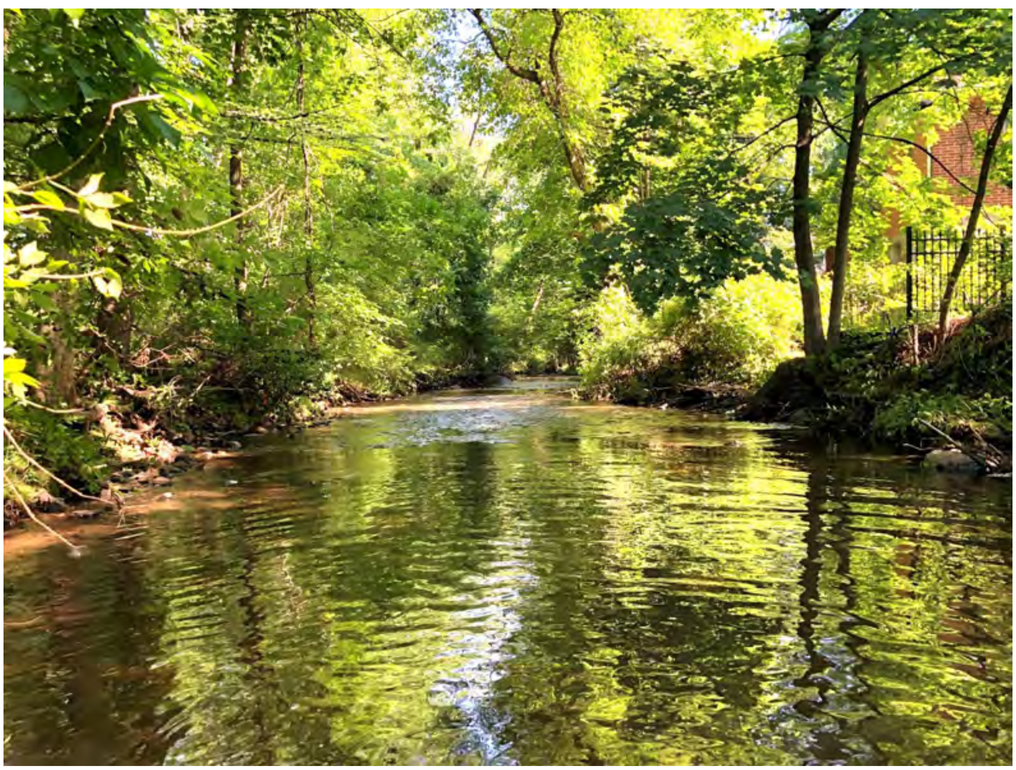
FLOOD MITIGATION & RESILIENCE REPORT

Sparkill Creek - SD115

Prepared for:

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

SLR #142.16511.00010.0040
January 2022



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New York State Office of General Services
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TABLES

FIGURES

ACRONYMS

ABFE	Advisory Base Flood Elevation
BFE	Base Flood Elevation
BIN	Bridge Identification Number
CCNY	City College of New York
CEA	Critical Environmental Area
CFS	Cubic Feet per Second
CMP	Corrugated Metal Pipe
CRRA	Community Risk and Resiliency Act
CRS	Community Rating System
DEC	Department of Environmental Conservation
EWP	Emergency Watershed protection
FEMA	Federal Emergency Management Agency
FHWA	Federal Highway Administration
FIRM	Flood Insurance Rate Map
FIS	Flood Insurance Study
FMA	Flood Mitigation Assistance
FMSP	Floodplain Management Services Program
HEC-RAS	Hydrologic Engineering Center – *River Analysis System*
HMGP	Hazard mitigation Grant Program
HMP	Hazard Mitigation Plan
HRA	High Risk Area
LWRP	Local Waterfront Revitalization Plan or Program
mph	Miles per Hour
MWRR	Municipal Waste Reduction and Recycling
N2N	Neighbor to Neighbor
NAACC	North Atlantic Aquatic Connectivity Collaborative
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
PIP	Palisades Interstate Parkway
PWRC	Piermont Waterfront Resiliency Commission
RCP	Representative Concentration Pathways
RFC	Repetitive Flood Claim

SFHA	Special Flood Hazard Area
SIR	Scientific Investigations Report
SLR	SLR Engineering, Landscape Architecture, and Land Surveying, P.C.
SRL	Severe Repetitive Loss
STA	Station (river)
TDR	Transfer of Development Rights
USACE	United States Army Corps of Engineers
USGS	United States Geological Survey
WSP	Water Supply Paper

SUMMARY

This analysis of Sparkill Creek is being conducted as part of the Resilient New York Program, an initiative of the New York State Department of Environmental Conservation. Sparkill Creek originates in southeastern Rockland County and drains to the Hudson River Estuary. When measured at its outlet to the Hudson River, the Sparkill Creek watershed is 11.2 square miles in size. The watershed includes 426 acres of wetlands, or approximately 6 percent of the watershed. Wetlands play an important role in flood mitigation by storing water and attenuating peak flows.

Rockland County, including the Sparkill Creek 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. Sparkill Creek has no active stream gauges. Based on stream flow records of peak flows from two nearby watercourses, it can be estimated that peak flows on Sparkill Creek during the August 2011 Tropical Storm Irene were near or possibly exceeded the 100-year flood event.

The Sparkill Creek watershed is located north-northwest of New York City and is part of the New York Metropolitan Area. Developed land is the most common land cover, representing 54 percent of the watershed. Forested land makes up 37 percent of the land cover in the watershed. An analysis of watershed land use is conducted, and a Flood Resiliency Best Practices Audit is conducted for each community within the watershed.

Flood-prone High Risk Areas, or HRAs, within the Sparkill Creek Watershed were identified, and an analysis of flood mitigation considerations within each HRA was undertaken. Factors with the potential to influence more than one HRA were also evaluated and discussed.

Much of the analysis focuses on stream crossings, where roads and railroads cross over Sparkill Creek, and the watercourse is conveyed under the roadway through a bridge or culvert. A number of stream crossings are identified as being hydraulically undersized and are recommended for replacement. Several municipal sewage treatment facilities and sanitary pump stations are located along the Sparkill. Many of these critical facilities are located within the Federal Emergency Management Agency's (FEMA's) Special Flood Hazard Area (SFHA), indicating that they are prone to flooding. Along the downstreammost section of Sparkill Creek, in the village of Piermont close to the confluence with the Hudson River Estuary, the potential for flooding is influenced by the diurnal tidal cycle of the Hudson River Estuary. Flooding in Piermont can be exacerbated by tidal surges and when high flow events on Sparkill Creek coincide with the high tide.

Several municipal sewage treatment facilities and sanitary pump stations are located along Sparkill Creek. Many of these critical facilities are located within the SFHA, indicating that they are prone to flooding.

1. INTRODUCTION

1.1 PROJECT BACKGROUND AND OVERVIEW

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

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

1.2 TERMINOLOGY

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

Stream stationing is used in the narrative and on maps as an address to identify specific points along the watercourse. Stationing is measured in feet and begins at station 0+00 where Sparkill Creek empties into the Hudson River Estuary and continues upstream to station 416+86 upstream of South Greenbush Avenue in the hamlet of Orangeburg, at the headwaters of Sparkill Creek. As an example, Sparkill Creek passes underneath Mountain View Avenue in Orangeburg at station 354+56.

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 Sparkill Creek and its tributaries.

2. DATA COLLECTION

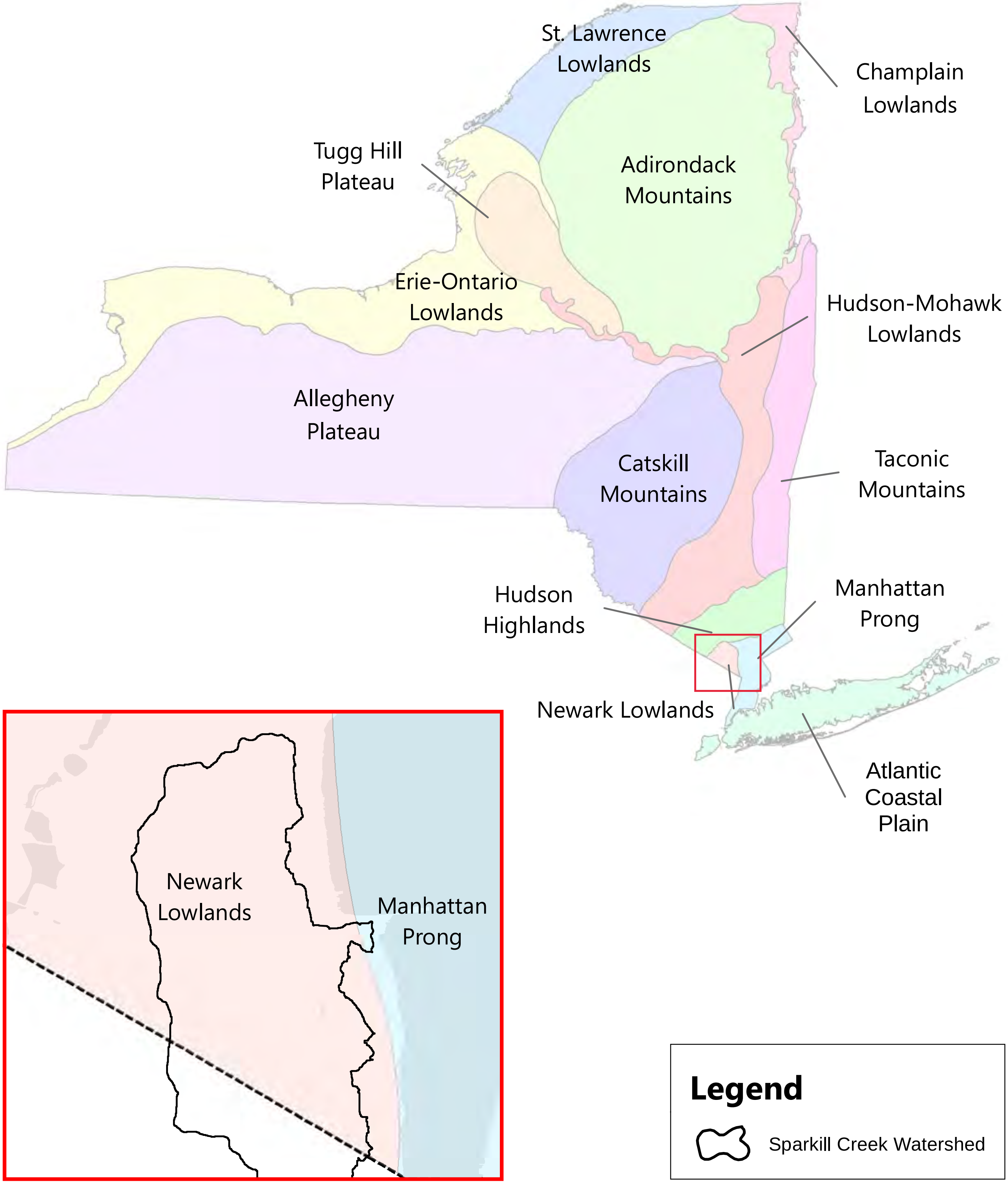
Data were gathered from various sources related to the hydrology and hydraulics of Sparkill Creek, Sparkill Creek watershed characteristics, recent and historical flooding in the affected communities, and factors that may contribute to flood hazards.

2.1 SPARKILL CREEK WATERSHED CHARACTERISTICS

The Sparkill Creek 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 drains eastward to the Hudson River Estuary and has an elongate shape, extending north to south. When measured at its outlet to the Hudson River Estuary, the Sparkill Creek watershed is 11.2 square miles in size. Figure 2-2 is a watershed map of the Sparkill Creek watershed. Watershed relief is depicted in Figure 2-3.

The Sparkill Creek watershed is underlain by bedrock that is classified as part of the Newark Group. Bedrock within this group dates from the Upper Triassic and has been mapped as distinct formations. The western portion of the watershed is underlain by bedrock of the Brunswick Formation, which consists of sandstone, siltstone, and mudstone. The eastern part of the watershed is mapped as Palisades Diabase, an igneous rock type containing light feldspar and dark augite, which give the rock a distinctive "salt-and-pepper" appearance. This rock type makes up the Palisades cliffs, which line the western side of the Hudson River.

Surficial materials underlying the Sparkill Creek watershed consist primarily of glacial till, with areas mapped as exposed bedrock occurring along the eastern boundary of the lower watershed (the area mapped as Palisades Diabase bedrock). Areas mapped as outwash sand and gravel and alluvium underlie the Sparkill Creek valley bottom. An area mapped as swamp deposits underlies a wetland in the lower watershed.



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NYS PHYSIOGRAPHIC REGIONS

SPARKILL CREEK FLOOD & RESILIENCY STUDY
SD115
ROCKLAND COUNTY
NEW YORK

SCALE 1 " = 300,000 '
DATE 1/6/2022
PROJ. NO. 16511.00006

FIG. 2-1

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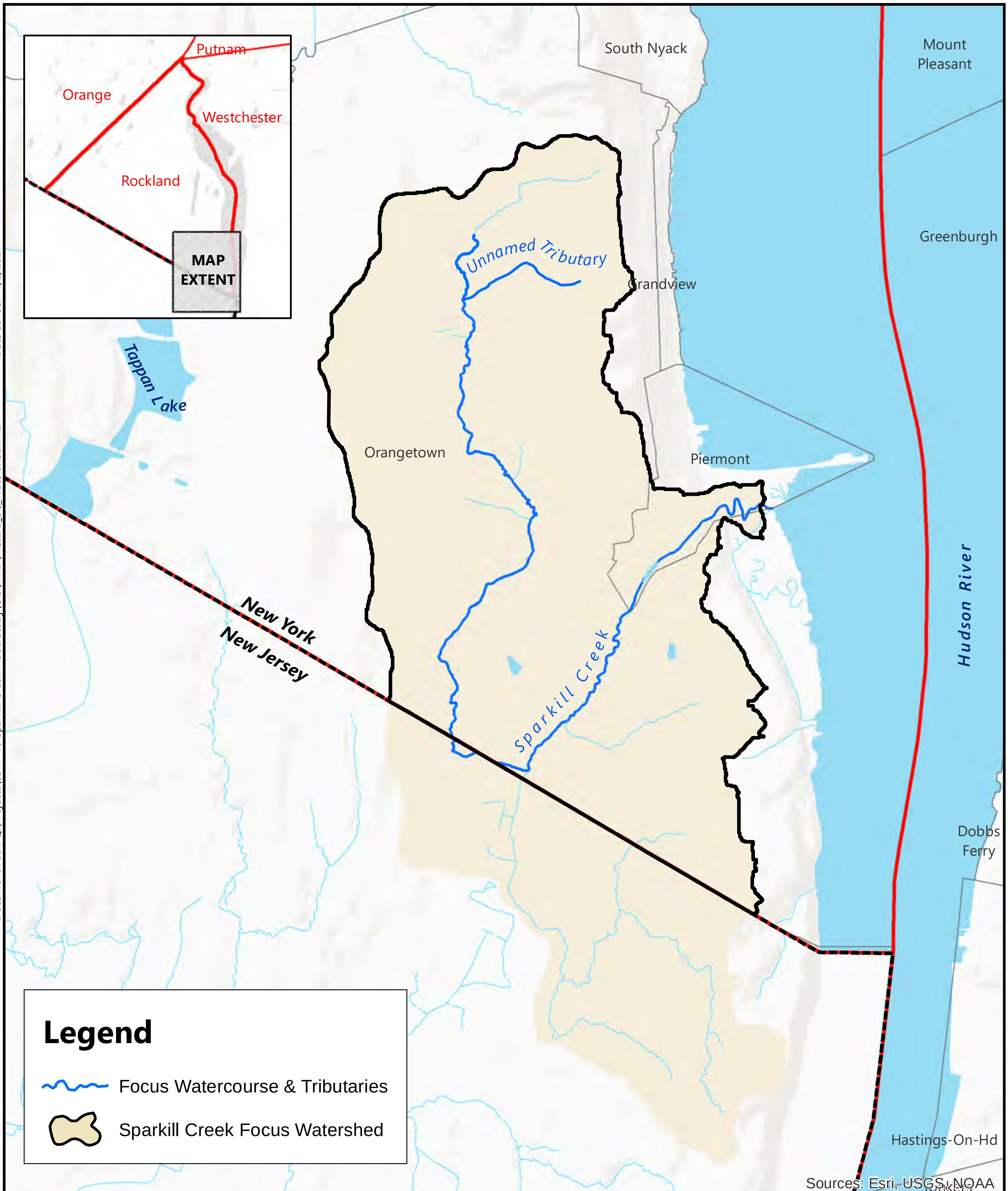

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SPARKILL CREEK WATERSHED MAP

SPARKILL CREEK FLOOD & RESILIENCY STUDY
SD115
ROCKLAND COUNTY
NEW YORK

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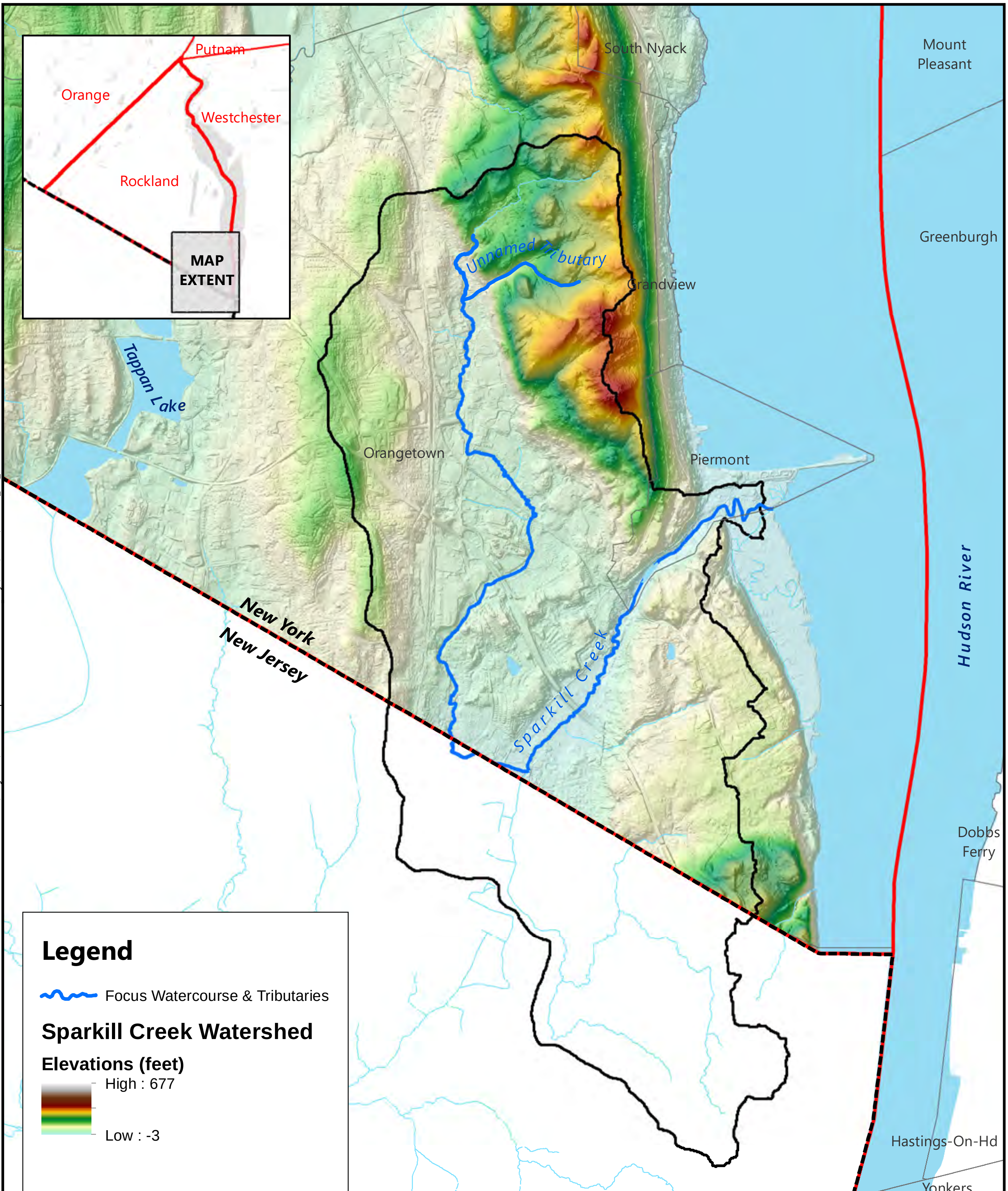
FIG. 2-2



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RELIEF MAP

SPARKILL CREEK FLOOD & RESILIENCY STUDY
SD115
ROCKLAND COUNTY
NEW YORK

SCALE 1 " = 4,500 '

DATE 11/4/2021

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PROJ. NO.

