

9.0 INTRODUCTION

This chapter examines the potential impacts to natural resources¹ from one or more proposed initiatives (Proposed Actions) intended to enhance coastal and social resiliency along the Tottenville shoreline of the South Shore of Staten Island, NY. These initiatives include the Living Breakwaters Project (Breakwaters Project) and Tottenville Shoreline Protection Project (Shoreline Project).

In accordance with the 2014 *City Environmental Quality Review (CEQR) Technical Manual* and the National Environmental Policy Act (NEPA), the chapter describes:

- The regulatory programs that protect groundwater, wetlands, water quality, aquatic biota including Essential Fish Habitat (EFH), wildlife, threatened or endangered species, or other natural resources within the study area;
- The current condition of natural resources (i.e., groundwater, wetlands, water quality and aquatic biota, sediment quality, ecological communities, wildlife, EFH, and threatened or endangered species and species of special concern) within the study area;
- The natural resources conditions in the future without the Proposed Actions (the No Action Alternative); and
- The potential impacts of the Proposed Actions on natural resources under three proposed alternatives (Alternative 2: the Layered Strategy, or the Preferred Alternative; Alternative 3: the Breakwaters Project without the Shoreline Project; and Alternative 4: the Shoreline Project without the Breakwaters Project).

9.1 PRINCIPAL CONCLUSIONS

The Proposed Actions would result in the implementation of one of three alternatives analyzed in this EIS; Alternative 2 includes both the Breakwaters Project and the Shoreline Project; Alternative 3 includes only the Breakwater Project component; and Alternative 4 includes only the Shoreline Project component. A No Action Alternative was also analyzed.

Under the No Action Alternative – no new structural risk reduction or marine habitat restoration projects would be implemented within Raritan Bay off the south shore of Staten Island or along the adjacent shoreline and in the upland areas within Conference House Park. The existing man-made temporary dune system would remain in 2020, the end of the construction period for the Proposed Actions, and would continue to experience intense wave energy and be at risk from storm wave damage. Under this alternative, high rates of erosion would continue in the future,

¹ The *CEQR Technical Manual* defines natural resources as “(1) the City’s biodiversity (plants, wildlife, and other organisms); (2) any aquatic or terrestrial areas capable of providing suitable habitat to sustain the life processes of plants, wildlife, and other organisms; and (3) any areas capable of functioning in support of the ecological systems that maintain the City’s environmental stability.”

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further reducing the width of the beach in certain locations. Additionally, strategies to educate the public on risks posed by climate change would remain the same.

Under Alternative 2, the proposed breakwaters system of the Breakwaters Project would be installed within Raritan Bay off the south shore of Staten Island and the Shoreline Project elements and proposed Water Hub elements of the Breakwaters Project would be implemented along the adjacent shoreline and in upland areas almost entirely within Conference House Park.² Only one of three potential Water Hub locations would be selected: two of these potential locations are on-shore within Conference House Park and one of these potential locations is a vessel operated by a non-profit organization that would visit the project area periodically for observation and education with on-shore wayfinding and interpretive elements and kayak storage. The Proposed Actions would not result in significant adverse impacts to terrestrial resources. Temporary impacts resulting from construction of on-shore components, such as vegetation removal, wildlife displacement, and alteration of New York State Department of Environmental Conservation (NYSDEC) littoral zone tidal wetlands and the tidal wetland adjacent area (TWAA), and the delineated tidal wetland, would be minimized through the use of erosion and sediment control measures (e.g., silt fencing and hay bales), marsh mats, or low ground-pressure equipment within wetlands, vegetation protection and propagation measures, and compliance with the Stormwater Pollution Protection Plan (SWPPP) prepared for the project as required by New York State Pollutant Discharge Elimination System (SPDES) General Permit GP-0-15-002 for Stormwater Discharges from Construction Activity (General Permit). Permanent impacts to the delineated tidal wetland (0.14 acres out of the 0.8-acre delineated wetland due to a portion of the hybrid dune/revetment, and a length of eco-revetment) would be primarily within the portion of the wetland dominated by *Phragmites australis* (phragmites, or common reed). An existing sand bridge and culvert comprising unpermitted fill (approximately 0.01 acres) would be removed in order to construct the eco-revetment which would remove an existing impediment to tidal exchange within the eastern portion of this wetland. With the removal of the sand bridge, the net change in fill within the wetland would be 0.13 acres. While the loss of a portion of the wetland would be an adverse effect, it would be offset by the enhancement of the tidal wetland plant community that would include improved tidal exchange through modification of the inlet to Raritan Bay and removal of the sand bridge, removal of phragmites from within the wetland, and restoration of a native tidal wetland plant community. The portion of the eco-revetment that would be within the wetland would be designed in consultation with the NYSDEC and the United States Army Corps of Engineers (USACE) to minimize adverse effects to the tidal wetland.

Protection programs (e.g., transplant, and seed collection and propagation) would be developed in coordination with New York City Department of Parks and Recreation (NYC Parks) and New York State Natural Heritage Program (NYSNHP) for populations of the state-listed plant species that would have the potential to be affected by construction of the Shoreline Project: northern gamma grass (endangered), and dune sandspur (threatened). With the implementation of these measures the Proposed Actions would not result in significant adverse impacts to threatened or endangered plant species.

To minimize potential effects to migratory bird species, any tree clearing would be scheduled outside the early May through July primary bird breeding season, to the extent practicable. Should

² With the exception of a small portion of the Shoreline Project proposed within an unbuilt portion of the NYCDOT Surf Avenue right-of-way, all on-shore project components would be constructed within the boundaries of Conference House Park.

construction activities requiring tree clearing be necessary during April or August (i.e., the beginning and end of the breeding period), active nest surveys would be conducted in coordination with the US Fish and Wildlife Service to support tree cutting during this period. To minimize direct effects to eastern box turtles, any eastern box turtles encountered in the area of disturbance prior to or during the construction of earthen berm and eco-revetment in the vicinity of the delineated wetland would be relocated to an area beyond the silt fencing. With these measures in place, the Proposed Actions would not result in significant adverse impacts to terrestrial wildlife.

Excavation of soils to construct the on-shore components of the Proposed Actions would not have the potential to adversely affect groundwater due to soil contamination. The proposed removal of soil determined to meet the NYSDEC Soil Cleanup Objectives (SCOs) for residential use and for protection of groundwater would not adversely affect groundwater. Groundwater removed during any dewatering activities, if any, would be treated prior to discharge to Raritan Bay. Green infrastructure measures incorporated into the Shoreline Project and the on-shore Water Hub component of the Breakwaters Project at Potential Location 1 would allow runoff to infiltrate into the soil and recharge to groundwater. The landscaped areas within the Shoreline Project and at the on-shore Water Hub locations would be maintained using Integrated Pest Management (IPM) techniques thereby substantially diminishing the need for the use of pesticides and other chemicals and minimizing adverse effects to groundwater quality. Therefore, the Proposed Actions would not result in significant adverse impacts to groundwater.

During placement of the breakwater materials and sand for the shoreline restoration, measures would be implemented to minimize resuspension of bottom sediment. Increases in suspended sediment that would result from in-water construction activities would be temporary and localized, would dissipate upon cessation of the sediment disturbing activities, and would not result in significant adverse effects to aquatic biota. Fish and mobile benthic invertebrates would be expected to avoid the portions of the bay in which in-water activities would be occurring, moving to similar available habitat nearby. Increased vessel traffic and underwater construction noise would be within the range of typical vessel activity in Raritan Bay and is unlikely to adversely affect aquatic resources. Shading of aquatic habitat due to construction barges would be temporary and would not result in adverse effects to aquatic biota. Unavoidable loss of NYSDEC littoral zone wetlands within the footprint of six breakwater segments and a small portion of a 7th segment (about 7.1 acres) and the portion of shoreline restoration below mean high water (MHW) (2.6 acres) would be small in comparison to the amount of unaffected NYSDEC littoral zone tidal wetlands within Raritan Bay and would not result in significant adverse impacts to the NYSDEC littoral zone wetland resources.

Operation of the Proposed Actions would not result in significant adverse impacts to terrestrial resources and would result in an overall beneficial effect on these resources. Shoreline risk reduction measures combined with the reduced shoreline erosion and wave attenuation afforded by the breakwaters system would increase resiliency of the south shore of Staten Island, and the natural resources therein, to storm events. The Shoreline Project would stabilize and protect the upland shoreline, and would incorporate green infrastructure, such as bioswales, to maintain the protective function of NYSDEC TWAA. On-shore planting with native coastal species would enhance the native coastal habitats available throughout the Shoreline Project and the proposed Water Hub at Potential Location 1 of the Breakwaters Project. Enhancement of the remaining 0.66-acre portion of the approximately 0.8-acre delineated tidal wetland that would not be within the footprint of the Shoreline Project through increased tidal exchange, removal of phragmites and restoration of a native tidal wetland plant community would benefit wetland resources and wildlife that would use this wetland. The 3.1 acres of shoreline restoration (2.6 acres below MHW) would

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increase availability of beach habitat for coastal wildlife. The approximately 4.6 acres of native coastal vegetation that would be established within the Shoreline Project would benefit ecological communities and the wildlife that would use these habitats.

The Proposed Actions would result in the placement of floating structures within Raritan Bay only if the Water Hub is sited at Potential Locations 1 and 2. These floating structures would include: an approximately 210-foot-long and 8-foot-wide seasonal boat launch at the Water Hub at Potential Location 1 to facilitate research activities at the breakwaters; a seasonal boat launch to provide water access as part of the Water Hub at Potential Location 2; and a 30 by 50-foot-wide seasonal floating dock near the breakwater segments to facilitate monitoring and research activities as part of the Water Hub at Potential Locations 1 and 2. The width of the boat launches and seasonal floating dock would be narrow enough to allow some light to penetrate to the aquatic habitat beneath them during some portion of the day and would not result in significant adverse impacts to aquatic habitat and biota. The Water Hub at Potential Location 3 would be a vessel that would visit the project area and would not require floating structures.

The Proposed Actions would result in the placement of breakwater segments within Raritan Bay. The breakwater system is designed and located to maintain and restore the beach while minimizing down-drift³ impacts. The breakwaters would attenuate waves and alter the sediment transport along the shore for this purpose. Local sediment transport rates and accretion would be altered but the natural processes would not be blocked as there would still be sediment transport along the shore and tidal circulation around the breakwaters. The breakwater segments have been designed to minimize changes to tidal flushing and water residence time in order to avoid adverse impacts to water quality. The increased width and stability of the beaches within Conference House Park would improve spawning habitat for horseshoe crabs, provide beach habitat for other organisms while protecting the shoreline against wave action and coastal erosion, and stabilize the NYSDEC littoral zone tidal wetlands and TWAA.

The breakwaters (excluding the shoreline restoration) would convert approximately 11.4 acres of existing sand/gravel bottom habitat and the approximately 115,990 cubic yards (CY) of open water habitat below MHW overlying this portion of Raritan Bay to complex hard structure (a habitat that was historically present but currently scarce in Raritan Bay). This area of bottom habitat represents about 2 percent of existing sand/gravel bottom habitat and within the approximately 610-acre portion of Raritan Bay within the study area. While the breakwaters would convert a portion of open water to structured habitat, this loss would be small compared to the extensive open water habitat available within the study area and Raritan Bay as a whole. Additionally, the structures would not hinder the movement of fish and other aquatic biota through the water column, nor would they disrupt water circulation in Raritan Bay. Fish and other aquatic biota, including anadromous species and early life stages, would be able to pass (either actively or passively) around the individual breakwater segments at any given time. The conversion of sand and gravel habitat and open water habitat to structure would not occur all at once, but rather sequentially over an 11-month period (6 months in the first year and 5 months in the second year) as the breakwater segments are constructed. This habitat conversion would result in high-relief, complex, rocky reef-like habitat within the breakwater segments. By design, the breakwater system would incorporate ecological enhancements expected to benefit the target species groups

³ Down-drift erosion – when a headland, inlet, river, bay, canyon, reef or shoal blocks the natural longshore drift of materials, such as sand and gravel, by waves and currents, resulting in accumulation of sediments on the up-drift side, while a depletion of material occurs on the down-drift side (Bruun 1995).

identified for the project. The high-relief rocky habitat provided by the breakwaters would be designed to attract and retain habitat-creating benthic invertebrates and shellfish, including bivalves. Ecological design features of the breakwaters (i.e., varying levels of elevation, inclination, bio-enhancing materials, textures, interstitial spaces, water retaining elements, reef streets and rock size variations) would facilitate the recruitment of a rich benthic community of habitat-forming encrusting invertebrates and algae, while also providing suitable sheltering and foraging habitat for fish and benthic invertebrates, including threatened and/or endangered species that could occur in Raritan Bay. Additionally, crevices and void spaces at the interface of the breakwaters segments with the seafloor would be available for use by benthic fish and invertebrate species. In addition to the ecological enhancements, the Proposed Actions would incorporate other measures to minimize potential adverse effects to EFH and other aquatic biota. These include timing the shoreline restoration activities and breakwater construction activities to be outside spawning windows specified by NMFS (e.g., horseshoe crab and winter flounder); maintaining at least 2 feet of clearance between the bay bottom and construction vessels or working when tide levels are sufficient to keep construction barges and vessels off the bottom; constructing breakwater segments sequentially such that the habitat conversion occurs gradually; and incorporating post-construction monitoring and adaptive management. With respect to aquatic resources, the loss of approximately 3.6 acres of Waters of the U.S. and associated habitat due to the portion of the breakwaters above MHW would result in adverse impacts and would be mitigated pursuant to the Clean Water Act through measures that may include available credits from an approved mitigation bank, and restoration/enhancement of Waters of the U.S. within the Raritan Bay watershed in New York.

The shoreline restoration over time would result in a net gain of intertidal habitat of approximately 0.5 acres and a net loss of subtidal (open water) habitat of approximately 0.5 acres. The conversion of open water habitat would represent a small reduction in this type of habitat in the study area within Raritan Bay, and similar habitat at equivalent water depths would continue to be available in the vicinity.

Under Alternative 3, the Breakwaters Project, including the in-water breakwaters, shoreline restoration, and Water Hub, would be implemented without the Shoreline Project. Under this alternative, the same temporary and permanent impacts to NYSDEC littoral zone tidal wetlands and mapped NWI estuarine wetlands, water quality, sediment quality, and conversion of soft bottom and open water habitat designed to benefit target species through the increased diversity of the high-relief, complex, rocky reef-like habitat of the breakwater segments as Alternative 2 would be expected. However, the NYSDEC TWAA would not be protected against wave energy and erosion and the delineated tidal wetland would not be enhanced through improved tidal flushing. Alternative 3 would reduce wave energy at the shoreline and reduce or reverse shoreline erosion, but the temporary man-made dune would remain the only shoreline risk reduction feature. On-shore habitat would remain fragmented and less suitable for wildlife species that breed or forage on beaches without the Shoreline Project. Overall, Alternative 3 would not obtain the same level of coastal resiliency as Alternative 2.

Under Alternative 4, the Shoreline Project would be developed without the in-water breakwaters structures, the shoreline restoration, or the Water Hub. The earthen berm, hybrid dune/revetment system, wetland enhancement, eco-revetments, and raised edge would be implemented and would result in the same effects as discussed under Alternative 2. This alternative would not result in conversion of soft bottom sand habitat to high-relief, complex, rocky reef-like habitat. While this alternative would stabilize the upland shoreline, the Shoreline Project structures, NYSDEC TWAA, ecological communities, and wildlife would remain vulnerable to coastal storm surges

and the beach communities would be subject to loss due to erosion. Overall, Alternative 4 would not obtain the same level of coastal resiliency as Alternative 2.

9.2 REGULATORY CONTEXT

9.2.1 FEDERAL

- **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.
 - Section 404 of the Act requires authorization from the Secretary of the Army, acting through the U.S. Army Corps of Engineers (USACE), for the discharge of dredged or fill material into waters of the United States. Activities authorized under Section 404 must comply with Section 401 of the Act. All permit applications submitted to USACE, including those submitted for a Department of Army permit under Section 404 of the Clean Water Act, must undergo a public interest review in accordance with 33 CFR Part 320.4. The public interest review for the elements of the Preferred Alternative under USACE jurisdiction is included as Appendix E-1.
 - Under Section 401 of the Act, any applicant for a federal permit or license for an activity that may result in a discharge to navigable waters must provide to the federal agency issuing a certificate (either from the state where the discharge would occur or from an interstate water pollution control agency) that the discharge would comply with Sections 301, 302, 303, 306, 307, and 316 (b) of the Clean Water Act. Applicants for discharges to navigable waters in New York must obtain a Section 401 Water Quality Certificate from the NYSDEC.
- **Rivers and Harbors Act of 1899.** Section 10 of the Rivers and Harbors Act of 1899 requires authorization from the Secretary of the Army, acting through USACE, for the construction of any structure in or over any navigable water of the United States, the excavation from or deposition of material in these waters, or any obstruction or alteration in navigable waters of the United States. The purpose of this Act is to protect navigation and navigable channels. Any structures placed in or over navigable waters, such as pilings, piers, or bridge abutments up to the mean high water line, are regulated pursuant to this Act. All permit applications submitted to USACE, including those submitted for a Department of Army permit under Section 10 of the Rivers and Harbors Act, must undergo a public interest review in accordance with 33 CFR Part 320.4 (see Appendix E-1).
- **Magnuson-Stevens Act (16 USC §§ 1801–1883).** Section 305(b)(2)-(4) of the Magnuson-Stevens Act outlines the process for the National Marine Fisheries Service (NMFS) and the Regional Fishery Management Councils (in this case, the Mid-Atlantic Fishery Management Council) to comment on activities proposed by federal agencies (issuing permits or funding projects) that may adversely impact areas designated as EFH. EFH is defined as those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity (16 USC §1802[10]). Adverse impacts on EFH, as defined in 50 CFR 600.910(A), include any impact that reduces the quality and/or quantity of EFH. Adverse impacts may include: direct impacts, such as physical disruption or the release of contaminants; indirect impacts, such as

- the loss of prey or reduction in the fecundity (number of offspring produced) of a managed species; and site-specific or habitat-wide impacts that may include individual, cumulative, or synergistic consequences of a federal action.
- **EO 11990, “Protection of Wetlands.”** In accordance with EO 11990, “Protection of Wetlands,” federal agencies must avoid undertaking or providing assistance for new construction in wetlands unless there is no practical alternative to such construction and the proposed action includes all practicable measures to minimize harm to the wetland. Title 24, Subtitle A Part 55 of the Code of Federal Regulations (24 CFR § 55) contains the U.S. Department of Housing and Urban Development’s (HUD) regulations implementing the requirements of EO 11988 Floodplains and EO 11990, and the eight-step decision-making process for making determinations on compliance with these two Executive Orders.
 - **EO 13112, “Invasive Species.”** In accordance with EO 13112, “Invasive Species,” federal agencies must prevent, to the extent practicable and permitted by law, the introduction of invasive species and provide for their control and to minimize the economic, ecological, and human health impacts that invasive species cause.
 - **Endangered Species Act of 1973 (16 USC §§ 1531–1544).** The Endangered Species Act of 1973 recognizes that endangered species of wildlife and plants are of aesthetic, ecological, educational, historical, recreational, and scientific value to the nation and its people. The Act provides for the protection of critical habitats on which endangered or threatened species depend for survival. The Act also prohibits the importation, exportation, taking, possession, and other activities involving illegally taken species covered under the Act, and interstate or foreign commercial activities.
 - **Migratory Bird Treaty Act [50 CFR 10, 20, 21, EO 13186].** The Migratory Bird Treaty Act (MBTA) of 1918 was implemented following the 1916 convention between the U.S. and Great Britain (on behalf of Canada) for the protection of birds migrating between the U.S. and Canada. Subsequent amendments implemented treaties between the U.S. and Mexico, Japan, and the former Soviet Union. The MBTA makes it unlawful to pursue, hunt, take, capture, kill or sell birds listed therein. Over 800 species are currently protected under the Act. The statute applies equally to both live and dead birds, and grants full protection to any bird parts, including feathers, eggs, and nests.
 - **Fish and Wildlife Coordination Act (16 USC 661–667e).** The Fish and Wildlife Coordination Act entrusts the Secretary of the Interior with providing assistance to, and cooperation with, federal, state and public or private agencies and organizations to ensure that wildlife conservation receives equal consideration and coordination with other water-resource development programs. These programs can include the control (such as a diversion), modification (such as channel deepening), or impoundment (dam) of a body of water. The Fish and Wildlife Coordination Act, along with the Fish and Wildlife Act of 1956 and the Migratory Marine Game-Fish Act, express the will of Congress to protect the quality of the aquatic environment as it affects the conservation, improvement, and enjoyment of fish and wildlife resources.
 - **Bald and Golden Eagle Protection Act (16 USC 668–668c).** The Bald and Golden Eagle Protection Act prohibits anyone without a permit issued by the Secretary of the Interior, acting through USFWS, from taking bald or golden eagles, including their parts, nests, or eggs. The Act defines “take” as “pursue, shoot, shoot at, poison, wound, kill, capture, trap, collect, molest, or disturb.”

