Chapter 14: Topography, Geology, and Soils

14-1 INTRODUCTION

This chapter describes existing topography, geology, and soils in the study area; potential environmental effects of the project alternatives on these resources.

Topography addresses issues related to slopes. Geology considers both bedrock (e.g., sandstone, shale, gneiss, etc.) and unconsolidated surficial deposits (e.g., sand, gravel, clay, etc.). The section on soils considers the uppermost layer of the ground, which has been exposed to climatic and erosive forces. Impacts to topography, geology, and soils are primarily associated with construction activities, which are discussed in more detail in Chapter 18, "Construction Impacts." As detailed in the analyses below, operation of the project would not result in any adverse impacts to these resources.

14-2 REGULATORY CONTEXT

The regulatory implications of geology are generally established through building codes or other engineering criteria that dictate design requirements for project elements. Examples include design codes for earthquake resistance and bearing capacity of foundations. Seismic design requirements for roadway and bridge structures, for example, are prescribed by the American Association of State Highway and Transportation Officials (AASHTO) and the New York State Department of Transportation (NYSDOT) in its *Bridge Safety Assurance* and *Blue Pages* manuals. Such codes and criteria are typically accounted for during detailed design of project-related structures.

The New York State Department of Environmental Conservation (NYSDEC) administers the State Pollutant Discharge and Elimination System (SPDES) program that protects waterways from soil erosion and pollutant impacts during construction and operation of projects under the authority of the federal Clean Water Act of 1972 (CWA). While this chapter addresses impacts related to ground disturbance, surface water runoff and the SPDES program are discussed further in Chapter 15, "Water Resources," and Chapter 18, "Construction Impacts." Prime farmland soils are protected and regulated by the Natural Resources Conservation Service (NRCS) of the U.S. Department of Agriculture (USDA) under the *Farmland Protection Policy Act (FPPA)*. However, this is not applicable to the study area for this project.

14-3 METHODOLOGY

The potential for impacts to topography, geology, and soils is related to direct ground disturbance (also referred to as the "limit of disturbance"). The study area evaluated for this chapter is coterminous with the proposed limit of disturbance boundary, and is shown on the figures that accompany this chapter.

Topographic and slopes data for the study area are based on Geographic Information Systems (GIS) resources for Rockland and Westchester Counties. Other sources include the NRCS, the U.S. Geological Survey (USGS), and the New York State Geological Survey (NYSGS). Bedrock and surficial geologic conditions are based on published maps for the southern New York region. Soils data are provided by soil surveys from the NRCS (formerly the Soil Conservation Service).

14-4 AFFECTED ENVIRONMENT

This section characterizes existing topographic, geologic, and soils conditions in the study area. As discussed above, existing conditions are largely based on available mapping and surveys of the study area, as well as preliminary geotechnical investigations conducted by Mueser Rutlege Consulting Engineers (MRCE). More extensive geotechnical investigations would occur during final design of the project.

14-4-1 TOPOGRAPHY

The study area is located within the Hudson River Valley and is primarily characterized by rolling topography with steeper embankments along the Hudson River shoreline. As shown on **Figure 14-1**, the study area ascends from the shoreline to approximately 200 feet above sea level at South Broadway. Just west of the study area in Rockland County, a prominent ridge results in an abrupt change in elevation. This ridge is commonly referred to as “the Palisades.”

As shown on **Figure 14-2**, the majority of the study area comprises minimal slopes (i.e., 0-15 percent). The area along the Hudson River in Westchester County exhibits steeper slopes ranging between 25 and 35 percent. The Hudson River shoreline in Rockland County also exhibits some slopes, but they are primarily less than 15 percent. The existing Interstate 87/287 is elevated over the areas of steeper slopes and touches ground in more level areas of the study area.

