7.0 Geologic Resources

7.1. Introduction

This chapter defines the geologic and soil resources pertinent to the Long Bridge Project (the Project), and defines the regulatory context, methodology, and Affected Environment. For each Action Alternative and the No Action Alternative, this chapter assesses the potential short-term and long-term impacts on geology and soil. This chapter also discusses proposed avoidance, minimization, and mitigation measures to reduce adverse impacts of the Project.

Geologic and soil resources include geologic formations or features such as point bar deposits, creek/river channels, sediments, banks, and other Coastal Plain and Piedmont sediments that comprise the foundation upon which the Project would be constructed. The Piedmont is mostly made of metamorphic rocks, and the Coastal Plain is made of sedimentary rocks. The environmental analysis considers geologic and soil resources because the Project would include ground altering activities that have the potential for impacts. Key features of the geologic resources for the Project include the soil or sediment types, texture, percent slope, and erodibility of upland and estuarine areas; geomorphic features or the form of the landscape such as bars, channels, and river banks; and geologic hazards such as faults and fractures or potential earthquake zones.

7.2. Regulatory Context and Methodology

This section describes the most pertinent regulatory context for evaluating impacts to geological and soil resources and summarizes the methodology for evaluating current conditions and the probable consequences of the alternatives. This section also includes a description of the Study Area. **Appendix D1, Methodology Report**, provides the complete list of laws, regulations, and other guidance considered, and a full description of the analysis methodology.

7.2.1. Regulatory Context

There are no relevant Federal, state or local laws, regulations, or Executive Orders for geologic resources. However, a geotechnical evaluation of geologic resources, including soil borings and collections, would be required during final design to determine appropriate foundations for the project. As a result, authorization would be required from the National Park Service (NPS), typically granted through a Scientific Research and Collecting Permit, for activities on property owned by NPS. It is also anticipated that permits would be required by the District of Columbia (the District), Arlington County, and the United States Army Corps of Engineers (USACE). The USACE, having regulatory authority through Section 10 of the Rivers and Harbors Act of 1899,[1] would likely issue a Nationwide Permit 6 – Survey Activities to authorize the geotechnical evaluation work. In addition, soil sampling and testing may be required to evaluate levels of contaminants. The local jurisdictions regulate reporting and disposal of soils samples.

[1] 33 USC 403, 33 CFR 322

An Erosion and Sediment Control Plan would address discharge of soils (erosion) during rainfall events when construction activities have exposed soils. Approval by the local jurisdiction (the District and Arlington County) of an Erosion and Sediment Control Plan would be required as part of the construction plan documents. Upon approval of the Erosion and Sediment Control Plan, the local jurisdictions provide review and approval of a Stormwater Pollution Prevention Plan (SWPPP) to ensure that erosion control measures are permitted, implemented, monitored, and reported under the National Pollutant Discharge Elimination System of the Clean Water Act of 1972.[2]

7.2.2. Methodology

The Local Study Area (shown in **Figure 7-1**) is a 0.25-mile buffer around the Long Bridge Corridor based on an estimated area for the Limits of Disturbance required for construction and construction access and staging. The Regional Study Area considered the Washington Metropolitan Region, which encompasses the geologic resources of interest for the Project.

To document the Affected Environment, the analysis assessed the geologic and soil resources within the Local Study Area, including the features, location, and condition. Information sources included available data online, reports and data such as subsurface investigations completed for the Project or nearby projects, Natural Resources Conservation Service (NRCS) soil surveys, geologic mapping, reports, and local Geographic Information Systems (GIS) data. The analysis mapped estimates of the size and extent of the resources using GIS.

Evaluation of direct and indirect impacts identified the likelihood that the Project alternatives would affect or impact geologic and soil resources and considered both temporary and permanent impacts.