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- **Wild and Scenic Rivers Act of 1968 (16 USC 1271 et seq).** The Wild and Scenic Rivers Act of 1968 protects selected rivers in a free-flowing wild and scenic condition and requires that federal agencies consider the effects of their actions on those qualities of a listed river for which it was designated, including the river's free-flowing condition, water quality, and outstanding resource values. There are no Wild and Scenic rivers or Wild and Scenic River Systems within Richmond County, NY, as designated by the U.S. Department of the Interior. The closest Wild and Scenic River is the Lower Delaware River, approximately 186,673 feet (35 miles) from the study area (see **Appendix A**, Figure 3). Therefore, the Proposed Actions will not impact wild and scenic rivers.
- **Coastal Barrier Resource Act of 1982 (16 USC 3501).** The Coastal Barrier Resource Act (CBRA) of 1982 prohibits federally funded projects on designated relatively undeveloped coastal barriers along the Atlantic and Gulf coasts. No federally funded projects can occur in an area designated within the CBRA, with the exception of exempt activities (e.g., nature trails) which may be granted permission following consultation with USFWS. The Preferred Alternative is not within an area designated under the CBRA, and is not adjacent to any such area. The closest CBRA is Sayreville Unit NJ-15P (Panel 37-001A), located approximately 6,900 feet (1.3 miles) from the study area (see **Appendix A**, Figure 1). The next closes CBRA is Seidler Beach Unit NJ-02 located approximately 12,095 feet (2.3 miles) from the study area. Therefore, the Proposed Actions would not impact the CBRA systems and is in compliance with CBRA.
- **Safe Drinking Water Act of 1974 (42 USC 300 et seq).** The Sole Source Aquifer (SSA) Protection Program is authorized by Section 1424(e) of the Safe Drinking Water Act of 1974 (Public Law 93-523, 42 U.S.C. 300 et. seq), which states that no commitment for federal financial assistance may be entered into for any project that may contaminate an area that has been determined to be a sole source aquifer and would create a significant hazard to public health. Such assistance may be used to plan or design the project to ensure that it will not contaminate the aquifer. The Environmental Protection Agency (EPA) defines a sole source aquifer as "one which supplies at least 50 percent of the drinking water consumed in the area overlying the aquifer." USEPA also stipulates that these areas can have no alternative drinking water source(s) that could physically, legally, and economically supply all those who depend upon the aquifer for drinking water. The closest SSA is the NJ Coastal Plain SSA located approximately 948 feet from the study area (see **Appendix A**, Figure 2). Therefore, the Proposed Actions would not impact a SSA and is in compliance with the Safe Drinking Water Act.

9.2.2 STATE

- **Protection of Waters, Article 15, Title 5, New York Environmental Conservation Law (ECL), Implementing Regulations 6, New York City Codes, Rules and Regulations (NYCRR) Part 608.** NYSDEC is responsible for administering the Protection of Waters Act and regulations to govern activities on surface waters (rivers, streams, lakes, and ponds). The Protection of Waters Permit Program regulates five different categories of activities: disturbance of stream beds or banks of a protected stream or other watercourse; construction, reconstruction, or repair of dams and other impoundment structures; construction, reconstruction, or expansion of docking and mooring facilities; excavation or placement of fill in navigable waters and their adjacent and contiguous wetlands; and Water Quality Certification for placing fill or other activities that result in a discharge to waters of the United States in accordance with Section 401 of the Clean Water Act.

- **State Pollutant Discharge Elimination System (SPDES) (ECL Article 3, Title 3; Article 15; Article 17, Titles 3, 5, 7, 8; Article 21; Article 70, Title 1; Article 71, Title 19; Implementing Regulations 6 NYCRR Articles 2, 3).** Title 8 of Article 17, ECL, Water Pollution Control, authorized the creation of SPDES to regulate discharges to New York State's waters pursuant to a delegation by U.S. Environmental Protection Agency (USEPA) to New York State of permitting authority pursuant to the Clean Water Act. Activities requiring a SPDES permit include point source discharges of wastewater into surface or groundwater of the state, constructing or operating a disposal system (sewage treatment plant), discharge of stormwater, and construction activities that disturb one or more acres.
- **Tidal Wetlands Act, Article 25, ECL, Implementing Regulations 6 NYCRR Part 661.** Tidal wetlands regulations apply anywhere tidal inundation occurs on a daily, monthly, or intermittent basis. In New York, tidal wetlands occur along the tidal waters of the Hudson River up to the salt line and along the saltwater shore, bays, inlets, canals, and estuaries of Long Island, New York City, and Westchester County. NYSDEC administers the tidal wetlands regulatory program and the mapping of the state's tidal wetlands. A permit is required for almost any activity that would alter wetlands or the adjacent areas (up to 300 feet inland from wetland boundary or up to 150 feet inland within New York City).
- **Freshwater Wetlands Act, Article 24, ECL, Implementing Regulations 6 NYCRR Part 663.** The Freshwater Wetlands Act requires NYSDEC to map freshwater wetlands protected by the Act (12.4 acres or greater in size or of "unusual local importance" containing wetland vegetation characteristic of freshwater wetlands as specified in the Act). Around each mapped wetland is a protected 100-foot adjacent area that serves as a buffer. In accordance with the Act, the NYSDEC ranks wetlands in one of four classes that range from Class I, which represents the greatest benefits and is the most restrictive, to Class IV. The permit requirements are more stringent for a Class I wetland than for a Class IV wetland. Certain activities (e.g., normal agricultural activities, fishing, hunting, hiking, swimming, camping or picnicking, routine maintenance of structures and lawns, and selective cutting of trees and harvesting fuel wood) are exempt from regulation. Activities that could have negative impact on wetlands are regulated and require a permit if conducted in a protected wetland or its adjacent area.
- **Endangered and Threatened Species of Fish and Wildlife; Species of Special Concern (ECL, Sections 11-0535[1]-[2], 11-0536[2], [4], Implementing Regulations 6 NYCRR Part 182).** The Endangered and Threatened Species of Fish and Wildlife, Species of Special Concern Regulations prohibit the taking, import, transport, possession, or selling of any endangered or threatened species of fish or wildlife, or any hide, or other part of these species as listed in 6 NYCRR Part 182.6. Under these regulations, adverse modification of occupied habitat of endangered or threatened species is prohibited without authorization from NYSDEC.
- **Removal of Trees and Protected Plants (ECL, Section 9-1503).** Section 9-1503 of the ECL states that: "[n]o person shall, in any area designated by such list or lists, knowingly pick, pluck, sever, remove, damage by the application of herbicides or defoliants, or carry away without the consent of the owner thereof, any protected plant."
- **Solid Waste Management Facilities, General Provisions, Beneficial Use 6 NYCRR Part 360-1.15.** A beneficial use determination (BUD) is a designation made by NYSDEC as to whether Part 360 Solid Waste Management Facilities regulations have jurisdiction over waste material that is to be beneficially used. Any proposed reuse of solid waste that is not specifically identified in Part 360-1.15(b) can be petitioned for a case-specific BUD in

accordance with Part 316-1.15(d). A case-specific BUD petition requires a NYSDEC petition form and all information required by Part 360-1.15(d)(1), including a description of the solid waste under review and its proposed use, the chemical and physical characteristics of the solid waste, a demonstration that there is a market for the intended use of the solid waste, and a demonstration that the solid waste will not adversely affect human health and safety, the environment and natural resources. Upon a determination that the solid waste under review is approved for a given beneficial use, NYSDEC will determine at exactly which point before the intended use the material will no longer be regulated as a solid waste.

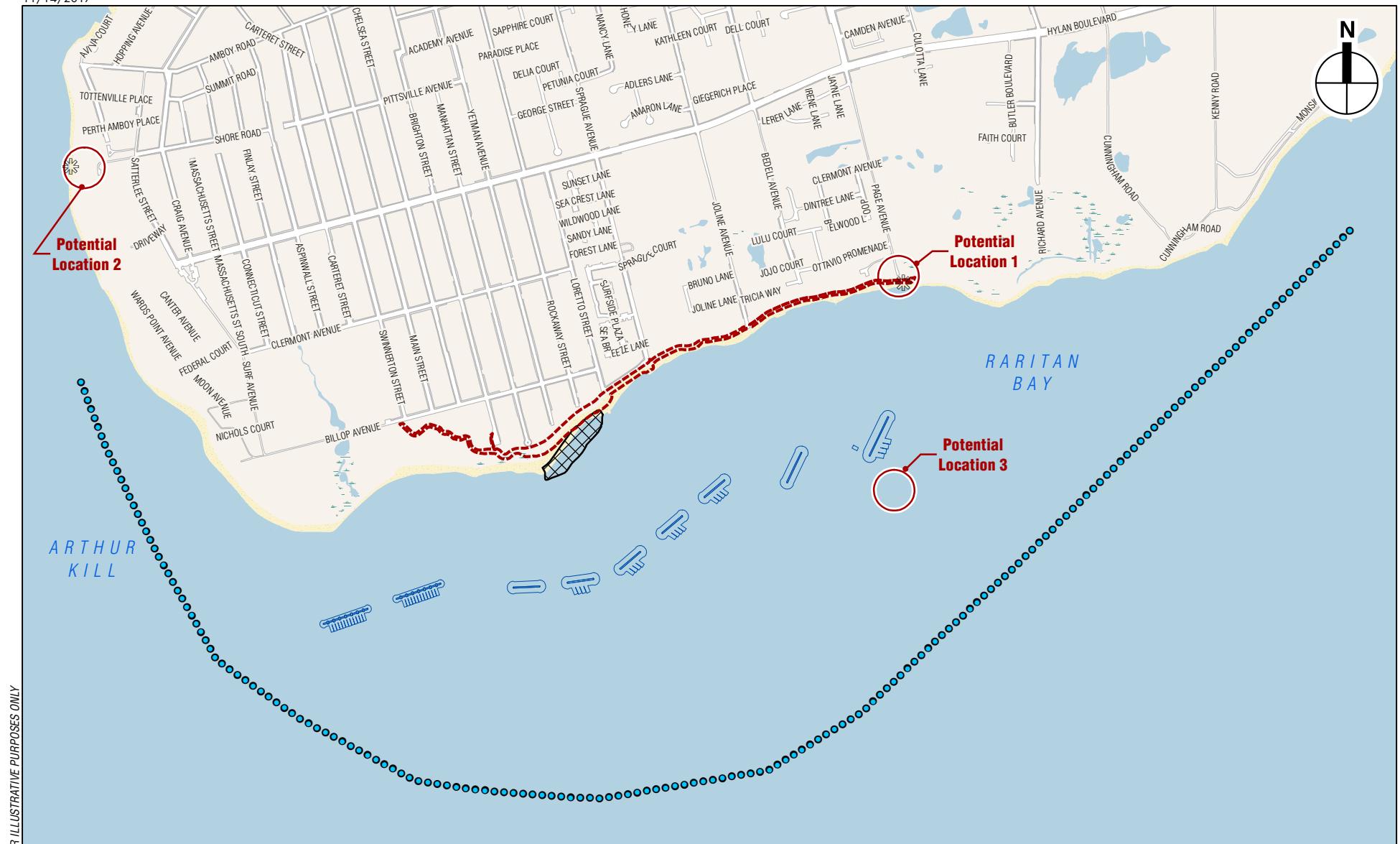
9.3 METHODOLOGY

9.3.1 STUDY AREA

The Proposed Actions would be undertaken in the Tottenville area of Staten Island, along the neighborhood's southern shoreline and nearshore waters within the waters of Raritan Bay. Tottenville is located at the southwestern tip of Staten Island, and is the southernmost neighborhood in New York City (see **Figure 9-1**). It is bounded by water on three sides, with the Arthur Kill to the west and north and Raritan Bay to the south.

The Breakwaters Project would comprise approximately 3,200 linear feet off the Tottenville shoreline of Staten Island (see **Figure 9-1**). With the exception of a small portion of the Shoreline Project proposed within an unbuilt portion of the New York City Department of Transportation (NYCDOT) Surf Avenue right-of-way, the Shoreline Project and the Water Hub component of the Breakwaters Project at Potential Location 1, would occupy the portion of the south shore of Staten Island within Conference House Park from approximately west of the intersection of Swinnerton Street and Billop Avenue to Page Avenue. The Water Hub at Potential Location 2 would occupy the north-western portion of Conference House Park between approximately Hylan Boulevard and Shore Road. The Proposed Actions would be tailored to the changing character of the shoreline along these stretches (see **Figure 9-1**). The proposed Water Hub at Potential Location 1 would be located near the waterfront at one of two possible locations at the terminus of Page Avenue and would comprise onshore and near-shore elements including a building, parking area, seasonal boat launch and landscape elements. It would provide a place for access to the waterfront and water, orientation, education, information on the Living Breakwaters and coastal resiliency and the ecology of the Raritan Bay / Lower Harbor, gathering space and, if located on-shore, equipment storage. Similar to Potential Location 1, Potential Location 2 would include access to the water. This access would be provided in the area of one of two existing NYC Parks structures within Conference House Park, the Henry Hogg Biddle House (Biddle House) or the Rutan-Beckett House, which would be adaptively reused for Water Hub activities. If sited at Potential Location 2, water access would be provided with Americans with Disabilities Act (ADA) accessible pathways and ramps from the grounds of the house to the beach in the vicinity of a seasonally deployed temporary floating boat launch. The proposed Water Hub at Potential Location 3 would include a vessel that would periodically visit the project area. Should Water Hub programming be located at Potential Locations 2 or 3, wayfinding, interpretive signage and monitoring elements would be located along the length of the shoreline. Potential Locations 2 and 3 would also include storage for kayaks near the terminus of Page Avenue. Water Hub programming at all Potential Locations would engage students in waterfront education, water and shoreline monitoring, and would cultivate long-term estuary stewardship. The Water Hub programs are intended to educate residents on the risks and benefits of living in the coastal environment as well as estuary ecology and build coastal hazard awareness and preparedness within the community.

11/14/2017



Coastal and Social Resiliency Initiatives for Tottenville Shoreline

Potential Location
Figure 9-1

Proposed Floating Dock (associated with
Water Hub Potential Locations 1 and 2 only)

Potential Water Access

Aquatic Resources Study Area (Outer Boundary)

Proposed Breakwater Features

Proposed Shoreline
Restoration Area

Proposed Shoreline Project Elements

Potential Location of Proposed Water Hub
(exact location to be determined)

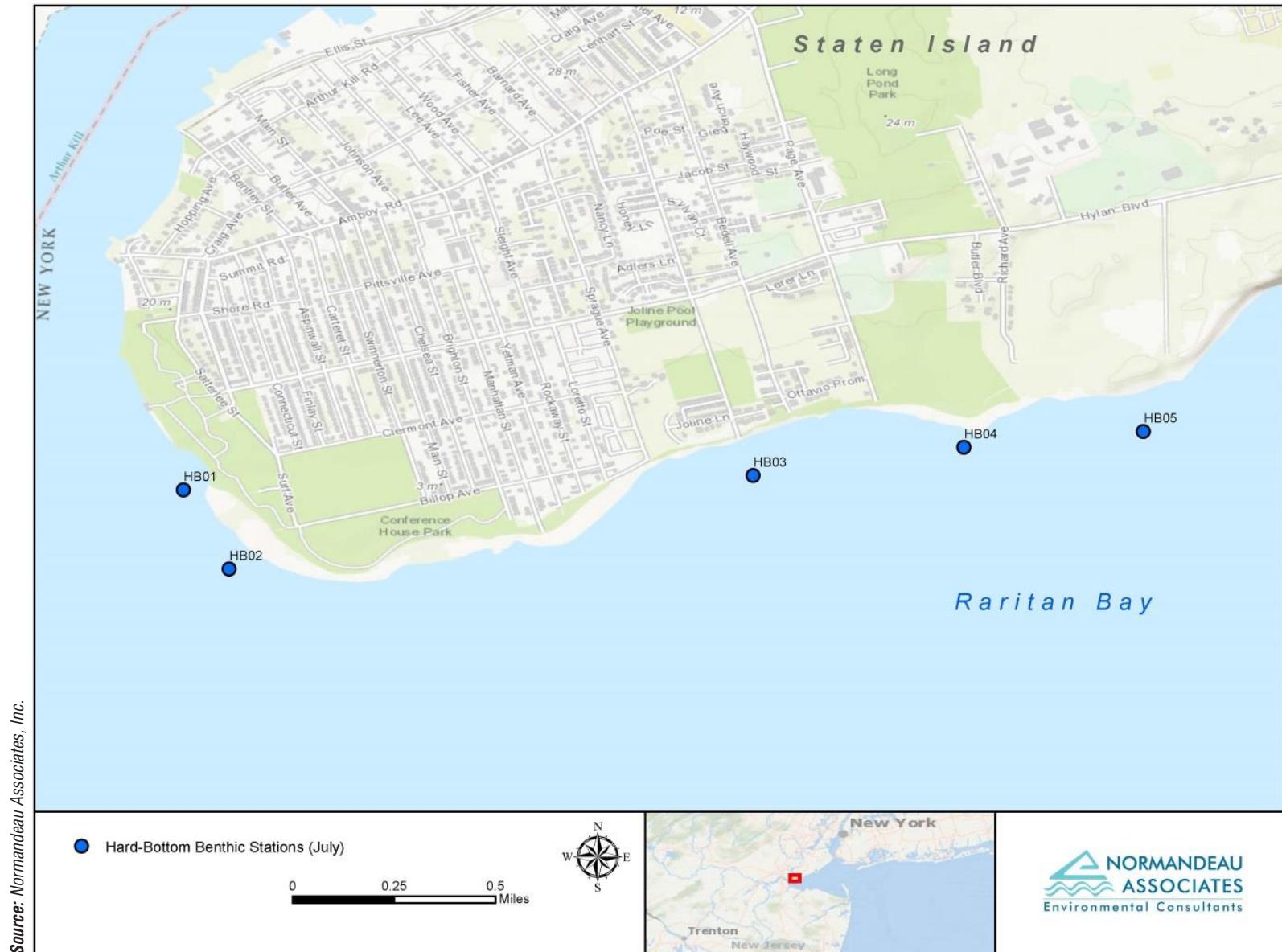
For the purposes of this assessment, the study area for aquatic resources consists of the portion of Raritan Bay from the edge of the navigation channel to the southern Staten Island shoreline and adjacent to the outboard side of the proposed breakwater structures. The study area for all other natural resources comprises the footprint area of the Shoreline Project, the shoreline restoration, the Water Hub Potential Locations 1 and 2 (see **Figure 9-1**), and the area adjacent to these project elements, as well as any areas on land within Conference House Park with the potential to be used as temporary access and/or staging areas during construction.

9.3.2 EXISTING CONDITIONS

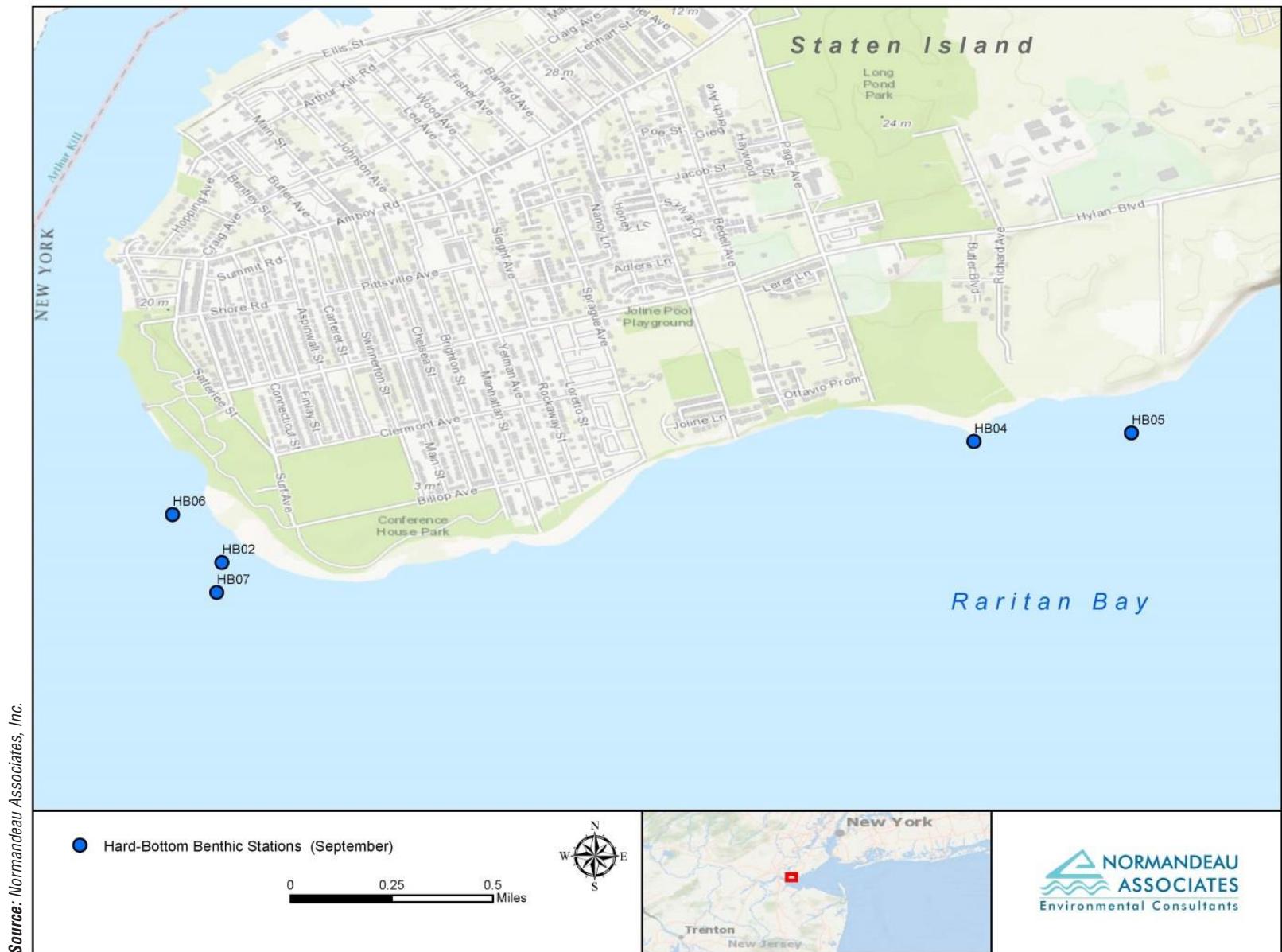
Existing conditions for natural resources within the study area were summarized using information from published literature and internet sources (as cited within), and the following databases, terrestrial reconnaissance, and aquatic sampling as summarized in **Table 9-1**:

- USFWS National Wetland Inventory (NWI) maps and Information for Planning and Conservation System (IPaC) list of federally endangered, threatened, proposed, and candidate species in Richmond County.
- NYSDEC wetlands maps, 2000–2005 Breeding Bird Atlas results for Block 5548D, and Herp Atlas Project results for the Arthur Kill Quadrangle.
- New York State Department of State (NYSDOS) Significant Coastal Fish and Wildlife maps.
- Responses to requests for information on rare, threatened, and endangered species and special habitats within the vicinity of the study area made to the NYNHP and NMFS (see **Appendix E-2**).
- NMFS EFH information (<http://www.greateratlantic.fisheries.noaa.gov/hcd/webintro.html>).
- New York City Department of Environmental Protection (NYCDEP) Harbor Water Quality Survey reports.
- Observations made during reconnaissance of terrestrial vegetation on May 26, 2015, and September 1, 2015, and terrestrial wildlife on May 18 and June 9, 2015, within the study area.
- Results of four aquatic sampling programs conducted within the study area by Normandeau Associates, Inc. (Normandeau) in 2015 comprising fish, benthic macroinvertebrates, hard-bottom benthic communities, clam tissue, water quality, sediment quality, and sediment characteristics, and results of two aquatic sampling programs conducted by Normandeau in 2017, as listed in **Table 9-1**. **Appendix E-3** summarizes the aquatic sampling program. **Figures 9-2a and 9-2b** indicate the hard bottom sampling locations. **Figures 9-3a through 9-3d** indicate the benthic macroinvertebrate, sediment sampling for physical characteristics and water quality sampling locations. **Figure 9-4** indicates the clam tissue and sediment quality sampling locations. **Figures 9-6a through 9-6f** indicate the fish sampling locations. **Appendix E-4** contains the aquatic sampling reports and data.
- Results of a horseshoe crab egg survey conducted within and near the location of the proposed dune on June 9, 2015, and June 7 and 10, 2017 (see **Figure 9-5**) as described in **Appendix E-3**.