14-4-2 GEOLOGY

14-4-2-1 BEDROCK GEOLOGY

The Rockland County portion of the study area is underlain by sedimentary rock of the Newark Group. Published geologic maps indicate that this bedrock is of the Brunswick formation (Trba), comprising mudstone, sandstone, and arkose (see **Figure 14-3**). Just west of the study area is a notable north-south trending geologic feature classified as Palisade Diabase (Trp), forming the Palisades ridge discussed above.

The Brunswick formation extends under the western portion of the Hudson River. Near the western shoreline, bedrock is located at approximately 60 feet below mean sea level (MSL) but drops abruptly to more than 700 feet below MSL (Worzel and Drake, 1959) due to a pre-glacial river channel. Near the middle of the Hudson River, bedrock is located between 220 and 270 feet below MSL. **Figure 14-4** provides a cross-section of the Hudson River’s geological characteristics.

The eastern section of the Hudson River is underlain by metamorphic rock identified as Fordham gneiss, which extends into the Westchester County portion of the study area. Two subcategories of Fordham gneiss are located in this area: 1) fe: garnet-biotite-quartz-

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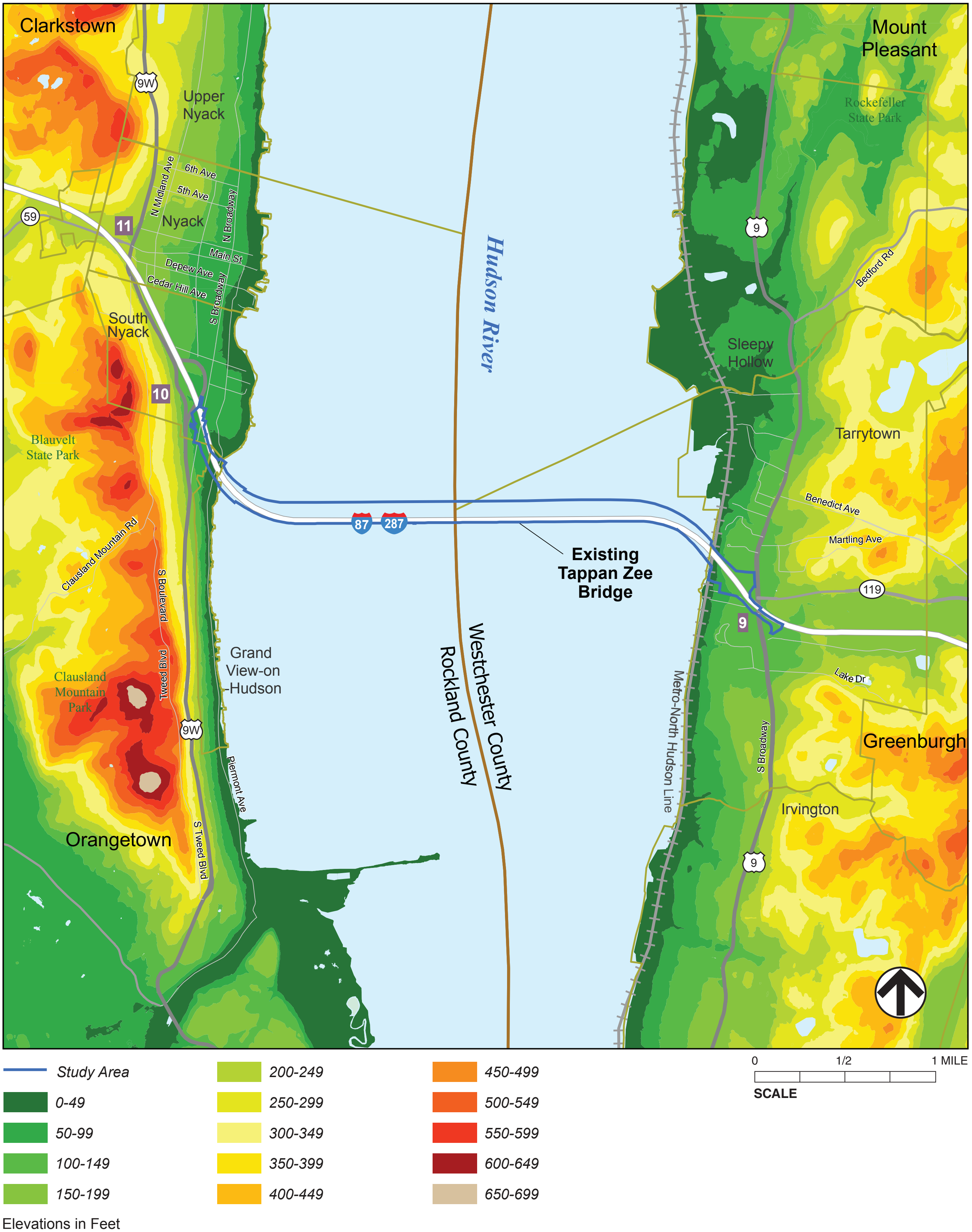