7.3. Affected Environment

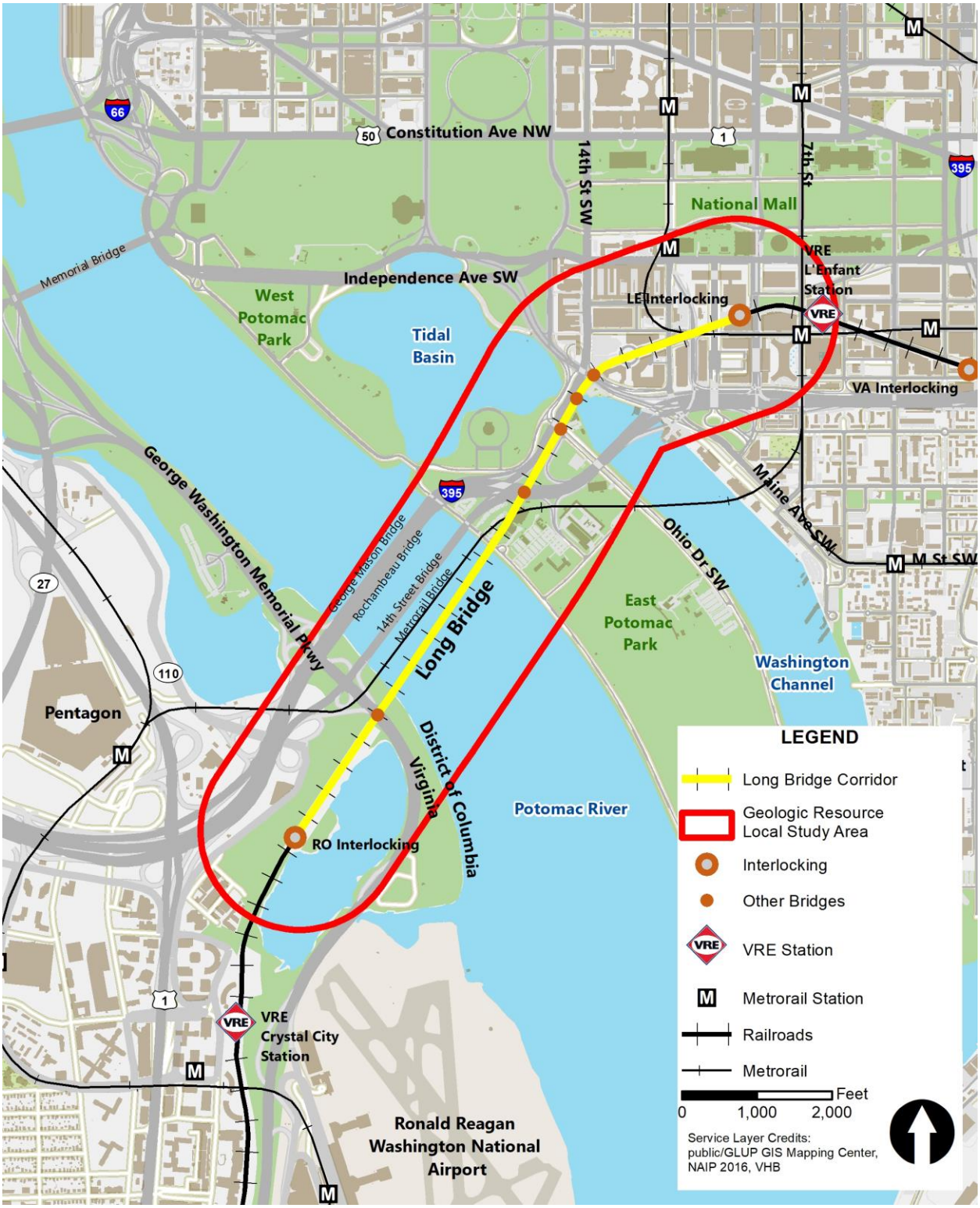
This section summarizes the existing conditions of the geologic and soil resources. For a complete description of the Affected Environment, see **Appendix D2, Affected Environment Report.**

The District is approximately 70 square miles on the northeast side of the Potomac River, adjacent to the mouth of the Anacostia River, and is located where the Piedmont region of the Appalachian Mountains and the Coastal Plains meet.[3] Most of the District lies on the deposits of an old system of canals and swamps.