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. Over 65 percent of the mapped soils in the Sparkill Creek watershed are classified as hydrologic soil group C, C/D, or D, indicating a low capacity for infiltration and a high tendency for runoff (Figure 2-4). This contributes to flash flooding in the watershed as rainfall runoff moves swiftly into streams rather than gradually seeping through the soils.

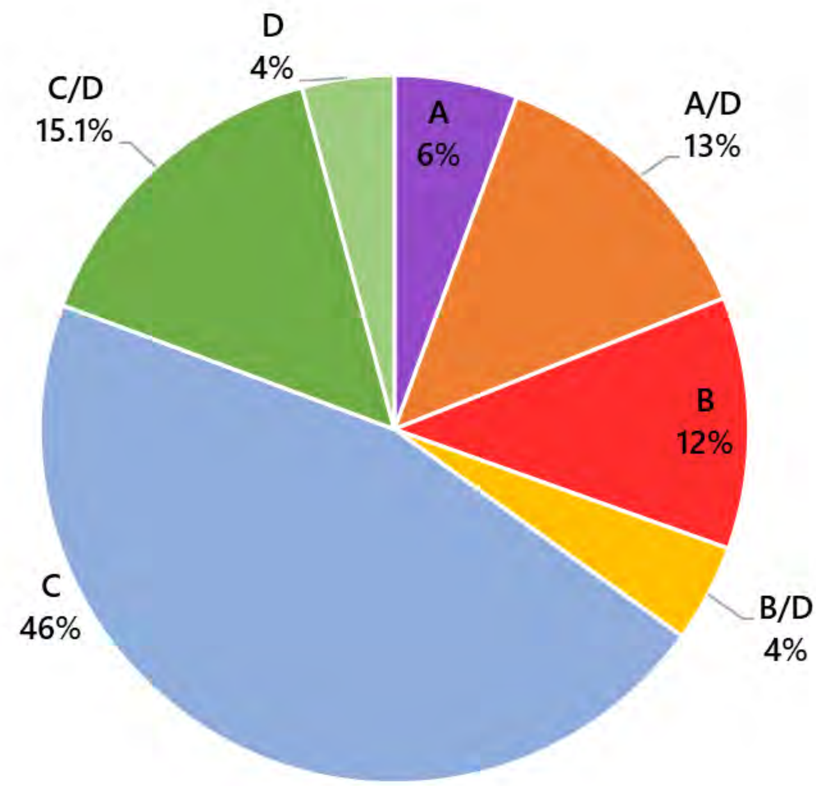


Figure 2-4: Hydrologic Grouping of Soils within the Sparkill Creek Watershed

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 Sparkill Creek 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 54 percent of the watershed. Forested land consists of deciduous, coniferous, and mixed forest types and makes up

37 percent of the land cover in the watershed. Open water and wetlands make up 8 percent of the land cover. The remaining land cover consists of agricultural land, grassland and shrubland, and barren land, each making up less than 1 percent of the watershed.

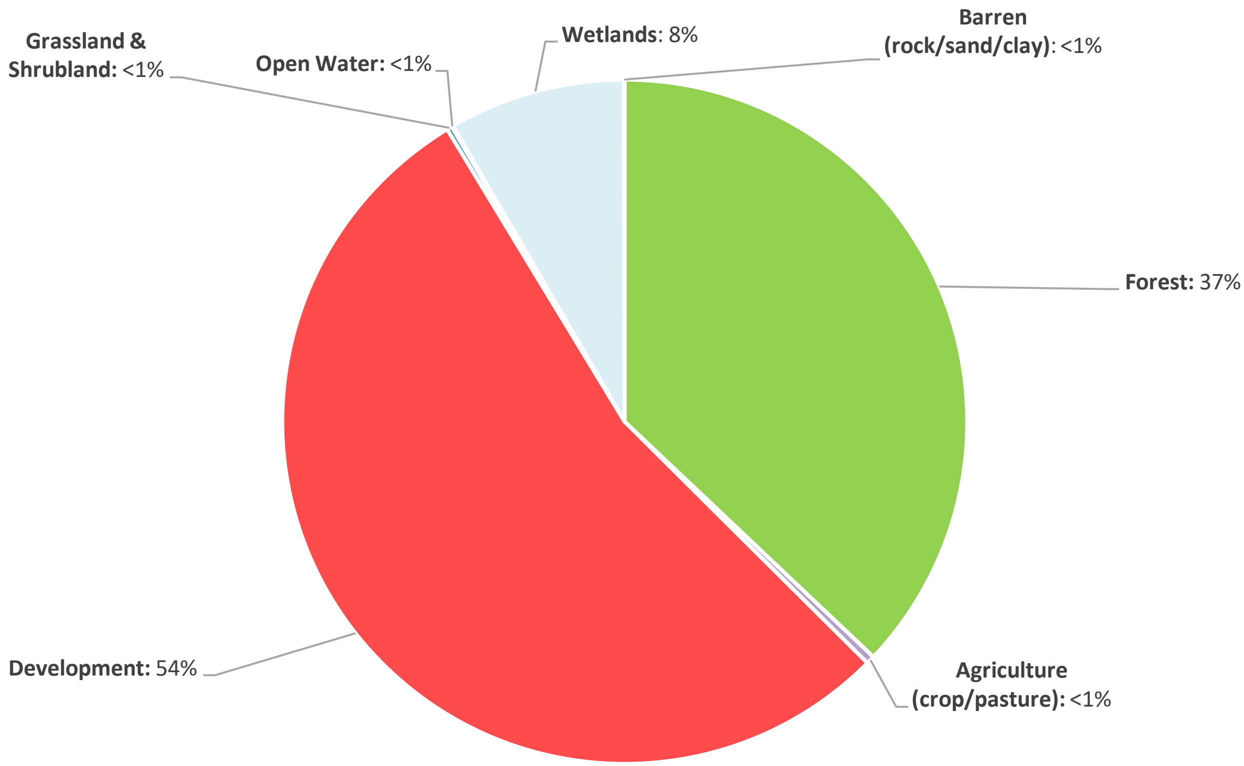


Figure 2-5: Land Cover within the Sparkill Creek Watershed

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 426 acres of wetlands in the Sparkill Creek watershed, or approximately 6 percent of the watershed. This amount is fairly close to the estimate above based on land cover and includes the following types of wetland habitats: estuarine, freshwater forest/shrub wetland, freshwater emergent wetland, freshwater pond, and riverine wetland. 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.

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.

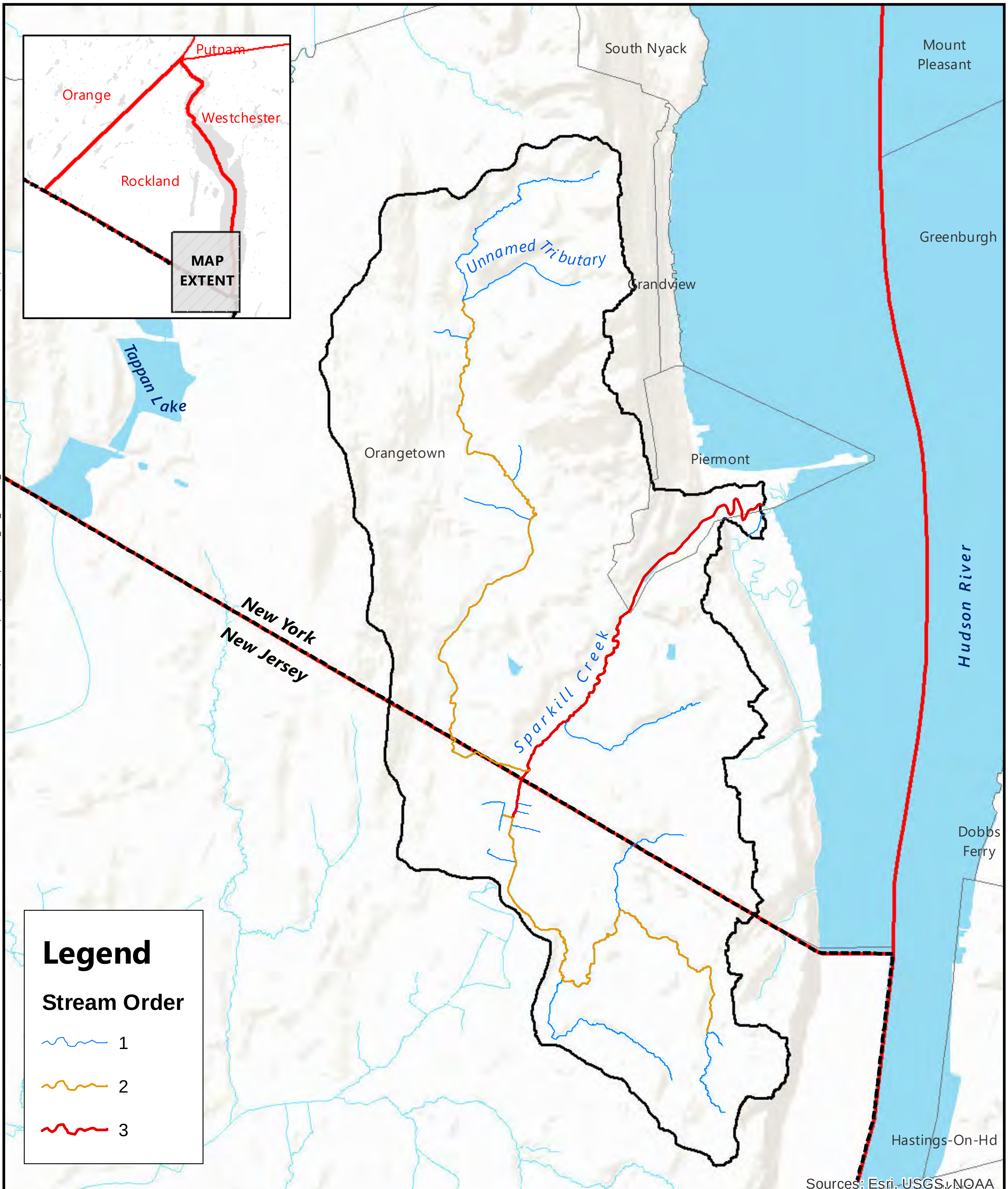
NYSDEC-mapped wetlands in the Sparkill Creek watershed include a 36-acre wetland located along Sparkill Creek just east of the interchange of the Palisades Interstate Parkway and Route 303; a 17.8-acre wetland to the south of the interchange of the Palisades Interstate Parkway and Route 303; and an 88.2-acre wetland located both upstream and downstream of where Sparkill Creek passes the Palisades Interstate

Parkway just south of Sparkill. Piermont Marsh, a 1,000-acre system of brackish tidal marsh, shallows, and intertidal flats, is located at the edge of the village of Piermont where Sparkill Creek meets the Hudson River Estuary (Figure 2-6). Coastal wetlands such as Piermont Marsh help to protect coastal communities from flooding and erosion by acting as a buffer to storm surges.

Figure 2-6: Piermont Marsh, a 1,000-Acre System of Brackish Tidal Marsh, Shallows, and Intertidal Flats at the Edge of the Village of Piermont Where Sparkill Creek Meets the Hudson River Estuary

2.2 SPARKILL CREEK WATERCOURSE

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. Sparkill Creek can be characterized as a second-order stream for much of its length as it flows southward through Orangetown. As Sparkill Creek bends to flow in a northeasterly direction at the state line, it is joined by Sparkill Brook, which enters from New Jersey, and becomes a third-order stream. It remains a third-order stream as it discharges to the Hudson River Estuary. Figure 2-7 is a map depicting stream order in the Sparkill Creek watershed.



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STREAM ORDER

SPARKILL CREEK FLOOD & RESILIENCY STUDY
SD115
ROCKLAND COUNTY
NEW YORK

N

0 2,000 4,000
Feet

SCALE 1 " = 4,500 '

DATE 11/12/2021

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FIG. 2-7

Characteristics of each order of stream (total length, average slope, and percentage of overall stream network) are summarized in Table 2-1. First- and second-order streams account for most of the overall stream length within the Sparkill Creek watershed (17.1 miles or 84 percent). First-order streams are steeper in slope than second-order streams, which are steeper than third order.

Table 2-1 Stream Order Characteristics in the Sparkill Creek Watershed

Stream Order	Total Length (miles)	Percentage of Overall Network Length (%)	Average Slope (%)
1st	9.1	45	2.4
2nd	8.0	39	0.8
3rd	3.2	16	0.5
Total	**20.3**	**100**	

2.3 HYDROLOGY

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

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.

A simplified diagram of the hydrologic cycle is presented in Figure 2-8.

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 snow pack or soil saturation, can impact the timing, duration, and severity of flooding.

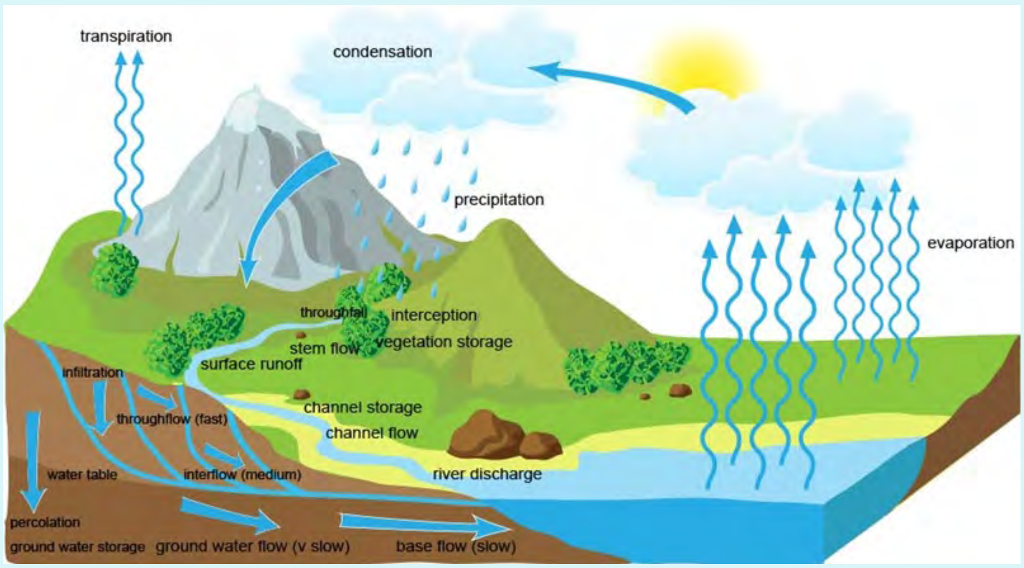

Figure 2-8: Diagram of Simplified Hydrologic Cycle

Flood hydrology for Sparkill Creek was taken from the FEMA effective Flood Insurance Study (FIS) for Rockland County (36087CV001A). The FEMA analysis is the most recently completed hydrologic analysis for Sparkill Creek; therefore, those computed peak flows were used for hydraulic analysis. Discharge estimates at various locations along the creek are reported in the FEMA FIS for the 10-, 50-, 100-, and 500-year floods based on regional regression equations developed for New York State detailed in USGS Scientific Investigations Report (SIR) 2006-5112, as well as the urban runoff regressions defined in USGS Water Supply Paper (WSP) 2207. Flood flows on Sparkill Creek are presented in Table 2-2.

Table 2-2: Flood Hydrology for Sparkill Creek Developed for the Rockland County FIS (36087CV001A)

Location	Drainage Area (sq. mi.)	Peak Flood Discharge (cfs)			
		10-Year	50-Year	100-Year	500-Year
STA 0+00, At confluence with Hudson River	13.00	660	1,050	1,300	2,716
STA 81+00, At corporate limits of the Village of Piermont	12.29	773	1,190	1,430	2,716
STA 175+00, Upstream of railroad at state boundary	5.61	974	1,566	1,888	2,716
STA 201+75, 200 feet downstream of Oak Tree Road	5.25	920	1,477	1,786	2,577
STA 245+50, Upstream of Route 303	4.57	796	1,282	1,555	2,236
STA 335+00, At State Route 303 upstream of Route 340	2.47	572	919	1,103	1,567
STA 340+00, At Orangeburg Road and Old School Lane	1.95	434	701	841	1,196
STA 390+00, Downstream of Spruce Street	0.86	341	451	495	605

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

Precipitation data were evaluated for two future scenarios, termed "Representative Concentration Pathways" (RCP), which provide estimates of the extent to which greenhouse gas concentrations in the atmosphere are likely to change through the 21st century. RCP refers to potential future emissions trajectories of greenhouse gases such as carbon dioxide. RCP 4.5 is considered a midrange-emissions scenario, and RCP 8.5 is a high-emissions scenario. Resulting precipitation and runoff estimates are based on five different climate models and are input into the USGS *StreamStats* program, a web-based implementation of regional hydrologic regression equations. Percent increases over *StreamStats* regression estimates based on current climatic data, as computed for the Sparkill Creek watershed, were applied to corresponding design flood flows in the FEMA hydraulic model at the flow change points along Sparkill Creek. The flows based on the more moderate greenhouse gas scenario RCP 4.5 were used in this analysis. Mean estimated increases for the 50- and 100-year floods based on the five climate models are presented in Table 2-3. These are based on regressions for Flood Frequency Region 2 in New York. Current and predicted future flows are compared in Table 2-4.

Table 2-3: Projected Increases in Flood Flows on Sparkill Creek

Mean Change in Discharge (%)	2025-2049		2050-2074		2075-2099	
Greenhouse Gas Scenario	50-Year Flood	100-Year Flood	50-Year Flood	100-Year Flood	50-Year Flood	100-Year Flood
RCP 4.5	15	15	18	19	16	17
RCP 8.5	15	15	16	17	22	23

Table 2-4: Current and Projected Future Flood Flows Used in Hydraulic Analyses on Sparkill Creek

Location	Peak Flood Discharge (cfs)			
	Current		Projected Future	
	50-Year	100-Year	50-Year	100-Year
STA 0+00, At confluence with Hudson River	1,050	1,300	1,208	1,495
STA 81+00, At corporate limits of Village of Piermont	1,190	1,430	1,369	1,645
STA 175+00, Upstream of railroad at state boundary	1,566	1,888	1,801	2,171
STA 201+75, 200 feet downstream of Oak Tree Road	1,477	1,786	1,699	2,054
STA 245+50, Upstream of Route 303	1,282	1,555	1,474	1,788
STA 335+00, At State Route 303 upstream of Route 340	919	1,103	1,057	1,268
STA 340+00, At Orangeburg Road and Old School Lane	701	841	806	967
STA 390+00, Downstream of Spruce Street	451	495	519	569

Hudson River flood elevation estimates were obtained from the effective FIS for Rockland County, shown in Table 2-5. Projected sea-level rise in the estuary was based on New York State Sea-level Rise Projections (6 NYCRR Part 490) that were developed in accordance with the Community Risk and Resiliency Act to help prepare for the coastal impacts of climate change. Projected increases in sea level in the Hudson River Estuary within the "Lower Hudson" region, where Sparkill Creek is located, are reproduced below as Table 2-6. These are predicted increases over the baseline of the average elevation measured from 2000 to 2004. Several scenarios are possible, ranging from less to more severe; however, "while there is some uncertainty regarding the precise rate at which sea level will rise, there is relative certainty that global sea level will ultimately rise at least six feet over current levels" (6 NYCRR Part 490). For the purpose of this analysis, Hudson River tailwater elevations used in hydraulic modeling of future flood scenarios on Sparkill Creek were increased by 16 inches over the elevations reported in the current effective FIS. This represents the "medium" sea level rise scenario for the 2050s time period.

Table 2-5: Stillwater Flood Elevations in Hudson River Estuary as Reported in FIS for Rockland County

Flood Event	Stillwater Flood Elevations (feet, NAVD88)
10-Year	5.1
50-Year	6.1
100-Year	6.7
500-Year	7.9

Table 2-6: New York State Sea-Level Rise Projections, Lower Hudson River Estuary (from 6 NYCRR 490)

	Projected Sea Level Rise in the Lower Hudson/NYC Region (inches)				
Projection Scenario	Low	Low-Medium	Medium	High-Medium	High
2020s	2	4	6	8	10
2050s	8	11	16	21	30
2080s	13	18	29	39	58
2100	15	22	36	50	75

2.4 HYDRAULICS

To develop hydraulic modeling to assess flood mitigation alternatives, effective FEMA HEC-RAS hydraulic models were sought for Sparkill Creek. The model was obtained from the NYSDEC, Floodplain Management Section, Bureau of Flood Protection and Dam Safety, which is gratefully acknowledged.

Hydraulic analyses on Sparkill Creek 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 of flow through the channel. The momentum equation is used in situations where the water surface profile is rapidly varied such as hydraulic jumps, mixed-flow regime calculations, hydraulics of dams and bridges, and evaluating profiles at a river confluence.

Stream crossings over Sparkill Creek where a FEMA HEC-RAS model was unavailable were modeled with the Federal Highway Administration's *HY-8 Culvert Hydraulics Analysis Program* (Version 7.60; FHWA 2019). This software 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.

