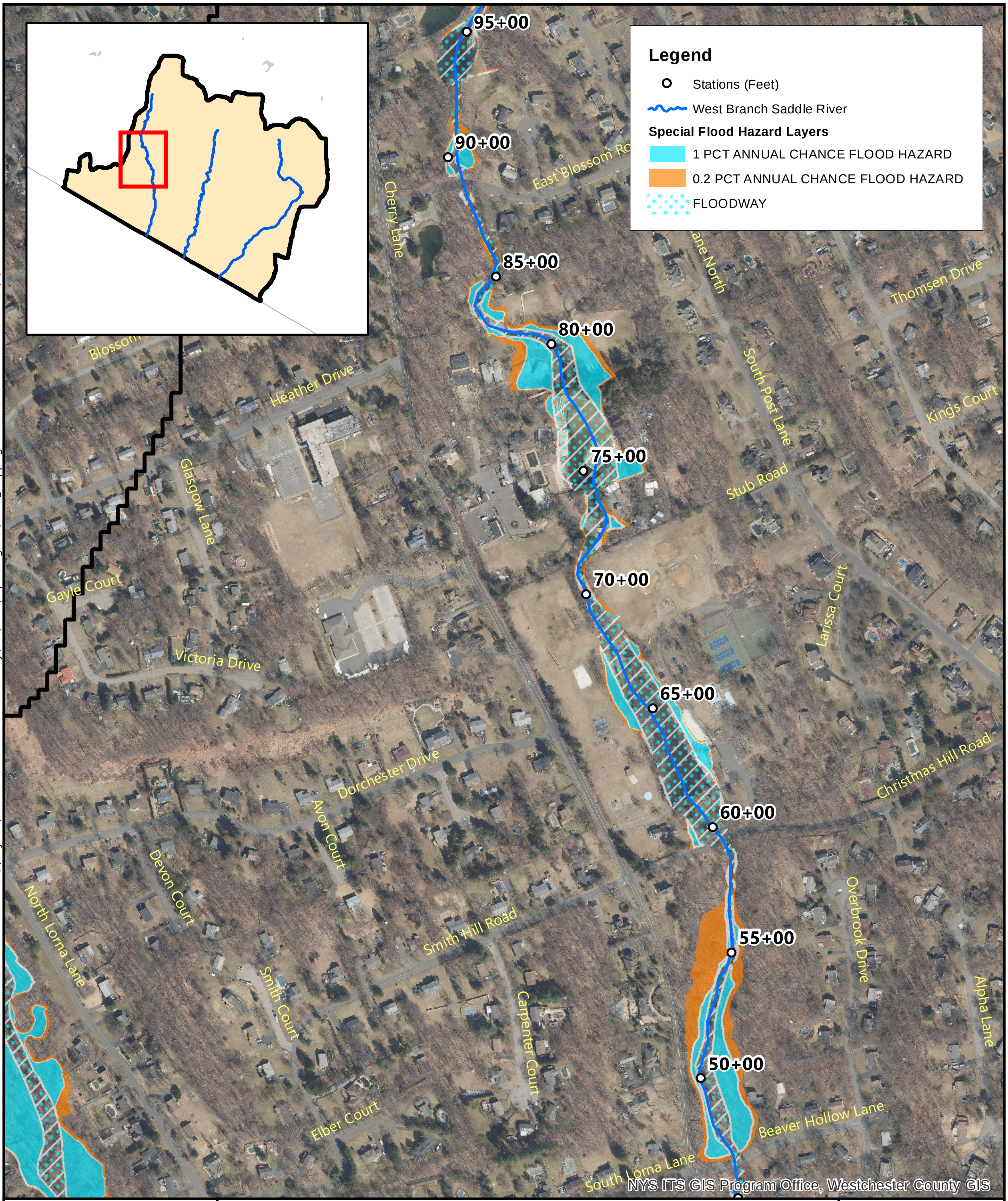

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SUITE 102
NEW PALTZ, NY 12561
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FEMA MAPPING - WEST BRANCH SADDLE RIVER

SADDLE RIVER FLOOD & RESILIENCE STUDY

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FIG. 3-3

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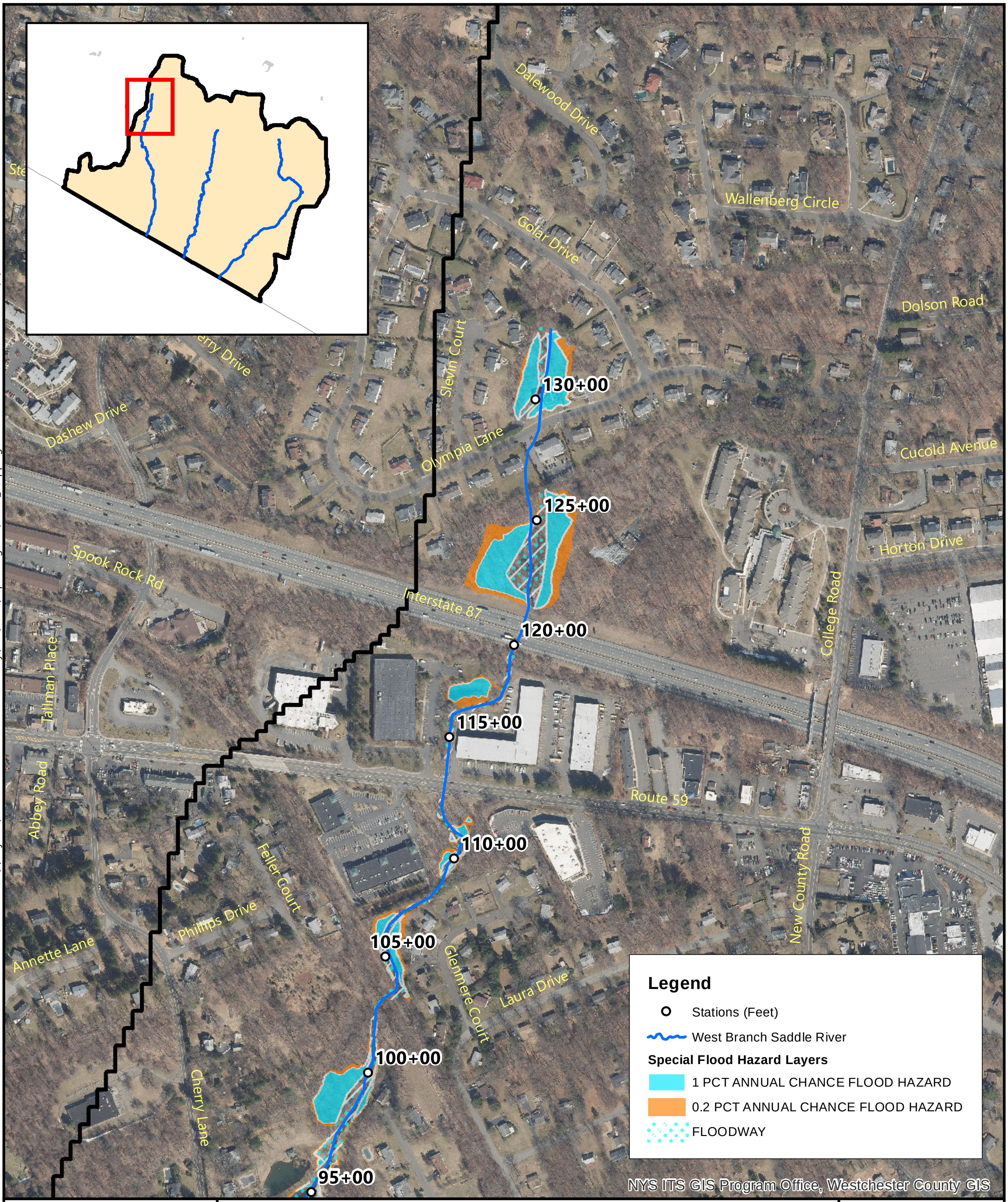

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FEMA MAPPING - WEST BRANCH SADDLE RIVER
SADDLE RIVER FLOOD & RESILIENCE STUDY
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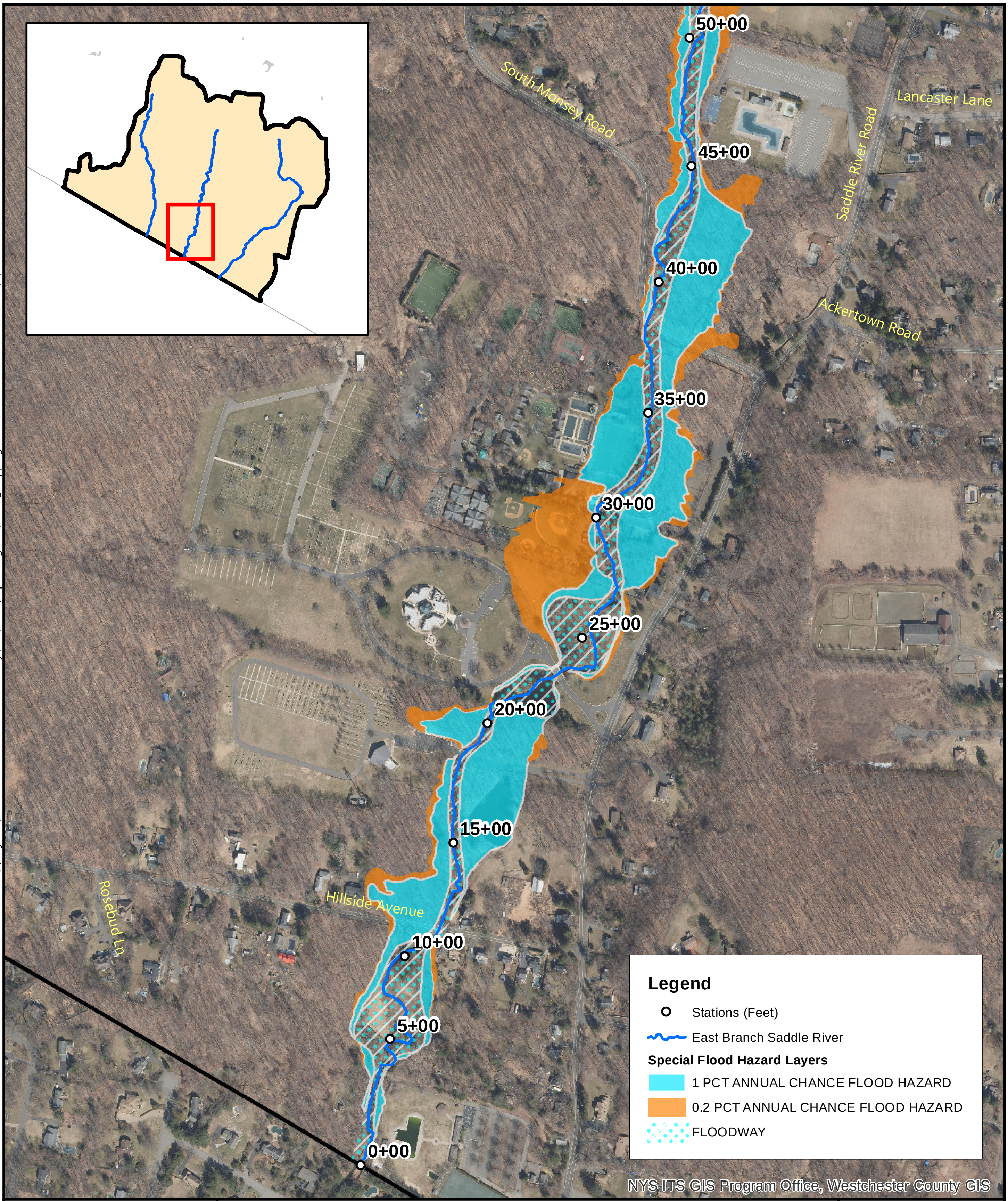
FIG. 3-4



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FEMA MAPPING - EAST BRANCH SADDLE RIVER

SADDLE RIVER FLOOD & RESILIENCE STUDY

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NEW YORK

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FIG. 3-5

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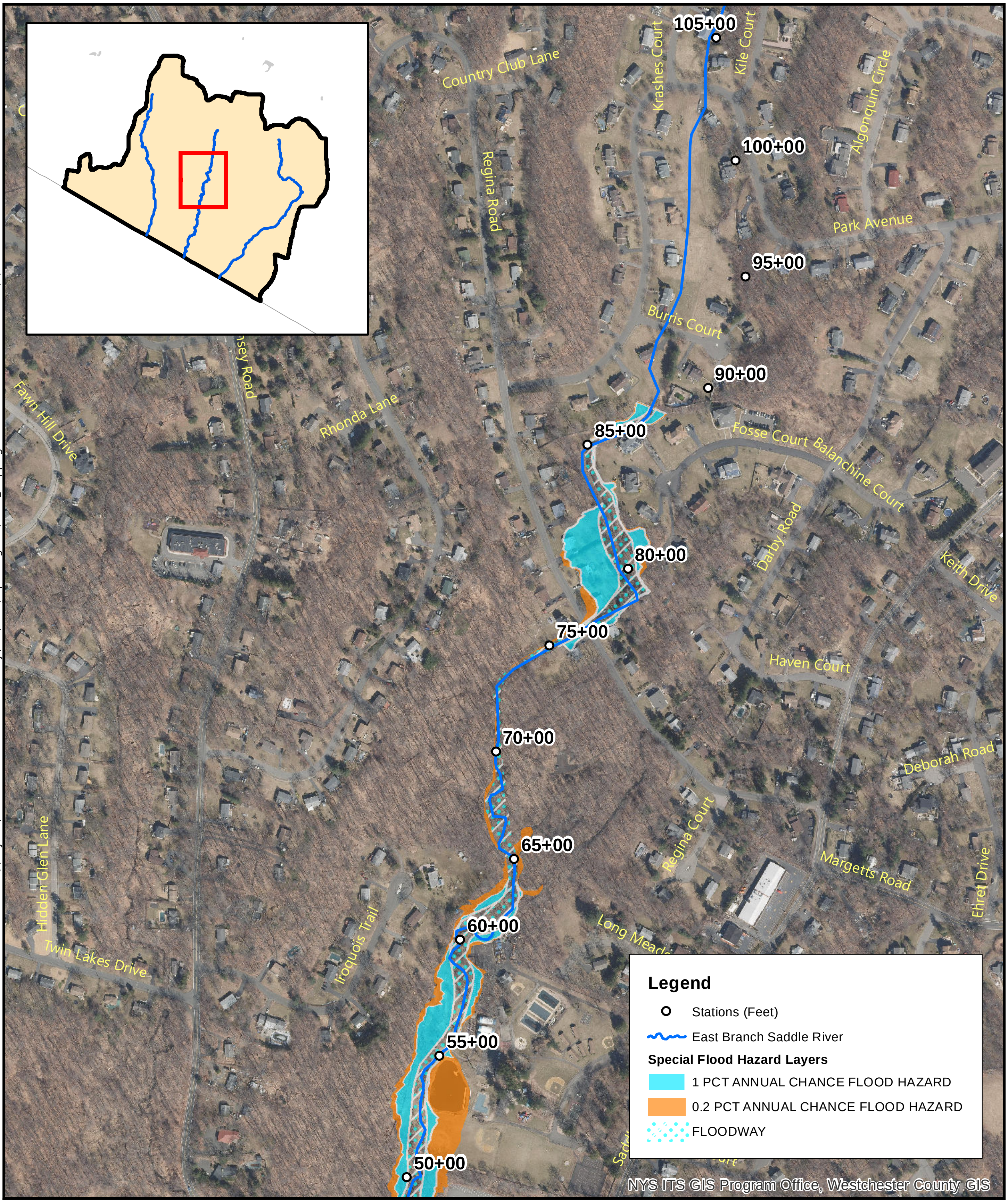

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FEMA MAPPING - EAST BRANCH SADDLE RIVER
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FIG. 3-6

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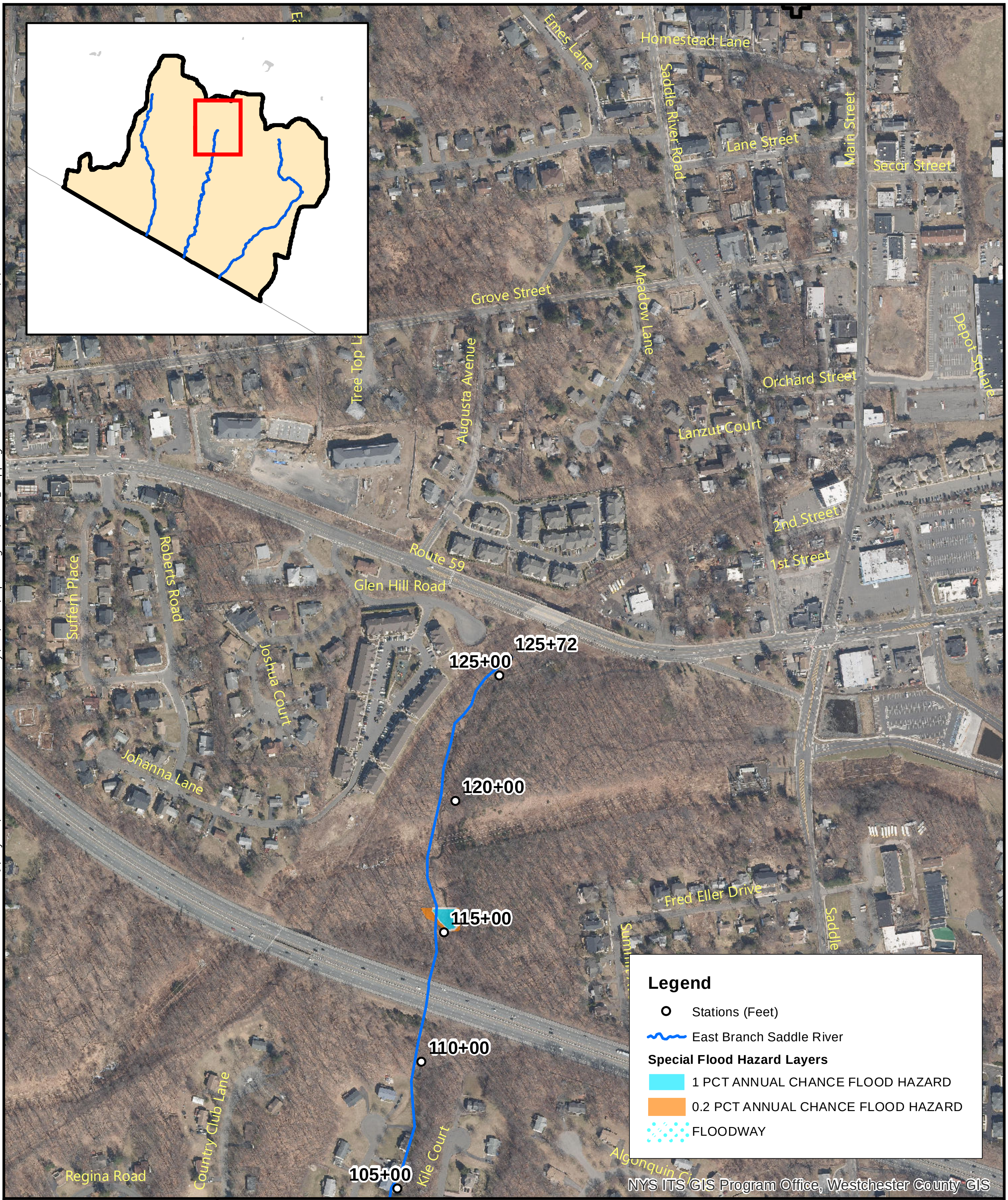

SLR 231 MAIN STREET SUITE 102 NEW PALTZ, NY 12561 845.633.8153	FEMA MAPPING - EAST BRANCH SADDLE RIVER SADDLE RIVER FLOOD & RESILIENCE STUDY SD 114 ROCKLAND COUNTY NEW YORK N 0 500 Feet	SCALE 1 " = 500 ' DATE 6/7/2022 16511.00009 PROJ. NO. **FIG. 3-7**

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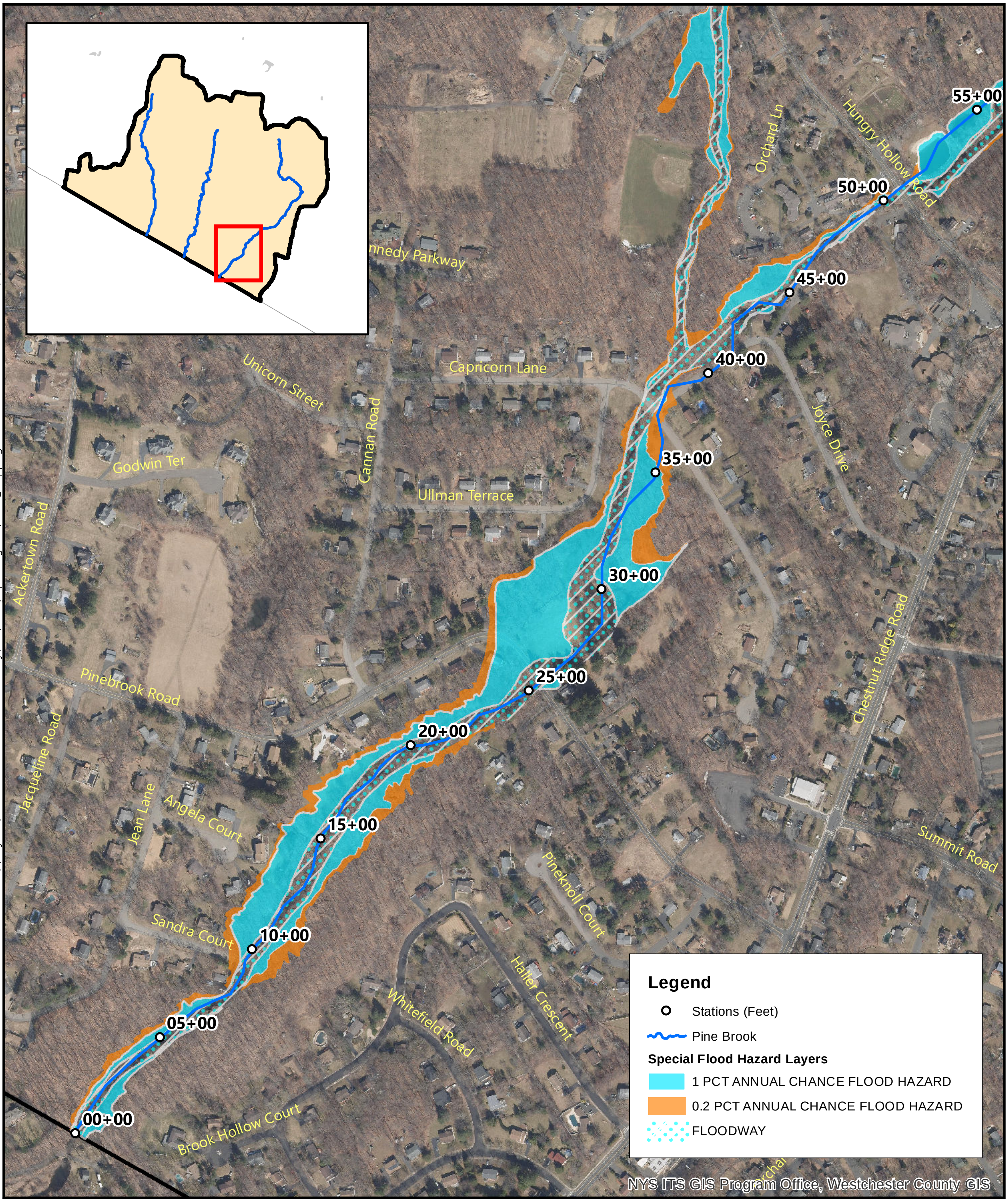