Figure 14-1
Existing Topography

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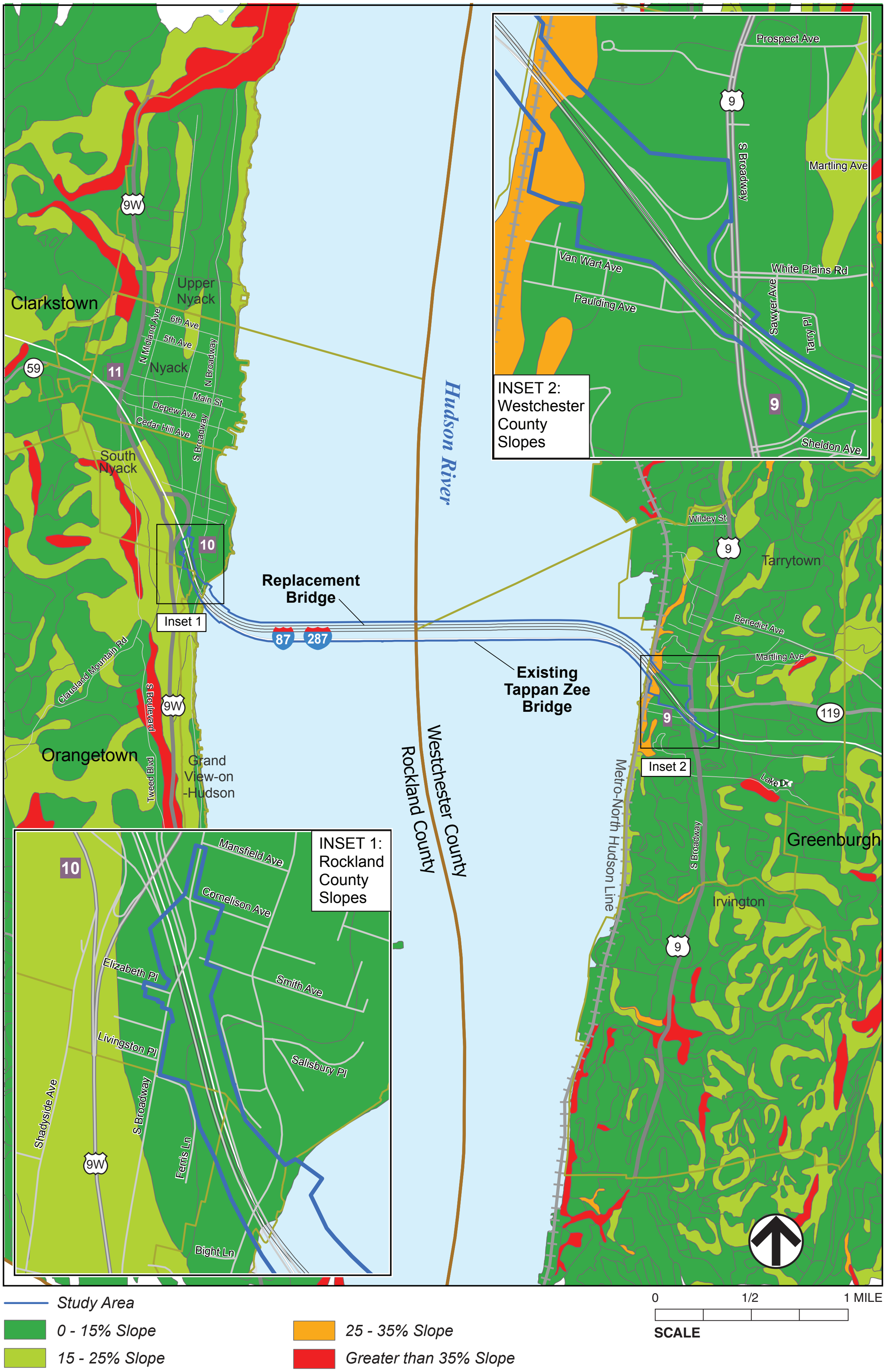
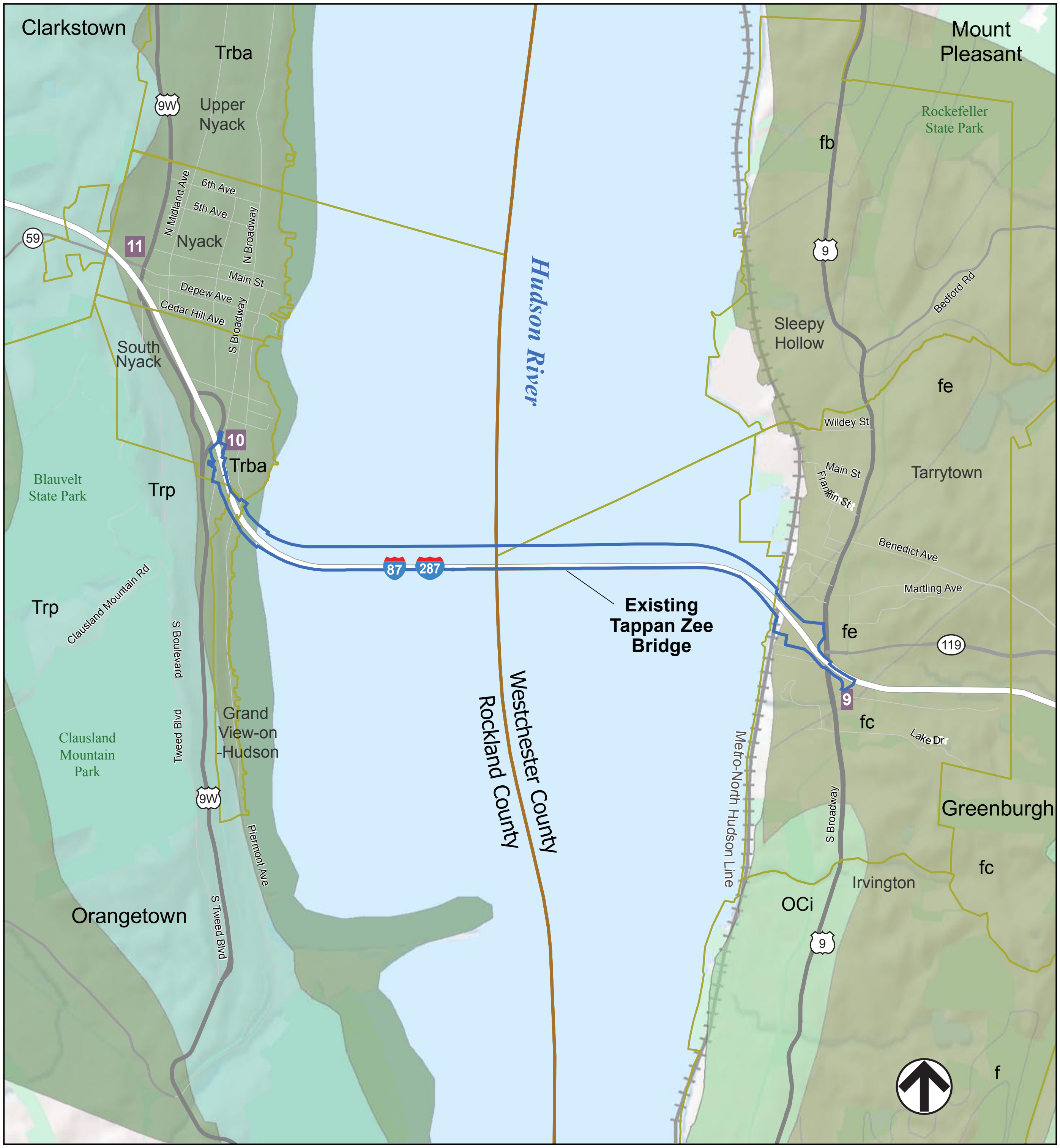