2.5 STAKEHOLDER MEETINGS

An important component of the data gathering for this study took place through stakeholder engagement. Two formal stakeholder meetings have been convened by video conference call. The first meeting was held on December 15, 2020. This meeting was geared toward participation by government agencies, county, and municipal staff and included participation from NYSDEC, OGS, Rockland County, and watershed towns. The second meeting was held on the evening of February 4, 2021, with participation from members of watershed groups. In addition to the formal video conferences, many one-on-one conversations took place with representatives from the watershed municipalities and groups.

2.6 INFRASTRUCTURE

Sparkill Creek flows through many bridges and culvert. These structures and summary details are listed below in Table 2-7. Many of the listed crossings fail to span the estimated bankfull width of the watercourse, indicating that they may be hydraulically undersized and may contribute to flooding. NYSDEC stream crossing guidance indicates that stream crossings should have a span of at least 1.25 times the watercourse's bankfull width.

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.
- Hydrologic analysis will include an evaluation of future predicted flows.

- Headwater at culverts will be limited to an elevation that:
    - o Would not result in damage to upland property,
    - o Would not increase the water surface elevation allowed by floodplain regulations, and
    - o 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 require that the following best management guidelines will be incorporated:

- Provide a minimum opening width of 1.25 times the bankfull width of the waterway in the vicinity of the crossing.
- Use open-bottom or embedded, closed-bottom structures, which allow 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.

In this analysis, proposed replacement stream crossings were assessed based on the flood flows the structure would be expected to encounter over its design lifetime. When modeling culverts, the 2050-2074 projections were employed, as a 50-year design life is typical for such structures; the 2075-2099 projections were used for bridges, which are often in service for 75 to 100 years or more.

Table 2-7: Summary Data for Assessed Bridge and Culvert Crossings of Sparkill Creek

Roadway	Structure	Primary Owner	NBI BIN*	River Station (feet)	Number of Spans/ Barrels	Total Span (feet)	Rise Above Streambed (feet)	Bankfull Width (feet) (Regional Regressions)
Ferdon Avenue	Timber Slab Bridge	Rockland County	3346080	38+53	4	47.5	8.3	48.5
Rockland Avenue	Masonry Arch Bridge	Village of Piermont	3224170	51+70	1	18	10.7	48.5
Valentine Avenue	Concrete Arch Bridge	New York State Department of Transportation	1091550	80+65	1	27.5	7.6	48.1
William Street	Concrete Tee Beam Bridge	Rockland County	3346070	82+59	1	29.5	8.1	48.1
Palisade Interstate Parkway	Concrete Culvert	Palisades Interstate Parkway Commission	1068549	126+26	1	21.7	9.4	47
Oak Tree Road	Concrete Arch Bridge	Rockland County	3346090	149+24	1	29.5	7.1	47
Railroad		CSX Transportation	Not Listed	165+00	1	38.5	5.8	47
Oak Tree Road	Concrete Box Beam Bridge	Town of Orangetown	2271060	201+85	1	40	7.0	39
Pedestrian Bridge			Not Listed					
Washington Street	Concrete Box Girder Bridge	Rockland County	3346060	209+25	1	18	5.8	39
Kings Highway	Concrete Girder Bridge	Town of Orangetown	2224130	219+44	1	22	6.0	39
State Route 303	Concrete Culvert	New York State Department of Transportation	1045350	245+93	2	11	8.5	37.5
Palisade Interstate Parkway (Southbound)	Concrete Culvert	Palisades Interstate Parkway Commission	1068591	257+85	1	27	9.5	37.5
Palisade Interstate Parkway (Northbound)	Concrete Culvert	Palisades Interstate Parkway Commission	1068592	259+27	1	27	9.5	37.5

Roadway	Structure	Primary Owner	NBI BIN*	River Station (feet)	Number of Spans/ Barrels	Total Span (feet)	Rise Above Streambed (feet)	Bankfull Width (feet) (Regional Regressions)
Rail Trail Bridge		Norfolk Southern Railway Co.	Not Listed	285+78				
Rockland County Sewer Facility Bridge		Not Listed	Not Listed	324+19	1	22.0	10	31.1
Route 340	Round Corrugated Metal Pipe Culverts	Not Listed	Not Listed	330+71	4	5	5	31.1
Route 303	Concrete Slab Bridge	New York State Department of Transportation	1045370	335+00	1	21.8	9	31.1
Old School Lane/ Orangeburg Road	Concrete Culvert	Rockland County	3364730	340+00	2	30.4	8.3	31.1
Innovative Plastics Private Bridge	Concrete Slab Bridge	Private	N/A	344+65	1	16.1	4.7	31.1
Mountain View Avenue		Not Listed	Not Listed	354+56	1	17.4	4.8	31.1
Route 303	Concrete Slab Bridge	New York State Department of Transportation	1045380	356+55	1	20.4	5.3	31.1

*NBI BIN = National Bridge Inventory Bridge Identification Number

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 Sparkill Creek watershed. The flood history is summarized from the FEMA FIS for Rockland County and the Rockland County Multi-Jurisdictional Hazard Mitigation Plan.

Table 3-1 Sparkill Creek Flood History

Date	Flood Event	Notes
1863 to 1915	Four unnamed tropical storms	
1972	Tropical Storm Agnes	
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.
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 Depressions 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 Depressions by the time it reached Rockland County

Date	Flood Event	Notes
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 Depressions by the time it reached Rockland County
August and September, 2011	Tropical Storm Irene and Tropical Storm Lee	Hurricane Irene formed from a tropical wave on August 21, 2011, in the tropical Atlantic Ocean. It moved west-northwestward, 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 on 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 Over 30,000 people were affected by boil water notices in Rockland County from both Hurricane Irene and Tropical Storm Lee. A total of five wastewater and sewage treatment facilities experienced overflow, bypass, or inundation during Hurricane Irene. Over 30 facilities in New York State (NYS) released untreated wastewater into tributaries or the Hudson itself. Rockland County had three municipalities with 67 percent to 90 percent of its residents without power as of 8:30 a.m. on August 29, 2011. Twenty-three municipalities had 34 percent to 66 percent of their residents without power. The rest of the municipalities in the county either had 11 percent to 33 percent or 1 percent to 10 percent of their people without power. According to direct measures compiled by the Hudson River Estuary Program and NYSDEC, the costs from Hurricane Irene and Tropical Storm Lee amounted to $27,909,828.44 in Rockland County. That includes estimated storm recovery costs, expenditures from Project Hope (crisis counseling for residents impacted by Hurricane Irene), FEMA individual assistance aid, and costs of spill response and cleanup.
October 29, 2012	Hurricane Sandy	Hurricane Sandy was the deadliest and most destructive hurricane of the 2012 Atlantic hurricane season, as well as the second-costliest hurricane in United States history. 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.

There are no active USGS stream gauges on Sparkill Creek. Annual peak flow on the nearby Hackensack River, recorded at Rivervale, New Jersey, since 1942 at USGS gauge 01377000 provides a useful view of flood events. 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. Two flood events stand out: the April 2007 nor'easter and the August 2011 Tropical Storm Irene. Both events exceeded the 100-year flood at Rivervale.

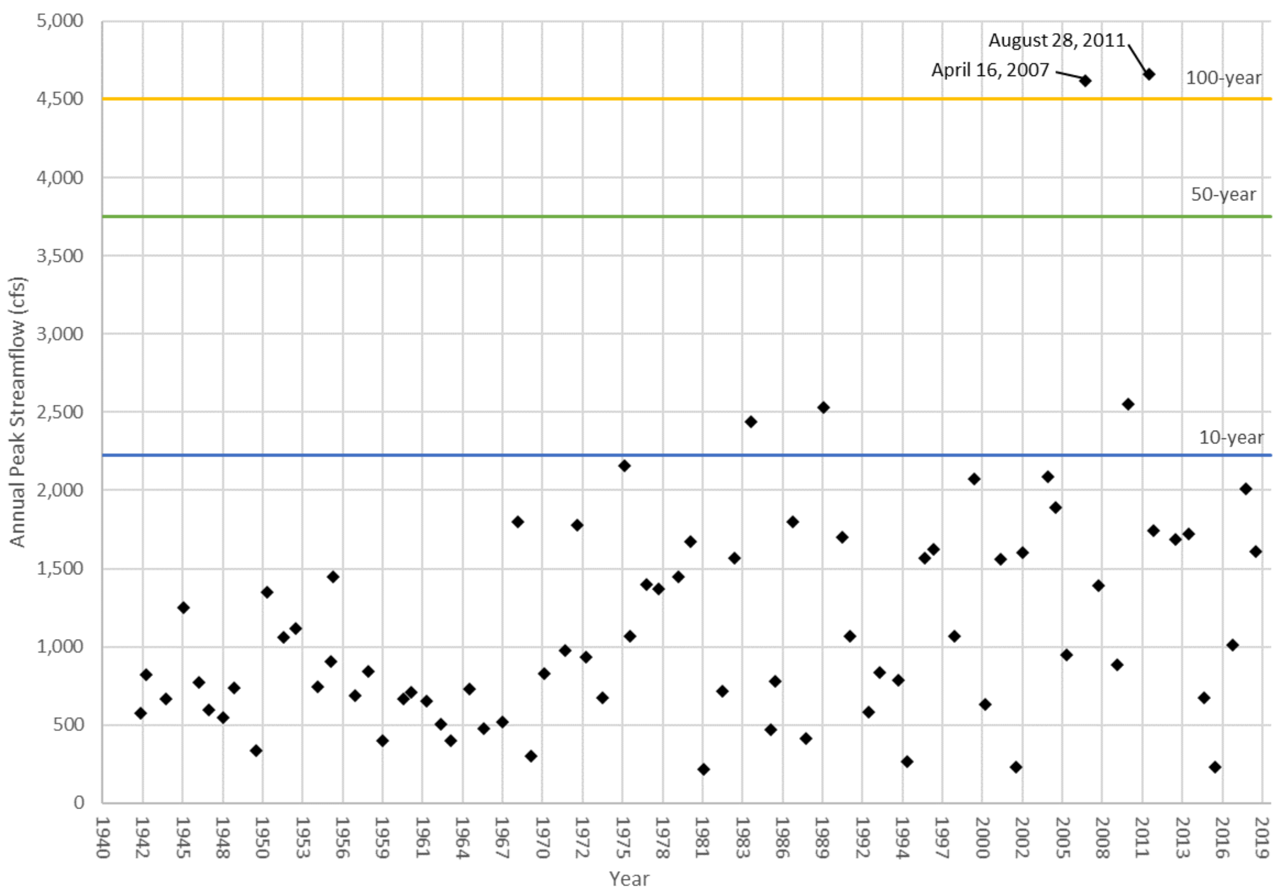

Figure 3-1: Hydrograph of Annual Peak Flow on the Nearby Hackensack River at Rivervale, New Jersey 1942 – 2018

Annual peak flow on the nearby Mahwah River, recorded at Suffern since 1959, also provides a useful view of local flood magnitude. Figure 3-2 is a hydrograph showing annual peak flows with flood recurrence information superimposed. The August 2011 Tropical Storm Irene exceeded the 100-year flood at Suffern. Based on these two records of peak flows from nearby watercourses, it can be estimated that peak flows on Sparkill Creek were near the 100-year flood event.

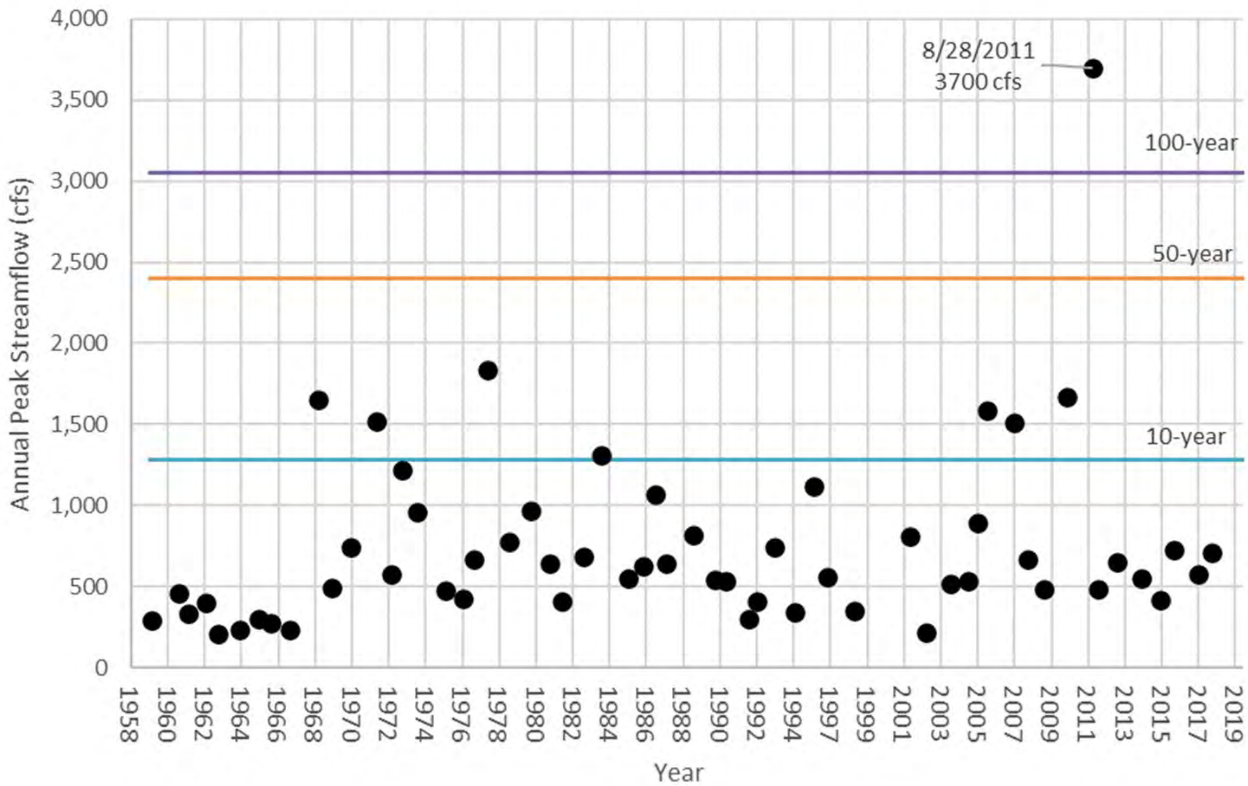

Figure 3-2: Hydrograph of Annual Peak Flow on the Nearby Mahwah River at Suffern, New York 1959 – 2018

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. Effective FIRM panels for Sparkill Creek from Orangeburg downstream to the Hudson River were produced based on hydraulic modeling completed in 2011 under Contract No. DOS1427 for NYSOGS. The flood hazard areas delineated by FEMA are mapped in each of the HRAs illustrated in Figure 3-3 through Figure 3-10. Each figure shows the 100-year flood hazard areas computed with both the current flows and predicted future flows for the upcoming 25-year period (2025-2049) as defined earlier in this report. 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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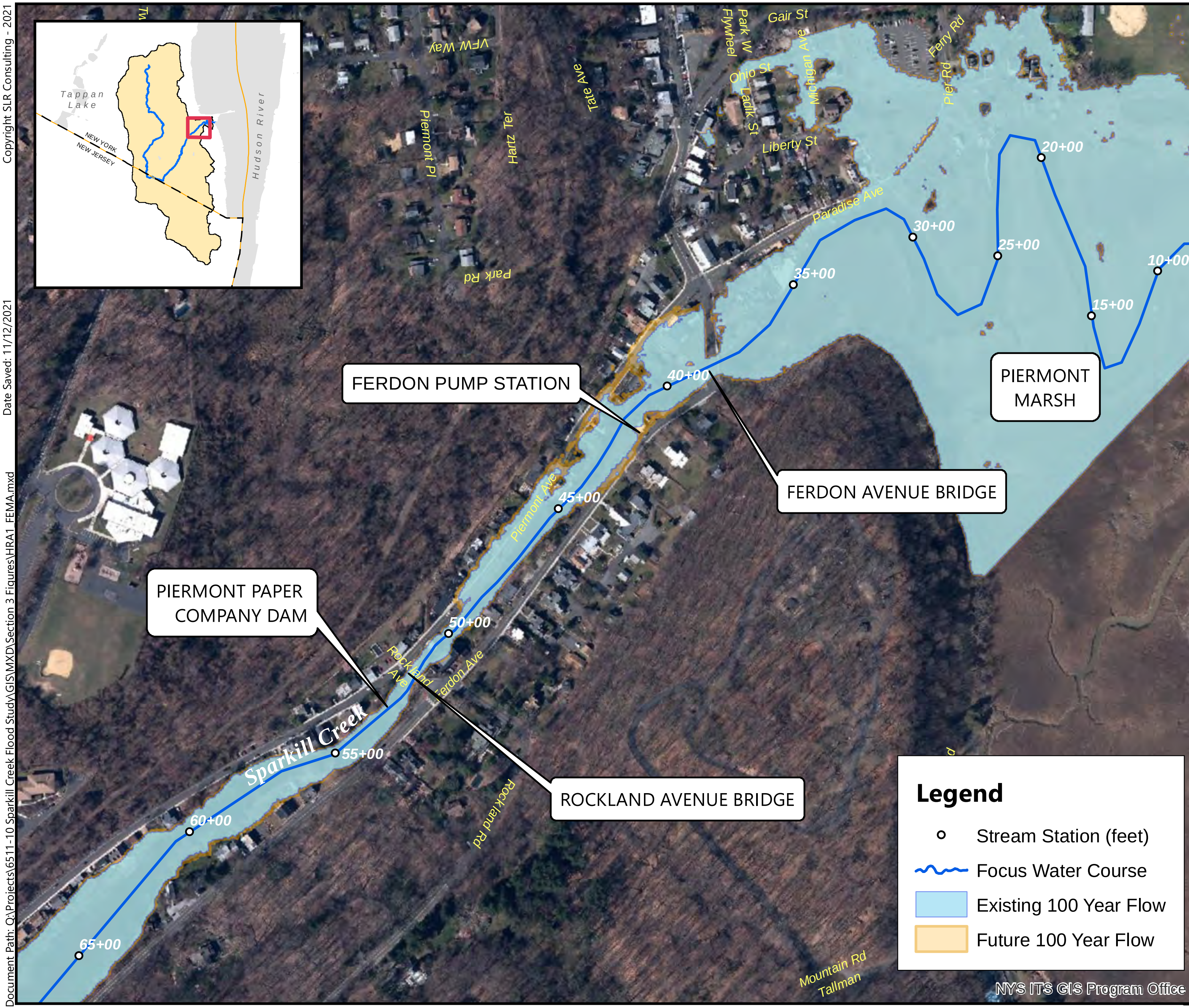

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SLR
231 MAIN STREET
SUITE 102
NEW PALTZ, NY 12561
845.633.8153

HIGH RISK AREA #1 - FEMA MAPPING

SPARKILL CREEK FLOOD & RESILIENCE STUDY

SD115

ROCKLAND COUNTY
NEW YORK

SCALE 1 " = 400 '

