Chapter 15: Water Resources

15-1 INTRODUCTION

This chapter describes existing groundwater, floodplain, and surface water resources in the study area and presents potential impacts of the operation of the No Build and Replacement Bridge Alternatives. The chapter concludes that the project would not result in adverse impacts on water resources. Freshwater wetlands, tidal wetlands, and ecological resources within the Hudson River and the potential impacts to these resources from the operation of the No Build and Replacement Bridge Alternatives are discussed in Chapter 16, "Ecology." Chapter 18, "Construction Impacts," assesses the potential environmental impacts from the construction of the Replacement Bridge Alternative.

15-2 REGULATORY CONTEXT

The Replacement Bridge Alternative has the potential to affect groundwater and surface water resources from the discharge of stormwater runoff, floodplains due to alignment modification, and river bottom sediments (i.e. scour and deposition) due to changes in river flow around the new bridge piers. Activities within the floodplain, and discharges to surface water and groundwater must comply with the federal and state legislation and regulatory programs as described below.

- ***Clean Water Act (33 USC §§ 1251 - 1387).*** The objective of the Clean Water Act, also known as the Federal Water Pollution Control Act, is to restore and maintain the chemical, physical, and biological integrity of the waters of the United States. It regulates point sources of water pollution, such as discharges of municipal sewage, industrial wastewater, and stormwater runoff; the discharge of dredged or fill material into navigable waters and other waters; and non-point source pollution (e.g. runoff from streets, construction sites, etc.) that enter water bodies from sources other than the end of a pipe. Applicants for discharges to navigable waters in New York must obtain a Water Quality Certificate from NYSDEC.

- ***National Wild and Scenic Rivers Act of 1968 (16 USC §§ 1271-1287).*** Under Section 7 of the National Wild and Scenic Rivers Act, federal agencies with "water resources" projects (defined as those that would affect the free-flowing nature of the river)—including projects that require permits from the USACE—must consult with the river-administering agency regarding effects to rivers that are part of the National Wild and Scenic Rivers System, designated as Study Rivers under Section 5(a) of the National Wild and Scenic Rivers Act, or listed on the Nationwide Rivers Inventory. However, no portion of the Hudson River is classified as a National Wild and Scenic River.

- ***Hudson River Valley National Heritage Area.*** Congress designated the Hudson River Valley National Heritage Area under Title IX of Public Law 104-333 (1996), as amended by Section 324 of Public Law 105-83 (1997). The National Heritage Area extends from Yonkers, New York to Troy, New York, comprising the 10 counties of Albany, Rensselaer, Columbia, Greene, Ulster, Dutchess, Orange, Putnam, Westchester, and Rockland, and the Village of Waterford in Saratoga County. The Hudson River Valley National Heritage Area Act of 1996 has the following purposes:

> (1) To recognize the importance of the history and the resources of the Hudson River Valley to the Nation.
>
> (2) To assist the State of New York and the communities of the Hudson River Valley in preserving, protecting, and interpreting these resources for the benefit of the Nation.
>
> (3) To authorize Federal financial and technical assistance to serve these purposes. (Public Law 104-333 Title IX Sec. 903)

The Hudson River Valley Greenway Communities Council and the Greenway Conservancy serve as the management entities, and must develop a management plan for the National Heritage Area. The Hudson River Valley National Heritage Area Management Plan was approved by the Secretary of the Interior in 2002. The Management Plan's goals include, among others, to safeguard and enhance the area's natural heritage through conservation of its resources.

- ***National Flood Insurance Act of 1968 (44 CFR § 59) and Floodplain Management Executive Order 11988 (42 FR 26951).*** Development in floodplains defined by Federal Emergency Management Agency (FEMA) mapping is regulated at the federal level by the Floodplain Management Executive Order 11988 and National Flood Insurance Act of 1968 (44 CFR § 59). Executive Order 11988 requires federal agencies to avoid to the extent possible the long and short-term adverse impacts associated with the occupancy and modification of floodplains and to avoid direct and indirect support of floodplain development wherever there is a practicable alternative.
- ***Section 1424(e) of the Safe Drinking Water Act.*** Section 1424(e) of the Safe Drinking Water Act of 1974 [P.L. 93-523] authorizes the Administrator of the US Environmental Protection Agency (USEPA) to designate an aquifer for special protection if it is the sole or principal drinking water resource for an area (i.e., supplies 50 percent or more of the drinking water in a particular area), and if its contamination would create a significant hazard to public health. No commitment for federal financial assistance may be entered into for any project that the Administrator determines may contaminate such a designated aquifer so as to create a significant hazard to public health.
- ***Executive Order 12898, Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations.*** To the greatest extent practicable and permitted by law, and consistent with the principles set forth In the report on the National Performance Review, each Federal agency shall make achieving environmental justice part of its mission by identifying and addressing, as appropriate, disproportionately high and adverse human health or environmental effects of its programs, policies, and activities on minority populations and low-

income populations in the United States and its territories and possessions, the District of Columbia, the Commonwealth of Puerto Rico, and the Commonwealth of the Marian islands.

- ***Floodplain Management Criteria for State Projects (6 NYCRR § 502).*** The implementation of Part 502 by all State agencies will insure that the use of State lands and the siting, construction, administration and disposition of State-owned and State-financed facilities are conducted in ways that will minimize flood hazards and losses.
- ***State Pollutant Discharge Elimination System (SPDES) (ECL Article 17; 6 NYCRR Part 750).*** Title 8 of ECL Article 17 authorized the creation of SPDES to regulate discharges to New York State's waters. Activities requiring a SPDES permit include point source discharges of wastewater into surface or groundwater of the state, including the intake and discharge of water for cooling purposes, constructing or operating a disposal system (sewage treatment plant), discharge of stormwater runoff, and construction activities that disturb one or more acres.

15-3 METHODOLOGY

The study area for the evaluation of impacts to groundwater, floodplains, and water quality comprises the area extending ½ mile north and south of the Interstate 87/287 right-of-way generally between Interchange 10 (US Route 9W) in Rockland County and Interchange 9 (US Route 9) in Westchester County (see **Figure 15-1**). This study area incorporates the portions of the roadway and bridge landings included within which stormwater management measures would be implemented as part of the project.

Primary data sources used to identify and characterize surface and groundwater resources, and floodplains include the United States Geological Survey (USGS) National Hydrographic Dataset (NHD), New York State Department of Environmental Conservation (NYSDEC) surface water classification system, National Oceanic and Atmospheric Administration (NOAA) navigation charts, FEMA Flood Insurance Rate Maps (FIRM), water quality data from the USGS gauge station south of Poughkeepsie (#01372058), water and sediment quality data from the NYSDEC's Hudson River Benthic Mapping Project, and results of surface water and sediment quality sampling, high-resolution acoustic survey to estimate the depth, volume and distribution of (post-1930) industrial era (i.e., 20th Century) sediments, bathymetric, tidal, suspended solid concentration (SSC), and current studies conducted for this project.

In 2006 and 2008, water quality data were collected for the project to better characterize water quality conditions within the study area in the vicinity of the Tappan Zee Bridge (see **Figure 15-2**) and to provide data required as inputs for hydrodynamic and sediment transport modeling.

Two sediment-sampling programs were also implemented in 2006 and 2008 to gather data about the physical and chemical characteristics of Hudson River sediments within the study area. Both programs used vibracore samplers to obtain 4-inch-diameter sediment cores from 38 locations, as shown on **Figure 15-3**. Except where the vibracore device encountered refusal at shallower depths, each vibracore was driven to a depth of at least 6 feet.

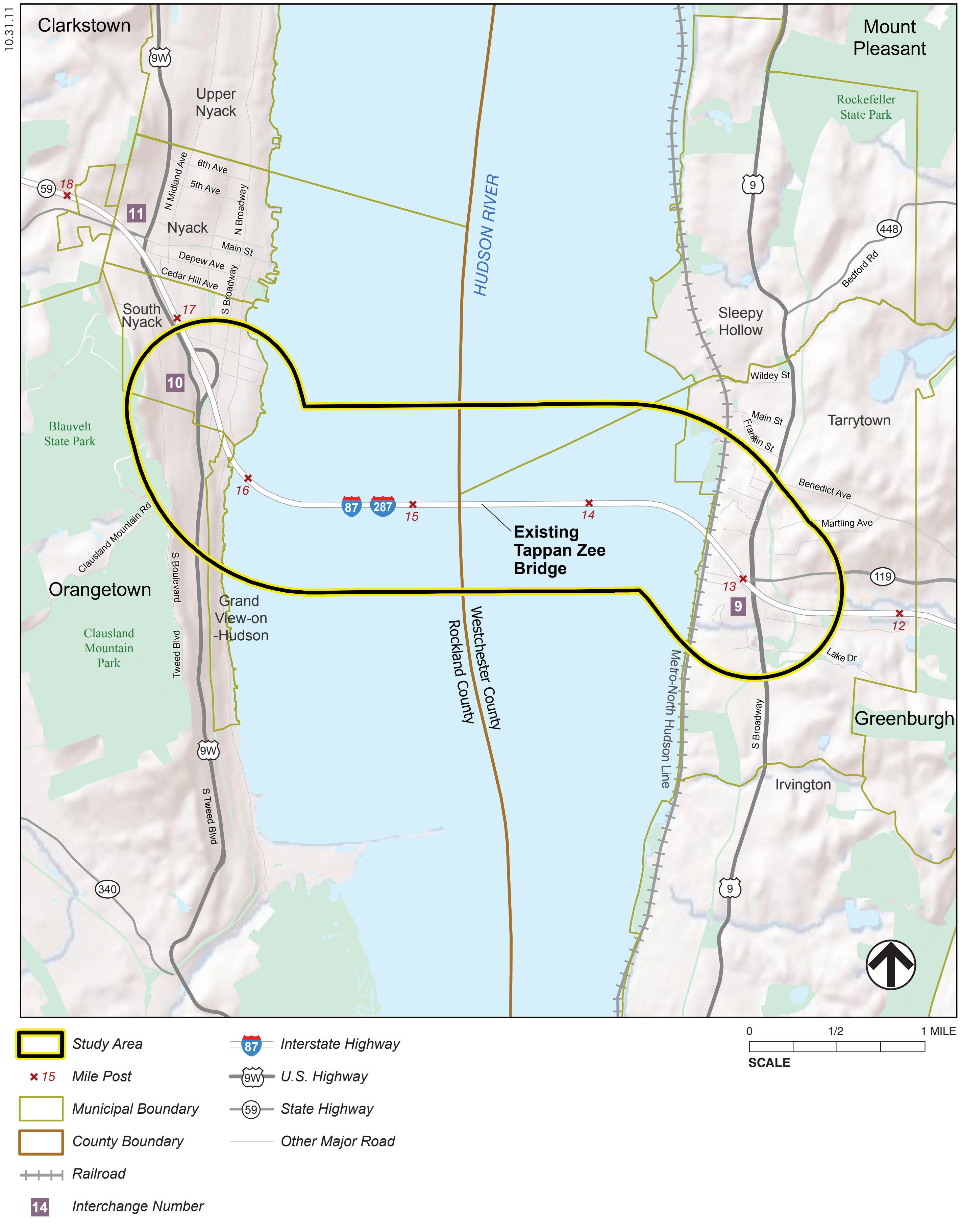

Figure 15-1
Study Area

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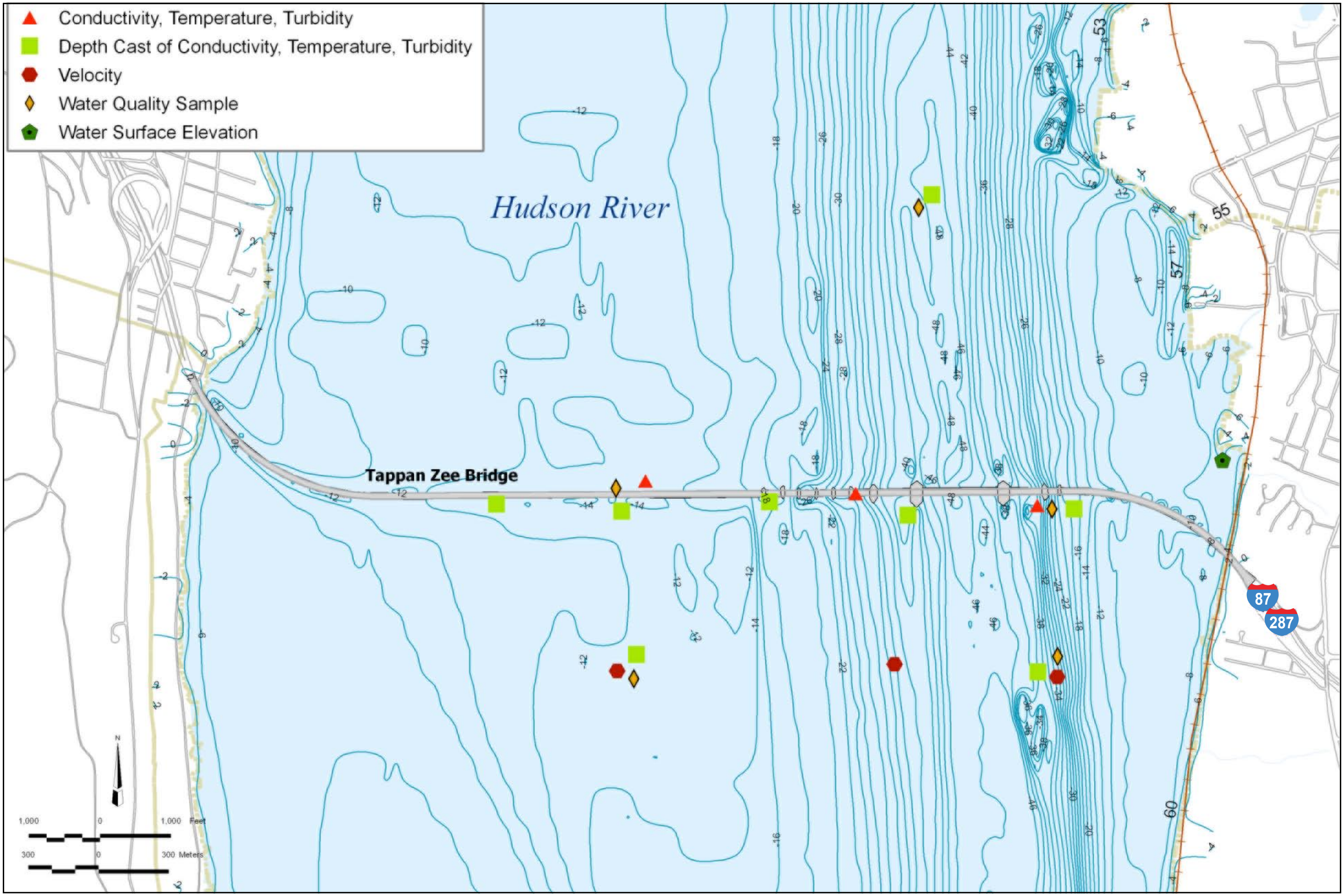