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FEMA MAPPING - PINE BROOK

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SD 114

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FIG. 3-8

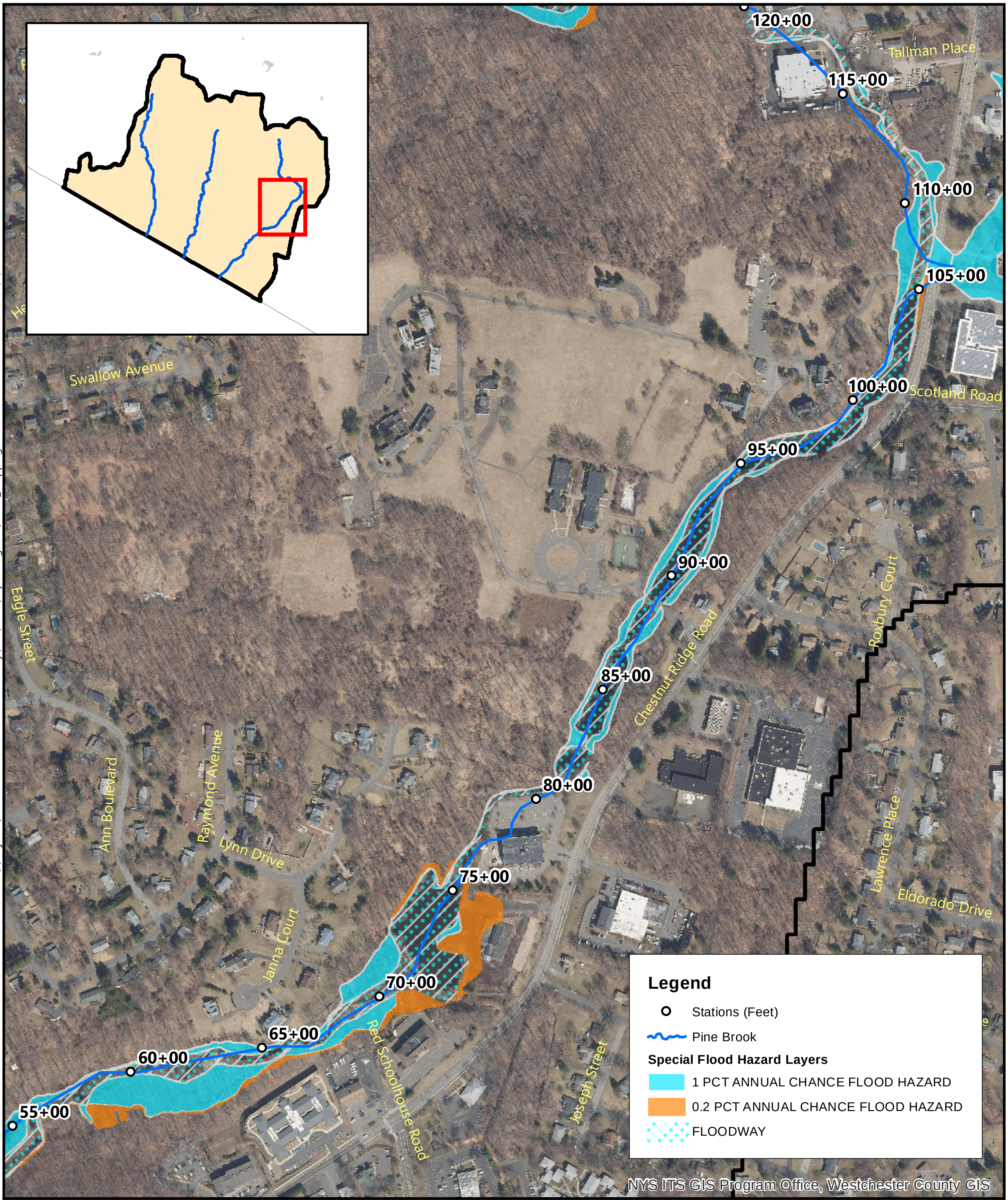

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FIG. 3-9

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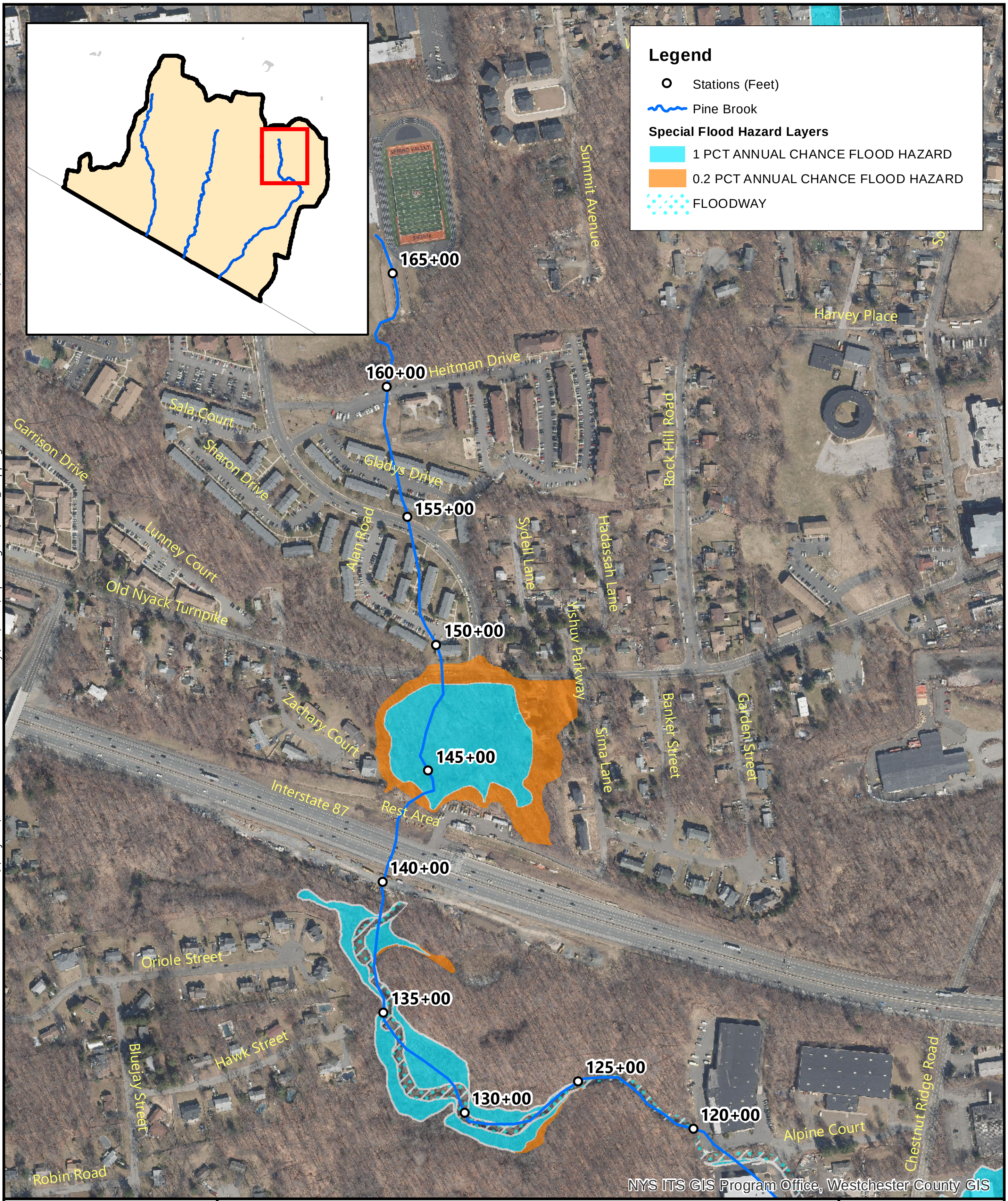

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FEMA MAPPING - PINE BROOK

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SD 114

ROCKLAND COUNTY

NEW YORK

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FIG. 3-10

4. FLOOD MITIGATION ANALYSIS

In this section, flood-prone areas along West Branch Saddle River, East Branch Saddle River, and Pine Brook 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 the FEMA FIS and FIRMs, County Hazard Mitigation Plans, 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 HRAs within the Saddle River watershed.

4.1 HIGH RISK AREA 1: PINE BROOK

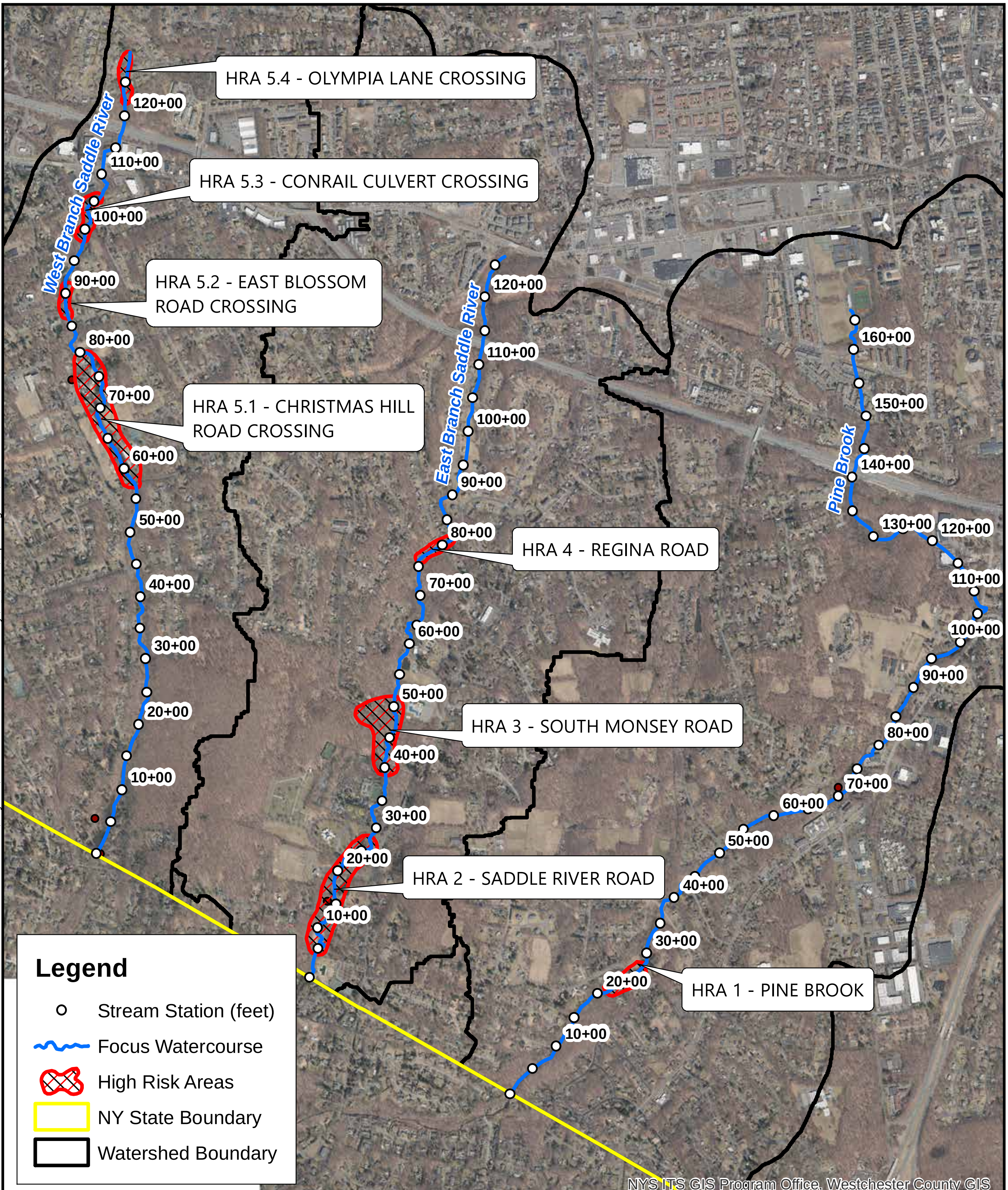
HRA 1 is located in the village of Chestnut Ridge at the crossing of Pine Brook Road over Pine Brook and extends from STA 21+00 to STA 28+00 (Figure 4-2). In the Rockland County Hazard Mitigation Plan, properties along Pine Brook Road and Haller Crescent were reported to be prone to flooding. The FEMA FIRM indicates that the area is prone to flooding, and the FEMA flood profiles indicate that the crossing of Pine Brook Road over Pine Brook is insufficiently sized to pass the 10-year flood event.

The crossing of Pine Brook at Pine Brook Road (STA 25+50) is a concrete box culvert with a 12-foot span and 4-foot rise (Figure 4-3). The ownership of this crossing in the National Bridge Inventory is unlisted. Peak flow data for the location is given in Table 2-10, with data from the FEMA FIS report. The nearest reported location to the crossing is approximately 370 feet downstream of Pine Brook Road. An HY-8 analysis of the culvert shows that the capacity is 289 cfs, which results in overtopping of the road during a 10-year flood event with flows of 550 cfs. Peak flow data for higher frequency flood events is not available for this location.

A detailed hydraulic and hydrologic analysis is recommended to properly size a replacement structure for the culvert under Pine Brook Road. According to the USGS Future Flows Explorer, an online tool to predict changes in stream flow, this watershed will experience about a 10 percent increase in recurrence flow levels over the next 50 to 100 years. The design 100-year future flow at this crossing is 1,130 cfs. According to the HY-8 model, increasing the crossing span to 43 feet increases the capacity to 1,130 cfs without overtopping of the roadway. This model includes an increase in the slope of the crossing to match that of the tailwater, 0.015. Adjustments to the channel upstream and downstream of the crossing are necessary to account for the change.

The HY-8 hydraulic modeling software used here is designed to model culverts rather than bridges. The proposed crossing is outside the recommended range for this modeling software. The recommended crossing span can also be determined based on the bankfull width of Pine Brook. According to regional regression equations, the bankfull width at this location is 30 feet. A crossing span of 1.25 times the bankfull width, or approximately 38 feet, was determined. When future flows are considered, the recommended crossing span is similar to the 43-foot span recommended above.

A conceptual layout showing the improvement described above is depicted in Figure 4-4.



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SADDLE RIVER WATERSHED HIGH RISK AREAS

SADDLE RIVER FLOOD & RESILIENCE STUDY
SD 114
ROCKLAND COUNTY
NEW YORK

N
0 500 1,000
Feet

SCALE 1 " = 1,939 '
DATE 6/7/2022
16511.00009
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FIG. 4-1

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HIGH RISK AREA #1: PINE BROOK
SADDLE RIVER FLOOD & RESILIENCE STUDY
SD 114
ROCKLAND COUNTY
NEW YORK

N
0 150 Feet

SCALE 1 " = 151 '
DATE 6/7/2022
PROJ. NO. 6511.00009

FIG. 4-2

Figure 4-3: Pine Brook Road crossing of Pine Brook

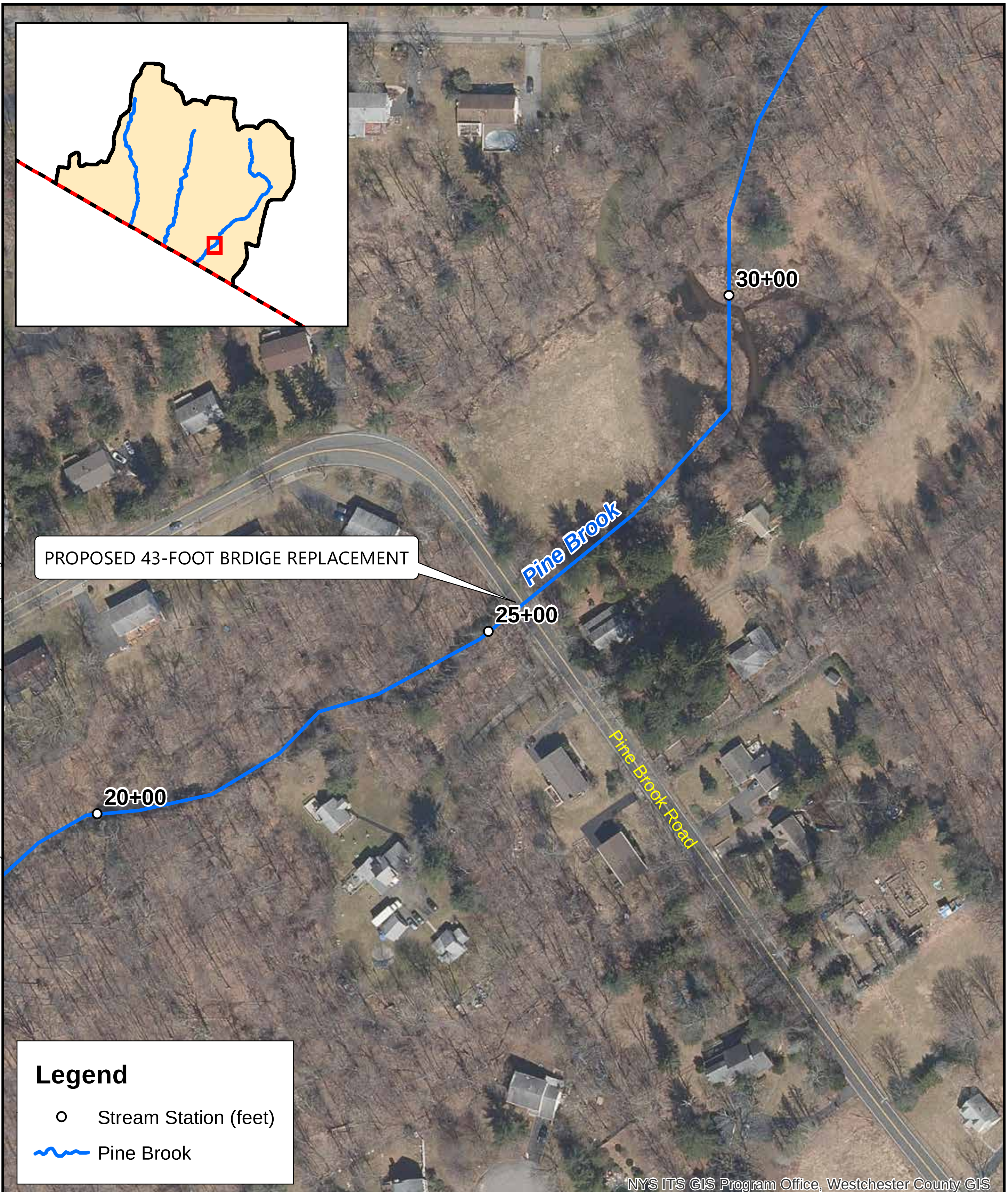
4.2 HIGH RISK AREA 2: EAST BRANCH SADDLE RIVER NEAR SADDLE RIVER ROAD

HRA 2 is located on the East Branch Saddle River in the town of Airmont along several side streets that extend off Saddle River Road and cross over the East Branch Saddle River. HRA 2 extends from STA 10+00 to STA 30+00 (Figure 4-5). Stream crossings in HRA 2 include the Ascension Cemetery driveway, the Gates of Zion Cemetery driveway, and Hillside Avenue. There is also a dam in this region between the Ascension Cemetery and Gates of Zion Cemetery. According to the Rockland County Hazard Mitigation Plan, properties along Saddle River Road have been prone to flooding. Homeowners near the Hillside Avenue crossing report flooding issues as well. The FEMA flood profiles show that the Ascension Cemetery driveway and Hillside Avenue are both overtopped by the 10-, 50-, and 100-year floods.

The peak flow data in HRA 2 is taken from the FEMA FIS report for the nearest location, which is at the town of Ramapo corporate limits (STA 0+00). Table 2-9 shows the current recurrence flows. Additionally, the future flow is considered and calculated as a 10 percent increase of the current peak flows.

4.2.1 ASCENSION CEMETERY DRIVEWAY

Furthest upstream in this section, the privately owned Ascension Cemetery driveway crosses the East Branch Saddle River at STA 25+00 with two open-bottom concrete arches (Figure 4-6). An HY-8 analysis of the crossing shows a capacity of 413 cfs. This is less than the 10-year flood peak flow of 710 cfs, resulting in overtopping of the crossing. The slope of the tailwater is very flat due to a downstream dam.



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CONCEPT MAP: HRA #1

SADDLE RIVER FLOOD & RESILIENCE STUDY
SD 114
ROCKLAND COUNTY
NEW YORK

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Feet

SCALE 1 " = 151 '
DATE 6/7/2022
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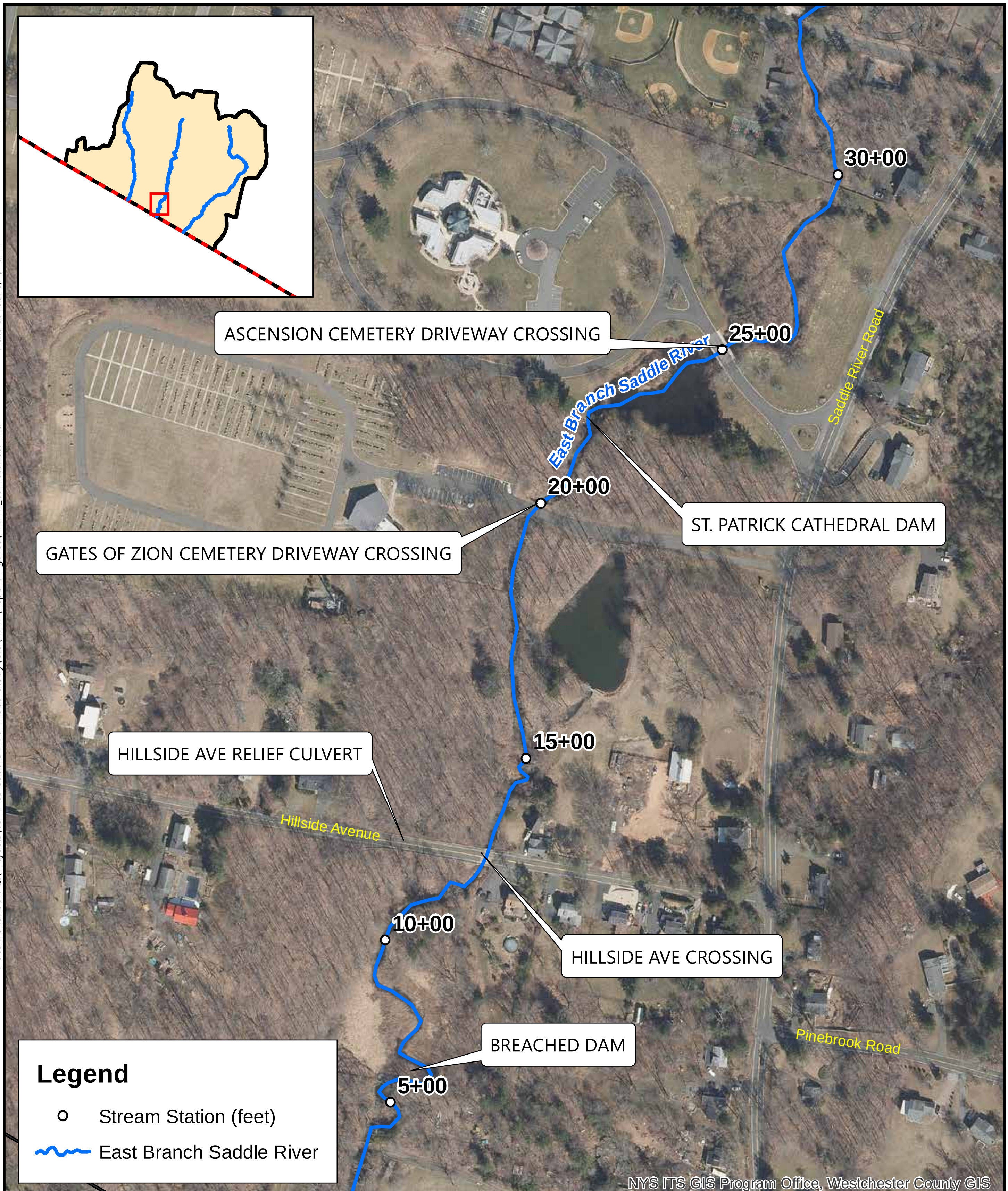
FIG. 4-4



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HIGH RISK AREA #2: SADDLE RIVER ROAD

SADDLE RIVER FLOOD & RESILIENCE STUDY
SD 114
ROCKLAND COUNTY
NEW YORK

N

0 260
Feet

SCALE 1 " = 252 '
DATE 6/7/2022
6511.00009
PROJ. NO.