1.25.17

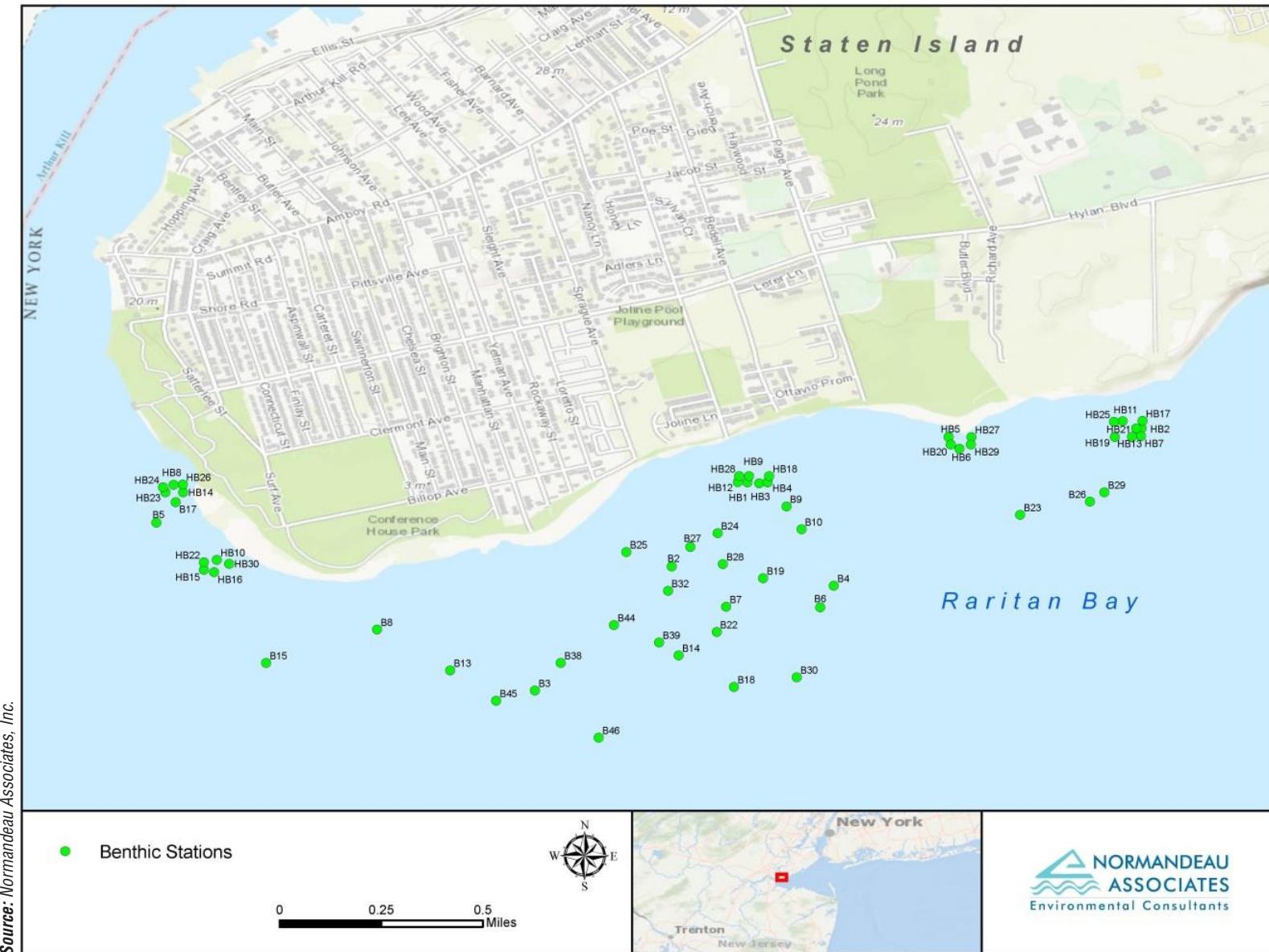


1.25.17



Hard Bottom Sampling Locations
September 2015

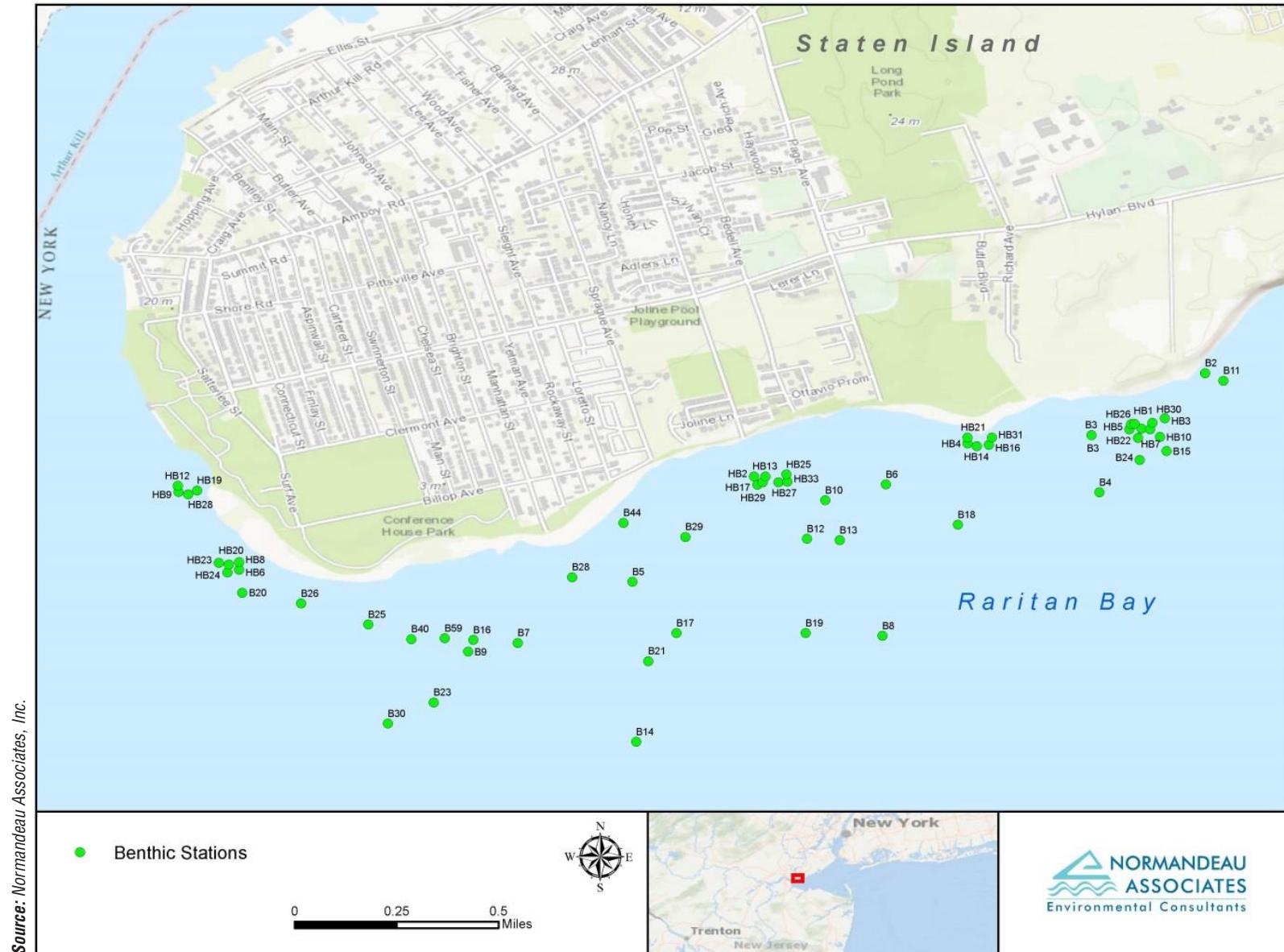
12.12.17



Location of Benthic and Water Quality Sampling Stations

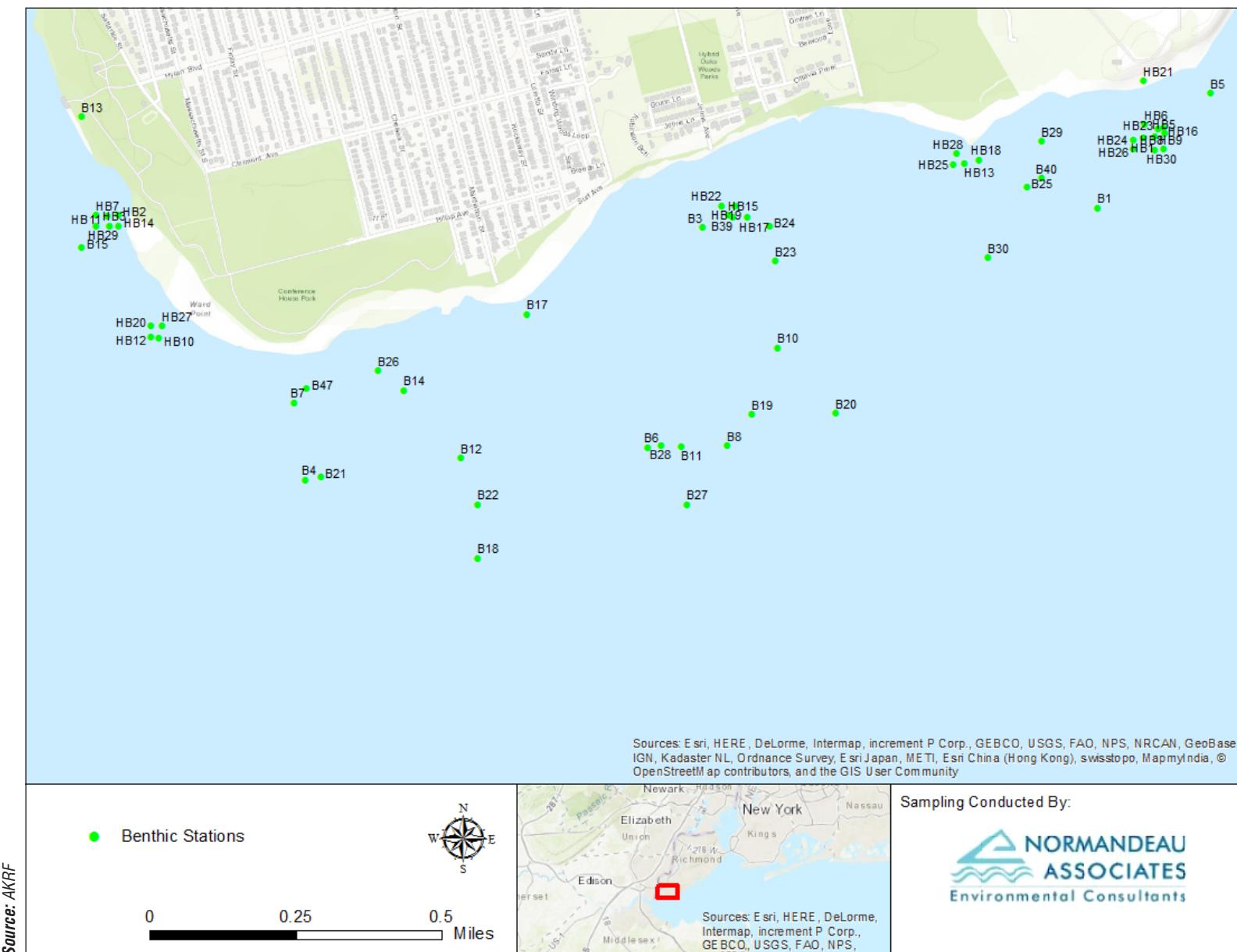
June 2015

12.12.17

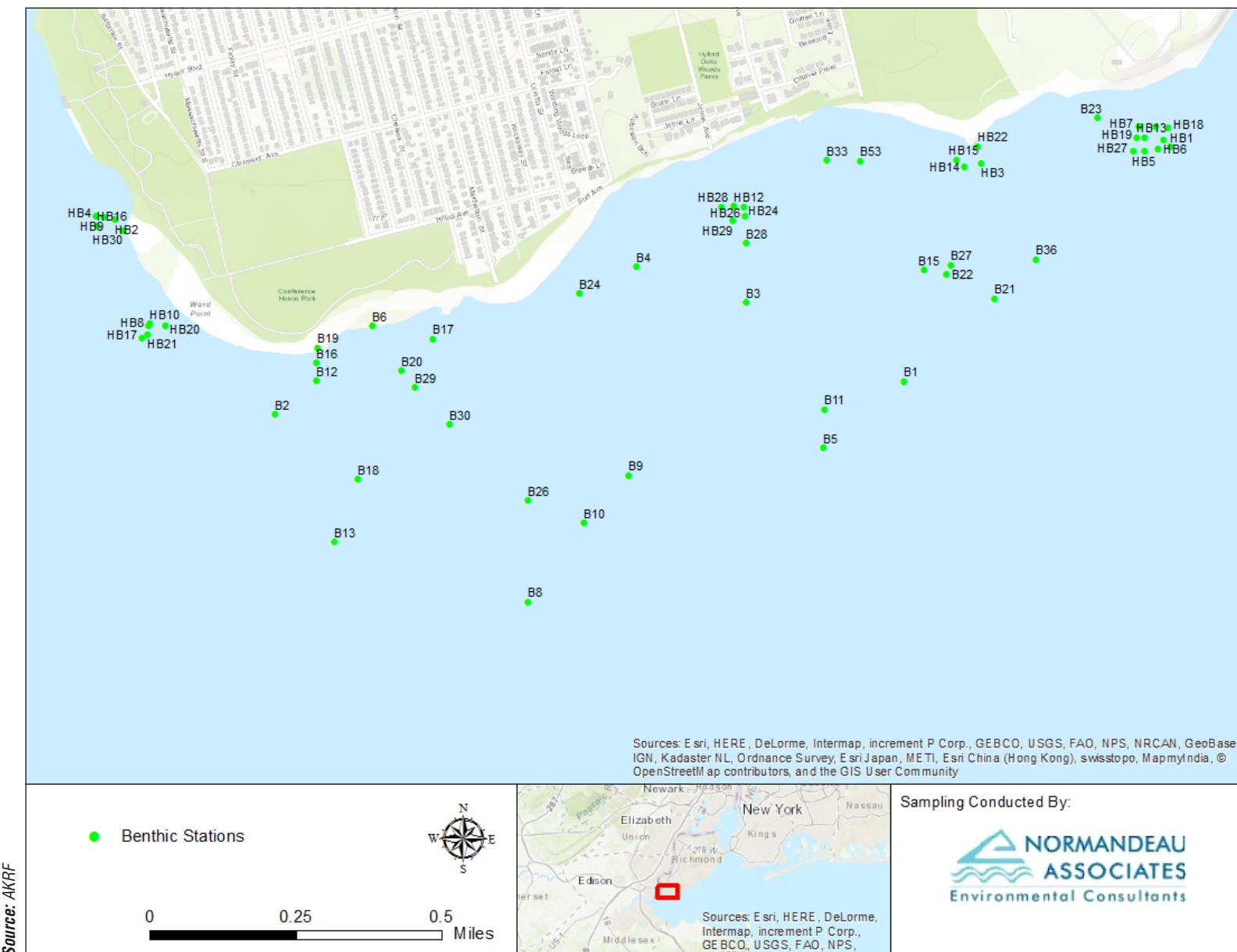


Location of Benthic and Water Quality Sampling Stations
September 2015

12.12.17

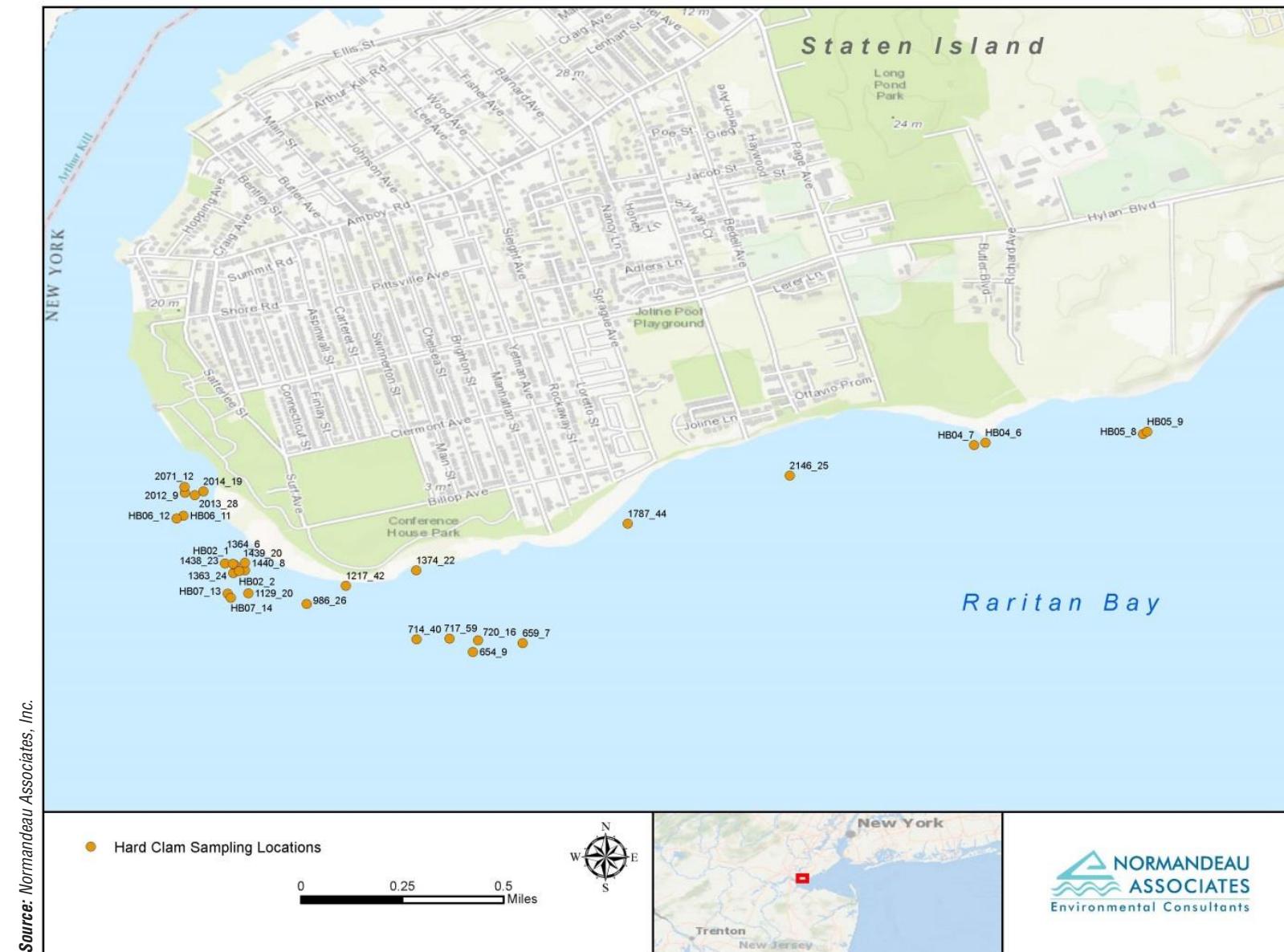


12.12.17



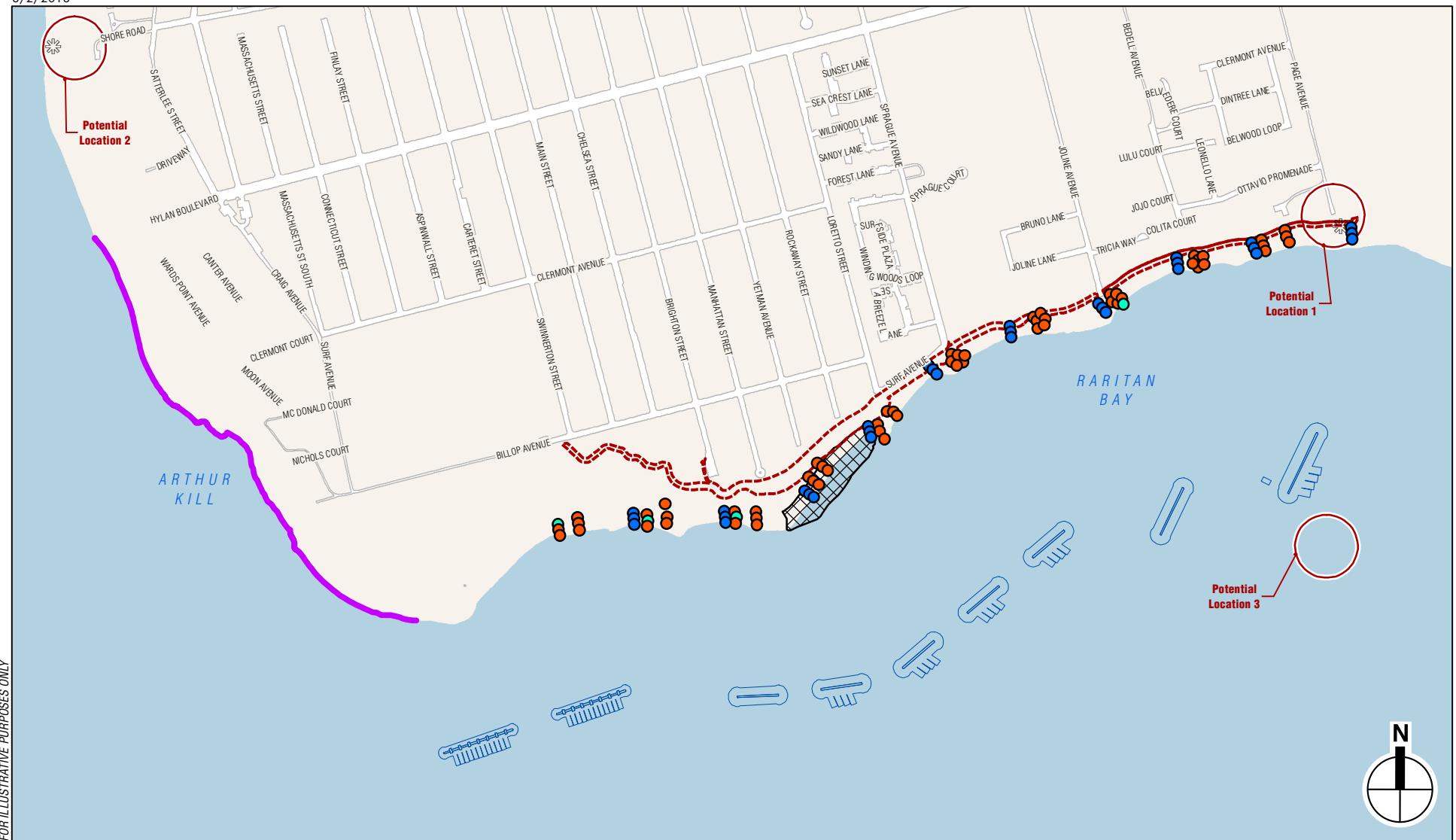
Location of Benthic and Water Quality Sampling Stations
September 2017

1.25.17



Location of Hard Clam and Sediment Sampling Stations
September 2015

3/2/2018



Proposed Breakwater Features

Proposed Shoreline Restoration Area

Proposed Floating Dock (associated with Water Hub Potential Locations 1 and 2 only)

Proposed Shoring Project Elements

Potential Location of Proposed Water Hub
(exact location to be determined)

Potential Water Access

Sampling Locations (June 7 and June 10, 2017)

Eggs Found

No Eggs Found

Visual Survey of Spawning Pairs (June 7, 2017)

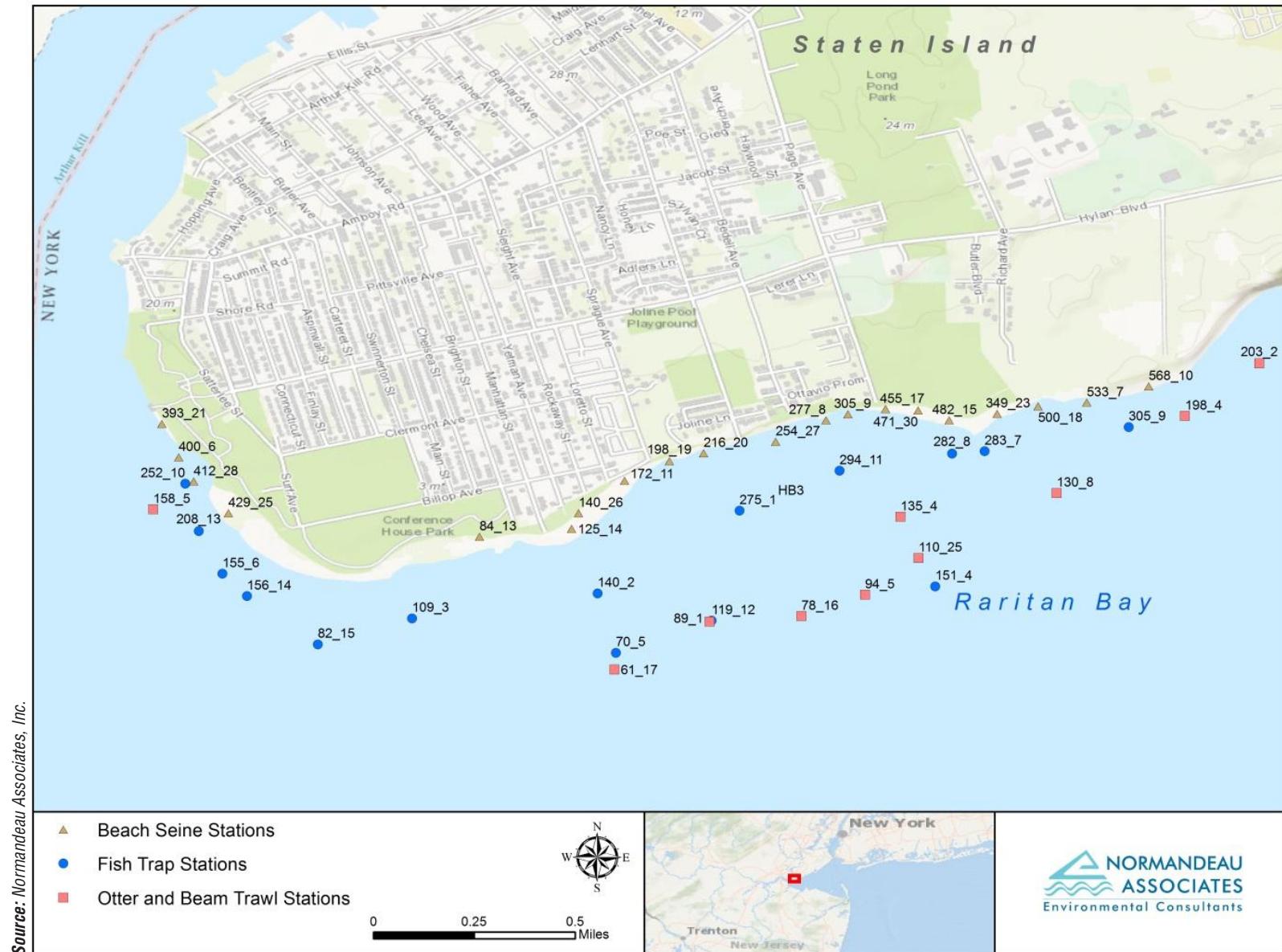
Sampling Locations (June 2015)

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Horseshoe Crab Survey
June 2015 and June 2017