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Figure 15-2
Bathymetry

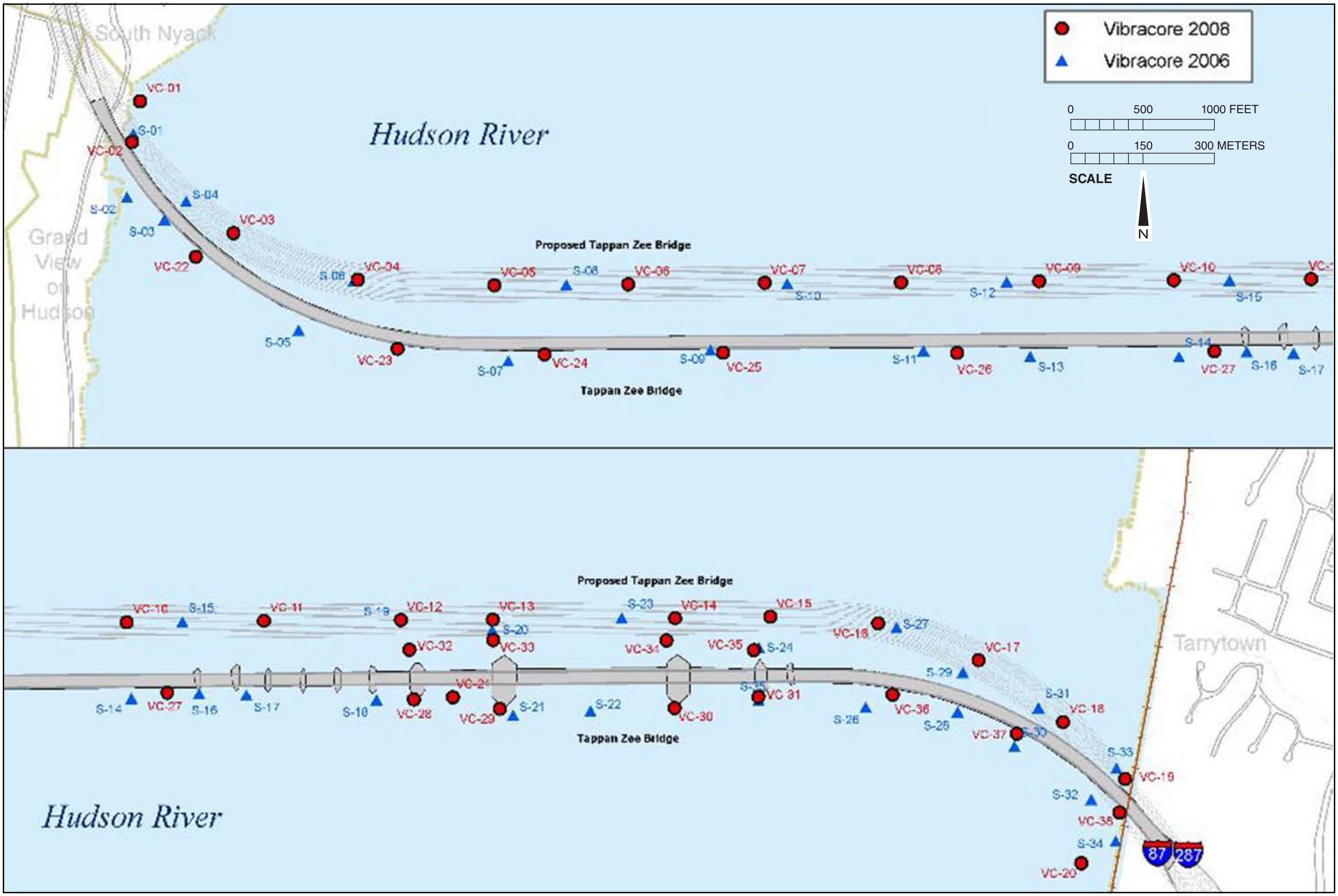

Figure 15-3
Sediment Sample Locations

A total of 156 samples from 38 cores were submitted for sediment chemistry analyses, including Semivolatile Organic Compounds (SVOCs)-base/neutral fraction, pesticides, Polycyclic Aromatic Hydrocarbons (PAHs) and metals. A subset of 17 samples from 10 cores was submitted for dioxins analysis. Eighty samples form 36 cores were submitted for geotechnical analyses that included grain-size analysis, Atterberg[1] limits, water content, visual classification[2], and unit weight analysis.

With the project, stormwater runoff discharged to the Hudson River from the replacement bridge could affect the Hudson River's water quality and aquatic habitats. Additionally, the new bridge piers have the potential to result in scouring of the river bottom, and deposition of resuspended bottom material. Potential impacts on groundwater, floodplain, and water quality of the Hudson River were assessed by considering the following:

- The existing groundwater and floodplain resources and Hudson River water quality within the study areas;
- The potential for the Replacement Bridge Alternative to adversely affect groundwater resources; and
- Results of the stormwater runoff pollutant loading analysis and the scour and depositional analysis are described in greater detail below.

15-3-1 STORMWATER ANALYSIS METHODOLOGY

Potential effects to Hudson River water quality due to the discharge of stormwater runoff from the project were assessed by considering the change in impervious surfaces and changes in pollutant loadings discharged to the Hudson River.

A pollutant loading analysis was performed to evaluate the quality of the stormwater runoff in existing and proposed conditions using the pollutant coefficient method, as outlined in *Reducing the Impacts of Stormwater Runoff from New Development* published by the New York State Department of Environmental Conservation (NYSDEC) in April 1992. Pollutant coefficient values were used to best evaluate the pre- and post-development conditions based on the land use type, which was predominantly impervious surfaces. Following the pollutant coefficient method, the upland portion of the study area was broken up into three major drainage areas on the basis of topography: Rockland landing, bridge, and Westchester landing. The predominant land use within these three drainages is roadways or impervious surface. Therefore, a pollutant loading coefficient of 0.6 pounds per year (lbs/acre/year) was used for phosphorus and 833 lbs/acre/year was used for total suspended solids (TSS). The contributing drainage areas are multiplied by the pollutant loading coefficient for the associate land use resulting in the total annual pollutant load to the Hudson River.

[1] These test methods are used as an integral part of several engineering classification systems to characterize the fine-grained fractions of soils and to specify the fine-grained fraction of construction materials. The liquid limit, plastic limit, and plasticity index of soils are also used extensively, either individually or together, with other soil properties to correlate with engineering behavior such as compressibility, hydraulic conductivity (permeability), compactibility, shrink-swell, and shear strength. The liquid and plastic limits of a soil and its water content can be used to express its relative consistency or liquidity index (http://www.astm.org/Standards/D4318.htm).

[2] Unified Soil Classification System (USCS).

Appendix E provides the detailed pollutant loading calculations: On the basis of the New York State Stormwater Management Design Manual (SWMDM), the stormwater management practices that would be implemented to treat the stormwater runoff are capable of reducing Total Suspended Solids (TSS) by 80 percent and total phosphorus (TP) by 40 percent. These pollutant removal rates are then applied to the calculated total pollutant load to determine the final pollutant load to the Hudson River.

15-3-2 SCOUR AND DEPOSITION ANALYSIS METHODOLOGY

Bridge piers can have morphological effects on a body of water by altering local hydrodynamic conditions, resulting in areas of scour (depressions) and deposition/accretion (mounding). While the exact effects depend on pier configuration, piers typically both increase and decrease localized water velocities, resulting in scour or accretion of bed material at different locations. Scoured bottom material is resuspended and deposited elsewhere in the estuary. In assessing the effects of pier scour, the main question is whether or not a depression is likely to develop at a particular pier and if so, to what extent and depth. Detailed bathymetry data were used to delineate the extent of scour at the existing Tappan Zee Bridge. The analysis to delineate existing scour patterns assumed the conditions present during the bathymetric survey are typical. This is reasonable as tidal forces dominate currents near the Tappan Zee Bridge. Existing scour was delineated as those areas that were depressed more than 1 foot below the unaffected area north of the bridge. The results of the analysis of the existing pier scour were used to calibrate the model used to project areas of scour and erosion from the Replacement Bridge Alternative and to assess potential changes within the footprint of the existing bridge.

Pier scour and depositional zones resulting from the Replacement Bridge Alternative were predicted using relationships established in the FHWA Hydraulic Engineering Circular No. 18 (HEC-18) (FHWA, 2001) with some parameters calibrated based on observations of existing conditions observed during hydrographic surveys conducted for the project. The Replacement Bridge Alternative options will have span lengths of a similar magnitude to the eastern approach spans which only experience local scour. Subsequently, the predictive analyses are focused on the existing condition at eastern piers and the expected condition of the proposed structure. Velocities used for the environmental pier scour analyses were taken from the calibrated RMA-2 model[1] run of the April 2007 Nor'easter, which was approximately a 10- to 50-year storm which coincided with a spring tide, which is likely to moderately over-represent the magnitude of scour which will have ecological impacts.

The basic scour equation presented in HEC-18 is modified for a variety of foundation configurations. Two modifications were used in the predictive analyses. The first is where the pile caps occupy the entire water column depth and are significantly wider than the water depth. In this circumstance, the basic pier scour equation was used with the addition of a correction factor to account for the wide pier width. The second modification to the basic scour equation was required for complex foundations in which piles are exposed below the pile caps. This modification involves calculating the scour component of individual foundation components and then using superposition to sum

[1] The RMA-2 model is a widely tested model that is used extensively for bridge scour evaluations in estuaries.

the results. For pier scour analyses, the majority of piers are considered complex foundations. Other correction factors were determined based on the pier characteristics and the sediment grain size distribution.

15-4 AFFECTED ENVIRONMENT

The following sections describe the existing groundwater resources, floodplains and water resources within the study area for the project.

15-4-1 GROUNDWATER RESOURCES

Groundwater is present in almost all geologic media below the ground surface, as a result of infiltrating precipitation. When precipitation falls to the ground, a portion of the precipitation is returned to the atmosphere through evapotranspiration. Another portion of the precipitation runs off through drainage courses or overland flow (sheet flow) to streams and rivers where it may infiltrate the groundwater regime or continue downstream as surface flow.

Rockland and Westchester Counties have an array of groundwater resources, some of which are near the study area. Geologic materials that can yield appreciable quantities of groundwater are referred to as aquifers. In 1987, NYSDEC identified the region's Primary and Principal Aquifers, which were used to determine presence of aquifers within the study area. Primary Aquifers are highly productive and heavily used for water supplies. Principal Aquifers are known to be highly productive, but are not used as a public water supply. The USEPA also identifies and maps Sole Source Aquifers (SSAs) throughout the country. An SSA is an aquifer that supplies 50 percent or more of the drinking water in a particular area. The USEPA reviews all projects with federal financial assistance in order to ensure that such projects do not have the potential to contaminate designated SSAs and create a significant hazard to public health. There are no Principal or Primary Aquifers designated by the NYSDEC or SSAs designated by the USEPA within the study area for the project.

The primary source of groundwater resources within the study area is contributed by the river itself, with minor contributions from recharge areas. The area recharging to the Hudson River within the study area extends approximately 1 mile and 3 miles from the river's west and east banks at the Tappan Zee Bridge, respectively.

15-4-2 SURFACE WATER RESOURCES

15-4-2-1 WATERSHEDS AND WATERBODIES

The surface water resources within the study area include the Hudson River and Sheldon Brook. **Figure 15-4** shows the watersheds, or drainage basins, in the vicinity of the study area. While generically the term watershed can be applied to the drainage area tributary to any point, as defined in the National Hydrographic Database (NHD) the term watershed refers to the delineation of entire tributary areas to major rivers, such as the Hudson River. Activities affecting the volume and quality of runoff in the study area have the potential to affect the character, health, and potential human uses of the Hudson River and Sheldon Brook.

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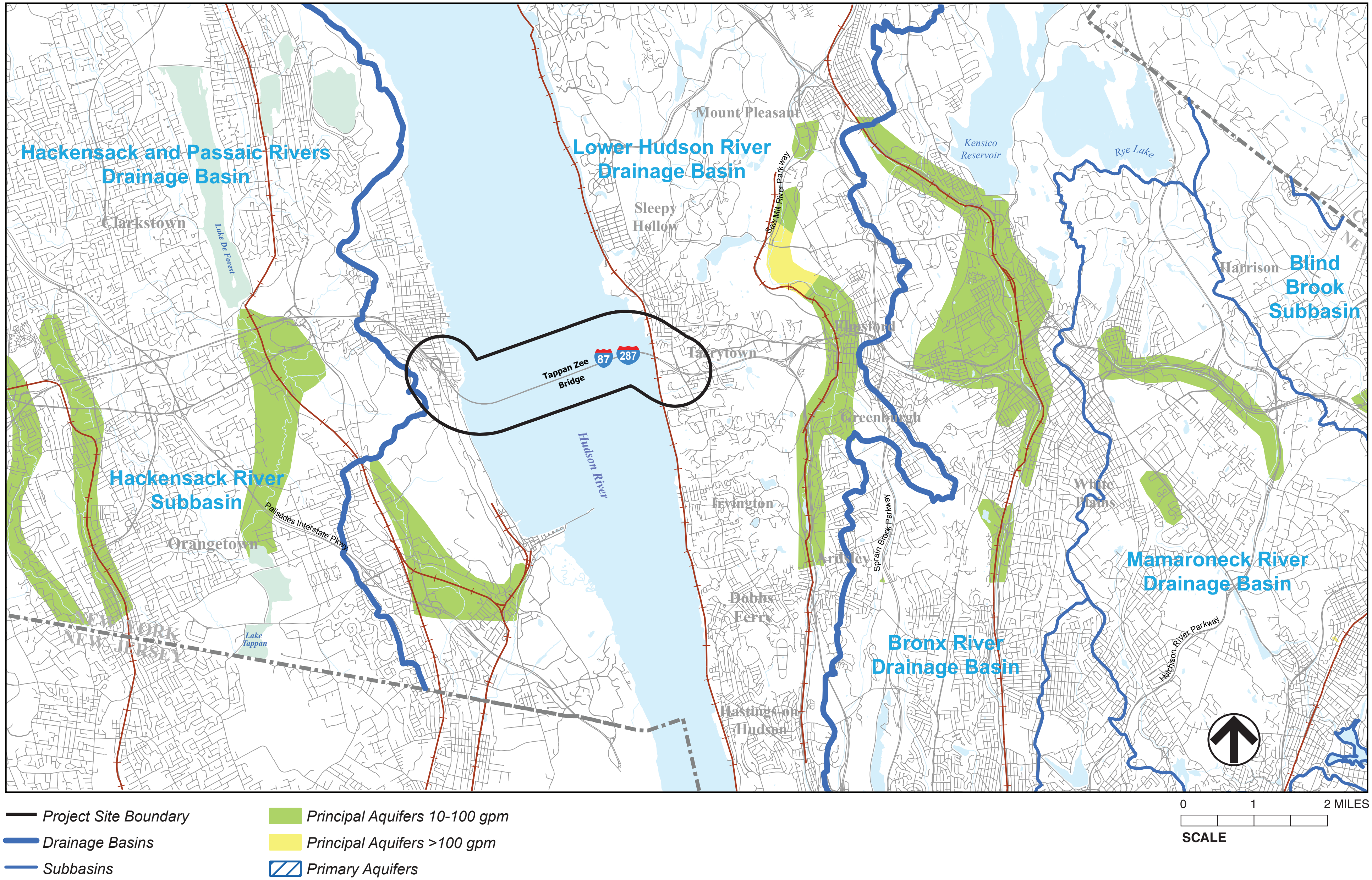

Figure 15-4
Aquifer and Drainage Basins

15-4-2-2 FLOODPLAINS

A 100-year floodplain is a geographic area that is flooded by a storm that has a 1 percent chance of being equaled or exceeded in any given year. **Figure 15-5** presents the 100-year and 500-year floodplains (i.e., the areas with a 1 percent chance and 0.2 percent chance, respectively, of flooding in a given year) within the study area. The Hudson River is tidally influenced and commonly referred to as the Hudson River estuary. Tides in the Hudson River estuary are semidiurnal, having two high and low waters each day. In the study area, the average tidal range is 3.2 feet (NOAA 2009). The Hudson River near the eastern shoreline (Westchester County) is classified as FEMA Zone AE (100-year floodplain) with a base flood elevation of 7 feet (North American Vertical Datum of 1988 (NAVD 88)), whereas portions of the shoreline along the Hudson within Tarrytown are classified as FEMA Zone X (500-year floodplain). Sheldon Brook in Tarrytown is located within the 100-year floodplain. The Hudson River near the western shoreline (Rockland County) is classified as FEMA Zone A3 (100-year floodplain) with a base flood elevation of 8 feet (National Geodetic Vertical Datum of 1929 (NGVD 29), whereas the shoreline along the Hudson within Grand View-on-Hudson is classified as FEMA Zone B (500-year floodplain) (see **Figure 15-5**).