FIG. 4-5

Figure 4-6: Ascension Cemetery driveway crossing of East Branch Saddle River

A detailed hydraulic and hydrologic analysis is recommended to properly size a replacement structure. The analysis should also include changes to the tailwater slope if the dam is removed as recommended below. The design flow for the resized structure is 1,430 cfs, the 100-year future peak flow, a 10 percent increase from the current 100-year peak flow. Including an increase in tailwater slope, the HY-8 analysis shows that a bridge with a 46-foot span and 7-foot rise has sufficient capacity to pass the 100-year future peak flow without overtopping the road.

The HY-8 hydraulic modeling software used here is designed to model culverts rather than bridges. The proposed crossing is outside the recommended range for this modeling software. The recommended crossing span can also be determined based on the bankfull width of East Branch Saddle River. According to regional regression equations, the bankfull width at this location is 29 feet. A crossing span of 1.25 times the bankfull width, or approximately 36 feet, was determined. When future flows are considered, the recommended crossing span is less than the 46-foot span recommended above. Additional analysis of the bankfull width and bed slope is recommended for greater precision.

4.2.2 ST. PATRICK CATHEDRAL CEMETERY DAM

Between the Ascension Cemetery and Gates of Zion Cemetery driveways is the St. Patrick Cathedral Cemetery Dam (State ID 196-5797; Federal ID NY 16950) at STA 22+00 (Figure 4-7). Based on review of NYSDEC dam information, this dam is privately owned and has a hazard classification of D. Class D dams are considered by NYSDEC to be defunct dams posing negligible or no hazard. During SLR's site visit, the area behind the dam was dry and vegetated. The East Branch Saddle River was a single channel with some pooling at the inlet and outlet of the dam. During high water events, the dam restricts flow, flooding the upstream area. While the flooded area is undeveloped, the pooling reduces the capacity of the crossing of the Ascension Cemetery driveway.

Figure 4-7: Outlet of dam downstream of Ascension Cemetery driveway

If the dam is no longer serving a function, it is recommended that it be removed to support the capacity of the Ascension Cemetery driveway crossing during flood events. The removal of the dam would also improve aquatic organism passage along the East Branch Saddle River and improve river health.

4.2.3 GATES OF ZION CEMETERY DRIVEWAY CROSSING

The next crossing of the East Branch Saddle River is the driveway of the Gates of Zion Cemetery at STA 20+00. It is made up of two arched pipes and is privately owned. The tailwater slope is very flat, approximately 0.5 percent, which is influenced by the scour pool at the outlet in Figure 4-8. An HY-8 analysis of the crossing shows that its current capacity is 760 cfs before overtopping, which is greater than the current 10-year peak flow of 710 cfs.

Figure 4-8: Gates of Zion Cemetery driveway crossing outlet

When due for replacement, it is recommended to upsize the culvert to an open-bottom bridge. The NYSDEC recommends open-bottom stream crossings. A detailed hydraulic and hydrologic analysis is recommended to properly size a replacement structure. With the current slope conditions, a bridge with a 36-foot span and 6.8-foot rise is needed to pass 100-year future flows of 1,430 cfs without overtopping of the road.

The HY-8 hydraulic modeling software used here is designed to model culverts rather than bridges. The proposed crossing is outside the recommended range for this modeling software. The recommended crossing span can also be determined based on the bankfull width of East Branch Saddle River. According to regional regression equations, the bankfull width at this location is 29 feet. A crossing span of 1.25 times the bankfull width, or approximately 36 feet, was determined. When future flows are considered, the recommended crossing span is similar to the span recommended above.

4.2.4 HILLSIDE AVENUE CROSSING

Hillside Avenue crosses the East Branch Saddle River at STA 12+80 with a concrete box culvert (BIN 2224150), shown in Figure 4-9. Approximately 150 feet west along Hillside Avenue is a relief culvert (Figure 4-10). The inlet of the relief culvert is a single metal pipe that empties into a concrete chamber. The chamber connects to the outlet via two plastic pipes, approximately 10 feet long. It appears that other drainage pipes empty into the chamber as well.

The main crossing, owned by the county, has a span of 22.8 feet and a rise of 6.5 feet. Using an HY-8 analysis, the culvert's capacity is 1,440 cfs. The relief culvert adds an additional capacity of 220 cfs. The

100-year future flow at this crossing is estimated to be 1,430 cfs, which is less than the currently available capacity. It is not necessary to resize this crossing based on this analysis.

Other sources of the reported flooding, such as undersized channels, were not studied along the East Branch Saddle River. A detailed HEC-RAS hydraulic model has not been produced by FEMA for this river.

Figure 4-9: Looking upstream through the crossing of Hillside Avenue over the East Branch Saddle River

Figure 4-10: Relief culvert along Hillside Avenue: Single inlet (L) splits into two outlet pipes (R)

4.2.5 UNNAMED BREACHED DAM

During a site visit to Hillside Avenue, a nearby resident reported the presence of a dam on the East Branch Saddle River downstream of the Hillside Avenue bridge. Upon further inspection, a dam that was observed to be breached was discovered at STA 4+50. Figures 4-11 and 4-12 depict the current condition and extents of the former dam and impoundment. The dam is not registered in NYSDEC's inventory of dams.

The dam measures over 250 feet long, ranges from 4 to 10 feet high, and is approximately 6 feet wide. Although the structure has been breached over the active channel, its levees cutoff floodplain access relief and may be influencing upstream water surface elevations. A full removal of the former dam and its components is recommended. This would entail the removal of about 225 liner feet of embankment fill material over the East Branch Saddle River's floodplain. Restoration of the immediate channel reach that is being disrupted by the presence of the collapsed mortared stone is also recommended. Removal of the obstruction will provide stream health and aquatic organism passage benefits, and the potential for flood reduction benefits may also exists. A rigorous hydrologic and hydraulic examination is recommended to assess the flood mitigation impacts of the recommended dam removal.

Figure 4-11: Looking upstream at the breached section of the unregistered dam over the East Branch Saddle River at STA 4+50

Figure 4-12: Looking downstream at the dam remnants to the left of the breach

A conceptual layout showing the improvements and recommendations described for HRA 2 is depicted in Figure 4-13.

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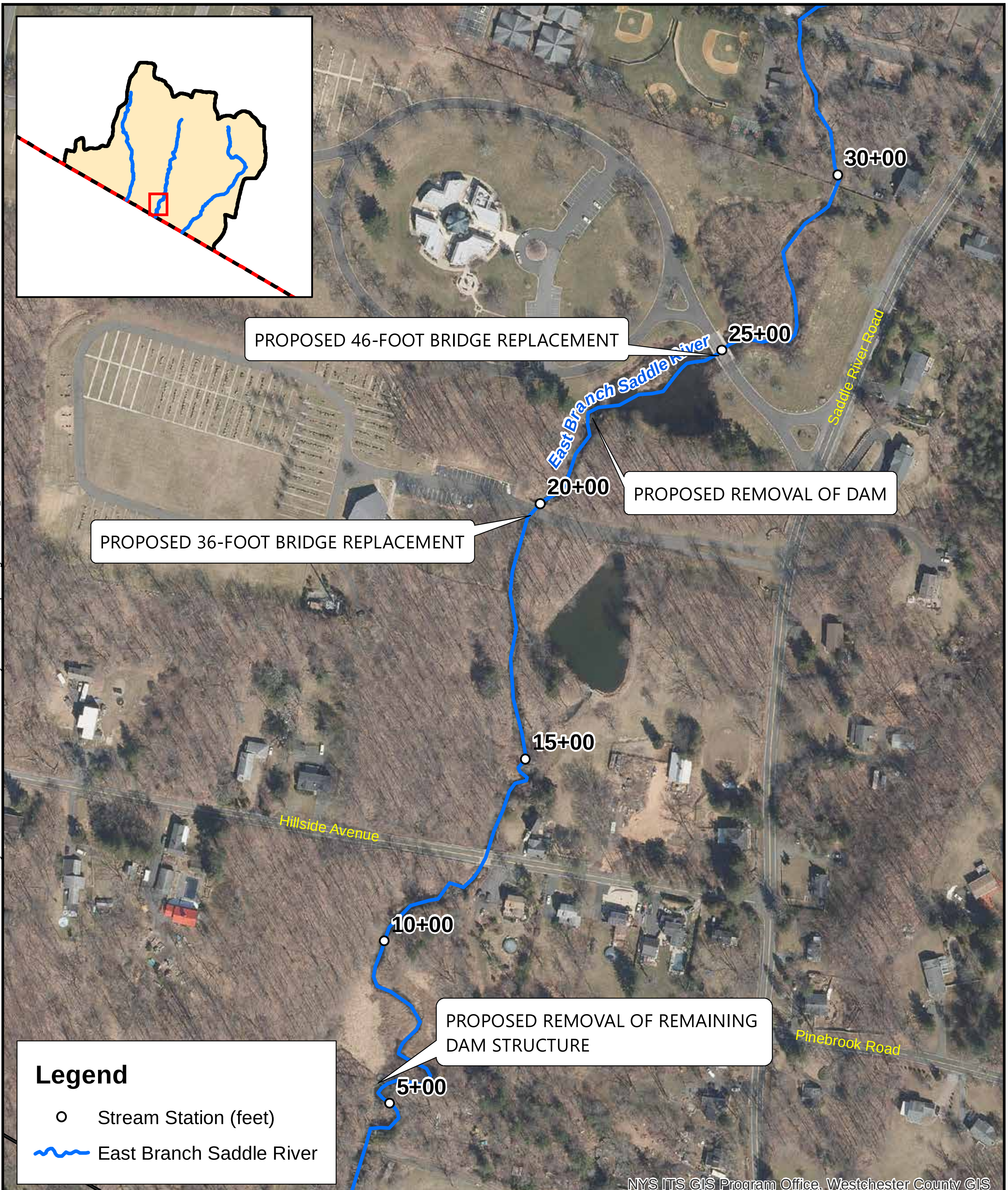


SLR 231 MAIN STREET SUITE 102 NEW PALTZ, NY 12561 845.633.8153	CONCEPT MAP: HRA #2 SADDLE RIVER FLOOD & RESILIENCE STUDY SD 114 ROCKLAND COUNTY NEW YORK		SCALE 1 " = 252 ' DATE 6/7/2022 6511.00009 PROJ. NO. FIG. 4-13

4.3 HIGH RISK AREA 3: EAST BRANCH SADDLE RIVER ALONG SOUTH MONSEY ROAD

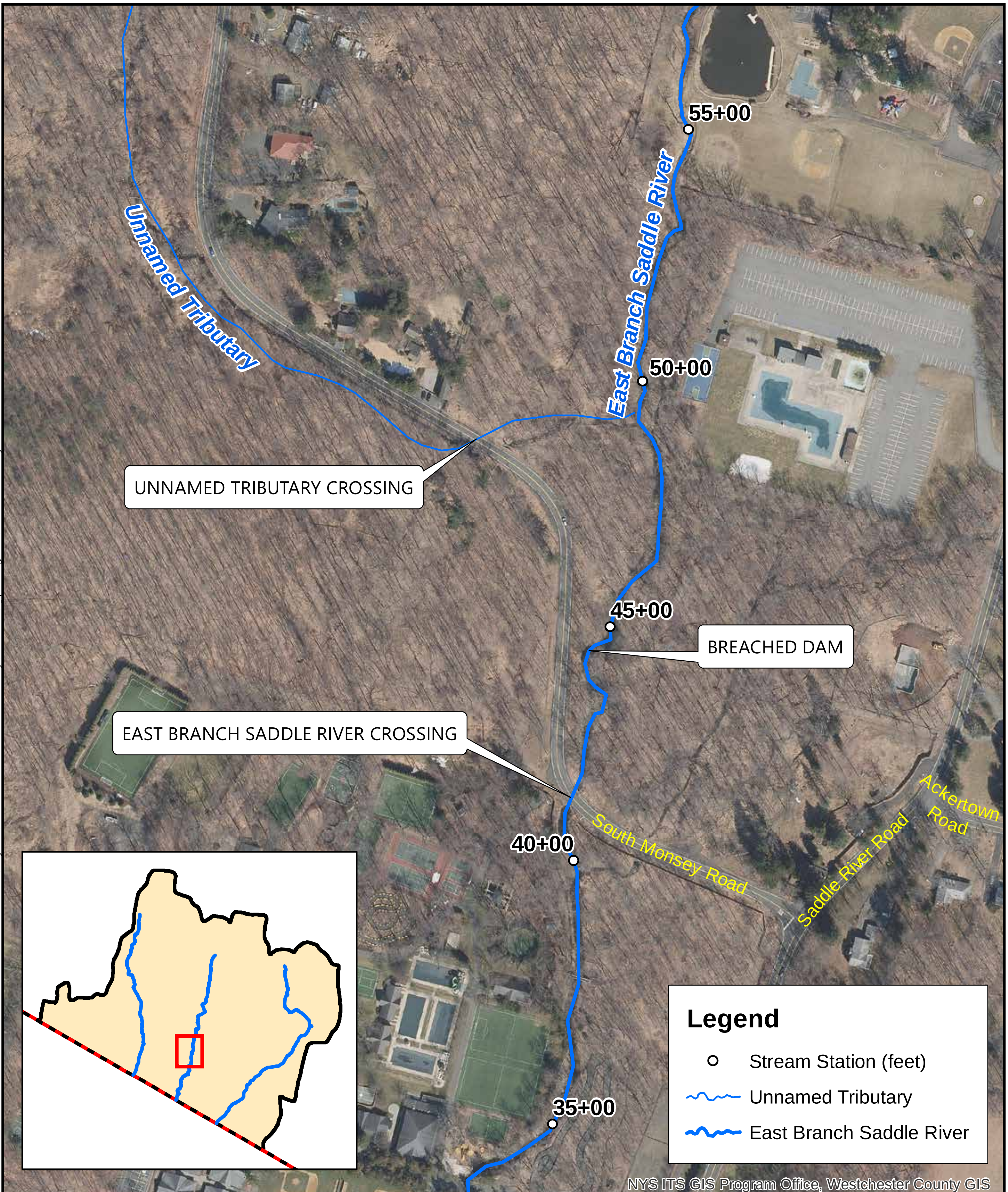
HRA 3 is located on the East Branch Saddle River (STA 38+80 to STA 51+60) and includes the confluence with an unnamed tributary in the town of Airmont along South Monsey Road (Figure 4-14). Two stream crossings and a breached dam are located within HRA 3. According to the Rockland County Hazard Mitigation Plan, the intersection of East Branch Saddle River and South Monsey Road is prone to flooding. While visiting the area for a preliminary assessment, it was observed that the road and road shoulder directly downstream of where the unnamed tributary crosses South Monsey Road was recently damaged due to flooding and the road shoulder had been reinforced with riprap.

South Monsey Road has two stream crossings. The road crosses the East Branch Saddle River approximately 500 feet west of the intersection with Saddle River Road. The second crossing is over an unnamed tributary to the East Branch Saddle River, approximately 700 feet farther along South Monsey Road. There is a breached dam on the East Branch Saddle River, upstream of the crossing with South Monsey Road.

4.3.1 SOUTH MONSEY ROAD – EAST BRANCH SADDLE RIVER

The crossing of South Monsey Road over the East Branch Saddle River at STA 41+30 is a concrete box culvert with a span of 8 feet and a rise of 3.5 feet (Figure 4-15). An HY-8 analysis evaluates the culvert using peak flow data from the FEMA FIS report, reproduced in Table 2-9. Flows for the location nearest the crossing – approximately 554 feet upstream of South Monsey Road – are used to assess the culvert. The flow capacity of the culvert is 242 cfs, about half of the peak flow of a 10-year flood, 480 cfs. According to the USGS Future Flows Explorer online tool, the peak flows will increase by about 10 percent over the next 50 to 100 years. The design 100-year flood flow is 957 cfs.

For the East Branch Saddle River crossing, an open-bottom crossing is recommended by the NYSDEC. The bed slope should match that of the tailwater, 2.5 percent. This is an increase from 0.5 percent slope of the current culvert, which will increase the capacity of the crossing. The HY-8 analysis of a crossing with a 34-foot span, 4-foot rise, open bottom, and 2.5 percent slope gives a capacity of 998 cfs and no overtopping of the road in 100-year future flow. A detailed hydraulic and hydrologic analysis is recommended to properly size a replacement structure. Restoration of the channel upstream and downstream of the crossing is recommended to address the change in slope.



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HIGH RISK AREA #3: SOUTH MONSEY ROAD

SADDLE RIVER FLOOD & RESILIENCE STUDY

SD 114

ROCKLAND COUNTY

NEW YORK

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SCALE 1 " = 247 '

DATE 6/7/2022

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FIG. 4-14

Figure 4-15: Inlet of South Monsey Road crossing of East Branch Saddle River

4.3.2 UNNAMED BREACHED DAM

Upstream of the crossing with South Monsey Road, a breached dam was found during SLR's site visit. The stone dam (STA 44+50) is not registered in NYSDEC's inventory of dams. The area behind the structure is not developed. It is recommended that the former dam and its components are fully removed. Channel restoration in the area influenced by the structure is also recommended. Removal of the obstruction will provide stream health and aquatic organism passage benefits, and the potential for flood reduction benefits may also exists. Hydraulic and hydrologic analysis is recommended to assess the flood mitigation impacts of the removal of the dam.

4.3.3 SOUTH MONSEY ROAD – UNNAMED TRIBUTARY

South Monsey Road crosses the unnamed tributary with an open-bottom concrete box (Figure 4-16). This stream is not included in the FEMA FIS report, so peak flows at the crossing were estimated using regional regression equations for New York State. An HY-8 analysis of the culvert shows flow capacity of 113 cfs, which passes the 10-year flood flows of 85 cfs without overtopping. The design flood flow for this crossing is the future 100-year peak flood, which is 207 cfs.

For the crossing over the unnamed tributary, the HY-8 analysis shows that expanding the span from 10 feet to 17 feet and removing some of the large rocks at the inlet to increase the rise to 2.4 feet at the inlet results in a capacity of 211 cfs and no overtopping at 100-year future flow levels. Additional hydraulic and hydrologic analysis is recommended to resize this culvert when it is due for replacement.

Figure 4-16: Inlet of unnamed tributary of East Branch Saddle River crossing under South Monsey Road

A conceptual layout showing the recommendations described for HRA 3 is depicted in Figure 4-17.

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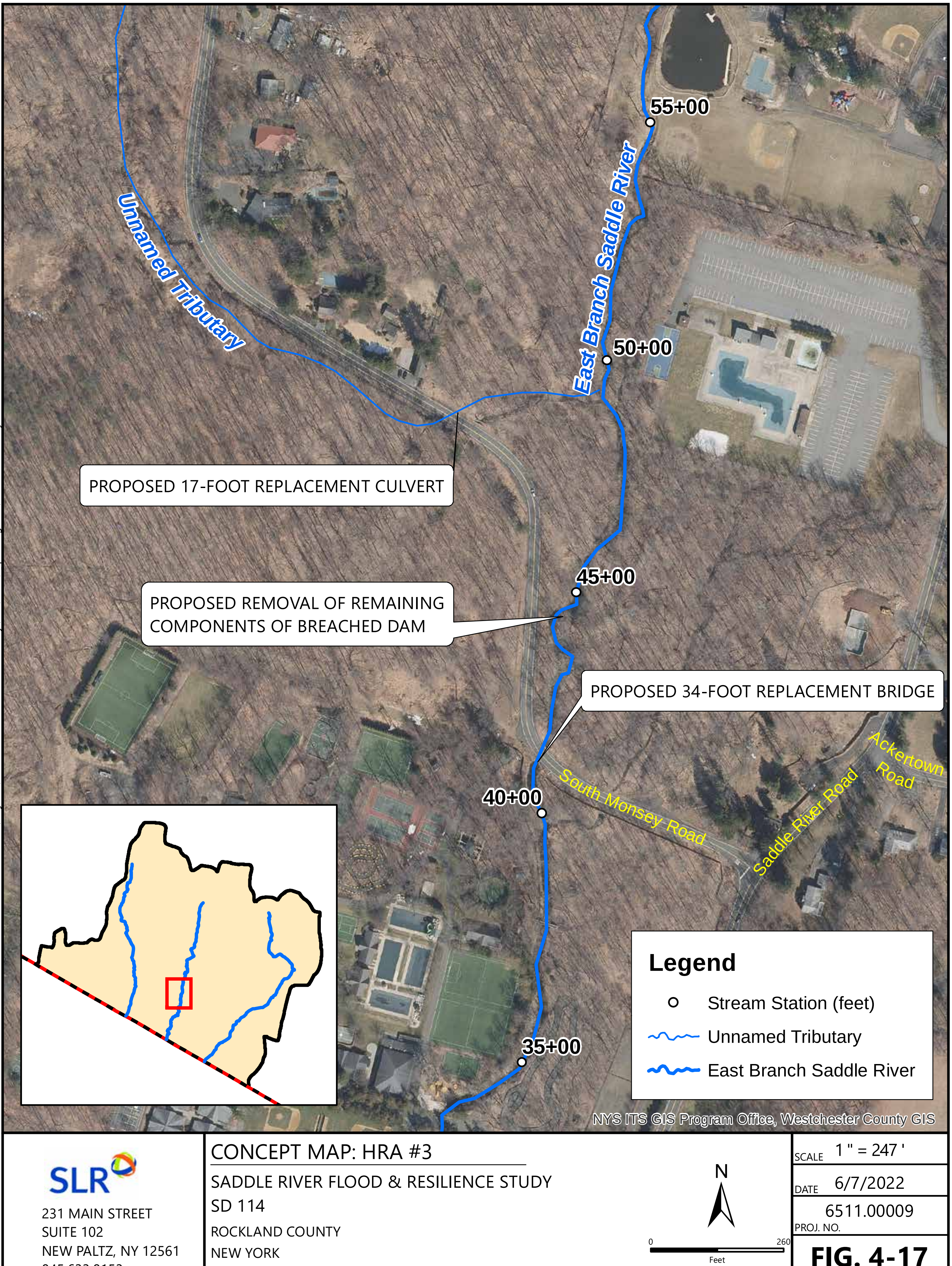

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CONCEPT MAP: HRA #3

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FIG. 4-17

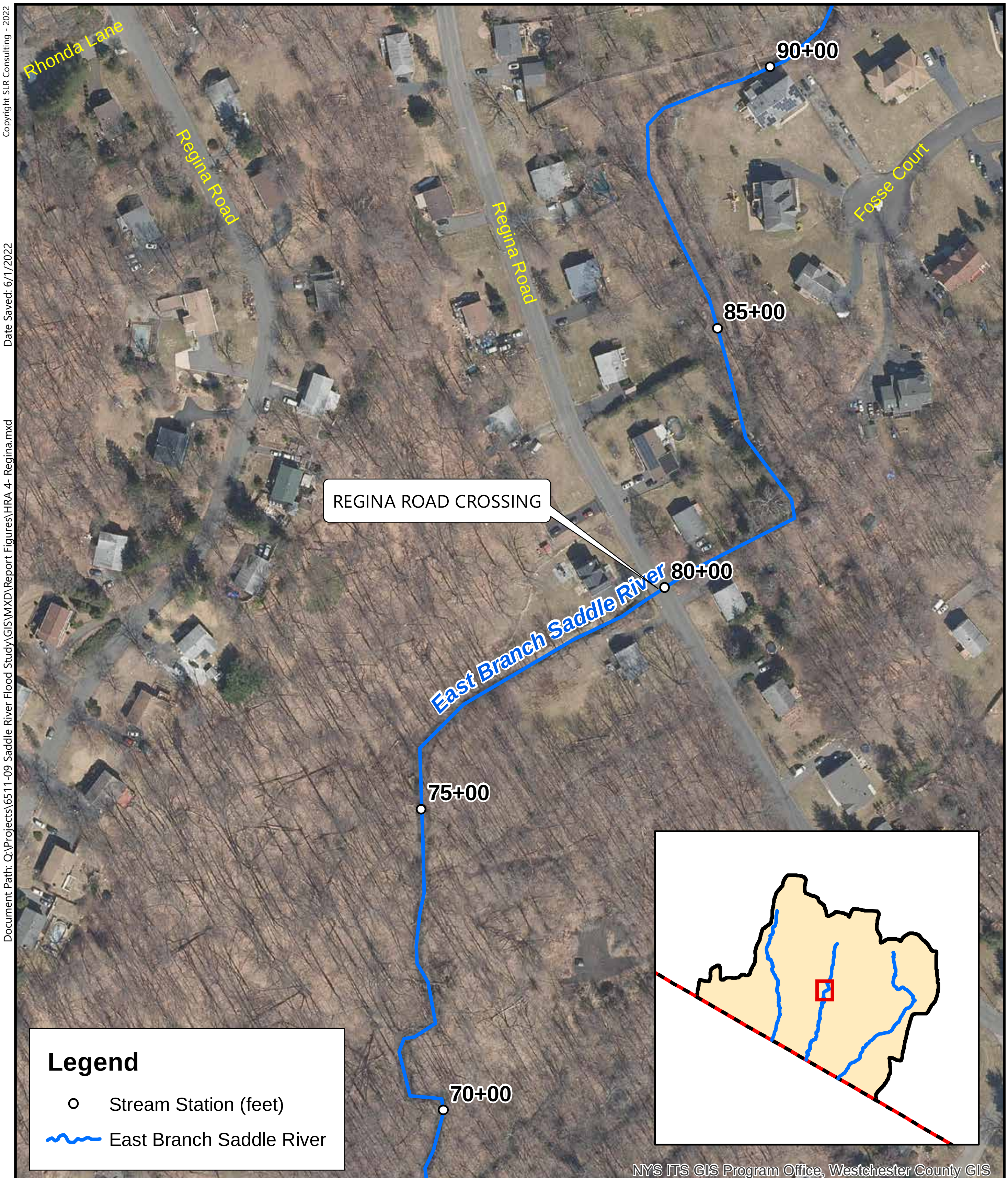
4.4 HIGH RISK AREA 4: EAST BRANCH SADDLE RIVER AT REGINA ROAD

HRA 4 is located on the East Branch Saddle River (STA 75+50 to STA 82+10) in the town of Airmont along Regina Road (Figure 4-18).