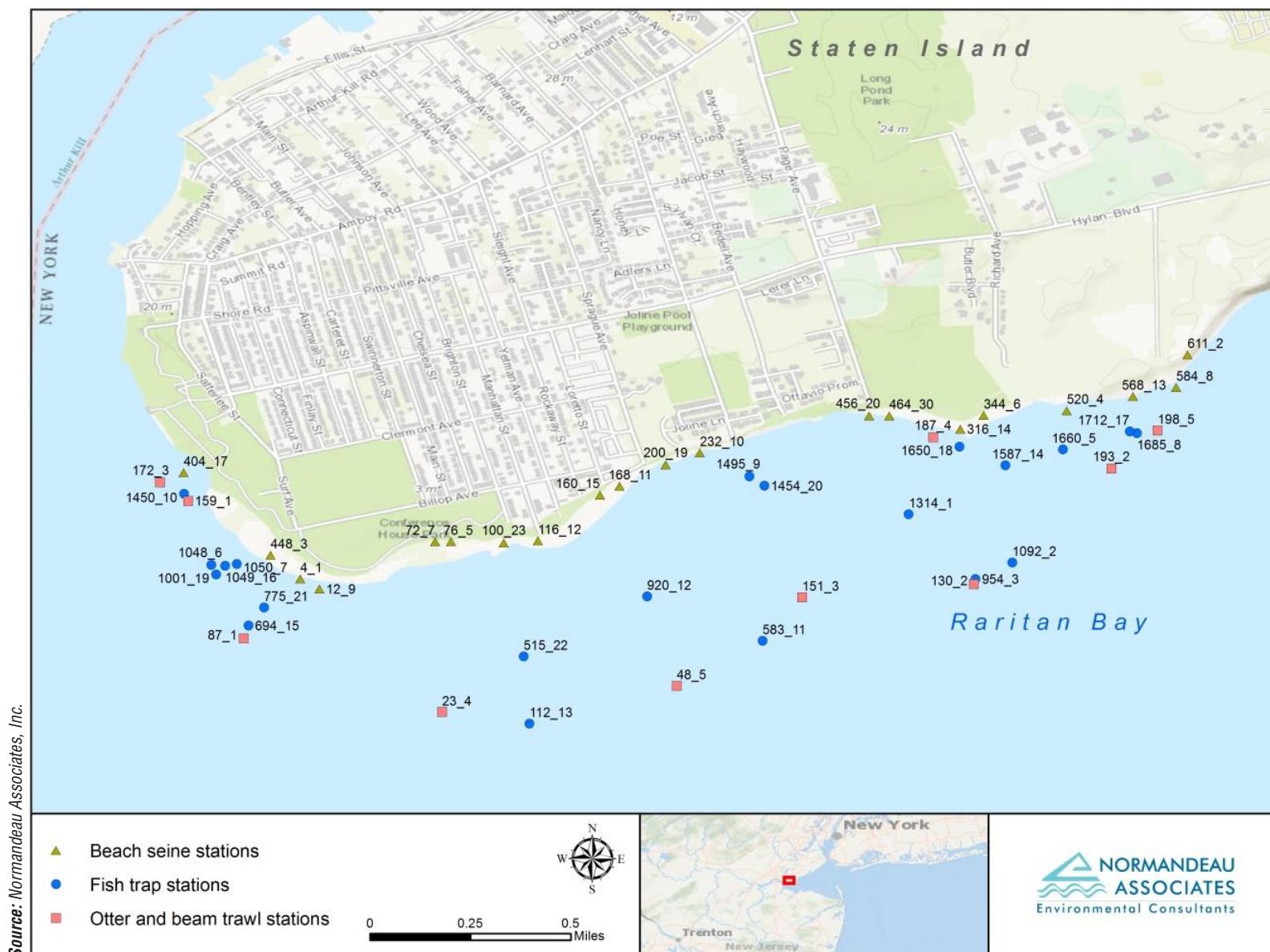
Figure 9-5

12.12.17



Location of Fish Sampling Stations
June 2015

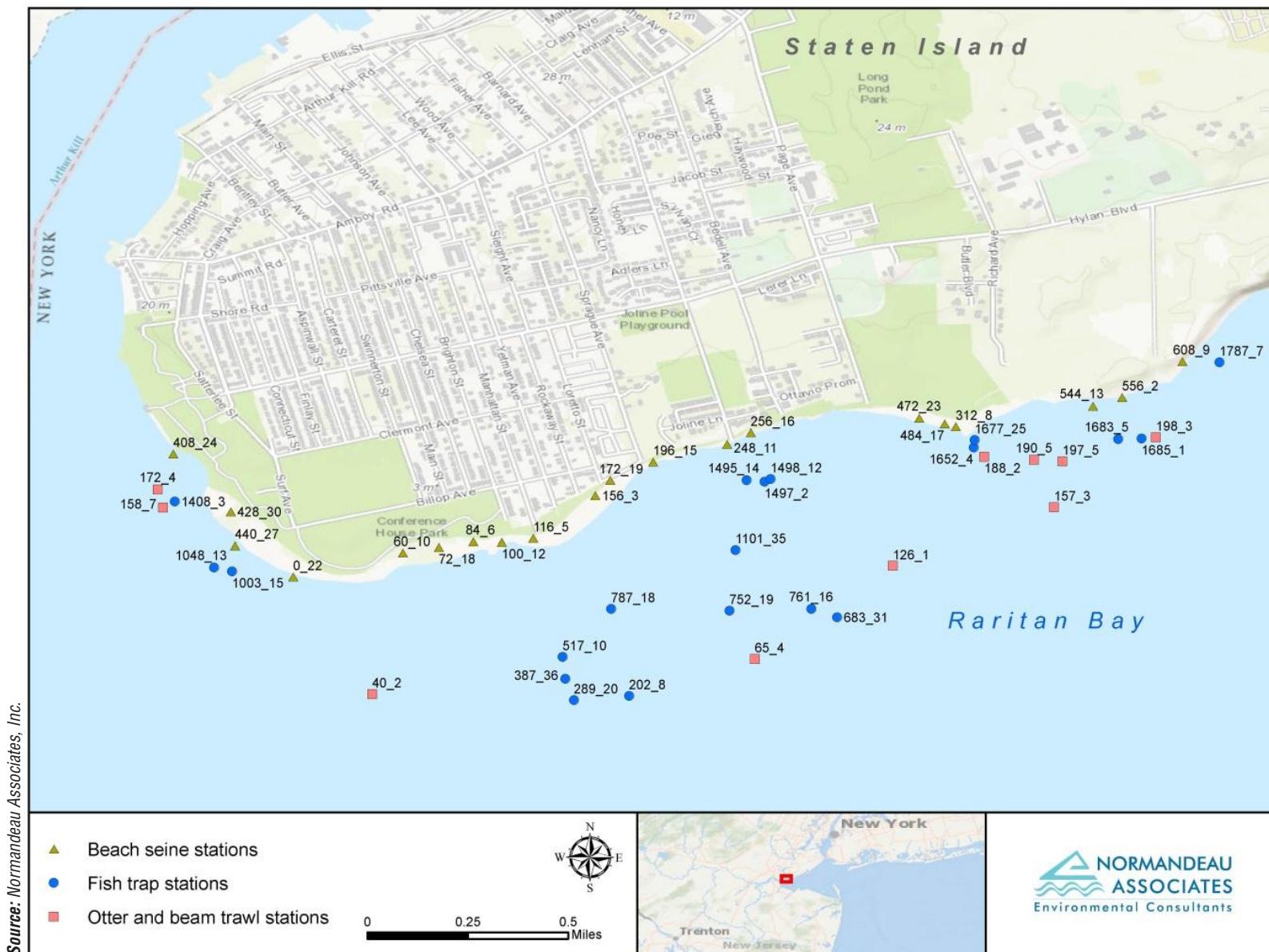
12.12.17



Location of Fish Sampling Stations
July 2015

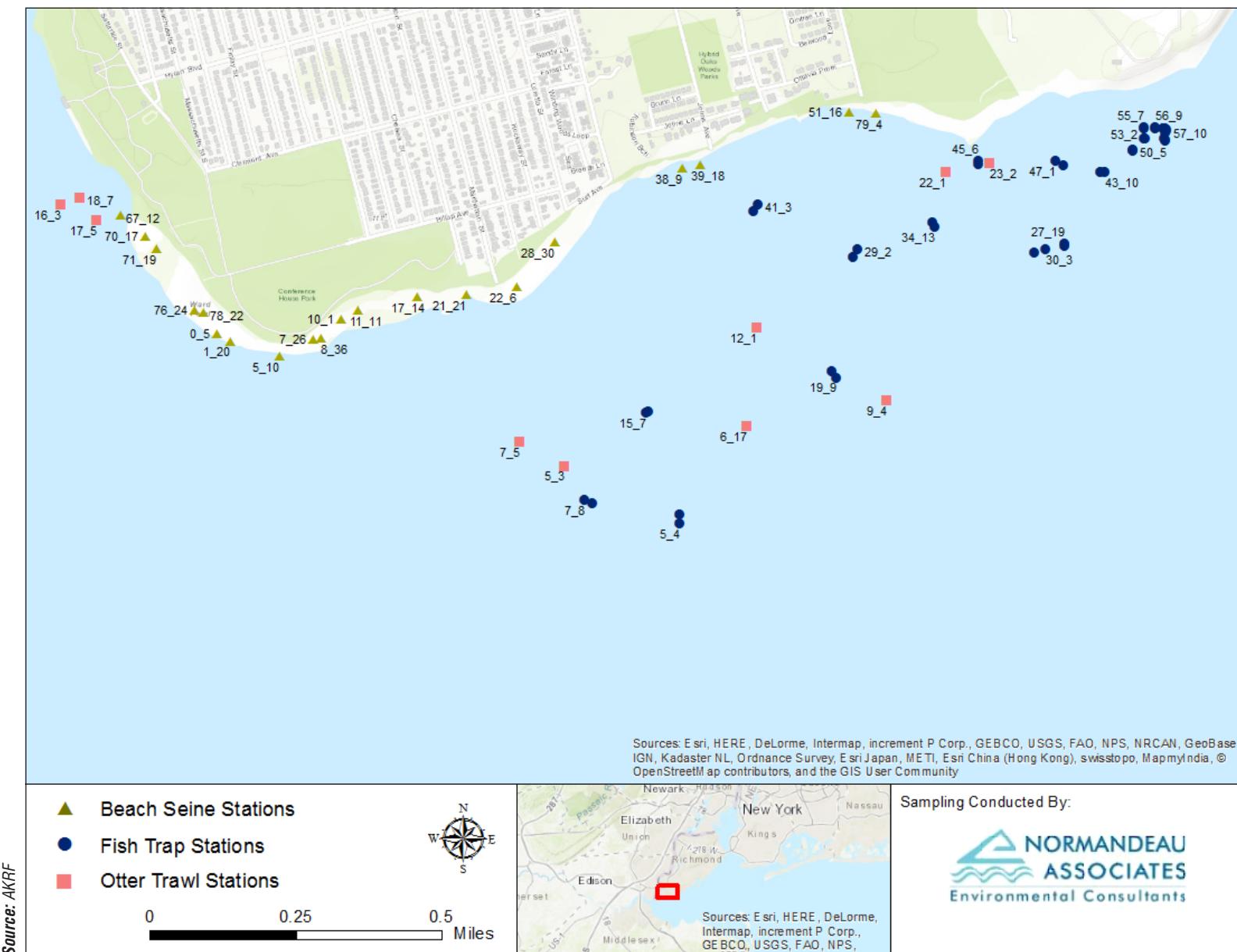
Figure 9-6b

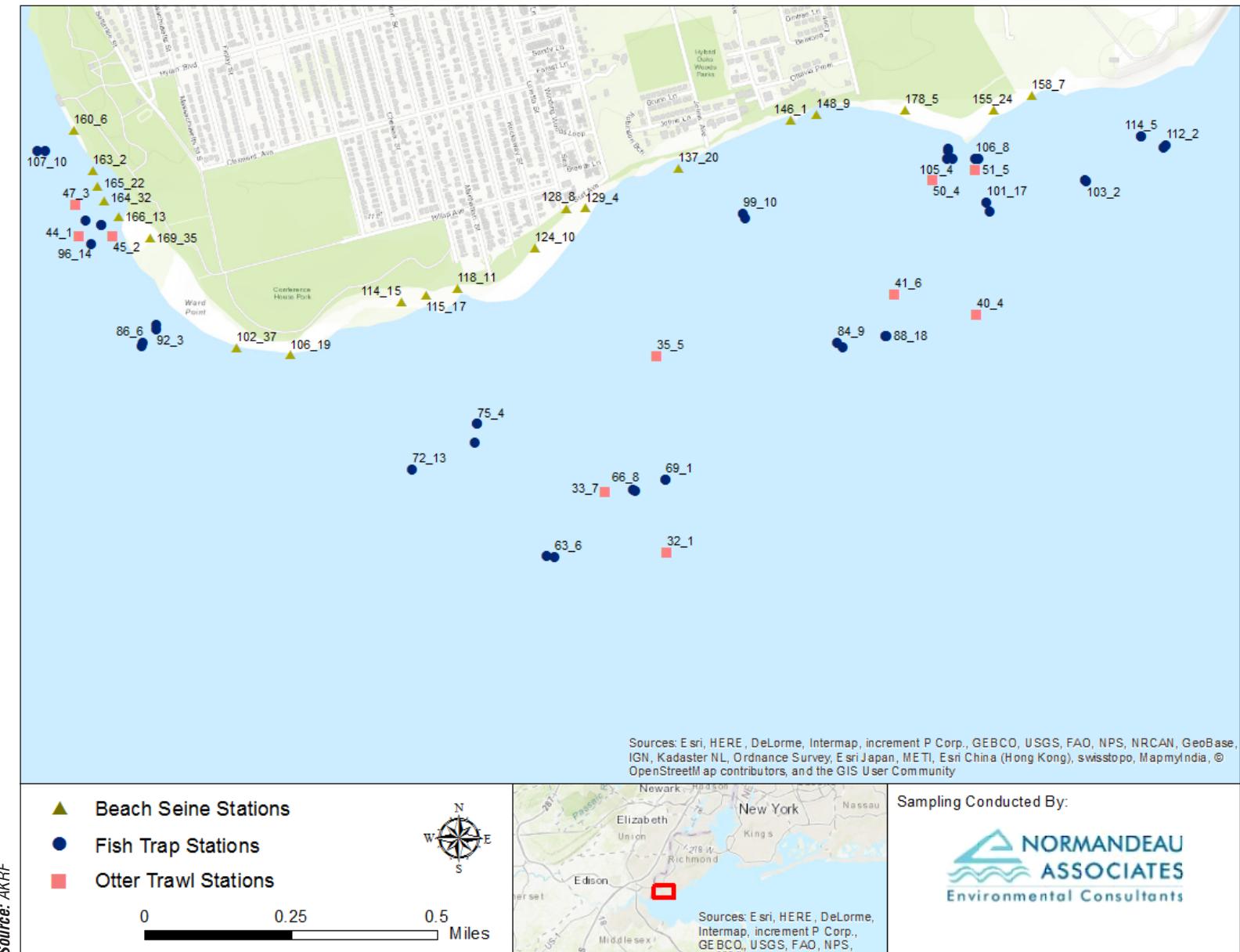
12.12.17



Location of Fish Sampling Stations
September 2015

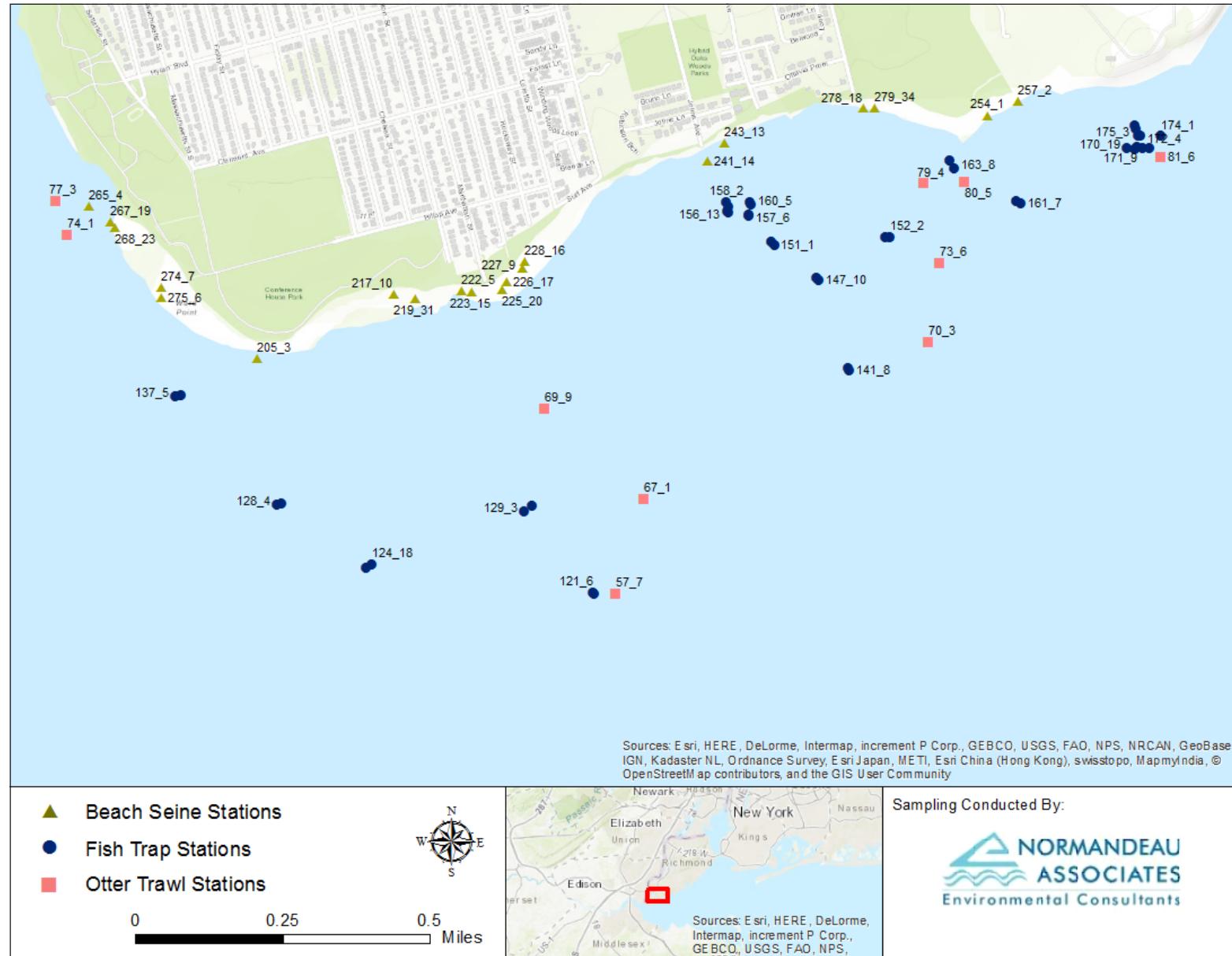
12.12.17





Location of Fish Sampling Stations July 2017

Figure 9-6e



Location of Fish Sampling Stations September 2017

Table 9-1
Sampling Programs and Associated Parameters

Benthic macroinvertebrates —Sampled June and September 2015, 2017
Benthic macrofauna count and identification
Hard Clams September 2015
Hard clams – wet-weight total mass
Hard clams – total dry weight
Clam tissue —Sampled September 2015
Dioxins/furans
Metals (Al, Sb, As, Ba, Be, Cd, Ca, Cr, Co, Cu, Fe, Pb, Mg, Mn, Hg, Ni, Ph, K, Ag, Na, Sr, Sn, Ti, V, Zn)
PAHs
PCBs
Pesticides
Lipids
Organic chlorides, per 6 NYCRR Part 375-6.8(b)
SVOCs
Sediment chemistry —Sampled June and September 2015
Metals at 6 NYCRR Part 375-6.8(b) (As, Ba, Be, Cd, Cu, Pb, Mn, Ni, Se, Ag, Zn, Cr)
Mercury
Cyanide
2,4,5-TP (Silvex)
Pesticides
PCBs
SVOCs
VOCs NY low-level
Sediment characteristics —Sampled May, June, and September 2015; June and September 2017
Grain size
Total organic carbon
Water quality —Sampled June and September 2015
Temperature (surface and bottom)
Dissolved oxygen (surface and bottom)
pH (surface and bottom)
Salinity (surface and bottom)
Secchi depth
Fecal coliform (surface)
Total nitrogen (surface)
Nitrate/Nitrite
Total Kjeldahl nitrogen
Fish (Identification, count, and measurement)
Beam trawl—Sampled June, July, and September 2015
Otter trawl—Sampled June; July; and September 2015; 2017
Trap—Sampled June, July, and September 2015, 2017
Seine—Sampled June, July, and September 2015, 2017
Hard bottom —Sampled July and September 2015
Algal biomass
Invertebrate population density
Percent cover for macroalgae
Percent cover for epibenthic macroinvertebrates
Video footage for interpretation

- Results of a field sampling program by SeArc Ecological Marine Consulting, Inc., comprising a survey of “adjacent artificial habitats” by sampling the fouling communities inhabiting artificial substrates within the study area (see **Appendix E-5**).
- Delineation of an unmapped wetland in the study area conducted on August 10, 2016, (see **Appendix E-8**).

BENTHIC AND FISH COMMUNITY ANALYSIS

Benthic Macroinvertebrate Community Analysis

The benthic community data were analyzed to compare similarity in species composition and abundance among sample months and benthic habitat type. Data were analyzed using the PRIMER community analysis software to compare similarity in species composition and abundance among sample months. Raw abundance data were square-root transformed to reduce the influence of abundant species on the comparison among samples. Transformed data were then used to create a matrix of Bray-Curtis similarity values. The resulting matrix was used to conduct a series of Analysis of Similarity (ANOSIM) tests to test the null hypothesis of no difference in benthic-community structure among months and among habitat types. ANOSIM is essentially the non-parametric equivalent of Analysis of Variance (ANOVA) and is commonly applied in the scientific literature to address similar ecological questions regarding faunal and floral communities. Habitat type was classified as mud, sand, or gravel based on field observations made during the collection of each sample. The Similarity Percentage (SIMPER) procedure was used to identify those benthic invertebrate taxa that were most characteristic of each sampling month and habitat type and which accounted for the dissimilarity among month and habitat type.

Fish Community Analysis

The same analytical approach described above for the analysis of the benthic macroinvertebrate community was applied to the fish community. Bray-Curtis similarities of square-root transformed fish data were used to conduct a series of ANOSIM tests to test the null hypothesis of no difference in fish-community structure among months. The SIMPER procedure was used to identify those fish species that were most characteristic of each sampling month and accounted for the dissimilarity among months.

9.3.3 THE FUTURE WITHOUT THE PROPOSED ACTIONS

The anticipated condition of natural resources within the study area in the future, without the Proposed Actions, was determined primarily by considering ongoing and planned restoration and land acquisition projects of the Hudson-Raritan Estuary Comprehensive Restoration Plan (HRE-CRP) in Raritan Bay and nearby portions of the bay’s Staten Island and New Jersey shorelines. The HRE-CRP was completed in 2009 by the USACE in partnership with the Port Authority of New York and New Jersey and the New York-New Jersey Harbor Estuary Program, and aims to achieve eleven “Target Ecosystem Characteristics” of a successfully restored and healthy estuary. The HRE-CRP identified 296 sites for potential acquisition and/or restoration, and set measurable objectives for 2015 and 2050. Some of these sites are within or along Raritan Bay, and ongoing or planned HRE-CRP projects at these sites were evaluated for their potential to benefit natural resources within the study area and the bay as a whole. Implementation of the USACE South Shore of Staten Island Coastal Storm Risk Management Project, with construction currently estimated to begin early 2019, was also considered in evaluating natural resources in the future without the Proposed Actions.

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Other city-wide initiatives that have the potential to affect natural resources in the study area in the future without the Proposed Actions were also considered, including Vision 2020, Green Infrastructure Plan, PlaNYC, and OneNYC. The MillionTreesNYC initiative of PlaNYC has included ongoing reforestation of treeless areas of Conference House Park, NYC Parks invasive plant species removal efforts at Conference House Park,s, and restoration of maritime forest within the park.

9.3.4 EFFECTS ASSESSMENT

This section of the chapter examines potential impacts on natural resources that include short-term construction-related effects and long-term effects due to the operation of the Proposed Actions in the build year, 2020, by which time the full build-out associated with the Proposed Actions are expected to be complete. Potential impacts are examined under three alternatives:

- Alternative 2: the Layered Strategy, or the Preferred Alternative,
- Alternative 3: the Breakwaters Project without the Shoreline Project, and
- Alternative 4: the Shoreline Project without the Breakwaters Project.

These potential effects include: (1) short-term upland and in-water construction effects, such as temporary increases in suspended sediment during construction of the Breakwaters and Shoreline projects, noise and other construction-related disturbances to terrestrial and aquatic organisms (e.g., vessel movement, upland construction vehicles, construction worker activity), (2) permanent loss of beach and other upland habitat types within the footprint of the Shoreline Project and the potential effects on terrestrial biota, (3) changes in stormwater runoff and vegetation composition in areas landward and waterward of the Shoreline Project, (4) temporary loss of fish habitat until the breakwater structures are established and colonized, (5) loss of benthic invertebrates within the footprint of the breakwater, (6) long-term effects to areas of the bay on either side of the breakwater, such as changes in water circulation, water quality, sediment transport, and erosion, (7) increased habitat diversity for benthic invertebrates, fish, and other aquatic biota resulting from the conversion of soft bottom habitat and the open water column habitat above it to ecologically enhanced complex rocky reef-like habitat, (8) benefits to coastal wildlife from the Shoreline Project, (9) water quality improvements that would result from the establishment of filter-feeding organisms on the breakwater, (10) loss of Waters of the U.S. and associated habitat that would no longer be available to aquatic organisms due to the portion of the breakwaters above MHW (3.6 acres), and (11) increase in beach habitat through the reduction or reversal of erosion, and through accretion over time as a result of the breakwaters.

