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HIGH RISK AREA #1 - CONCEPT MAP

HACKENSACK RIVER FLOOD & RESILIENCE STUDY
SD109
ROCKLAND COUNTY
NEW YORK

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SCALE 1 " = 1,000 '

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FIG. 4-5

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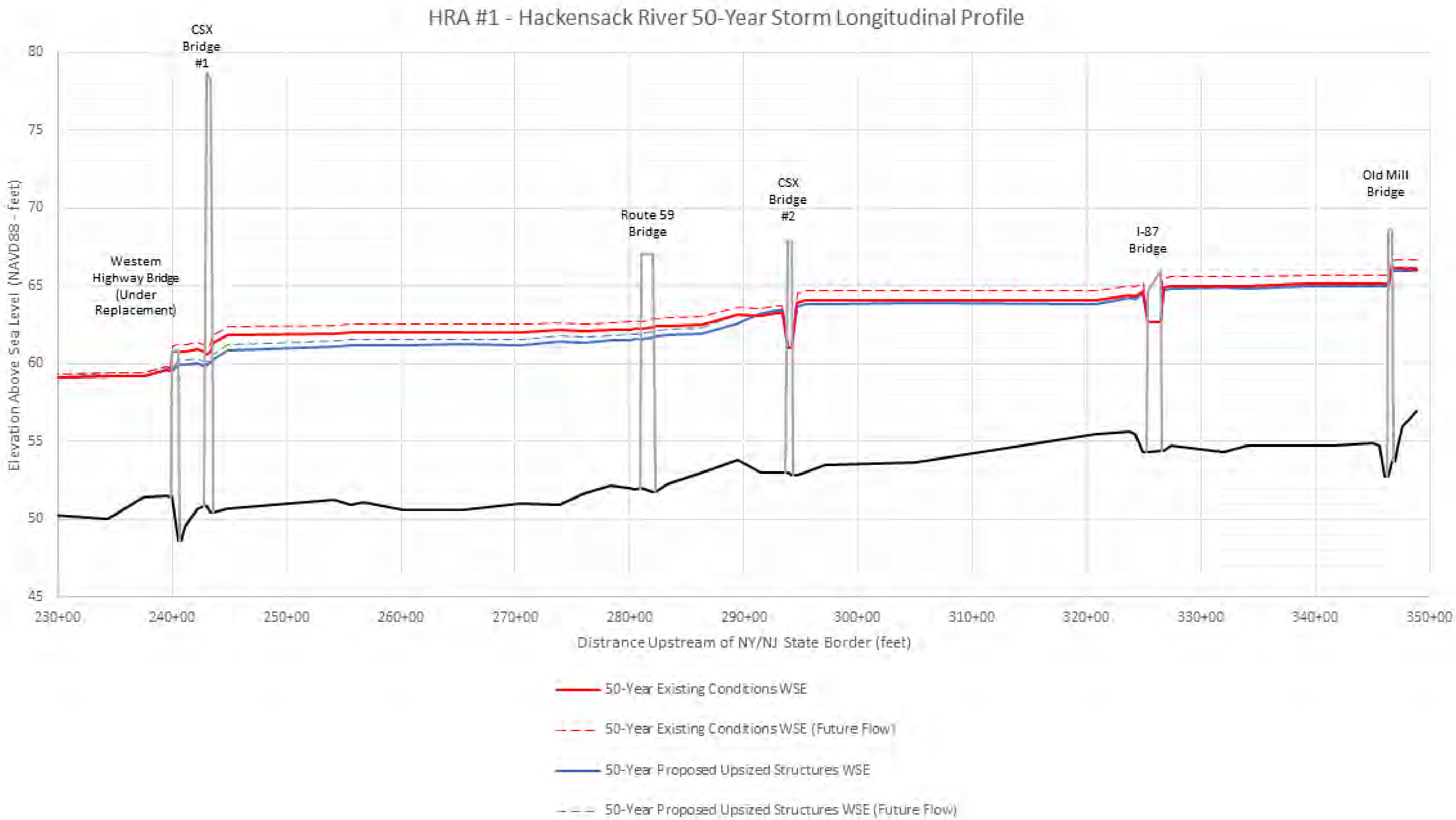


Figure 4-6: Longitudinal Profile Showing Recommended Improvements in HRA 1 During 50-Year Flood Event

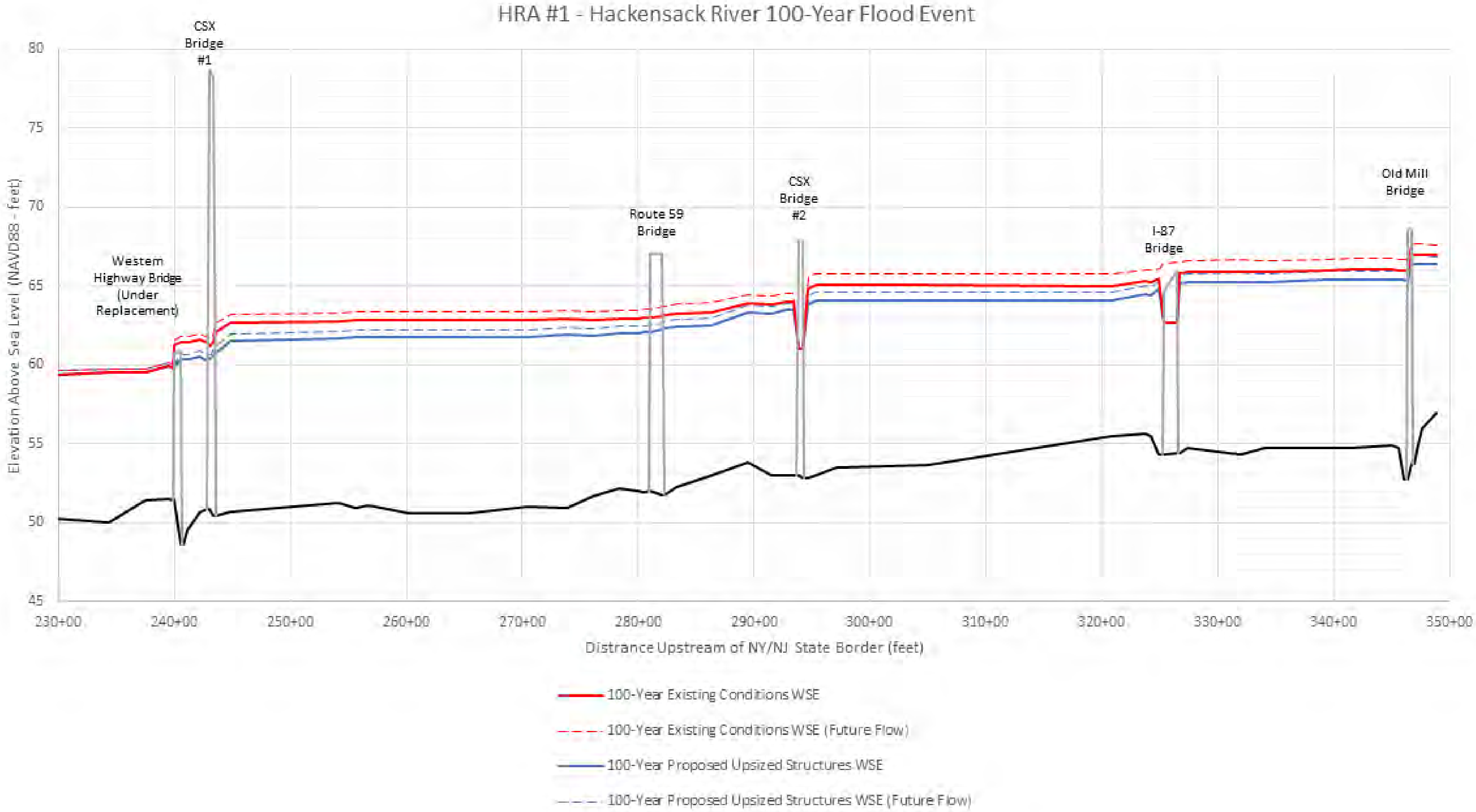
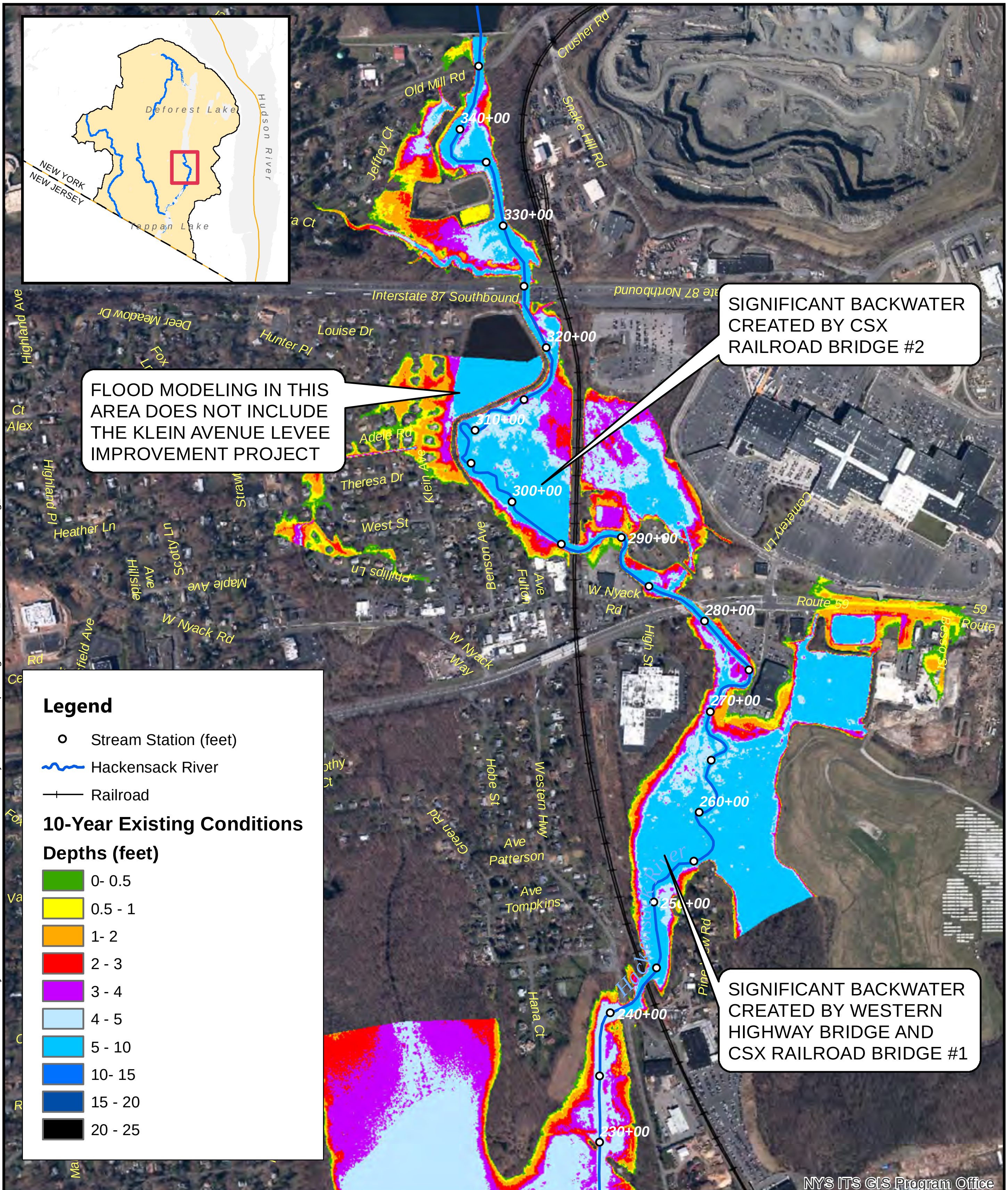


Figure 4-7: Longitudinal Profile Showing Recommended Improvements in HRA 1 During 100-Year Flood Event



HIGH RISK AREA #1 - 10-YEAR EXISTING CONDITIONS

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FIG. 4-8

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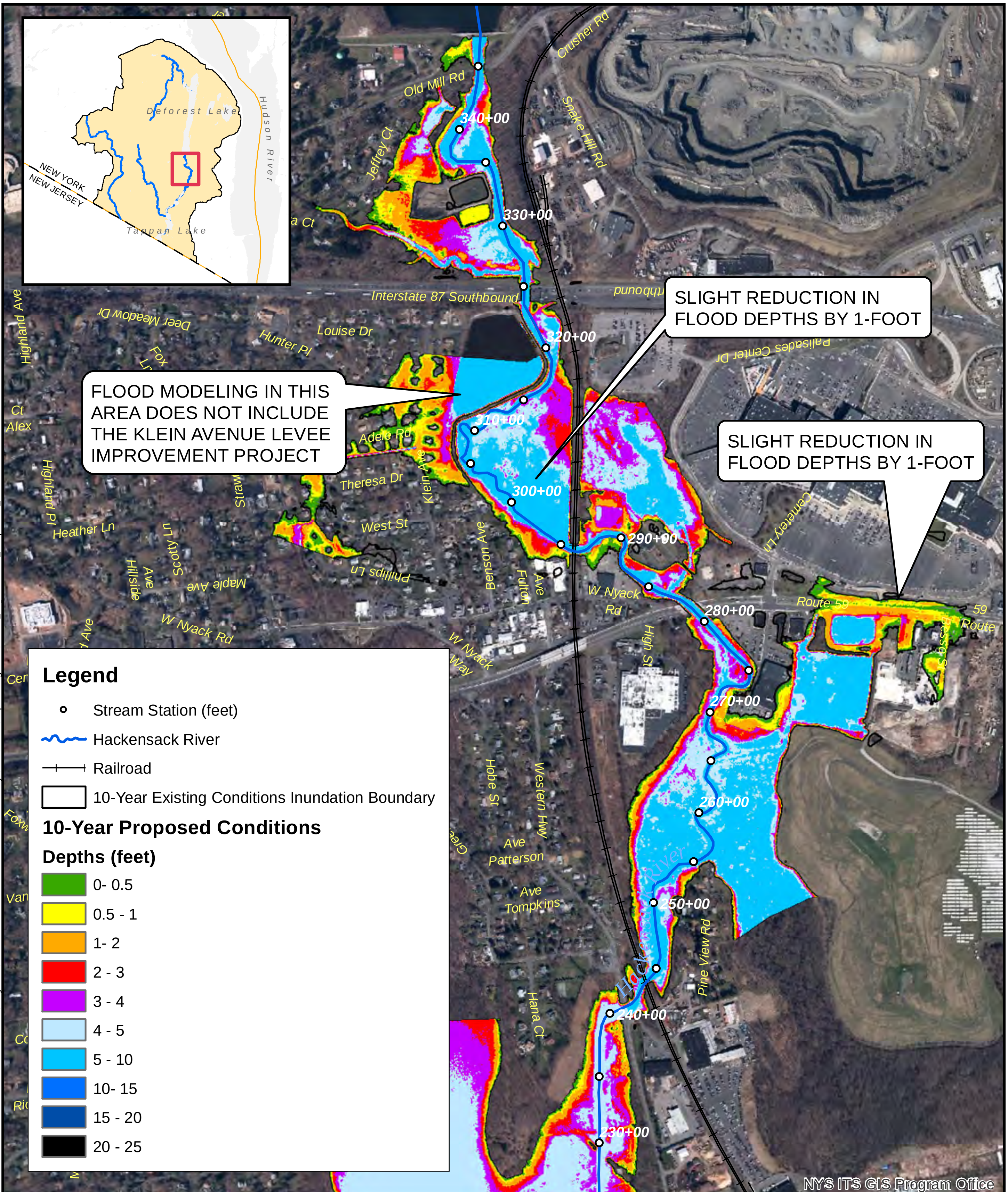

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HIGH RISK AREA #1 - 10-YEAR PROPOSED CONDITIONS

HACKENSACK RIVER FLOOD & RESILIENCE STUDY
SD109
ROCKLAND COUNTY
NEW YORK

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FIG. 4-9

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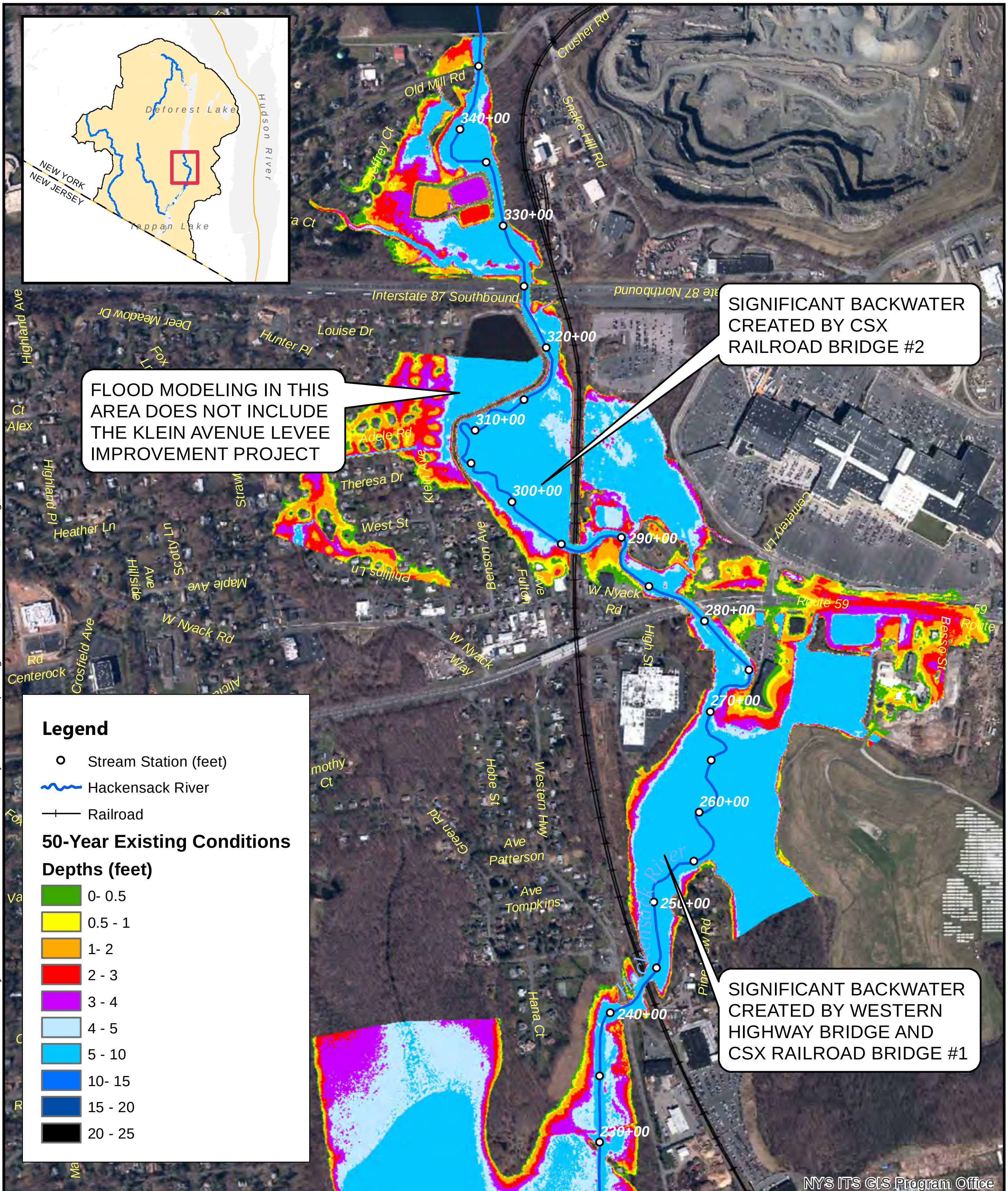

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HIGH RISK AREA #1 - 50-YEAR EXISTING CONDITIONS