15-4-2-3 WATER QUALITY

Article 17, Title 3 the ECL (Water Pollution Control) authorizes the NYSDEC to develop a surface water classification system and promulgate regulations to administer the surface water quality program. NYSDEC classifies waterbodies based on their best uses (as determined by physical characteristics). The Federal Clean Water Act requires states to periodically assess (every two years) and report on the quality of waters in their state. Section 303(d) of the Act also requires states to identify *Impaired Waters*—waters whose water quality does not fully support their designated use. For these *Impaired Waters,* states must consider the development of a Total Maximum Daily Load (TMDL) or other strategy to reduce the input of the specific pollutant(s) that restrict waterbody uses, in order to restore and protect such uses. New York State's 2010 303(d) list of impaired waters was approved by the USEPA, and published in June 2010 (http://www.dec.ny.gov/docs/water_pdf/303dlistfinal10.pdf).

Non-point source pollution from urban and suburban development is a major contributor to pollutant loadings in watercourses. Contaminants typically associated with urban stormwater run-off are sediments, nutrients, organic compounds, pathogens, and heavy metals. Pollutants originating from vehicles can make up a substantial portion of those pollutant loads.

Sheldon Brook

Sheldon Brook is a second-order stream that discharges into the Hudson River on the east side of the study area. Sheldon Brook crosses Interstate 87/287 twice in the village of Tarrytown while en route to the Hudson River. The western crossing flows from northeast to southwest, and is part of a long series of culverts near Interchange 9. The drainage area for Sheldon Brook is about 2.5 square miles, of which approximately 2 square miles is upstream of the most downstream crossing of Interstate 87/287.

In this area, Sheldon Brook is shallow and has low, gradually-sloping banks. This portion of Sheldon Brook has been designated as Class SC/C waters by NYSDEC.

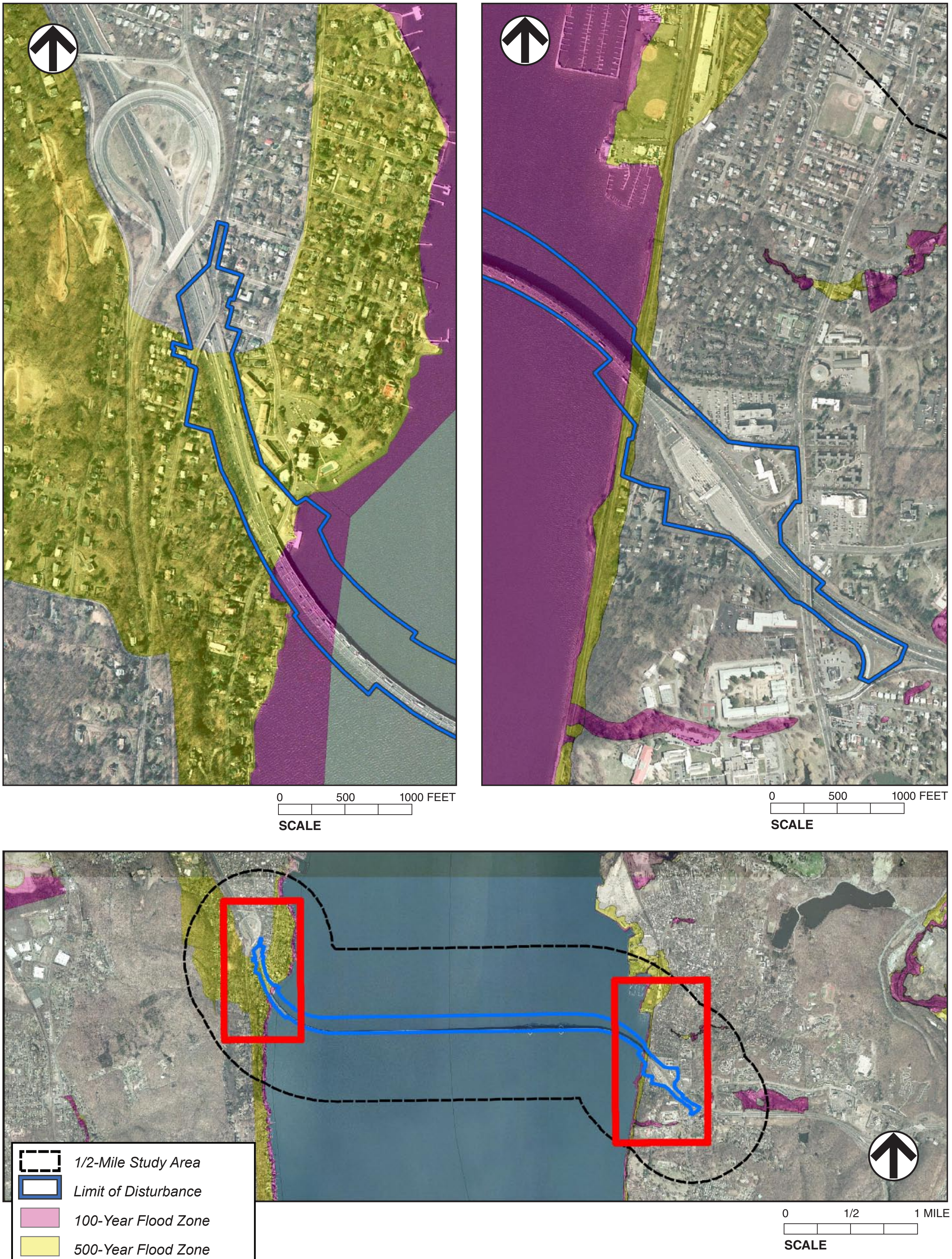

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Figure 15-5
Floodplain

Class SC/C waters are suitable for fishing, fish propagation and survival, and primary and secondary recreation. Sheldon Brook is not on the 2010 NYSDEC Section 303(d) list of impaired waterbodies.

Hudson River

The approximately 3-mile-wide portion of the Hudson River within the study area is designated by NYSDEC as a Class SB waterbody. Best usages of Class SB saline surface waters are primary and secondary contact recreation and fishing; these waters shall be suitable for fish propagation and survival. Within the study area, the Hudson River is included on the 2010 New York State 303(d) list due to the presence of contaminated sediment containing Polychlorinated Biphenyls (PCBs) (NYSDEC 2010).

In the vicinity of the Tappan Zee Bridge, the river ranges in depth from less than 12 feet at mean lower low water (MLLW) along the western causeway to greater than 47 feet at MLLW in the shipping channel under the main span (see **Figure 15-2**). The Hudson River is tidally influenced from the Battery to the Federal Dam at Troy, New York. Tidal currents are generally greatest in the navigational channel. Results of field surveys conducted for the project in April 2007 and November 2008 indicate that peak vertically averaged tidal currents in the navigational channel are about 2.5 feet per second (ft/sec). Peak velocities during the spring freshet— a time of high freshwater inflows resulting from snow and ice melt in rivers—may be greater than 3 ft/sec. Velocities are generally lower in the western mud flats in the vicinity of the bridge, with peak velocities generally on the order of 1 to 2 ft/sec. The tidal excursion at the Tappan Zee Bridge is approximately 4.0 and 6.2 miles for the flood and ebb tide, respectively (DiLorenzo et al. 1999).

Salinity

The salt front, as defined by the USGS for the Hudson River estuary, is where chloride concentration begins to exceed 100 milligrams per liter (mg/L) (Devries and Weiss, 2001). Seawater has a chloride concentration of about 19,400 mg/L. With the exception of very large freshwater discharge events, there is always a salt front present in the Hudson River estuary, the location of which varies at a given time with tidal forcing and the magnitude of freshwater discharge. In general, the salt front is located between 15 and 75 miles upstream of the Battery. It is located farther upriver during the summer when there are low freshwater inflows, and farther downriver during the spring when freshwater flows are greatest.

The term salt wedge is a more generic term that describes the tendency for saltwater to intrude beneath freshwater without substantial mixing. A salt wedge is marked by a steep salinity gradient, or halocline, in the vertical direction. The presence of a salt wedge does not indicate an immediate horizontal transition from fresh to salt water. In the Hudson River estuary, the transition is often 50 miles long.

Figure 15-6 shows average salinities in Practical Salinity Units (PSU) over a 16-year period at the USGS gauge at Hastings-on-Hudson (#1376304), which is about 6 miles downstream of the Tappan Zee Bridge. Although salinity concentrations are somewhat lower at the Tappan Zee Bridge, the salinity at Hastings-on-Hudson is indicative of the magnitude and yearly variation of salinity at the bridge. At the Hastings-on-Hudson station, salinity ranged from about 2 to 6 PSU during high freshwater flow periods in the

Figure 15-6
Average Salinity Concentration at Hastings-on-Hudson

spring to a high of about 8 to 10 PSU during low freshwater flow periods in the summer. Salinities in the winter varied between 4 and 6 PSU. Salinities recorded during the 2006 and 2008 sampling program conducted for the project were similar to those recorded at Hastings-on-Hudson.

Temperature

Water temperatures are relatively uniform throughout the freshwater reach of the Hudson River estuary, and follow a similar cycle each year. At the mouth of the Hudson River estuary, near the Battery, temperatures are substantially affected by the inflow of water from the New York Bight and tend to exhibit a milder degree of variation throughout the year. **Figure 15-7** demonstrates the average yearly cycle in water temperature in the upper reach of the Hudson River estuary near Albany, and near its mouth, near the Battery over a period of 2002-2009. The NOAA Gauge at the Battery (#8518750) is 26.5 miles downstream of the bridge. The USGS gauge at Albany (#1359139) is 118 miles upstream of the bridge.

In the lower reaches of the Hudson River estuary and near the Tappan Zee Bridge, ocean water intrudes beneath fresh water to form a salt wedge, often resulting in a large degree of stratification in the water column. In these areas large vertical variations in temperature may be present. Average water temperatures at the Tappan Zee Bridge are generally close to the average of temperatures at the Battery and Albany, NY, ranging from below close to 0º Celsius (C) (32º Fahrenheit (F)) in the winter to about 25º C (77º F) in the summer, with temperatures in the spring ranging between 2º C and 10º C (36º F to 50º F).

Suspended Solids

Generally, suspended solids concentrations (SSC) show a strong correlation with water-column depth, with higher concentrations near the bottom of the river. Significant variation based on a variety of river conditions can also be expected, with the tidal cycle and magnitude of freshwater discharge being the most dominant factors. During the spring freshet sediment concentrations much higher than normal can be expected.

The USGS operates an Acoustic Doppler Current Profiler (ADCP) at the Hudson River estuary gauge station south of Poughkeepsie, approximately 27 miles north of the bridge. The station uses backscatter information from the ADCP to estimate suspended solids concentration (Wall et al. 2006). Using the SSC data combined with the current data measured by the device, an estimate of total sediment discharge is also calculated. This gauge has been monitoring SSC almost continuously since 2002, and represents the most complete data set of sediment concentration and sediment loading in the Hudson River estuary.

For the purposes of impact evaluation, an understanding of the typical sediment concentrations at the study area, and their variability, is useful. To aid in this understanding, the yearly variation of the depth-averaged SSC concentration at the USGS gauge south of Poughkeepsie is presented in **Figure 15-8** for the period 2002 through 2009. It is expected that the suspended sediment concentration at the Tappan Zee Bridge will be similarly inherently variable and seasonally dependent, as indicated by the USGS gauge upstream. Depth averaged SSC measurements made during field