Figure 14-2
Existing Slopes



Study Area

Trp - Palisade Diabase Sill

Trba - Brunswick Formation

fc/fe - Fordham Gneiss

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SCALE

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Figure 14-3
Bedrock Geology

Figure 14-4
Geologic Cross Section

plagioclase gneiss and amphibolite; and 2) fc: biotite-hornblende-quartz-plagioclase gneiss, quartz-feldspar lenses, amphibolite, biotite, and/or hornblende-quartz-feldspar gneiss.[1]

The results of the geotechnical investigation and boring logs prepared by MRCE are consistent with the geology mapping of this area.

14-4-2-2 SURFICIAL GEOLOGY

The surficial geology of the study area is shown on **Figure 14-5**. Maps of unconsolidated deposits indicate that the surficial geology of the Rockland County portion of the study area comprises till with the following characteristics: “variable texture (e.g., clay, silt-clay, boulder clay), usually poorly sorted diamict, deposition beneath glacial ice, relatively impermeable (loamy matrix), variable clast content.”[2]

The surficial geology of the Westchester County portion of the study area is primarily characterized as bedrock. However, just north of Interstate 87/287, bedrock is overlaid by artificial fill, deposited for development purposes. The surficial geology of the far eastern portion of the study area is characterized by till.

The surficial geology of the Hudson River bottom primarily comprises organic silt and clay with traces of shells, decayed roots, and peat (Mueser Rutledge, 2008). The upper portion of this deposit is approximately 10 to 150 feet thick.

14-4-2-3 SEISMIC CONDITIONS

According to the Seismic Zoning Map for the New York State Seismic Building Code (Multidisciplinary Center for Earthquake Engineering Research, 2002), the study area is in a region with the potential for an earthquake. The USGS “Earthquake Probability Map” estimates that there is a 15 to 18 percent probability of an earthquake of magnitude 4.75 or higher occurring in the study area within the next 100 years. General earthquake probability in Rockland and Westchester Counties is similar. The Ramapo (or Ramapo-Canopus) Fault is the largest structure and only known active fault in proximity to the study area. This fault extends northeastward from New Jersey, through Suffern, and along the eastern edge of the Hudson Highlands, approximately 12 miles west of the study area.

14-4-3 SOILS

The NRCS (formerly Soil Conservation Service) identifies major classifications of soils that have similar characteristics (such as texture and drainage) into a series. Within each series, soils differ in slope and other characteristics that affect their use. On the basis of these differences, soil series are further divided into phases (soil map units). Different soil phases exhibit variable water storage, erosion potential, and other characteristics that are important from a development perspective.

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[1] Fisher et. al. 1970. Geologic Map of New York, Lower Hudson Sheet. New York State Museum.

[2] Cadwell et al. 1986. Surficial Geologic Map of New York, Lower Hudson Sheet. New York State Geologic Survey.