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FIG. 4-10

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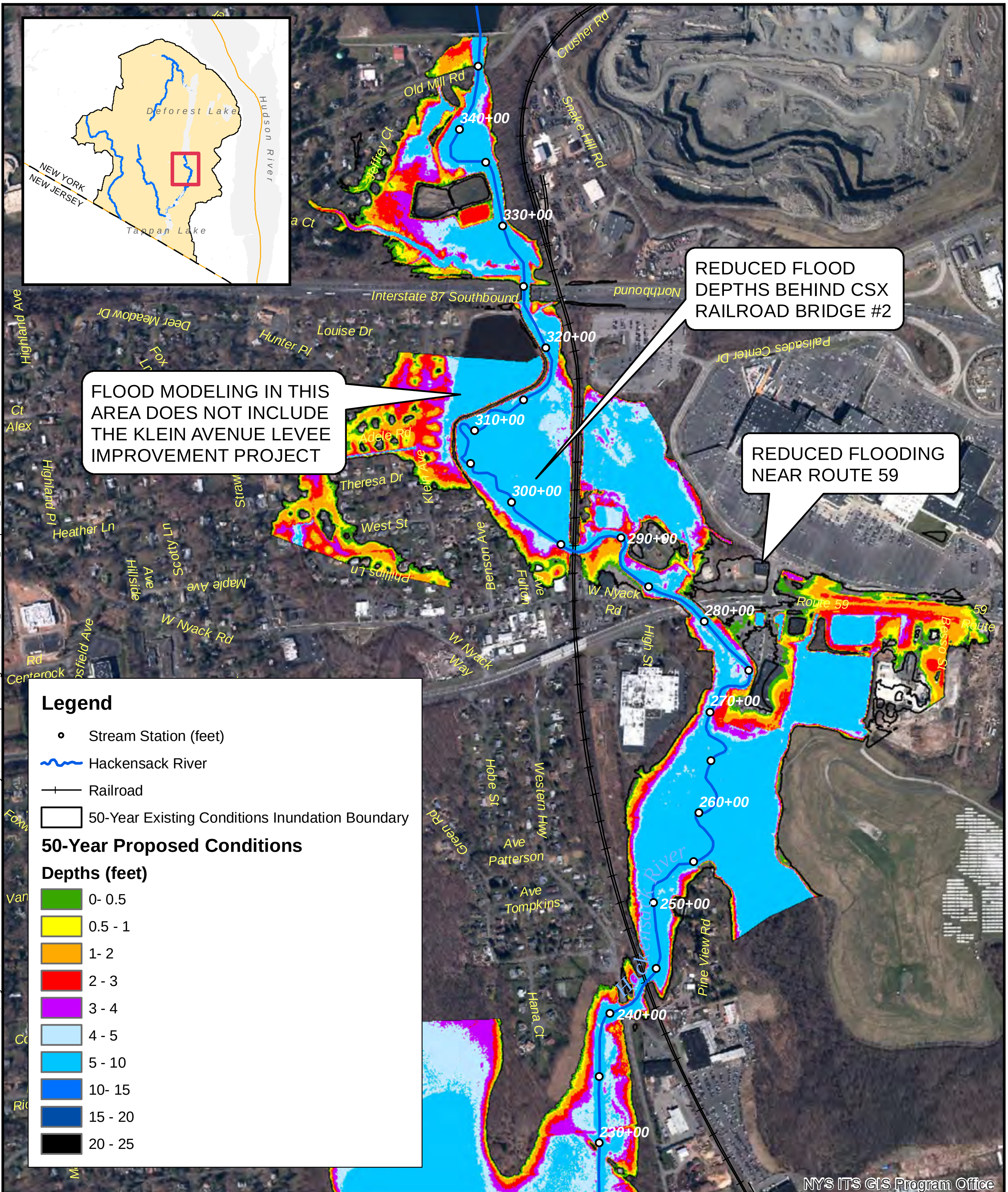

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HIGH RISK AREA #1 - 50-YEAR PROPOSED CONDITIONS

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FIG. 4-11

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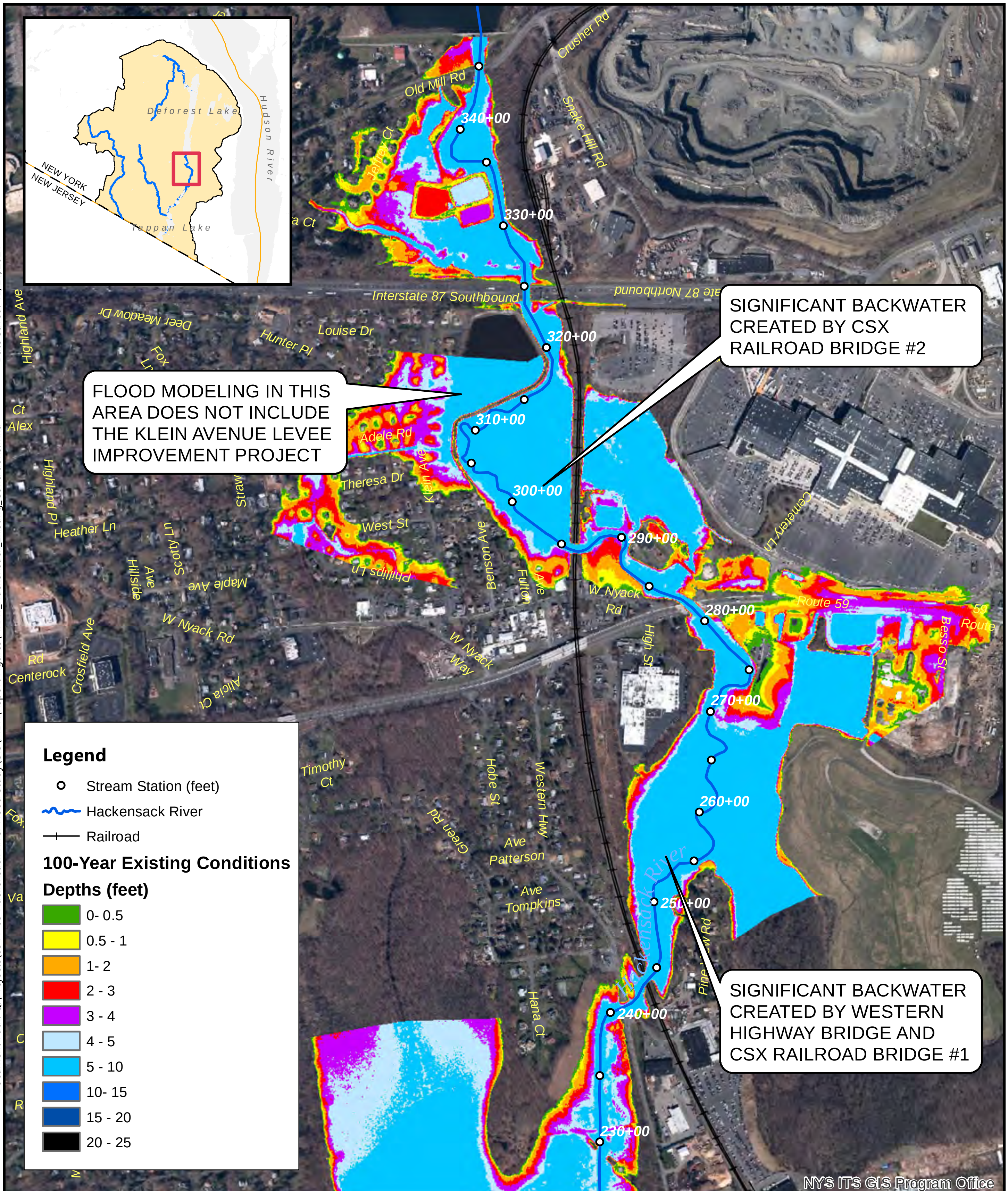

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HIGH RISK AREA #1 - 100-YEAR EXISTING CONDITIONS

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FIG. 4-12

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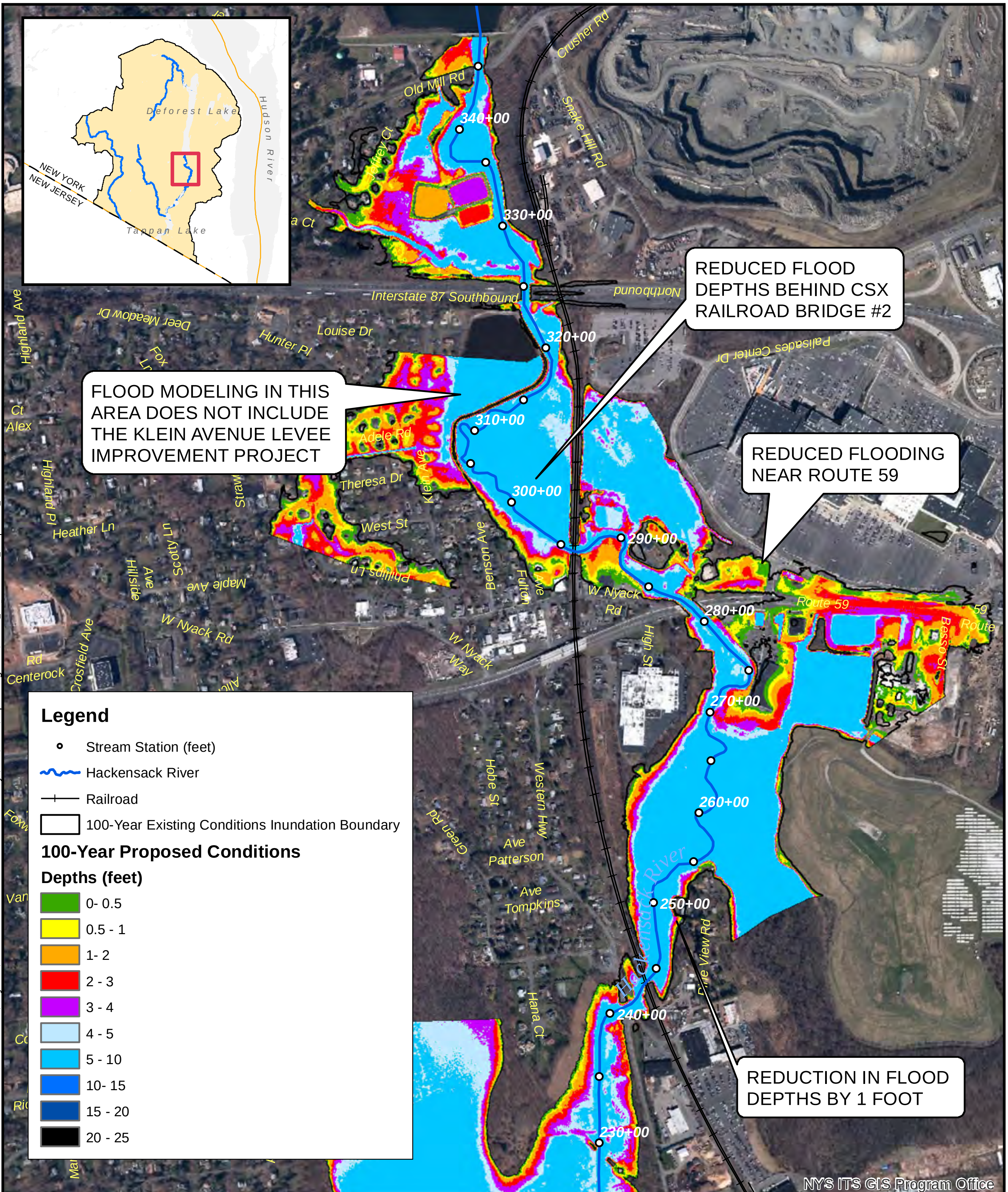

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HIGH RISK AREA #1 - 100-YEAR PROPOSED CONDITIONS

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0 500 1,000
Feet

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FIG. 4-13

SOURCE: 2016 AERIAL PHOTO, NYS ITS GIS Program Office

4.2 HIGH RISK AREA #2 – SQUADRON DRIVE AND CAVALRY DRIVE

HRA 2 includes a section of the Demarest Kill in the hamlet of New City between STA 95+00 and STA 125+00 (Figure 4-14) near New City Plaza and the New City Garden Apartments. This reach of the Demarest Kill passes through neighborhoods, industries, and commercial development. For much of the length of HRA 2, the watercourse is confined between Route 304 on its left and commercial buildings and parking lots on its right.

Hydraulic analysis was conducted within HRA 2 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. When modeling culverts, the 2050-2074 projections are employed.

Stream crossings in HRA 2 include Squadron Drive (STA 96+00) and Cavalry Drive (STA 111+00). The town-owned Squadron Drive culverts are twin 12-foot by 8-foot box culverts near New City Plaza, which currently pass up to the 50-year flood event (Figure 4-15). The Cavalry Drive bridge (ownership not listed) is an open-bottom arch bridge with a span of 18 feet and a rise of 7.5 feet, situated near the New City Garden Apartments. This bridge passes up to the 10-year flood event and causes a significant backwater, which results in flooding across State Route 304.

The hydraulic model was used to evaluate the Squadron Drive and Cavalry Drive crossings if they were to be replaced with new structures spanning 1.25 times the bankfull width, or approximately 44 feet. Under these conditions, a decrease in flood depths of over 2 feet at Squadron Drive and over 3.5 feet at Cavalry Drive was observed during the 100-year flows. Furthermore, widening the channel to at least the bankfull width of 35 feet upstream of Cavalry Drive, between STA 113+00 and STA 122+50, where the channel is tightly confined between Route 304 and commercial buildings and parking lots, and creating floodplain benches wherever possible along the channel added to the reduction in flooding across State Route 304. An approximately 850-linear-foot-long floodplain bench was modeled along the left bank, between STA 114+00 and STA 122+50, measuring 26 feet wide upstream and tapering down to 5 feet wide at its downstream terminus. In addition, a 340-foot-long, 16-foot-wide floodplain bench was modeled along the right bank between STA 114+00 and STA 117+40. The floodplain benches vary in depth but would be set at approximately 2.5 feet below existing grade.

With these improvements, both structures now pass up to the future projected 100-year peak flow, and flooding across State Route 304 has been significantly reduced. A conceptual schematic of the proposed flood mitigation alternatives is illustrated in Figure 4-16. Longitudinal profiles showing existing and proposed conditions under the 50-year, current and future flood events are depicted in Figure 4-17 and under the 100-year, current and future flood events in Figure 4-18. Existing and proposed conditions flood depth mapping for the 10-, 50-, and 100-year flood events is included in Figures 4-19 through Figure 4-24.

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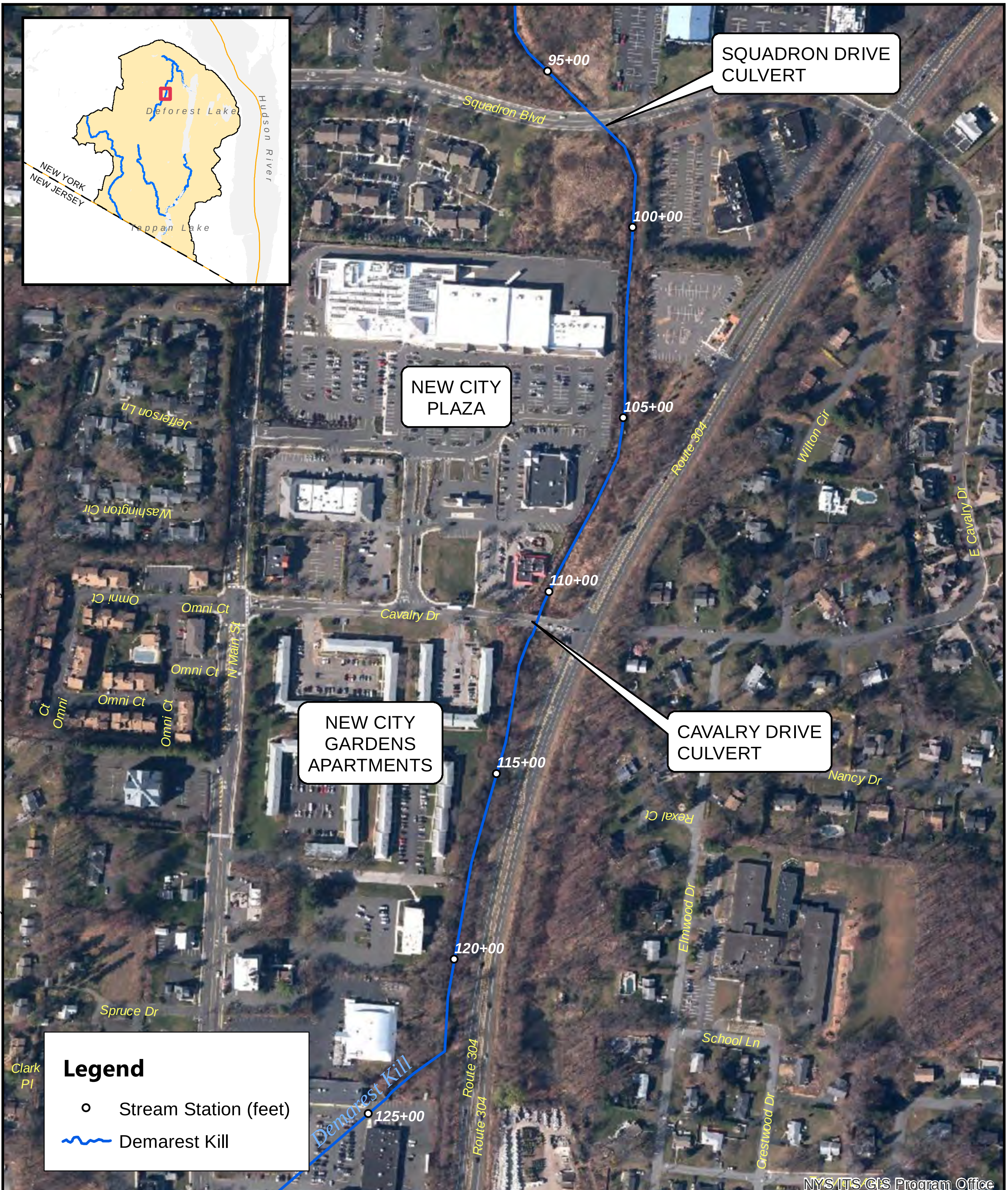

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HIGH RISK AREA #2 - SQUADRON DRIVE AND CAVALRY DRIVE

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SD109
ROCKLAND COUNTY
NEW YORK

N

0 350
Feet

SCALE 1 " = 350 '