[2] 33 USC 1251

[3] Carr, Martha. 1950. *The District of Columbia, Its Rocks and Its History*. Geological Survey Bulletin 967. Accessed from https://pubs.usgs.gov/bul/0967/report.pdf. Accessed June 13, 2018.

Figure 7-1 | Local Study Area for Geologic Resources



7.3.1. Geology and Soils

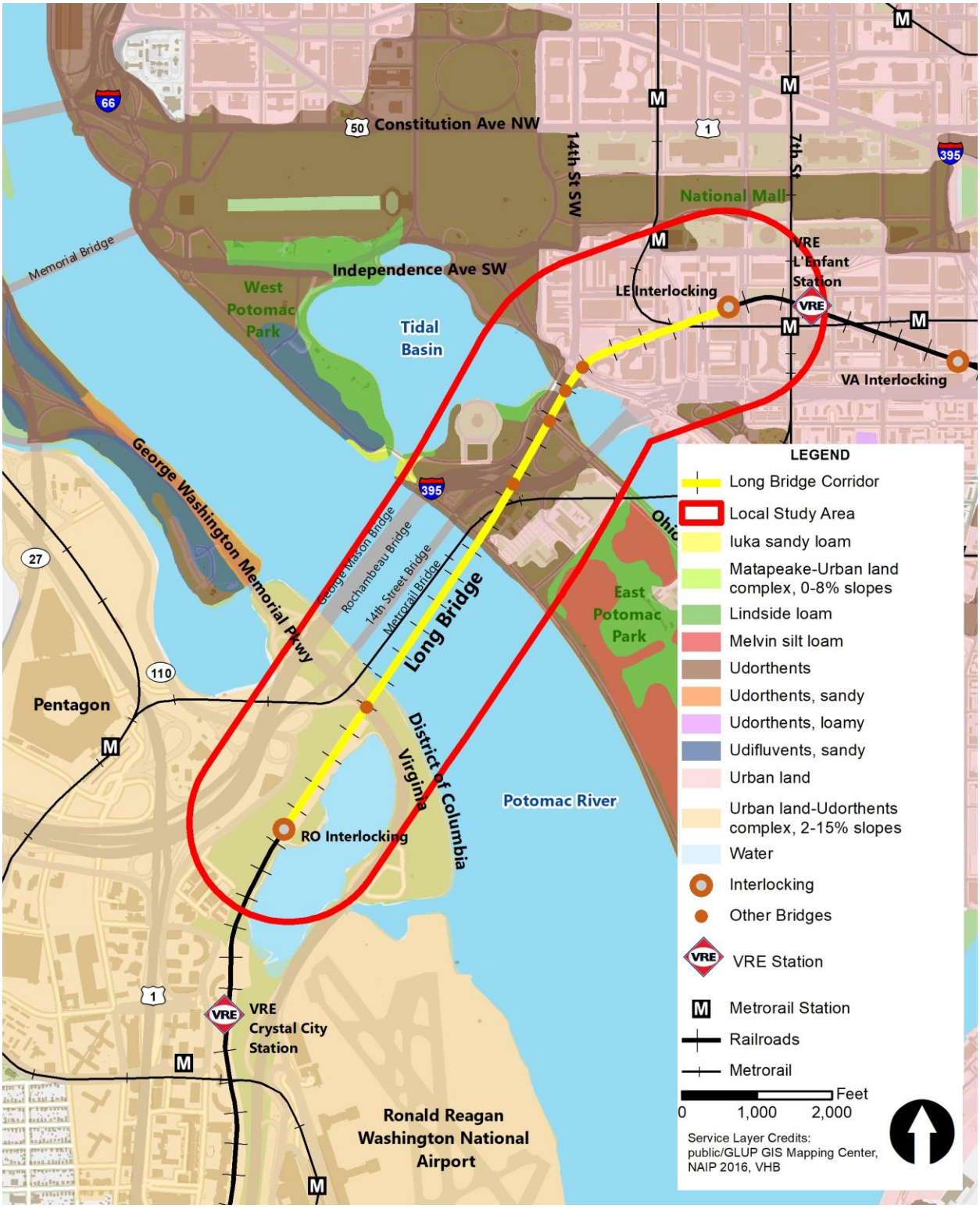
The Project is located entirely within the Atlantic Coastal Plain Physiographic Province. The Atlantic Coastal Plain consists of an eastward-thickening wedge of generally unconsolidated, interbedded sands, gravels, silts, and clays that overlie older, crystalline rock of the Piedmont Physiographic Province.[4,5] Within the Local Study Area, deposits on the Virginia side of the Potomac River are recent alluvium (Qal), while deposits within the District are Patapsco Formation and recent alluvium (Qp).[6] Bedrock within the Local Study Area has been observed at approximately 100 feet to 125 feet below mean low water elevation. More detailed information regarding the thickness and character of sedimentary deposits within the Local Study Area can be found in **Appendix B3, Geotechnical Engineering Report**.