WAVE, SHORELINE, AND WATER QUALITY MODELING

Appendix E-6 presents the results of modeling conducted to assess wave condition and shoreline response to the Proposed Actions and to determine the preferred layout of the breakwaters structures to reduce shoreline erosion and wave exposure (see **Appendix E-6**). As an initial step, a baseline wave climate of Raritan Bay was developed to determine historic wave conditions and as input to modeling used to predict breakwater impacts on wave climate and long-term shoreline change. The long-term wave climate was developed by transforming wave hindcast⁴ data from a USACE Wave Information Study station at the entrance of New York Harbor to the project region. In parallel, historical aerial imagery was used to determine how the shoreline has changed over time. Orthoimagery of the shoreline between 1978 and 2012 was used to develop historical

⁴ Retrospective forecasting of waves using measured wind and wave information.

shoreline positions and to calibrate the shoreline change model. Additionally, a hydrodynamic model of tidal circulation in the bay was developed. Using these baseline data, modeling was conducted to assess changes in the shoreline position, wave environment, and water circulation in response to the proposed breakwater system. A total of fifteen breakwater alignments were examined in the 30 percent design and a preferred design was chosen and analyzed in the Draft Environmental Impact Statement (DEIS).

Subsequent to the publication of the DEIS, during 60 percent design, additional modeling was undertaken to optimize the breakwater layout. These design modifications included increasing the spacing between the breakwaters in the central section which resulted in the elimination of one breakwater segment (six to five). Additionally, the eastern group of two breakwaters was modified by shortening both and moving one closer to shore. The resulting layout met the performance goals of shoreline retention and wave attenuation while minimizing breakwater footprint and volume. This layout with shoreline restoration is proposed as the preliminary 60 percent design scenario and is analysis as Part of Alternative 2, the Preferred Alternative in this Final Environmental Impact Statement (FEIS).

In order to determine potential impacts the Shoreline Project could have on long-term shoreline change in Tottenville, several modeling efforts were undertaken to determine future performance of the four main Proposed Actions elements: the earthen berm, hybrid dune/revetment, eco-revetments, and raised edge (revetment with trail). Using cross-shore transect data in the spring of 2016, the existing condition of the beach at each transect was modeled using the Storm Induced Beach Change Model (SBEACH), a USACE numerical model that simulates beach profile change by predicting beach, berm, and dune erosion caused by storm waves and water levels. The condition of the shoreline (overtopping, run-up, and scour) at each transect was simulated under 10, 25, 50, and 100-year return periods, and Superstorm Sandy. Each simulation included an assumed 30 inches of sea level rise. Additional models were used to simulate sediment settlement, slope stability, and drainage and seepage patters at each of the Shoreline Project components.

These modeling efforts were used to inform the design of the components of the Living Breakwaters Project, the Shoreline Project, collectively the “Layered Strategy,” that would increase the overall coastal resiliency of the Tottenville shoreline. The preferred layout of the breakwaters would attenuate wave energy and reduce shoreline erosion at the water’s edge, effectively holding, or in some locations increasing, beach width, while the Shoreline Project would provide some level of risk reduction from coastal flooding, and erosion protection, in areas landward of the earthen berm, hybrid dune/revetment, eco-revetments, and raised edge. The hybrid dune/revetment and eco-revetments would provide additional wave attenuation.

IMPACTS TO AQUATIC BIOTA—TARGET SPECIES RATIONALE

The design, construction, and operation of the Breakwaters Project would result in the creation of ecologically designed, three-dimensional structures that would increase the diversity of the aquatic habitats available for a variety of marine animals, plant and invertebrate species that provide or form habitat found in Raritan Bay (e.g., brown algae and local shellfish like mussels, barnacles, and oysters). As habitat forming species recruit and mature on the breakwater structures, the newly created matrix of physical and biogenic⁵ structures should facilitate recruitment and retention of resident and transient fishes, crabs, bivalves, small invertebrate, and plankton (e.g., Nestlerode

⁵ Biogenic—substance produced by life processes and may include constituents or secretions of plants or animals.

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2004; Burt et al. 2012; Firth et al. 2014; Perkol-Finkel and Sella 2014, 2015; Sella and Perkol-Finkel 2015).

Design considerations for the Breakwaters Project incorporate materials and methods that would facilitate the attraction of several functional species groups (i.e., target groups) by using a combination of materials and structures engineered to facilitate recruitment and retention of habitat forming species, careful consideration of breakwater design (e.g., number, slopes, orientation, reef-fingers, and reef streets), and placement of ecologically enhanced structural units. The key ecological relationships (e.g., predator-prey, competition, facilitation, recruitment) expected from reef-like habitat are more likely to occur on the Breakwaters Project than standard breakwaters because the design process considers the specific ecological needs of the local estuarine flora and fauna—particularly those of ecosystem engineers⁶ like oysters and other bivalves, polychaetes, and encrusting organisms (Bruno et al. 2003; Browne and Chapman 2011).

Because the newly created structured habitat is expected to accommodate numerous species of Raritan Bay fish, benthic invertebrates, plants, and plankton, metrics of habitat enhancement progress should consider the broad suite of species groups likely to use the breakwaters in terms of their representative ecological functions, as well as their social and economic values. Adopting this perspective lends to a more holistic view that considers enhancing ecosystem functions to an ecologically degraded region rather than pinning success on the presence of any single species that, for external factors unrelated to the Breakwaters Project, may not successfully colonize to the study area.

The target species groups discussed below and identified in **Table 9-2** reflect species that were found in the fish surveys conducted for the Breakwaters Project as well as the larger potential pool of species historically present in Raritan Bay. **Appendix E-7, Target Species Rationale**, provides a detailed discussion of the ecological roles and economic value of each species group, and aspects of the Breakwaters Project's design considerations that focus on the attraction and retention of these species groups (and their prey), as well as factors to consider when developing programs to monitor ecosystem enhancements.

⁶ Ecosystem engineer—species that affect the physical space in which other species live and their direct effects can last longer than the lifetime of the organism (Hastings et al. 2007).