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FIG. 4-14

SOURCE: 2016 AERIAL PHOTO, NYS ITS GIS Program Office

Figure 4-15: One of the Twin Box Culverts Under Squadron Drive

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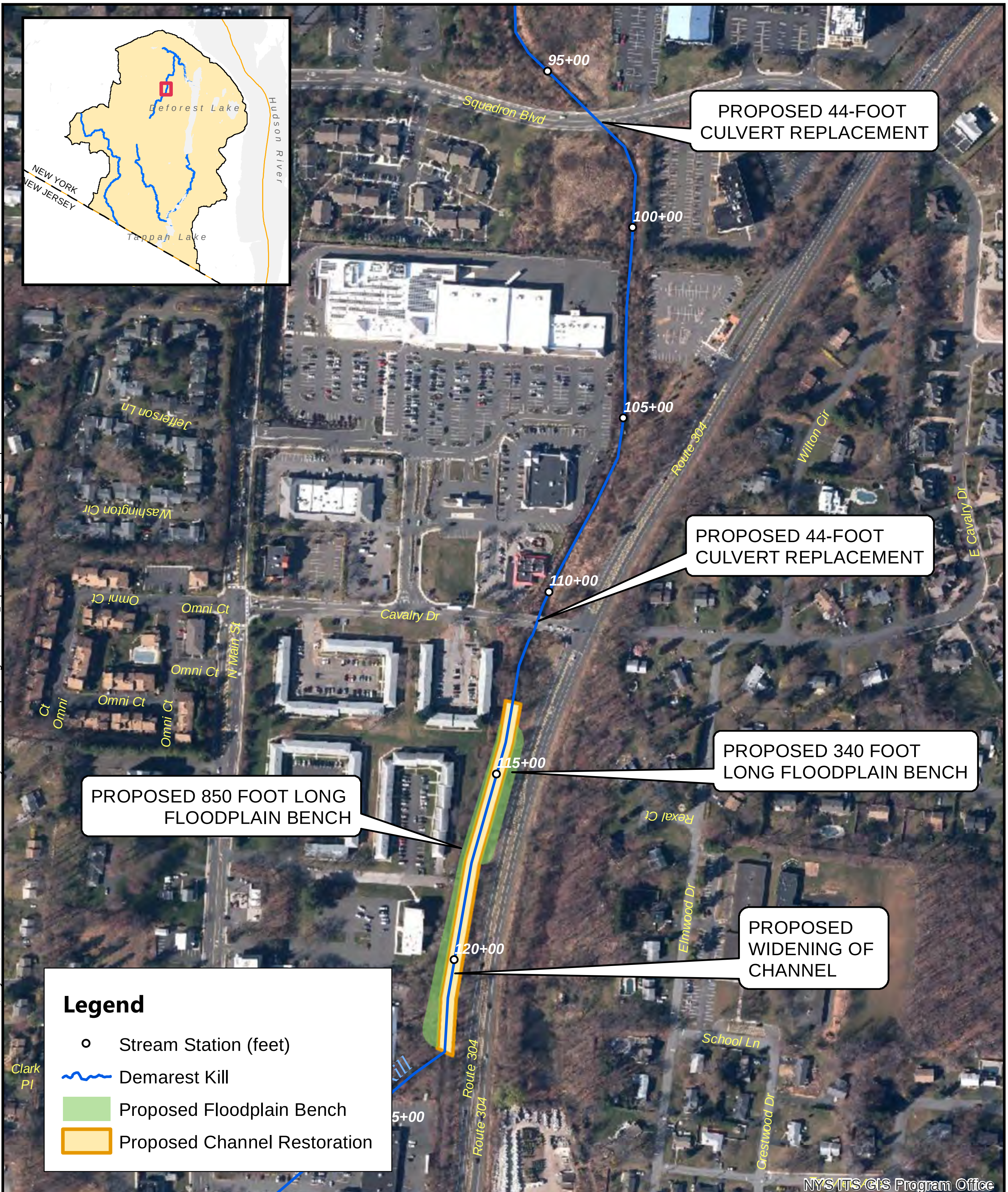

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HIGH RISK AREA #2 - CONCEPT MAP

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SD109

ROCKLAND COUNTY
NEW YORK

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SCALE 1 " = 350 '

DATE 12/29/2021

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FIG. 4-16

SOURCE: 2016 AERIAL PHOTO, NYS ITS GIS Program Office

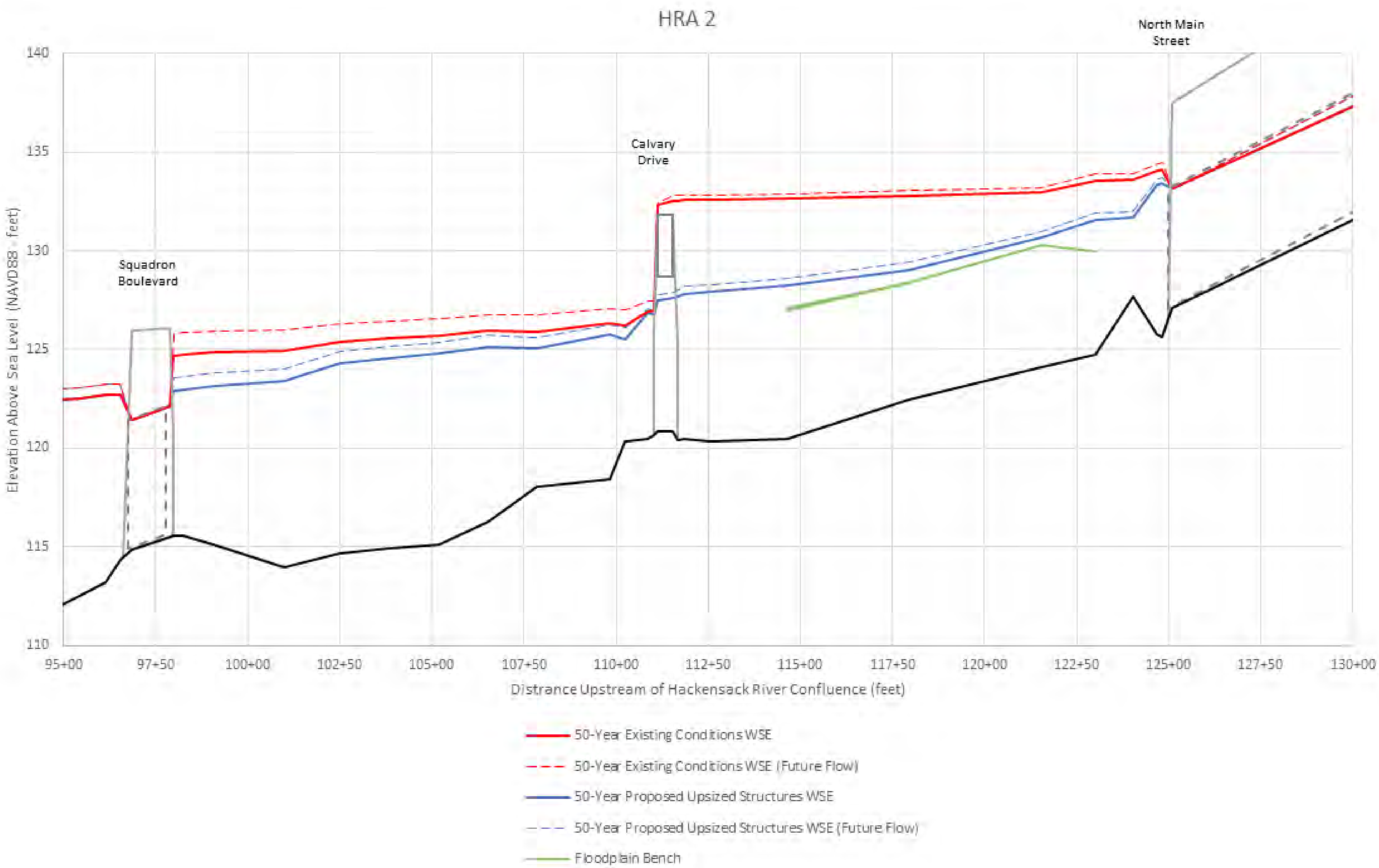

Figure 4-17: Longitudinal Profile Showing Recommended Improvements in HRA 2 During 50-Year Flood Event

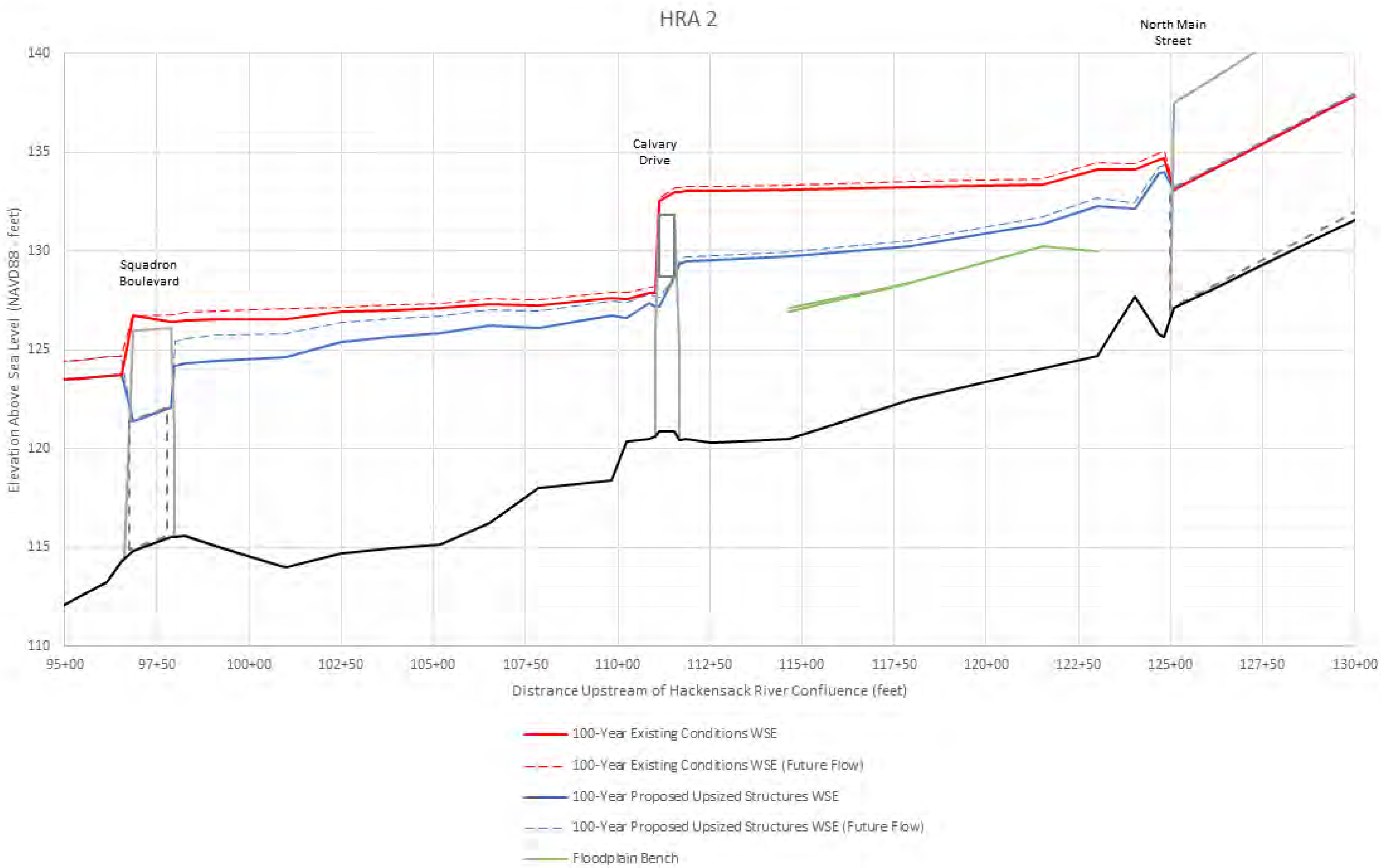

Figure 4-18: Longitudinal Profile Showing Recommended Improvements in HRA 2 During 100-Year Flood Event

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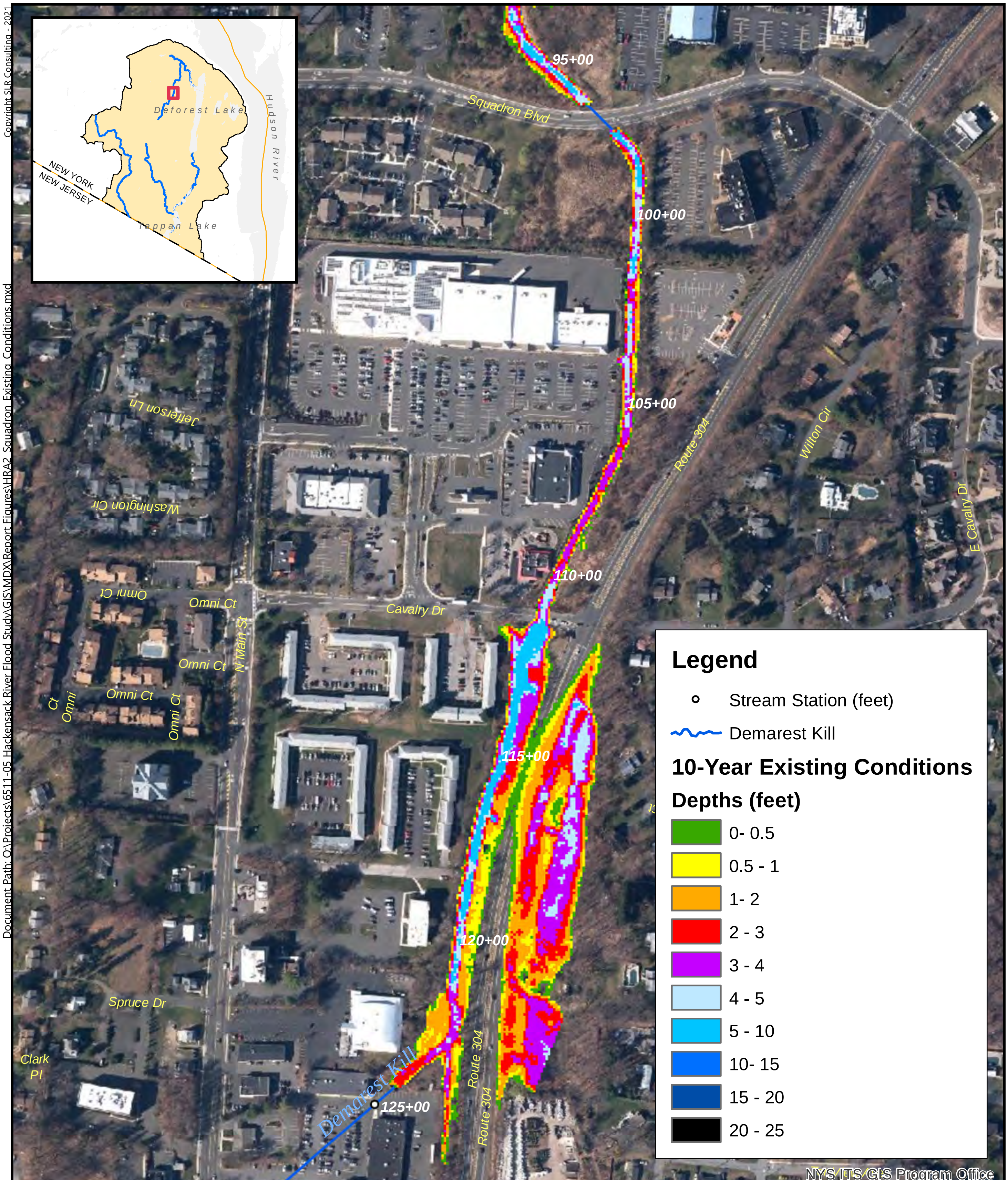

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HIGH RISK AREA #2 - 10-YEAR EXISTING CONDITIONS

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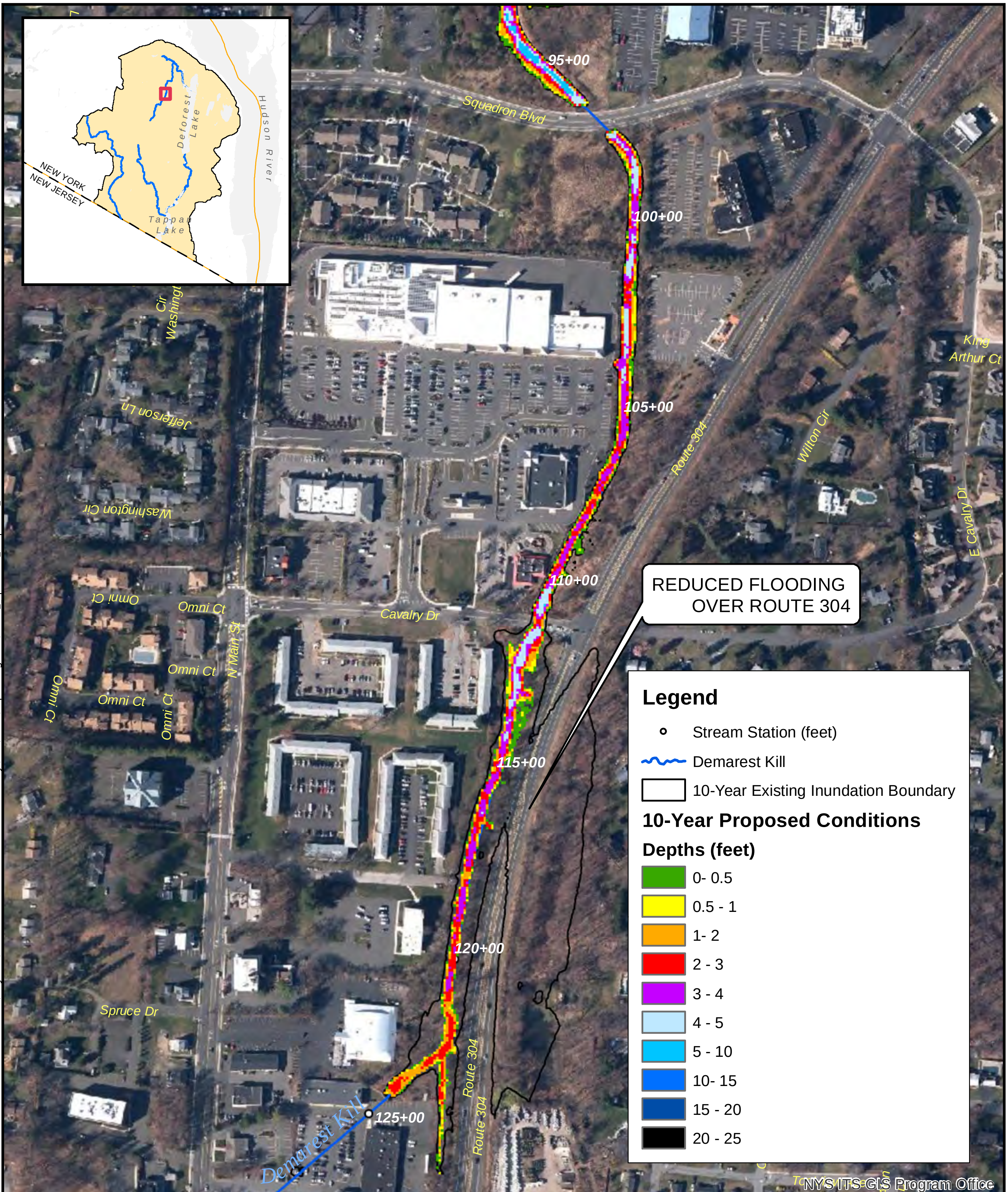
FIG. 4-19

SOURCE: 2016 AERIAL PHOTO, NYS ITS GIS Program Office



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HIGH RISK AREA #2 - 10-YEAR PROPOSED CONDITIONS