The Regina Road crossing of the East Branch Saddle River at STA 80+00 is a concrete box culvert with a span of 10 feet and a negative slope of -0.007 (Figure 4-19). An HY-8 analysis was used to evaluate the crossing. Peak flow data for the site is assumed to be the same as the nearest location listed in the FEMA FIS report (reproduced in Table 2-9), which is approximately 425 feet downstream of the crossing. The current culvert configuration has a capacity of 362 cfs, which results in overtopping of the road during a 10-year flood event with flows of 450 cfs. Peak flow data for higher frequency flood events are not included in the FIS report.

The NYSDEC recommends a stream bottom to improve aquatic organism passage rather than the closed bottom currently at the site. The slope should match the stream bed slope at about 2 percent. The current 100-year flow rate is estimated to be 620 cfs. A 10 percent increase in peak flows is expected over the next 100 years, resulting in design flow of 682 cfs.

The HY-8 analysis of a crossing with a 22-foot span, 3.4-foot rise, open bottom, and slope of 2 percent shows a capacity of 690 cfs, which passes the 100-year future flow without overtopping. When due for replacement, a detailed hydraulic and hydrologic analysis is recommended to properly size a replacement structure for the culvert under Regina Road and should include restoration of the upstream and downstream channel sections to correct for the break in slope.



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HIGH RISK AREA #4: REGINA ROAD

SADDLE RIVER FLOOD & RESILIENCE STUDY

SD 114

ROCKLAND COUNTY

NEW YORK

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SCALE	1 " = 185 '
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FIG. 4-18

Figure 4-19: Outlet of Regina Road crossing of East Branch Saddle River

A conceptual layout showing the recommendation described above for HRA 4 is depicted in Figure 4-20.

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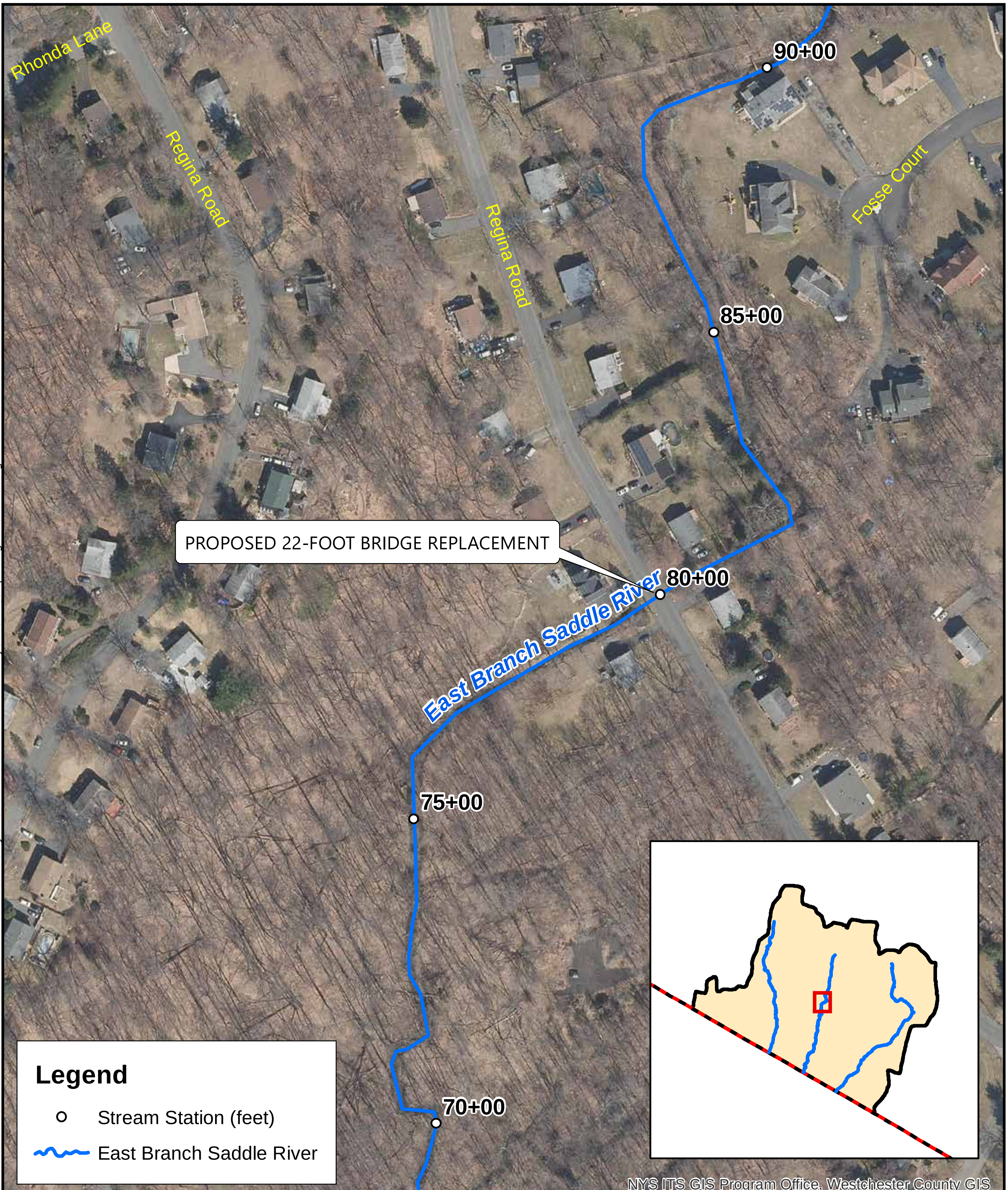

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CONCEPT MAP: HRA #4

SADDLE RIVER FLOOD & RESILIENCE STUDY
SD 114
ROCKLAND COUNTY
NEW YORK

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SCALE 1 " = 185 '
DATE 6/7/2022
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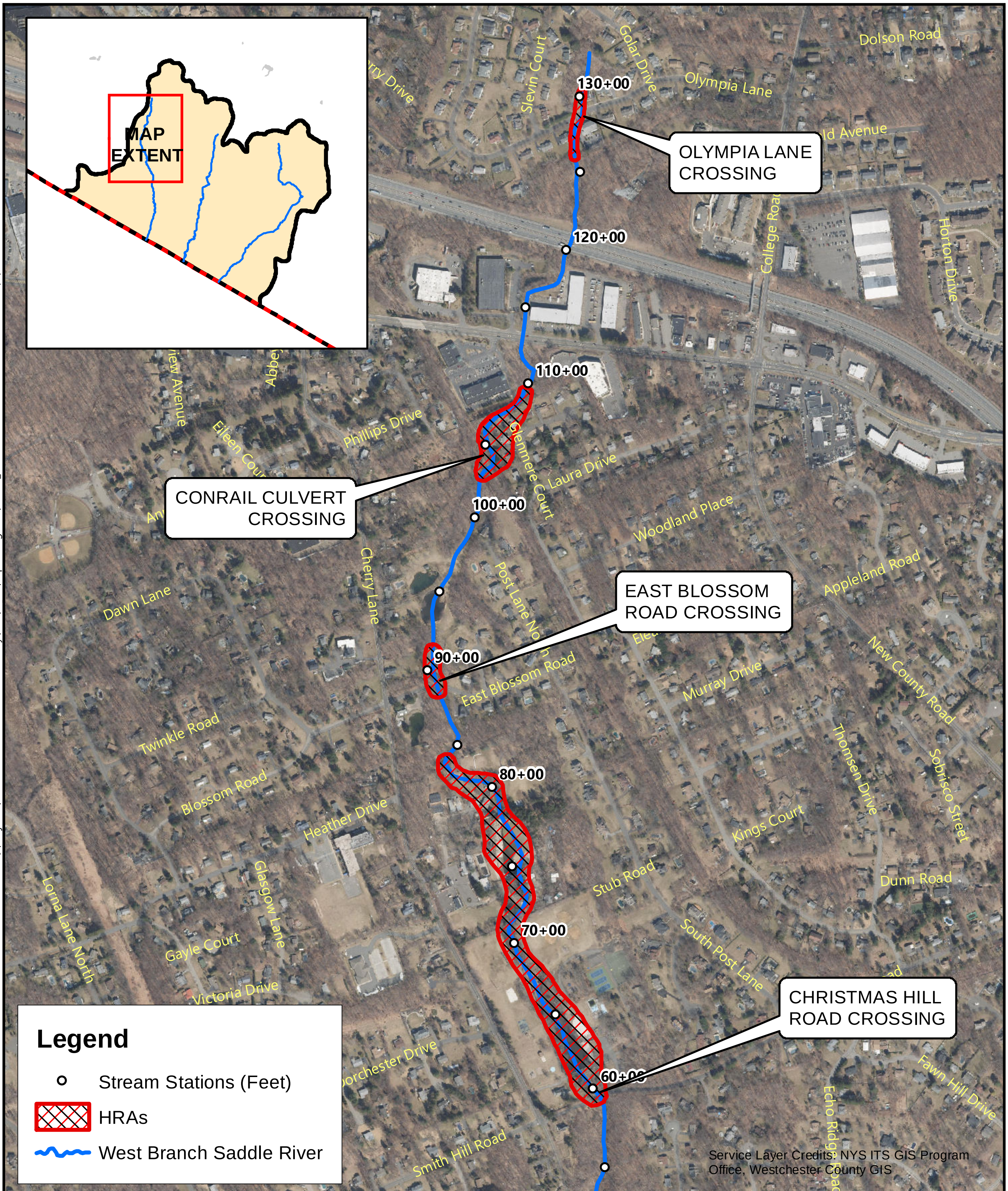
FIG. 4-20

4.5 HIGH RISK AREA 5: WEST BRANCH SADDLE RIVER

HRA 5 is located on West Branch Saddle River in the town of Ramapo and includes four stream crossings, located between STA 59+50 and 128+00 (Figure 4-21). This reach of the West Branch Saddle River passes through moderately developed residential areas, commercial development, and a forested area.

Hydraulic analysis was conducted using the most recent FEMA effective HEC-RAS hydraulic model to evaluate flood mitigation scenarios. Current and future flows were used in the analysis. Proposed replacement stream crossings were assessed based on the flood flows the structure would be expected to encounter over its design lifetime.

Listed downstream to upstream, stream crossings in HRA 5 include Christmas Hill Road (STA 59+50), East Blossom Road (STA 87+00), an abandoned railroad culvert structure (STA 104+00), and Olympia Lane (STA 128+00). Several dams and footbridges also span West Branch Saddle River within HRA 5.



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HIGH RISK AREA #5: WEST BRANCH SADDLE RIVER

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SD 114
ROCKLAND COUNTY
NEW YORK

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SCALE 1 " = 800 '
DATE 6/7/2022
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FIG. 4-21

4.5.1 CHRISTMAS HILL ROAD CROSSING

The downstream-most reach of West Branch Saddle River to be evaluated includes a crossing at Christmas Hill Road (STA 59+50) and an area upstream of the crossing (STA 59+50 to STA 89+50) that contains three dams and three footbridges. A map of the Christmas Hill Road crossing is depicted in Figure 4-22.

The stream crossing at Christmas Hill Road (ownership unknown) consists of a corrugated metal closed-bottom arch culvert with a span of 17 feet and a rise of 6.5 feet (Figure 4-23). The culvert currently passes up to the current 50-year flood event but overtops at the current 100-year and 500-year flood events. Based on modeling results, the structure is flanked by floodwaters at the current 50-year flood event at a low spot in the road to the right of the culvert (Figure 4-24). The culvert lacks the hydraulic capacity to pass the future 50-year, 100-year, or 500-year flood events. The structure's hydraulic performance is controlled by its outlet. While visiting the structure for a field assessment, it was noted that the floor of the culvert was severely deteriorated. The culvert outlet is perched, which presents a barrier to aquatic organism passage, and a scour pool was observed at the outlet, indicating high velocities through the culvert during high flow events.

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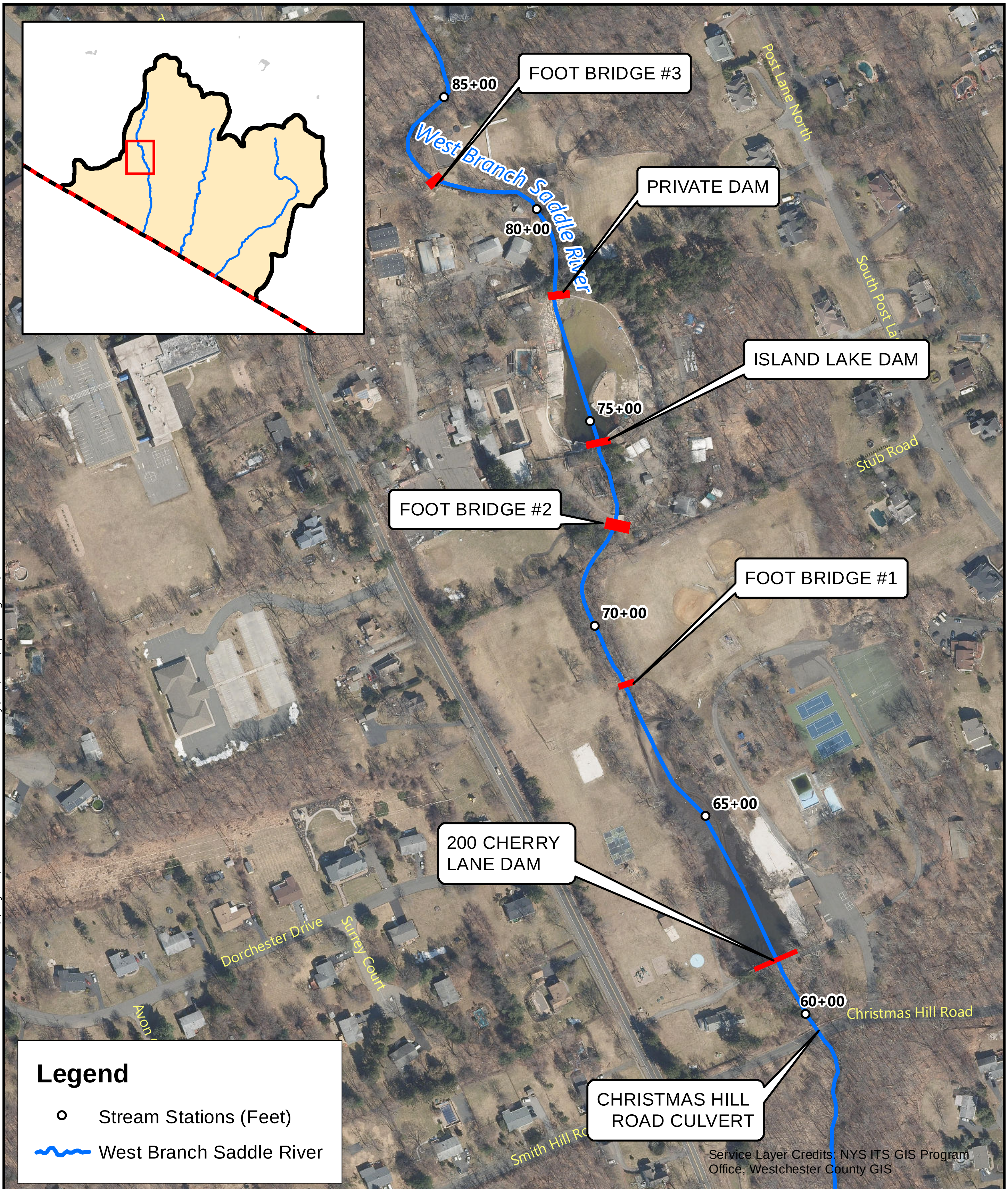

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HIGH RISK AREA #5: CHRISTMAS HILL ROAD

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SD 114
ROCKLAND COUNTY
NEW YORK

SCALE 1 " = 300 '
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FIG. 4-22

Figure 4-23: Looking upstream at the outlet of Christmas Hill Road culvert

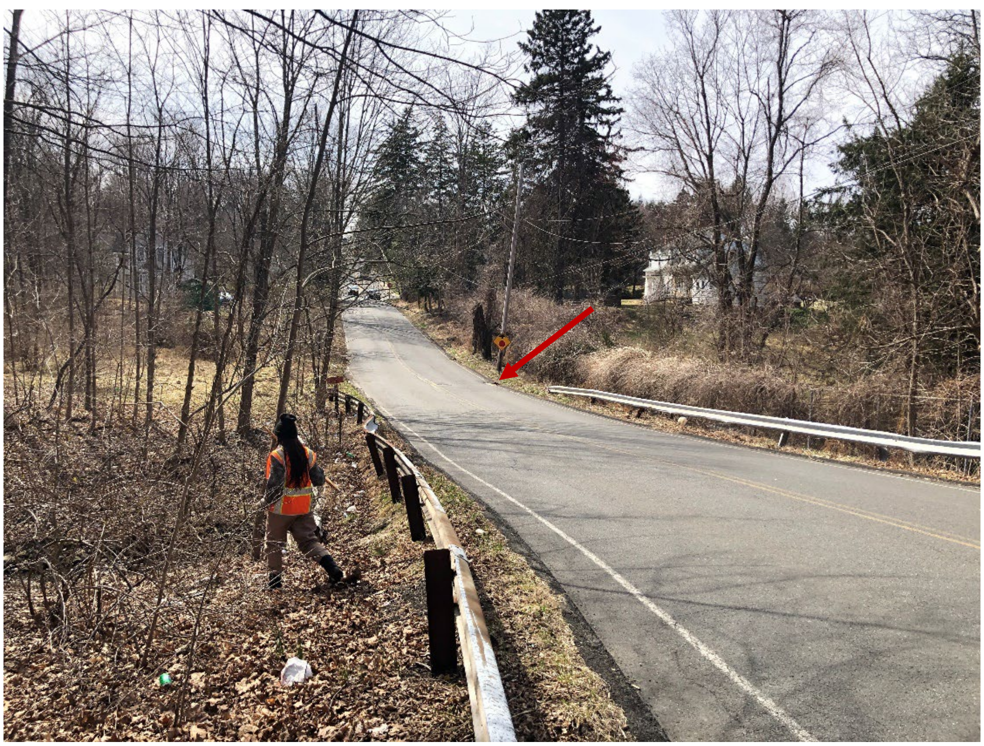

Figure 4-24: Low spot in Christmas Hill Road where culvert gets flanked

The hydraulic model was used to evaluate the Christmas Hill Road culvert if it were to be replaced with a new structure spanning 19 feet and a rise of 7 feet. Replacement of the Christmas Hill Road culvert with a single-barrel concrete box culvert of those dimensions lowers the current 50-year and the future 50-year flood event headwater depths by 0.7 and 0.6 feet, respectively. The structure overtops at the current 500-year and future 100-year flood event but can pass all other modeled flood events.

The area upstream of Christmas Hill Road and downstream of East Blossom Road (STA 60+00 to STA 89+50) is occupied by a camp and two schools. The two schools, located between STA 73+00 and STA 83+00, are partially inundated in all modeled flood events. Three inline dams, located at STA 62+00, 74+80, and 78+00, and three footbridges, located at STA 69+00, 73+00, and 83+00, span the West Branch Saddle River through this section. Each dam creates a backwater effect, and with the exception of the footbridge at STA 74+80, all the footbridges are overtopped by all modeled flood events. The footbridge at STA 74+80 passes the 10-year flood event with no freeboard and is overtopped by all other modeled flood events.

Two of the dams in this area are registered with the NYSDEC. One, located approximately 190 feet upstream of the Christmas Hill crossing at STA 62+00, is an earth and stone dam named 200 Cherry Lane Dam, owned by the Town of Ramapo. The structure is 12 feet in height and 180 feet in length. It is a low hazard dam, categorized as a hazard 'A' dam. Federal ID is 3942, and state ID is 196-5717. Its stated purpose is water supply. The backwater created by this dam extends for almost 650 feet upstream from the spillway. The hydraulic model was used to evaluate the flood depths if the 200 Cherry Lane Dam were to be removed from the West Branch Saddle River. Based on modeling results, water surface elevations in the area would be reduced by 5 feet in the 10-year flood event and 4.8 feet in the 100-year flood event.

The second NYSDEC registered dam, located at STA 74+60, is a privately owned earthen dam named Island Lake Dam. It has a height of 10 feet and a hazard classification of 'A', a low hazard dam. Federal ID is 4831, and state ID is 196-0968. It currently is used for recreational purposes. It has two spillways: a stop log sluice and a concrete overflow. The backwater from this structure extends for 220 feet upstream from the spillway. The hydraulic model was used to evaluate the flood depths if Island Lake Dam were to be removed from the West Branch Saddle River. When measured at the upstream end of the dam, water surface elevations would be reduced by 5.8 feet in the 10-year flood event and by 5 feet in the 100-year flood event.

The third dam located within this area, at STA 78+00, is not registered with the NYSDEC. It is included in the hydraulic model as an inline structure that spans the active channel. It has a height of 8 feet and an embankment length of 18 feet. The backwater created from this inline structure extends for 320 feet upstream from the spillway. The hydraulic model was used to evaluate the flood reduction if the dam located at STA 78+00 were to be removed from the West Branch Saddle River. When measured at the upstream end of the dam, water surface elevations would be reduced by 1.7 feet in the 10-year flood event and by 2.0 feet in the 100-year flood event.