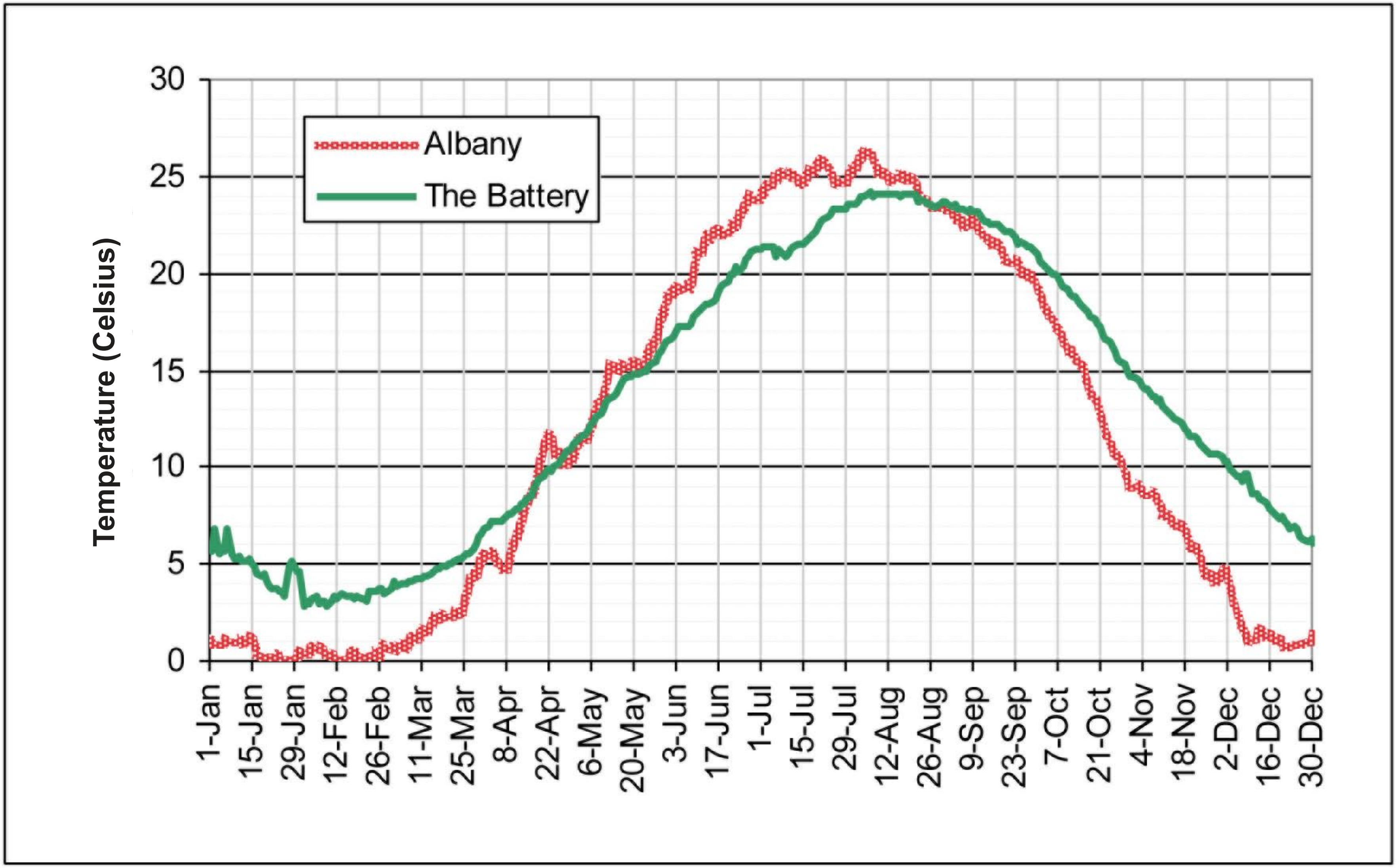

Figure 15-7
Average Water Temperature at Albany and the Battery

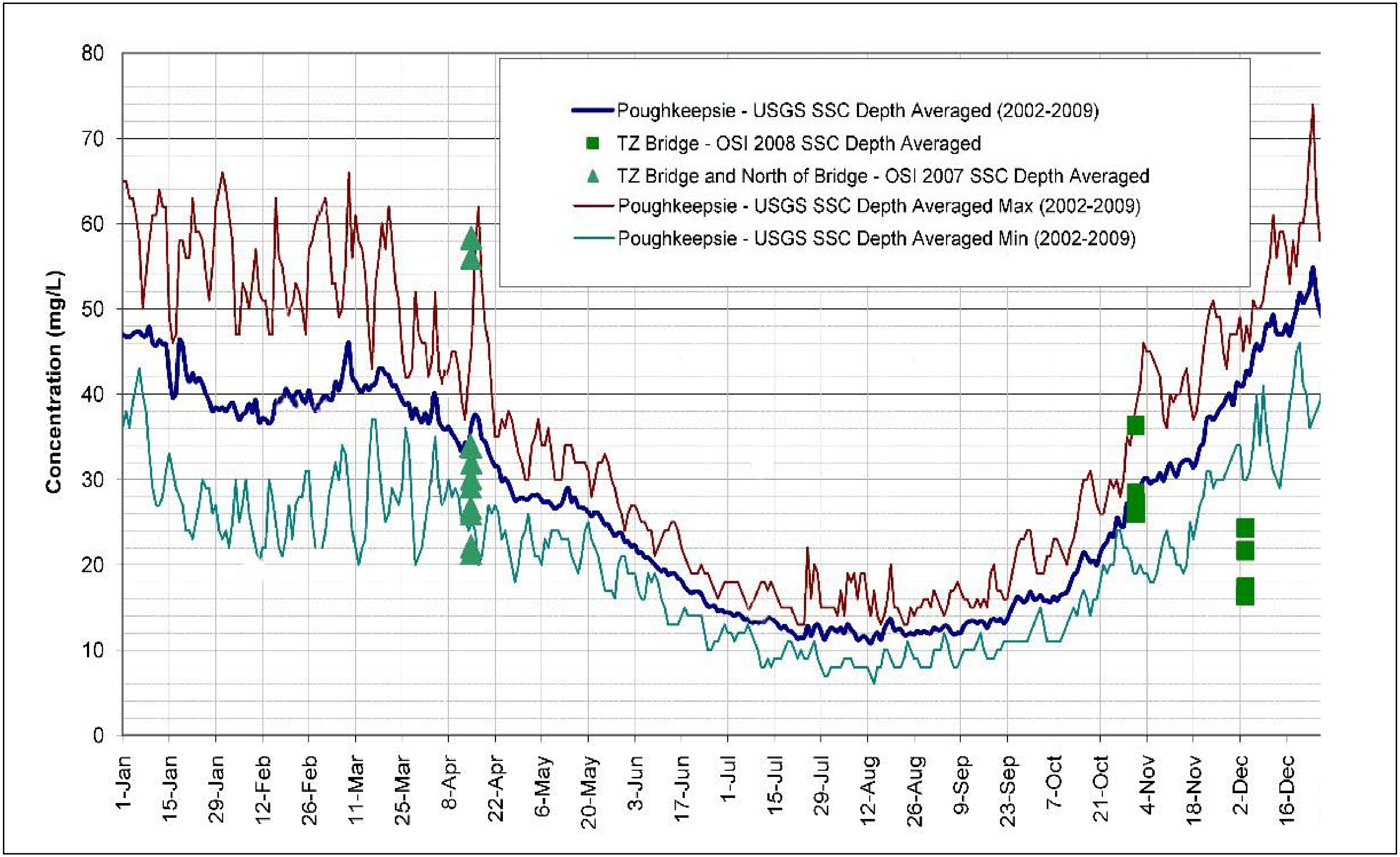

Figure 15-8
SSC Data

surveys of the Tappan Zee were similar in magnitude to those recorded at the Poughkeepsie station (see **Figure 15-8**).

SSC was recorded during water quality sampling conducted from late October through early December 2008 within the study area. Results showed that increases in SSC with depth were more dramatic at deep locations than at shallow water locations. Fluctuations in SSC occurred over each tidal cycle, with the highest SSC observed at max flood and max ebb tides. SSC recorded during this time frame generally ranged from about 10 to 75 mg/L, with maximum concentrations recorded of about 140 mg/L. Depth averaged water-column sediment samples in the vicinity of the Tappan Zee Bridge appear to range from 15 to 50 (mg/L) under normal conditions, and may exceed 100 mg/L during large freshwater events.

15-4-3 SEDIMENT QUALITY

15-4-3-1 SEDIMENT CHARACTERISTICS

Hudson River bottom sediments in the vicinity of the bridge comprise primarily clayey silt (see **Figure 15-9**). Accumulations of sand, silt and clay material are observed along the causeway section of the existing bridge. Gravelly sediments are also found extensively near the eastern shore of the Hudson River and across a large swath of the mud flats north of the existing causeway section.

Due to releases from industrial activity, sediments deposited on the river bottom during the twentieth century are more likely to exhibit signs of contamination. Examples of industrial contamination include heavy metals, volatile or semivolatile organic compounds (VOCs or SVOCs), pesticides, and PCBs. Industrial-era sediments were identified through a combination of seismic-profiling data and the concentration of lead in sediment samples. The thickness of industrial era sediment deposits in the vicinity of the Tappan Zee Bridge is shown on **Figure 15-10**. While recently deposited sediments (i.e., from the 20th and 21st centuries) can be found throughout much of the study area, deposition of recent sediments north of the existing bridge is limited, ranging from no deposition to a depth of about 2 feet, with most of the recent deposits occurring between 0 and about 8 inches. South of the bridge deposition of recent sediments is limited on the western margin (ranging from 0 to 8 inches) with some areas of deeper deposition further east along the causeway (2 to 4 feet), deposition along the eastern margin appears to be greater (ranging from 0 to at least 6 feet). On the basis of the evaluation of recent sediment deposits, the net rate of deposition within the vicinity of the existing bridge is estimated to range from 0 inches per year to as high as 1 inch per year in the eastern margin south of the existing bridge.

15-4-3-2 SEDIMENT SCOUR AND DEPOSITION

Permanent structures such as bridge piers can have morphological effects by altering local hydrodynamic conditions. While the exact effects depend on pier configuration, piers typically both increase and decrease localized water velocities, resulting in scour or accretion of bed material at different locations. Once initial deposition occurs, the sediment may be subsequently resuspended as part of the natural sediment transport processes within the Hudson River Estuary. These cycles of resuspension and deposition may occur over larger time periods than those considered by the hydraulic analysis, on the order of weeks and months. Published information suggests that large

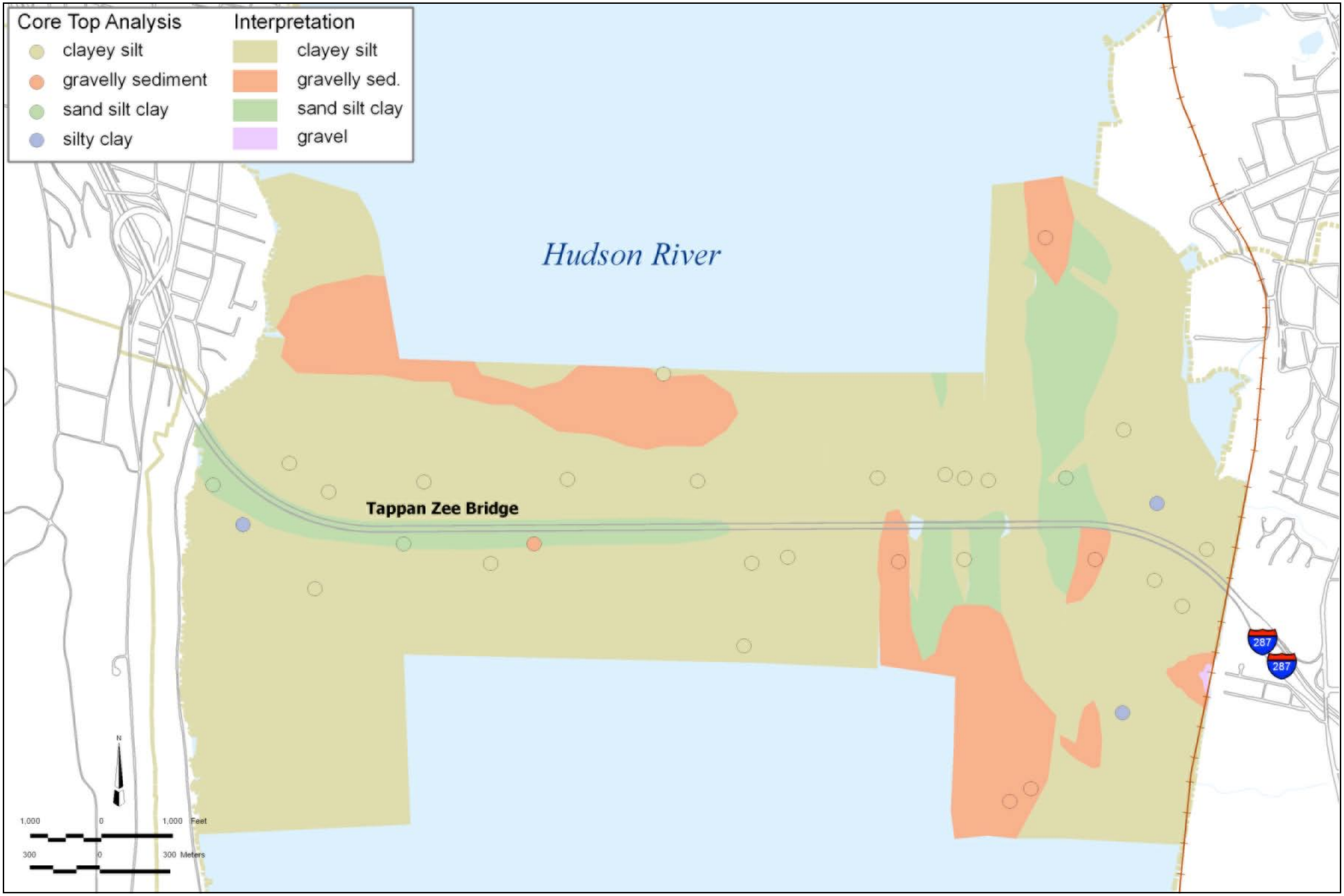

Figure 15-9
Sediment Texture

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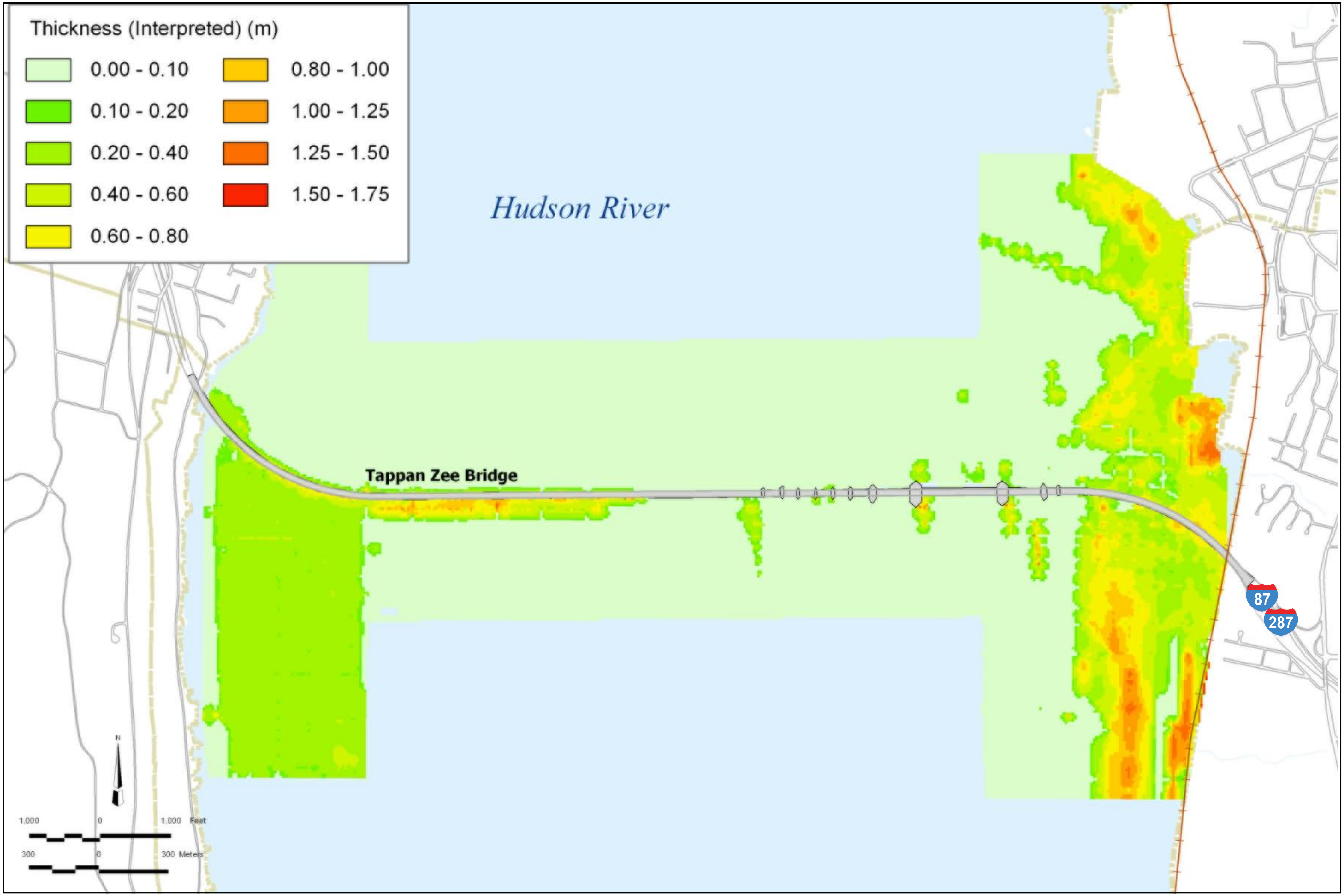


Figure 15-10
Recent Sediment Deposit Thickness

discharge events can flush long term sediment deposits within the estuary into New York Harbor and Bay on a decadal time scale.