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FIG. 4-20

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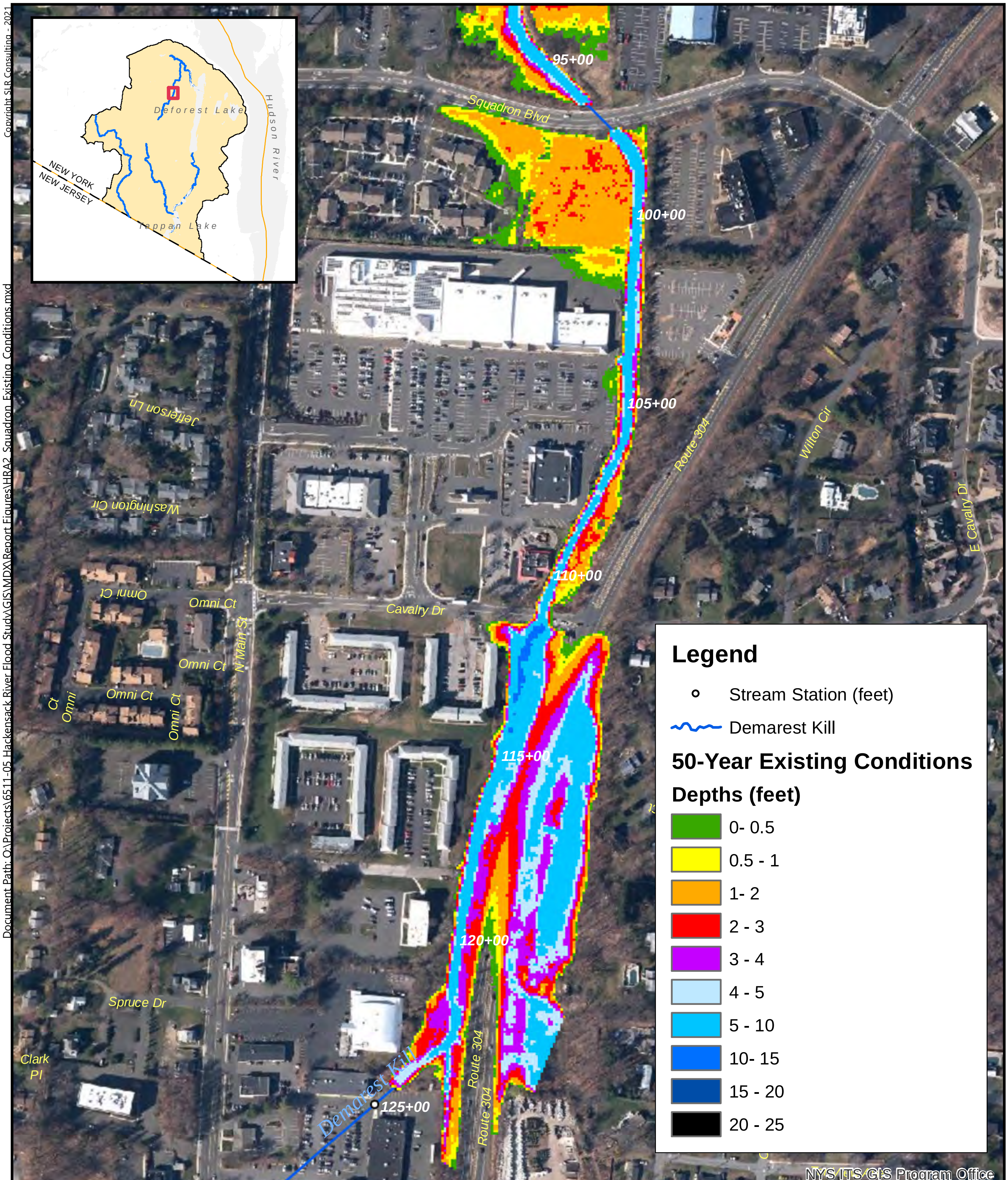
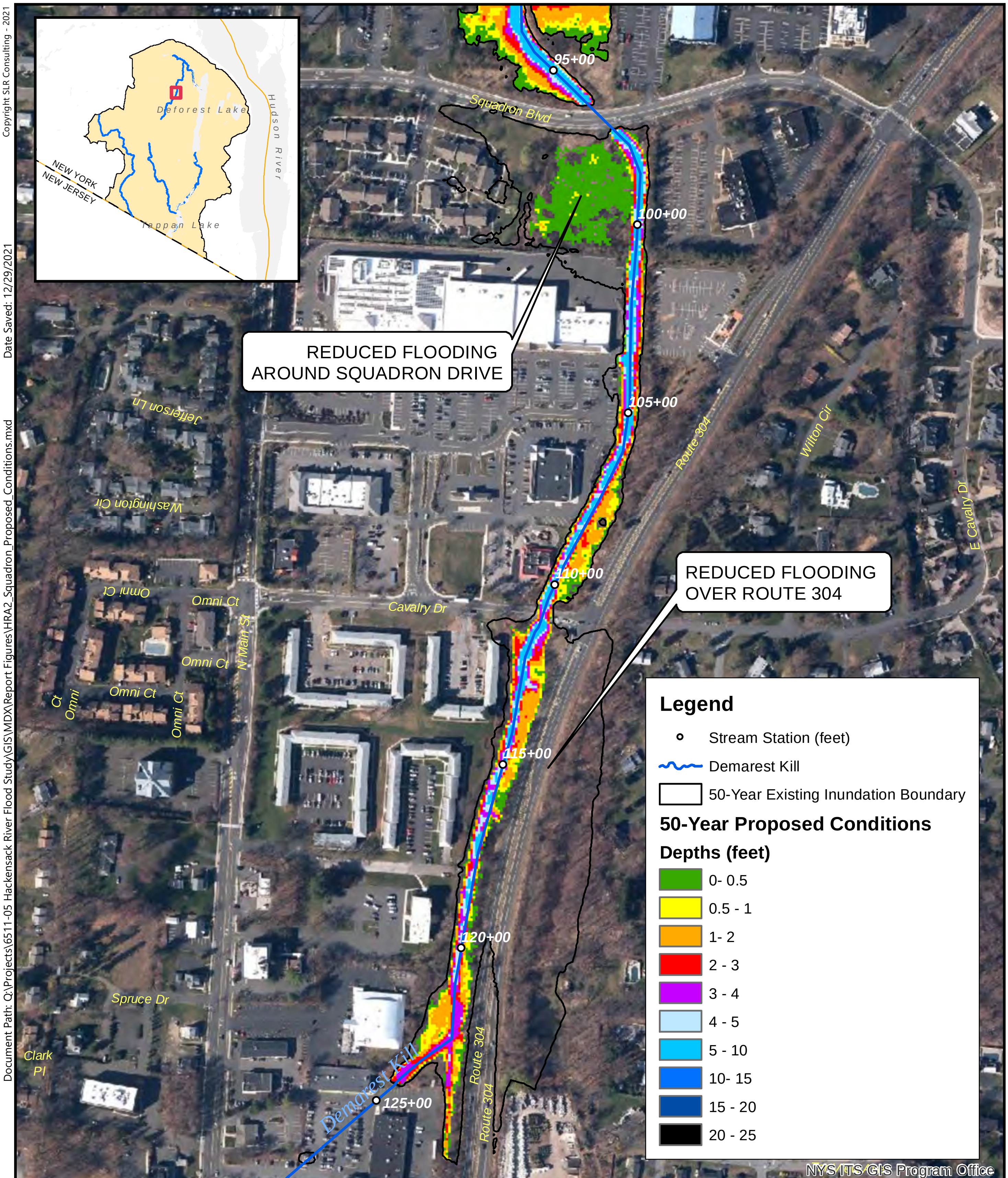


SLR 231 MAIN STREET SUITE 102 NEW PALTZ, NY 12561 845.633.8153	HIGH RISK AREA #2 - 50-YEAR EXISTING CONDITIONS HACKENSACK RIVER FLOOD & RESILIENCE STUDY SD109 ROCKLAND COUNTY NEW YORK N 0 370 Feet SOURCE: 2016 AERIAL PHOTO, NYS ITS GIS Program Office	SCALE 1 " = 350 ' DATE 12/29/2021 PROJ. NO. 16511.00005 **FIG. 4-21**



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HIGH RISK AREA #2 - 50-YEAR PROPOSED CONDITIONS

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FIG. 4-22

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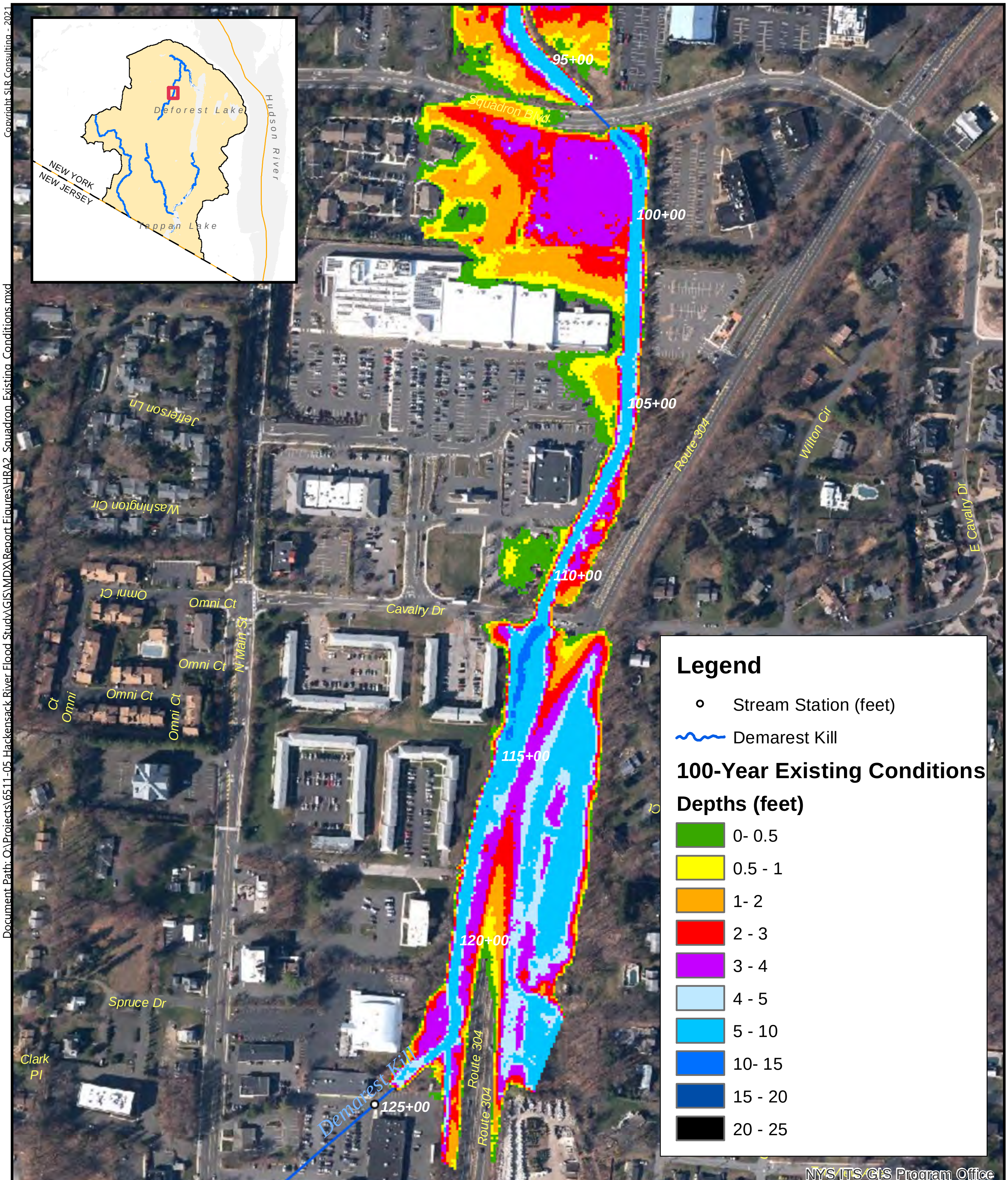

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HIGH RISK AREA #2 - 100-YEAR EXISTING CONDITIONS

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NEW YORK

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FIG. 4-23

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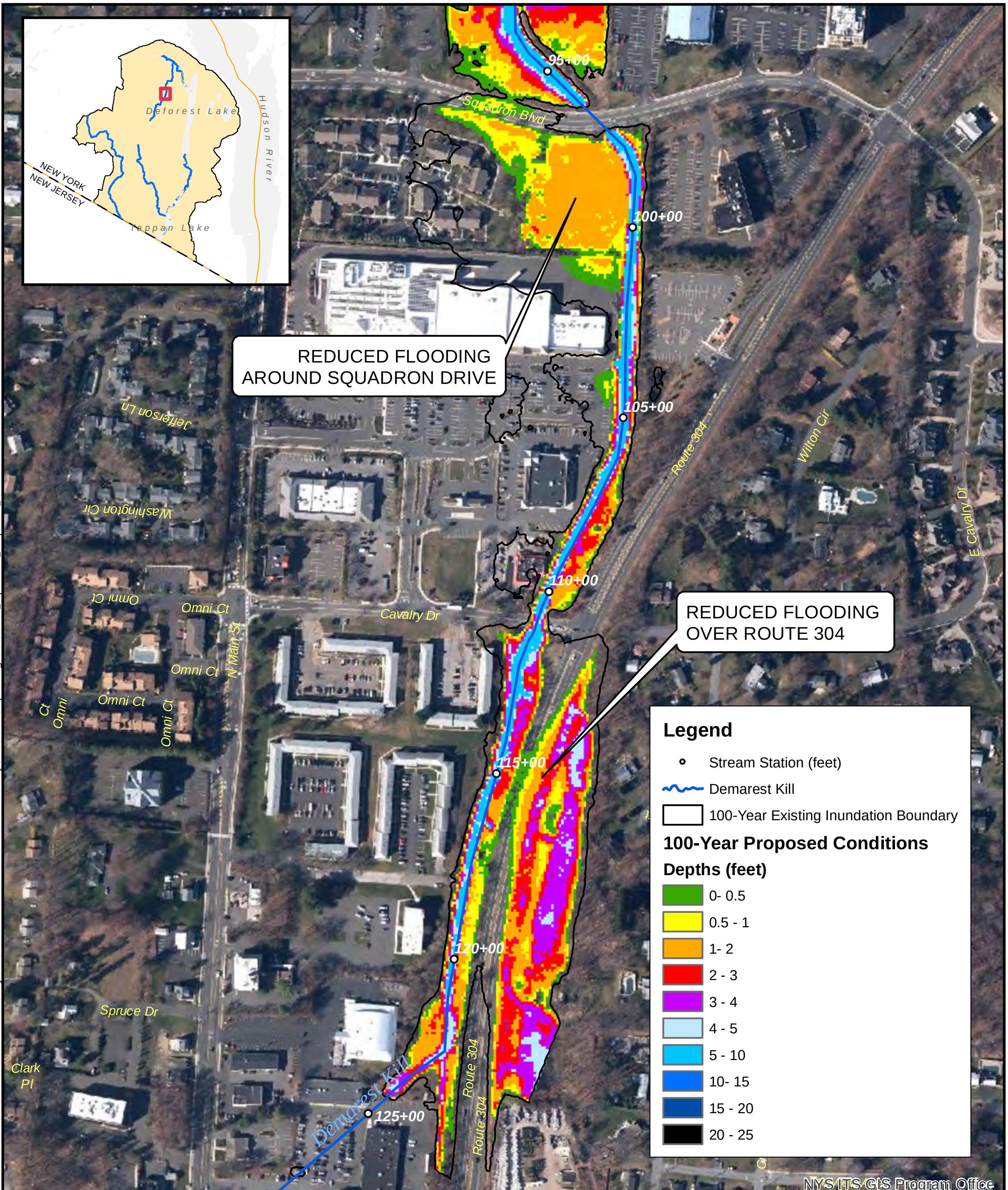

HIGH RISK AREA #2 - 100-YEAR PROPOSED CONDITIONS

HACKENSACK RIVER FLOOD & RESILIENCE STUDY
SD109
ROCKLAND COUNTY
NEW YORK

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FIG. 4-24

SOURCE: 2016 AERIAL PHOTO, NYS ITS GIS Program Office

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4.3 HIGH RISK AREA #3 – MAIN STREET AND NEW HEMPSTEAD ROAD

HRA 3 is located on the Demarest Kill in New City, in the vicinity of New Hempstead Road and the nearby shopping plaza on North Main Street, running from STA 125+00 upstream to STA 155+00 as shown in Figure 4-25. Stream crossings in HRA 3 include a lengthy, Rockland County owned culvert that passes under a bank parking lot, North Main Street (STA 132+50), and a shopping plaza parking lot, and a Rockland County owned bridge at New Hempstead Road (STA 136+00). HRA 3 was particularly devastated during the 2011 flood from Tropical Storm Irene where both the New Hempstead Road and North Main Street roadways were both overtopped by floodwaters, disrupting traffic, endangering lives, and flooding nearby commercial buildings (Figures 4-26 and 4-27).

Twin 11-foot by 6-foot box culverts run 925 linear feet under the bank parking lot, North Main Street, and the shopping plaza parking lot. While the inlet and outlet dimensions of the twin culverts were measured for the purpose of this analysis, the exact path and dimensions of the culverts as they pass under the plaza parking lot are not known.

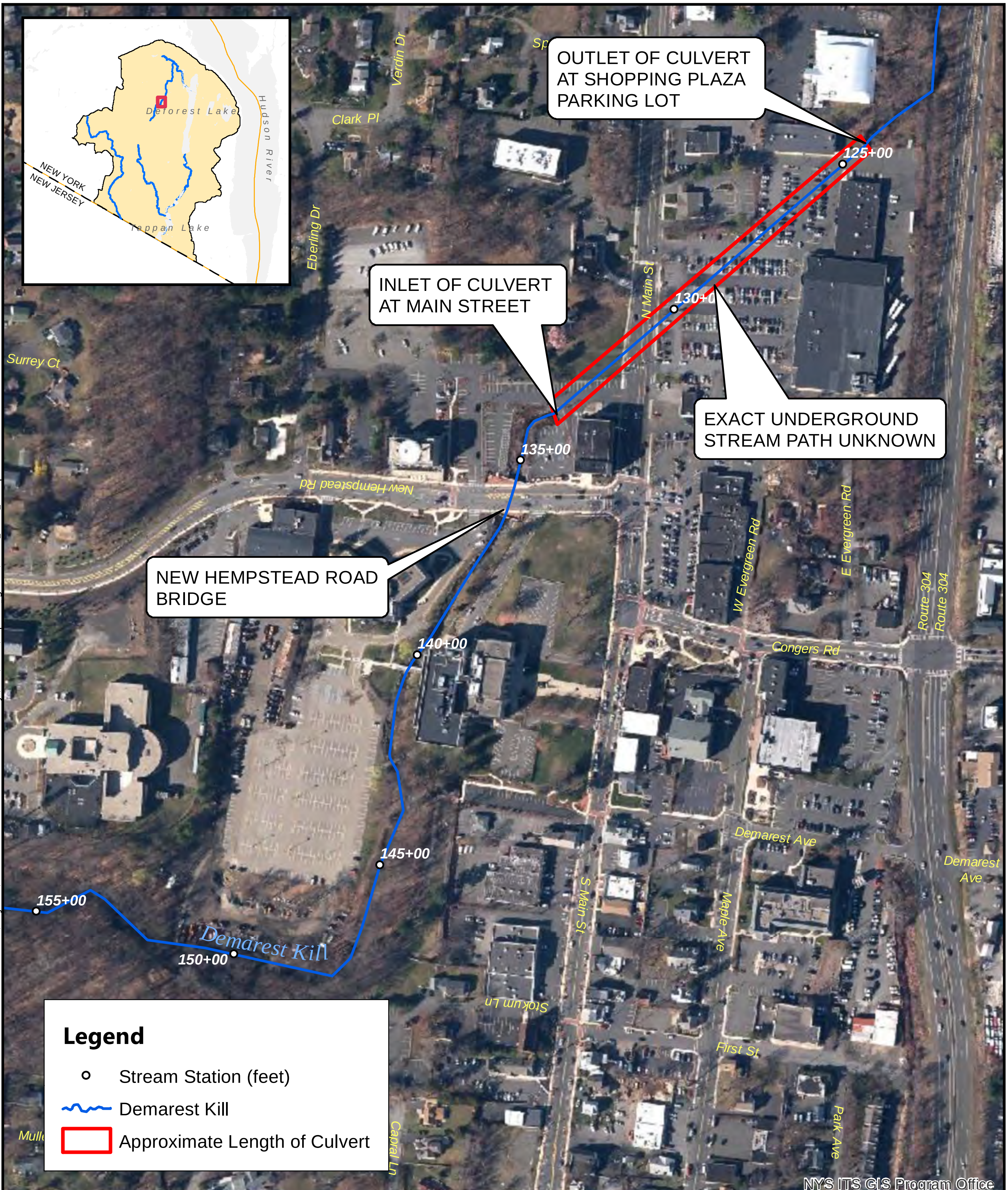
Hydraulic analysis was conducted within HRA 3 to evaluate flood mitigation scenarios. Current and future flows were used in the analysis. Analysis was conducted based on the flood flows the structure within the HRA would be expected to encounter. When modeling the twin culverts that run under the bank parking lot, North Main Street, and the plaza, the 2050-2074 future flow projections were employed as a 50-year design life is typical for such a structure.