As shown in **Figure 7-2**, Udorthents and Urban Land soils make up the majority of the surficial soils within the Local Study Area.[7,8] **Udorthents** are deep, drained, nearly level to very steep, loamy and clayey soils. Udorthents mostly consist of disturbed soils that could be surface materials stripped from previous mining or other land disturbance activities. **Urban Land soils** are areas covered by impervious materials (such as asphalt, concrete, or man-made structures).

The Virginia segment of the Local Study Area is approximately 150 acres with soils defined as Urban Land-Udorthents. This area is comprised of passive park lands, sports fields, parking areas, buildings, interstate, and other open-space areas. Approximately 59 percent of the Virginia Urban Land-Udorthents are pervious surfaces, or soils, that are mostly vegetated. Impervious surfaces such as concrete, asphalt, gravel, and buildings cover the remaining 41 percent of area. The northern segment of the Local Study Area within the District is more developed, with approximately 73 percent classified as impervious Urban Land. The remaining 27 percent of the area is defined as Udorthents that are mostly open grassed areas with more mature landscaping throughout. Much of this area comprises park land administered by NPS.

[4] Meng, A.A., and Harsh, J.F. 1988. *Hydrogeologic Framework of the Virginia Coastal Plain*. U.S. Geological Survey Professional Paper 1404-C. Accessed from https://pubs.usgs.gov/pp/pp1404-C/pdf/pp_1404-c.pdf. Accessed June 13, 2018.
[5] Johnston, P.M. 1964. *Geology and Ground-Water Resources of Washington D.C., and Vicinity*. Geological Survey Water-Supply Paper 1776. Plate 1. Accessed from https://pubs.usgs.goc/wps/1776/report.pdf. Accessed May 3, 2018.
[6] The USGS defines alluvium as a general term for clay, silt, sand, gravel, or similar unconsolidated detrital material that was deposited during recent geologic time by a stream or other body of running water, as a sorted or semi-sorted sedimentary deposit.
[7] Harper, John David. 2007. NRCS, United States Department of Agriculture. Soil Survey of Arlington County, Virginia. Accessed from https://websoilsurvey.nrcs.usda.gov/. Accessed May 3, 2018.
[8] Smith, Horace. 1976. NRCS, United States Department of Agriculture. Soil Survey of District of Columbia. Accessed from https://websoilsurvey.nrcs.usda.gov/. Accessed May 3, 2018.