It is recommended to replace the Christmas Hill Road culvert and entirely removing the three dams. Replacing the Christmas Hill Road crossing with a structure containing a minimum span of 19 feet and a minimum rise of 7 feet would adequately prevent the road from overtopping during modeled storm events. In addition, removing the three dams from the stream will reduce flood depths and eliminate inundation of multiple structures during the 100-year flood event. If the dams are removed, the immediate river reach upstream should be restored to more natural conditions as well. According to regional regression equations, the bankfull width in this section of the West Branch Saddle River is 24.5 feet and the bankfull depth is 1.7 feet. It is advised to implement this channel geometry while restoring the channel.

The three footbridges are hydraulically undersized. The footbridge at STA 74+80 passes the 10-year flood event with no freeboard and is overtopped by all other modeled flood events. The other footbridges are overtopped by all modeled flood events. It is recommended that the footbridges be permanently removed or that they be replaced by adequately sized crossings. If the footbridges are to be replaced, a detailed hydraulic and hydrologic analysis should be conducted to properly size a replacement structure.

The improvements described above are depicted in concept in Figure 4-25. Figure 4-26 depicts the extent of flooding during the current and future 50-year flood event under existing conditions. Figure 4-27 depicts the extent of flooding during the current and future 50-year flood event if the Christmas Hill Road culvert were to be replaced and the three footbridges and three dams were to be removed (proposed conditions).

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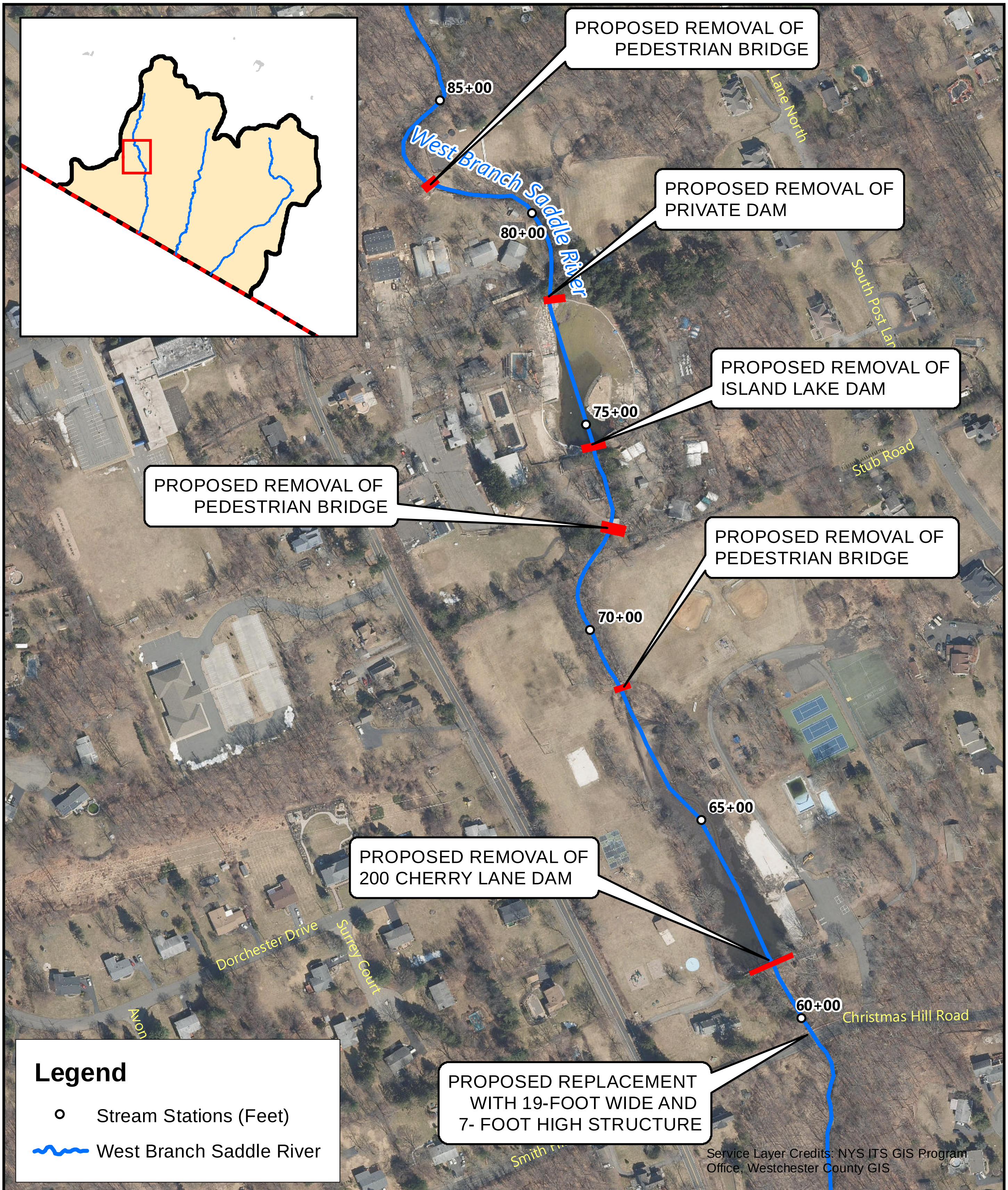

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CONCEPT MAP: CHRISTMAS HILL ROAD

SADDLE RIVER FLOOD & RESILIENCE STUDY
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ROCKLAND COUNTY
NEW YORK

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FIG. 4-25

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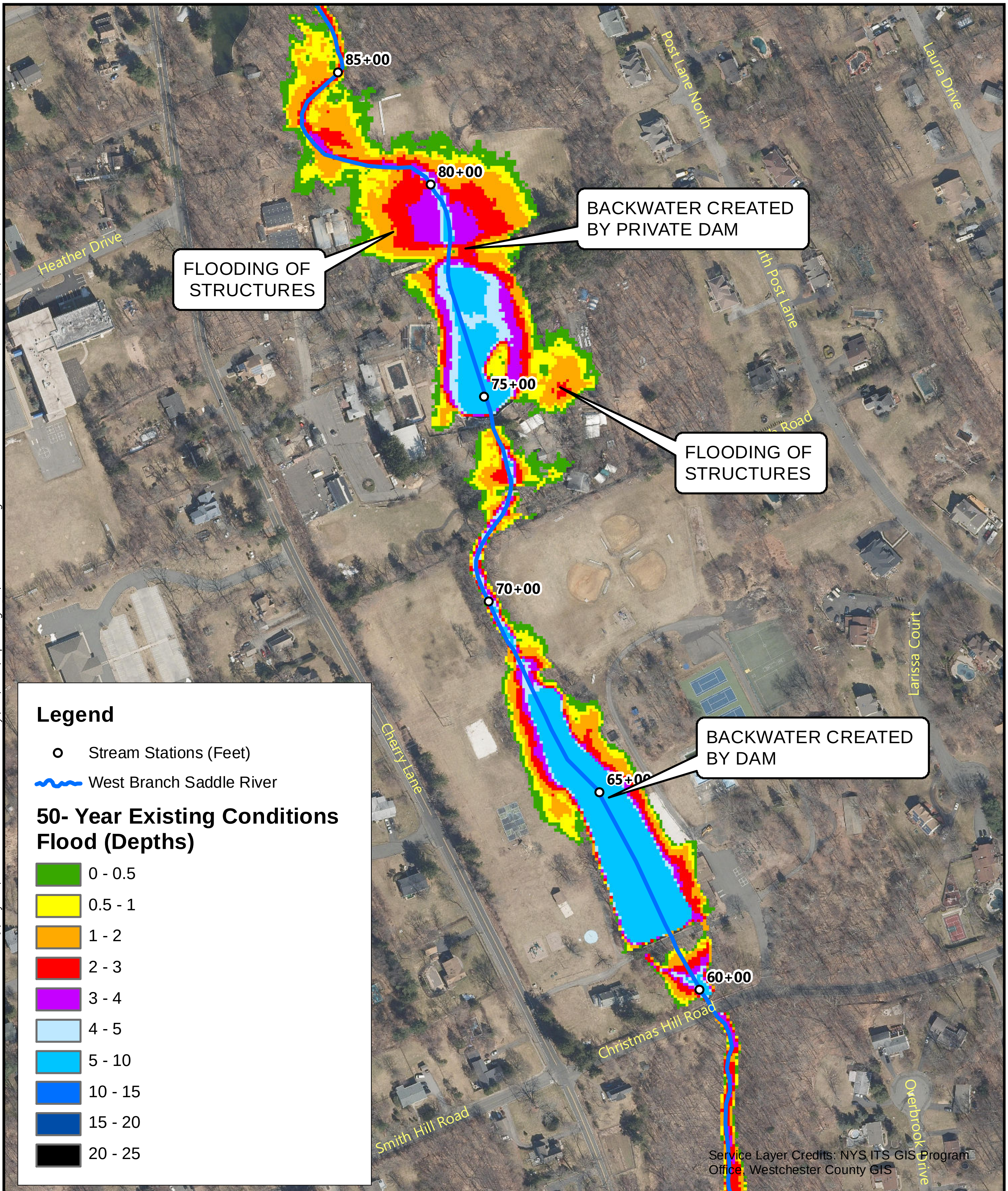

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CHRISTMAS HILL RD: 50-YEAR EXISTING CONDITIONS

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FIG. 4-26

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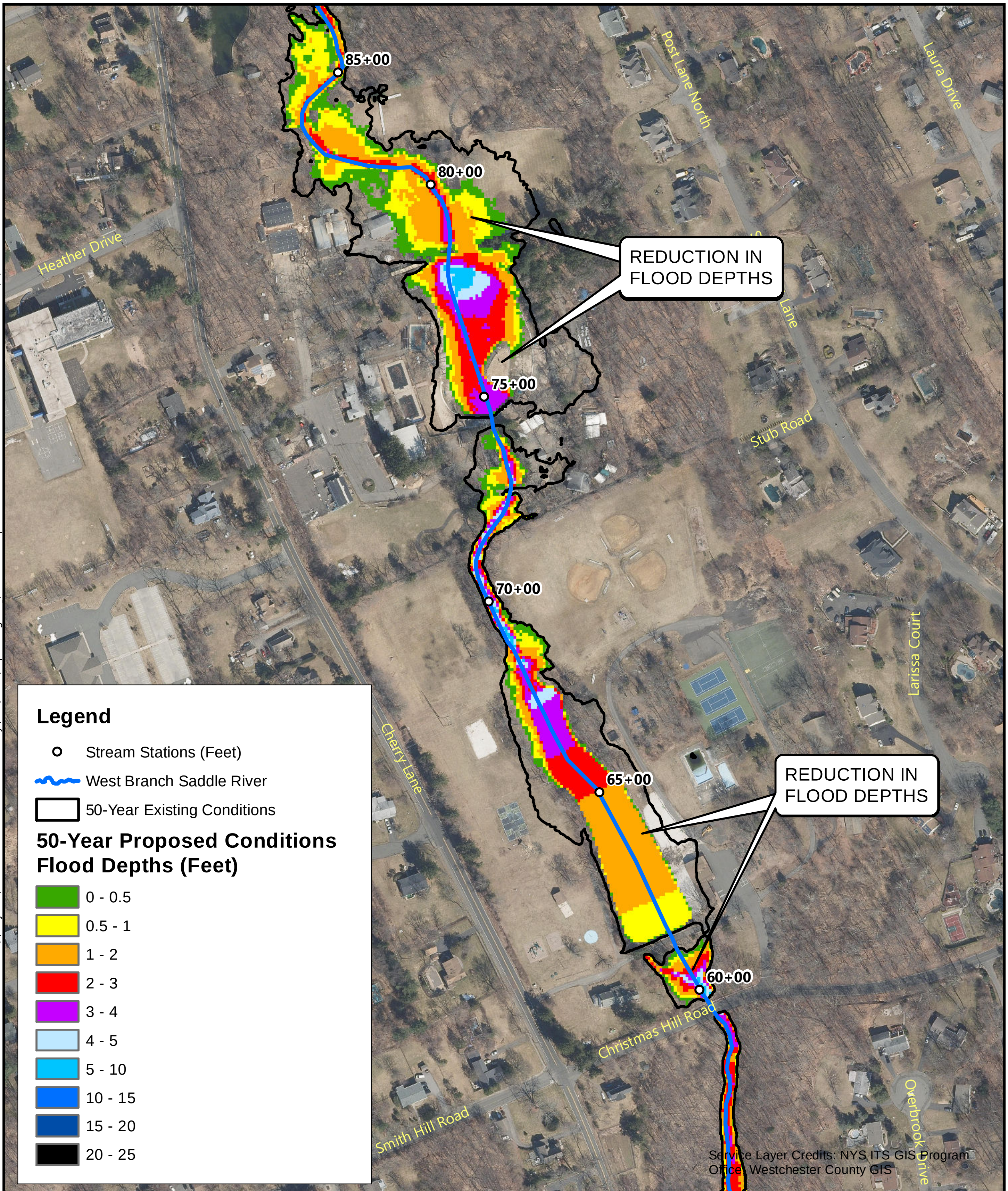

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CHRISTMAS HILL ROAD: 50-YEAR PROPOSED CONDITIONS
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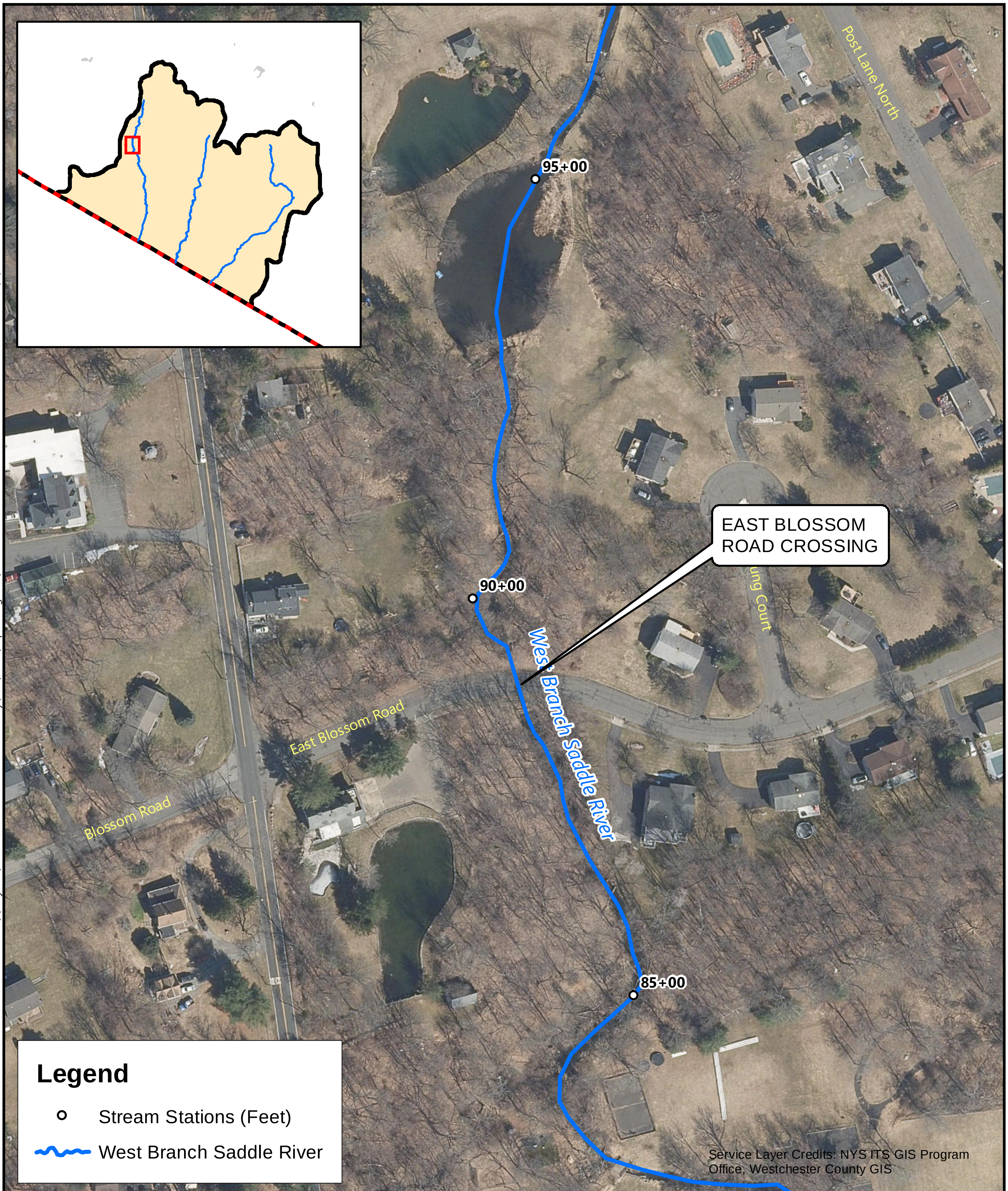
FIG. 4-27

4.5.2 EAST BLOSSOM ROAD CROSSING

The stream crossing at East Blossom Road (STA 88+80), ownership unknown, consists of two corrugated metal arch culverts (Figure 4-29). The left culvert has a height of 3.55 feet and a width of 5.5 feet. The right culvert has a height of 3.1 feet and a width of 5.5 feet. Both culverts are likely supposed to be identical and have a height of 4.0 feet, but deposition of fine sediment at the inlet has created some discrepancies in height. Upon inspection in the field, the right culvert appears to be bowing at the center underneath the road and may have started to collapse (Figure 4-30). Based on hydraulic modeling results, the twin culverts are capable of passing the current 10-year flood event but overtop at the 50-, 100-, and 500-year flood events. The culverts cannot pass any of the modeled future flood events. A map of the East Blossom Road crossing is depicted in Figure 4-28.



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HIGH RISK AREA #5: EAST BLOSSOM ROAD

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FIG. 4-28

Figure 4-29: Looking downstream at the inlet of East Blossom Road culverts

Figure 4-30: Looking downstream at the inside of the river-right culvert. The collapse in the center of the culvert is indicated by the red arrow.

The hydraulic model was used to evaluate the East Blossom Road culvert if it were to be replaced with a new structure spanning 12 feet with a rise of 5 feet and elevated by 1 foot. Slope was also adjusted to be shallower and mimic the natural slope of the stream (from 0.85 percent to 0.6 percent). Replacement of the East Blossom Road crossing with a single-barrel concrete box culvert of those dimensions lowers the current 50-year and the future 50-year flood event headwater depths by 3.5 feet and 1.0 feet, respectively, as depicted in longitudinal profile in Figure 4-32. The replacement crossing would pass all modeled current and future flow events, excluding the 500-year flood event.

In addition to replacement of the structure, any sediment blockage would have to be removed and the structure maintained to ensure that flows are not blocked by debris. According to the NYSDEC, crossings that are susceptible to be clogged or partially clogged, especially undersized ones, can intensify the effect of floods. Costly maintenance is often required as well. A structure that is adequately sized to promote stream continuity will be less likely to be clogged by debris.

The improvements described above are depicted in concept in Figure 4-31.

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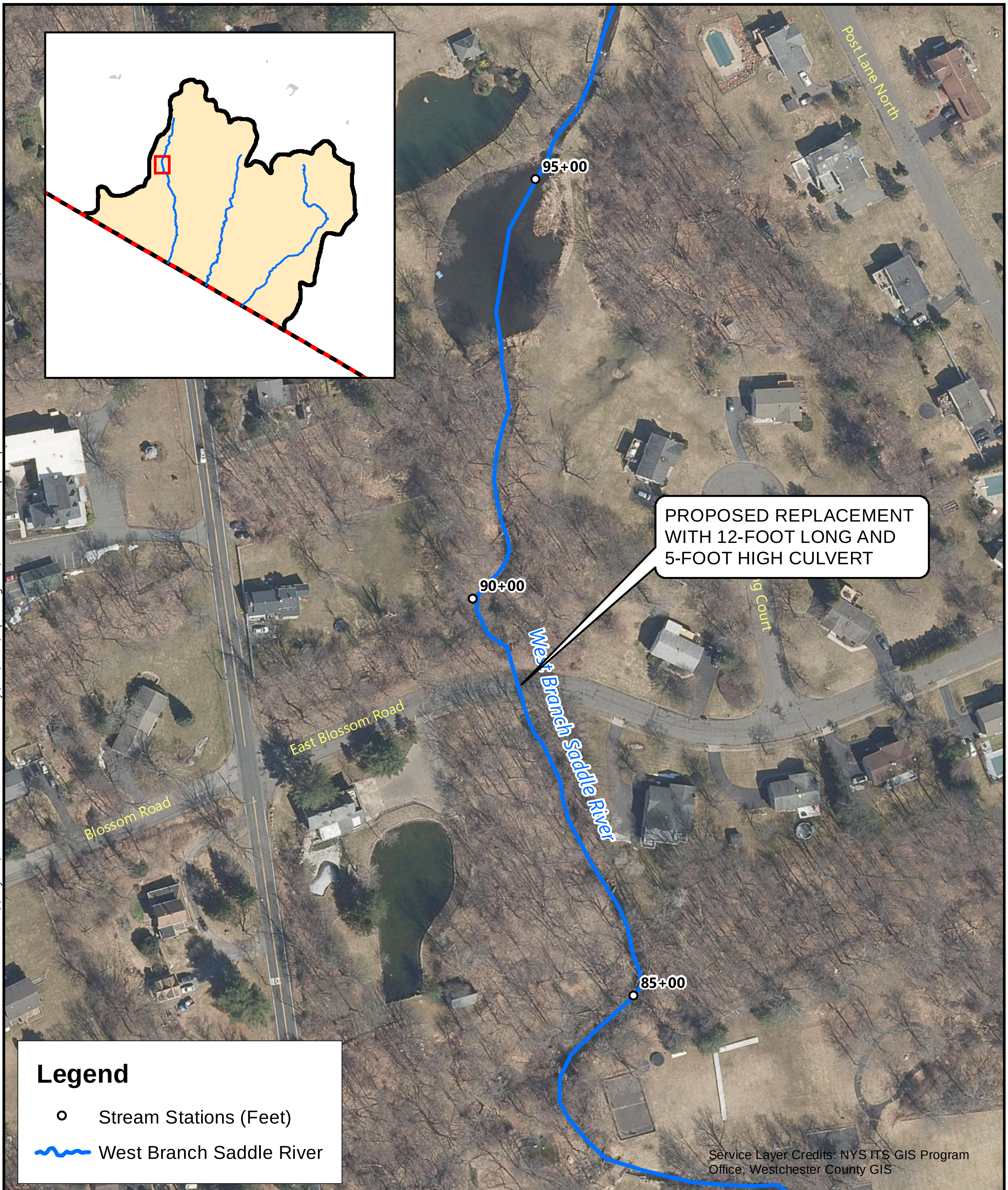


SLR 231 MAIN STREET SUITE 102 NEW PALTZ, NY 12561 845.633.8153	CONCEPT MAP: EAST BLOSSOM ROAD SADDLE RIVER FLOOD & RESILIENCE STUDY SD 114 ROCKLAND COUNTY NEW YORK	N 0 150 Feet	SCALE 1 " = 150 ' DATE 6/7/2022 16511.00009 PROJ. NO. **FIG. 4-31**