DATE 11/15/2021

PROJ. NO. 16511.00010

FIG. 3-3

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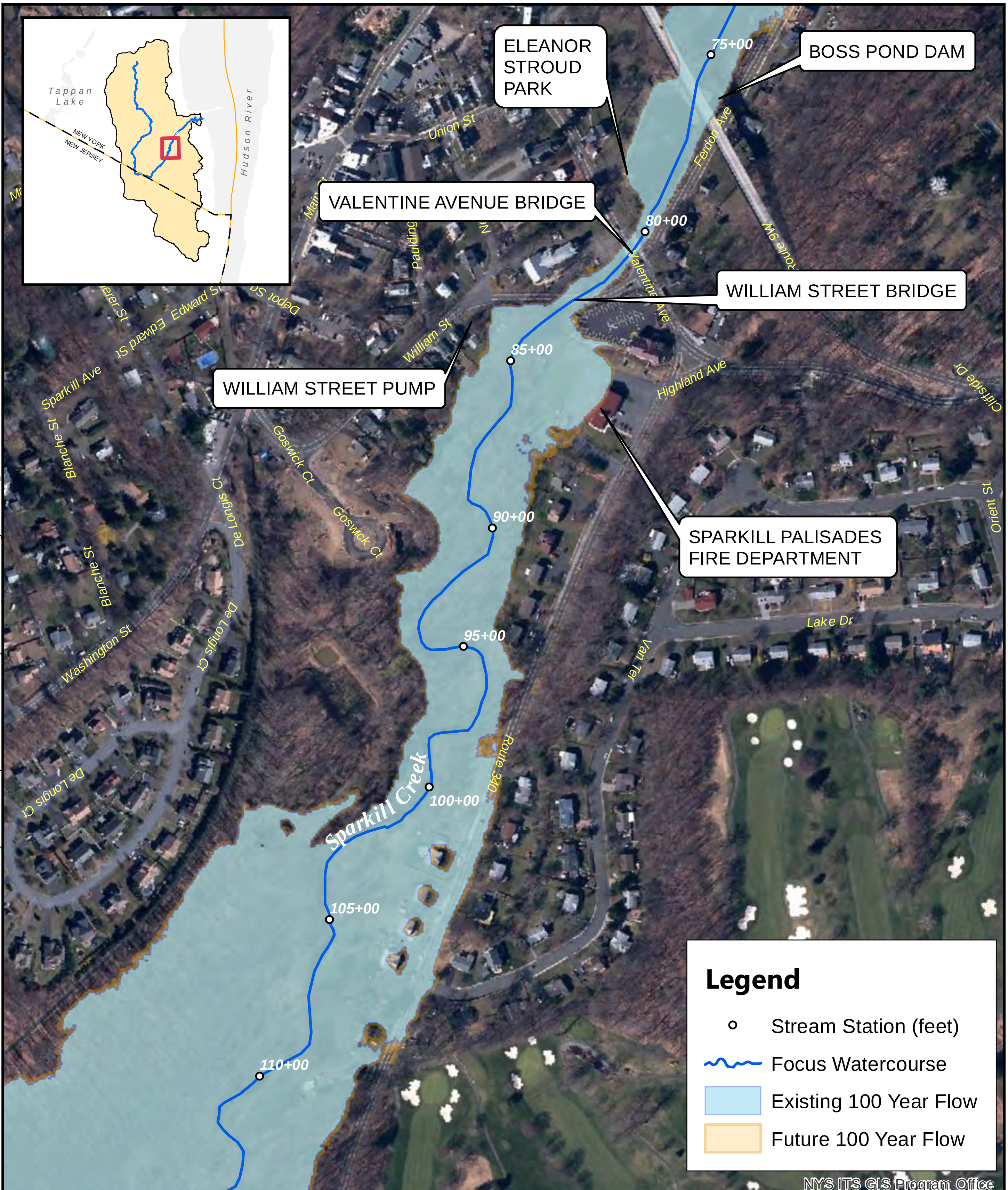

SLR

231 MAIN STREET
SUITE 102
NEW PALTZ, NY 12561
845.633.8153

HIGH RISK AREA #2 - FEMA MAPPING

SPARKILL CREEK FLOOD & RESILIENCE STUDY
SD115
ROCKLAND COUNTY
NEW YORK

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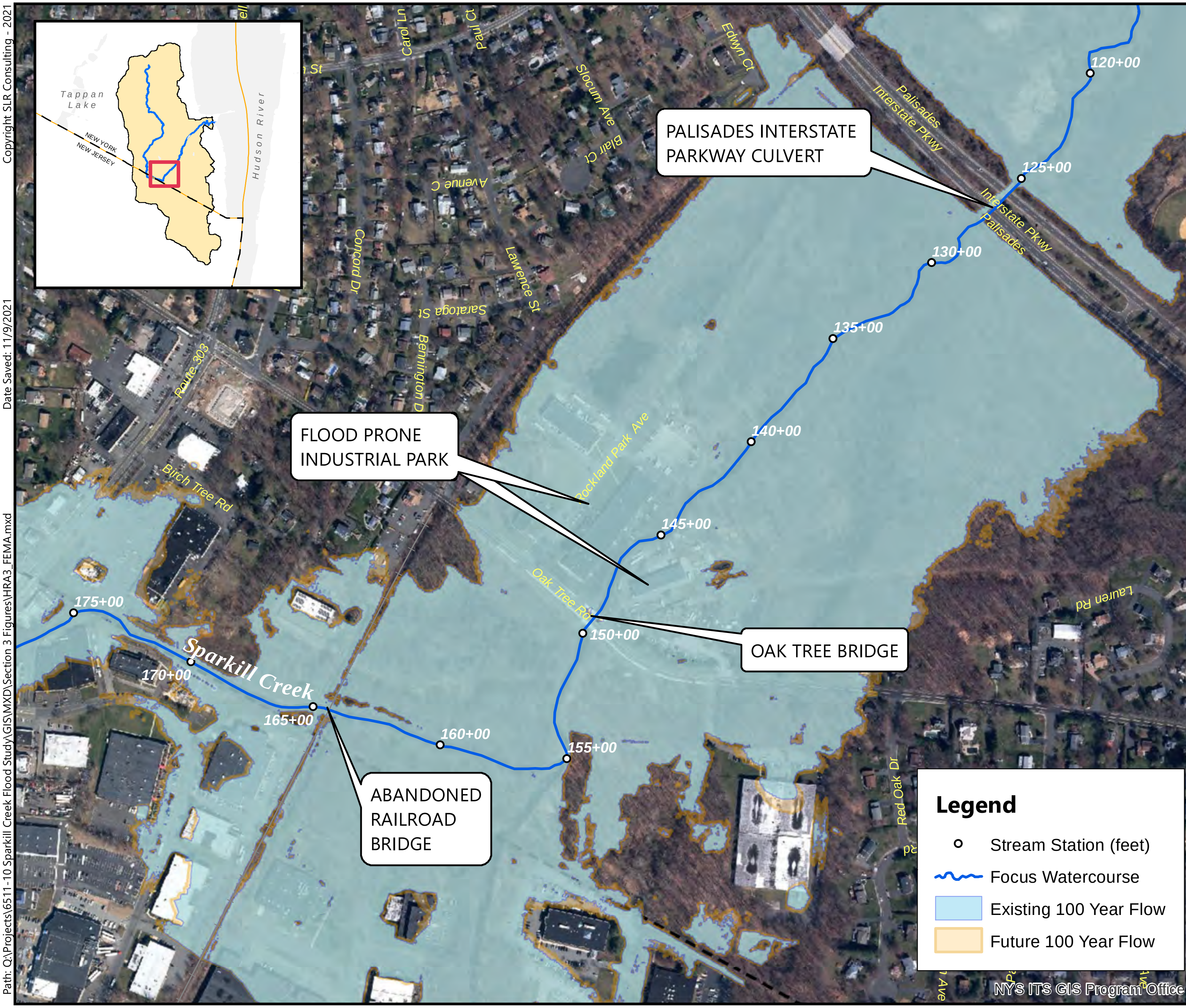
SCALE 1 " = 350 '

DATE 11/9/2021

PROJ. NO. 16511.00010

FIG. 3-4

SOURCE: 2016 AERIAL PHOTO, NYS ITS GIS Program Office



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231 MAIN STREET
SUITE 102
NEW PALTZ, NY 12561
845.633.8153

HIGH RISK AREA #3 - FEMA MAPPING
SPARKILL CREEK FLOOD & RESILIENCE STUDY
SD115
ROCKLAND COUNTY
NEW YORK

SCALE 1 " = 500 '
DATE 11/9/2021
PROJ. NO. 16511.00010

FIG. 3-5

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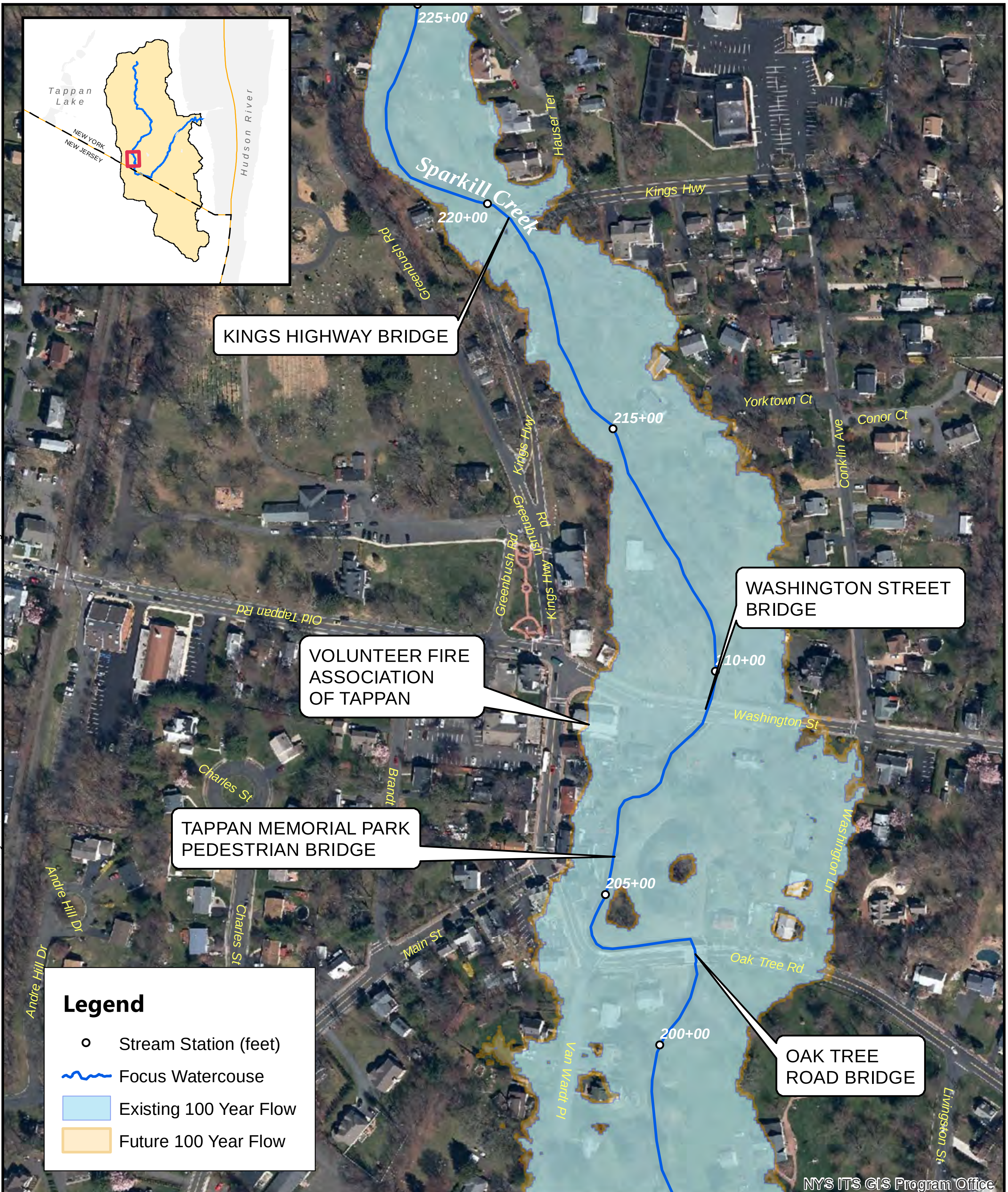

SLR
231 MAIN STREET
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NEW PALTZ, NY 12561
845.633.8153

HIGH RISK AREA #4 - FEMA MAPPING

SPARKILL CREEK FLOOD & RESILIENCE STUDY
SD115
ROCKLAND COUNTY
NEW YORK

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Feet

SCALE 1 " = 250 '
DATE 11/9/2021
PROJ. NO. 16511.00010

FIG. 3-6

SOURCE: 2016 AERIAL PHOTO, NYS ITS GIS Program Office

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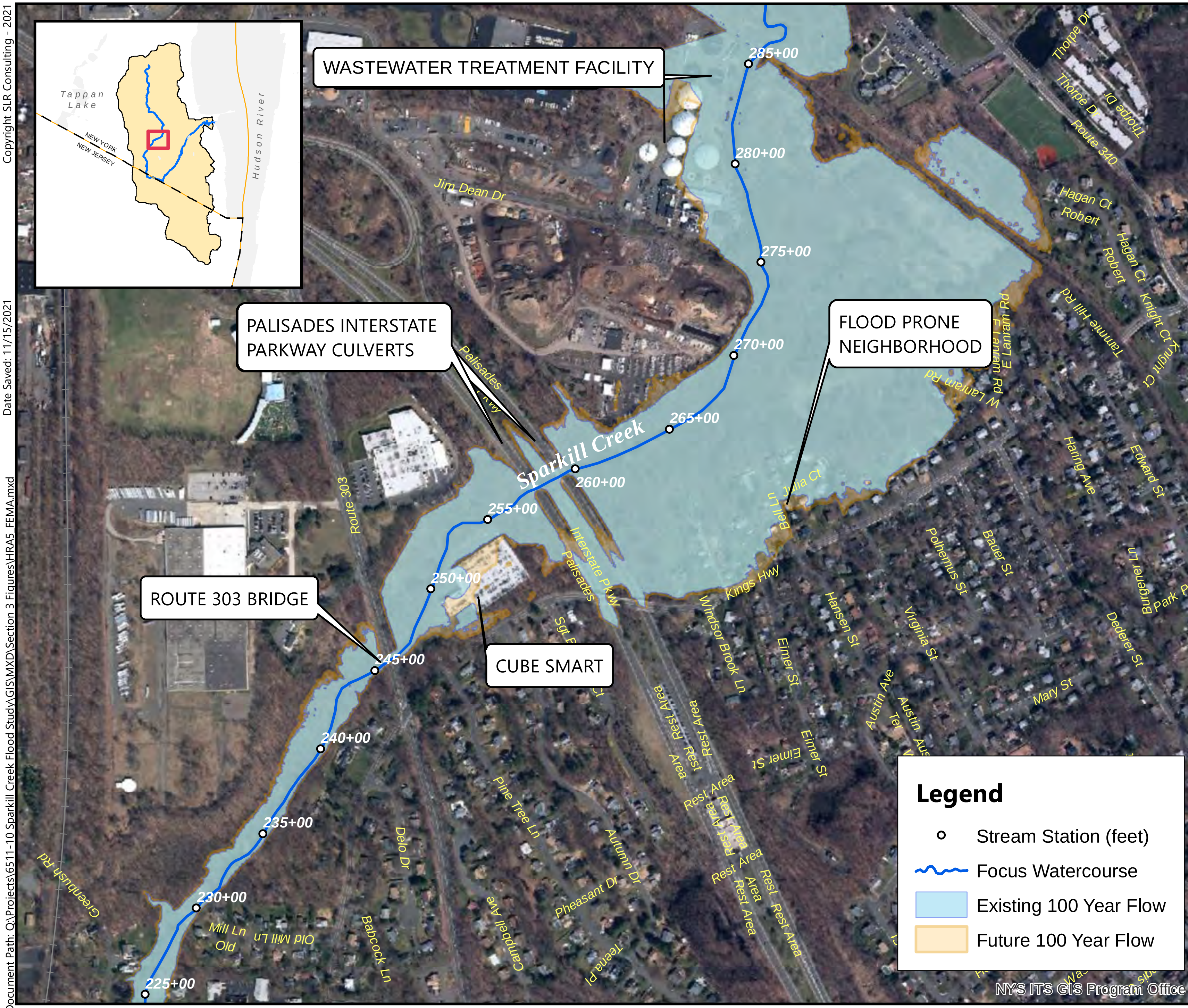

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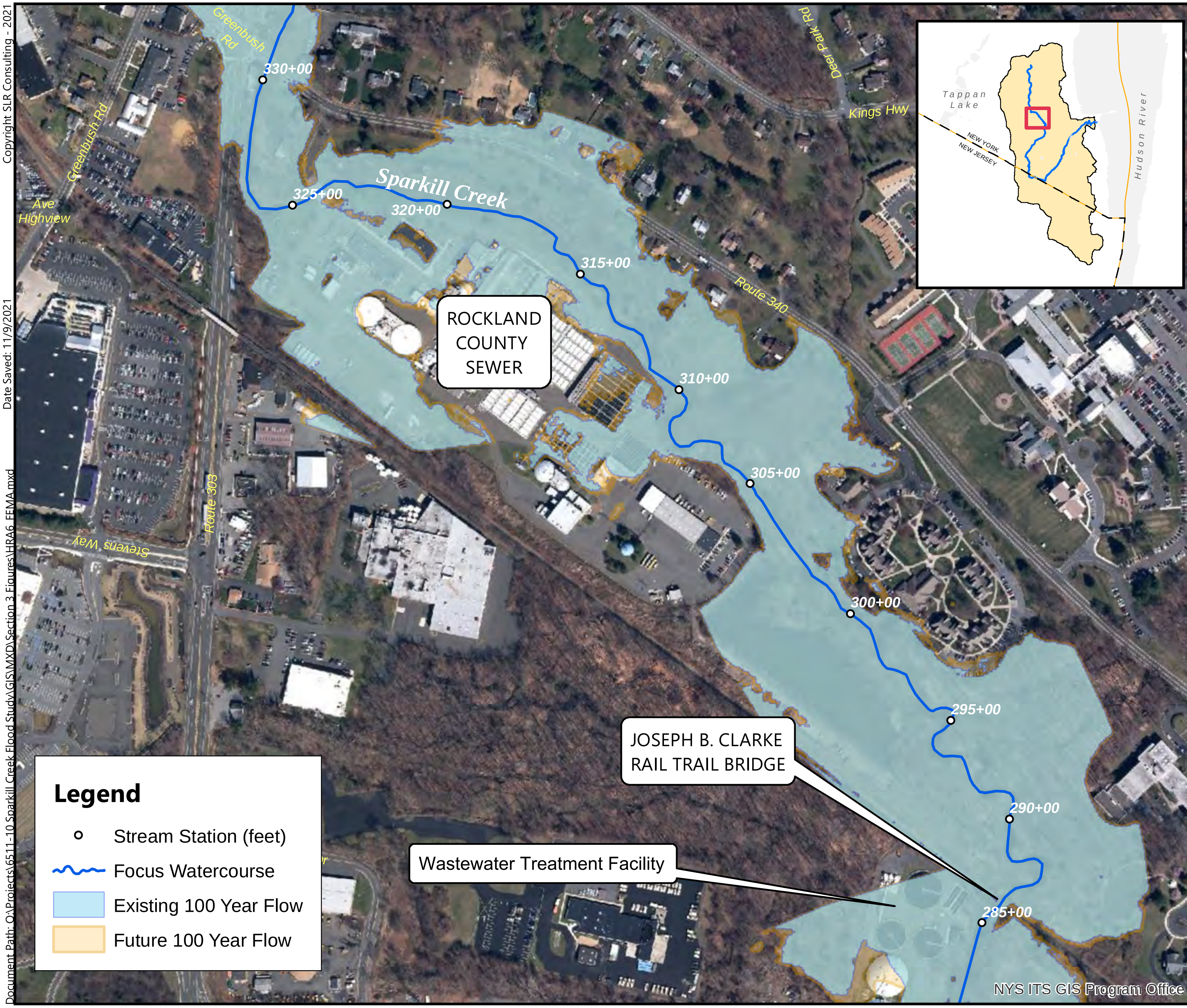
231 MAIN STREET
SUITE 102
NEW PALTZ, NY 12561
845.633.8153

HIGH RISK AREA #5 - FEMA MAPPING
SPARKILL CREEK FLOOD & RESILIENCE STUDY
SD115
ROCKLAND COUNTY
NEW YORK

SCALE 1 " = 650 '
DATE 11/15/2021
PROJ. NO. 16511.00010

FIG. 3-7



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HIGH RISK AREA #6 - FEMA MAPPING
SPARKILL CREEK FLOOD & RESILIENCE STUDY
SD115
ROCKLAND COUNTY
NEW YORK

SCALE 1 " = 400 '