Figure 7-2 | NRCS Soil Survey of Arlington County and District of Columbia



7.3.2. Geomorphic Features

Typical geomorphic features associated with Coastal Plain rivers include floodplains, levees, river banks, a thalweg,[9] and shallower broad flats within the river bottom. The Local Study Area contains all of these features, although human-induced activities have altered some features, including the river banks where levees would normally be. Segments of both the northern and southern sections of the Local Study Area extend onto floodplains that border the Potomac River. The floodplain areas include Urban Lands and Udorthents soils that mining and excavation have disturbed.

Both river banks extend approximately 2,000 linear feet from the upstream to downstream limits of the Local Study Area. The river bank along the Virginia shoreline is more natural, with a sloped bank that has various woody and herbaceous plants growing within and along the top of the bank. Some locations have larger rock materials installed on the bank to slow the erosional forces of the river. The river bank along the District shoreline has been hardened with a vertical bulkhead, or seawall, supporting a pedestrian walkway that extends through the Local Study Area.

The thalweg, or channel, is located more towards the southern side of the Potomac River and is approximately 150 to 200 feet wide with water depths as much as 20 feet. The edges of the channel slope up to shallower flats located on each side of the river. These shallower areas have water depths that range between 5 and 10 feet. The northern side of the river is a broad, shallow flat that extends for more than 1,000 feet to the District shoreline.

7.3.3. Geologic Hazards

The Central Virginia Seismic Zone is the nearest seismic zone to the Local Study Area. The Local Study Area is situated within an area mapped by the United States Geological Survey (USGS) as having a very low earthquake risk, with a total of 11 earthquakes since 1981. The USGS reports there is a 0.46 percent chance of a major earthquake within 50 kilometers (31 miles) of the District within the next 50 years.[10] On August 23, 2011, an earthquake with a magnitude of 5.8 occurred with an epicenter area located 90 miles from the Local Study Area, in Louisa County, Virginia.[11] The 2011 earthquake caused no damage to bridges. The earthquake damaged several landmarks in the District including the Washington Monument, located approximately 1,000 feet northwest of the Local Study Area.

7.4. Permanent or Long-Term Effects

This section discusses the permanent or long-term effects following the construction of the No Action Alternative and Action Alternatives on the geologic and soil resources within the Local and Regional Study Areas. For a complete description of the permanent or long-term effects, see **Appendix D3, Environmental Consequences Report**.

[9] A thalweg is the deepest point of the river normally associated with the navigation channel.
[10] Petersen et. al. 2014. Documentation for the 2014 Update of the United States National Seismic Hazard Maps. Accessed from https://pubs.usgs.gov/of/2014/1091/pdf/ofr2014-1092.pdf. Accessed May 3, 2018.
[11] Horton, J.W. Jr. and R.A. Williams. 2012. The 2011 Virginia Earthquake: What are Scientists Learning? EOS Trans. AGU 93(33), 317. Accessed from http://onlinelibrary.wiley.com/doi/10.1029/eost2012EO33/epdf. Accessed May 3, 2018.

7.4.1. Geologic Resources

7.4.1.1. No Action Alternative

The No Action Alternative would have no long-term effects to geologic resources because there would be no changes to the existing geologic or geomorphic features within the Local Study Area. Potential construction activities within the Local Study Area include the addition of a fourth track from the AF to RO Interlocking and LE to VA Interlocking, VRE L'Enfant Station Improvements, and VRE's North and South Storage Tracks. Additionally, proposed improvements at Long Bridge Park include a new aquatics center, parking, and support facilities. These projects would not alter or change any geologic or geomorphic features since they are located outside the river floodplain, river banks, river thalweg, and shallow flats of the river. The existing railroad bridge and infrastructure throughout the Long Bridge Corridor would continue to function and operate under existing conditions. The existing bridges and structural components would continue to be susceptible to earthquake activity occurring in the Regional Study Area.