Table 9-2
Target Species Group Descriptions

Target Species Groups	Ecological Roles and Societal Value	Representative Taxa	Existing Conditions	Essential Fish Habitat	Recreational or Commercial Value
Habitat-forming autotrophs	Primary producers; foraging/ refuge/nursery habitat; coastal protection	Red branching algae	Yes	-	-
		Red filamentous algae	Yes	-	-
		Green algae	Yes	-	-
		Brown algae	-	-	-
Bivalve habitat-forming sessile invertebrates	Refuge and substrate for primary producers, benthic and epibenthic invertebrates, and fish; filter-feeding (benthic-pelagic coupling); shoreline protection	Eastern oyster	-	-	Yes
		Blue mussel	Yes	-	Yes
		Hard clams	Yes	-	Yes
Non-bivalve habitat-forming sessile invertebrates	Forage; filtering (benthic-pelagic coupling; increased habitat rugosity)	Barnacles	Yes	-	-
		Bryozoans	Yes	-	-
		Tunicates	Yes	-	-
		Tubeworms	Yes	-	-
		Sponges	Yes	-	-
Cryptic fish	Forage for higher trophic-level fish, seabirds; eggs adhere to structure; use structure for refuge; wide range of prey from algae to plankton to crustaceans, mollusks, other benthic invertebrates	Gobies	<u>Yes</u>	-	-
		Blennies	-	-	-
		Rock gunnel	-	-	-
		Oyster toadfish	<u>Yes</u>	-	-
Structure oriented reef fish	Consume benthic invertebrates and fish near structured habitat; commercial and recreational fisheries	Tautog	Yes	-	-
		Black sea bass	Yes	Yes	Yes
Transient/pelagic forage fish	Forage for higher trophic-level fish, shorebirds; consume zooplankton and planktonic fish and macroinvertebrate larvae	Cunner	Yes	-	Yes
		Alewife/Blueback herring	<u>Yes</u>	-	Yes
		American sandlance	-	-	<u>Yes</u>
		American shad	-	-	Yes
		Atlantic herring	-	Yes	Yes
		Atlantic menhaden	Yes	-	Yes
		Atlantic silverside	Yes	-	-
		Atlantic tomcod	<u>Yes</u>	=	=
		Bay anchovy	Yes	-	-
		Inland silverside	-	-	-
		Mummichog	Yes	-	-
		Northern kingfish	<u>Yes</u>	=	=
		Rainbow smelt	-	-	-
		Sheepshead minnow	Yes	-	-
		Spot	Yes	-	Yes
		Sticklebacks	Yes	-	-
		Striped anchovy	-	-	-
		Striped killifish	<u>Yes</u>	=	=
Upper trophic level reef-transient fish	Predatory fish that feed on forage fish linked to or associated with (oyster) reef habitat; commercial and recreational fisheries	Tidewater silverside	-	-	-
		White mullet	<u>Yes</u>	=	=
		American eel	Yes	-	Yes
		Atlantic butterfish	<u>Yes</u>	Yes	Yes
		Atlantic cod	-	=	Yes
		Atlantic mackerel	-	Yes	Yes
		Atlantic striped bass	Yes	-	Yes
		Atlantic sturgeon	-	-	-
		Black drum	-	-	Yes
		Bluefish	Yes	Yes	Yes
		Crevalle Jack	<u>Yes</u>	-	Yes
		Hogchoker	<u>Yes</u>	-	-
		Monkfish	-	Yes	Yes
		Northern puffer	<u>Yes</u>	-	-

Table 9-2 (cont'd)
Target Species Group Descriptions

Target Species Groups	Ecological Roles and Societal Value	Representative Taxa	Existing Conditions	Essential Fish Habitat	Recreational or Commercial Value
Upper trophic level reef-transient fish	Predatory fish that feed on forage fish linked to or associated with (oyster) reef habitat; commercial and recreational fisheries	Weakfish	Yes	-	Yes
		White perch	Yes	-	Yes
		Windowpane	Yes	Yes	Yes
		Witch flounder	-	-	Yes
		Winter flounder	Yes	Yes	Yes
		Yellowtail flounder	-	-	Yes
Benthic macroinvertebrates	Consumers of small fish and epibenthic invertebrates; horseshoe crab eggs prey for shore birds; important prey and predators of estuarine systems	Blue crab	Yes	-	Yes
		Other crabs	Yes	-	-
		Horseshoe crab	Yes	-	Yes
		Knobbed whelk	-	-	Yes
		Lobsters	-	-	Yes

Notes: Species in **bold** denote taxa that were dominant in 2015 and/or 2017 fish and hard bottom surveys. Dominant taxa represented 5 percent or more of the total fish abundance collected in a gear during either year. In both years, the most abundant species collected were Atlantic silverside (39.1 percent in 2015 and 44.2 percent in 2017) and Atlantic menhaden (15.2 percent in 2015 and 27.2 percent in 2017). Dominant macroinvertebrate taxa in the 2015 hard bottom survey were *Amphibalanus improvisus* (barnacle, 44 percent) and nine species of polychaete worm (between 2 percent and 9 percent of all individuals); these ten taxa represented 83 percent of the hard bottom community by total abundance.

9.4 EXISTING CONDITIONS

The study area includes natural resources within a portion of Raritan Bay, and wetland and terrestrial resources on the southern shore of Staten Island, within Tottenville. Raritan Bay, off the southern and eastern shorelines of Staten Island, is a shallow estuary that contains significant habitat for shellfish and marine, estuarine, and anadromous fish. It supports multiple commercial fisheries and recreationally important fish species. The open waters of the bay provide important habitat for overwintering and staging waterfowl and marine mammals can occur in the area. However, Raritan Bay is an urban estuary, and the bay and its tributaries have been impacted by decades of continuous development and discharge of organic and inorganic pollutants that have degraded water and habitat quality, and have contaminated sediment. In turn, the overall richness and diversity of organisms occurring within the bay has been reduced relative to pre-industrial times (MacKenzie 1990).

The Tottenville shoreline of Staten Island contains large areas of natural open space comprising City- and State-owned areas such as Conference House Park, Hybrid Oak Woods Park and Mount Loretto Unique Area, including Butler Manor Woods (see **Figure 9-7**). These open spaces contain upland forest and estuarine and freshwater wetland systems that support numerous species of native plants and animals. The shoreline is fringed by a sand and cobble beach. A man-made temporary dune comprising sand filled barrier bags topped with sand installed following Superstorm Sandy provides temporary erosion control measures and coastal flood risk reduction between approximately Swinnerton Street and Sprague Avenue. Portions of this man-made dune have eroded, exposing the barrier bags.

The following sections characterize the existing natural resources within the study area for the Breakwaters and Shoreline projects.



FOR ILLUSTRATIVE PURPOSES ONLY

Proposed Breakwater Features

Proposed Shoreline Project Elements

Potential Water Access

Proposed Shoreline Restoration Area

Study Area

Potential Location of Proposed Water Hub
(exact location to be determined)

Proposed Floating Dock (associated with
Water Hub Potential Locations 1 and 2 only)

NYS Significant Natural Communities

NYC Significant Coastal Fish and Wildlife Habitat

NY State Forest

NYS Unique Area

0 2,000 FEET

9.4.1 GROUNDWATER

Fresh groundwater on Staten Island occurs in the unconsolidated sandy Upper Cretaceous and Upper Pleistocene deposits and the underlying Upper Proterozoic to Lower Jurassic bedrock. It occurs under both unconfined (i.e., water-table) and confined (i.e., artesian) conditions. It is surrounded by saline groundwater on all sides of the island and deep below. The principal source of fresh groundwater recharge is precipitation that percolates through pervious surfaces down to the water table. It then generally moves outward from the island's middle toward the Atlantic Ocean and the Arthur Kill, and down toward the saline groundwater that underlies it at greater depths (Soren 1988). Depth to groundwater within the upland portion of the study area along the shoreline ranges from 4 to 6 feet, varying with season, precipitation and tides.

Drinking water for Staten Island is provided by New York City's system of upstate reservoirs. Groundwater has not been used as a source of potable water on Staten Island since the mid-20th century (Rosenberg 2013).

9.4.2 WETLANDS

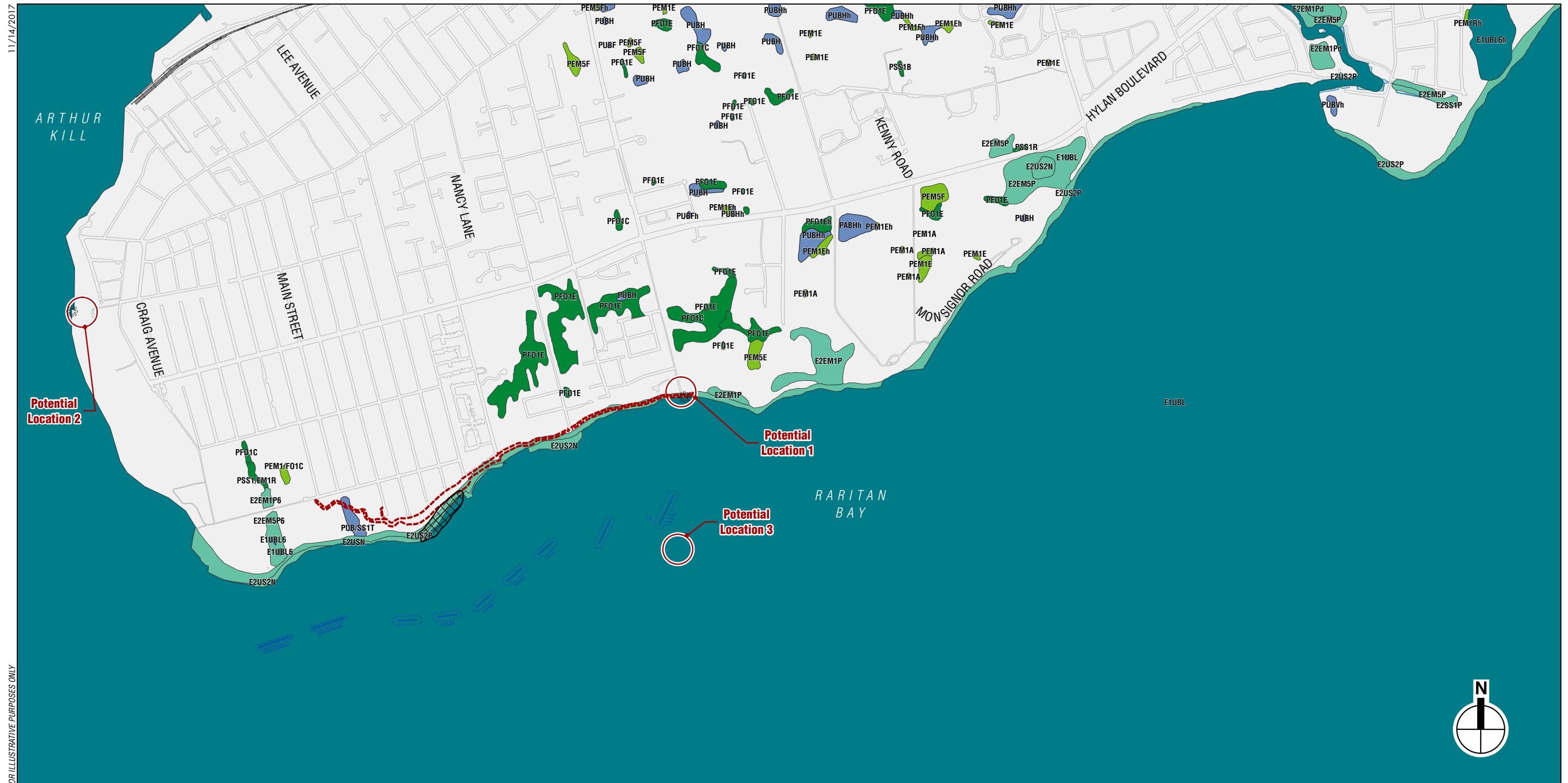
Figure 9-8 shows the USFWS NWI-mapped wetlands in the study area. The open waters of Raritan Bay, including the area in which the proposed breakwater structure would be located, are mapped as E1UBL (estuarine, subtidal, unconsolidated bottom).⁷ This area of NWI-mapped E1UBL wetland does not meet the characteristics of wetland soils, hydrology, or hydrophytic vegetation to be under federal jurisdiction of the USACE as wetlands, but would be regulated by the USACE as waters of the United States.

Moving towards shore, Raritan Bay transitions from subtidal E1UBL to intertidal areas that are mapped by the NWI as E2US2N (estuarine, intertidal, unconsolidated shore, sand, regularly flooded).⁸ Further landward, the intertidal area is mapped as E2US2P (estuarine, intertidal, unconsolidated shore, sand, irregularly flooded), which has the same properties as E2US2N, with the exception of having less than daily exposure. Similar to the NWI wetlands within the vicinity of the proposed breakwater structures, these NWI-mapped wetlands do not meet the characteristics of wetland soils, hydrology, or hydrophytic vegetation to be under federal jurisdiction of the USACE as wetlands but would be regulated as waters of the United States. An approximately 2.4-acre marsh within Conference House Park that is fed by a combination of downstream freshwater input from the Twin Streams of the Lenape and upstream tidal influences from Raritan Bay is mapped by the NWI as E2EM5P6 (estuarine, intertidal, emergent, *Phragmites australis*, irregularly flooded, oligohaline).⁹ Within this marsh are two areas with ponded water that are mapped by the NWI as a separate category, E1UBL6 (estuarine, subtidal, unconsolidated bottom, oligohaline), because these portions of the marsh are permanently flooded (i.e., subtidal). To the east of this wetland, also within Conference House Park, is a 1.5-acre NWI-mapped freshwater wetland that is classified as PUB/SS1T. This category refers to nontidal wetlands that occur in

⁷ E1UBL NWI mapped wetlands are deep-water, tidal habitats and adjacent tidal wetlands that are located along low-energy coastlines and have variable salinity, continuously submerged substrates consisting of 25 percent cover of particles smaller than stones (less than 6-7 centimeters), and less than 30 percent vegetative cover.

⁸ E2US2N are areas between extreme low water and extreme high water with unconsolidated substrates of mostly sand, less than 30 percent vegetative cover, and daily exposure during receding tides.

⁹ E2EM5P6 are estuarine, intertidal wetlands that are flooded less than daily, have salinities ranging from 0.5 to 5 ppm, and are dominated by common reed (*Phragmites australis*).



Proposed Breakwater Features

A rectangular box containing a diagonal cross-hatch pattern, indicating a proposed shoreline restoration area.

----- Proposed Shoreline Project Elements

- Potential Location of Proposed Water Hub
(exact location to be determined)

Proposed Floating Dock (associated with

- Water Hub Potential Locations 1 and 2 only)
- Potential Water Access

* Potential Water Access

Estuarine and Marine Deepwater

Freshwater Forested/Shrub Wetland

Freshwater Emergent Wetland

Freshwater Pond

Estuarine and Marine Wetland

0 2,000 FEET

Coastal and Social Resiliency Initiatives for Tottenville Shoreline

USFWS National Wetlands Inventory

Figure 9-8

Coastal and Social Resiliency Initiatives for Tottenville Shoreline FEIS

coastal areas, have ocean-derived salinity levels below 0.5 parts per trillion, and are dominated by deciduous scrub/shrub vegetation (woody plants less than 20 feet tall) that is stunted due to environmental (maritime) conditions. The 1.5-acre PUB/SS1T wetland was not observed within the study area during the August 10, 2016, wetland delineation. The proposed Shoreline Project would be located to the east and would not intersect either of these two NWI-mapped wetland areas.

Figure 9-9 shows the NYSDEC freshwater wetlands that are mapped within the study area. The approximately 17-acre wetland (AR-22) within Conference House Park is fed by the Twin Streams of the Lenape and extends from the outlet on the Raritan Bay shoreline to the headwaters near Clermont Avenue. To the east, between Sprague Avenue and Joline Avenue, and north of where the proposed Shoreline Project would be located, is a NYSDEC-mapped 104-acre freshwater wetland (AR-15) that spans Hybrid Oak Woods Park, private lots to the east, and into Butler Manor Woods and Mount Loretto Unique Area. No components of the Proposed Actions would be located within or near either wetland or their regulated buffer zones.

Raritan Bay, up to the MHW elevation boundary of the shoreline is mapped by NYSDEC as littoral zone tidal wetland.¹⁰ A portion of the proposed Breakwater Project would be located in an area that has a depth less than or equal to 6 feet at Mean Low Water (MLW) and would be located within NYSDEC littoral zone tidal wetlands. The proposed seasonal floating boat launch associated with the two of the potential Water Hub locations would extend from the shoreline into Raritan Bay and would be located within the NYSDEC littoral zone tidal wetland. Portions of the proposed Shoreline Project and the proposed parking areas for the Water Hub component of the Breakwater Project would be located within the NYSDEC TWAA¹¹ and would require authorization from NYSDEC under ECL Article 25.

An unmapped tidal wetland approximately 0.8 acres in size is present within the study area located south of the terminus of Brighton Street and Surf Avenue, west of Manhattan Street, east of Chelsea Street, and north of the beach (see Figure 9-10). Currently, there is limited connectivity between this wetland and the open waters of Raritan Bay due to the presence of the temporary dune and sand clogged inlet structure. The wetland is currently split by a section of unpermitted fill forming a sand bridge that further restricts tidal flow to the eastern end of the wetland. Spike grass (*Distichlis spicata*), black grass (*Juncus gerardii*), and common reed are the dominant plant species within the wetland. Salt marsh cordgrass (*Spartina alterniflora*) is present in the western portion of the wetland in lower elevation areas, while the eastern two thirds of the wetland is a monoculture of common reed. This wetland was delineated on August 10, 2016, and determined to meet the criteria (hydrophytic vegetation, wetland hydrology, and hydric soils) necessary to be under federal jurisdiction of the USACE (see Appendix E-8).

¹⁰ The tidal wetlands zone, which includes all lands under tidal waters not included in any other category, and that are no deeper than six feet at mean low water.

¹¹ Within New York City, the NYSDEC TWAA extends 150 feet landward of the most landward boundary of a tidal wetland; or to the seaward edge of the closest lawfully and presently existing (i.e., as of August 20, 1977), functional and substantial fabricated structure (including, but not limited to, paved streets and highways, railroads, bulkheads and sea walls, and rip-rap walls) which lies generally parallel to said most tidal wetland landward boundary and which is a minimum of 100 feet in; or to the elevation contour of 10 feet above mean sea level, whichever comes first.



■ Proposed Breakwater Features — Proposed Shoreline Project Elements
☒ Proposed Shoreline Restoration Area ○ Potential Location of Proposed Water Hub
 (exact location to be determined)

□ Proposed Floating Dock (associated with Water Hub Potential Locations 1 and 2 only)
▢ Potential Water Access

■ State-regulated freshwater wetlands
■ High Marsh
■ Intertidal Marsh
■ Littoral Zone
■ Coastal Shoals, Bars and Mudflats

0 2,000 FEET

12/13/2017



Delineated Tidal Wetland

Proposed Shoreline Restoration Area

Earthen Berm

Eco-Revetment

Hybrid Dune/Revetment System

0 100 FEET

Coastal and Social Resiliency Initiatives for Tottenville Shoreline

Delineated Tidal Wetland
Figure 9-10

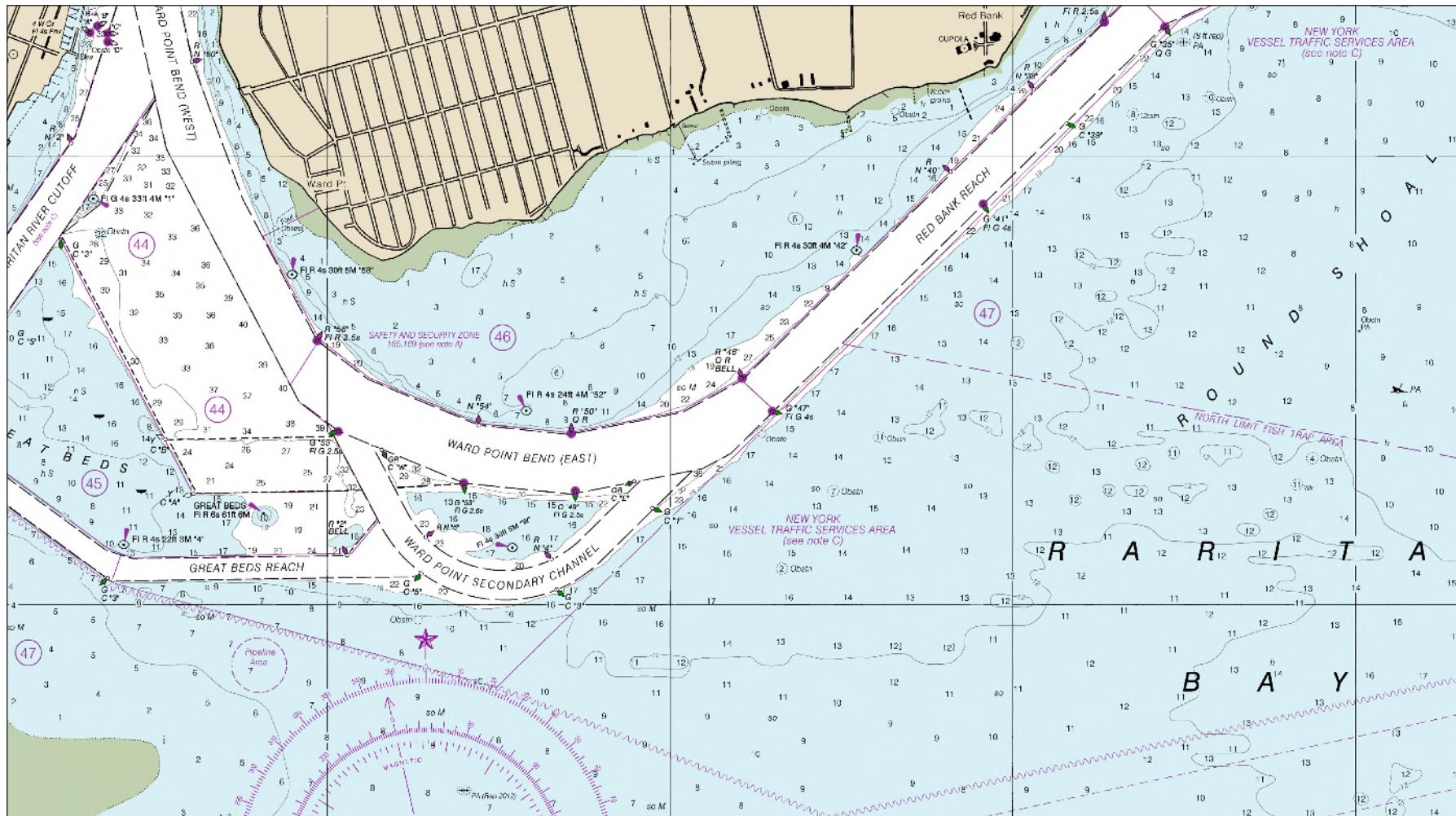
9.4.3 AQUATIC RESOURCES

Raritan Bay is part of the Lower New York Bay Complex in the New York-New Jersey Harbor. The Lower Bay Complex consists of three connected bays (Lower Bay, Raritan Bay, and Sandy Hook Bay) and is bounded by Brooklyn, the Atlantic Ocean, and Sandy Hook in the east, New Jersey to the south, and Staten Island to the west. The Lower Bay Complex is generally shallow and well-mixed, with only dredged ship channels, sand mining areas, and the region near the Narrows exceeding 8 meters (about 26 feet) in depth (Cerrato 2006). Raritan Bay extends from Staten Island to New Jersey's Monmouth and Middlesex counties, and is generally bounded by the Arthur Kill tidal strait to the west and integrates with the Lower New York Bay in the east around Great Kills. Within the Lower Bay Complex, Raritan Bay is shallow, with water depths generally less than 18 feet, except for a small area at the eastern end of the bay and within the dredged channels (Kastens et al. 1978). Raritan Bay Channel, which is maintained at depths down to an authorized depth of 35 feet at Mean Lower Low Water (MLLW), extends westward from the tip of Sandy Hook through the northern part of Raritan Bay to connect with Arthur Kill and the Raritan River. Water depths within the portion of Raritan Bay within the study area range from 1 to 27 feet at MLLW (NOAA Nautical Chart #12331; see **Figure 9-11**). The results of the hydrographic survey conducted within the study area for the Breakwater Project found water depths ranged from less than 2 feet to about 24 feet at MLW, with a few depressional areas where the water depths are deeper in the eastern and western portions of the study area (see **Figure 9-12**).