Based on hydraulic analysis using field measurements of the inlet and outlet, the twin culverts are capable of passing all modeled peak discharges, including the 100-year flood event, without overtopping when the model is run under unobstructed conditions. The structure's performance is controlled by its inlet in the 10-year and 50-year flood events. During the 100-year flood event, the structure switches to being outlet controlled. Depending on the actual size, condition, unknown inputs, and path of the buried system, there is a high probability that the hydraulic model may be overestimating the capacity of the structure, which is currently being modeled as a singular, twin-barreled culvert with a constant slope and no bends or interior changes in dimension.

A sensitivity analysis was performed at the inlet of the twin culverts to assess the impact of blockage. A 30-percent blockage would result in overtopping during the 50-year flood event. A 50-percent blockage would result in overtopping starting at the 10-year flood event.

Based on initial hydraulic analysis with limited information about the twin culverts, it can be concluded that replacing the culverts with a larger structure or supplementing the existing culverts with a parallel culvert to increase capacity would provide flood reduction benefits.

It is recommended that detailed mapping and measurements be obtained for the entire length of the system. Once this information is obtained, a detailed hydraulic analysis should be undertaken to accurately model and evaluate the hydraulic capacity of the structure and recommend improvements.



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HIGH RISK AREA #3 - MAIN STREET & NEW HEMPSTEAD ROAD

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SCALE 1 " = 300 '

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FIG. 4-25

SOURCE: 2016 AERIAL PHOTO, NYS ITS GIS Program Office

Figure 4-26: Portion of North Main Street under water during Tropical Storm Irene in 2011. A vehicle is shown trapped in the flood waters. (Photo Courtesy of Patch Local News)

If further hydraulic analysis determines that replacement of the twin culverts is required, it is recommended that channel restoration be undertaken by daylighting all or portions of the culverts where they currently flow under the bank and plaza parking lots. (The term "daylighting" is used to refer to the restoration of an originally open-air watercourse that at some point has been placed into a below-ground culvert back into a restored, above-ground channel.)

The New Hempstead Road bridge is a newly replaced open-bottom arch bridge spanning 40 feet, with a 10-foot rise (Figure 4-28). The crossing is located about 180 linear feet upstream of the Main Street culverts. Hydraulic analysis indicates that the new bridge can convey up to the predicted future 100-year peak flow without overtopping or causing substantial flooding.

A concept map showing recommendations for HRA 3 is depicted as Figure 4-29.

Figure 4-28: Recently Replaced New Hempstead Road Bridge

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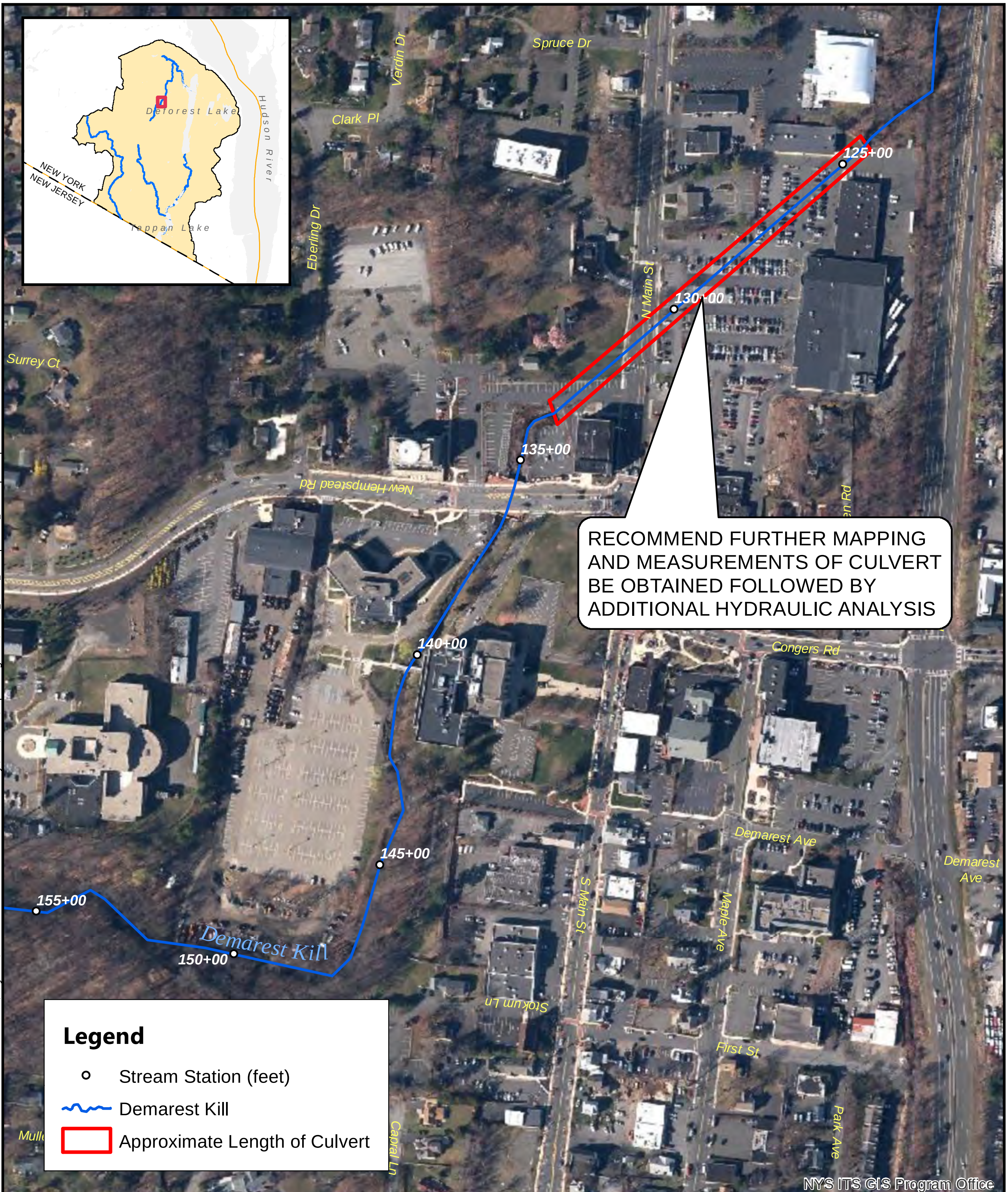

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HIGH RISK AREA #3 - CONCEPT MAP

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NEW YORK

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Feet

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FIG. 4-29

SOURCE: 2016 AERIAL PHOTO, NYS ITS GIS Program Office

4.4 HIGH RISK AREA #4 – STATE ROUTE 304 AND BLAUVELT ROAD

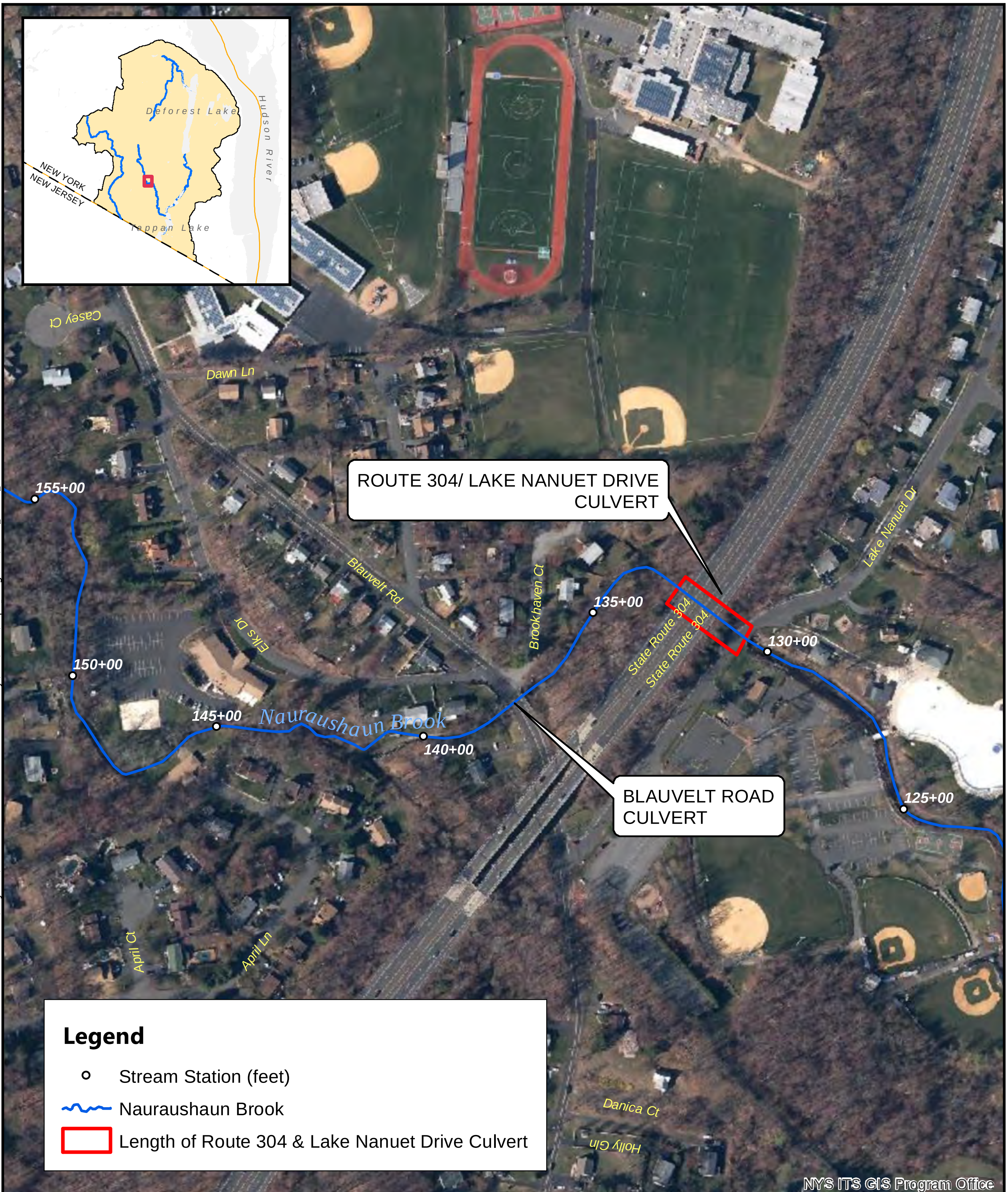
HRA 4 includes a stretch of Nauraushaun Brook in the hamlet of Nanuet, from STA 125+00 upstream to STA 155+00 as shown in Figure 4-30. The watercourse runs behind multiple private dwellings, most of which are partially mapped inside the FEMA 100-year floodplain. Pertinent crossings include a state-owned culvert that crosses under both State Route 304 and Lake Nanuet Drive (STA 132+00), and the Blauvelt Road culvert (STA 137+50), ownership unlisted. Hydraulic modeling and FEMA mapping indicate that flooding occurs along Nauraushaun Brook in this area, inundating sections of State Route 304, Brookhaven Court, and Pelham Avenue, and flooding homes along these roads.

The FEMA hydraulic model for Nauraushaun Brook in HRA 4 included a railroad crossing at STA 141+18. A review of aerial images revealed that the railroad bridge was removed during the period between 2007 and 2010. Therefore, for analysis of HRA 4, the railroad bridge was removed from the hydraulic model to reflect current-day conditions. The former railroad bridge was acting as a hydraulic constriction, and its removal will result in reduced flooding in HRA 4.

The current State Route 304/Lake Nanuet Drive crossing is a 15-foot by 7-foot, 230-foot-long concrete box culvert that passes under both roadways. Hydraulic modeling indicates that this culvert is adequate to pass all modeled storm events up to the future 100-year without overtopping the roadway although, the roadway embankment stands at approximately 20 feet above the streambed and causes a major backwater that extends almost 400 feet upstream to the next crossing at Blauvelt Road. The Blauvelt Road crossing (Figure 4-31) is a 12-foot by 6-foot concrete box culvert. The structure is shown to pass only the current 10-year flood event and becomes overtopped during any larger storm event. Hydraulic analysis indicates that both crossings are hydraulically undersized and together create a significant backwater that contributes to flooding of upstream homes and roads within HRA 4. The Nauraushaun Brook channel is also undersized as it passes through the Blauvelt Road culvert, through the section of channel between the two culverts, and through the State Route 304/Lake Nanuet Drive culvert.

Replacement of the Blauvelt Road crossing with a new bridge with a span of 45 feet and widening of the channel to a bankfull width of 36 feet would result in a 3.8-foot reduction in flood depths immediately upstream of the bridge during the 100-year flood event. This reduction would extend for approximately 720 feet upstream, to STA 144+70, before fully diminishing. The replacement structure under Blauvelt Road would have a greater hydraulic capacity allowing it to pass up to the future 50-year storm event without overtopping.

Replacement of the State Route 304/Lake Nanuet Drive crossing with a new bridge with a span of 45 feet and widening of the channel to a bankfull width of 36 feet result in over a 7.5-foot reduction in flood depths immediately upstream of the crossing during the 100-year storm event. These reductions would pull homes along Brookhaven Court out of the 100-year inundation extents. Furthermore, replacing the State Route 304/Lake Nanuet Drive culvert would reduce upstream tailwater elevations and therefore improve the hydraulic performance at Blauvelt Road during the 10-year flood event and would reduce upstream flood depths by almost 5 feet. However, there would be only minimal benefits during larger flood events since the larger constriction is the undersized culvert under Blauvelt Road.



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HIGH RISK AREA #4 - STATE ROUTE 304/LAKE NANUET DRIVE & BLAUVELT ROAD

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ROCKLAND COUNTY
NEW YORK

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Feet

SCALE 1 " = 300 '
DATE 12/29/2021
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FIG. 4-30

SOURCE: 2016 AERIAL PHOTO, NYS ITS GIS Program Office

A combined replacement of the culverts that carry Blauvelt Road and Route 304/Lake Nanuet Drive along with widening 900 linear feet of channel from STA 130+00 to STA 139+00 to a bankfull width of 36 feet would result in 7.7 feet of reduction upstream of Blauvelt Road during the 100-year event. A combined replacement would increase the capacity of the new Blauvelt Road crossing to pass the future 100-year storm event. The combined replacement of both culverts with larger crossings pulls several homes and roads out of the 100-year flood extents.

A concept map showing the proposed culvert replacements and channel restoration is depicted in Figure 4-32. Longitudinal profiles showing existing and proposed conditions under the 50-year, current and future flood events are depicted in Figure 4-33 and under the 100-year, current and future flood events in Figure 4-34. Flood reduction benefits are illustrated in the existing versus proposed depth grid maps on Figure 4-35 through Figure 4-40 for the current 10-, 50-, and 100-year peak flows.

If the above recommendations to increase the size of the crossings at Blauvelt Road and Route 304/Lake Nanuet Drive cannot be implemented, floodproofing and voluntary buyouts of flood-prone homes are recommended in HRA 4.

Figure 4-31: Blauvelt Road Box Culvert

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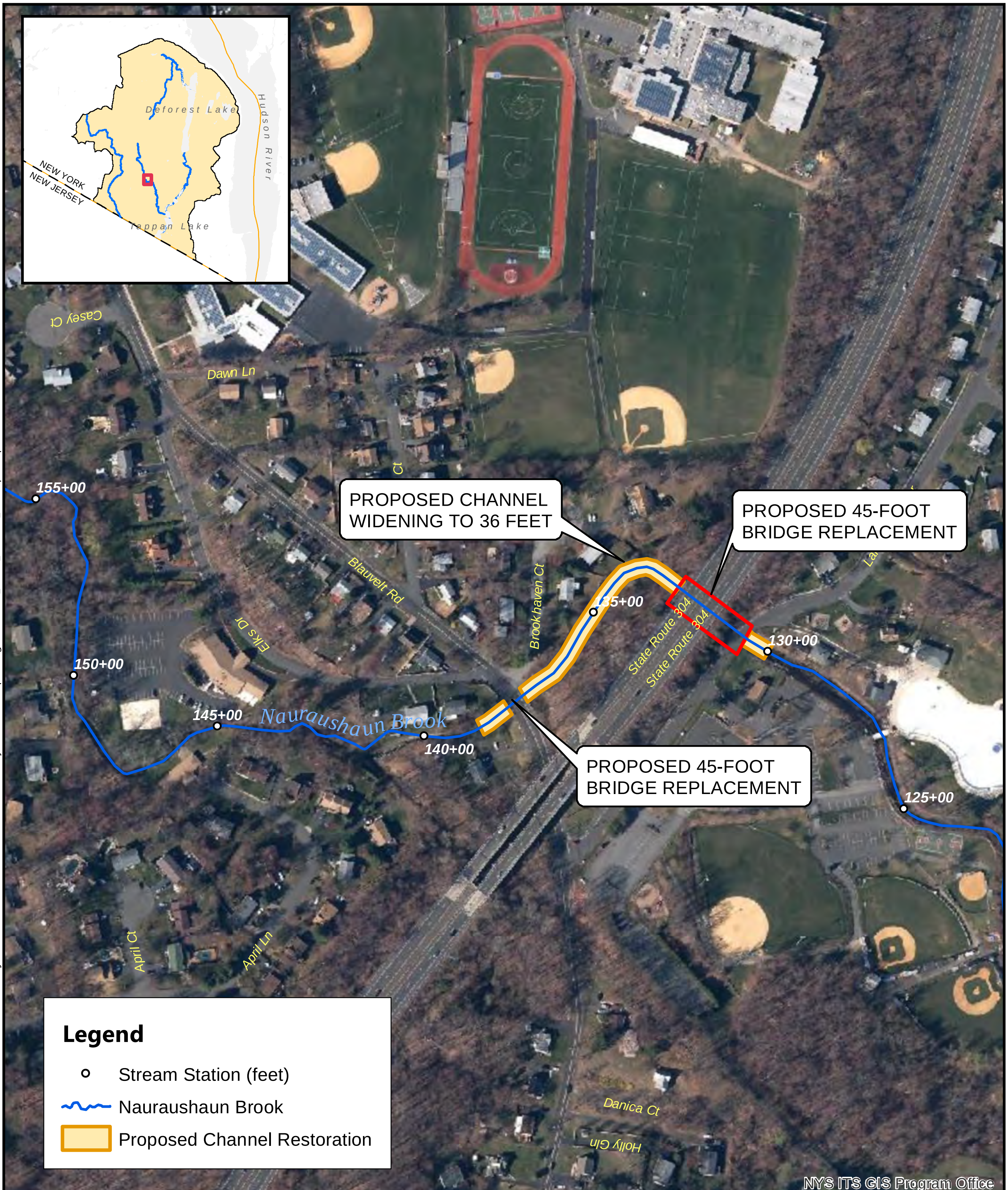

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HIGH RISK AREA #4 - CONCEPT MAP

HACKENSACK RIVER FLOOD & RESILIENCE STUDY
SD109
ROCKLAND COUNTY
NEW YORK

N

0 300 Feet

SOURCE: 2016 AERIAL PHOTO, NYS ITS GIS Program Office

SCALE 1 " = 300 '
DATE 12/29/2021
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FIG. 4-32