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FIG. 3-8

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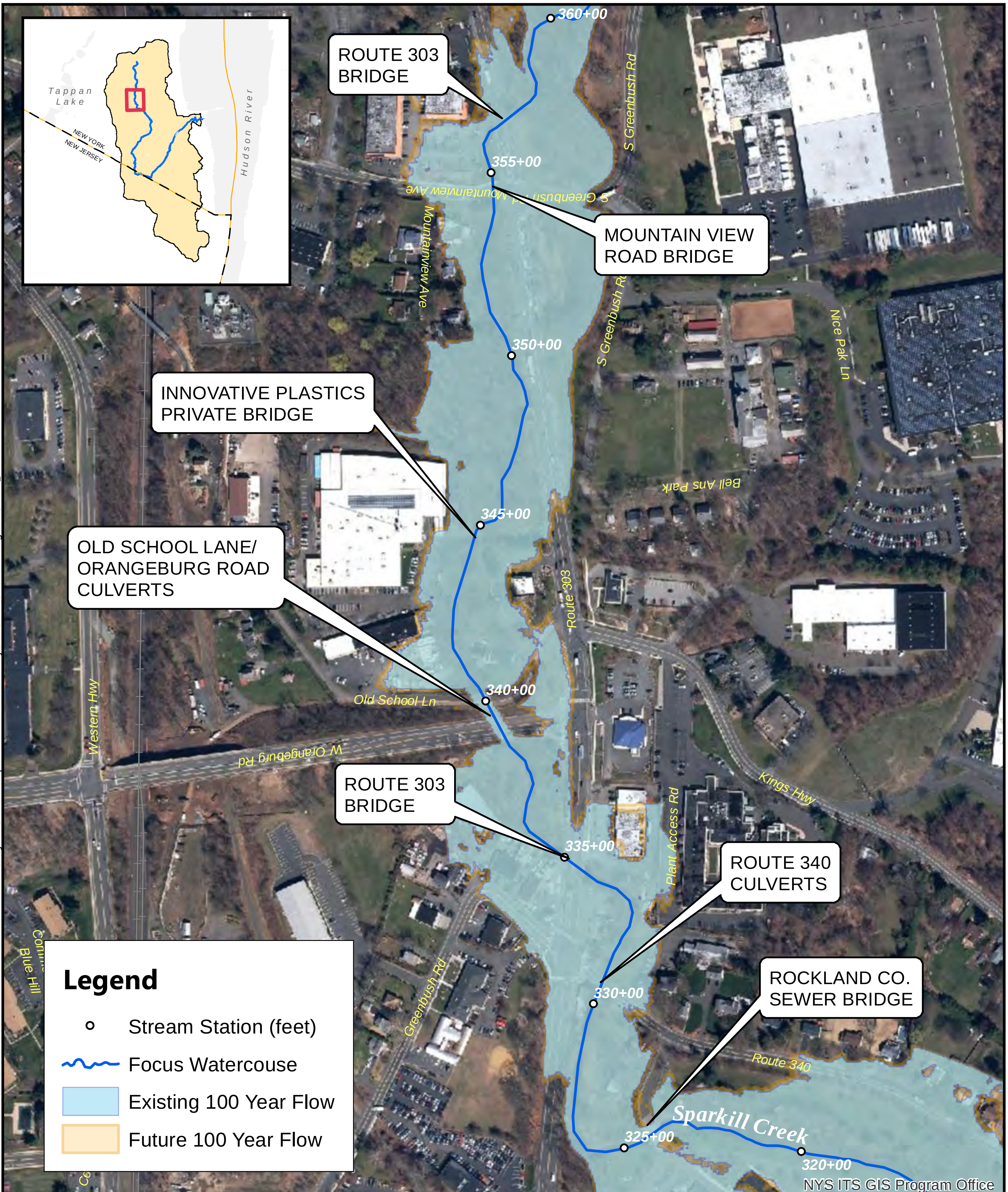

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HIGH RISK AREA #7 - FEMA MAPPING

SPARKILL CREEK FLOOD & RESILIENCE STUDY
SD115
ROCKLAND COUNTY
NEW YORK

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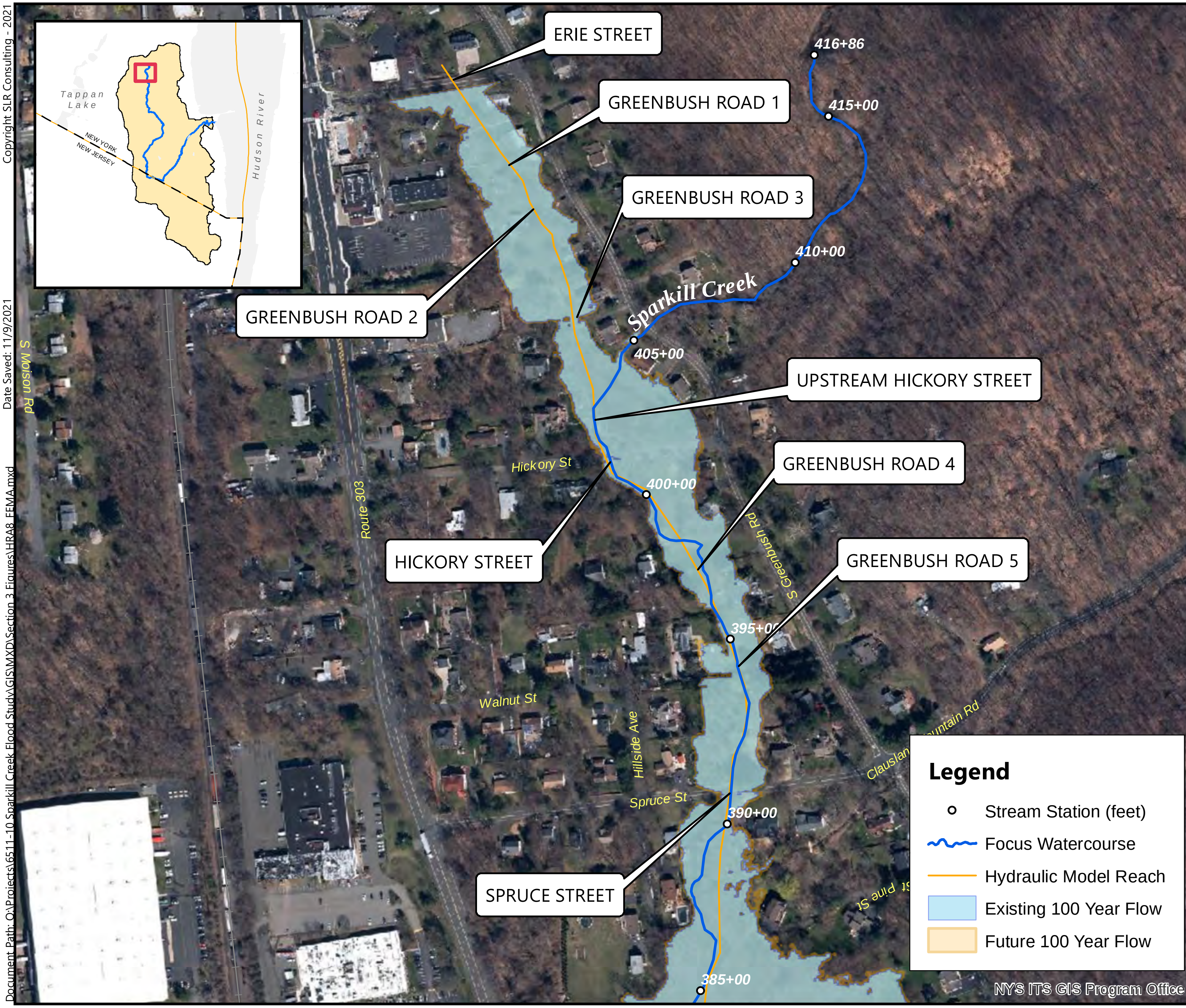
SCALE 1 " = 350 '

DATE 11/9/2021

PROJ. NO. 16511.00010

FIG. 3-9

SOURCE: 2016 AERIAL PHOTO, NYS ITS GIS Program Office



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231 MAIN STREET
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NEW PALTZ, NY 12561
845.633.8153

HIGH RISK AREA #8 - FEMA MAPPING

SPARKILL CREEK FLOOD & RESILIENCE STUDY

SD115

ROCKLAND COUNTY
NEW YORK

SCALE 1 " = 350 '

DATE 11/9/2021

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FIG. 3-10

4. FLOOD MITIGATION ANALYSIS

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

4.1 HIGH RISK AREA #1 – VILLAGE OF PIERMONT

HRA 1 includes the downstreammost section of Sparkill Creek, in the village of Piermont close to the confluence with the Hudson River Estuary, from station (STA) 35+00 to STA 55+00 (Figure 4-2). The watershed of the creek at this location is over 11 square miles. Water surface elevations in the creek in HRA 1 are influenced by the diurnal tidal cycle of the Hudson River Estuary. Flooding in HRA 1 can be exacerbated by tidal surges and when flood events on Sparkill Creek coincide with the high tide. Data collected by FEMA indicates that, as of 2019, 16 properties in Piermont were identified as repetitive loss or severe repetitive loss. Most of these properties are located along Paradise Avenue, Liberty Street, and Piermont Avenue.

A sanitary pump station is located in HRA 1 on Ferdon Avenue in Piermont, which feeds to the sewer outfall located in the Hudson River channel. The Village of Piermont Department of Public Works, a critical facility, is located along Piermont Avenue. Vehicle crossings over Sparkill Creek in HRA 1 include Rockland Road (owned by Village of Piermont) and Ferdon Avenue (owned by Rockland County). The historic Bridge Street bridge spans the creek as a pedestrian bridge just upstream of the Ferdon Avenue bridge (Figure 4-3). The Rockland Road bridge spans 20 feet; its North Atlantic Aquatic Connectivity Collaborative (NAACC) crossing code is *xy4103504773919177*, and it has an aquatic passability score of 0.99 out of 1.0: an *insignificant barrier*. The Ferdon Avenue bridge spans 47.5 feet; its NAACC crossing code is *xy4103757973915817*, and it has an aquatic passability score of 0.99 out of 1.0: an *insignificant barrier*. Just 45 feet upstream of the Rockland Road bridge, there is a former hydroelectric dam registered in the NYS dam inventory as the Piermont Paper Company Dam. The structure is a Hazard Code A, low hazard, dam constructed in 1910. It measures 8 feet heigh, 70 feet long and has a 50-foot-wide spillway.

> The extent and depth of flooding along the lower section of Sparkill Creek through Piermont is highly dependent upon the tidal stage on the Hudson River Estuary at the time that peak flood flow occurs on Sparkill Creek.

Hydraulic analyses were conducted under a range of flood flows on Sparkill Creek and under a range of tidal conditions in the Hudson River Estuary. The analyses indicate that the severity of flooding in HRA 1 and the ability of the bridges that span Sparkill Creek to safely convey flood events without overtopping are highly dependent on the tidal stage in the Hudson River Estuary at the time when peak flow occurs on Sparkill Creek.

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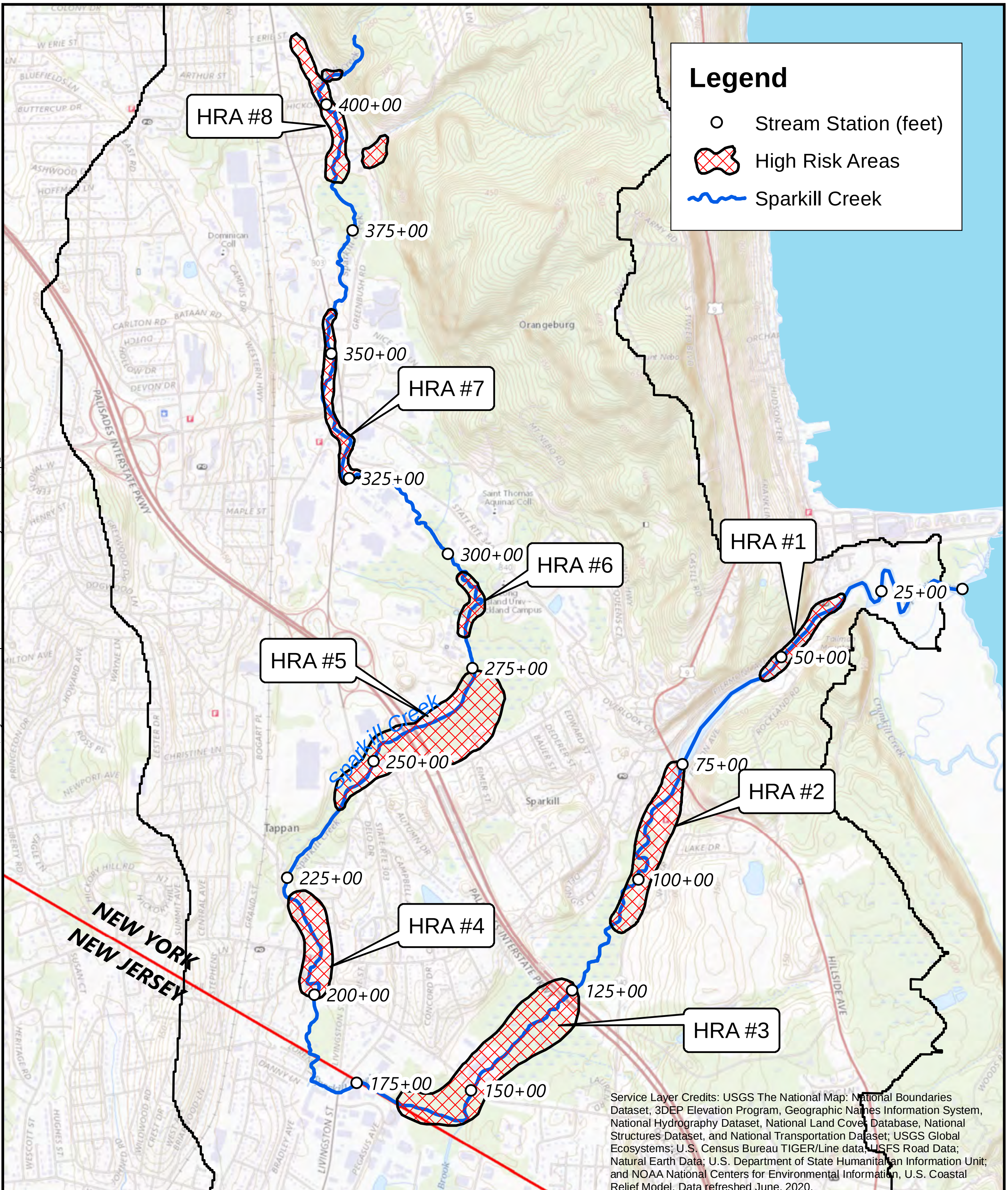

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231 MAIN STREET
SUITE 102
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SPARKILL CREEK HIGH RISK AREAS

SPARKILL CREEK FLOOD & RESILIENCE STUDY
SD115
ROCKLAND COUNTY
NEW YORK

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FIG. 4-1

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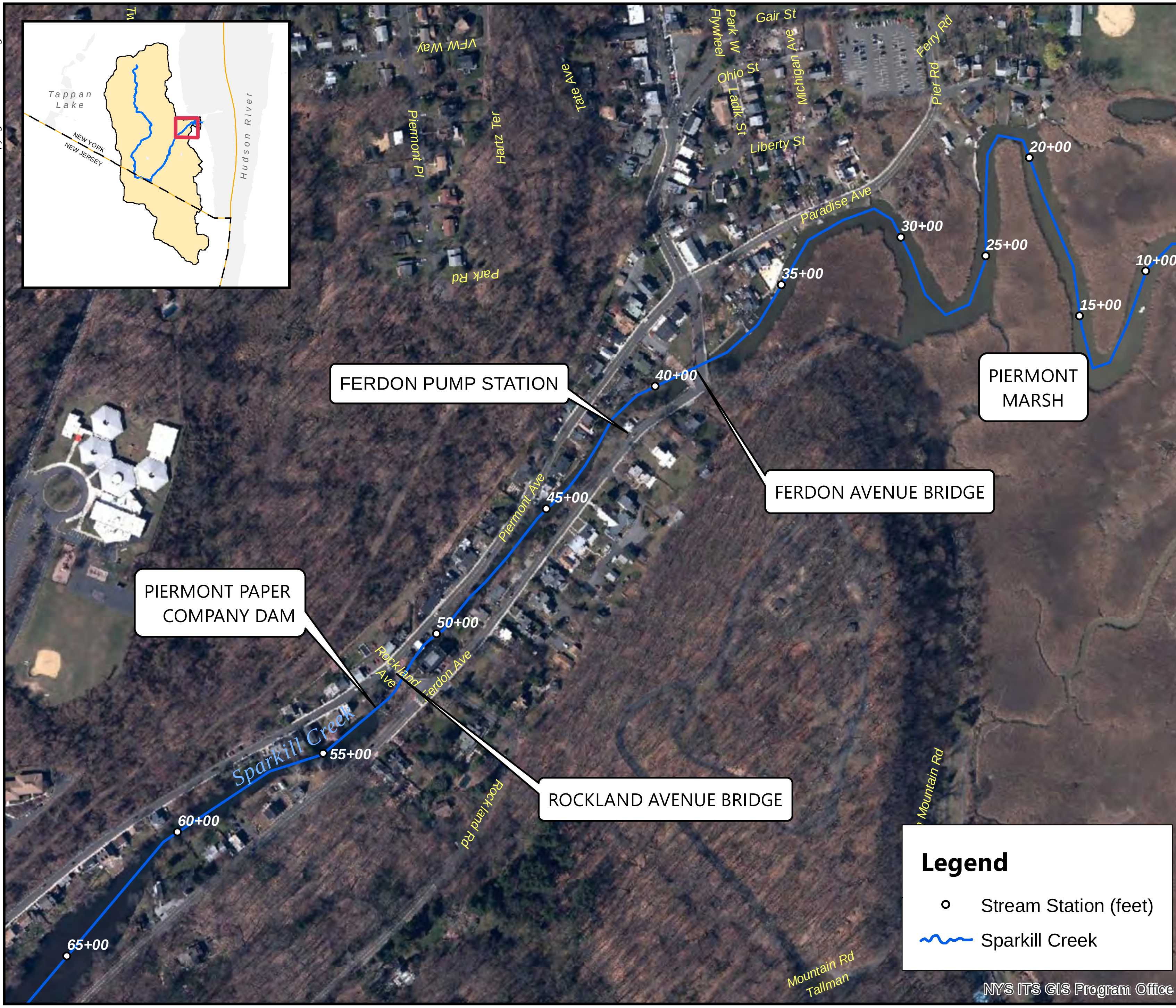

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231 MAIN STREET
SUITE 102
NEW PALTZ, NY 12561
845.633.8153

HIGH RISK AREA #1 - VILLAGE OF PIERMONT
SPARKILL CREEK FLOOD & RESILIENCE STUDY
SD115
ROCKLAND COUNTY
NEW YORK

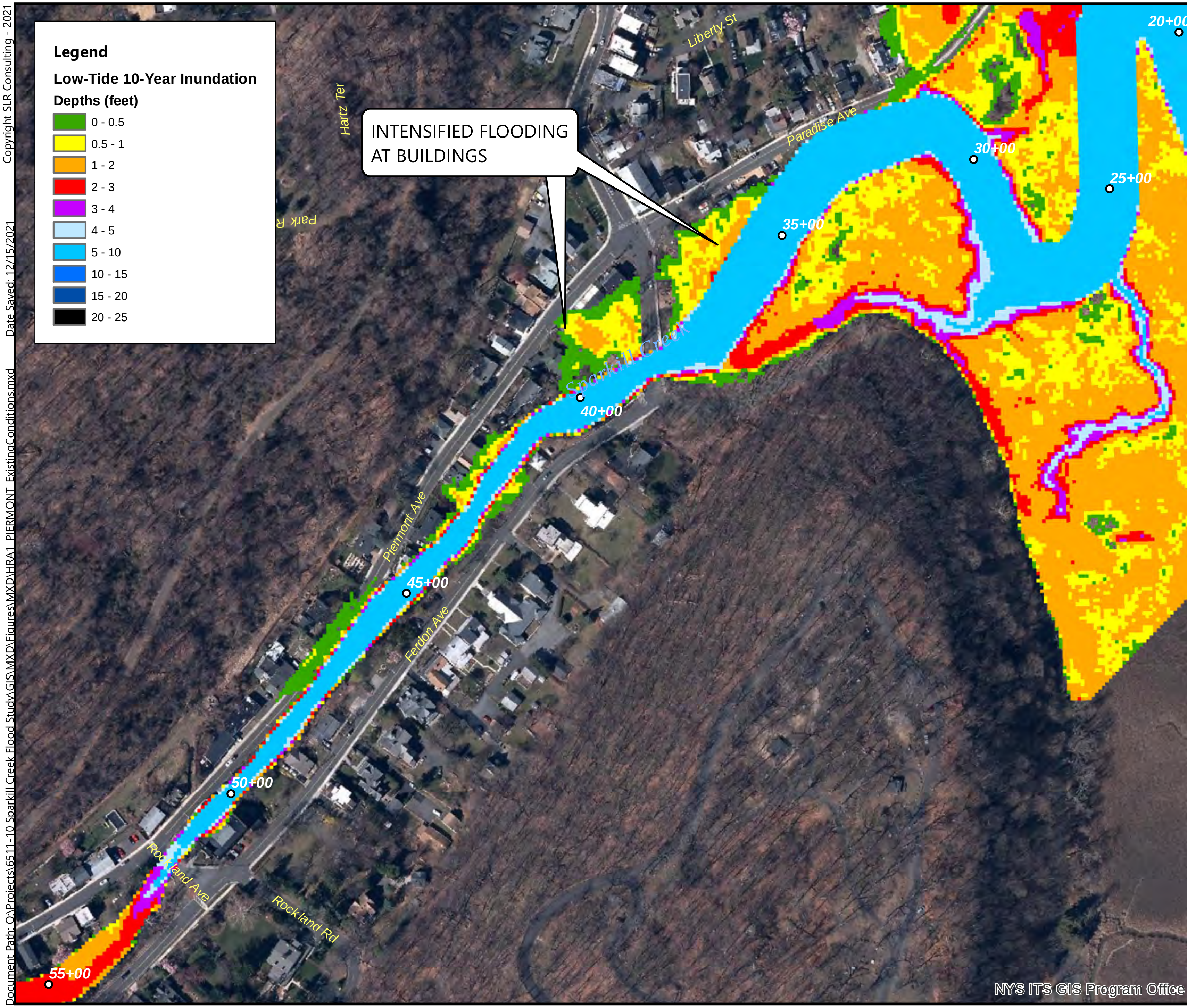
SCALE 1 " = 400 '
DATE 11/15/2021
PROJ. NO. 16511.00010

FIG. 4-2

Figure 4-3 The historic Bridge Street bridge spans the Sparkill Creek as a pedestrian bridge just upstream of the Ferdon Avenue bridge.