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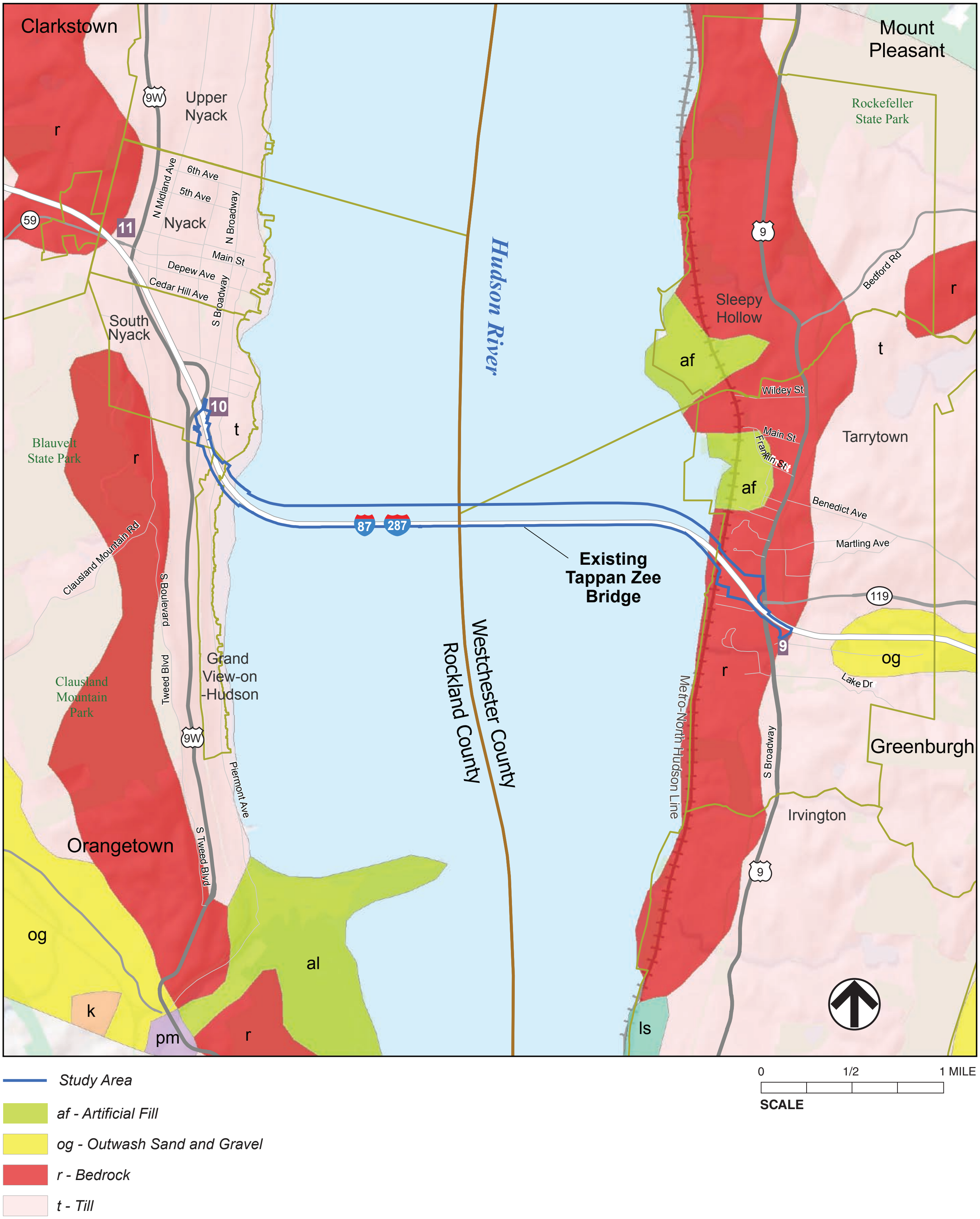

Figure 14-5
Surficial Geology

Table 14-1 contains a complete list of the soil mapping units located within the study area and lists their primary characteristics. The spatial arrangement of these soil types, as mapped by the NRCS Soils Survey of Rockland County (1990) and the Soil Survey of Putnam and Westchester Counties (1994), is shown on **Figure 14-6**.