The existing causeway and bridge piers cause river currents to locally scour the bottom sediments, resulting in depressions in the bottom of the river alongside the bridge (see **Figures 15-11 and 15-12**). A large area near the existing bridge is subject to scour due to the small column spacing. The western causeway is dominated by contraction scour (i.e., bottom erosion due to increased water velocity and shear stress resulting from the narrow spacing between piers) with a moderate amount of local scour (i.e., bottom erosion around bridge piers and abutments due to the acceleration of water flow around these structures and vortices that occur when this flow is obstructed) occurring at the tips of the piers. The western shoals of the Tappan Zee Reach are relatively flat and featureless, and the effect of the western causeway on bathymetry is clear. The existing scour at the piers of the existing eastern causeway are dominated by local scour. The existing total scour area associated with pier scour is about 62 acres.

15-4-3-3 SEDIMENT QUALITY

River bottom sediment quality is important to understand for purposes of dredging or other river bottom disturbance. Hudson River sediment samples collected for the project were compared to existing sediment chemistry data for the Hudson River based on NYSDEC’s Hudson River Benthic Mapping Project. Sediment quality was evaluated based on various NYSDEC screening criteria and guidance. Appendix 4 of NYSDEC’s Technical Guidance for Screening Contaminated Sediments (NYSDEC 1999) establishes the Effects Range-Low (ERL) and the Effects Range-Median (ERM) sediment criteria. ERL and ERM criteria for specific contaminants are used to determine levels of contamination, as described in **Table 15-1**. Where ERL and ERM values are not listed, benthic aquatic (BA) chronic and acute criteria and wildlife bio-accumulation (WA) criteria can be used.

Table 15-1
ERL and ERM Screening Criteria

Screening Criteria	Potential Effect
< ERL value	Minimal-Effects Range - Effects would be rarely observed
≥ ERL value, < ERM value	Possible-Effects Range - Effects could occasionally occur
≥ ERM value	Probable-Effects Range - Effects could frequently occur
Sources: Long et al. 1995	

Sediment quality thresholds for in-water/riparian placement are based on NYSDEC’s In-Water and Riparian Management of Sediment and Dredged Material (Technical and Operational Guidance Series (TOGS) 5.1.9, NYSDEC 2004). TOGS 5.1.9 establishes three classes of sediment quality thresholds for areas proposed for dredging and for dredged material proposed for in-water/riparian placement based on concentration of contaminants identified (see **Table 15-2**).

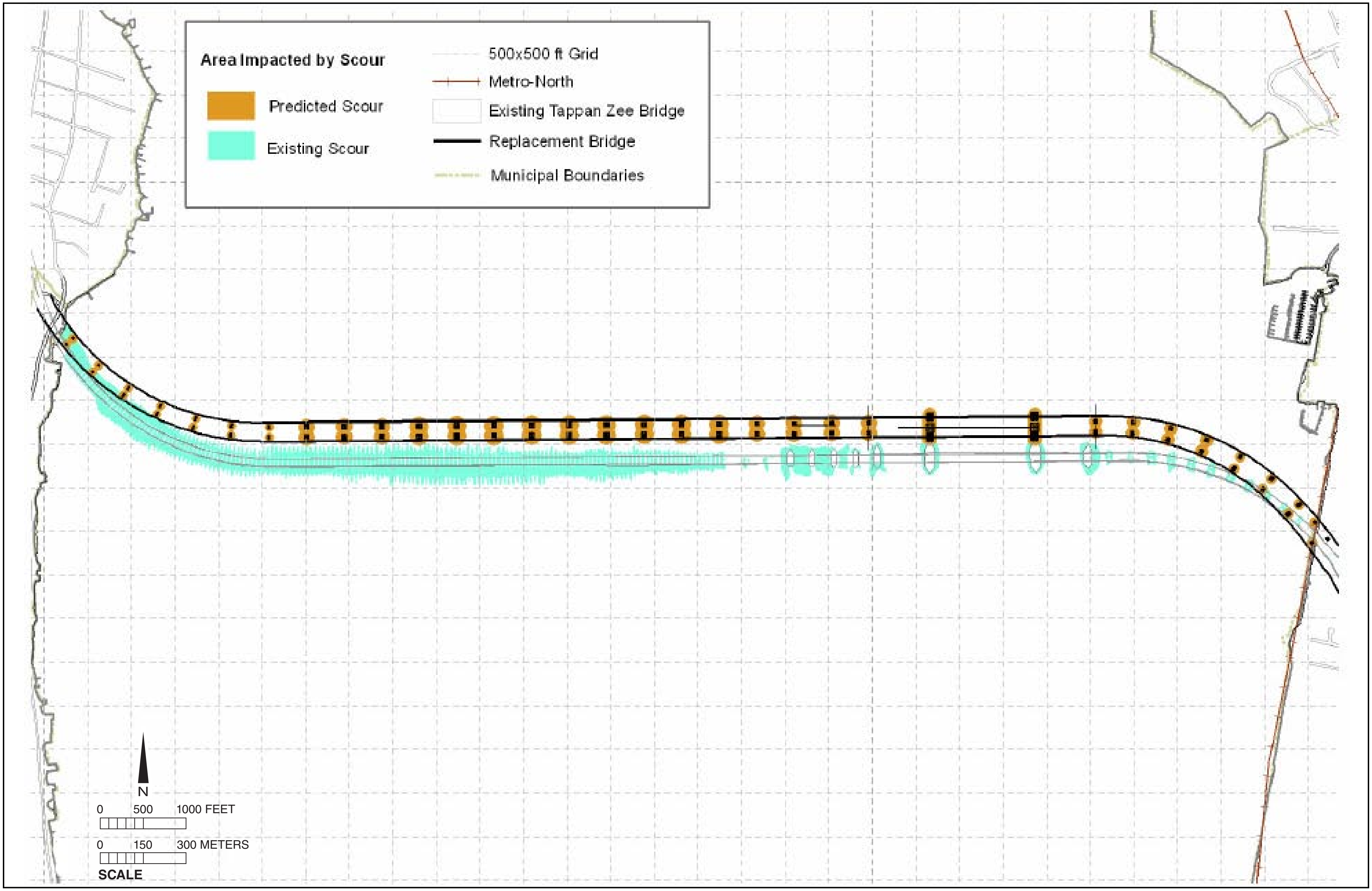


Figure 15-11
Long Span Option Scour

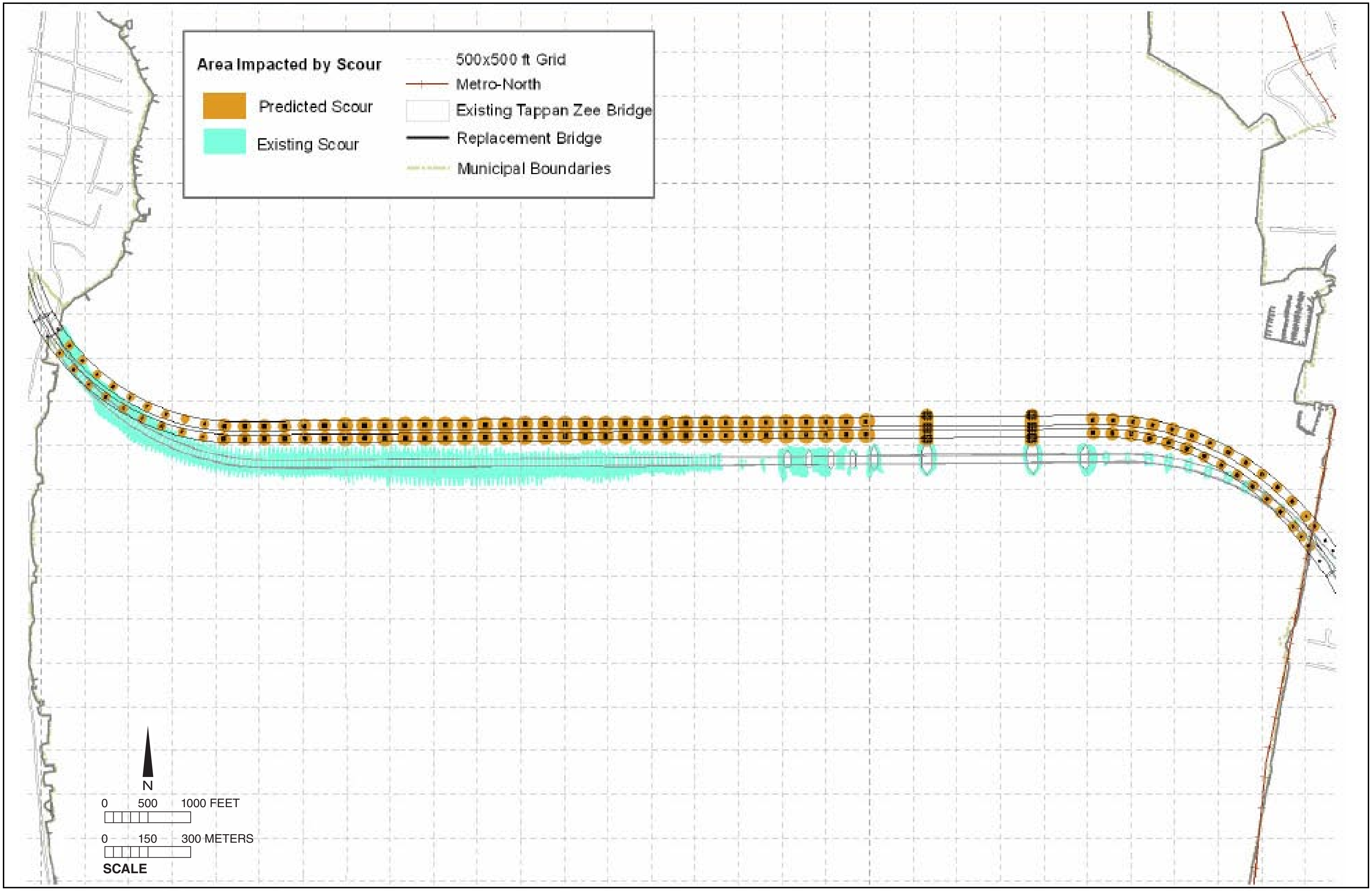


Figure 15-12
Short Span Option Scour

Table 15-2
TOGS 5.1.9 Sediment Quality Thresholds

Threshold	Potential Effect
Class A	No appreciable contamination (no toxicity to aquatic life) and dredging and in-water or riparian placement, at approved locations, can generally proceed
Class B	Moderate contamination (chronic toxicity to aquatic life) and dredging and riparian placement may be conducted with several restrictions.
Class C	High contamination (acute toxicity to aquatic life) and dredging and disposal requirements may be stringent (NYSDEC 2004).
Sources: NYSDEC 2004	

Summaries of the sediment-chemistry analyses for metals; SVOCs; and pesticides, PCBs, and dioxins are presented in **Tables 15-3 through 15-5**. Only data for compounds that were detected in at least one sample are included in these tables. **Figures 15-13 through 15-16** illustrate the sediment sampling locations for which concentrations of contaminants are classified as Class B or C according to TOGS 5.1.9. The salinity of the Hudson River in the vicinity of the project area ranges from 2 to 10 PSU. The marine values for TOGS thresholds were used wherever they differed sufficiently from freshwater values. Contaminants not indicated in **Figures 15-13 through 15-16** as Class B and C at the sediment sampling locations were classified as Class A. Dieldren concentrations in all of the samples were classified as Class A. Contaminants for which concentrations were classified as Class B or C include Total PCBs, Total PAH, mercury, dioxin/furan TEQ, Total DDT, DDD and DDE, arsenic, copper, and cadmium. As indicated in **Figures 15-13 through 15-16**, Class C concentrations (Total PAH, dioxin/furan TEQ, mercury, Total PCBs, and cadmium) and the Class B concentrations for dioxin/furan TEQ, occurred in only a few locations, which coincided with areas identified as having thicker deposits of industrial age sediments (ranging from about 8 inches to 6 feet)—north and south of the existing bridge on the western and eastern margins, and north and south of the piers for the main span. The locations of Class B contaminant concentrations are more widely distributed north and south of the bridge but are also associated with portions of the river bottom identified as having accumulation of industrial age sediment deposits. Class B and C contaminant concentrations typically decrease to concentrations classified as Class A within 2 to 4 feet of the surface with the exception of sampling locations south of the bridge along the eastern shoreline of the Hudson River identified as having the deepest accumulation of recent deposits.

Results from the 2006/2008 sediment sampling were compared to results found for historic Hudson River sampling conducted by Llanso et al (2003). In general, levels of contaminants such as metals, pesticides, and PCBs in the sediment samples collected within the study area are similar to average levels found elsewhere in the Hudson River as indicated by the Hudson River Benthic Mapping Project. On the basis of the 20th century deposits mapping and the results of the laboratory analysis of 2006 and 2008 sediment cores, the upper few feet of river sediment would be characterized as moderately contaminated following TOGS 5.1.9 with the exception of a few locations near the western and eastern Hudson River shorelines and south of the main span bridge piers where higher concentrations appear to have accumulated.