During low tide on the Hudson River Estuary, the 10-year flood event on Sparkill Creek inundates a section of Piermont Avenue midway between Rockland Avenue and Ferdon Avenue. Buildings in the vicinity of the intersection of Piermont Avenue and Bridge Street, including the post office, are flooded. Paradise Avenue and neighborhoods along Paradise Avenue, Liberty Street, and Ohio Street are inundated. Flooding extents and depths become more severe during the low tide, 50- and 100-year flood events. Both the Rockland Road and Ferdon Avenue bridges can safely pass up to the 100-year flow event on Sparkill Creek if the peak flow corresponds with low tide. Maps showing modeled flooding depths and extents within HRA 1 under a low-tide condition during the 10-, 50-, and 100-year flood events on Sparkill Creek are depicted in Figures 4-4, 4-5, and 4-6, respectively.

When peak flows on Sparkill Creek coincide with a high-tide event, flooding becomes much more severe. The 10-year flood event inundates nearly all of Piermont Avenue downstream of Rockland Avenue. Ferdon Avenue is flooded downstream of Rockland Avenue. The sanitary pump station on Ferdon Avenue becomes inundated. Buildings along both sides of Piermont Avenue are severely flooded. Paradise Avenue and neighborhoods along Paradise Avenue, Liberty Street, and Ohio Street are inundated with flood depths reaching 3 to 5 feet in some areas. Flooding extents and depths become more severe during the high tide, 50- and 100-year flood events. The deck of the Ferdon Avenue bridge is overtopped by flood flows during the 10-, 50-, and 100-year flood event if it corresponds with the high tide. Maps showing modeled flooding depths and extents within HRA 1 under a high-tide condition during the 10-, 50-, and 100-year flood events are depicted in Figures 4-7, 4-8, and 4-9, respectively.



N

0 250 Feet

SLR

231 MAIN STREET
SUITE 102
NEW PALTZ, NY 12561
845.633.8153

HRA #1 - LOW-TIDE 10-YEAR INUNDATION

SPARKILL CREEK FLOOD & RESILIENCE STUDY
SD115
ROCKLAND COUNTY
NEW YORK

SCALE 1 " = 250 '

DATE 12/15/2021

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FIG. 4-4

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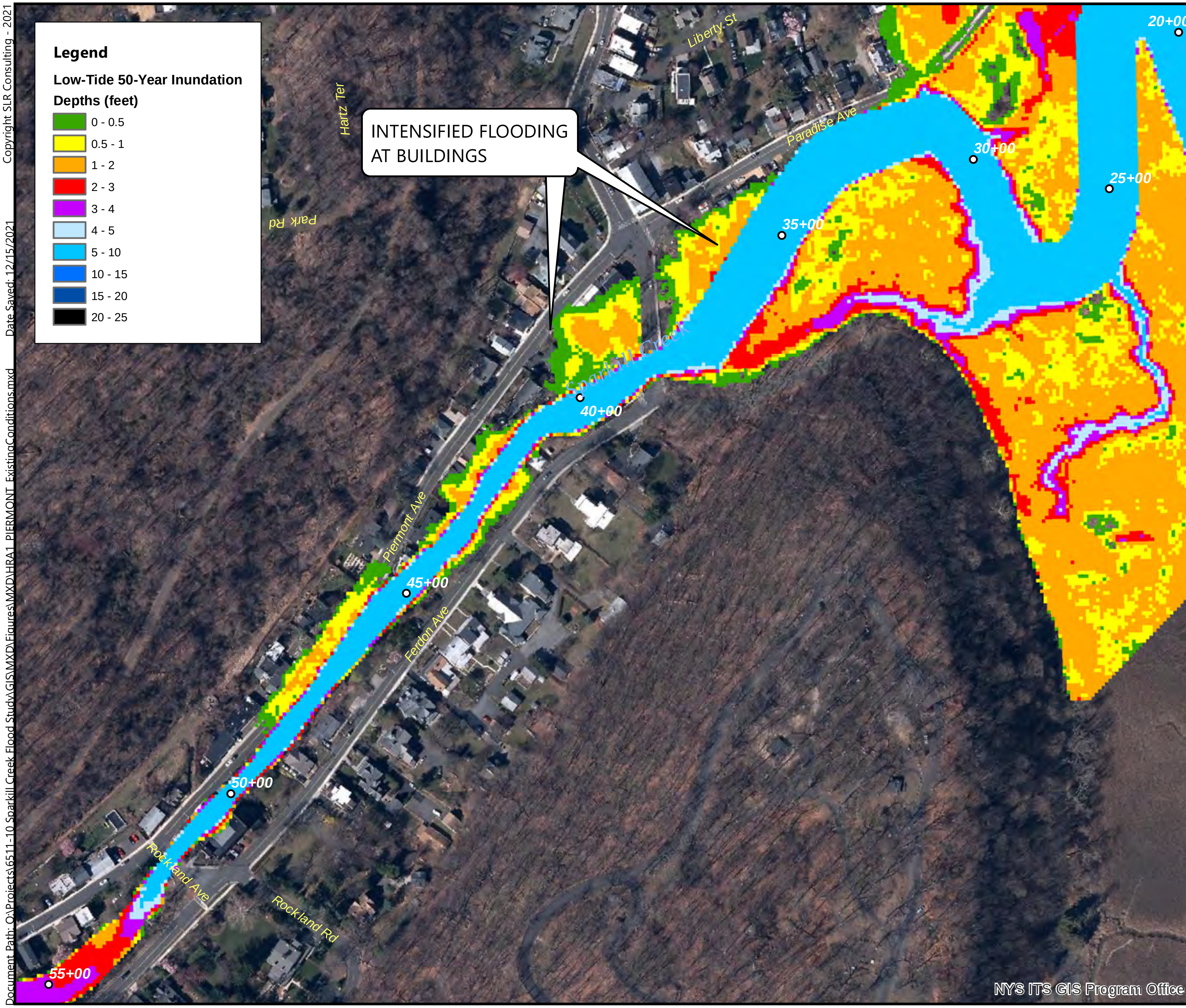

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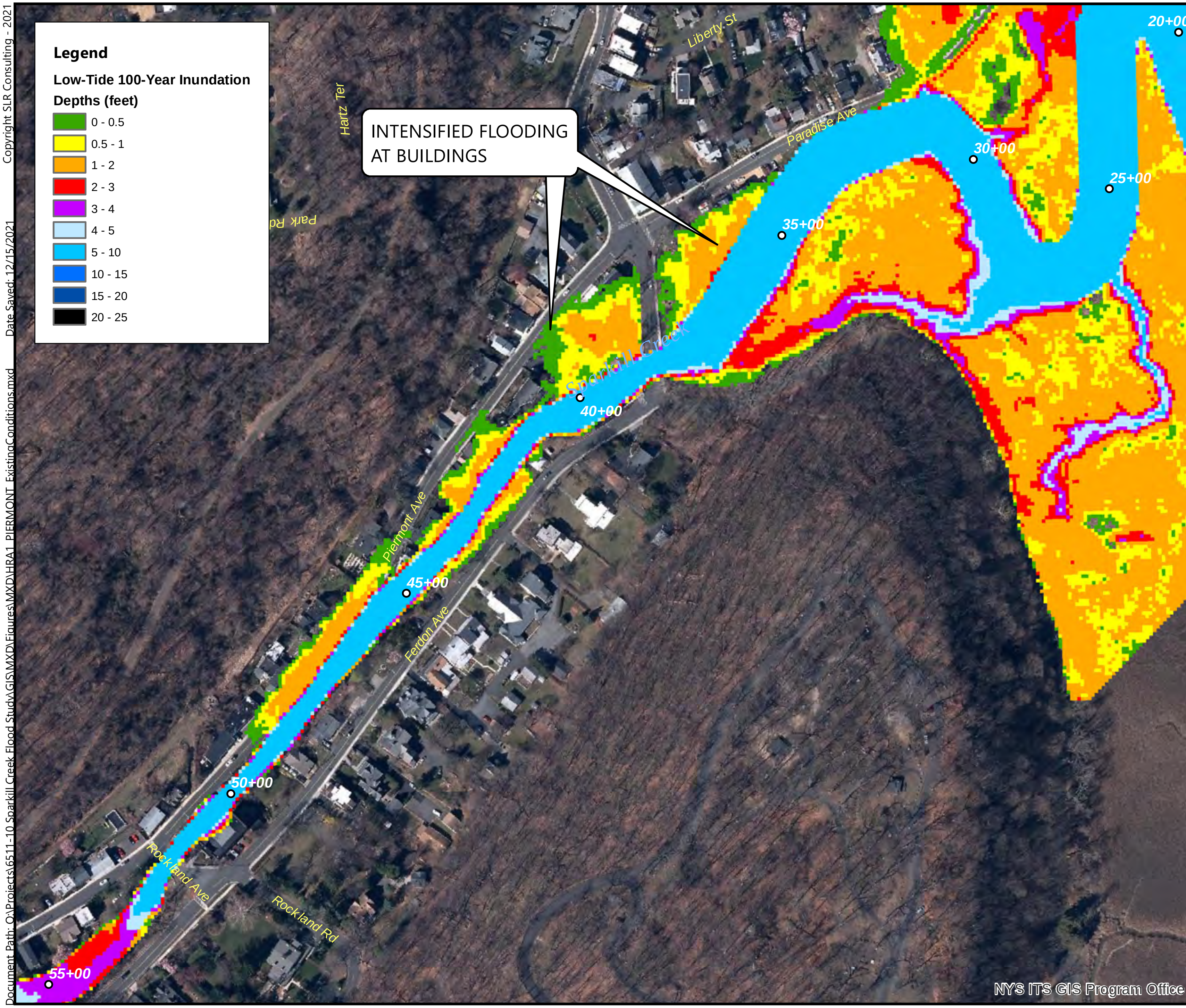
Feet

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

HRA #1 - LOW-TIDE 50-YEAR INUNDATION
SPARKILL CREEK FLOOD & RESILIENCE STUDY
SD115
ROCKLAND COUNTY
NEW YORK

SCALE 1 " = 250 '
DATE 12/15/2021
PROJ. NO. 16511.00010

FIG. 4-5



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SLR
231 MAIN STREET
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HRA #1 - LOW-TIDE 100-YEAR INUNDATION

SPARKILL CREEK FLOOD & RESILIENCE STUDY

SD115

ROCKLAND COUNTY

NEW YORK

SCALE 1 " = 250 '

DATE 12/15/2021

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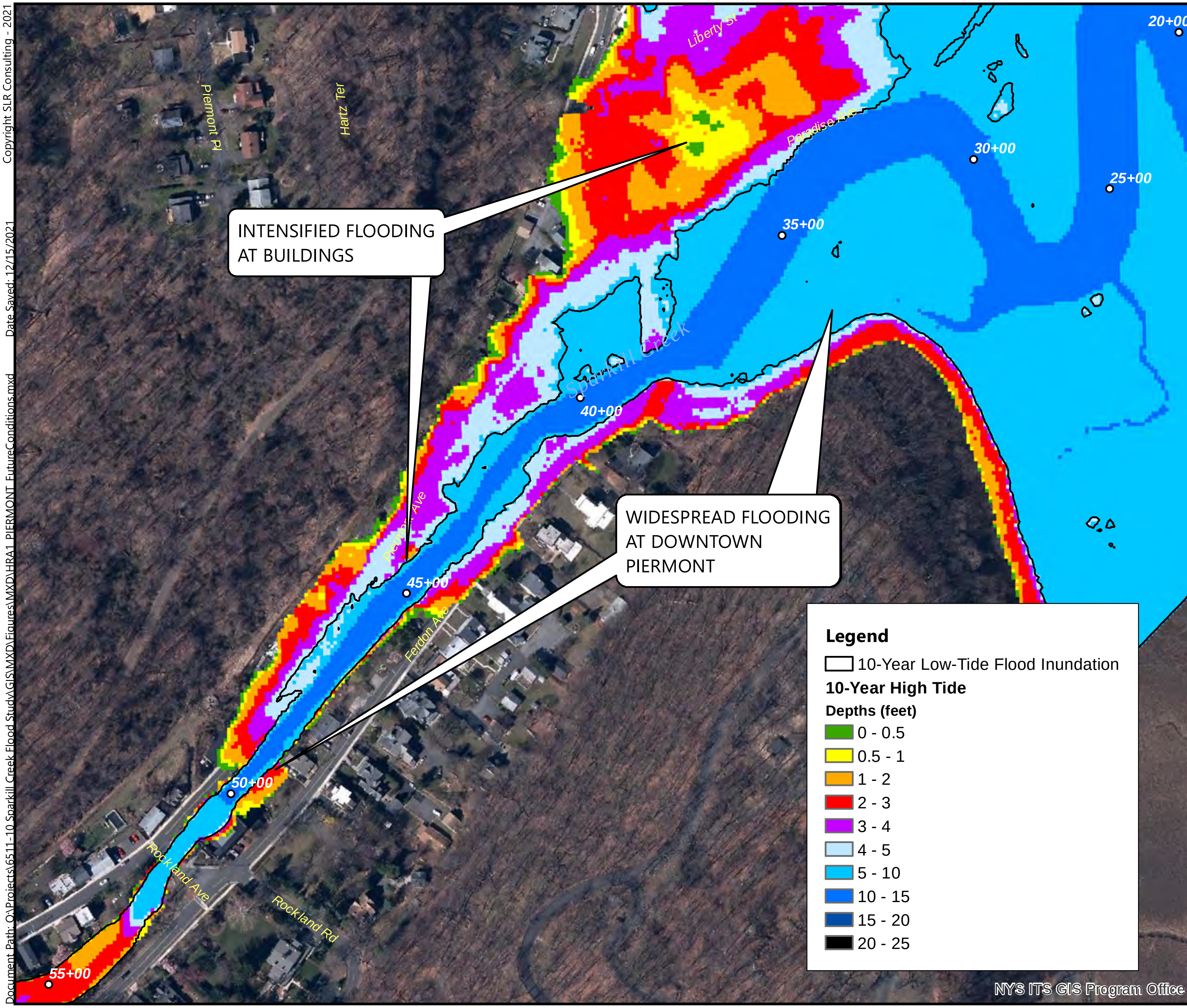
FIG. 4-6



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HRA #1 - HIGH-TIDE 10-YEAR INUNDATION

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FIG. 4-7

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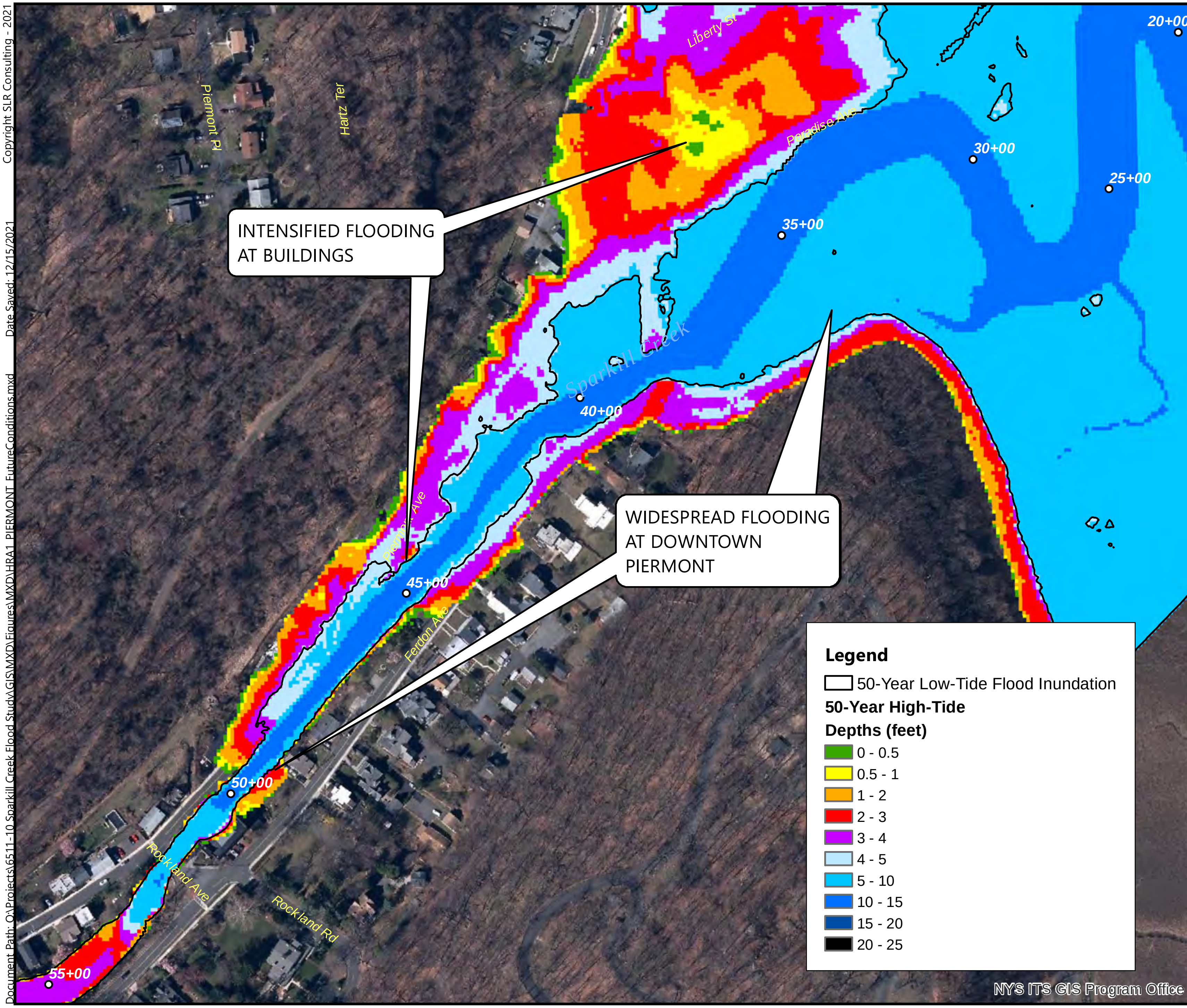

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HRA #1 - HIGH-TIDE 50-YEAR INUNDATION
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SD115
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NEW YORK

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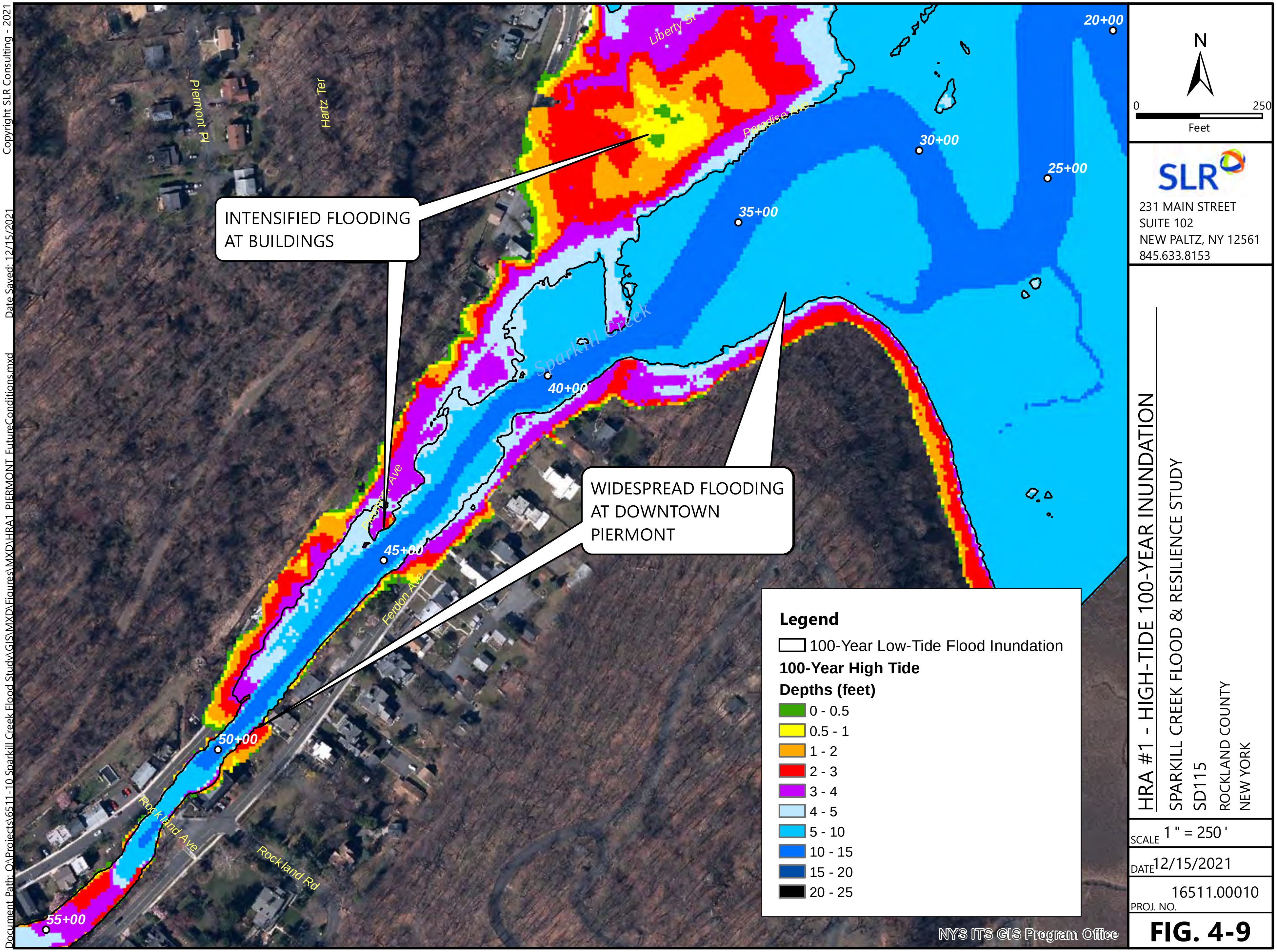
FIG. 4-8



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HRA #1 - HIGH-TIDE 100-YEAR INUNDATION

SPARKILL CREEK FLOOD & RESILIENCE STUDY

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FIG. 4-9

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Accounting for projected increases in water surface elevations on the Hudson River Estuary due to sea level rise (as discussed in Section 2.3 of this report), flooding along Sparkill Creek is greatly exacerbated. For the purpose of this analysis, Hudson River Estuary elevations used in hydraulic modeling of future flood scenarios on Sparkill Creek were increased by 18 inches over the current high-tide level modeled in the scenarios described above. This 18-inch rise represents the "medium" sea level rise scenario for the 2050s time period. Under this condition, flooding of the areas described during the normal low- and high-tide scenarios above is made more severe, even during the 10-year flood event on Sparkill Creek, including areas upstream of the Piermont Dam. Maps showing modeled flooding depths and extents within HRA 1 under a future sea level rise condition during the 10-, 50-, and 100-year flood events are depicted in Figures 4-10, 4-11, and 4-12, respectively.