Table 14-1
Soils in the Study Area

Symbol	Soil Series Name	Depth to Bedrock	Depth to Water Table	Characteristics
Rockland County				
WuB	Wethersfield-Urban land complex, 2 to 8 percent slopes	More than 60 inches	1.5 to 2.5 feet below the surface from February to April	Well drained. Permeability is moderate in the surface layer and subsoil and slow or very slow in the substratum. Main limitation for development of local roads and streets is seasonal wetness and frost action. Erosion hazard is moderate, surface runoff medium, and water capacity moderate. "K" Factor: 0.24 to 0.32. Hydrologic Group is C.
WuC	Wethersfield-Urban land complex, 8 to 15 percent slopes	More than 60 inches	1.5 to 2.5 feet below the surface from February to April	Well drained. Permeability is moderate in the surface layer and subsoil and slow or very slow in the substratum. Main limitation for development of local roads and streets is seasonal wetness, frost action, and slope. Erosion hazard is severe, surface runoff rapid, and water capacity moderate. "K" Factor: 0.24 to 0.32. Hydrologic Group is C.
Westchester County				
ChB	Charlton loam, 2 to 8 percent slopes	More than 60 inches	At a depth of more than 6 feet throughout the year	Well drained. Permeability is moderate or moderately rapid throughout the profile. No major limitations for local roads and streets. Erosion hazard is slight, surface runoff is medium, and water capacity is moderate. "K" Factor: 0.24. Hydrologic Group is B. Capability subclass is IIe.
ChC	Charlton loam, 8 to 15 percent slopes	More than 60 inches	At a depth of more than 6 feet throughout the year	Well drained. Permeability is moderate or moderately rapid throughout the profile. Main limitation for local roads and streets is slope. Erosion hazard is moderate, surface runoff is medium, and water capacity is moderate. "K" Factor: 0.24. Hydrologic Group is B. Capability subclass is IIIe.
ChE	Charlton loam, 25 to 35 percent slopes	More than 60 inches	At a depth of more than 6 feet throughout the year	Well drained. Permeability is moderate or moderately rapid throughout the profile. Main limitation for local roads and streets is slope. Erosion hazard is very severe, surface runoff is very rapid, and water capacity is moderate. "K" Factor: 0.24. Hydrologic Group is B. Capability subclass is Vle.
Uf	Urban land	---	---	Developed land.
UlC	Urban land-Charlton-Chatfield complex, rolling, very rocky	24 inches, fractured granitic bedrock	More than 60 inches	Well drained. Permeability is moderate or moderately rapid throughout the profile. Main limitation for local roads and streets is variable depth to bedrock and frost action. Erosion hazard is severe during construction, surface runoff is rapid, and water capacity is moderate.

Note: "K" Factor given indicates the erosion potential of each soil type. This indicates the susceptibility of a soil to sheet and rill erosion by water. Values of "K" range from 0.05 to 0.69. The higher the value, the more susceptible the soil is to erosion.
Sources: Soil Survey of Rockland County, New York, USDA Soil Conservation Service (now NRCS)
Soil Survey of Putnam and Westchester Counties, New York, USDA Soil Conservation Service (now NRCS)

The primary concerns related to soils are erosion and suitability for construction. Erosion characteristics for the soils in the study area range from moderate to very severe. The main limitations for construction of roadways are slopes, variable depth to

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Rockland County

Westchester County

— — —	*Study Area*	**ChC**	*Charlton Loam, 8-15% Slopes*
WuB	*Wethersfield-Urban Land Complex, 2-8% Slopes*	**ChE**	*Charlton Loam, 25-35% Slopes*
WuC	*Wethersfield-Urban Land Complex, 8-15% Slopes*	**Uf**	*Urban Land*
ChB	*Charlton Loam, 2-8% Slopes*	**UlC**	*Urban Land-Charlton-Chatfiled Complex, Rolling, Very Rocky*

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Figure 14-6
Soils Map

bedrock, and frost action, all of which are common for this region. Grading, erosion and sediment control plans, and other engineering measures can and will be put in place to overcome these limitations.