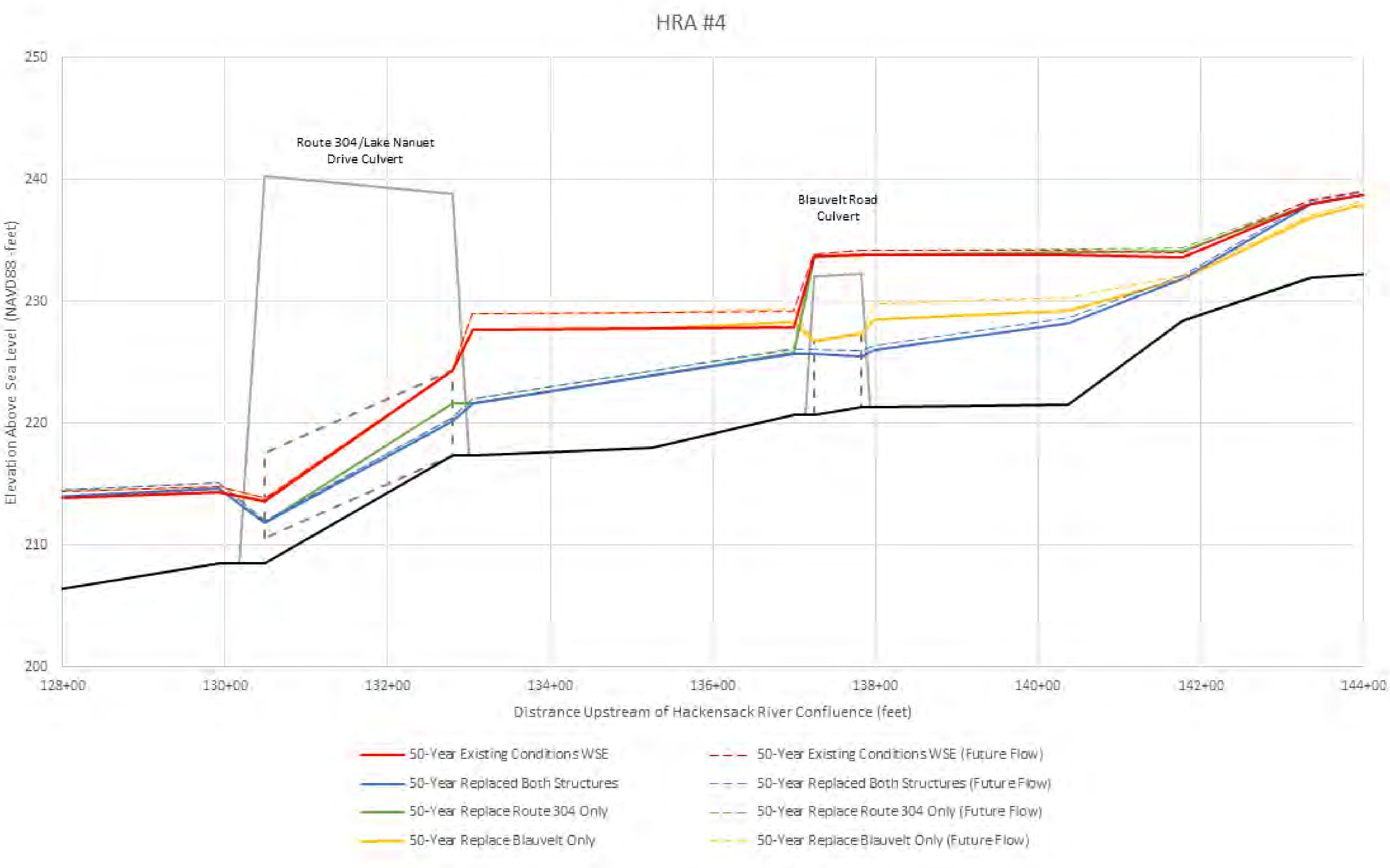

Figure 4-33: Longitudinal Profile Showing Recommended Improvements in HRA 4 During 50-Year Flood Event

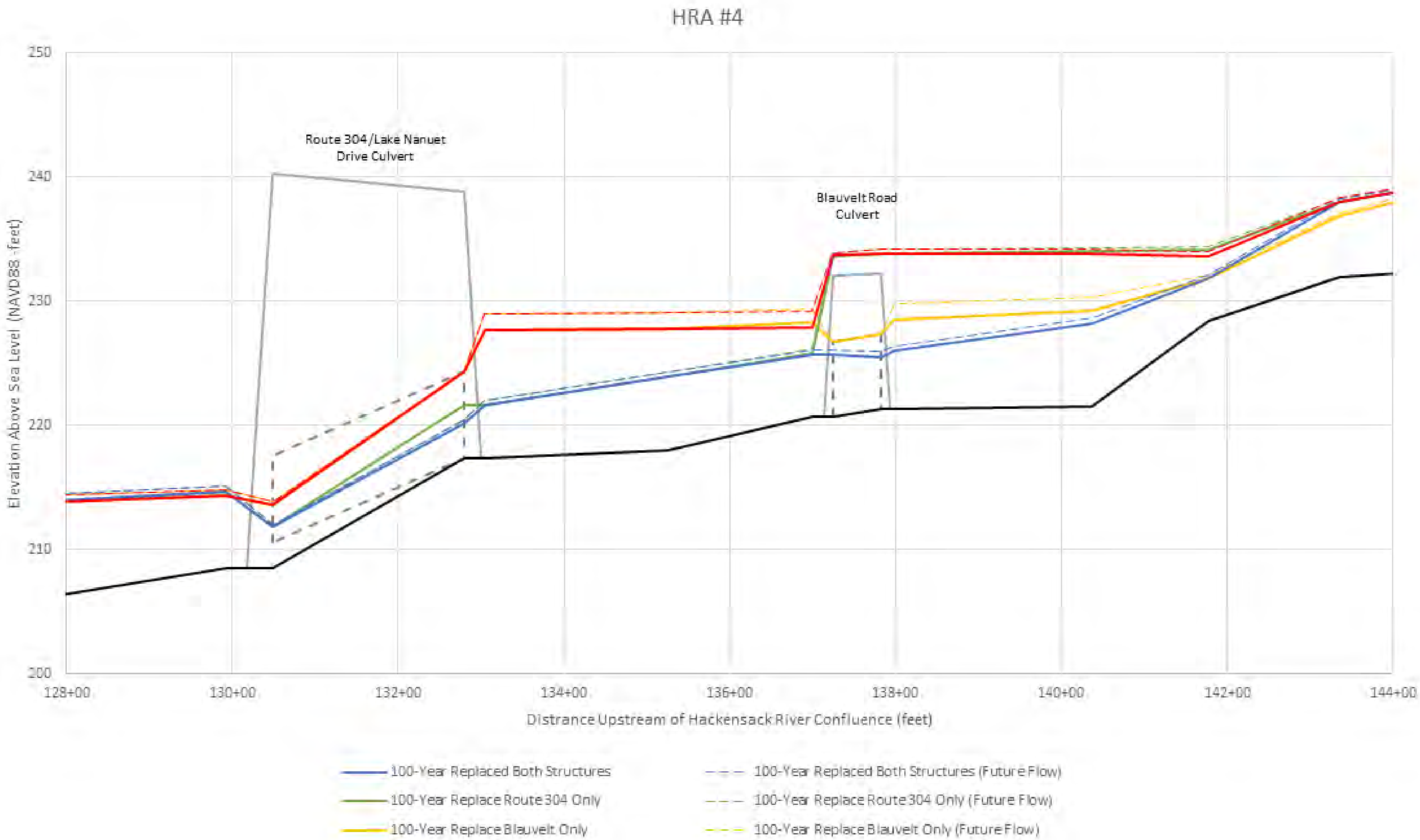

Figure 4-34: Longitudinal Profile Showing Recommended Improvements in HRA 4 During 100-Year Flood Event

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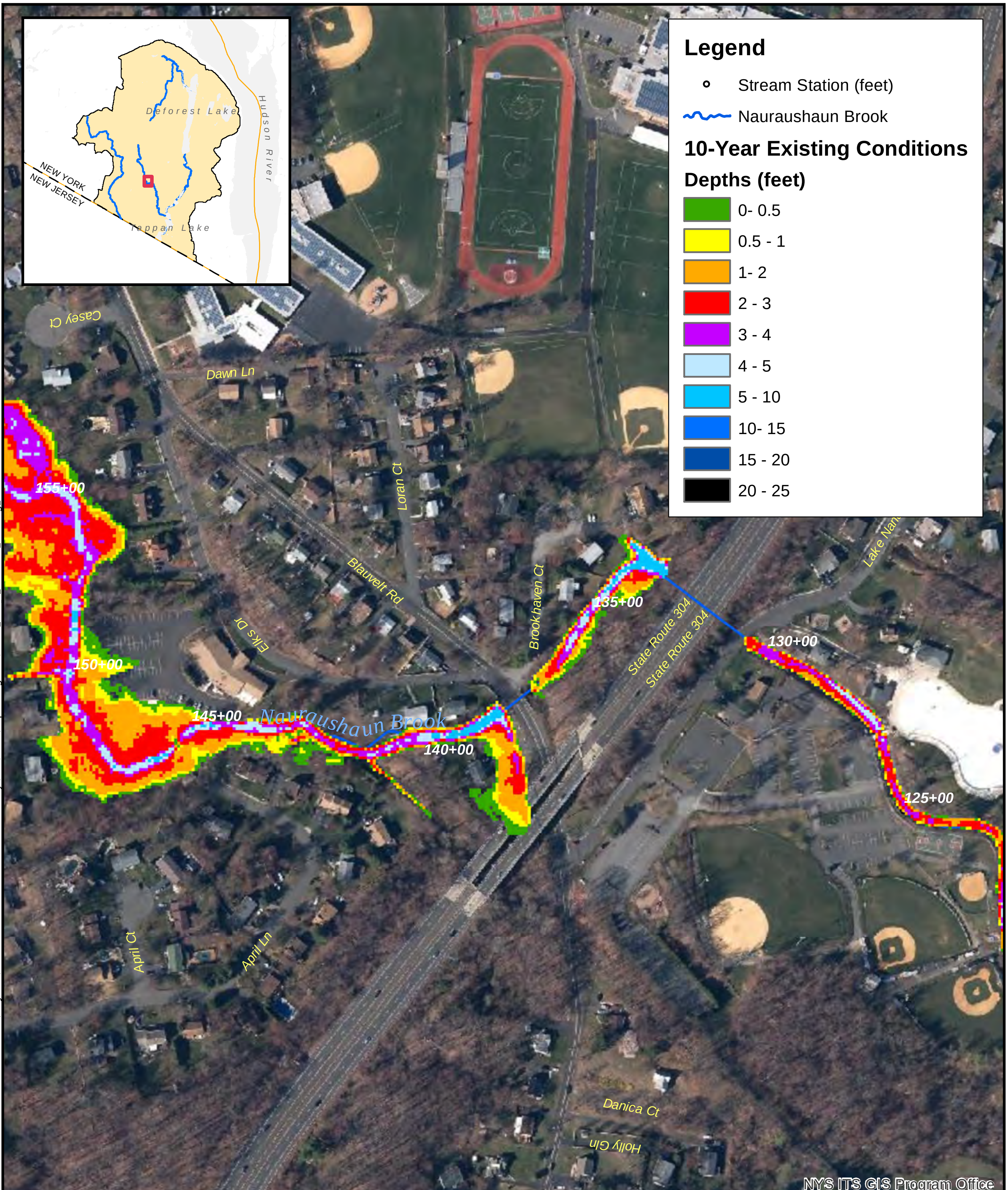

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HIGH RISK AREA #4 - 10-YEAR EXISTING CONDITIONS

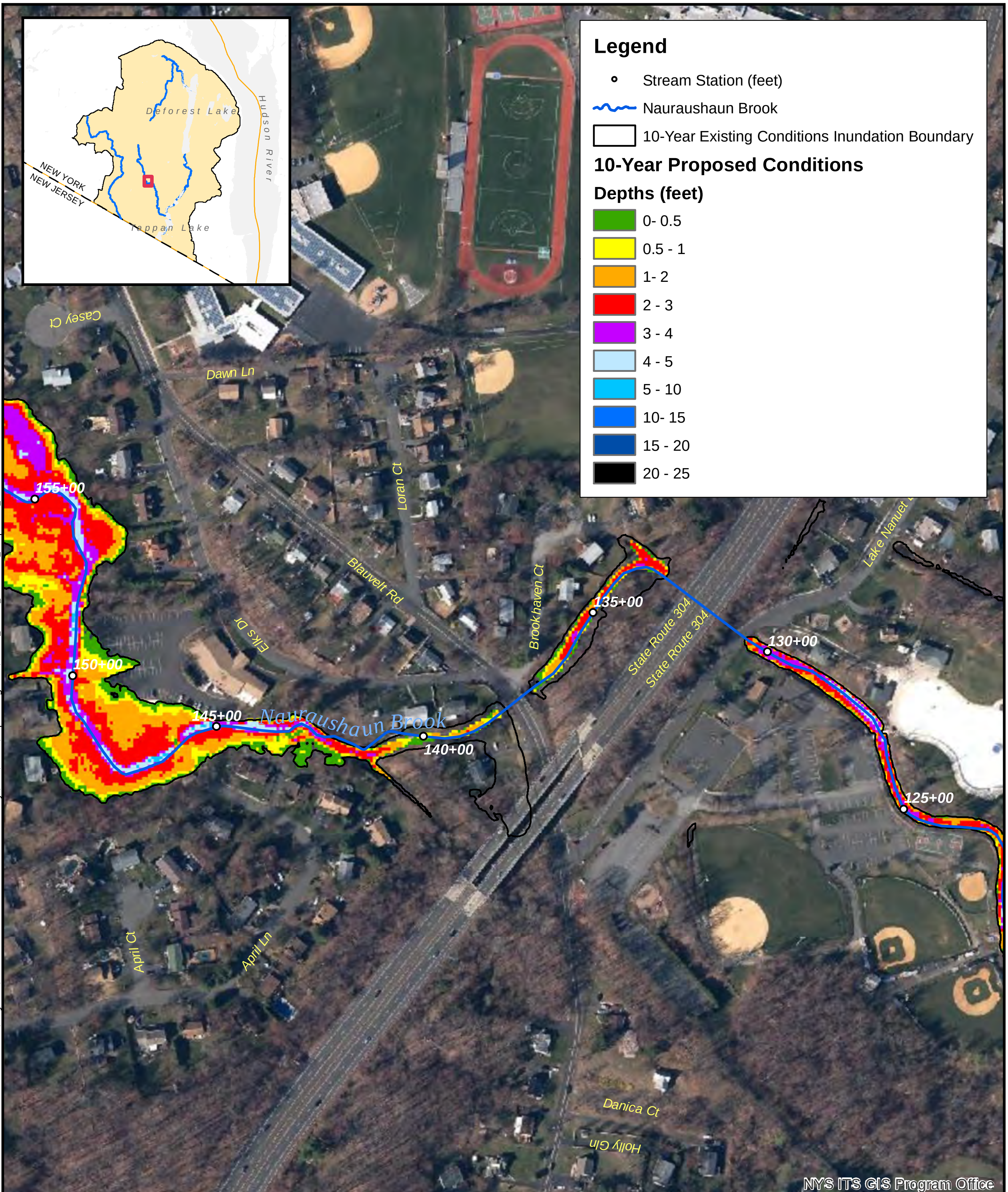
HACKENSACK RIVER FLOOD & RESILIENCE STUDY
SD109
ROCKLAND COUNTY
NEW YORK

N
0 310
Feet

SCALE 1 " = 300 '
DATE 12/17/2021
PROJ. NO. 16511.00005

FIG. 4-35

SOURCE: 2016 AERIAL PHOTO, NYS ITS GIS Program Office



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HIGH RISK AREA #4 - 10-YEAR PROPOSED CONDITIONS

HACKENSACK RIVER FLOOD & RESILIENCE STUDY
SD109

ROCKLAND COUNTY
NEW YORK

N

0 310
Feet

SCALE 1 " = 300 '

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FIG. 4-36

SOURCE: 2016 AERIAL PHOTO, NYS ITS GIS Program Office

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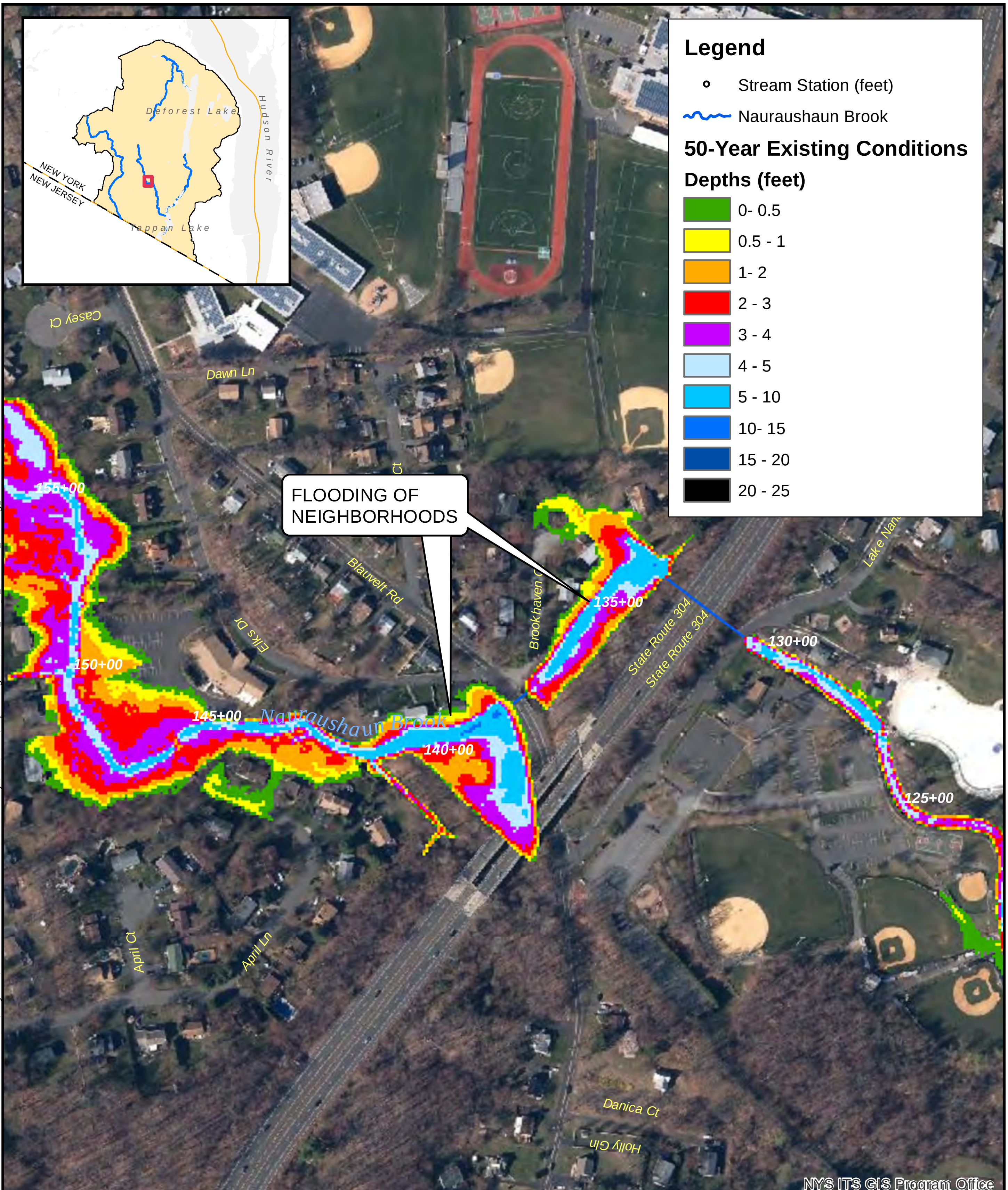
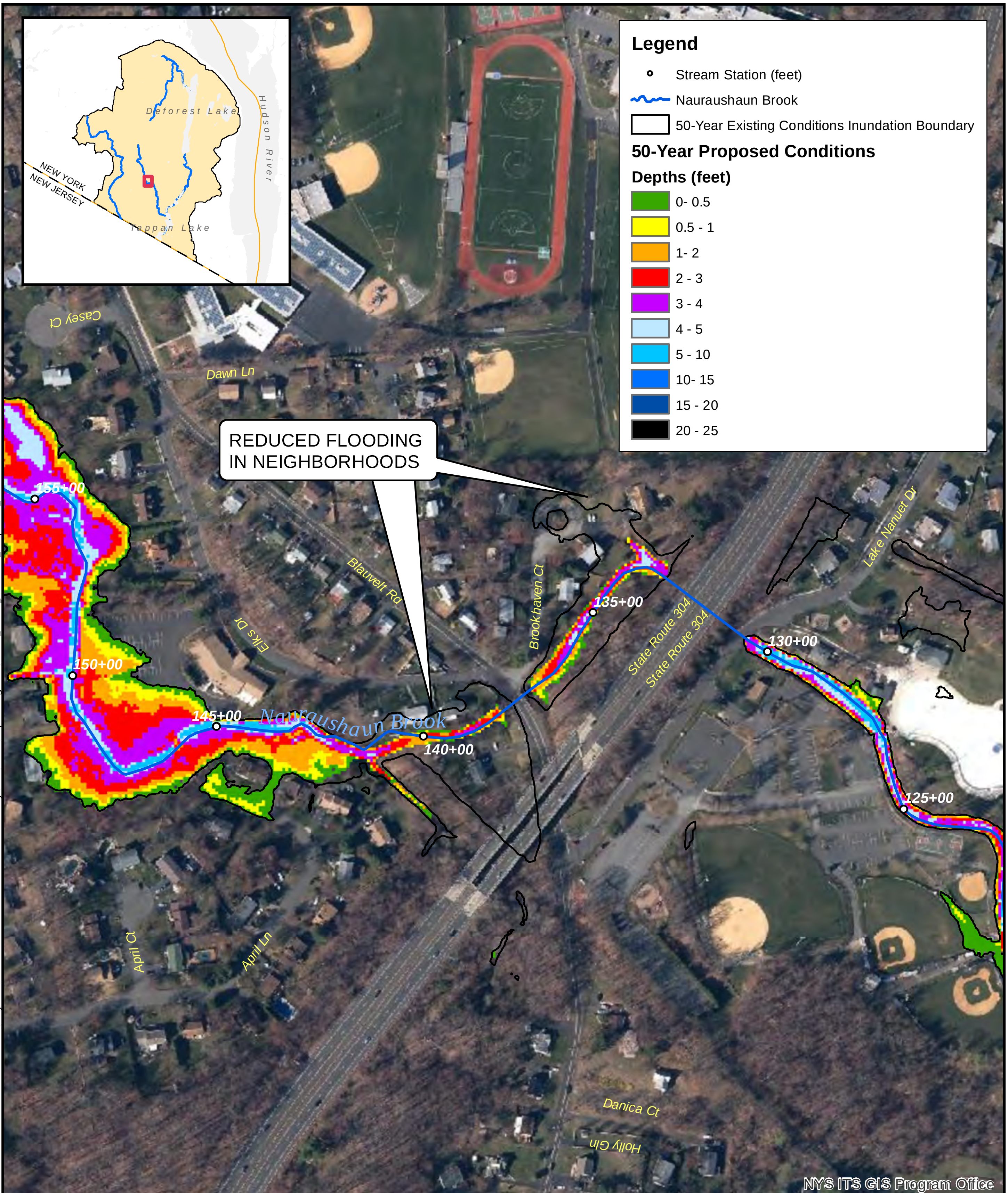