7.4.1.2. Action Alternative A (Preferred Alternative)

Action Alternative A would have minor permanent direct adverse impacts to geologic resources since the footprint of the railroad widening and bridge structures is relatively small and localized and would not affect the function or integrity of the resource. Specifically:

- Placement of a new two-track bridge upstream of the existing Long Bridge and the redevelopment of the existing Corridor to expand the north-south railroad system from two to four tracks would require new foundation systems secured into the ground or riverbed of the Potomac River and Washington Channel, as well as earthwork and earth retaining structures within the Corridor.
- Minor alterations to the geomorphic features within the Local Study Area would include grading and filling of approximately 5,000 square feet of floodplain for landside track expansion and bridge construction, but these modifications would not affect the function or integrity of the resource. See **Chapter 6.4.3, Flood Hazards and Floodplain Management**, for further discussion on the effects to floodplain functions.
- Bridge foundations within the river would exist below the riverbed with only cylindrical piles extending through the water column to support the new bridge structures. For the Potomac River, the new bridge structures would impact approximately 600 square feet of the broad, shallow flats located on either side of the river channel. The Washington Channel bridge piles would impact approximately 100 square feet of the river bed, but the effects from both crossings would be minor, localized, and would not affect the function or integrity of the resource.
- New bridges and structures would be less susceptible than existing structures to earthquake activity occurring in the Regional Study Area since they would be constructed in accordance with current seismic structural criteria. However, the existing bridges and structural components would continue to be susceptible to earthquake activity occurring in the Regional Study Area.

The new bridges, retaining walls, and embankment construction would be designed in accordance with recommendations based on site specific geotechnical and hydrologic and hydraulic investigations to be completed during final design. These investigations would further the understanding and assessment of effects and would include a scour analysis to assess the stability of the geomorphic features adjacent to the proposed structures. These future studies would also include potential mitigation measures for any impacts.

7.4.1.3. Action Alternative B

Action Alternative B would have similar effects as Action Alternative A. However, demolition and replacement of the existing bridge would require replacing abutments, foundations, and bridge structures between the George Washington Memorial Parkway (GWMP) and Ohio Drive SW. The replacement work would occur within the same general footprint as the existing infrastructure and would represent small, localized changes to geomorphic features within the Local Study Area. All project elements under Action Alternative B would be less susceptible to earthquake activity occurring in the Regional Study Area as everything would be constructed in accordance with current seismic structural criteria.

7.4.2. Soils

7.4.2.1. No Action Alternative

The No Action Alternative would have permanent direct adverse impacts to soil resources since there would be soil disturbances or surficial changes within the Local Study Area. Potential improvements within the Local Study Area would be the same as those described in **Section 7.4.1.1, Geologic Resources, No Action Alternative**. These projects would result in a net loss of soils as buildings, parking, and track expansions are added within the Local Study Area. However, most of the expansion areas would occur upon existing impervious surfaces. The existing railroad bridge and infrastructure within the Local Study Area would continue to function and operate under existing conditions (see **Figure 7-2**). Any railroad maintenance activities within the Corridor would disturb railroad ballast stone and would not affect natural soils.

7.4.2.2. Action Alternative A (Preferred Alternative)

Action Alternative A would have minor permanent direct adverse impacts to soil resources since the footprint of the railroad widening and bridge structures would be relatively small and localized and would not affect the function or integrity of the resource. Construction of a new two-track bridge upstream of the existing Long Bridge and the redevelopment of the existing Corridor to expand the north-south railroad system from two to four tracks would require earthwork activities to expand the railroad embankments, to construct new bridge abutments, and to install supporting infrastructure. Approximately 4,200 square feet of soil resources would be replaced with structural elements associated with Action Alternative A.

The primary concern related to soils is the potential for soil loss from erosion during and following construction, as described in **Section 7.5.2, Soils**.

7.4.2.3. Action Alternative B

Action Alternative B would result in similar effects as described for Action Alternative A, which are minor permanent direct adverse impacts to soil resources. The primary difference with Action Alternative B is the replacement of existing infrastructure within the Corridor that would include replacing abutments, foundations, and new bridge structures between the GWMP and Ohio Drive SW. The additional infrastructure replacement would occur within the same general footprint as the existing infrastructure, representing small, localized changes or disturbances to soils within the Local Study Area.