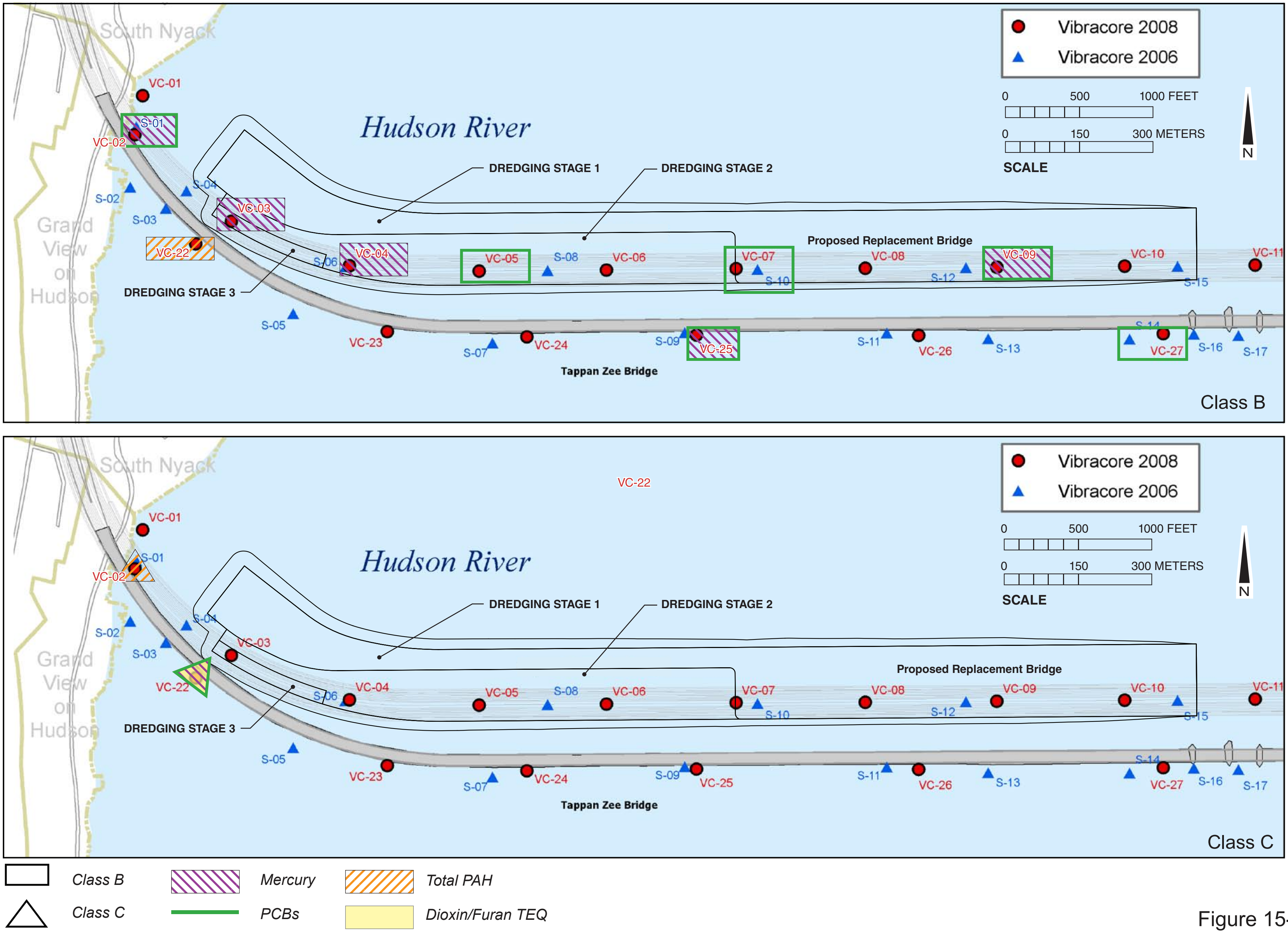


Figure 15-13

Sediment Sample Locations and TOGS 5.1.9 Sediment Quality Classifications

1.3.12

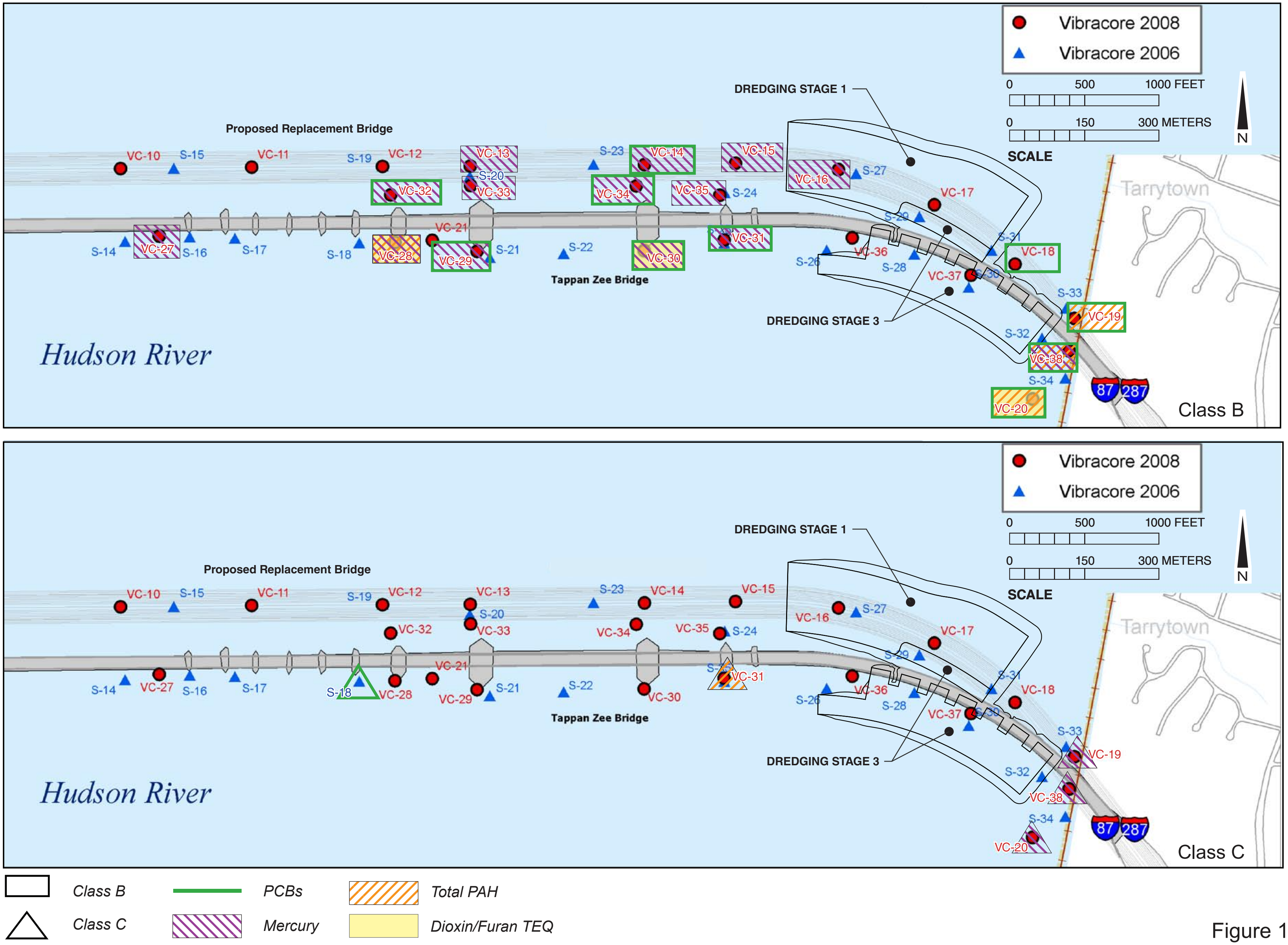
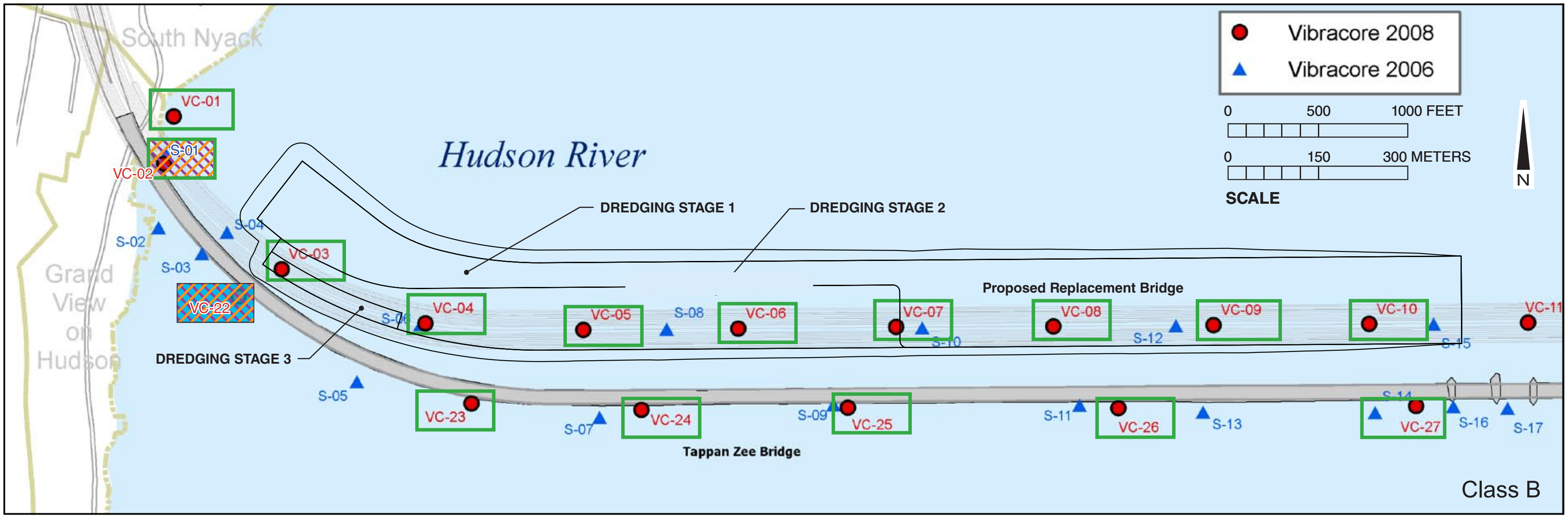
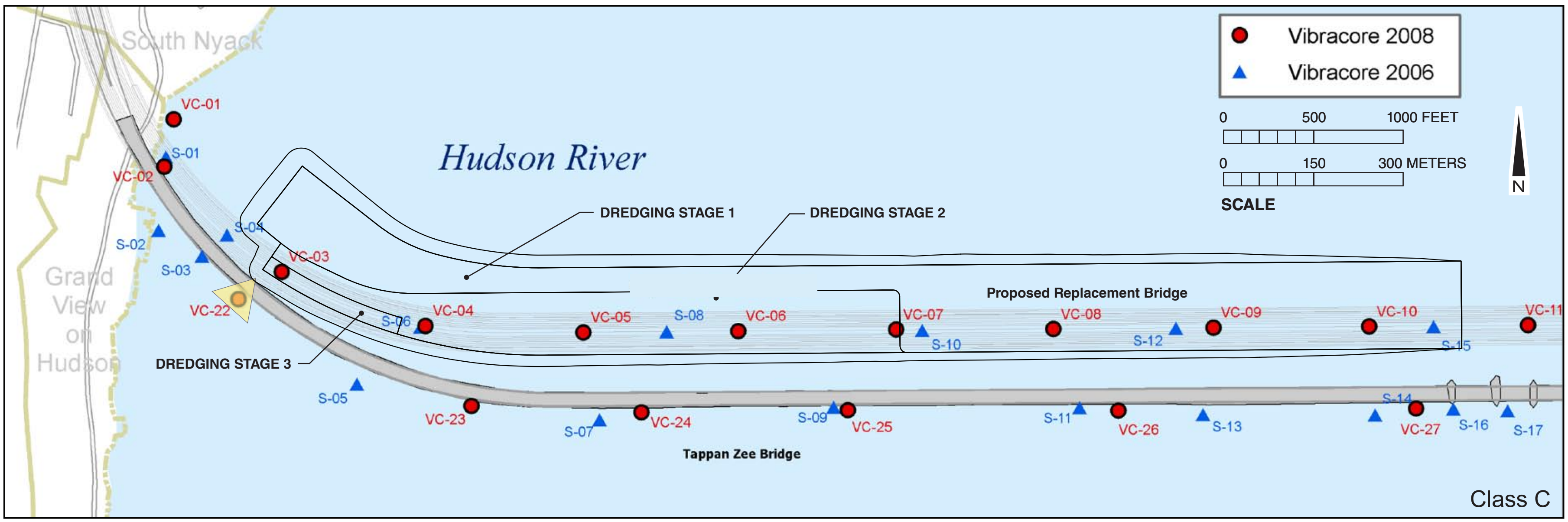