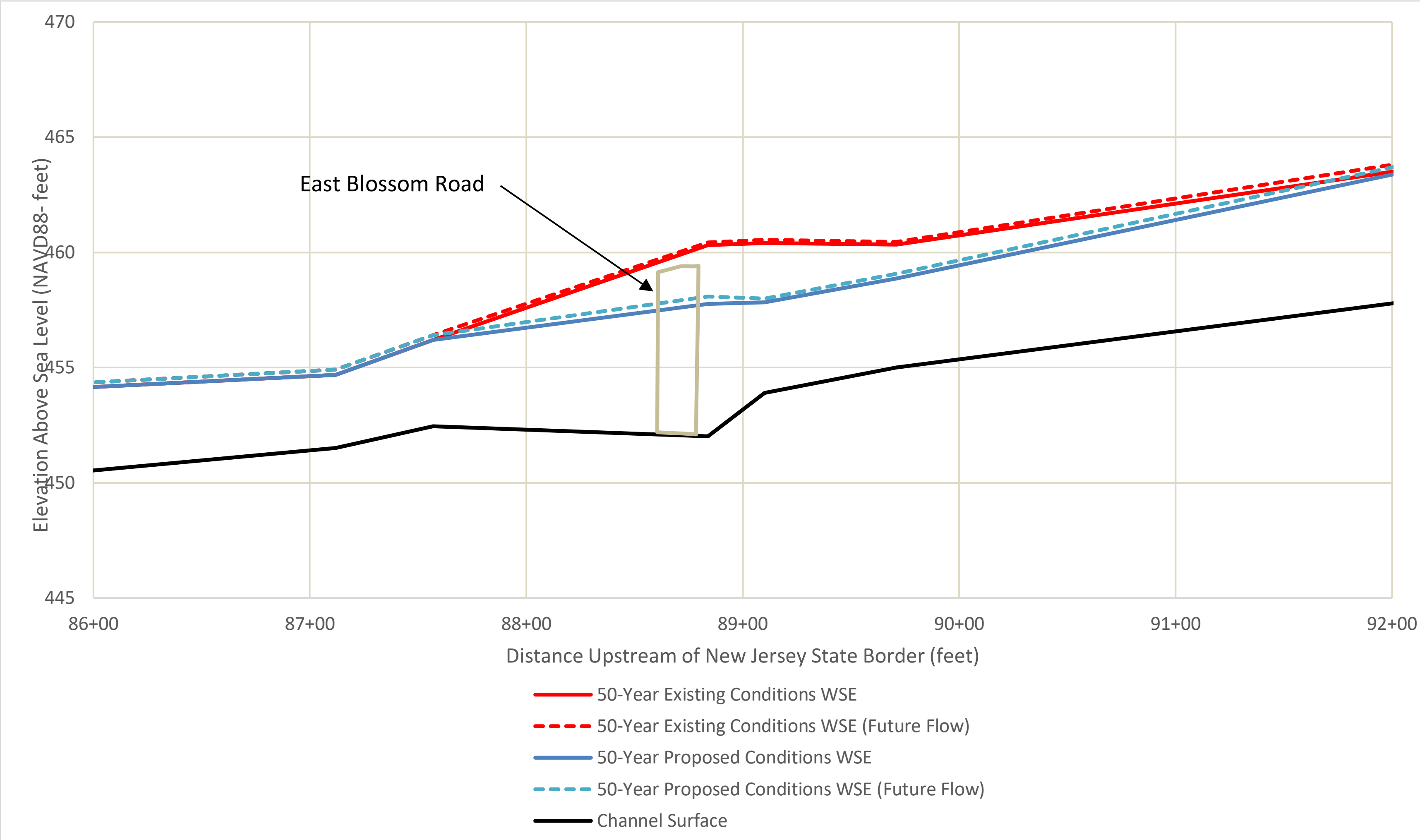
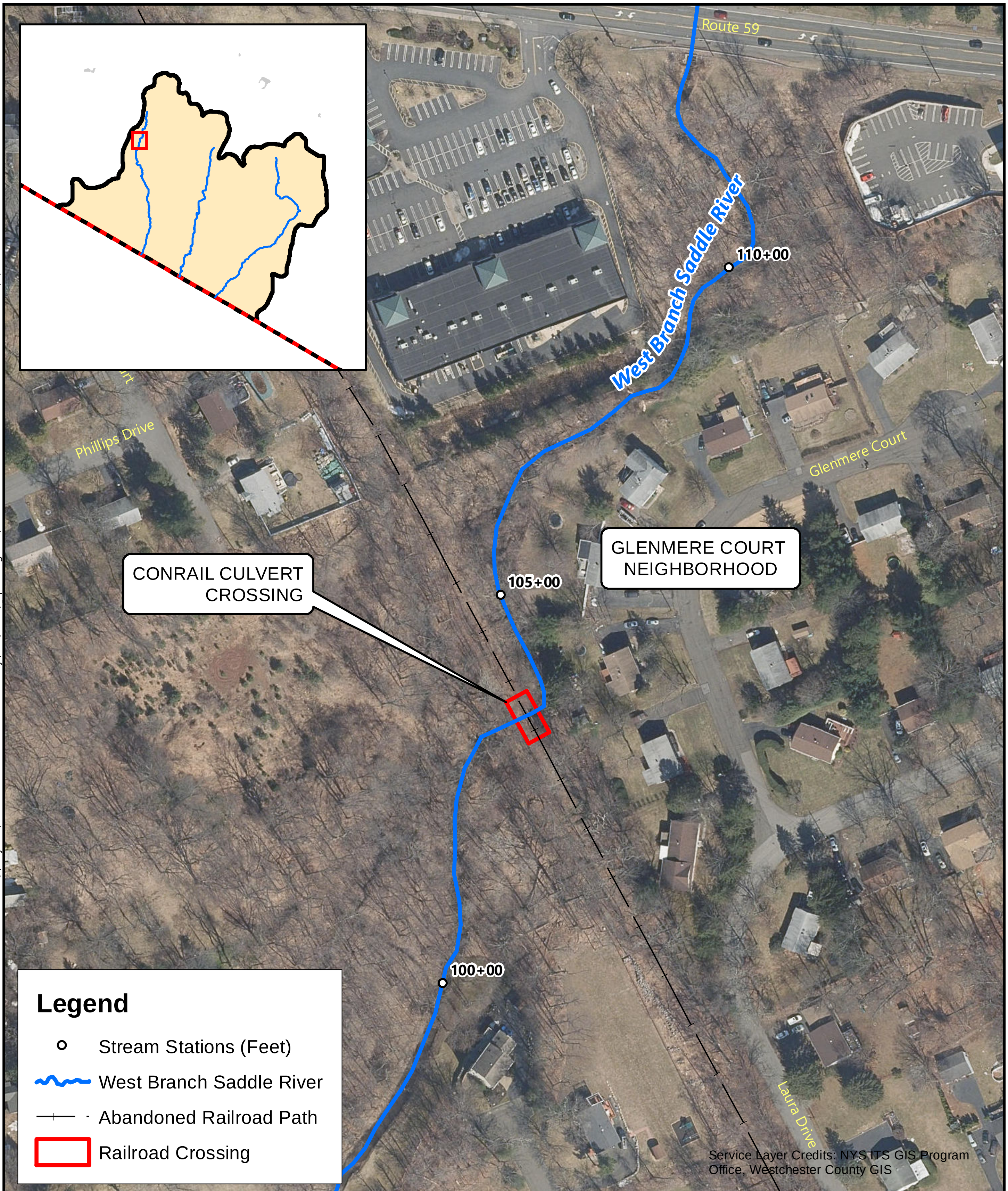


Figure 4-32: Reach Profile for 50-Year Flows Under Current Conditions and Proposed Conditions in HRA 5.2 (East Blossom Road)

4.5.3 ABANDONED RAILROAD CROSSING

The stream crossing at the Conrail railroad tracks is located at STA 104+00 and consists of a concrete arch culvert approximately 7.6 feet high and 6 feet wide (Figure 4-34). The culvert has a rectangular curb at the bottom right of the arch that is approximately 1.5 feet high. The West Branch Saddle River enters the inlet at a near 90-degree bend. The drainage area at this location is 0.65 square miles. The West Branch Saddle River flows through a moderately developed area in this reach and is sandwiched between properties on Glenmere Court on its river left, with a plaza and an abandoned railroad embankment on its river right. While the neighborhood is not shown to be in the FEMA Special Flood Hazard 100-year or 500-year floodplain, it was noted in the Rockland County Hazard Mitigation Plan that the area is prone to flooding. A map of the railroad crossing is depicted in Figure 4-33.



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HIGH RISK AREA #5: RAILROAD CROSSING

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FIG. 4-33

Figure 4-34: Looking downstream at the inlet of the Conrail bridge structure

Hydraulic modeling shows that the railroad structure can pass all modeled flood events but creates a backwater effect that extends over 300 feet upstream of the culvert inlet, with flood depths at the 10-year flood event ranging from 6 feet at the inlet to 3 feet near the upstream end of the backwater. The structure is controlled by its inlet, which means the culvert is capable of carrying more flow than the inlet will accept. The combination of the skewed inlet and the perched inlet caused by the rectangular curb, along with the undersized inlet, contributes to the inlet control demonstrated in this crossing.

While conducting a field inspection, woody debris was noted to be partially obstructing the inlet (Figure 4-35). Additional debris, both woody and anthropogenic, was noted along the stream upstream of the inlet. According to the NYSDEC, crossings that are susceptible to be clogged or partially clogged, especially undersized ones, can intensify the effect of floods. When the structure is modeled with an inlet 25 percent clogged by debris to represent conditions observed in the field, flood extents expand during all modeled flood events. Multiple houses adjacent to the West Branch Saddle River on river left become inundated during the current 50- and 100-year flood events.

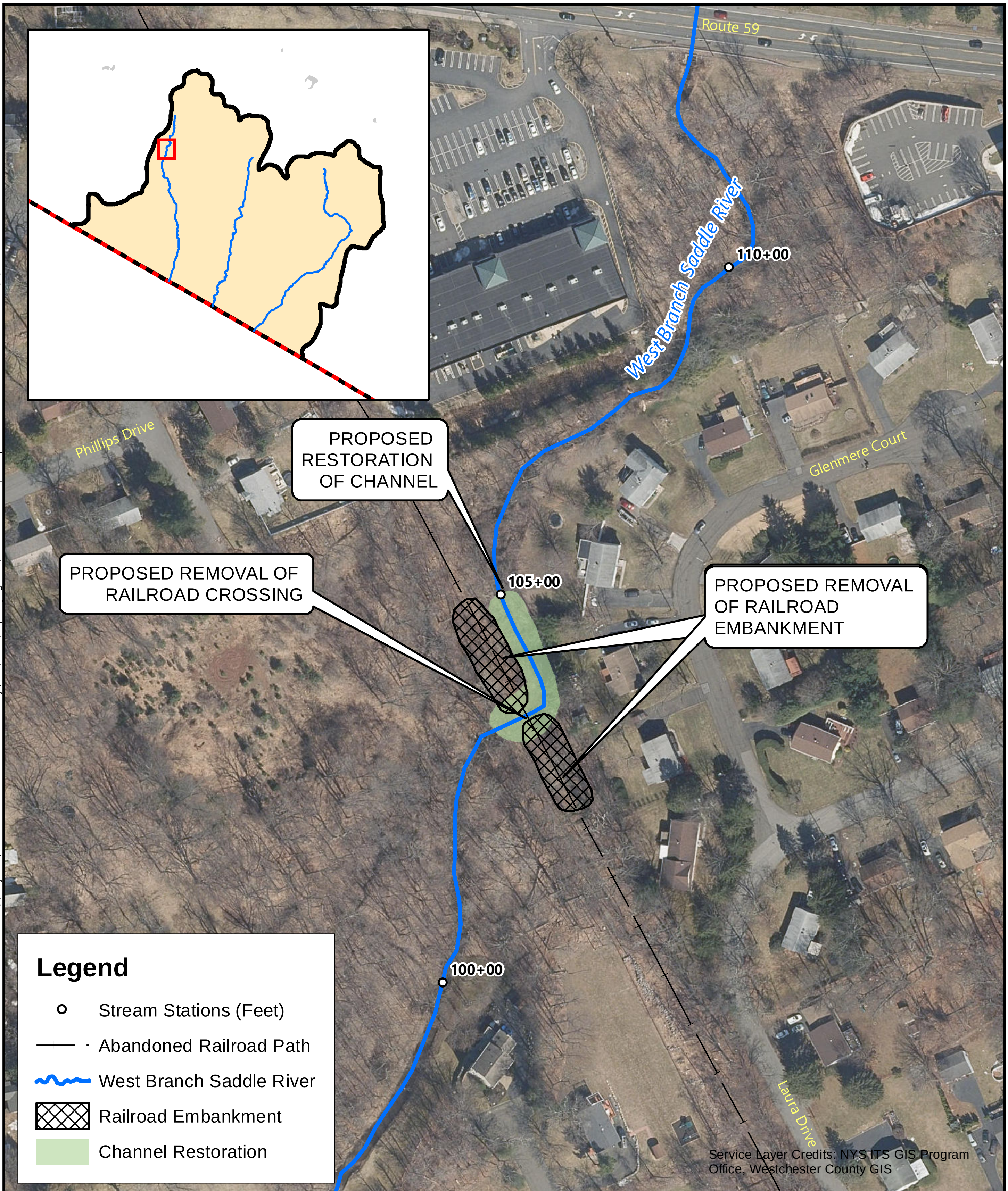
Figure 4-35: Looking at woody debris partially obstructing Conrail structure inlet

Upon research and visual inspection in the field, the railroad line that passes over the West Branch Saddle River at this location is determined to be abandoned. Therefore, rather than replacing the structure, it is recommended to remove the crossing completely and restore the channel. Hydraulic modeling shows that the backwater effect is eliminated, and flood depths decrease by 3 feet when the railroad structure is removed.

Restoring the channel would include removing the culvert along with the railroad tracks and its embankment and realigning the channel as well as creation 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. According to regional regressions, the bankfull width of the West Branch Saddle River at the inlet of the railroad crossing is 21 feet and the bankfull depth is 1.5 feet. It is recommended to implement those measurements while restoring the channel. Channel restoration work should extend to at least STA 105+00.

If a pedestrian bridge is needed within this reach, it is recommended that the bridge has a span of at least 26 feet, which is 1.25 times the bankfull width (21 feet). According to the NYSDEC, an inlet should be at least 1.25 times the width of the stream channel bed. The width is measured bank to bank at the ordinary high-water level or edges of terrestrial, rooted vegetation. According to *Design of Road Culverts for Fish Passage* by the Washington Department of Fish and Wildlife, which is cited as a reference on the NYSDEC "Stream Crossing" webpage, ordinary high-water marks are less related to physical channel processes than the bankfull width and are therefore less relevant to culvert design. The most reliable parameter for bed width in alluvial channels is the distance between channel bankfull elevations, so it is suggested to use bankfull width noted above in determining an adequate span for the pedestrian bridge. However, a complete detailed hydraulic and hydrologic analysis to properly size a replacement structure is always preferred.

The improvements described above are depicted in concept in Figure 4-36. Figure 4-37 depicts the extent of flooding during the current and future 100-year flood event under existing conditions. Figure 4-38 depicts the extent of flooding during the current and future 100-year flood event under existing conditions with the inlet 25 percent blocked by debris. Figure 4-39 depicts the extent of flooding during the current and future 100-year flood event if the Conrail railroad structure were to be removed (proposed conditions).



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CONCEPT MAP: RAILROAD CROSSING

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FIG. 4-36

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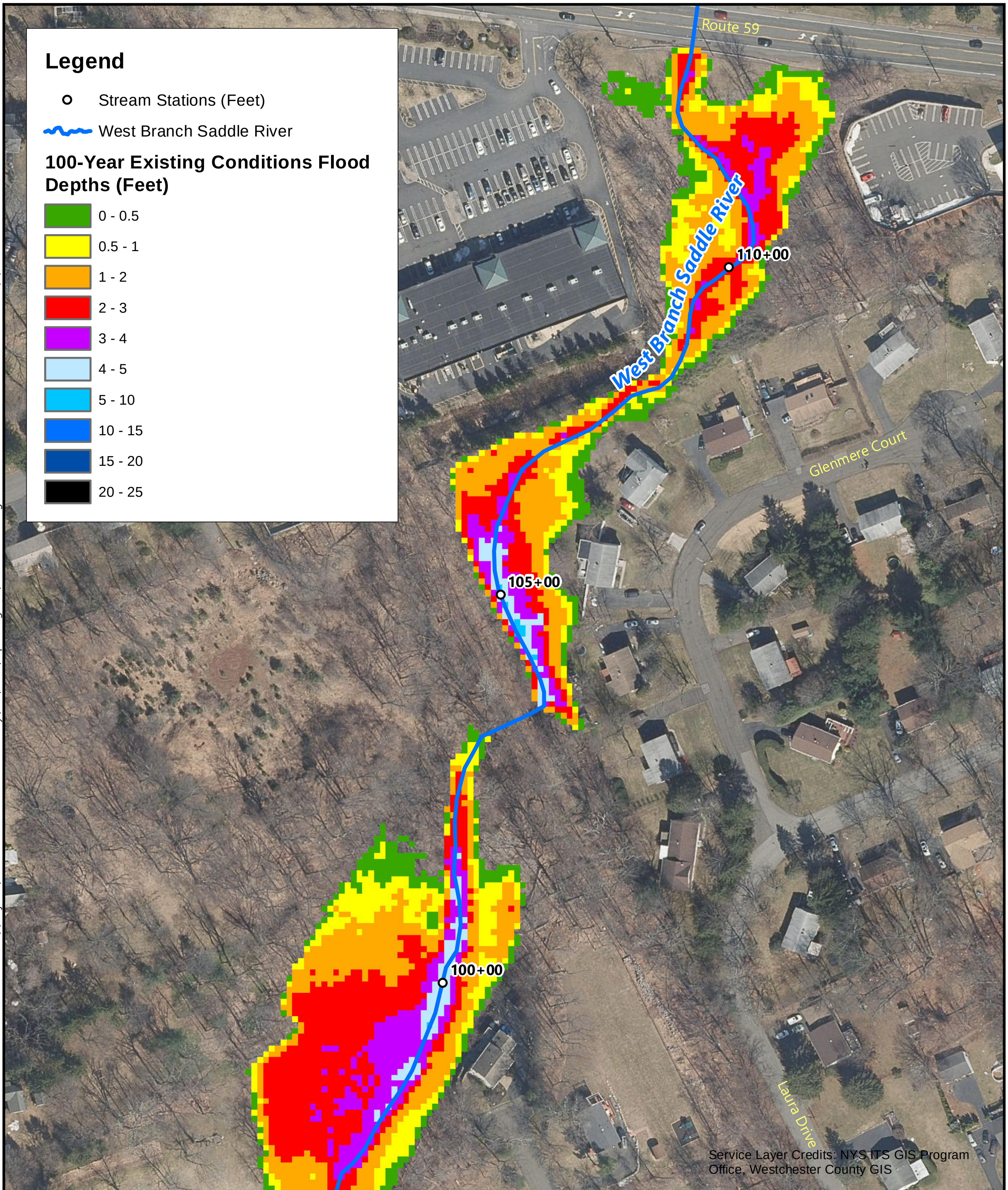

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RAILROAD CROSSING: 100-YR EXISTING CONDITIONS

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FIG. 4-37

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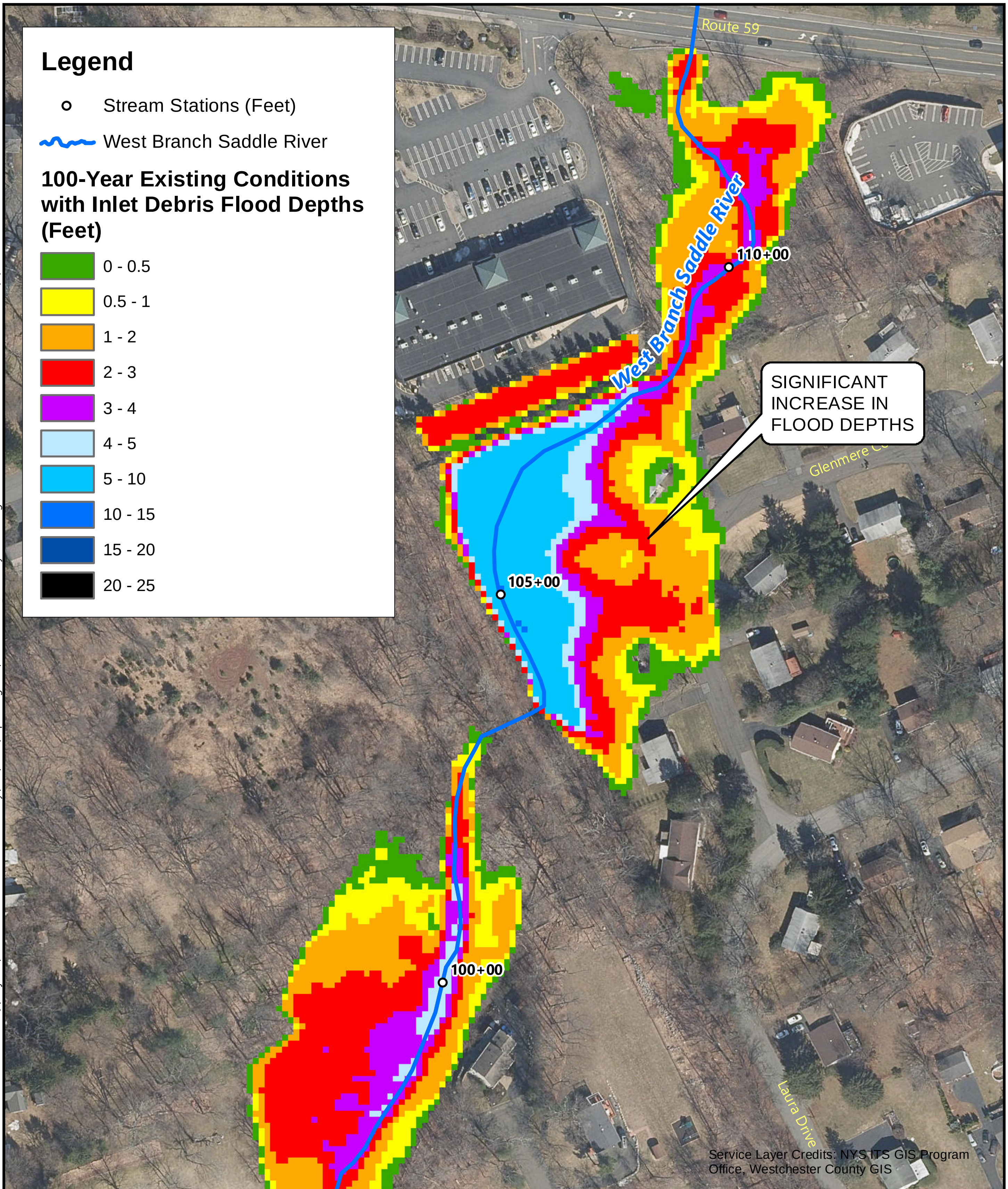

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RAILROAD CROSSING: 100-YR EXISTING CONDITIONS WITH DEBRIS
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FIG. 4-38

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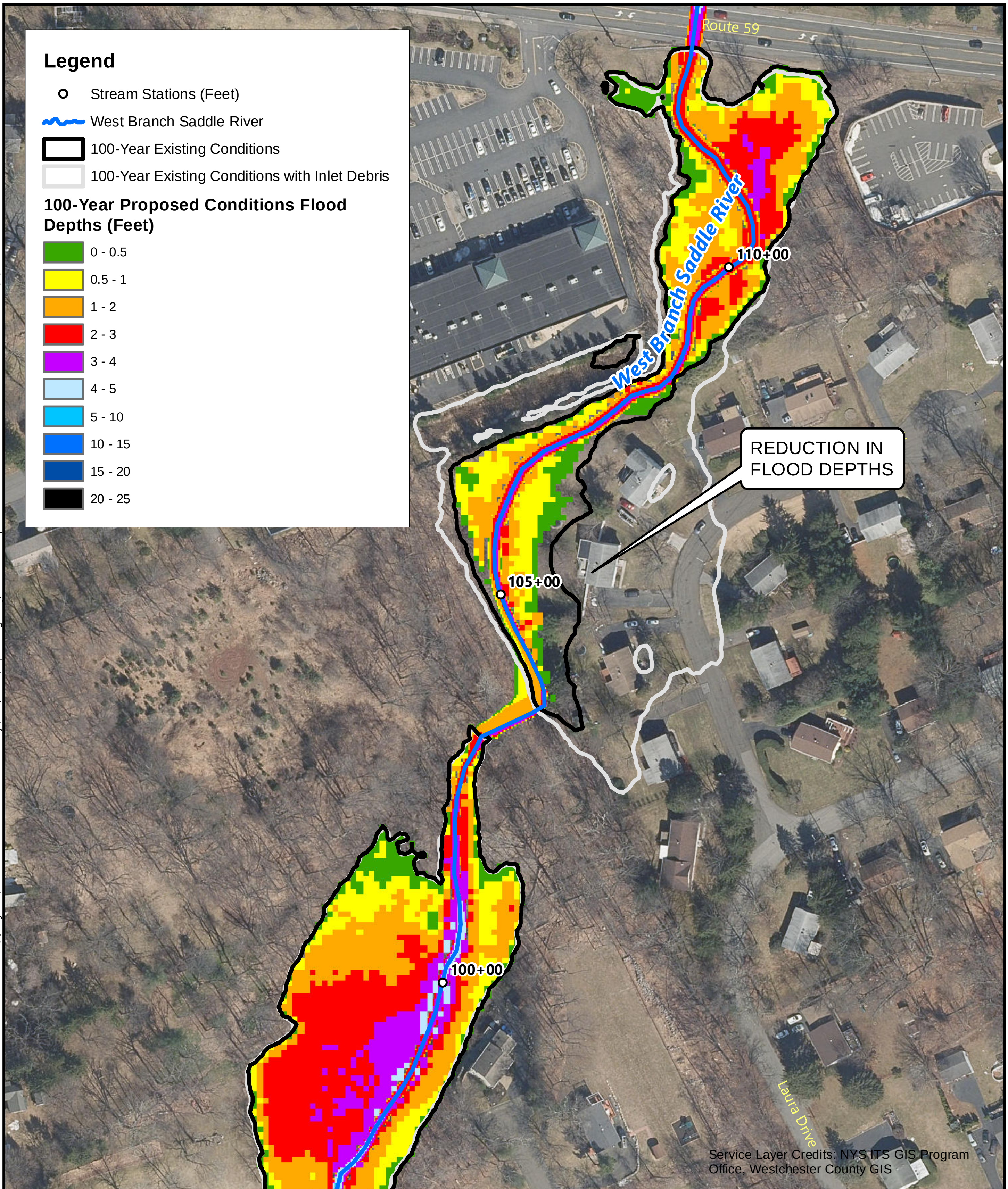

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RAILROAD CROSSING: 100-YEAR PROPOSED CONDITIONS

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FIG. 4-39

4.5.4 OLYMPIA LANE CROSSING

The most upstream stream crossing in HRA 5 is at Olympia Lane (Figure 4-41). This crossing (STA 129+25), ownership unknown, is within the headwaters of the West Branch Saddle River watershed, which is located within the hamlet of Viola. The West Branch Saddle River flows through a residential neighborhood in this section. The Olympia Lane crossing consists of a 6-foot circular concrete pipe and has a length of approximately 280 feet. The pipe bends approximately 30 degrees underground (Figure 4-42). The structure is capable of passing the 10-year flow event but overtops at the 50-year, 100-year, and 500-year flood events. A map of the Olympia Lane crossing is depicted in Figure 4-40.