7.5. Temporary Effects

This section discusses the direct or indirect temporary effects of the No Action Alternative and Action Alternatives during construction, based on conceptual engineering design. For the complete technical analysis of the potential temporary impacts to geologic and soil resources, see **Appendix D3, Environmental Consequences Report**.

During the construction phase of the Project, each Action Alternative is expected to have construction access and staging areas that could disturb the existing landside and waterside features adjacent to the permanent improvements.

7.5.1. Geologic Resources

7.5.1.1. No Action Alternative

The No Action Alternative would have no temporary effects to geologic resources. Potential improvements within the Local Study Area would be the same as those described in **Section 7.4.1.1, Geologic Resources, No Action Alternative.** These projects would be located outside geologic resources being evaluated such as the floodplain, river banks, thalweg, and shallow river flats. Under the No Action Alternative, the existing railroad bridge and infrastructure throughout the Long Bridge Corridor would continue to function and operate under existing conditions.

7.5.1.2. Action Alternative A (Preferred Alternative)

Action Alternative A would have minor temporary direct adverse impacts to geologic resources. Construction impacts would occur over a period of approximately 5 years. During the construction phases of Action Alternative A, various points of access would occur throughout the Corridor including areas such as Long Bridge Park, East Potomac Park, and the Potomac River shoreline. Impacts associated with temporary construction access roads, storage, and staging would temporarily disturb approximately 5.7 acres of floodplain. Demolition of the existing two-track bridges over I-395, Ohio Drive, Washington Channel, Maine Avenue, and Maiden Avenue would occur, but once demolition and construction are completed, the temporarily disturbed features would be returned to pre-construction conditions.

Temporary impacts to riverine features such as the shallow riverbed adjacent to the channel would occur through the installation of cofferdams around the 22 proposed bridge piers. Riverbed material would be removed from within the cofferdam to facilitate construction of the bridge foundations. The cofferdam structures, covering approximately 42,000 square feet of riverbed, would be removed once the foundation construction was complete and the riverbed adjacent to the new bridge supports would

be returned to pre-construction conditions. The restored riverbed would be exposed to existing tidal currents and frequent flood events that constantly move river sediments, potentially returning these temporary impact areas to more natural conditions in a relatively quick timeframe.

7.5.1.3. Action Alternative B

Action Alternative B would result in similar effects as described for Action Alternative A—minor temporary direct adverse impacts to geologic resources—except that Action Alternative B would include additional temporary effects from the replacement of existing infrastructure within the Corridor. Construction impacts would occur over a period of approximately 8 years and 3 months. Additional work would include demolishing and replacing abutments, foundations, and bridge structures between the GWMP and Ohio Drive SW. The additional infrastructure replacement would occur within the same general footprint as the existing infrastructure, representing small, localized changes or disturbances to geologic resources (floodplain and riverbed features) within the Local Study Area.

7.5.2. Soils

7.5.2.1. No Action Alternative

The No Action Alternative would have adverse temporary effects to soil resources. Potential improvements within the Local Study Area would be similar to those described in **Section 7.4.1.1, Geologic Resources, No Action Alternative**. Temporary effects to soil resources would occur as permanent improvements are constructed, such as construction access, staging and stockpiling, and demolition/construction work. However, portions of the expansion areas would occur in areas where there are no soil resources due to urban development. In this case, there would be no adverse temporary effects to soil resources. Under the No Action Alternative, the existing railroad bridge and infrastructure throughout the Long Bridge Corridor would continue to function and operate under existing conditions.