Figure 15-14

Sediment Sample Locations and TOGS 5.1.9 Sediment Quality Classifications





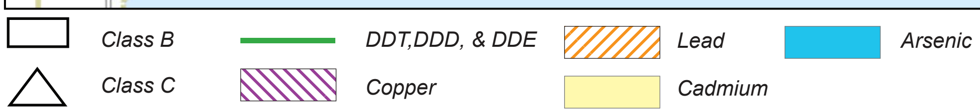


Figure 15-15

Sediment Sample Locations and TOGS 5.1.9 Sediment Quality Classifications

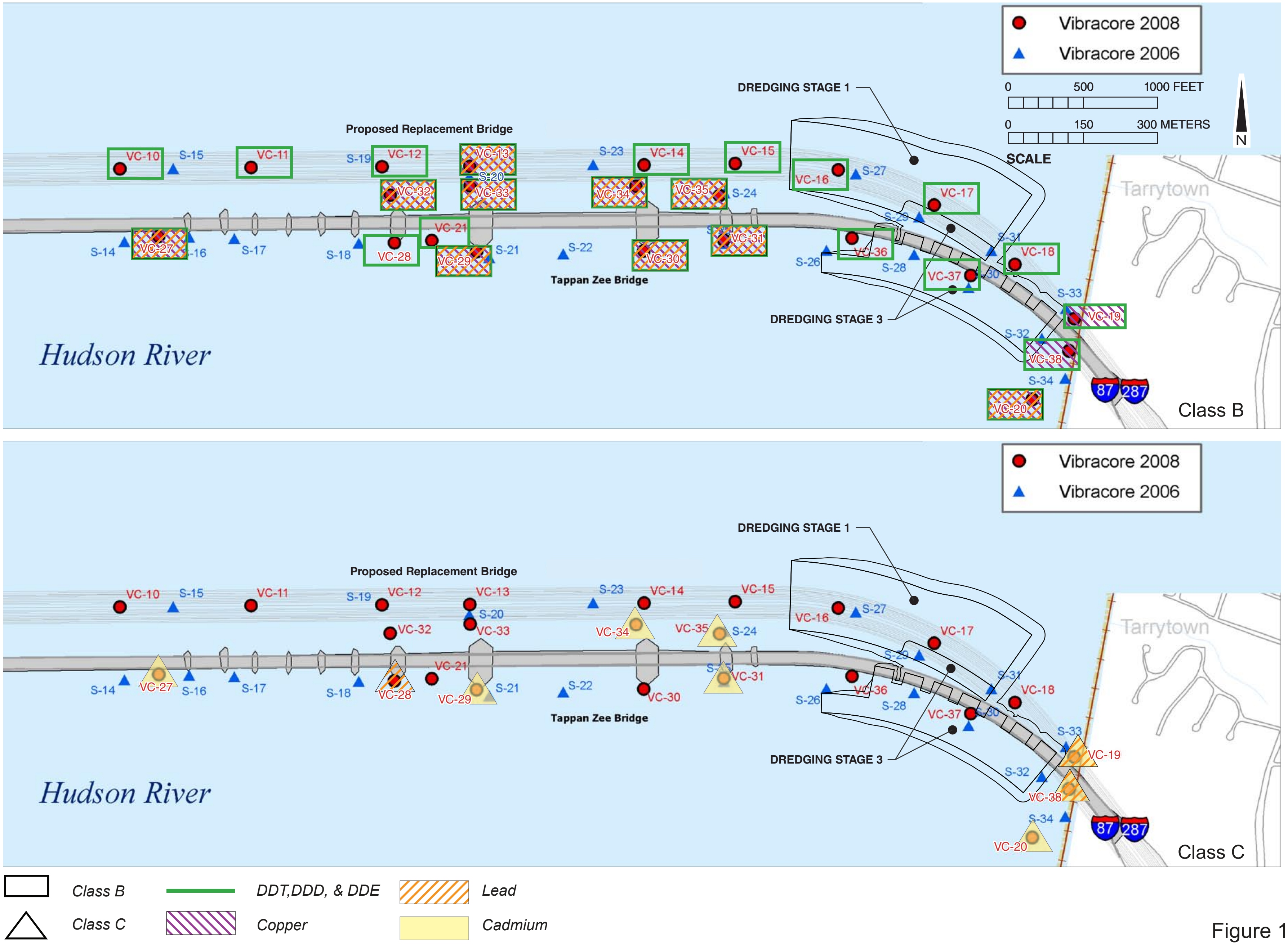


Figure 15-16

Sediment Sample Locations and TOGS 5.1.9 Sediment Quality Classifications

Table 15-3
Metals

Parameter	Sediment Criteria		Hudson River Average[2]	Number of Samples Analyzed	Detection Rate	Minimum (mg/kg)	Average (mg/kg)	Median (mg/kg)	95th Percentile (mg/kg)	Maximum (mg/kg)
	ERL[1] (mg/kg)	ERM[1] (mg/kg)								
Aluminum	NC	NC	10256.9	313	100%	483	11,714	11,700	17,300	21,700
Antimony	NC	NC	--	156	0%	ND	ND	ND	ND	ND
Arsenic	8.2	70	7.2	313	97%	ND	8.06[A]	7.4[A]	14[B]	26.4[B]
Barium	NC	NC	--	313	92%	ND	43	32.9	91.04	190
Beryllium	NC	NC	--	313	47%	ND	0.79	0.76	1.1	2.61
Cadmium	1.2	9.6	1.0	313	46%	ND	1.9[B]	1.92[B]	3.2[B]	6[B]
Calcium	NC	NC	--	313	98%	ND	4,919	2,620	16,550	64,600
Chromium	81	370	38.1	313	100%	1.17	31	21.9	85.86	116
Cobalt	NC	NC	--	313	96%	ND	10	9.8	13.7	17.3
Copper	34	270	42.4	313	99%	ND	32[A]	12.4[A]	102.55[B]	1,550[C]
Iron	NC	NC	--	313	100%	1380	24,227	24,200	32,600	40,900
Lead	46.7	218	44.6	313	100%	1.42[A]	36[A]	10.9[A]	137.4[B]	604[C]
Magnesium	NC	NC	--	313	100%	252	5,765	5,760	7,476	39,600
Manganese	NC	NC	--	313	100%	21.8	626	587	1,170	1,600
Mercury	0.15	0.71	0.38	313	37%	ND	0.89[B]	0.53[B]	2.46[C]	6.33[C]
Nickel	20.9	51.9	21.5	313	99%	ND	21	20.6	32.6	38.3
Potassium	NC	NC	--	313	97%	ND	2181	2,130	3,257	4,460
Selenium	NC	NC	--	313	43%	ND	4.01	3.945	6.2775	12.6
Silver	1	3.7	1.5	156	17%	ND	2.02	1.9	3.04	3.3
Sodium	NC	NC	--	313	94%	ND	2,229	2,035	3,761.50	5,730
Thallium	NC	NC	--	156	1%	ND	12.4	12.4	12.4	12.4
Vanadium	NC	NC	--	313	99%	ND	24.7	23.7	36.3	54.1
Zinc	150	410	129.2	313	100%	8.74	90	65	221	399

Notes: mg/kg = milligrams per kilogram; NC = no criteria; ND = not detected, -- = not available.
Sources:
[1] NYSDEC 1999
[2] Llanso et al. 2003
[A] Concentration falls within Class A - no appreciable contamination/no toxicity to aquatic life (NYSDEC 2004).
[B] Concentration falls within Class B - moderate contamination/chronic toxicity to aquatic life (NYSDEC 2004).
[C] Concentration falls within Class C - high contamination/acute toxicity to aquatic life (NYSDEC 2004).

Table 15-4
SVOCs

Parameter	Sediment Criteria		Hudson River Average[3]	Number of Samples Analyzed	Detection Rate	Minimum (µg/kg)	Average (µg/kg)	Median (µg/kg)	95th Percentile (µg/kg)	Maximum (µg/kg)
	ERL[1] (µg/kg)	ERM[1] (µg/kg)								
Acenaphthene	16	500	289.4	156	8%	ND	36	ND	89	3,270
Acenaphthylene	44	640	139.2	156	16%	ND	13	ND	111	206
Anthracene	85.3	1,100	283.2	156	27%	ND	47	ND	155	2,030
Benzo(a)anthracene	261	1,600	176.4	156	43%	ND	130	ND	418	3,760
Benzo(a)pyrene	430	1,600	174.1	156	51%	ND	133	37	496	3,020
Benzo(b)fluoranthene	NC	NC	184.7	156	42%	ND	110	ND	445	2,460
Benzo(g,h,i)perylene	NC	NC	123.5	156	42%	ND	64	ND	260	1,530
Benzo(k)fluoranthene	NC	NC	163.4	156	42%	ND	91	ND	328	2,370
Chrysene	384	2,800	178.7	156	44%	ND	134	ND	487	3,490
Dibenzo(a,h)anthracene	63.4	260	--	156	15%	ND	14	ND	78	456
Fluoranthene	600	5,100	218.9	156	49%	ND	333	ND	994	13,300
Fluorene	19	540	291.2	156	10%	ND	28	ND	81	2,210
Indeno(1,2,3-c,d)pyrene	NC	NC	104.8	156	33%	ND	53	ND	220	1,510
2-Methylnaphthalene	70	670	--	156	1%	ND	0.96	ND	ND	113
Naphthalene	160	2,100	111.0	156	9%	ND	11	ND	49	504
Phenanthrene	240	1,500	299.1	156	40%	ND	163	ND	539	7,030
Pyrene	665	2,600	265.7	156	48%	ND	288	ND	999	9,570
Total PAHs (sum of above)	4,020	44,792	3,003	156	--	22.8[A]	1,673[A]	113[A]	6,079[B]	48,211[C]
bis(2-Ethylhexyl)phthalate	NC	NC	--	156	33%	ND	82	ND	259	4,240
Butyl benzyl phthalate	NC	NC	--	156	12%	ND	101	ND	289	5,140
Carbazole	NC	NC	--	156	3%	ND	5.25	ND	ND	349
Dibenzofuran	NC	NC	--	156	5%	ND	20	ND	6.6	2,660
Di-n-butyl phthalate	NC	NC	--	156	3%	ND	30	ND	ND	4,360

Notes: µg/kg = micrograms per kilogram; NC = no criteria; ND = not detected; -- = not available.
Sources:
[1] NYSDEC 1999; [2] NYSDEC 1999; [3] Llanso et al. 2003
[A] Concentration falls within Class A - no appreciable contamination/no toxicity to aquatic life (NYSDEC 2004).
[B] Concentration falls within Class B - moderate contamination/chronic toxicity to aquatic life (NYSDEC 2004).
[C] Concentration falls within Class C - high contamination/acute toxicity to aquatic life (NYSDEC 2004).

Table 15-5
Pesticides, PCBs, and Dioxins

Parameter	Sediment Criteria					Hudson River Average[2]	Number of Samples Analyzed	Detection Rate	Minimum (µg/kg)	Average (µg/kg)	Median (µg/kg)	95th Percentile (µg/kg)	Maximum (µg/kg)
	ERL[1] (µg/kg)	ERM[1] (µg/kg)	BA- Chronic[1] (µg/gOC)	BA- Acute[1] (µg/gOC)	WA[1] (µg/gOC)								
alpha-Chlordane	NC	NC	NC	NC	0.006	--	156	1%	ND	0.1	ND	ND	16
gamma-Chlordane	NC	NC	NC	NC	0.006	--	156	1%	ND	0.09	ND	ND	15
Chlordane (sum of above)	NC	NC	0.002	0.05		--	156	--	--	0.19[A]	--	--	31[B]
Dieldrin	NC	NC	17.0	NC	NC	--	156	1%	ND	0.03[A]	ND	ND	4.8[A]
4,4'-DDD	NC	NC	-	-	NC	5.7	156	14%	ND	2.07	ND	12	54
4,4'-DDE	2.2	27	-	-	NC	--	156	7%	ND	0.47	ND	3.85	17
4,4'-DDT	1	7	1	130	NC	19.7	156	5%	ND	2.47	ND	0.73	352
Sum of DDT, DDD, and DDE	1.58	46.1	-	-		25.4	156	--	--	5.01[B]	--	16.58[B]	423[C]
Aroclor 1242	NC	NC	NC	NC	NC	--	156	13%	ND	51	ND	280	1,520
Aroclor 1248	NC	NC	NC	NC	NC	--	156	8%	ND	35	ND	239	1,200
Aroclor 1254	NC	NC	NC	NC	NC	--	156	4%	ND	6.13	ND	ND	221
Total PCBs	22.7	180	-	-	NC	726.8	156	--	40[A]	169.95*[B]	64[A]	682.25[B]	1,520*[C]
TCDD TEQ (pptr)	NC	NC	NC	NC	0.0002	--	17	100%	0.069[A]	11.84[C]	0.89[A]	54.2[C]	94.67[C]

Notes: µg/gOC = micrograms per gram of organic carbon; µg/kg = micrograms per kilogram; NC = no criteria; ND = not detected; BA = Benthic Aquatic; WA = Wildlife Accumulation; -- = not available; - ERM/ ERL applies.

Sources:

[1] NYSDEC1999

[2] Llanso et al. 2003

* The sum of PCBs is multiplied by two to determine the total PCB concentration (NYSDEC 2004).

[A] Concentration falls within Class A - no appreciable contamination/no toxicity to aquatic life (NYSDEC 2004).

[B] Concentration falls within Class B - moderate contamination/chronic toxicity to aquatic life (NYSDEC 2004).

[C] Concentration falls within Class C - high contamination/acute toxicity to aquatic life (NYSDEC 2004).

15-5 ENVIRONMENTAL EFFECTS

This section assesses potential impacts of the No Build Alternative and Replacement Bridge Alternative to groundwater, floodplains, and surface water resources within the study area.

15-5-1 NO BUILD ALTERNATIVE

15-5-1-1 GROUNDWATER RESOURCES

Under the No Build Alternative, the primary source of groundwater resources within the study area would continue to be contributed by the Hudson River with minor contributions from recharge areas. Land use changes within the small portion of the recharge area located within the study area (about 1 mile from the west bank and 3 miles from the east bank (see **Figure 15-4**) would not have the potential to adversely affect groundwater resources within the study area.

15-5-1-2 SURFACE WATER RESOURCES

The No Build Alternative would not result in changes to land uses within the study area that would have the potential to affect surface water resources and floodplains of Sheldon Brook and the Hudson River. This alternative would involve the continued operation of the existing bridge with ongoing maintenance to keep the bridge in a state of good repair. There would be no construction that would result in development of additional water quality management facilities for stormwater runoff from the existing highway or portions of the existing Tappan Zee Bridge in Rockland or Westchester counties. As with existing conditions, no treatment of stormwater would take place on the bridge. Maintenance of existing drainage systems along Interstate 87/287 would continue according to current practices for the foreseeable future.

15-5-1-3 SEDIMENTS

Under the No Build Alternative, the patterns of pier scour and deposition would remain largely the same as existing conditions, although they may vary somewhat with changing water column conditions. Under this condition, which is described under Affected Environment above, a large area near the existing bridge is subject to scour due to the narrow column spacing.

15-5-2 REPLACEMENT BRIDGE ALTERNATIVE

The Replacement Bridge Alternative would replace the existing Tappan Zee Bridge with two new parallel structures to the north of its existing location. As described in Chapter 2, “Alternatives,” there are two options for the Replacement Bridge Alternative’s approach spans (Short Span and Long Span Options) and two for the main span (Cable-stayed and Arch Option). The evaluation of potential impacts from these options considers the potential impacts from the Replacement Bridge Alternative in general, noting differences in the potential for adverse impacts for the two approach span options as appropriate. There would be no difference in the potential for affects to groundwater or surface water resources between the two main span options.

15-5-2-1 GROUNDWATER RESOURCES

Potential impacts to groundwater would occur primarily from the infiltration of chlorides (a residue of roadway deicing) or roadway pollutants (e.g., petroleum products, heavy metals, etc.) into the groundwater. Because there are no SSAs or NYSDEC-designated Primary or Principal Aquifers located within the study area, the Replacement Bridge Alternative would not have the potential to affect groundwater supplies. As was discussed for the No Build Alternative, the primary source of groundwater resources within the study area for the Replacement Bridge Alternative would continue to be contributed by the Hudson River with minor contributions from recharge areas. For the Long and Short Span Options, the approximately 27-acre and 17-acre upland landings of the Replacement Bridge Alternative on the Rockland and Westchester County sides of the Hudson River, respectively, comprise a small portion of the recharge area located within the study area. Therefore, operation of the landing areas for both approach options would not have a potential to result in adverse environmental impacts to groundwater resources within the study area. Additionally, the proposed collection and treatment of stormwater runoff from both landing areas prior to discharge to the Hudson River (discussed in section 15-5-2-2 below under Water Quality and Stormwater Management) would further minimize the potential for operation of the landings to result in adverse environmental impacts to groundwater resources. Therefore, the Replacement Bridge Alternative would be consistent with the goals of the Hudson River Valley National Heritage Area's Management Plan to preserve and protect the area's resources.

15-5-2-2 SURFACE WATER RESOURCES

Floodplains

Impacts to floodplains are estimated based on the encroachment into the 100-year floodplain (also known as the base flood). The water surface elevations of the 100 year flood elevation, or base flood elevation, were used in conjunction with cross-sections of the build alternatives to determine the area and volume of impacts of the Replacement Bridge Alternative to the 100-year floodplain.

No floodways have been designated within the study area for Sheldon Brook or the Hudson River.

For the Short and Long Span Options, approximately 0.3 acres of the replacement bridge landing in Rockland County would be located within 100-year floodplain and about 10 acres of the replacement bridge landing would be located within the 500-year floodplain (see **Figure 15-5**). The use of a portion of the 100-year and 500-year floodplain within the Rockland County portion of the study area for the replacement bridge landing would not result in adverse impacts to floodplain resources or result in increased flooding of adjacent areas. Piers for the replacement bridge would be located within the Hudson River in the 100-year floodplain. The Hudson River within the study area is tidally influenced and as such is affected by coastal flooding, which is influenced by astronomic tide and meteorological forces and, therefore, would not be affected by the Replacement Bridge Alternative. Minimal portions of the piers for the replacement bridge alternative would be located within the 500-year floodplain for the Hudson River within Westchester County on the east side of the Hudson River. No portion of the Replacement Bridge Alternative would be located within the 100-year floodplain for

Sheldon Brook within Westchester County. The Replacement Bridge Alternative would not affect floodplain elevations, and therefore, it would be in compliance with Executive Order 11988.

Water Quality and Stormwater Management

For the Hudson River, the principal potential impact to water quality of the Hudson River from the operation of the Replacement Bridge Alternative is the discharge of stormwater runoff from the decks of the replacement bridge. NYSDEC General Permit GP-0-10-001 regulates the discharge of stormwater runoff from construction activities associated with soil disturbance, including both water quality and quantity controls. NYSDEC requires treatment of stormwater runoff from areas of soil disturbance to improve water quality, as well as a reduction of peak flows of stormwater runoff providing channel protection, overbank flood protection and flood control. The technical standards and design criteria for stormwater management facilities are presented in NYSDEC's New York State SWMDM (NYSDEC 2010).

The stormwater quality management goals stated in the SWMDM are to achieve an 80 percent reduction in TSS and a 40 percent reduction in TP. Most water quality treatment practices accomplish this goal by collecting the stormwater runoff and detaining it for some length of time, infiltrating it into the ground or filtering it. These practices, commonly referred to as "standard practices," are assumed to meet the required removal efficiencies if designed according to the requirements presented in the SWMDM. Other treatment systems, or proprietary practices, such as hydrodynamic separators and grit chambers, can also be employed for water quality treatment. Typically proprietary practices are used when there are certain site specific conditions that prohibit the implementation of "standard practices."