SLR 231 MAIN STREET SUITE 102 NEW PALTZ, NY 12561 845.633.8153	HIGH RISK AREA #4 - 50-YEAR EXISTING CONDITIONS HACKENSACK RIVER FLOOD & RESILIENCE STUDY SD109 ROCKLAND COUNTY NEW YORK N 0 310 Feet	SCALE 1 " = 300 ' DATE 12/17/2021 PROJ. NO. 16511.00005 **FIG. 4-37**

SOURCE: 2016 AERIAL PHOTO, NYS ITS GIS Program Office



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HIGH RISK AREA #4 - 50-YEAR PROPOSED CONDITIONS

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SD109
ROCKLAND COUNTY
NEW YORK

N

0 310
Feet

SCALE 1 " = 300 '

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FIG. 4-38

SOURCE: 2016 AERIAL PHOTO, NYS ITS GIS Program Office

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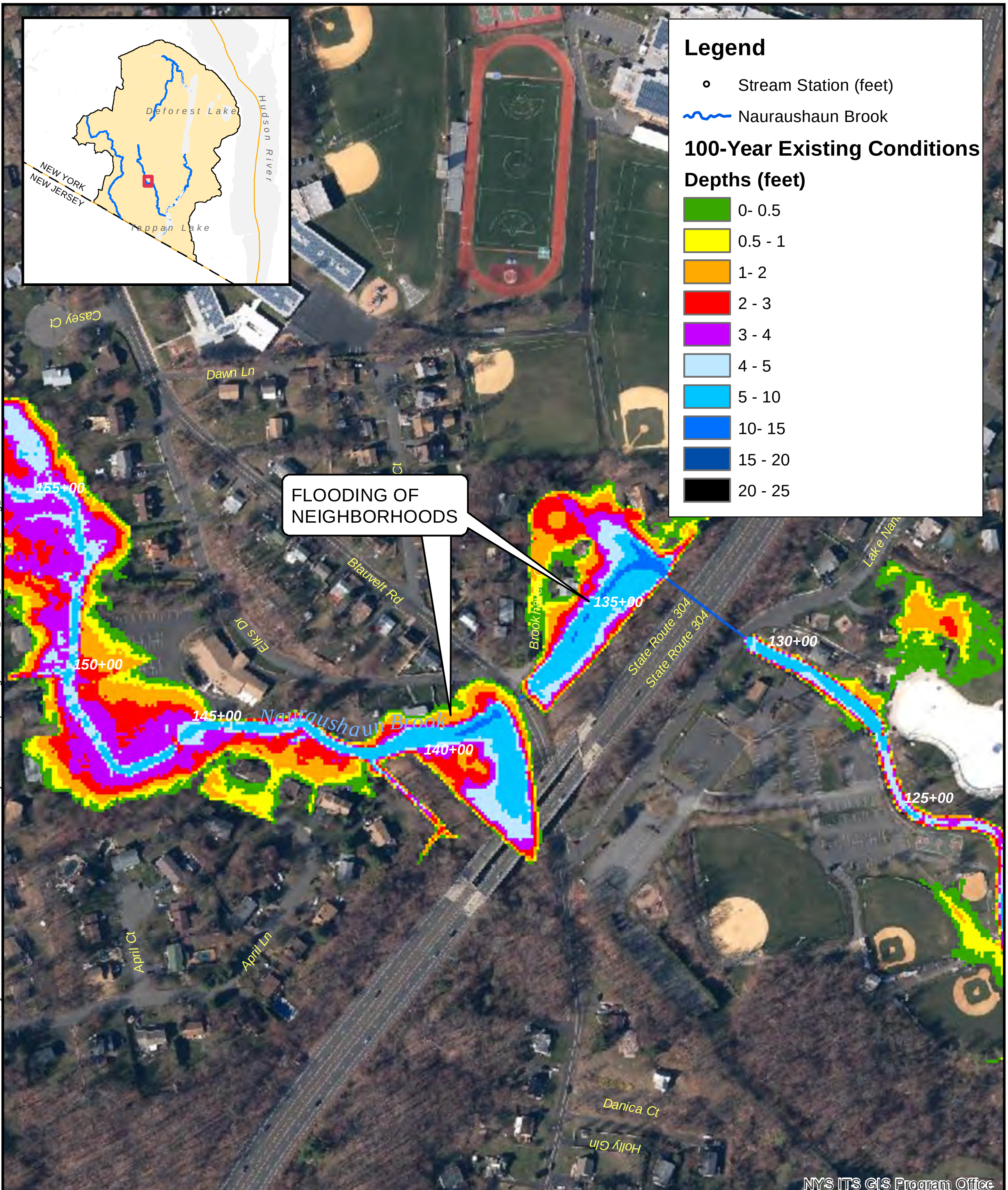

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HIGH RISK AREA #4 - 100-YEAR EXISTING CONDITIONS

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SD109
ROCKLAND COUNTY
NEW YORK

N
0 310
Feet

SCALE 1 " = 300 '
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FIG. 4-39

SOURCE: 2016 AERIAL PHOTO, NYS ITS GIS Program Office

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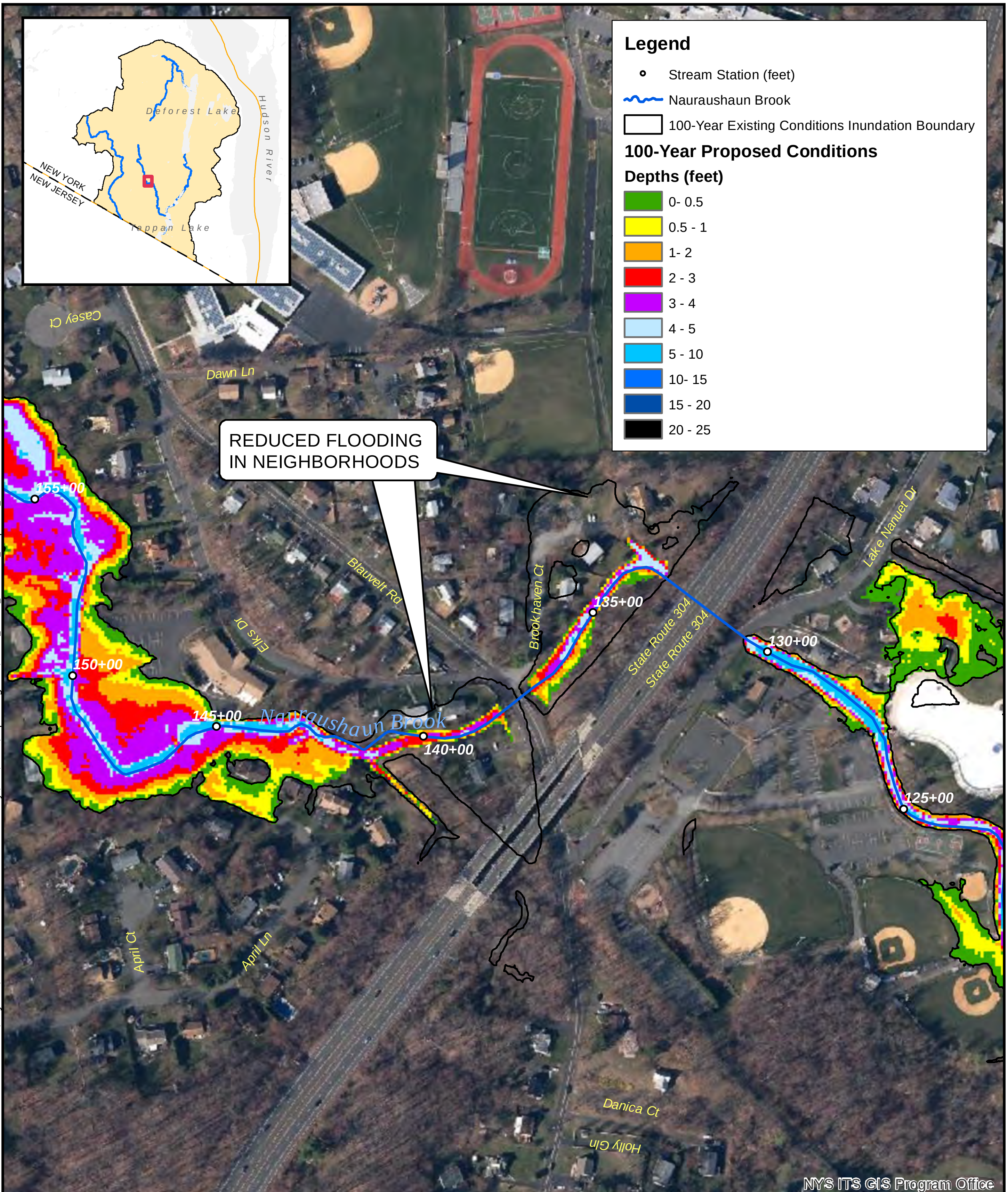

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HIGH RISK AREA #4 - 100-YEAR PROPOSED CONDITIONS

HACKENSACK RIVER FLOOD & RESILIENCE STUDY
SD109
ROCKLAND COUNTY
NEW YORK

N
0 310
Feet

SCALE 1 " = 300 '

DATE 12/29/2021

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FIG. 4-40

SOURCE: 2016 AERIAL PHOTO, NYS ITS GIS Program Office

4.5 HIGH RISK AREA #5 – NORMANDY VILLAGE

In HRA 5, Nauraushaun Brook flows through the Normandy Village apartment complex in the hamlet of Nanuet (Figure 4-41), between STA 185+00 and STA 200+00. The brook flows under First Street (STA 197+00), ownership unlisted, winds tightly through the Normandy Village apartment complex where it passes under two privately owned bridges (STA 193+00 and STA 191+50), then flows under East Charles Street (STA 187+00), ownership unlisted.

Hydraulic analysis was conducted within HRA 5 using current and future flows. Proposed replacement stream crossings were assessed based on the flood flows the structure would be expected to encounter over its design lifetime. The 2075-2099 projections were used to evaluate bridges in HRA 5, which are anticipated to be in service for 75 to 100 years or more.

Both Normandy Village bridges are made up of triple-pipe arch culverts (Figure 4-42). Both crossings are unable to pass the 10-year flood event, creating over a 1.5-foot backwater and contributing to flooding at the Normandy Village apartments.

In addition to evaluation of the crossings, the hydraulic model was used to evaluate channel restoration, which entails widening of the channel to a bankfull width of approximately 36 feet. The channel restoration is recommended for a distance of 300 linear feet as Nauraushaun Brook passes through Normandy Village, between STA 191+50 and STA 194+50. The replacement of both bridges with new structures with a span of at least 45 feet, combined with channel widening resulted in a reduction in water surface elevation of over 2 feet in the 10-year flood event, and both structures now pass up to the 50-year storm event. The effects of these changes can be seen across a 700-foot reach of the brook and would significantly improve the hydraulic performance of the upstream crossing at First Street.

Figure 4-43 illustrates a concept map of HRA 5 and the proposed bridge replacement and stream restoration that are being recommended. Longitudinal profiles showing existing and proposed conditions under the 50-year, current and future flood events are depicted in Figure 4-44 and under the 100-year, current and future flood events in Figure 4-45. Flood reduction benefits are illustrated in the existing versus proposed depth grid maps on Figure 4-46 through Figure 4-51 for the current 10-, 50-, and 100-year peak flows.

If the above recommendations to increase the size of the crossings and undertake channel restoration cannot be implemented, floodproofing and voluntary buyouts of flood-prone homes are recommended in HRA 5.

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HIGH RISK AREA #5 - NORMANDY VILLAGE

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SD109
ROCKLAND COUNTY
NEW YORK

N
0 210
Feet

SCALE 1 " = 200 '
DATE 12/29/2021
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FIG. 4-41

SOURCE: 2016 AERIAL PHOTO, NYS ITS GIS Program Office

Figure 4-42: One of the Triple-Pipe Arch Culvert Bridges in Normandy Village

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HIGH RISK AREA #5 - CONCEPT MAP

HACKENSACK RIVER FLOOD & RESILIENCE STUDY
SD109
ROCKLAND COUNTY
NEW YORK

N

0 210
Feet

SCALE 1 " = 200 '

DATE 12/29/2021

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FIG. 4-43

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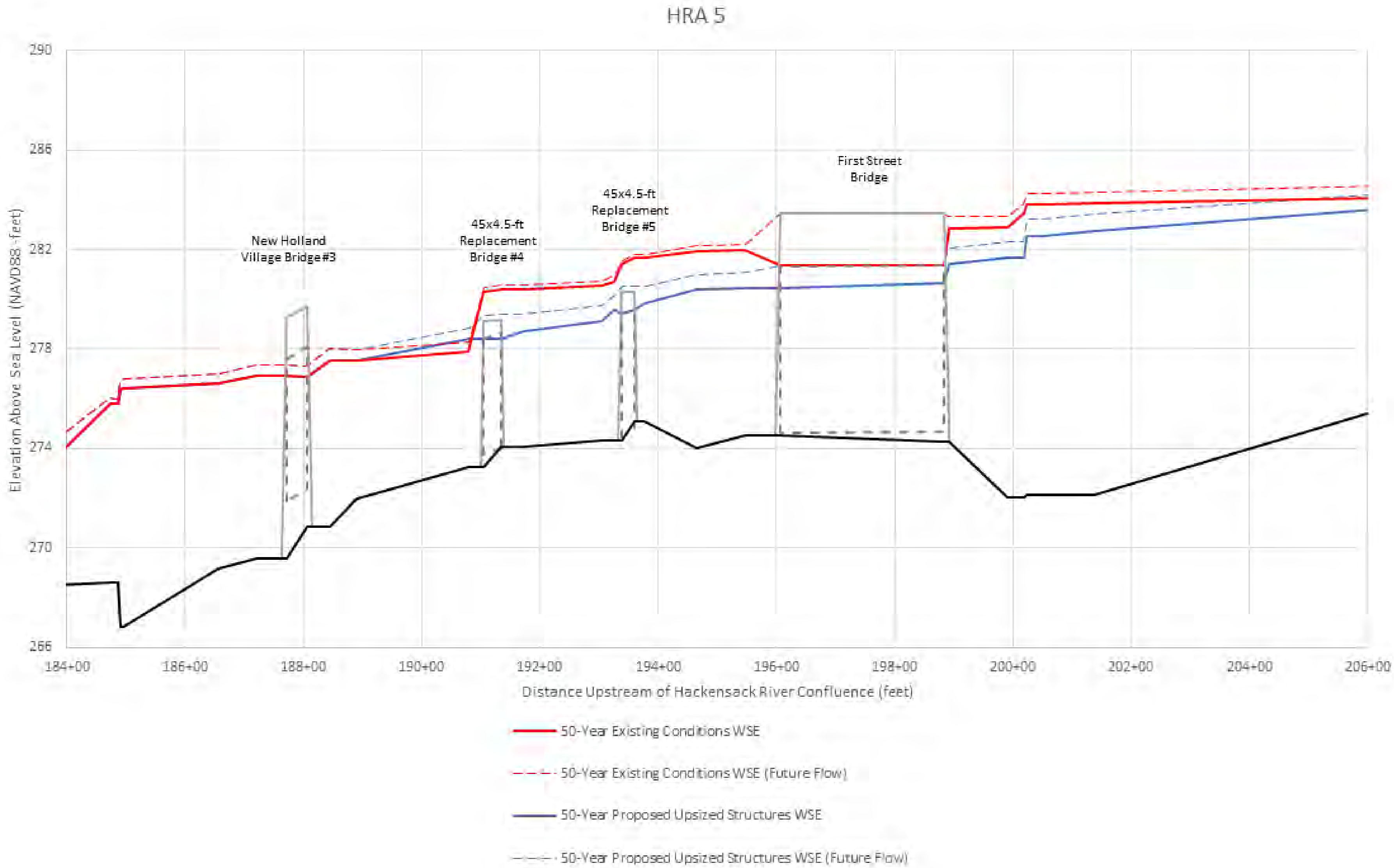


Figure 4-44: Longitudinal Profile Showing Recommended Improvements in HRA 5 During 50-Year Flood Event