7.5.2.2. Action Alternative A (Preferred Alternative)

Action Alternative A would have minor temporary direct adverse impacts to soil resources since the disturbed areas would be returned to preconstruction conditions and would not affect the function or integrity of the resource. Construction impacts would occur over a period of approximately 5 years. Temporary effects to soil resources would result from construction access, staging and stockpiling, and demolition/construction work of the permanent improvements described in **Section 7.4.2.1, Soils, Action Alternative A**. Similar disturbances would occur during the demolition phase of the existing two-track bridges over I-395, Ohio Drive, Washington Channel, Maine Avenue, and Maiden Lane.

The primary concern related to soils is the potential for soil loss from erosion during and following demolition and construction. Removal of existing vegetative cover like trees and grasses can destabilize soils, making them susceptible to erosion during rainfall events. The erodibility of existing soils in the Local Study Area is variable due to previous disturbance and potentially imported materials. However, further investigations during the design phase would identify appropriate temporary stabilization measures for specific locations that could include items such as silt fences, rock check dams, soil stabilization blankets, turbidity curtains, and temporary seeding. A SWPPP would be developed to

provide guidance and strict adherence to erosion and sediment control measures developed for the project.

The project would require the excavation and removal of more than 29,000 cubic yards of soil for construction, primarily of the structure foundations and piers. These soils would be removed and disposed of offsite in accordance with applicable laws and regulations. See **Chapter 8, Solid Waste and Hazardous Materials**, for further discussion on the offsite disposal of potential soil materials. Temporary disturbances within the Potomac River and Washington Channel have the potential to increase localized levels of suspended sediments in the water column and effect water quality. See **Chapter 6, Water Resources and Water Quality**, for further discussion of suspended sediments.

7.5.2.3. Action Alternative B

Action Alternative B would generate temporary effects similar in location and extent as those caused in Action Alternative A, resulting in minor temporary direct adverse impacts to soil resources. Construction impacts would occur over a period of approximately 8 years and 3 months. The primary difference between Action Alternative A and Action Alternative B is the replacement of existing infrastructure within the Corridor, including the demolition and replacement of abutments, foundations, and piers between the GWMP and Ohio Drive SW in Action Alternative B. To enable the replacement of this infrastructure, approximately 16,000 cubic yards of soil would need to be removed, in addition to the 29,000 cubic yards that would be excavated and removed for the construction of the new structures, totaling approximately 45,000 cubic yards. The replacement of the infrastructure would occur within the same general footprint of the existing structures, representing localized changes or disturbances to soils within the Local Study Area. Temporary stabilization measures would be implemented as described in Action Alternative A to minimize temporary soil loss during construction.

7.6. Avoidance, Minimization, and Mitigation

This section describes proposed mitigation for the impacts to geologic resource and soil resources.

7.6.1. Geology

Minor adverse effects to geomorphic features like the floodplain and riverbed may occur due to construction of a new two-track bridge upstream of the existing Long Bridge. These geomorphic features cannot be avoided while achieving the goals and objectives of the Project. The Federal Railroad Administration and the District Department of Transportation have minimized adverse effects to the floodplain feature in design through the use of retaining walls along the track expansion. The vertical retaining walls would reduce the footprint and preserve existing floodplain features to the greatest extent practicable. Impacts would be minor, localized, and not affect the function or integrity of the resource; no mitigation is proposed.

7.6.2. Soils

The Action Alternatives would have minor adverse effects on soil resources within the Local Study Area due to the expanded railroad embankments, bridge abutment construction, and supporting infrastructure. The Virginia Department of Rail and Public Transportation, the project sponsor for final design and construction, would require the contractor to employ soil stabilization blankets, silt fences, rock check dams, and other best management practices designed to control soil loss during and

following construction to minimize erosion of soil resources. The use of retaining walls would also minimize the project footprint and disturbance to soil resources.

Final construction documents would include an approved erosion and sediment control plan and an approved SWPPP from the Virginia Department of Environmental Quality and the District Department of Energy and Environment, further minimizing long-term erosion hazards. Impacts would be minor, localized, and not affect the function or integrity of the resource, so no mitigation is proposed.