The sizing of any stormwater quality treatment practices as outlined in the SWMDM is based on the Water Quality volume (WQv). The WQv is based on the volume of runoff as a result of the 90 percent rainfall event (i.e., 1.3 inches of rainfall). The intent is to maximize the volume of stormwater runoff treated for quality since much of the pollution in stormwater runoff comes during the early stages of a rainfall event. As a result, the smaller, but more frequent, rainfall events that constitute 90 percent of the precipitation events are expected to account for a considerable fraction of the pollution in stormwater runoff.

Stormwater Management Practices (SMPs) are intended to improve the water quality from redeveloped or new impervious surfaces. However, NYSDEC recognizes the difficulties encountered by linear transportation projects, as well as the opportunity to substantially improve water quality through the installation of stormwater treatment practices at sites that currently have no runoff controls, but for which the installation of SMPs is impractical. The SWMDM offers alternative methods of calculating the treatment volume for redevelopment projects to demonstrate compliance with the construction general permit. The following three methods discuss means of calculating treatment volumes for redeveloped portions of the project depending on whether standard or alternative practices (or a combination of the two) are employed:

- Treatment with standard practices—A minimum of 25 percent of the WQv of the total disturbed area would be captured and treated within the standard stormwater management treatment practices. For portions of redevelopment, 25% of the existing impervious area and 100 percent of the additional impervious area would be captured and treated within a standard treatment practice.

- Treatment with alternative practices—If the site plan includes alternative water quality practices (or proprietary practices) that treat 75 percent of the WQv from the redeveloped site, plus any additional runoff from any undisturbed areas that are tributary to the practice, no additional treatment of stormwater runoff is required.
- Weighted average approach—If a site plan includes a combination of impervious cover reduction, standard practices and alternative practices that meets the weighted average criteria of the SWMDM, no additional treatment of stormwater runoff is required.

The redevelopment criteria described above apply only to existing areas of impervious cover that are disturbed during construction. If a site redevelopment results in the addition of impervious cover to an area that is currently pervious, then the water quality management criteria for new site development (i.e., 100 percent treatment using standard methods) applies.

Stormwater runoff discharges from the Replacement Bridge Alternative would be ultimately discharged into the Hudson River, a tidal water body. The Hudson River is not on the State's Section 303(d) list of waterbodies impaired by stormwater runoff or within a watershed improvement strategy area. Therefore, stormwater quantity or the channel protection volume, overbank flood protection or flood control sizing criteria would not be required. However, post-construction stormwater quality treatment practices would be required for runoff discharging to the Hudson River from the bridge landing portions of Interstate 87/287 in both Rockland and Westchester Counties. Stormwater runoff from the approaches and main span of the Replacement Bridge Alternative would be discharged directly to the Hudson River without treatment, as occurs for the existing bridge. However, the presence of full shoulders and emergency access lanes on the replacement bridge would permit faster emergency response to on-bridge incidents that could result in spills of hazardous materials or other contaminants than would be possible on the existing Tappan Zee Bridge.

With the implementation of post-construction or long-term quality treatment controls at the bridge landings, the net concentration of pollutants to the Hudson River from the Replacement Bridge Alternative (landings, approach spans, and main spans) would be expected to decrease for TSS and increase by only 4.6 pounds per year for TP (see **Table 15-7** below). Based on the treatment capabilities of the stormwater management practices the pollutant loading would result in a greater reduction of TSS than TP; thus, TP would increase whereas TSS would decrease in comparison to existing conditions. This increase in TP loadings from the Replacement Bridge Alternative would not result in adverse impacts to water quality of the Hudson River, or result in a failure to meet the Class SB water quality standards. Therefore, the Replacement Bridge Alternative would be consistent with the goals of the Hudson River Valley National Heritage Area's Management Plan to preserve and protect the area's resources. Additionally, when comparing just pollutant loadings within the landings under the existing and Replacement Bridge Alternative, pollutant loadings would decrease for TP and TSS (see **Table 15-8** below).

Table 15-6 provides a comparison of impervious surfaces based on the contributing drainage areas from Interstate 87/287 and bridge improvements (see **Figure 15-17**). Under current conditions, the 79-acre drainage area consists of approximately 27 acres of contributing drainage area from the Rockland County portion, approximately 17 acres from the Westchester County portion, and 35 acres is from the bridge span. The Replacement Bridge Alternative would increase the drainage area by 24 acres, primarily due to the proposed bridge span and other roadway improvements. Differences in impervious surface coverage between the Long Span Option and the Short Span Option would be negligible.

Table 15-6
Impervious Surface Comparison

	Existing		Replacement Bridge Alternative	
Location	Impervious Surface (sf)	Pervious Surface (sf)	Impervious Surface (sf)	Pervious Surface (sf)
Rockland County Approach	858,239	324,879	917,844	265,274
Bridge	1,511,630	NA	2,618,327	NA
Westchester County Approach	673,314	77,855	751,169	0
TOTAL	**3,043,183**	**402,734**	**4,287,340**	**265,274**

Under both the Short Span and Long Span Options, the ability to provide stormwater quality treatment for the proposed modification to the landings would be constrained by a number of factors that would preclude the development of large water quality management facilities. While treatment of the stormwater runoff from the bridge deck is not required by NYSDEC regulations, the Replacement Bridge Alternative would be required to collect the water quality volume or "first flush" stormwater runoff from the bridge landings in Rockland and Westchester Counties and convey it to proposed water quality treatment facilities located in these two areas. Stormwater runoff from the two bridge landings is currently collected and conveyed to the Hudson River without treatment. With the treatment of the runoff from the bridge landing areas, the Replacement Bridge Alternative would result in a net decrease in pollutant loading to the Hudson River for TSS and an increase of 4.6 pounds per year or a 10% increase for TP (see **Table 15-7**). **Table 15-7** includes the calculations for the entire project (landings, approaches, and bridge). **Table 15-8** shows only the landings. This was done to show the compliance with the General Permit, which typically addresses stormwater runoff from land disturbance.

11.29.11

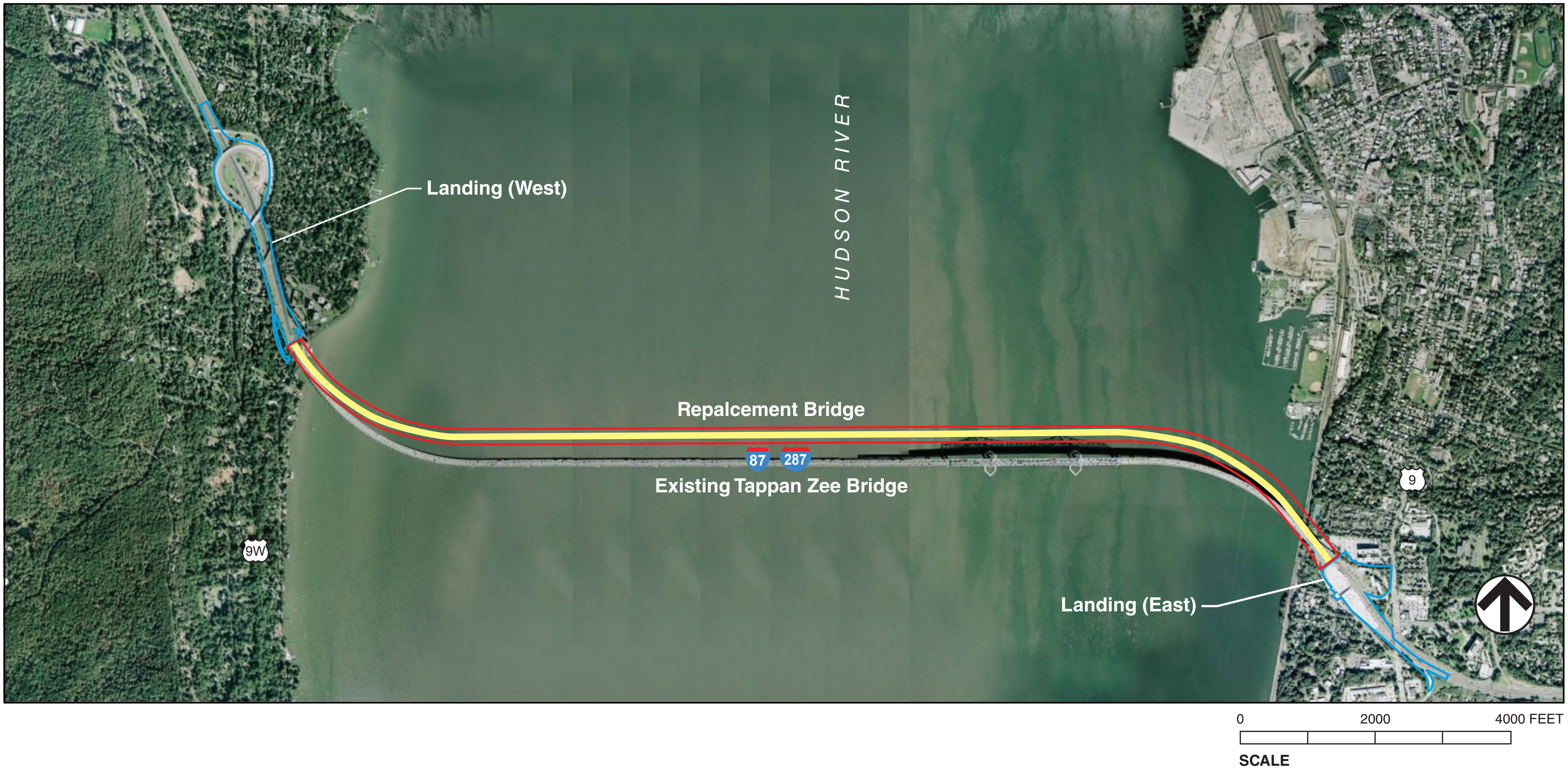


Figure 15-17

Drainage Areas

Table 15-7
Pollutant Loading Comparison

Existing		Replacement Bridge Alternative (with treatment[1])	
TP (lbs/year)	TSS (lbs/year)	TP (lbs/year)	TSS (lbs/year)
47.5	69,851	52.1	60,917

Note: The pollutant loading rates of 0.6 pounds per acre per year (lbs/acre/year) TP and 883 lbs/acre/year for TSS [source: Wanielista, MP and Yousef, YA, 1992] were used to estimate the annual pollutant load as a result of the increase in impervious surfaces. A reduction of 80 percent for TSS and 40 percent for TP was assumed for the total drainage area in the proposed condition.

1. Treatment proposed is for the landing only. No treatment proposed for the bridge.

Table 15-8
Pollutant Loading Comparison for Landings Only

Existing		Westchester and Rockland County Landings (with treatment[1])	
TP (lbs/year)	TSS (lbs/year)	TP (lbs/year)	TSS (lbs/year)
26.6	39,210	16	7,842

Note: The pollutant loading rates of 0.6 pounds per acre per year (lbs/acre/year) for TP and 883 lbs/acre/year for TSS [source: Wanielista, MP and Yousef, YA, 1992] were used to estimate the annual pollutant load as a result of the increase in impervious surfaces. A reduction of 80 percent for TSS and 40 percent for TP was assumed for the total drainage area in the proposed condition.

1. Treatment proposed is for the landing only (Westchester/Rockland Side). These calculations represent only the bridge landings and do not incorporate the bridge span. It assumed that stormwater runoff from the bridge span will be discharged directly to the Hudson River.

There are certain project site constraints, such as a limited right-of-way, proximity to the shoreline, and depth to water and bedrock, that make the location, sizing and design of post construction stormwater practices, such as created wetlands, extended detention ponds, wet ponds or surface filtering practices unachievable. Similarly, green infrastructure practices, such as stormwater planters, rain gardens or rainwater collection and reuse could not feasibly be implemented. Therefore, water quality treatment measures would be proposed to capture and treat the stormwater runoff from the roadway. The treatment measure implemented would include those demonstrated to be equal to the performance criteria required by the State of New York (i.e. 80 percent TSS removal and 40 percent TP removal) and have met the USEPA Environmental Technology Verification Program, the state of Washington Technology Assessment Protocol, or the Technology Acceptance Reciprocity Partnership Protocol Permanent stormwater controls would be designed and constructed in accordance with the NYSDEC’s SWMDM, NYSDOT Highway Design Manual, NYSDOT TEM Manual, and NYSTA engineering guidance. The permanent controls would be developed as part of the Stormwater Pollution Prevention Plan (SWPPP) for the Replacement Bridge Alternative. Locations for the facilities would be determined as the final design for the Replacement Bridge Alternative is developed.

15-5-2-3 SEDIMENTS

Figures 15-11 and 15-12 illustrate the results of the pier scour resulting from the existing bridge and Replacement Bridge Alternative, estimated using relationships established in the FHWA Hydraulic Engineering Circular No. 18 (HEC-18) (FHWA 2001). The existing Tappan Zee Bridge has 188 piers in the Hudson River. The estimated area of river bottom affected by scour is about 62 acres. The Replacement Bridge Alternative Short Span Option would have only 58 piers in the river and is projected to result in approximately 41 acres of scour and the Long Span Option would have only 32 piers in the river and result in about 26 acres of scour. Along the eastern approaches and in the main span there are a similar number of piers between both bridges; however, in the western causeway, the existing Tappan Zee Bridge contains 165 piers, where the Short Span Option would have 42 and the Long Span Option would have 22. For the existing Tappan Zee Bridge's western causeway, the piers are spaced approximately 50 feet apart. For the Replacement Bridge Alternative, the distance between piers would be approximately 230 to 430 feet. This increase in interpier area would attenuate the interpier water velocities from the existing condition and result in less scour. Reduced pier sediment scour rates would benefit the stability of the bridge structure and reduce sediment resuspension and movement and habitat disturbance.

Upon completion of the replacement bridge, the existing Tappan Zee Bridge would be demolished, and the bridge pier foundations would be removed. For the causeway spans, the timber piles for the foundations would be cut to just below the mudline. For the deck truss spans, the base slab of the caisson would be demolished and removed and the concrete demolished to the mudline. The steel H-piles below the caisson would not extend above the mudline and would remain in place. For the main span, the caissons would be demolished and the steel H-piles foundation piles would be cut to just below the mudline. With the removal of the piers, the hydraulic forces which cause pier scour at the existing bridge would also be removed, and the sediment bed in the vicinity of the existing bridge would gradually return to a natural condition. The rate of this transformation would begin at approximately 1 foot per year, likely decreasing as the bed nears it natural elevation. The time scale for the bed at the existing Tappan Zee Bridge to return to a quasi-natural condition is on the order of a decade.

15-6 MITIGATION

As noted above, with the implementation of stormwater management plans to treat stormwater quality for the landing areas for the Replacement Bridge Alternative designed and constructed in accordance with the NYSDEC's SWMDM, NYSDOT Highway Design Manual, NYSDOT TEM, and NYSTA engineering guidance, the discharge of stormwater runoff from the Replacement Bridge Alternative would not result in a net increase in pollutant loading to the Hudson River for TSS and would result in an increase in pollutant loading for TP which would not be substantial, minimizing the potential for substantial or long-term adverse changes to Hudson River water quality from the discharge of stormwater from the Replacement Bridge Alternative. Therefore, no additional mitigation would be required for the Replacement Bridge Alternative.