Floodproofing and elevation of pumps and electrical equipment are recommended at the sanitary pump station on Ferdon Avenue to ensure that it can continue to function as required during extreme weather events and under projected sea level rise scenarios.

The Piermont Paper Company Dam at STA 52+00 was evaluated to determine its influence on flooding within HRA 1. Homes along Sparkill Creek upstream of the dam are located close to the creek, often with the rear portion of the buildings mapped as falling within the SFHA. Removal of the dam and restoration of the Sparkill Creek channel through the former impoundment upstream of the dam would result in a reduction in flood depths upstream of the dam, which would benefit properties along Piermont Avenue and Ferdon Avenue between STA 52+00 and STA 65+00. The dam does not provide significant flood storage. Its removal will not exacerbate flooding downstream of the dam.

Flood extents and depths for the 10-year flood event with and without the Piermont Paper Company Dam in place are shown in Figure 4-12a and Figure 4-12b, respectively; for the 50-year flood event in Figure 4-12c and Figure 4-12d; and for the 100-year flood event in Figure 4-12e and Figure 4-12f.

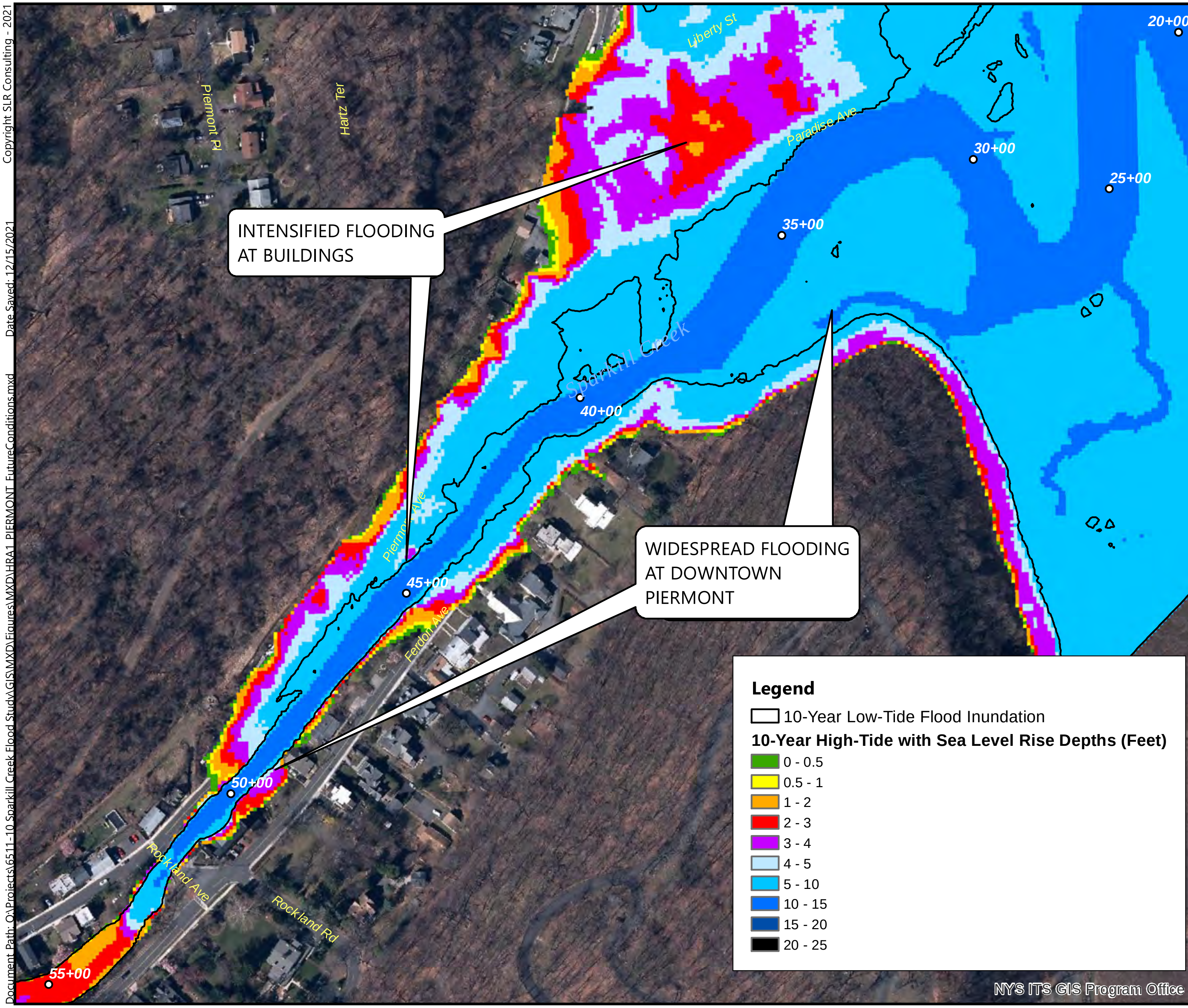
As demonstrated by sea level rise projections, it will become impractical for homes and businesses to remain at their current locations along Sparkill Creek. A generalized map showing recommendations and areas where relocation should be considered is depicted in Figure 4-13. The following recommendations are provided:

- Relocation of the Department of Public Works facility on Piermont Avenue to a location that is not prone to flooding is recommended.

- Relocations or elevations of flood-prone homes and businesses are recommended.

- Consideration should be given to a bundled relocation of flood-prone homes and businesses, the Department of Public Works facility, and other municipal buildings to a single location within the village that is outside of the SFHA and not prone to flooding.

- Removal of the Piermont Paper Company Dam and restoration of the Sparkill Creek channel through the former impoundment upstream of the dam are recommended.



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0 250
Feet

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HRA #1 - FUTURE SLR TIDE 10-YEAR INUNDATION

SPARKILL CREEK FLOOD & RESILIENCE STUDY

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ROCKLAND COUNTY
NEW YORK

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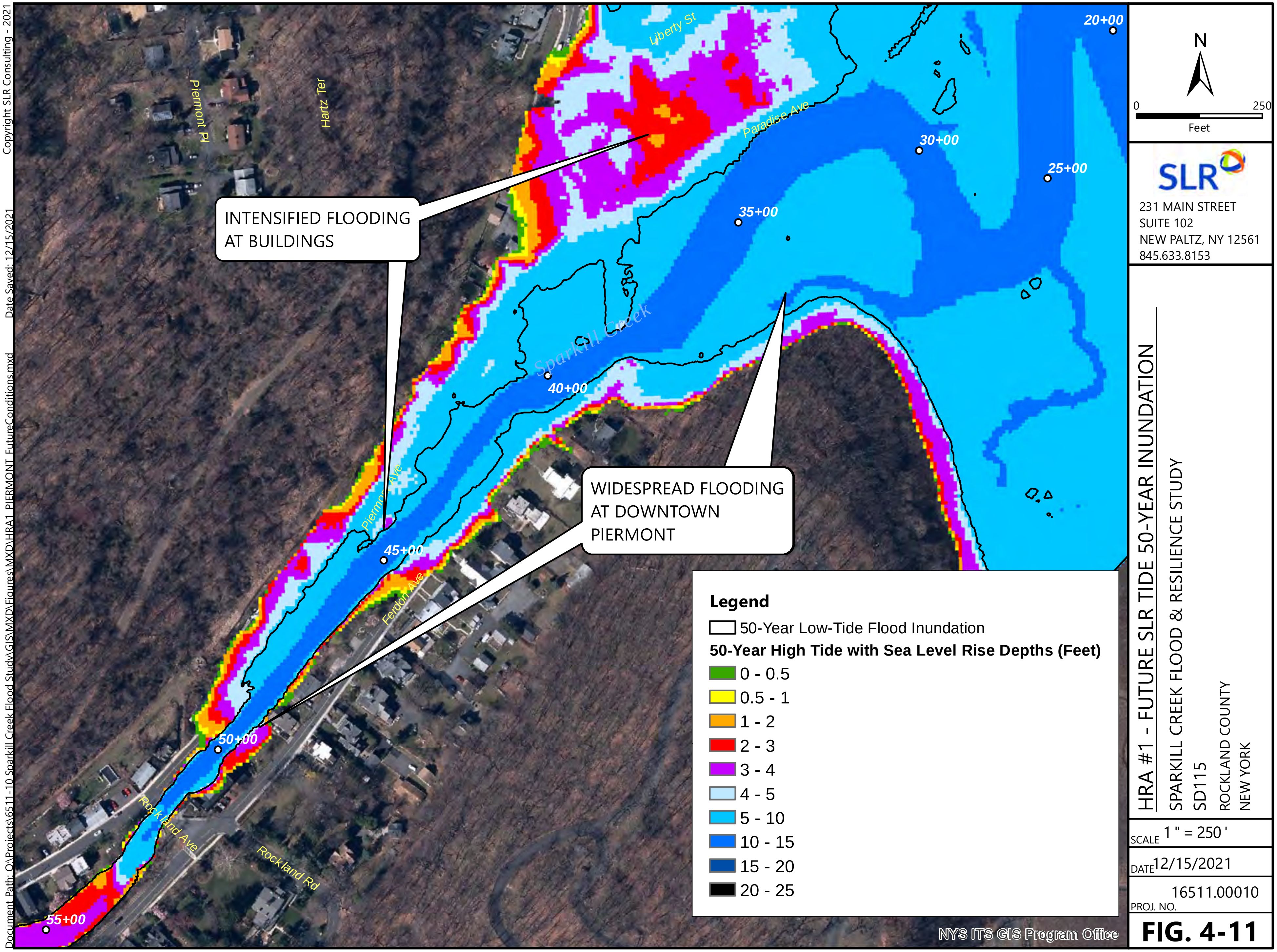
FIG. 4-10


Liberty St
Piermont Pl
Hartz Ter
Paradise Ave
Sparkill Creek
Piermont Ave
Ferdon Ave
Rockland Ave
Rockland Rd
20+00
25+00
30+00
35+00
40+00
45+00
50+00
55+00
INTENSIFIED FLOODING AT BUILDINGS
WIDESPREAD FLOODING AT DOWNTOWN PIERMONT
Legend
50-Year Low-Tide Flood Inundation
50-Year High Tide with Sea Level Rise Depths (Feet)
0 - 0.5
0.5 - 1
1 - 2
2 - 3
3 - 4
4 - 5
5 - 10
10 - 15
15 - 20
20 - 25
NYS ITS GIS Program Office
N
0
250
Feet
SLR
231 MAIN STREET
SUITE 102
NEW PALTZ, NY 12561
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HRA #1 - FUTURE SLR TIDE 50-YEAR INUNDATION
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NEW YORK
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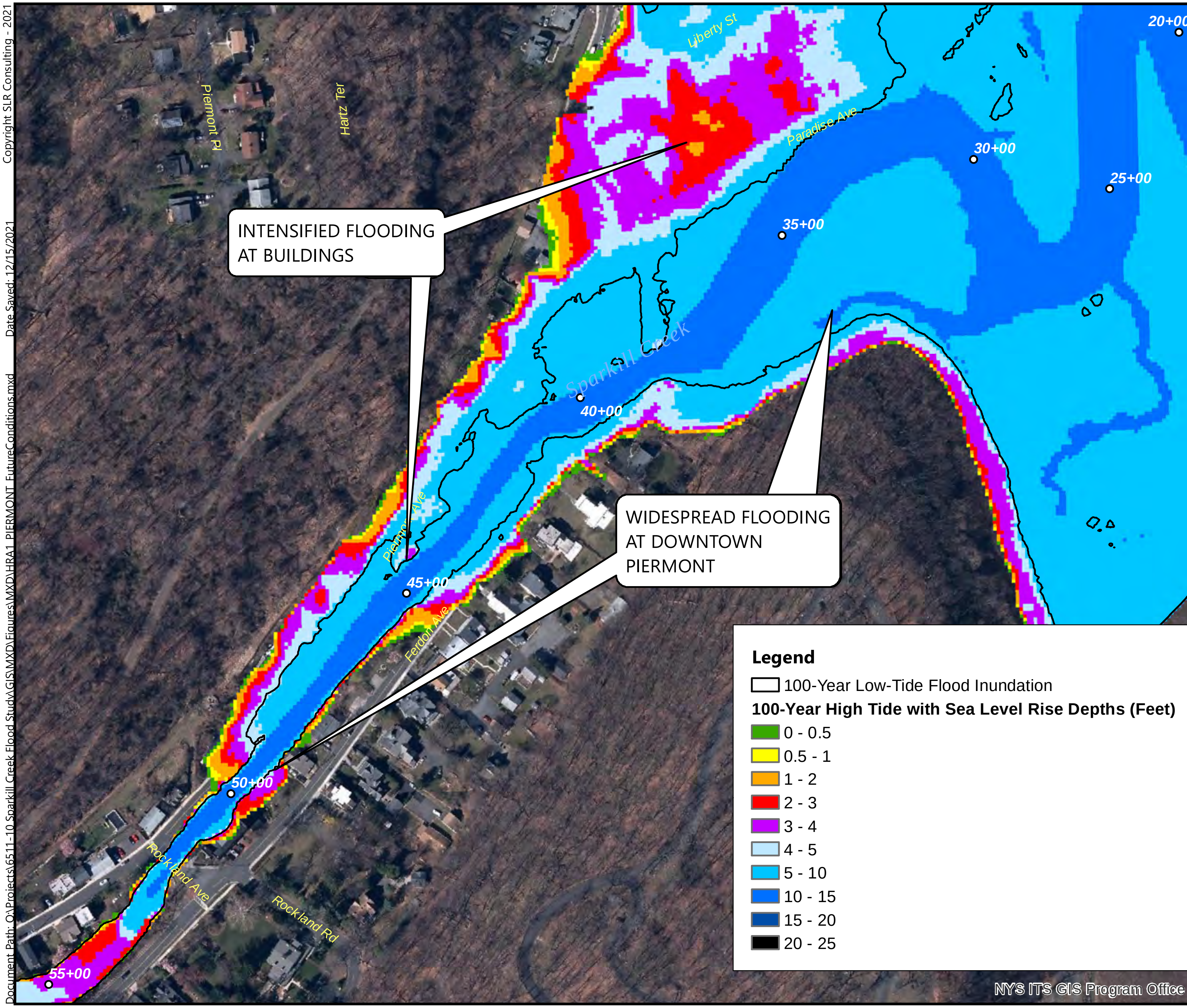
FIG. 4-11



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HRA #1 - FUTURE SLR TIDE 50-YEAR INUNDATION

SPARKILL CREEK FLOOD & RESILIENCE STUDY

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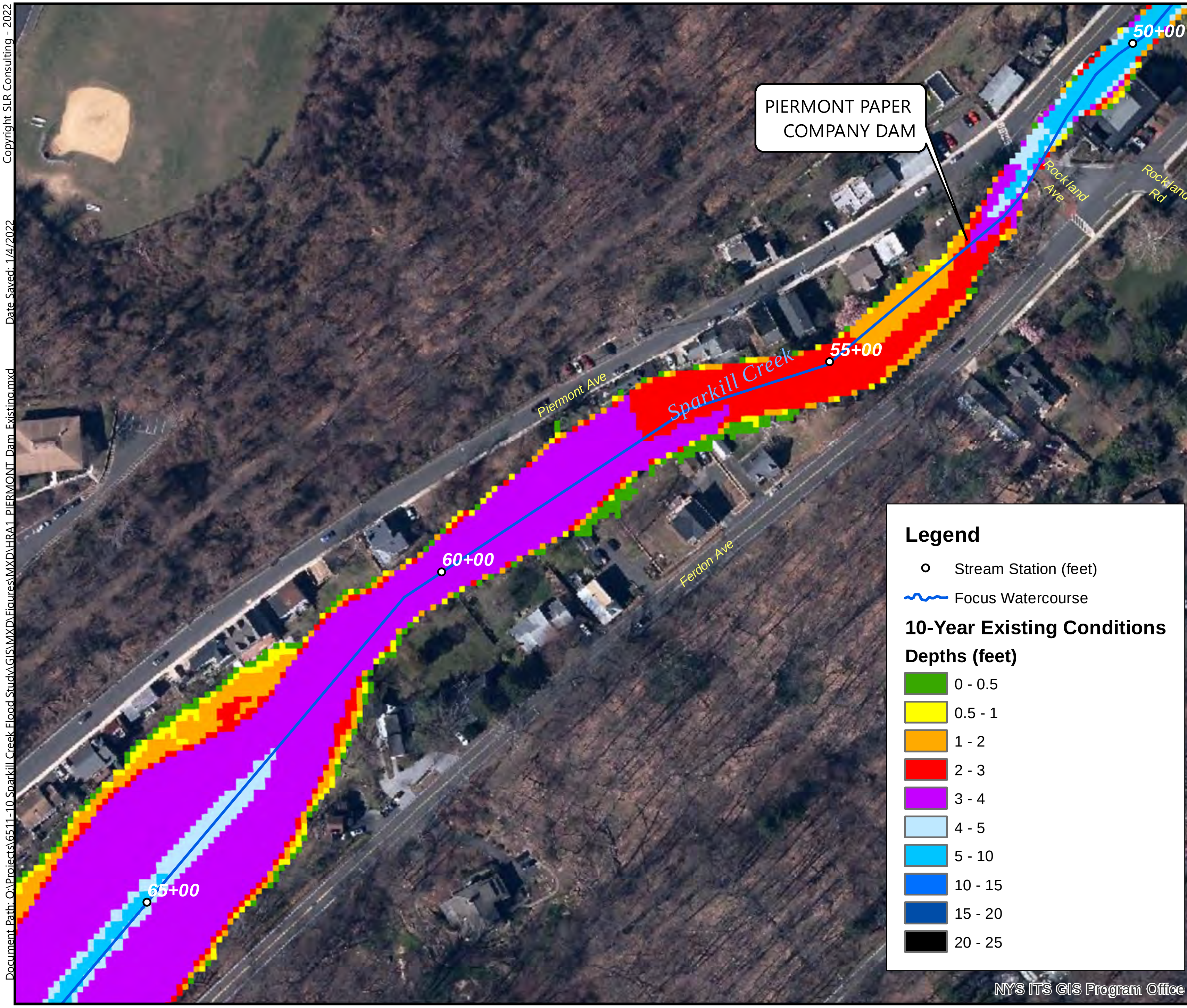
FIG. 4-12