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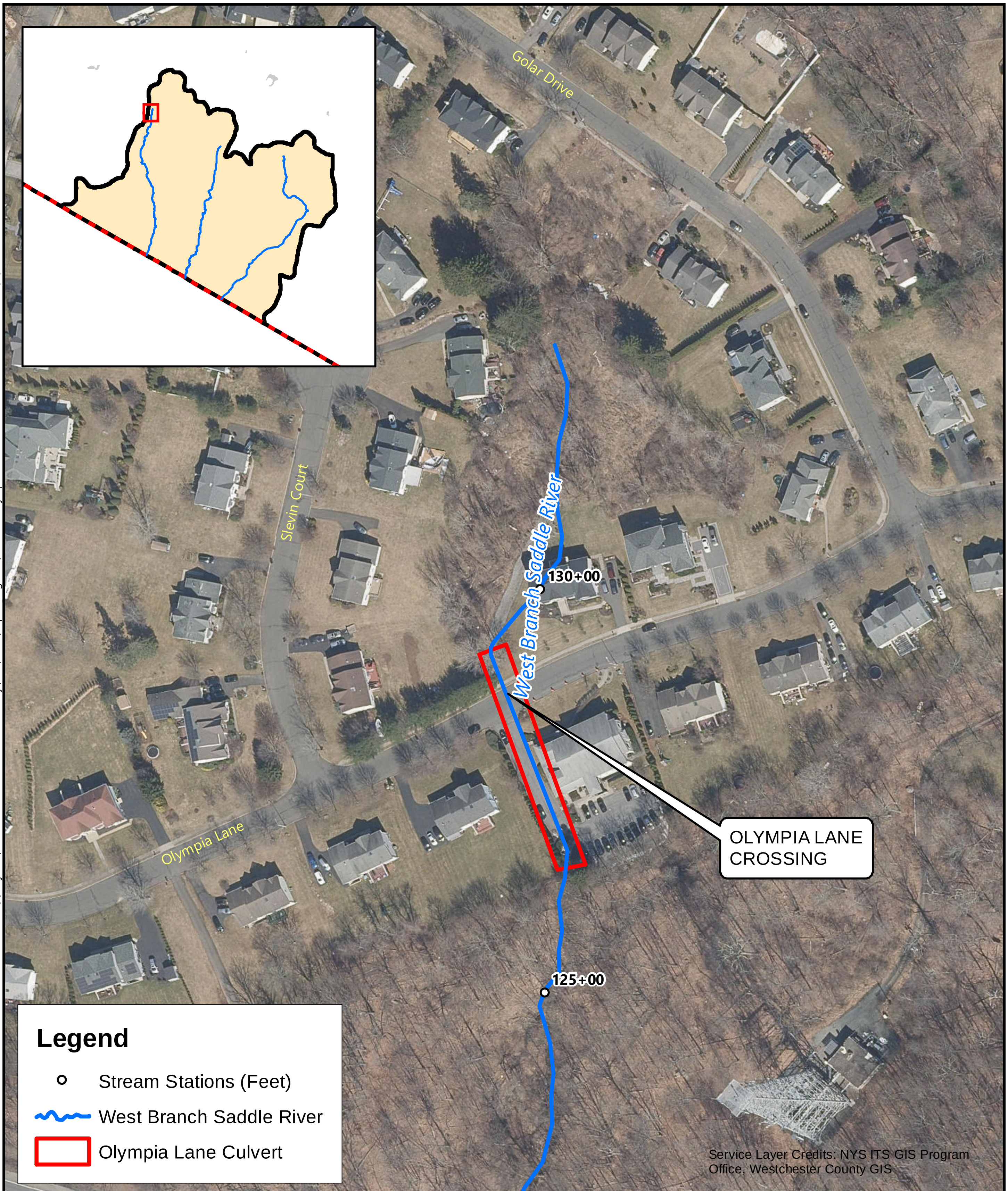

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HIGH RISK AREA #5: OLYMPIA LANE

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FIG. 4-40

Figure 4-41: Looking downstream at the inlet of the Olympia Lane culvert

Figure 4-42: Looking downstream inside the Olympia Lane culvert at the 30-degree bend

The hydraulic model was used to evaluate the Olympia Lane crossing if it were to be replaced with a new structure spanning 10 feet with a rise of 6 feet. Replacement of the Olympia Lane culvert with a single-barrel concrete box culvert of those dimensions reduces the current 50-year and future 50-year headwater depths by 4.5 and 4.3 feet, respectively. The flood reduction is depicted in longitudinal profile 4-44. The replacement structure would be able to pass all modeled current and future flow events. With the new structure, the house adjacent to the river left of the culvert on the upstream end would no longer be flooded during the 100-year flood event.

It is recommended that the Olympia Lane culvert is replaced by a structure with a minimum span of 10 feet and a rise of 6 feet, free of bends and straight. Given the length of the culvert, it is also suggested to daylight the stream where possible. Daylighting the stream 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.

According to regional regressions, the bankfull width of the West Branch Saddle River at the inlet of the Olympia Lane crossing is 16.2 feet and the bankfull depth is 1.25 feet. It is recommended to implement those measurements while restoring the channel.

The improvements described above are depicted in concept in Figure 4-30.

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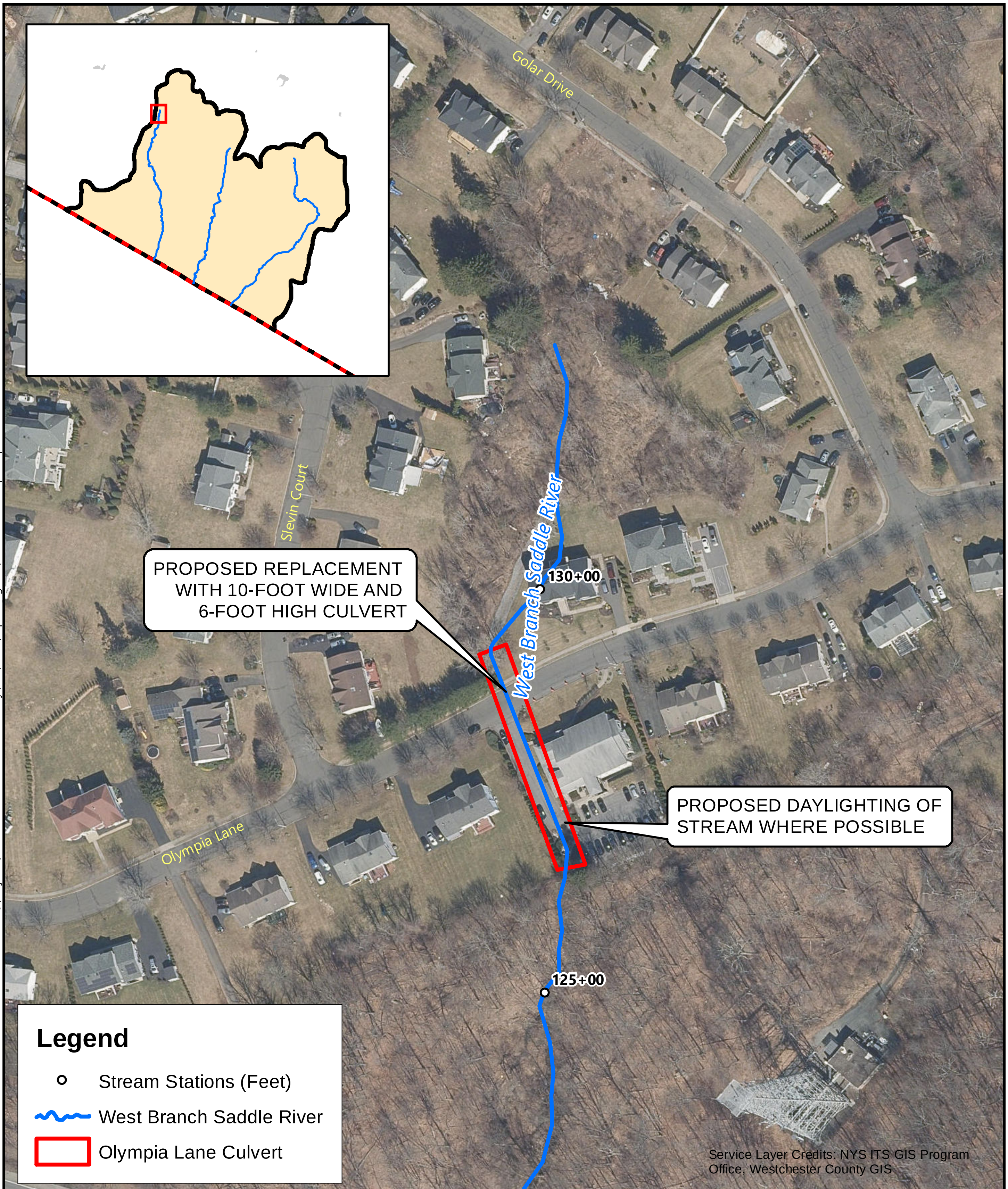

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CONCEPT MAP: OLYMPIA LANE

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FIG. 4-43

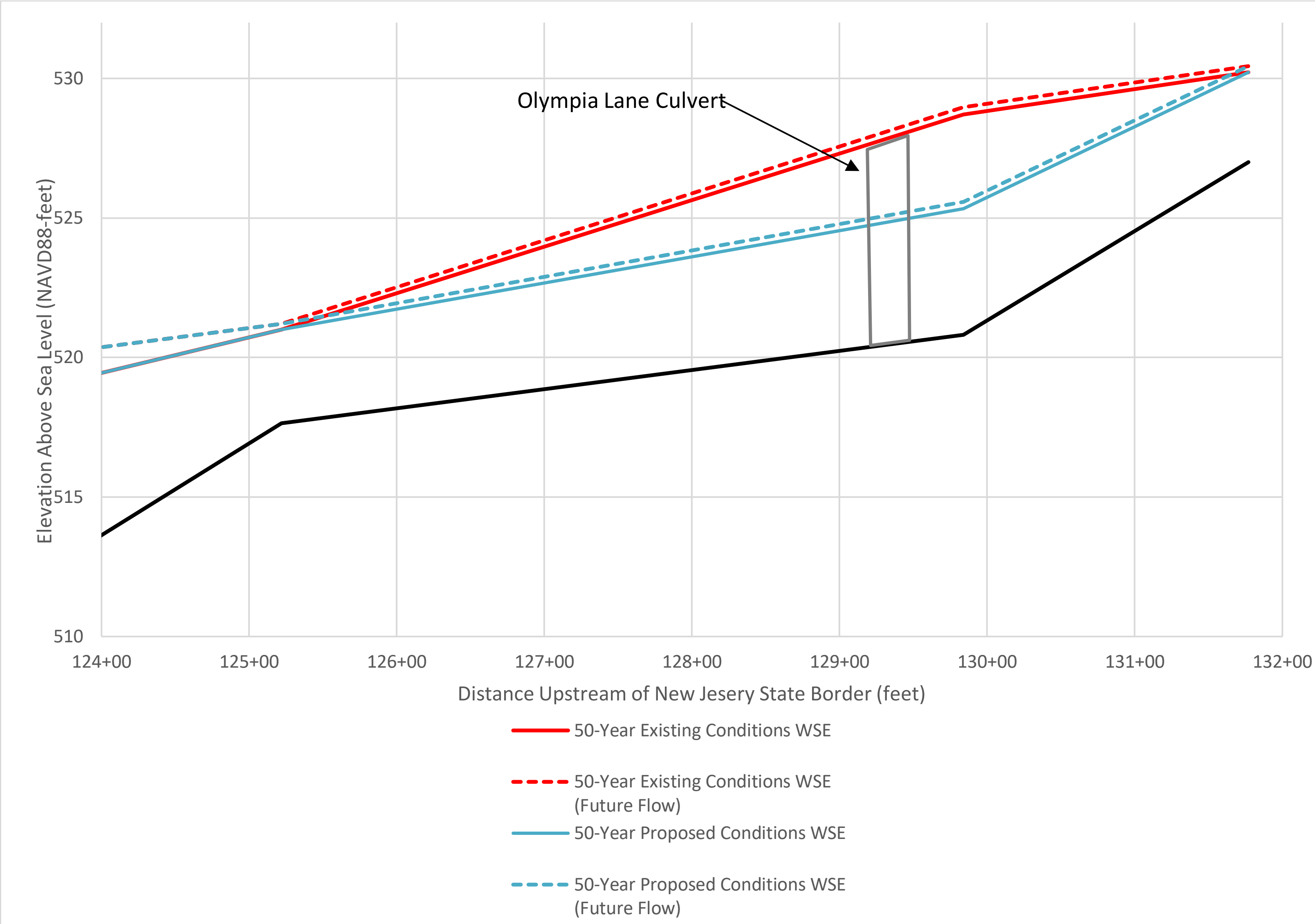


Figure 4-44 Reach Profile for 50-Year Flows Under Current Conditions and Proposed Conditions in HRA 5.4 (Olympia Lane Crossing)

4.5.5 SUMMARY OF HRA 5 RECOMMENDATIONS

A summary of the proposed replacement structures and the findings of the hydraulic analysis, evaluated under current conditions and under future conditions projecting for changes in hydrology due to climate change, are listed on Table 4-1.

Table 4-1 Key Findings From the Hydraulic Analysis Done Within HRA 5

					Replacement Structure Flood Capacity	
HRA	Stream Crossing	Existing Structure	Existing Flood Capacity	Modeled Replacement Structure Size	Current Hydrology	Projected Future Flows to Account for Climate Change
5.1	Christmas Hill Road	Corrugated Metal Arch 17’ Span and 6.5’ Rise	50-Year Flood	19’ Span by 7’ Rise	500-Year	100-Year
	200 Cherry Lane Dam	12’ Rise	N/A	Removal	N/A	N/A
	Island Lake Dam	10’ Rise	N/A	Removal	N/A	N/A
	STA 78+00 Unnamed Dam	8’ Rise	N/A	Removal	N/A	N/A
5.2	East Blossom Road	Twin Corrugated Metal Arch Pipes 5.5’ Span and 4’ Rise	50-Year Flood	12’ Span by 5’ Rise	500-Year	500-Year
5.3	Railroad Crossing	Concrete Arch 6’ Span and 7.6’ Rise	500-Year Flood	N/A	N/A	N/A
5.4	Olympia Lane	Concrete Pipe 6’ Diameter	50-Year Flood	10’ Span by 6’ Rise and Daylighting the Stream	Passes All Events	Passes All Events

5. RECOMMENDATIONS

5.1 HRA 1 RECOMMENDATIONS

The following recommendations are provided for HRA 1:

- The replacement of the current crossing of Pine Brook at Pine Brook Road with a new crossing with a span of 43 feet and a rise of 4 feet, which based on available modeling would accommodate the future 100-year flood event.

- A survey of the crossing and channel and a detailed hydraulic and hydrologic analysis is recommended to properly size a replacement structure for the culvert at Pine Brook Road.

5.2 HRA 2 RECOMMENDATIONS

The following recommendations are provided for HRA 2:

- Replacement of the Ascension Cemetery driveway crossing over the East Branch Saddle River with a new crossing with a span of 46 feet and a rise of 7 feet, which based on available modeling would accommodate the future 100-year flood event.

- Removal of the St. Patrick Cathedral Cemetery Dam located between the Ascension Cemetery and Gates of Zion Cemetery driveways.

- Replacement of the driveway of the Gates of Zion Cemetery crossing over the East Branch Saddle River with a new crossing with a span of 36 feet and a rise of 6.8 feet, which based on available modeling would accommodate the future 100-year flood event.

- A survey of the crossings and associated channel described above and a detailed hydraulic and hydrologic analysis is recommended to properly size replacement structures for these crossings over East Branch Saddle River.

- Removal of the unnamed, breached dam on East Branch Saddle River at STA 4+50. Full removal of the former dam and its components is recommended. Restoration of the immediate channel reach that is being disrupted by the presence of the collapsed mortared stone is also recommended. A rigorous hydrologic and hydraulic examination is recommended to assess the flood mitigation impacts of the dam removal.

5.3 HRA 3 RECOMMENDATIONS

The following recommendations are provided for HRA 3:

- Replacement of the South Monsey Road crossing over the East Branch Saddle River with a new crossing with a 34-foot span, a 4-foot rise, an open bottom, and 2.5 percent slope, which based on available modeling would accommodate the future 100-year flood event.

- Replacement of the South Monsey Road crosses over an unnamed tributary to the East Branch Saddle River with a new crossing with a span of 17 feet and removing large rocks at the culvert inlet to increase the rise to 2.4 feet, which based on available modeling would accommodate the future 100-year flood event.

- A survey of the crossings and associated channel and a detailed hydraulic and hydrologic analysis is recommended to properly size replacement structures for these crossings.

5.4 HRA 4 RECOMMENDATIONS

The following recommendations are provided for HRA 4:

- Replacement of the Regina Road crossing of the East Branch Saddle River with a new structure with a 22-foot span, a 3.4-foot rise, an open bottom, and a slope of 2 percent.

- A survey of the crossing and channel and a detailed hydraulic and hydrologic analysis is recommended to properly size a replacement structure for the culvert at Regina Road.

5.5 HRA 5 RECOMMENDATIONS

The following recommendations are provided for HRA 5:

- Replacement of the Christmas Hill Road crossing over West Branch Saddle River (STA 59+50) with a structure containing a minimum span of 19 feet and a minimum rise of 7 feet.

- Removal of the 200 Cherry Lane Dam, owned by the Town of Ramapo on West Branch Saddle River (STA 62+00), and restoration of the stream channel.

- Removal of the privately owned Island Lake Dam on West Branch Saddle River (STA 74+60) and restoration of the stream channel.

- Removal of the dam on West Branch Saddle River (STA 78+00) and restoration of the stream channel. The dam is not registered by NYSDEC, and its ownership is unknown.

- Permanent removal of three footbridges, located at STA 69+00, 73+00, and 83+00, that span the West Branch Saddle River. If it is not practical for the footbridges to be removed, it is recommended that they be replaced by adequately sized crossings. If the footbridges are to be replaced, a detailed hydraulic and hydrologic analysis should be conducted to properly size each replacement structure.

- Replacement of the East Blossom Road culvert over West Branch Saddle River (STA 88+80) with a new structure spanning 12 feet and a rise of 5 feet and elevated by 1 foot. The culvert slope should be adjusted from 0.85 percent to 0.6 percent to mimic the natural slope of the stream.

- Removal of the abandoned railroad crossing over West Branch Saddle River (STA 104+00) and restoration of the channel.

- Replacement of the Olympia Lane culvert over West Branch Saddle River (STA 129+25) by a structure with a minimum span of 10 feet and a rise of 6 feet, free of bends and straight. It is also suggested to daylight the stream where possible. Daylighting the structure would include, at minimum, physically uncovering the culvert, removing it, and restoring the channel.

- A survey of the crossings and associated channel and a detailed hydraulic and hydrologic analysis is recommended to properly size replacement structures for the new crossings described above.

5.6 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 Saddle River watershed be identified and prioritized for replacement. Guidance for this prioritization should be based on capacity modeling and aquatic organism passage data for culverts in Rockland County that have been assessed through the North Atlantic Aquatic Connectivity Collaborative (NAACC) program. Where multiple stream crossings are slated for replacement along a reach of watercourse, it is recommended that replacements begin at the downstream end and progress sequentially in an upstream direction.

5.7 UPDATED FEMA HYDRAULIC MODELING AND MAPPING

FEMA hydraulic modeling for East Branch Saddle River and Pine Brook is based on an antiquated HEC-2 analysis dating from the 1980s. It is recommended that new FEMA modeling for these watercourses be developed to reflect current hydraulic and hydrologic conditions. Updates to hydraulic modeling should then be reflected with updated FIRMs. The updated hydraulic modeling and mapping would reflect changes such as bridge replacements, dam removals, or updated flood hydrology.

5.8 INDIVIDUAL PROPERTY FLOOD PROTECTION

A variety of measures is 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.

5.9 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 Hackensack 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.

5.10 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. More specific estimated costs are provided where possible. 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 in the costs.