14-5 ENVIRONMENTAL EFFECTS

14-5-1 NO BUILD ALTERNATIVE

Under the No Build Alternative, the existing Tappan Zee Bridge and its approaches would continue to function and operate under existing conditions. There are no planned roadway or bridge improvements in this area, other than maintenance and upkeep of the Tappan Zee Bridge. As such, there would be no impacts to topography, geology, or soils under the No Build Alternative. Although some seismic retrofits would be undertaken, the bridge would be more susceptible to earthquakes than a new bridge would be.

14-5-2 REPLACEMENT BRIDGE ALTERNATIVE

Potential impacts related to topography, geology, and soils would be primarily associated with construction, which are described in Chapter 18, "Construction Impacts." Any potential impacts relevant to operation of the project are discussed below. The limit of disturbance area for each bridge option would be essentially the same. Therefore, both options are analyzed together below, with differences in the evaluation noted where applicable.

14-5-2-1 TOPOGRAPHY

The Replacement Bridge Alternative would not result in any substantial changes to topography or steep slopes. In Westchester County, the roadway would be elevated over the area of steep slopes (25-35 percent) along the Hudson River shoreline. In Rockland County, substantial regrading (using approximately 147,400 cubic yards of fill) would be required for the Long Span Option to elevate the ground for the bridge approach. As discussed further in Chapter 18, "Construction Impacts," engineering methods, including retaining walls, would be used to ensure that the ground is stabilized and could adequately support the bridge structure. Further, the project would comply with any applicable post-construction stormwater pollution prevention plans (SWPPP) and erosion and sediment control (ESC) plans to avoid long-term erosion and landslide hazards. Therefore, no adverse impacts related to topography and steep slopes from the Replacement Bridge Alternative would be expected.

14-5-2-2 GEOLOGY

Construction of the Replacement Bridge Alternative would require excavation of earth material, which is detailed further in Chapter 18, "Construction Impacts." The Replacement Bridge Alternative would be designed in accordance with the existing geologic conditions of the study area, as determined through geotechnical investigations. Bridge piers and piles would be secured into bedrock to the extent possible. Because bedrock drops to more than 700 feet below MSL under western sections of the Hudson River, some piers and piles would be secured into a layer of glacial varved silt and clay or till. Piles would be of sufficient diameter and be driven to sufficient depths in the ground to ensure that the bridge structure is adequately supported. Therefore, no adverse impacts to geologic resources would result from the Replacement Bridge Alternative.

Seismic Conditions

Given its location, the Replacement Bridge Alternative would be susceptible to earthquakes. The Replacement Bridge Alternative would be designed in accordance with seismic structural criteria for the downstate New York region established by AASHTO and NYSDOT. These design standards have been developed to ensure the structural integrity of bridges remains intact during seismic events of magnitudes that can be reasonably expected in this region. The Replacement Bridge Alternative would be a substantial improvement over the existing Tappan Zee Bridge, which pre-dates current seismic design standards and is considerably more vulnerable to earthquakes.

14-5-2-3 SOILS

The primary concerns with respect to soils are erosion and suitability for construction. Erosion would primarily be a potential impact during construction, as soils would be exposed to wind, rain, and other erosive forces (see Chapter 18, “Construction Impacts,” for further discussion.) Any areas of soil exposed during construction would be developed with highway improvements or maintenance facilities, or would be revegetated. As such, erosion would not be a substantial concern during operation of the project. Further, the project would operate in accordance with any NYSDEC-approved SWPPP and ESC plan to minimize long-term erosion hazards. Further, existing soils in the study area do not exhibit any severe limitations to roadway development, as described above. Therefore, no adverse impacts to soils would result from the Replacement Bridge Alternative.

14-6 MITIGATION

As the Replacement Bridge Alternative would not result in any adverse effects on topography, geology, and soils, no mitigation measures would be required.