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HRA #1 - 10-YEAR EXISTING CONDITONS

SPARKILL CREEK FLOOD & RESILIENCE STUDY

SD115

ROCKLAND COUNTY

NEW YORK

SCALE 1 " = 150 '

DATE 1/4/2022

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FIG. 4-12a

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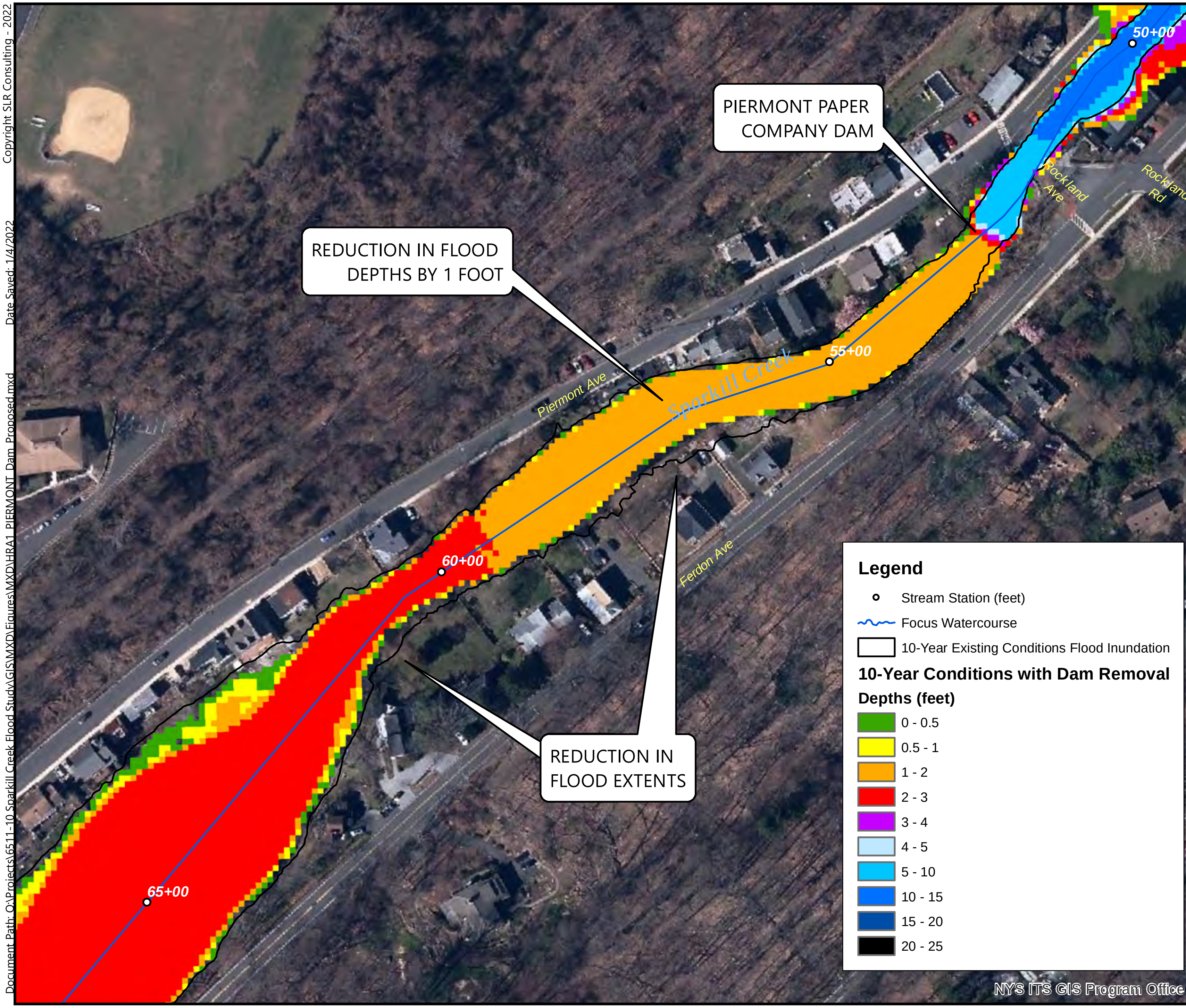

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HRA #1 - 10-YEAR CONDITIONS WITH DAM REMOVAL

SPARKILL CREEK FLOOD & RESILIENCE STUDY

SD115

ROCKLAND COUNTY
NEW YORK

SCALE 1 " = 150 '

DATE 1/4/2022

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FIG. 4-12b

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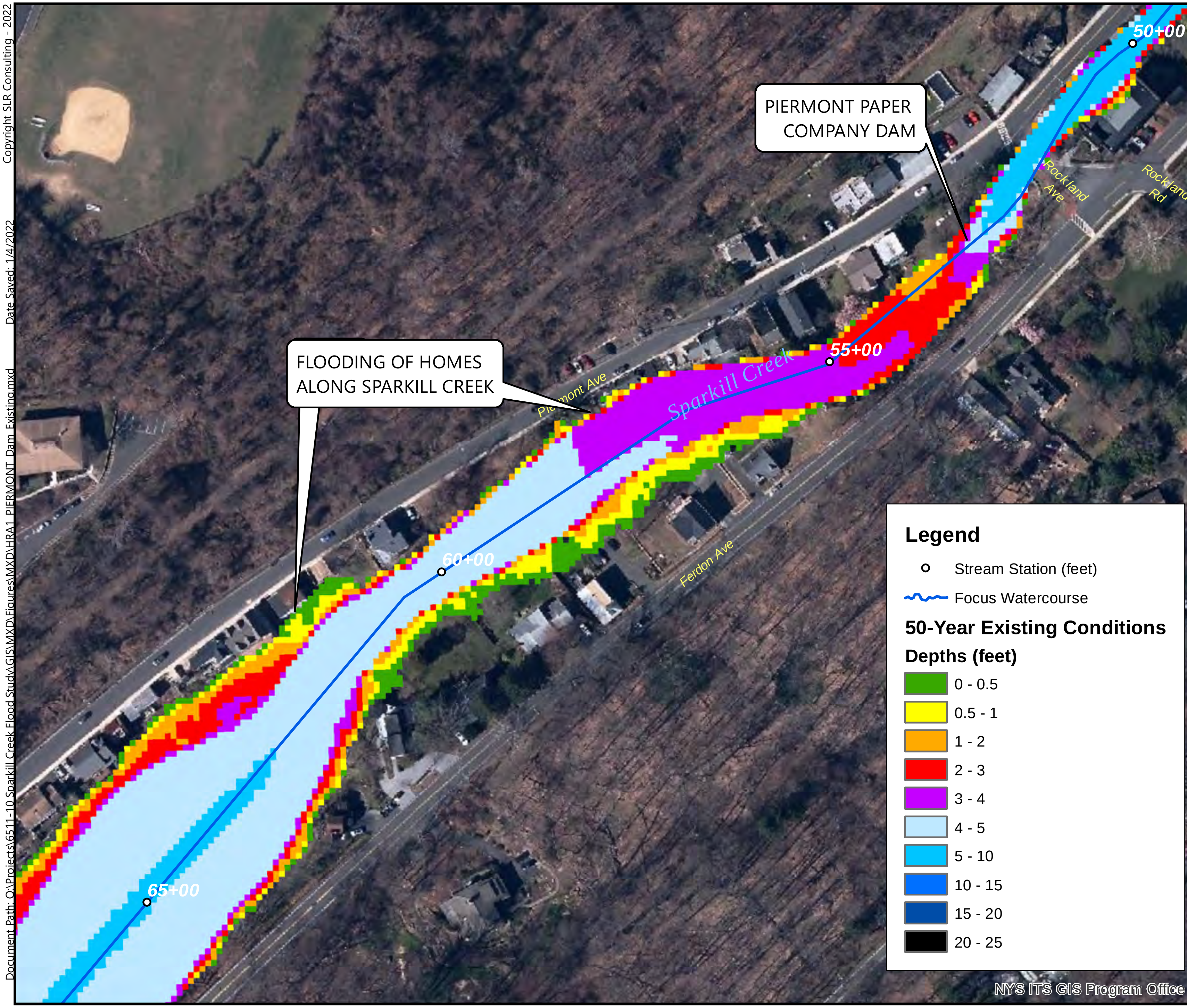

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HRA #1 - 50-YEAR EXISTING CONDITONS

SPARKILL CREEK FLOOD & RESILIENCE STUDY

SD115

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SCALE 1 " = 150 '

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FIG. 4-12c

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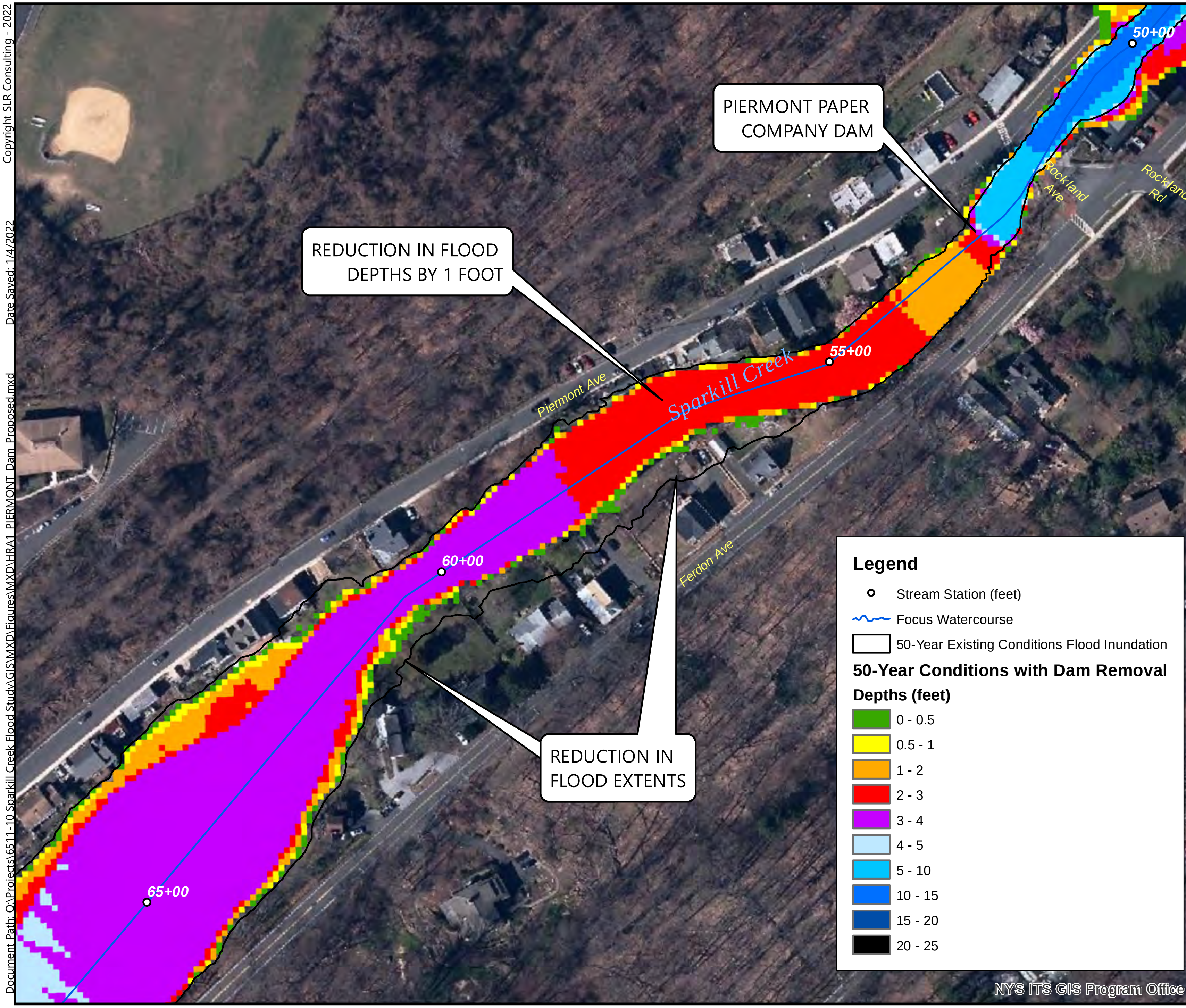

N

0 150
Feet

SLR

231 MAIN STREET
SUITE 102
NEW PALTZ, NY 12561
845.633.8153

HRA #1 - 50-YEAR CONDITIONS WITH DAM REMOVAL

SPARKILL CREEK FLOOD & RESILIENCE STUDY

SD115

ROCKLAND COUNTY
NEW YORK

SCALE 1 " = 150 '

DATE 1/4/2022

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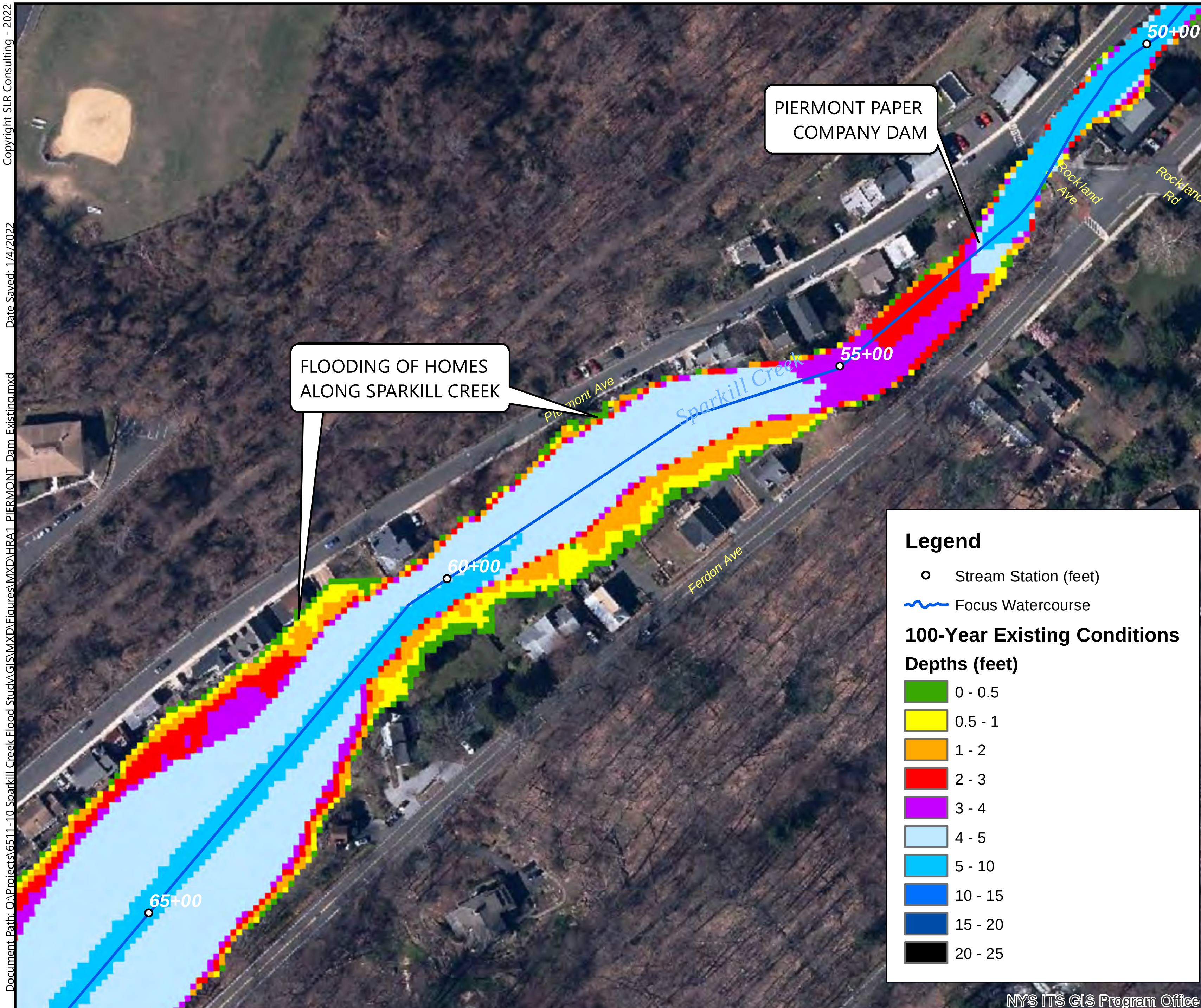
FIG. 4-12d



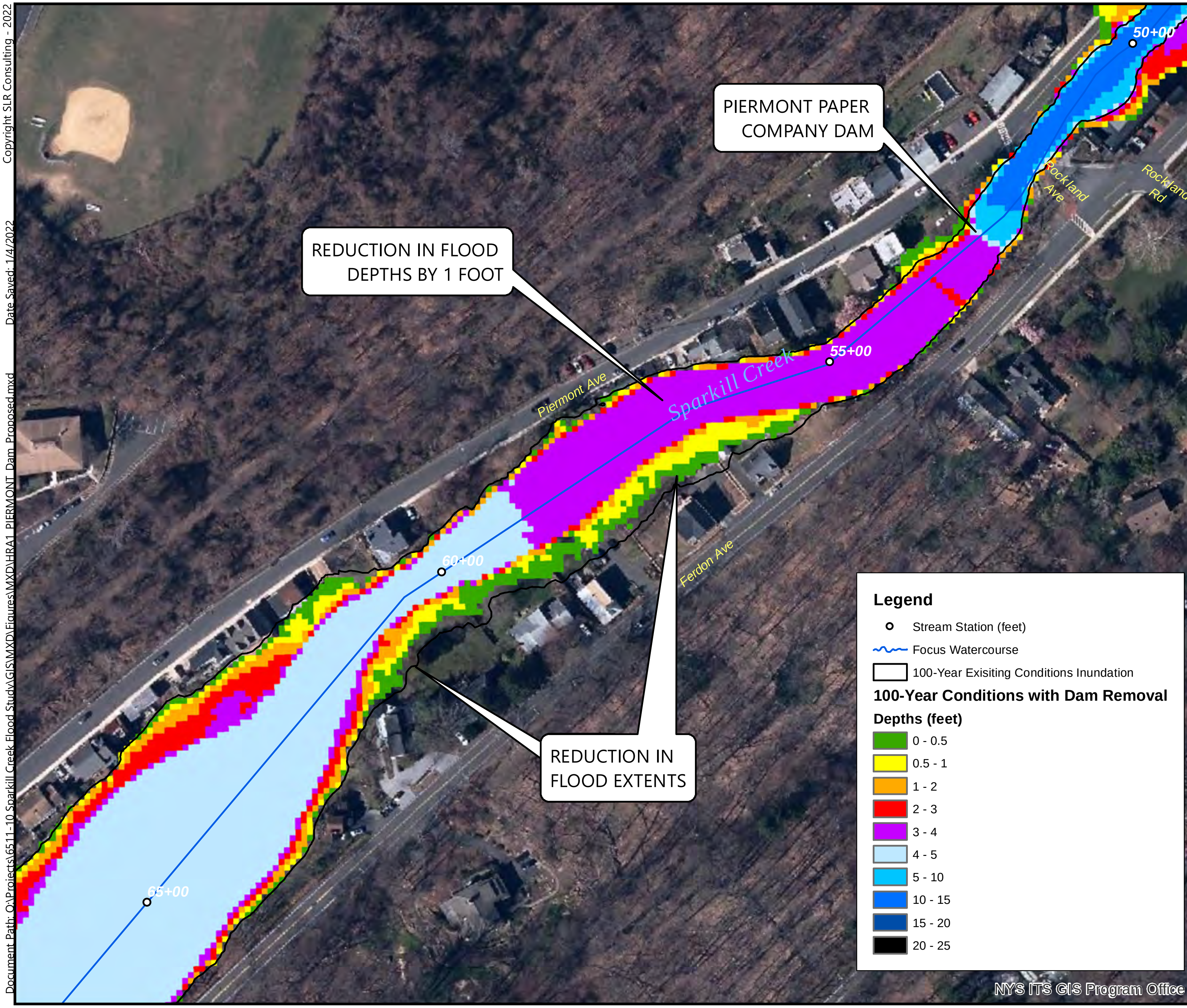
SLR
231 MAIN STREET
SUITE 102
NEW PALTZ, NY 12561
845.633.8153

HRA #1 - 100-YEAR EXISTING CONDITONS

SPARKILL CREEK FLOOD & RESILIENCE STUDY
SD115
ROCKLAND COUNTY
NEW YORK

SCALE 1 " = 150 '
DATE 1/4/2022
PROJ. NO. 16511.00010

FIG. 4-12e



N
0 150
Feet

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

HRA #1 - 100-YEAR CONDITIONS WITH DAM REMOVAL

SPARKILL CREEK FLOOD & RESILIENCE STUDY
SD115
ROCKLAND COUNTY
NEW YORK

SCALE 1 " = 150 '
DATE 1/4/2022
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FIG. 4-12f

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