The Raritan Bay-Sandy Hook Complex receives direct freshwater inflow from the Raritan River, the Shrewsbury and Navesink Rivers, and various smaller tributaries along the shorelines of Staten Island and New Jersey (USFWS 1997). Waters of the Lower Bay Complex also exchange and mix with the waters of the Upper Bay through the Narrows and with the Atlantic Ocean between Sandy Hook and Rockaway Point (Brinkhuis 1980). At the southern tip of Staten Island, the shoreline consists mainly of mud or sand flats and sand or gravel beaches, with some scattered vegetated areas (NOAA 2001).

Water mixes in a counterclockwise direction in the Lower Bay, dominated by semi-diurnal tidal currents (USGS 2015). During flood tide, higher salinity water enters the Lower Bay and moves in a counterclockwise pattern along the Staten Island shore; during ebb tide, lower salinity water from Sandy Hook and Raritan Bays and freshwater from the Raritan River moves around Sandy Hook into the New York Bight (Brinkhuis 1980). The estuary is generally well mixed, however fresh water discharge from the Raritan River can produce density gradients which drive eastward movement of surface waters and westward movement of bottom waters (Kastens et al. 1978). The average tidal range for the Raritan Bay-Sandy Hook Complex is about 5.5 feet (USFWS 1997), and flushing time¹² has been estimated at 16 to 21 days (or 32 to 42 tidal cycles) (Jeffries 1962, as cited in Steimle and Caracciolo-Ward 1989). A clockwise eddy off Great Kills effectively separates flows from the Raritan River in the west and the Hudson River in the east, creating different hydrographic regimes in the Lower Bay compared to Raritan and Sandy Hook Bays (Ayers et al. 1949). Because the Lower Bay is relatively shallow, circulation patterns are susceptible to wind and to changes in run-off volumes of freshwater from the Hudson and Raritan Rivers (Brinkhuis 1980, Walford 1971).

¹² Flushing time is defined as the time required to replace the existing freshwater accumulated in the estuary by the river discharge.



NOAA Nautical Chart 12331

11/14/2017



Coastal and Social Resiliency Initiatives for Tottenville Shoreline FEIS

WATER QUALITY

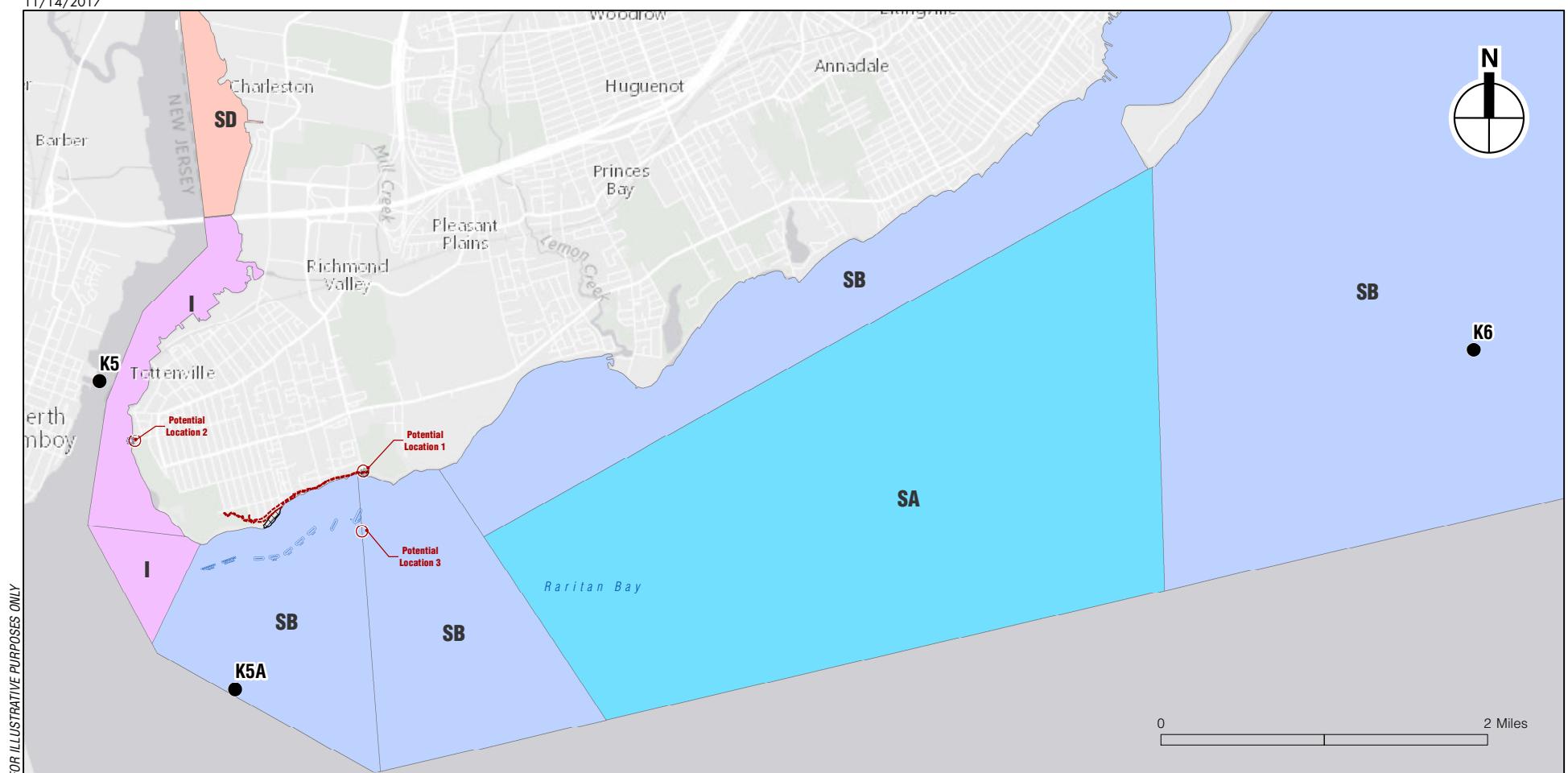
The Lower Bay and Raritan Bay are the most oceanic waterbodies in the New York Harbor system, and water quality conditions in the region are therefore influenced both by the connection to other waterways of the Harbor (i.e., Jamaica Bay, western Long Island Sound, East River, Upper Bay, Newark Bay) as well as to the Atlantic Ocean. The area is subject to a wide variety of fluctuations in temperature, salinity, and dissolved oxygen, both from natural and anthropogenic activity (USFWS 1997).

The study area comprises three water quality classifications under 6 NYCRR Part 885 (see **Figure 9-13**): around the southwestern corner of Staten Island approximately from Shore Road to Surf Avenue, Arthur Kill/Raritan Bay are classified as Class I waters, and from Surf Avenue east to Kenny Road, the Bay is classified as Class SB. Under 6 NYCRR 701, the best uses for Class I waters are secondary contact recreation and fishing; the best uses for Class SB waters are primary and secondary contact recreation and fishing. Both classifications indicate that the water should be suitable for fish, shellfish, and wildlife propagation and survival. Standards for Class I and Class SB waters are presented in **Table 9-3**. The Class SB waters of Raritan Bay are included on the 303(d) list of impaired waterbodies for metals, PCBs, aesthetics, pathogens, and nutrients (suspected) (NYSDEC 2014). Shellfishing and fish consumption uses are impaired in this portion of Raritan Bay from contaminated sediment, urban/storm runoff, CSOs, failing and/or inadequate on-site systems, illegal connections to storm sewers, boat pollution, and other sources (NYSDEC 2010). Most of the Raritan Bay region is also designated for bathing, except for the area directly surrounding the Narrows to the north (in Lower New York Bay) and the western tip of Raritan Bay near the mouths of the Arthur Kill and the Raritan River (NYCDEP 2012).

NYCDEP monitors water quality in New York Harbor, including Raritan Bay, through its annual Harbor Survey. The results of recent surveys (NYCDEP 2010, 2012) show that water quality has improved significantly due to measures undertaken by the City and other entities within the region. These measures include infrastructure improvements, elimination of 99 percent of raw dry-weather sewage discharges, reduction of illegal discharges, increased capture of wet-weather-related floatables, and reduction of toxic metals loadings from industrial sources (NYCDEP 2002). Data from NYCDEP water quality monitoring stations were analyzed to determine water quality characteristics within the study area: Station K5 is located at the confluence of the Arthur Kill with Raritan Bay, Station K5A is located in Raritan Bay just south of Tottenville at the southern tip of Staten Island, and Station K6 is near the Old Orchard Lighthouse in the Lower Bay southeast of Great Kills Park (see **Figure 9-13**). Station K5 is located in Class I waters; Stations K5A and K6 are located in Class SB waters (see **Figure 9-13**).

In the latest State of the Harbor Report from NYCDEP (2012), five of eight performance indicators showed improvement in the Lower New York Bay–Raritan Bay survey region. Dissolved oxygen (DO) levels showed some decline throughout the region, but met state standards and remained second best among other harbor water bodies. USACE (2004b) indicates that persistent low dissolved oxygen concentrations in Raritan Bay are likely the result of excess nutrients that enter the water column from sewage treatment plants, CSOs, and non-point sources. Fecal coliform levels improved overall, averaging 15.1 colony forming units (cfu)/100 mL, which easily met the state standard of less than 200 cfu/100 mL. Transparency (as indicated by secchi depth) and total suspended solids also improved; transparency increased to 5.7 feet, and total suspended solids (TSS) decreased to 5.8 mg/L at the surface and 7.2 mg/L at the bottom. Chlorophyll *a*, which is an indicator of nutrient loading, decreased to the lowest level in this region since 1990 (7.6 µg/L) (NYCDEP 2012).

11/14/2017



Proposed Breakwater Features

Proposed Shoreline Restoration Area

Proposed Shoreline Project Elements

Potential Location of Proposed Water Hub
(exact location to be determined)

Potential Water Access

Proposed Floating Dock (associated with
Water Hub Potential Locations 1 and 2 only)

The best usages of **Class SA** waters are shellfishing for market purposes, primary and secondary contact recreation and fishing. These waters shall be suitable for fish, shellfish, and wildlife propagation and survival.

The best usages of **Class SB** waters are primary and secondary contact recreation and fishing. These waters shall be suitable for fish, shellfish, and wildlife propagation and survival.

The best usages of **Class I** waters are secondary contact recreation and fishing. These waters shall be suitable for fish, shellfish, and wildlife propagation and survival.

The best usage of **Class SD** waters is fishing. These waters shall be suitable for fish, shellfish, and wildlife survival. This classification may be given to those waters that, because of natural or man-made conditions, cannot meet the requirements for primary and secondary contact recreation and fish propagation.

New York City Harbor Survey Monitoring Locations and
NYSDEC Surface Water Classifications in Raritan Bay

Figure 9-13

Table 9-4 presents NYCDEP water quality data near the project site for the most recent fifteen-year period, from January 1999 to December 2014. The Harbor Survey sampling sites within or near the study area are located in Class SB and Class I waters; the eastern-most sampling sites for water quality sampling conducted for the Breakwaters Project (see **Figures 9-3a and 9-3b**) may be on the border of Class SA waters. **Table 9-5** presents site-specific water quality data collected in the project location in June and September 2015, including temperature, DO, pH, salinity, secchi depth, fecal coliform, total nitrogen, nitrate/nitrite, and total Kjeldahl nitrogen. **Tables 9-6 and 9-7** present the Harbor Survey data for the 1999 to 2014 time period for the months of June and September. For June and September, sample sites extended from Hylan Boulevard near the mouth of the Arthur Kill to the Princes Bay lighthouse on the southern coast of Staten Island and ranged from about 4 to 40 feet in depth (see **Figures 9-3a and 9-3b**). All project-specific sampling locations corresponded with Class SB surface waters. Water quality near the study area was analyzed with respect to the NYSDEC standards for Class I and Class SB surface waters and also with respect to the USEPA's recreational water quality criteria (RWQC), under which USEPA has established a Bathing Standard for enterococci levels in marine and fresh waters, detailed below. NYSDEC does not identify a surface water quality standard for enterococcus.

Table 9-3
NYSDEC Surface Water Quality Standards

Parameter	Class I Waters	Class SB Waters	Class SA Waters
Temperature (°F)	No standard	No standard	No standard
Salinity (psu)	No standard	No standard	No standard
pH	Normal range shall not be extended by more than 0.1 pH unit	Normal range shall not be extended by more than 0.1 pH unit	Normal range shall not be extended by more than 0.1 pH unit
Dissolved oxygen (mg/L)	No standard	Chronic: Not less than 4.8 mg/L Acute: Never less than 3.0 mg/L	Chronic: Not less than 4.8 mg/L Acute: Never less than 3.0 mg/L
Fecal coliform (cfu/100 mL)	Monthly geometric mean, from a minimum of five examinations, shall not exceed 2,000	Monthly geometric mean, from a minimum of five examinations, shall not exceed 200	Median most probable number (MPN) value in any series of samples shall not exceed 70
Enterococcus (cfu/100mL) ⁽¹⁾	USEPA Bathing Standard = 35 cfu/100mL	USEPA Bathing Standard = 35 cfu/100mL	USEPA Bathing Standard = 35 cfu/100mL
Secchi transparency (ft)	No standard	No standard	No standard
Ammonia (µg/L) ⁽²⁾	Chronic: 35 µg/L Acute: 230 µg/L	Chronic: 35 µg/L Acute: 230 µg/L	Chronic: 35 µg/L Acute: 230 µg/L
Total nitrogen (mg/L)	None in amounts resulting in algae/weed/slime growth that will impair waters for best usages	None in amounts resulting in algae/weed/slime growth that will impair waters for best usages	None in amounts resulting in algae/weed/slime growth that will impair waters for best usages
Total phosphorus (mg/L)	None in amounts resulting in algae/weed/slime growth that will impair waters for best usages	None in amounts resulting in algae/weed/slime growth that will impair waters for best usages	None in amounts resulting in algae/weed/slime growth that will impair waters for best usages
Total suspended solids (mg/L)	None from sewage, industrial wastes or other wastes that will impair usage	None from sewage, industrial wastes or other wastes that will impair usage	None from sewage, industrial wastes or other wastes that will impair usage
Chlorophyll a (µg/L)	No standard	No standard	No standard

Notes:

⁽¹⁾ NYSDEC does not identify a standard for enterococcus; however, USEPA provides a standard for bathing of 35 cfu/100mL

⁽²⁾ The NYSDEC standard for ammonia applies to un-ionized ammonia as NH₃

Sources:

6 NYCRR Part 703 Surface Water and Groundwater Quality Standards and Groundwater Effluent Limitations; USEPA Recreational Water Quality Criteria (Office of Water 820-F-12-058)

Table 9-4
NYCDEP Water Quality Data for Raritan Bay Sampling Stations K5, K5A, and K6
(1999 – 2014; All Months)

Parameter	Station K5 (Class I Waters)						Station K5A (Class SB Waters)						Station K6 (Class SB Waters)					
	Surface Waters			Bottom Waters			Surface Waters			Bottom Waters			Surface Waters			Bottom Waters		
	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg
Temperature (°F)	33.5	81.6	65.8	34.1	80.6	63.9	33.3	80.2	64.8	33.7	77.5	63.2	33.3	80.2	64.8	33.7	77.5	63.2
Salinity (psu)	7	29	22	9	32	24	8	29	22	9	31	24	8	31	24	9	31	25
pH	6.9	8.8	7.6	6.9	8.8	7.6	6.8	9	7.7	6.9	8.9	7.6	7	8.9	7.9	7	8.9	7.8
Dissolved oxygen (mg/L) ⁽¹⁾	0.7	17.3	7.2	0.6	16.9	6.2	2.7	19.1	7.7	1.8	18.6	6.7	4.3	20.5	9.8	2.4	16.4	8.3
Fecal coliform (cfu/100 mL)	1	1,760	80	-	-	-	1	4,000	85	-	-	-	1	412	15	-	-	-
Enterococcus (cfu/100mL)	1	1,110	30	-	-	-	1	2,360	33	-	-	-	<1	1,750	10	-	-	-
Secchi transparency (ft)	0.5	9.5	4.2	-	-	-	0.5	10	4	-	-	-	1.5	14	4.6	-	-	-
Ammonia (µg/L)	0	2,460	434.9	-	-	-	0	2,600	392.8	-	-	-	0	1,920	225.9	-	-	-
Total nitrogen (mg/L) ⁽²⁾	0	5.5	1.5	-	-	-	0	5.6	1.4	-	-	-	0	3.6	0.9	-	-	-
Total phosphorus (mg/L)	0.05	46.5	5	-	-	-	0.07	76.7	4.9	-	-	-	0.05	61.4	4.7	-	-	-
Total suspended solids (mg/L)	1	90.4	13.8	-	-	-	0.5	117.4	14.5	-	-	-	0.3	105	15.5	-	-	-
Chlorophyll a (µg/L)	0.90	198	11.7	-	-	-	0.97	114	13.5	-	-	-	0.93	94.7	16.4	-	-	-

Notes:

Fecal coliform, enterococcus, secchi transparency, total nitrogen, ammonia, total phosphorus, total suspended solids, and chlorophyll-a were either not measured at all or not measured consistently in bottom waters.

⁽¹⁾ Compliance with the chronic DO standard is based on daily averages and not on the basis of the minimum DO value presented here, which is the minimum DO concentration recorded during weekly sampling events.

⁽²⁾ Total nitrogen was derived by summing the measured concentrations of nitrate/nitrite and Total Kjeldahl Nitrogen (TKN).

Sources: NYCDEP Harbor Survey Water Quality Data 1999–2014

Coastal and Social Resiliency Initiatives for Tottenville Shoreline FEIS

Table 9-5
Site Specific Water Quality Data (June and September 2015)

Parameter	June 2015						September 2015					
	Surface Waters			Bottom Waters			Surface Waters			Bottom Waters		
	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg
Temperature (°F)	71.6	74.1	72.3	69.8	73	71.8	69.8	72.5	71.2	70.2	72.3	71.2
Salinity (psu)	18	22.5	20.8	18	22	21.3	22	22.7	22.3	22	22.6	22.3
pH	7	7.1	7.1	-	-	-	7.4	8	7.8	-	-	-
Dissolved oxygen (mg/L) ⁽¹⁾	5.3	7.2	6.3	5.5	7.1	6.3	5.7	7.4	6.2	5.3	7.2	6.2
Fecal coliform (organisms/100 mL)	<10	99	23.3	-	-	-	<10	26	7	-	-	-
Secchi transparency (ft)	1.7	3.6	2.7	-	-	-	3.5	6.2	4.6	-	-	-
Total nitrogen (mg/L) ⁽²⁾	1.0	4.41	1.72	-	-	-	1.0	3.8	1.61	-	-	-

Notes:

pH, fecal coliform, secchi transparency, and total nitrogen were not measured in bottom waters.

⁽¹⁾ Compliance with the chronic DO standard is based on daily averages and not on the basis of the low DO value presented here, which is the minimum DO concentration recorded during weekly sampling events.

⁽²⁾ Total nitrogen was derived by summing the measured concentrations of nitrate/nitrite and Total Kjeldahl Nitrogen (TKN).