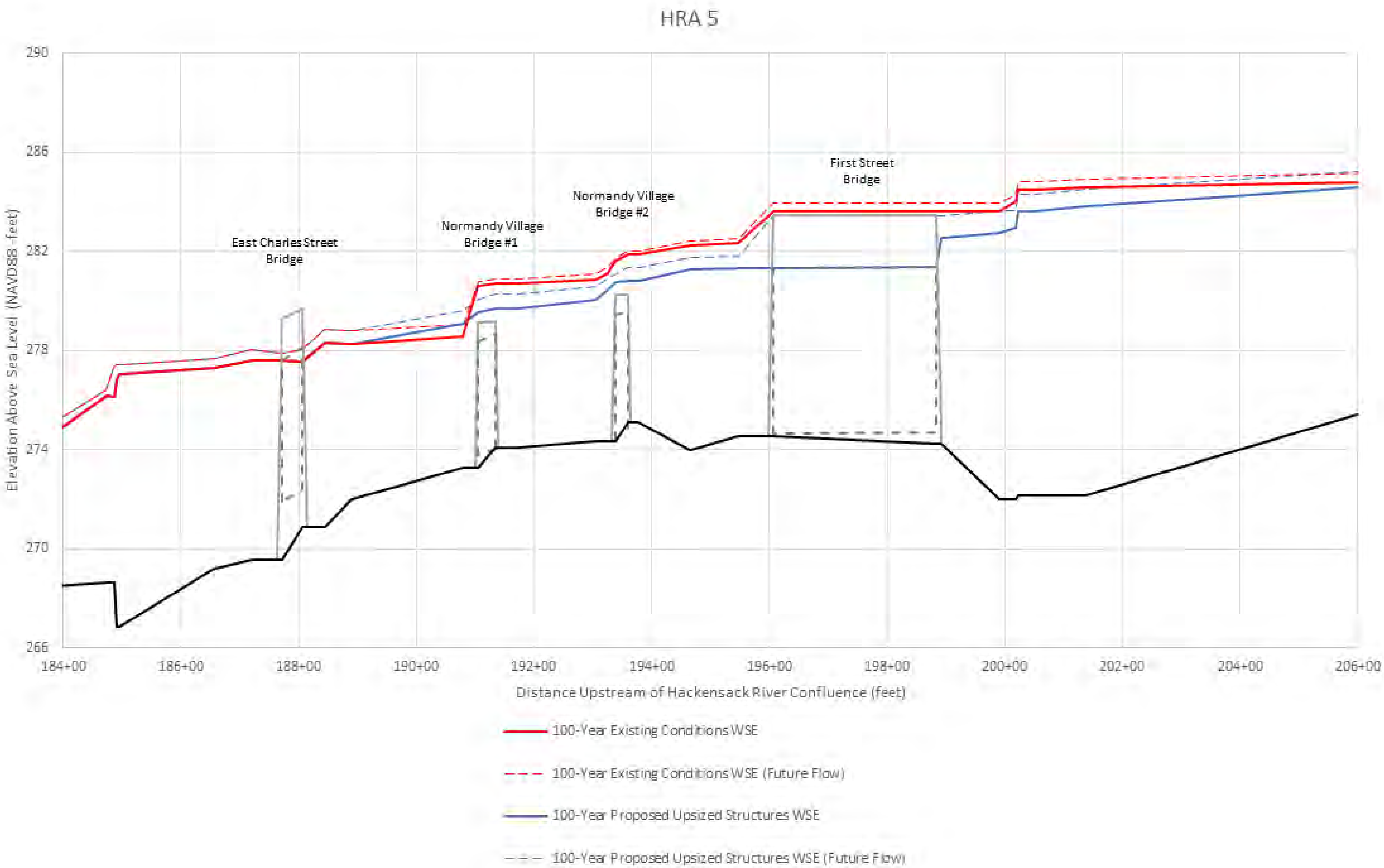
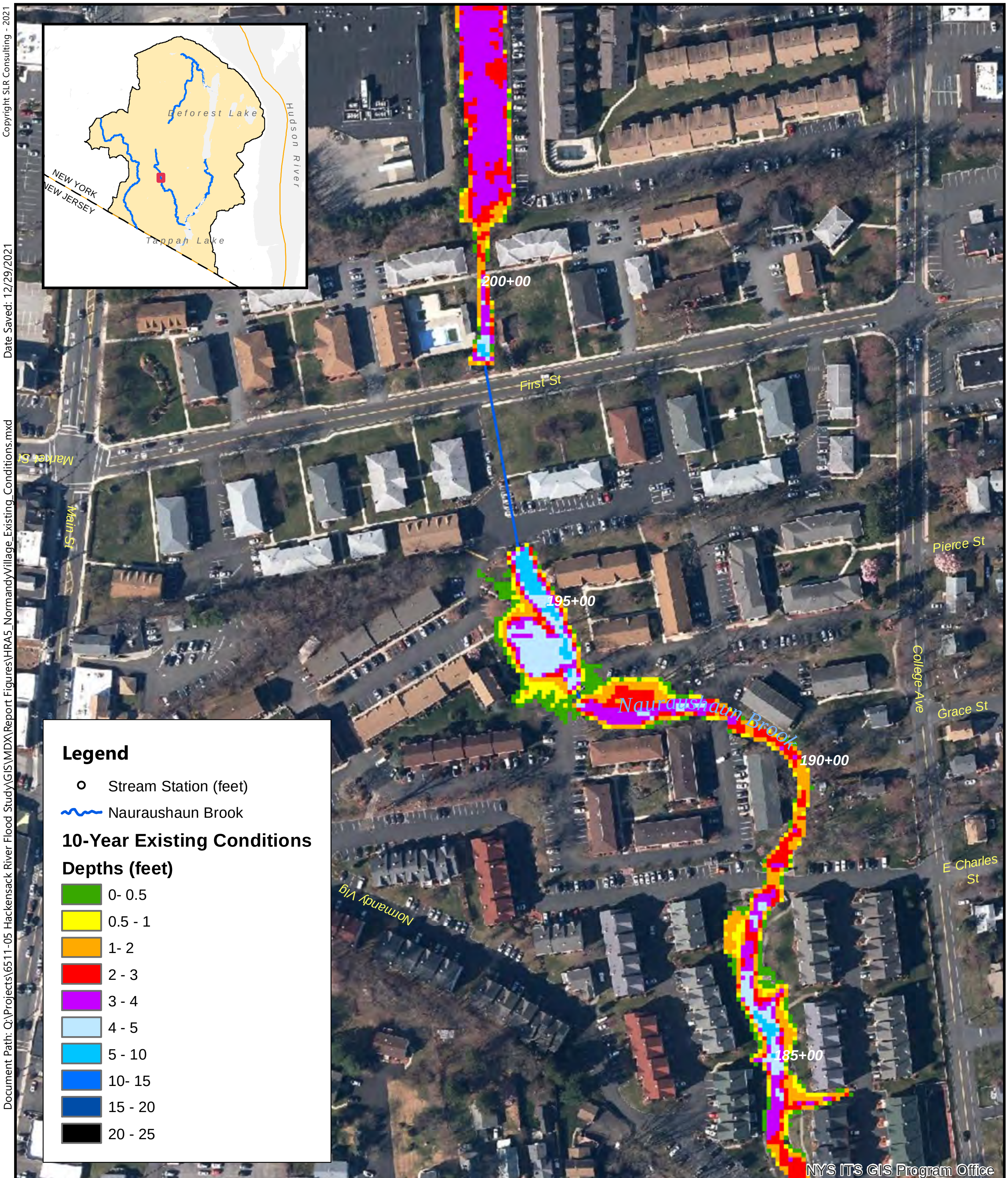


Figure 4-45: Longitudinal Profile Showing Recommended Improvements in HRA 5 During 100-Year Flood Event



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HIGH RISK AREA #5 - 10-YEAR EXISTING CONDITIONS

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SD109
ROCKLAND COUNTY
NEW YORK

N

0 210
Feet

SCALE 1 " = 200 '

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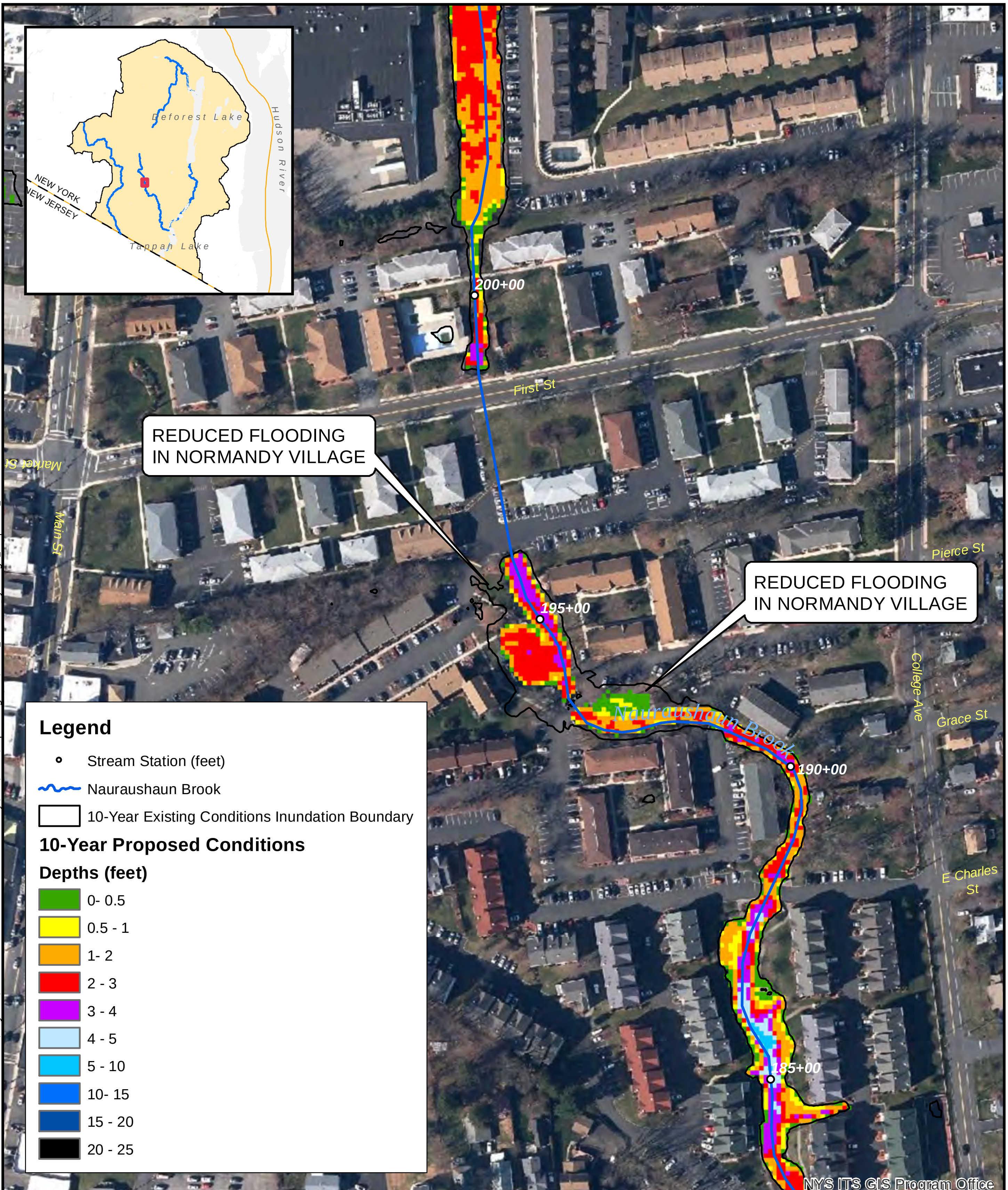
FIG. 4-46

SOURCE: 2016 AERIAL PHOTO, NYS ITS GIS Program Office



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HIGH RISK AREA #5 - 10-YEAR PROPOSED CONDITIONS

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SD109
ROCKLAND COUNTY
NEW YORK

N
0 210
Feet

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FIG. 4-47

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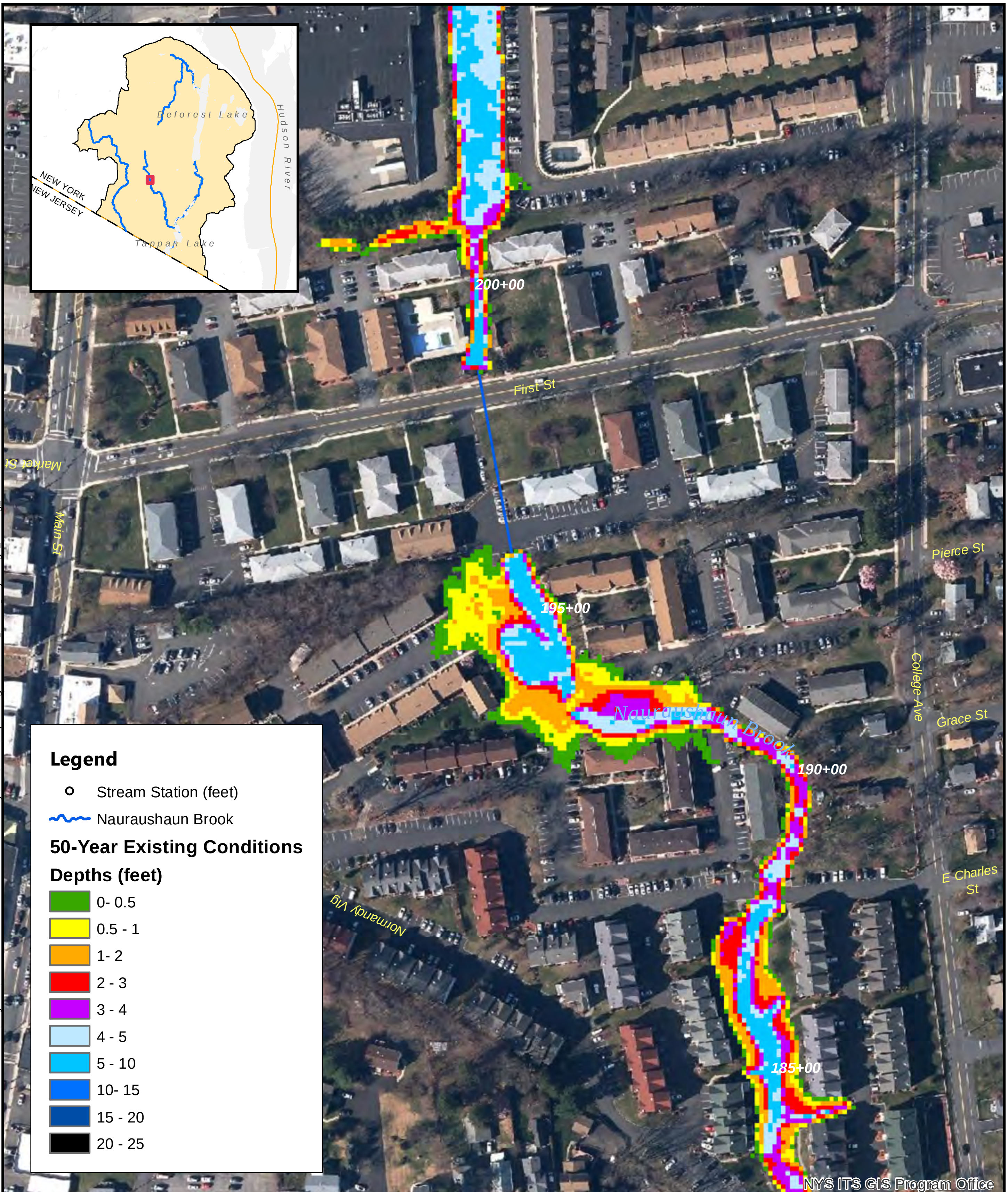

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HIGH RISK AREA #5 - 50-YEAR EXISTING CONDITIONS

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SD109

ROCKLAND COUNTY
NEW YORK

N

0 210
Feet

SCALE 1 " = 200 '

DATE 12/29/2021

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FIG. 4-48

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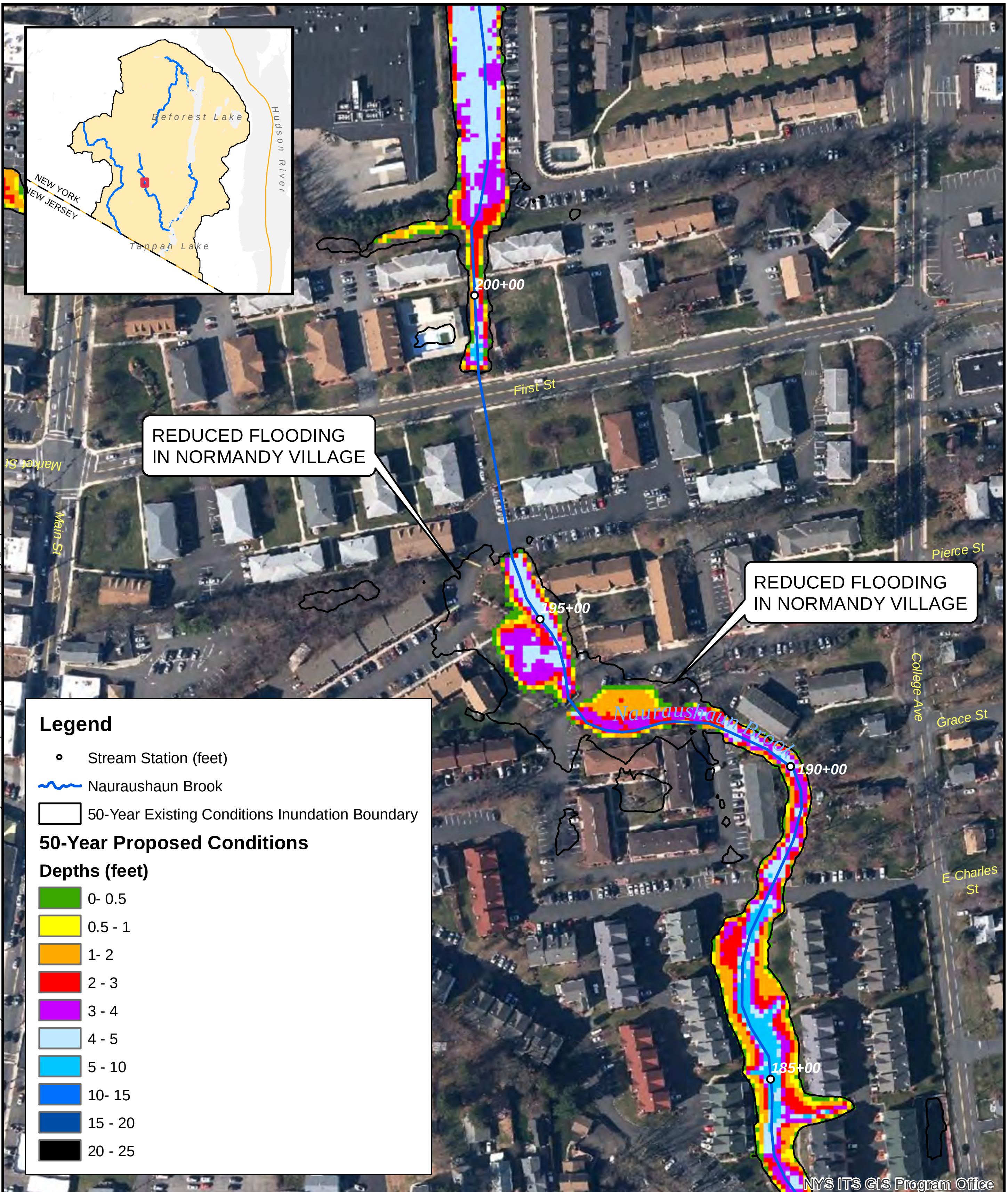

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HIGH RISK AREA #5 - 50-YEAR PROPOSED CONDITIONS

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SD109
ROCKLAND COUNTY
NEW YORK

N

0 210
Feet

SCALE 1 " = 200 '

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PROJ. NO. 16511.00005

FIG. 4-49

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