Table 5-1 Cost Range of Recommended Actions

Recommendation	< $100k	$100k - $500k	$500k - $1M
HRA 1 - Replacement of Pine Brook at Pine Brook Road with new crossing			X
HRA 2 - Replacement of Ascension Cemetery driveway over East Branch Saddle River with new crossing			X
HRA 2 - Removal of St. Patrick Cathedral Cemetery Dam		X	
HRA 2 - Replacement of driveway of Gates of Zion Cemetery over East Branch Saddle River with new crossing			X
HRA 3 – Replacement of South Monsey Road over East Branch Saddle River with new crossing			X
HRA 3 – Replacement of South Monsey Road crossing of unnamed tributary with new crossing		X	

Recommendation	< $100k	$100k - $500k	$500k - $1M
HRA 4 - Replacement of Regina Road crossing of East Branch Saddle River with new crossing			X
HRA 5 - Replacement of Christmas Hill Road crossing over West Branch Saddle River with new crossing		X	
HRA 5 - Removal of 200 Cherry Lane Dam on West Branch Saddle River and restoration of stream channel		X	
HRA 5 - Removal of Island Lake Dam on West Branch Saddle River and restoration of stream channel		X	
HRA 5 - Removal of dam on West Branch Saddle River (STA 78+00) and restoration of the stream channel		X	
HRA 5 - Permanent removal of three footbridges (STA 69+00, 73+00, 83+00) that span West Branch Saddle River	X		
HRA 5 - Replacement of East Blossom Road culvert over West Branch Saddle River (STA 88+80) with new structure		X	
HRA 5 - Removal of abandoned railroad crossing over West Branch Saddle River (STA 104+00) and restoration of channel		X	
HRA 5 - Replacement of Olympia Lane culvert over West Branch Saddle River (STA 129+25) and daylighting channel where possible			X

5.11 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.

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 Department of State 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.

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 in land use, particularly development proposals in close proximity to a water body or within a riparian buffer, can bring about issues and consequences not only 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 Rockland County, there has been a significant amount of work conducted by the state, county, and local municipalities, typically following a flood event such as Hurricane Sandy, 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.

One agency in Rockland County that has regulatory jurisdiction over activities within 100 feet of specified streams, including portions of the Saddle River tributaries discussed in this report, is the Rockland County Drainage Agency. http://rocklandgov.com/departments/highway/drainage-agency/

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 Rockland County can review and discuss implementing, if not already in the municipal code. A significant and positive finding from this effort is that every community assessed within the Saddle River Watershed has adopted a Flood Damage Prevention Ordinance. These ordinances, adopted in 1987 by Spring Valley (updated in early 2000s), 2013 by Chestnut Ridge, and 2014 in Ramapo, go a long way toward addressing potential issues and concerns related to flooding and land use planning.

Our review of the following documents did not find any municipal-specific land use or zoning recommendations to carry forward for this project. We have summarized any potential recommendations related specifically to flooding that may be useful to consider when assessing potential changes to existing zoning, subdivision, and other regulations that could impact flood-related conditions:

- Hudson River Estuary Habitat Restoration Plan – NYSDEC (2013)
  - This Plan identifies priority habitats vital to the health and resiliency of the estuary and actions for restoring them. The plan states that it is "…the basis for coordinating funding, planning, research and implementation of resources toward a single, focused goal: The enduring health and wellbeing of the Hudson River estuary, its inhabitants and the people of the Hudson River Valley and New York State." It states that despite improvements in the Hudson River, there "…remains a profound need for habitat restoration." There was nothing specific to Rockland County communities identified in this plan. That said, riparian buffer protections and related protections of vital habitats by municipalities will generally assist with the implementation and protection efforts identified and desired by this plan.

Additionally, while the watershed is not located within the estuary boundaries, it is within the Estuary Grant Program boundaries and, as such, could potentially utilize this program for efforts within the watershed.

- All Rockland County communities have a flood damage prevention ordinance. The standards adopted can vary from community to community, but they all provide construction standards for actions within flood hazard areas.

- All Rockland County communities are under the "umbrella" of the 2011 Rockland County Comprehensive Plan *Rockland Tomorrow: County Comprehensive Plan.* There are only a few specific mentions or recommendations related to flooding and flood prevention for individual municipalities, but where such a mention is made, it is included under that community below. All communities fall within the following recommendations from the Plan:
  - Land Use and Zoning Chapter
    - ➢ No key issues identified.
  - Natural Resources Chapter – Encourage the municipalities to establish buffers along streams as appropriate, with the specific distance dictated by conditions on the ground and scientific study.
  - Infrastructure Chapter – Use planning techniques for green infrastructure and stormwater management as provided by the New York State DEC.

- 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 Rockland 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 6 – Scenic Hudson is working with 16 land trusts and government agencies to save ridgelines with iconic views, forests, and wetlands critical to maintaining the Hudson Valley's extraordinary biological diversity and farmland.
    - ➢ 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.
- Rockland County Hazard Mitigation Plan
  - This plan "…demonstrates county and community commitment to reducing risks from all hazards and serves as a guide for decision makers as they commit resources to minimize the effects of hazards. The Hazard Mitigation Plan (HMP) is the blueprint for reducing the county's vulnerability to disasters and hazards. The HMP is intended to integrate with

county and municipal planning mechanisms already in place, such as building and zoning regulations, environmental planning, and long-range planning mechanisms."

- All Rockland County communities had a Jurisdictional Annex developed detailing information about their community. A summary of the relevant information from these annexes is provided below.

6.2 MUNICIPAL ASSESSMENTS

The following section details individual recommendations for each community being assessed within the Saddle River watershed. A map with the boundaries of the Saddle River watershed and the towns and villages that fall within it is depicted in Figure 6-1. In the recommendations section of this report are "best practices" that each community can review to assess whether or not they are already in their municipal code or are 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 TOWN OF RAMAPO

Zoning & Other Code(s) Analysis Highlights

https://ecode360.com/11858832

The town has a Flood Damage Prevention code (Chapter 149). This code has standards related to elevation and flood resistant construction.

The town also has a Streams and Watercourses section (Chapter 240), a Special Bulk Requirements section (Section 376-42), cluster regulations (Section 376-42), and a Stormwater Management and Sediment and Erosion Control Section (Chapter 237). Section 376-42 of the Zoning Ordinance requires that not more than 50 percent of a lot be land underwater or land in the 100-year floodplain. Finally, buffers are a defined term in the Code, but there do not to appear to be requirements for vegetated buffer zones along watercourses.

Other Land Use Documents Reviewed:

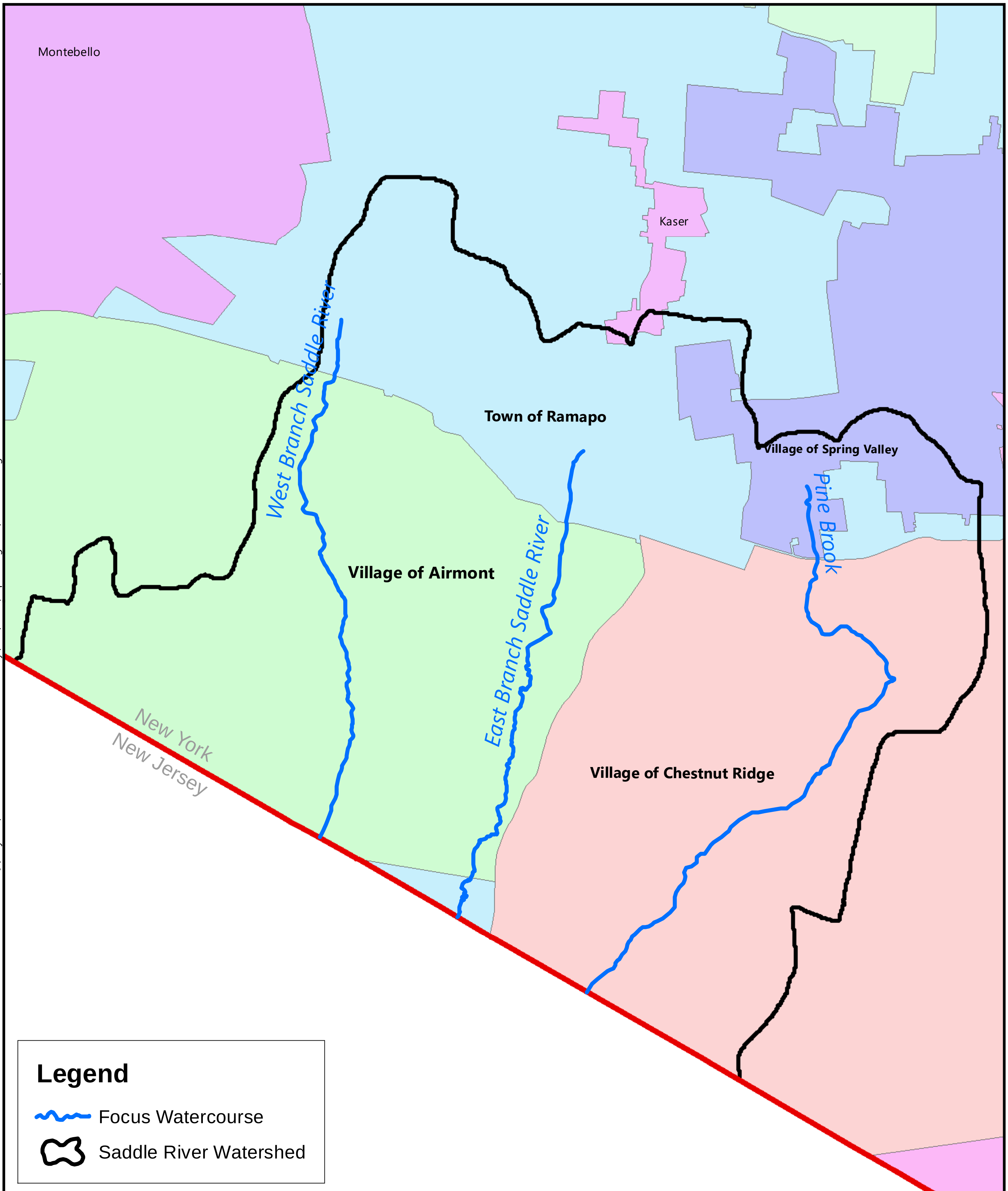
- *Town of Ramapo Comprehensive Plan 2004*
  - Assess whether or not to enact a wetlands law to provide an additional level of protection for wetlands. *Wetlands are a defined term in the Stormwater Control regulations, but there do not appear to be stand-alone wetlands regulations.*
  - Assess whether or not to require vegetation buffer zones along watercourses.
  - Consider reducing the permitted development intensity by:
    - Requiring that the area of the lot without the specified impediments be a contiguous area and in a location on the lot that makes development on it feasible in light of other considerations.
    - Increase the percentage of the lot that must be free of the specified impediments from 50 percent to a higher percentage (e.g., 75 percent).
    - Require that wetland areas be dedicated from minimum lot area requirements.

- ➢ Consider decreasing the percentage of such areas that may be counted toward meeting the lot area requirement from 50 percent to a lower percentage (e.g., 25 percent).
- ➢ Apply these provisions to lots intended for nonresidential use – the first sentence of Section 376-42.A states that these provisions apply only to a minimum lot area requirement for residential uses.

  Some code changes that relate to these topics have been implemented since the 2004 Comprehensive Plan.

- For subdivision regulations, consider the following revisions:
  - ➢ Identify any standards that are inconsistent with the objective of minimizing overall land disturbance during subdivision development. Examples include reducing roadway widths, required cul-de-sac dimensions, etc. to reduce the amount of land disturbance and impervious surface.
- The Town of Ramapo should protect rivers and streams, including their riparian buffers, banks, and floodplains. Preference should be given to:
  - ➢ Properties within the 100-year floodplain of rivers and streams
  - ➢ Properties adjacent to the water bodies identified as stressed, threatened, impaired, or precluded on the NYSDEC Priority Water Body List.
  - ➢ Properties adjacent to Class A (a water body classified by the NYSDEC as suitable for swimming) rivers or streams, or rivers and streams that support fish.
  - ➢ Riparian buffers (an area of trees, shrubs, and herbaceous vegetation located adjacent to and upslope from a lake, stream, or other body of water that maintains stream system integrity, protects water quality, and improves the habitat of plants and animals on land and in the water) along stream or river corridors.
  - ➢ Properties that surround or adjoin springs or intermittent streams.

  Some code changes that relate to these topics have been implemented since the 2004 Comprehensive Plan.
- The Town should protect its watershed. Preference should be given to:
  - ➢ Wetlands, floodplains, and riparian buffers
- For Housing…
  - ➢ Properties to be considered for multifamily rezoning should be unencumbered by environmental resources such as steep slopes, wetlands, streams, floodplains, and other factors that would suggest that the property is not suitable for the intensity of development proposed.
- A Northeast Corridor Planning effort is in development. Draft project materials and Generic Environmental Impact Statement/State Environmental Quality Review Act (GEIS/SEQRA) documentation is available online. The posted documents did not appear to include specifics related to flooding, other than summarizing elements of existing plans and existing code regulations.



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

SADDLE RIVER WATERSHED TOWNS & VILLAGES
SADDLE RIVER FLOOD & RESILIENCE STUDY
SD 114
ROCKLAND COUNTY
NEW YORK

SCALE 1 " = 3,000 '
DATE 6/7/2022
16511.00009
PROJ. NO.

FIG. 6-1

6.2.2 VILLAGE OF CHESTNUT RIDGE

Zoning & Other Code(s) Analysis Highlights

https://ecode360.com/CH3561

The Village has a Flood Damage Prevention code (Chapter 158) that was adopted in 1987 with many revisions since that time. The Chapter has standards related to elevation and flood resistant construction.

The Village also has a Wetlands code (Chapter 277), a Subdivision of Land code (Chapter 254), and a Stormwater Management code (Chapter 243). The Wetlands code provides policies and regulations related to preserving, protecting, and conserving wetlands, water bodies, and watercourses and to implement Article 24 of the NYS Environmental Conservation Law. The purpose statement specifically notes that protecting, preserving, and maintaining wetlands, water bodies, and watercourses can prevent or minimize erosion due to flooding and stormwater runoff. The Village Subdivision of Land code general standards state that land to be subdivided shall be of such character that it can be safely used for building purposes without danger to flooding. This code also has requirements for how land under water can be subdivided with no more than 25 percent of the minimum lot area required under the Zoning Law being satisfied by land that is under water. The Village Stormwater Management code includes standards for a Stormwater Pollution Prevention Plan (SWPPP) and requires details on any wetland or drainage patterns that could be impacted by construction activities.

Other Land Use documents reviewed:

- *Rockland County Multi-Jurisdictional Natural Hazard Mitigation Plan Update* 2018
  - Ensure that local comprehensive plans incorporate natural disaster mitigation techniques. This is a high priority Initiative (VP-1).
- *Village of Chestnut Ridge Comprehensive Plan – Draft October 14, 2020*
  - The Village was in the process of updating its Comprehensive Plan in late 2020 and had posted the DGEIS information online, but no new information has been posted since.
  - The Plan notes that the Hungry Hollow Brook, Pine Brook, and Pascack Brook all have FEMA-designated floodplains but that floodplains (and wetlands) comprise a relatively small area compared to other villages.
  - The Environmental Protection Goal & Objectives (Section 4.2, Goal #2.1) states that an objective is to "Protect environmentally stream ecosystems and floodplains, including Hungry Hollow Brook, Pine Brook, and Pascack Brook, and maintain adequate buffers between these systems and adjoining development."

6.2.3 VILLAGE OF SPRING VALLEY

Zoning & Other Code(s) Analysis Highlights

https://ecode360.com/9395826

The Village has a Flood Damage Prevention code (Chapter 126) that was adopted in 1987 with many revisions since that time. The Chapter has standards related to elevation and flood resistant construction.

The Village also has a Freshwater Wetlands code (Chapter 130), Subdivision code (Chapter 232), and Stormwater Management and Erosion and Sediment Control code. The Freshwater Wetlands code provides protections intended to, among other issues, assist in flood and storm control. The Standards for permit decisions includes the consideration or effects of a proposed activity or action as it relates to public health and welfare…flood, hurricane, and storm damages. The Subdivision code general standards state that land to be subdivided shall be of such character that it can be safely used for building purposes without danger from flooding, among other items. This code also has requirements for how land under water can be subdivided with no more than 25 percent of the minimum lot area required under the Zoning Law being satisfied by land that is under water. The Stormwater Management and Erosion and Sediment Control Code includes standards for a SWPPP and requires details on any wetland or drainage patterns that could be impacted by construction activities.

Other Land Use documents reviewed:

The Village of Spring Valley did not have any readily publicly available municipal planning documents for review.

- *Rockland County Multi-Jurisdictional Natural Hazard Mitigation Plan Update* 2018
    - Ensure that local comprehensive plans incorporate natural disaster mitigation techniques. This is a high priority Initiative (VP-1).

6.3 BEST PRACTICES RECOMMENDATIONS

The following details best practices concepts and implementation options identified in several documents, including documents assessed from within Rockland County; the American Planning Association PAS Report 6 of 2018 and PAS Report 3 of 2016, which summarized flood mitigation actions from across the country; the NYSDOS Model Local Laws Increase Resilience webpage; and New York City Zoning for Flood Resiliency website.

The following divides the best practice recommendations into two categories – zoning and subdivision. As noted in the 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."

These reports note that overlays can be used to protect areas without needing to adjust the underlying zoning. In effect, the Flood Damage Prevention Ordinances already in place essentially act as an overlay mapped through alternative map resources (FIRM mapping), which provides a specific geographic area within which such regulations apply.

Communities within the Saddle River watershed have, in many cases, undertaken the implementation of many 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, tributaries, and other water bodies is essential to continuing the work already undertaken and maximize its impact now and into the future.

The following zoning regulatory actions should be reviewed and assessed for potential incorporation into local laws, where applicable and feasible.

Resources utilized to develop the best practices audit matrix above included the following:

- 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 Saddle 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: Town of Ramapo
Table 6-2: Village of Chestnut Ridge
Table 6-3: Village of Spring Valley

Table 6-1: Flood Resiliency Best Practices Code Audit Checklist

Town of Ramapo 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 code restricts the lowest floor in certain zones to parking, access or storage and 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).	☑	☐	☐	Standards are included that require between 2' and 3' above BFE in certain zones as well as requirements for drainage paths in other zones for residential structures. For non-residential structures, the lowest floor should be elevated 2' above BFE if no FIRM number is specified. Structures are to be floodproofed so that the structure is watertight below two feet above the base flood elevation, including utilities and sanitary facilities. Within the A, when no base flood data are available, the lowest floor (including basement) shall be elevated at least 3' above the highest adjacent grade.
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 Ramapo Preliminary Audit	***In Existing Code***	***Consider for Implementation***	***N/A***	***Notes***
Zoning Code Ordinance Best Practices				
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.	☑	☐	☐	This exists in a way in the code. Regulations are subject to specific FIRM maps detailed in the code. This exists in a way in the code. 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 required and when the Village agrees to apply to FEMA for conditional Firm and floodway revision and approval is received, only then can construction or substantial improvements move forward.
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.
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 at least 2' above BFE. 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 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 a details of any watercourse alteration or relocation. There are detailed permit application requirements including a technical analysis to determine whether or not proposed development will result in physical damage to any other property.
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.	☐	☐	☐	There is a cluster provision in the code.
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. There are code requirements that only a percentage of land underwater count toward minimum lot area. 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.

Table 6-1: Flood Resiliency Best Practices Code Audit Checklist				
Town of Ramapo Preliminary Audit	***In Existing Code***	***Consider for Implementation***	***N/A***	***Notes***
Zoning Code Ordinance Best Practices				
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.	☑	☐	☐	The code includes a Streams and Watercourses section prohibiting certain actions along these features.
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 Pollution Prevention Plan (SWPPP) requirements.
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.	☐	☐	☐	

See Chapter __ for source information.

Code Sections Reviewed:

Flood Damage Prevention - Chapter 149

Stormwater Management and Sediment and Erosion Control - Chapter 237

Special Bulk Requirements - §376-42

Clustering - §376-43

Streams and Watercourses - Chapter 240

Table 6-2: Flood Resiliency Best Practices Code Audit Checklist *Village of Chestnut Ridge, 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 code restricts the lowest floor in certain zones to parking, access or storage and 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).	☑	☐	☐	Standards are included that require between 2' and 3' above BFE in certain zones as well as requirements for drainage paths in other zones for residential structures. For non-residential structures, the lowest floor should be elevated 2' above BFE. or be floodproofed so that the structure is watertight below two feet above the base flood elevation, including utilities and sanitary facilities. Within the A, when no base flood data are available, the lowest floor (including basement) shall be elevated at least 3' above the highest adjacent grade.
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.	☑	☐	☐	This exists in a way in the code. Within special flood hazard areas, construction or improvements are prohibited without a meeting the terms of the regulations. For encroachments, assessments and/or a technical evaluation is required and when the Village agrees to apply to FEMA for conditional Firm and floodway revision and approval is
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.	☑	☐	☐	

Table 6-2: Flood Resiliency Best Practices Code Audit Checklist				
Village of Chestnut Ridge, NY Preliminary Audit	***In Existing Code***	***Consider for Implementation***	***N/A***	***Notes***
Zoning Code Ordinance Best Practices				
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.	☑	☐	☐	received, only then can construction or substantial improvements move forward.
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.	☐	☐	☐	
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 at least 2' above BFE. 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 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 a details of any watercourse alteration or relocation. . There are detailed permit application requirements including a technical analysis to determine whether or not proposed development will result in physical damage to any other property.
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. There are code requirements that a lot not contain more than certain percentage of land under water. 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.

Table 6-2: Flood Resiliency Best Practices Code Audit Checklist				
Village of Chestnut Ridge, NY Preliminary Audit	***In Existing Code***	***Consider for Implementation***	***N/A***	***Notes***
Zoning Code Ordinance Best Practices				
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 Pollution Prevention Plan (SWPPP) requirements.
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.	☐	☐	☐	

See Chapter __ for source information.

Code Sections Reviewed:

Flood Damage Prevention - Chapter 158

Subdivision of Land - Chapter 254

Stormwater Management - Chapter 243

Wetlands - Chapter 277

Zoning - Local Law No. 1 of 2021

Table 6-3: Flood Resiliency Best Practices Code Audit Checklist				
Village of Spring Valley 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 code restricts the lowest floor, including basement or cellar, to be elevated to or above the base flood elevation.
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).	☑	☐	☐	A development permit must be obtained before the start of construction or any other development within the area of special flood hazard. Standards are included that require the lowest floor (including the basement) of structures to be elevated at least 2 feet above the highest adjacent grade next to the proposed foundation of teh structure.
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 6-3: Flood Resiliency Best Practices Code Audit Checklist				
Village of Spring Valley Preliminary Audit	*In Existing Code*	*Consider for Implementation*	*N/A*	*Notes*
Zoning Code Ordinance Best Practices				
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.	☑	☐	☐	This exists in a way in the code. Within special flood hazard areas, construction projects must meeting the terms of the regulations which vary depending on the location.
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 and the use of materials, utility equipment, and methods and practices that are resistant to flood damage and that minimize flood damage. 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 flood events.
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 details of any watercourse alteration or relocation. There are detailed permit application requirements including a technical analysis to determine whether or not proposed development will result in physical damage to any other property.
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. Base flood elevation data shall be provided for projects greater than 5 acres or 50 lots.

Table 6-3: Flood Resiliency Best Practices Code Audit Checklist				
Village of Spring Valley Preliminary Audit	***In Existing Code***	***Consider for Implementation***	***N/A***	***Notes***
Zoning Code Ordinance Best Practices				
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.	☑	☐	☐	The code includes a Streams and Watercourses section prohibiting certain actions along these features. The Village also has a wetlands code.
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 Pollution Prevention Plan (SWPPP) requirements.
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.	☐	☐	☐	

See Chapter __ for source information.

Code Sections Reviewed:

Flood Damage Prevention - Chapter 126

Subdivision of Land - Chapter 237-21

Stormwater Management - Chapter 222-7

Zoning - Chapter 376

Freshwater Wetlands - Chapter 130

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