Sources:

6 NYCRR Part 703 Surface Water and Groundwater Quality Standards and Groundwater Effluent Limitations;
Normandeau sampling data from June and September 2015

Table 9-6
NYCDEP Water Quality Data for Raritan Bay Sampling Stations K5, K5A, and K6
(1999–2014; June Only)

Parameter	Station K5 (Class I Waters)						Station K5A (Class SB Waters)						Station K6 (Class SB Waters)					
	Surface Waters			Bottom Waters			Surface Waters			Bottom Waters			Surface Waters			Bottom Waters		
	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg
Temperature (°F)	62.6	75.6	69.4	57	71.6	66.2	61	74.3	74.5	58.3	73.2	66.6	59.5	76.8	67.8	57.7	70.9	64.8
Salinity (psu)	13	25.7	21.1	18	27.4	24	15.6	25.1	21.2	19.2	27.3	23.6	15.9	26.7	23.1	20.8	26.9	24.7
pH	7.1	8.8	7.6	7	8.8	7.6	7.1	8.9	7.6	7.1	8.9	7.6	7.4	8.6	8	7.5	8.6	7.9
Dissolved oxygen (mg/L) ⁽¹⁾	3.7	17	7.2	2.7	13.9	5.9	3.6	17.8	7.6	3.7	16.4	6.5	4.7	18.9	11	4.7	16.4	8.6
Fecal coliform (cfu/100 mL)	1	840	88.3	-	-	-	1	560	62.9	-	-	-	1	124	15.6	-	-	-
Enterococcus (cfu/100mL)	1	180	15.1	-	-	-	1	1,300	37.5	-	-	-	1	1,750	41.9	-	-	-
Secchi transparency (ft)	1.5	9	4.1	-	-	-	0.5	8	4	-	-	-	2	8	4.3	-	-	-
Ammonia (µg/L)	0	2,050	411.1	-	-	-	0	1,820	364.2	-	-	-	0	1,170	176.2	-	-	-
Total nitrogen (mg/L) ⁽²⁾	0	2.8	1.4	-	-	-	0	2.7	1.3	-	-	-	0	1.8	0.8	-	-	-
Total phosphorus (mg/L)	0.1	24	4.2	-	-	-	0.1	24	4	-	-	-	0.1	56.2	5.1	-	-	-
Total suspended solids (mg/L)	1	65.5	13.9	-	-	-	0.5	53.4	15.2	-	-	-	0.3	105	19.4	-	-	-
Chlorophyll a (µg/L)	2.6	78.1	13.5	-	-	-	2.5	58.2	15	-	-	-	2.2	90.8	21.8	-	-	-

Notes:

Fecal coliform, enterococcus, secchi transparency, total nitrogen, ammonia, total phosphorus, total suspended solids, and chlorophyll-a were either not measured at all or not measured consistently in bottom waters.

⁽¹⁾ Compliance with the chronic DO standard is based on daily averages and not on the basis of the minimum DO value presented here, which is the minimum DO concentration recorded during weekly sampling events.

⁽²⁾ Total nitrogen was derived by summing the measured concentrations of nitrate/nitrite and Total Kjeldahl Nitrogen (TKN).

Sources:

NYCDEP Harbor Survey Water Quality Data 1999–2014, June data only

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Table 9-7
NYCDEP Water Quality Data for Raritan Bay Sampling Stations K5, K5A, and K6
(1999–2014; September Only)

Parameter	Station K5 (Class I Waters)						Station K5A (Class SB Waters)						Station K6 (Class SB Waters)					
	Surface Waters			Bottom Waters			Surface Waters			Bottom Waters			Surface Waters			Bottom Waters		
	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg
Temperature (°F)	66.7	79.5	72.7	66.6	78.1	71.8	66.9	78.8	72.3	66.4	78.4	71.4	65.1	78.1	70.9	65.7	77.5	70.5
Salinity (psu)	8.9	28.5	22.5	17.9	29.2	24.3	9	29.1	22.6	12.7	30.1	24.3	11.8	30.5	25.2	17.9	30.7	25.7
pH	6.9	8	7.5	6.9	8	7.5	6.9	8.1	7.5	6.9	8	7.5	7	8.4	7.8	7.1	8.3	7.8
Dissolved oxygen (mg/L) ⁽¹⁾	3.7	8.9	6.1	3.2	7.1	5.2	4.4	10	6.3	4	7.3	5.4	5.7	15.4	8.3	5.1	11.2	7.4
Fecal coliform (cfu/100 mL)	1	950	82.2	-	-	-	1	1,940	82.2	-	-	-	1	104	12.6	-	-	-
Enterococcus (cfu/100mL)	1	600	31.8	-	-	-	1	1,840	62.6	-	-	-	1	48	3.3	-	-	-
Secchi transparency (ft)	2	8.5	4.8	-	-	-	2	10	4.7	-	-	-	2	10	5.3	-	-	-
Ammonia (µg/L)	0	2,090	443.2	-	-	-	0	2,230	393.6	-	-	-	0	1,500	220.4	-	-	-
Total nitrogen (mg/L) ⁽²⁾	0	5.5	1.9	-	-	-	0	5.6	1.7	-	-	-	0	3.6	1.2	-	-	-
Total phosphorus (mg/L)	0.2	33.3	3.7	-	-	-	0.1	20.8	3.1	-	-	-	0.1	31.5	2.5	-	-	-
Total suspended solids (mg/L)	1.8	90.4	13.9	-	-	-	0.8	95.7	13.1	-	-	-	1.4	65.9	13.8	-	-	-
Chlorophyll a (µg/L)	1.5	38.1	10.1	-	-	-	1.8	114	11	-	-	-	2.3	58.9	15.5	-	-	-

Notes:

Fecal coliform, enterococcus, secchi transparency, total nitrogen, ammonia, total phosphorus, total suspended solids, and chlorophyll-a were either not measured at all or not measured consistently in bottom waters.

⁽¹⁾ Compliance with the chronic DO standard is based on daily averages and not on the basis of the minimum DO value presented here, which is the minimum DO concentration recorded during weekly sampling events.

⁽²⁾ Total nitrogen was derived by summing the measured concentrations of nitrate/nitrite and Total Kjeldahl Nitrogen (TKN).

Sources: NYCDEP Harbor Survey Water Quality Data 1999–2014, September data only

Temperature

Water temperatures at the three Harbor Survey stations varied temporally and by station location but were similar at the surface and bottom, indicating a fairly well-mixed system. Bottom temperatures were just slightly cooler, ranging from about 33°F to 82°F, with an average temperature at the surface and bottom ranging from about 65°F to 63°F, respectively (see **Table 9-4**). Site-specific surface and bottom temperatures measured within the study area in the spring (June) and fall (September) of 2015 (see **Table 9-5**) were consistent with the 15-year temperature ranges for the Harbor Survey sites. Surface and bottom temperatures were similar with bottom temperatures being just slightly cooler, ranging from about 70°F to 74°F in June, and about 70 to 73°F in September. Average temperatures were about 71°F and 74°F for the bottom and surface, respectively, in June, and about 71°F in September. On average, the surface temperatures recorded for the study area in June were slightly higher than those reported for the Harbor Survey, while September temperatures were slightly lower than those reported for the Harbor Survey (see **Tables 9-6 and 9-7**). For all stations, minimum temperatures occurred in late winter, and the maximum occurred in late summer. There is no NYSDEC standard for temperature.

Salinity

Salinity levels fluctuate seasonally and with the ebb and flood of the tidal cycle. While salinity was similar between NYCDEP Harbor Survey stations, it increased slightly from the western station K5 at the mouth of the Arthur Kill to the eastern most station K6 closest to the Atlantic Ocean. As with water temperature, salinity at the bottom was just slightly higher than at the surface. At Station K5 at the mouth of the Arthur Kill, salinity ranged from 7 to 22 psu¹³ at the surface and from 9 to 24 psu at the bottom, averaging 22 and 24 psu, respectively. Salinity at Station K5A in Raritan Bay ranged from 8 to 29 psu at the surface and from 8 to 24 psu at the bottom, averaging 22 psu and 24 psu, respectively. At Station K6, salinity ranged from 8 to 31 psu at the surface and from 9 to 31 psu at the bottom, averaging 24 and 25 psu, respectively (see **Table 9-4**). Site-specific salinity measurements taken within the study area in June and September of 2015 were consistent with those for the Harbor Survey sites; in June 2015, salinity ranged from 18 to 20.8 psu at the surface and from 18 to 21.3 psu at the bottom; averaging about 22 psu. In September 2015, salinity held steady around 22 psu, averaging 22.3 psu in both surface and bottom waters (see **Table 9-5**). Average salinities at the site-specific sample locations were about the same as those for the Harbor sites in June and a bit lower than the Harbor Survey sites in September (see **Tables 9-6 and 9-7**). There is no NYSDEC standard for salinity.

Dissolved Oxygen

Dissolved oxygen (DO) in the water column is necessary for respiration by aquatic biota; persistently low DO can degrade habitat and adversely affect aquatic biota. DO concentrations fluctuate seasonally, and is generally lower in the summer and higher in colder months; due in large part to temperature (colder water can hold more oxygen than warmer water) and also due to decomposition of organic material that occurs during warmer months and consumes DO. Similar to salinity, DO at the Harbor Survey stations generally increased from Station K5 at the mouth of the Arthur Kill to the eastern-most station, Station K6, and was slightly lower in the bottom than the surface. At Station K5 at the mouth of the Arthur Kill, DO ranged from 0.7 to 17.3 mg/L at the surface and from 0.6 to 16.9 mg/L at the bottom, with an average of 7.2 mg/L at the surface

¹³ Salinity has traditionally been defined in parts per thousand (ppt), but is commonly measured in practical salinity units (psu). According to NOAA, psu and ppt are nearly equivalent.

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and 6.2 mg/L at the bottom. At Station K5A in Raritan Bay near the mouth of the Raritan River, DO ranged from 2.7 to 19.1 mg/L at the surface and from 1.8 to 18.6 mg/L at the bottom, with an average of 7.7 mg/L at the surface and 6.7 mg/L at the bottom between 1999 and 2014. At Station K6 in the Lower Bay, DO ranged from 4.3 to 20.5 mg/L at the surface and from 2.4 to 16.4 mg/L at the bottom, with an average of 9.8 mg/L at the surface and 8.3 mg/L at the bottom (see **Table 9-4**).

While DO values recorded at the Harbor Survey stations were generally within the standards, concentrations occasionally dropped below the chronic¹⁴ and acute¹⁵ standards during the 15-year period. DO concentrations below the standards occurred more frequently at the bottom where DO is slightly lower than at the surface, and more often at Station K5A within the Bay than Station K6 nearest the Atlantic Ocean. DO at Station K5A dropped below the chronic standard a total of 28 times at the surface and 73 times at the bottom and dropped below the acute standard twice at the surface and 8 times at the bottom over the 15-year period. DO at Station K6 dropped below the chronic standard twice at the surface and 4 times at the bottom, and dropped below the acute standard only once at the bottom over the 15-year period. There is no DO standard for Class I waters, where Station K5 is located.

Site-specific average DO recorded within the study area in June and September of 2015 was lower than DO measured during the 15 period for the Harbor Survey sites in for June and September, but were within the general range of fluctuation for DO concentrations in the Harbor Survey (see **Tables 9-6 and 9-7**). DO measured in the project study area in June 2015 ranged from 5.3 to 7.2 mg/L at the surface and from 5.5 to 7.1 mg/L at the bottom; average DO in both surface and bottom waters was 6.3 mg/L (see **Table 9-5**). In September, DO ranged from 5.7 to 7.4 mg/L at the surface and from 5.3 to 7.2 mg/L at the bottom; averages were 6.2 for both surface and bottom waters. DO recorded during the site-specific water quality sampling within the study area was above the chronic and acute standards.

Fecal Coliform

Fecal coliform bacteria are used as an indicator of wastewater and the possible presence of pathogenic, or disease-producing, bacteria. Fecal coliform numbers were lowest at Station K6 nearest the Atlantic Ocean. Minimum fecal coliform levels ranged from 1 cfu/100mL at all three stations to 412 cfu/100mL at Station K6, 1,760 cfu/100mL at Station K5 near the mouth of the Arthur Kill, and 4,000 cfu/100mL at Station K5A in Raritan Bay near the mouth of the Raritan River. The average readings of 80 cfu/100mL at Station K5 and 85 cfu/100mL at Station K5A were higher than those for Station K6 in the Lower Bay, which had an average of 15 cfu/100mL (see **Table 9-4**). Data were not sufficient to determine compliance with the local fecal coliform standard;¹⁶ however, NYCDEP (2013) indicates that by 2012, fecal coliform levels had not exceeded the standard at any of its monitoring sites in the Harbor since the early 1990s. Site specific fecal coliform measurements taken within the study area in June 2015 were similar to those recorded at the Harbor Survey sites, with some variation by location. Measurements were lower in September than June. In June, site-specific measurements ranged from less than 10 to 99 cfu/mL and averaged 23.3 cfu/mL (see **Table 9-5**), which was significantly lower than the average

¹⁴ Chronic DO standard = Daily average no less than 4.8 mg/L

¹⁵ Acute DO standard = No less than 3.0 mg/L at any time

¹⁶ NYSDEC's standard for fecal coliform requires a minimum of 5 samples per month in order to determine whether a site meets the monthly geometric mean designated as the standard for the appropriate water quality classification.

fecal coliform levels at Stations K5 and K5A in the western portion of Raritan Bay, and slightly higher than those at Station K6 in deeper waters to the southeast of Staten Island (see **Table 9-6**). In September, site-specific values ranged from less than 10 to 26 cfu/mL and averaged 7 cfu/mL (see **Table 9-5**), much lower than those at each Harbor Survey station (see **Table 9-7**).

Enterococcus

Enterococcus spp. is an indicator of fecal contamination in marine and fresh water, and high levels can be detrimental to primary contact uses, such as swimming and other recreational activities. NYSDEC has not established water quality standards for enterococcus in Class SA waters, but USEPA provides recommendations for safe enterococcus levels for human contact and swimming under its RWQC. According to USEPA, primary contact recreation use is protected when the geometric mean for enterococcus does not exceed 35 cfu/100mL (the Bathing Standard) calculated over a 30-day period. All three Harbor Survey stations were well within the Bathing Standard for the full 15-year period: the geometric means for 1999–2014 were 4.6, 3.6, and 1.7 cfu/100mL for Stations K5, K5A, and K6, respectively. At Station K5, enterococcus measurements ranged from 1 to 1,110 cfu/100mL and averaged 30 cfu/100mL. At Station K5A, readings ranged from 1 to 2,360 cfu/100mL and averaged 33 cfu/100mL. At Station K6, enterococcus ranged from <1 to 1,750 cfu/100mL with an average of 10 cfu/100mL (see **Table 9-4**). Enterococcus was not included in site-specific measurements for the study area.

Secchi Transparency

Secchi transparency is a measure of surface water clarity. Reduced transparency (less than 5 feet) is typically due to high suspended solids concentrations or plankton blooms, leading to light-limiting conditions and affecting primary productivity and nutrient cycling (NYCDEP 2012). Secchi depths at the Harbor Survey stations generally increased from west to east, ranging from 0.5 to 9.5 feet at Station K5 near the mouth of the Arthur Kill, with an average of 4.2 feet; ranging from 0.5 to 10 feet at Station K5A in Raritan Bay near the mouth of the Raritan River, with an average of 4 feet; and ranging from 1.5 to 14 feet, with an average of 4.6 feet at Station K6 closest to the Atlantic Ocean (see **Table 9-4**). Transparency at these stations was slightly lower than that seen in the Lower New York Bay on a whole (NYCDEP 2012). Site-specific secchi depths taken within the study area in June and September of 2015 were lower than those for the Harbor Survey sites in June and about the same as the Harbor survey sites in September (see **Tables 9-6 and 9-7**). Secchi depth at the project location in June 2015 ranged from 1.7 to 3.6 feet with an average of 2.7 feet; in September, depths ranged from 3.5 to 6.2 feet with an average of 4.6 feet (see **Table 9-5**).

Ammonia

Ammonia (NH_3) is a contributor to total nitrogen in water; and is included in measurements of Total Kjeldahl Nitrogen (TKN), comprised of the total concentrations of organic nitrogen and ammonia) and can also be measured as a separate parameter. Ammonia concentrations recorded at the Harbor Survey stations decreased from west to east. At Station K5, ammonia ranged from 0 to 2,460 $\mu\text{g}/\text{L}$, with an average of 434.9 $\mu\text{g}/\text{L}$; ammonia at Station K5A ranged from 0 to 2,600 $\mu\text{g}/\text{L}$, with an average of 392.8 $\mu\text{g}/\text{L}$; ammonia at Station K6 ranged from 0 to 1,920 $\mu\text{g}/\text{L}$ and averaged 225.9 $\mu\text{g}/\text{L}$ (**Table 9-4**). At Station K5 at the mouth of the Arthur Kill, ammonia exceeded the chronic standard¹⁷ in 86 percent of samples and exceeded the acute standard¹⁸ in 72

¹⁷ Chronic ammonia standard = 35 $\mu\text{g}/\text{L}$

¹⁸ Acute ammonia standard = 230 $\mu\text{g}/\text{L}$

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percent of samples collected from 1999 to 2014. At Station K5A, ammonia exceeded the chronic standard in 85 percent of samples and exceeded the acute standard in 66 percent of samples. At Station K6, ammonia exceeded the chronic standard in 70 percent of samples and exceeded the acute standard in 34 percent of samples. Ammonia was not included in site-specific measurements for the study area.

Total Nitrogen

Excess nitrogen in water can promote algae growth and reduce DO levels. Nitrogen discharges have been identified as contributing to hypoxic events in certain parts of the Harbor in the summer months; however, wastewater treatment upgrades and improved wastewater effluent quality have led to a general downward trend for total nitrogen throughout the Harbor (NYCDEP 2012). Total nitrogen¹⁹ at the Harbor Survey station closest to the Atlantic Ocean (K6) was lower than Station 5 at the mouth of the Arthur Kill or Station K5A in Raritan Bay near the mouth of the Raritan River. Station K5 (Arthur Kill) ranged from 0 to 5.5 mg/L, with an average of 1.5 mg/L, and Station K5A (near mouth of Raritan River) ranged from 0 to 5.6 mg/L, with an average of 1.4 mg/L. Station K6, closest to the Atlantic Ocean, ranged from 0 to 3.6, with an average of 0.9 mg/L (**Table 9-4**). NYSDEC's narrative water quality standard for nitrogen states that nitrogen shall not be present in amounts that result in growths of algae, weeds, and slimes that impair the waters for their best usages. Total nitrogen concentrations recorded during site specific sampling within the study area in June and September were similar to those reported by the Harbor Survey. Total nitrogen at the project location in June 2015 ranged from 1.0 to 4.41 mg/L with an average of 1.72 mg/L; in September, total nitrogen at the site-specific locations ranged from 1.0 to 3.8 mg/L and averaged 1.61 mg/L (see **Table 9-5**). For both June and September, the site-specific measurements were lower than those reported for Harbor Survey Stations K5 and K5A in the western portion of Raritan Bay, but higher than measurements at Station K6 (see **Tables 9-6 and 9-7**).

Total Phosphorus

As with nitrogen, excess phosphorus in water can promote algae growth and reduce DO levels, leading to overgrowth of algae and primary producers, and eventually hypoxia. Total phosphorus concentrations at Station K5 near the mouth of the Arthur Kill ranged from 0.05 to 46.5 mg/L, with an average of 5 mg/L; at Station K5A in Raritan Bay near the mouth of the Raritan River, concentrations ranged from 0.07 to 76.7 mg/L, with an average of 4.9 mg/L; total phosphorus at Station K6 ranged from 0.05 to 61.4 mg/L and averaged 4.7 mg/L (see **Table 9-4**). NYSDEC's narrative water quality standard for phosphorus states that phosphorus shall not be present in amounts that result in growths of algae, weeds, and slimes that impair the waters for their best usages. Total phosphorus was not included in site-specific measurements for the study area.

Total Suspended Solids

TSS includes all particles suspended in water that will not pass through a filter. TSS absorbs sunlight, which can increase water temperature and decrease DO (NYCDEP 2012). Concentrations of TSS were greatest at Station K5A in Raritan Bay, followed by Station 5 at the mouth of the Arthur Kill and then K6. Station K5 ranged from 1 to 90.4 mg/L, with an average of 13.8 mg/L between 1999 and 2014. At Station K5A, TSS ranged from 0.5 to 117.4 mg/L, with an average of 14.5 mg/L; and TSS at Station K6 ranged from 0.3 to 105 mg/L, with an average of 15.5 mg/L (see **Table 9-4**). TSS measured at these stations was higher than that for the Lower

¹⁹ NYCDEP does not directly measure total nitrogen; however, total nitrogen can be derived by taking the sum of Total Kjeldahl Nitrogen (TKN), nitrite (NO₂), and nitrate (NO₃).

New York Bay region (NYCDEP 2012). Total suspended solids were not included in site-specific measurements for the study area.

Chlorophyll-a

Chlorophyll-a is used as an indicator of the health of an aquatic system's primary producers. Overgrowth of primary producers can indicate excess nutrients and eutrophication, which can lead to secondary impacts of reduced light penetration, low DO, and the formation of hypoxic zones (NYCDEP 2012). Concentrations of the plant pigment chlorophyll-a in water can be used to estimate productivity and the abundance of phytoplankton. Chlorophyll-a concentrations greater than 20 micrograms per liter ($\mu\text{g/L}$) are considered suggestive of eutrophic conditions (NYCDEP 2010). Chlorophyll-a levels are influenced by the prevalence of summer algal blooms in Raritan Bay, which receives waters from Arthur Kill and the Raritan River, both waterbodies with highly industrialized shorelines (NYCDEP 2012). Between 1999 and 2014, chlorophyll-a levels at Station K5 ranged from 0.90 to 198 $\mu\text{g/L}$, with an average of 11.7 $\mu\text{g/L}$. Station K5A ranged from 0.97 to 114 $\mu\text{g/L}$ and averaged 13.5 $\mu\text{g/L}$; Station K6 ranged from 0.93 to 94.7 $\mu\text{g/L}$ and averaged 16.4 $\mu\text{g/L}$ (see **Table 9-4**). These measurements are slightly higher than that of the Lower New York Bay as a whole, as described in the State of the Harbor Report (NYCDEP 2012). Chlorophyll-a was not included in site-specific measurements for the study area.

SEDIMENT QUALITY

Complex flow patterns between the Hudson River Estuary, Long Island Sound, Newark Bay, Upper New York Bay, Lower New York Bay, and Raritan Bay lead to widely variable sediment characteristics throughout the area. Suspended material is generally transported into the Lower Bay from the Hudson and Raritan Rivers (Brinkhuis 1980). Compared to elsewhere in the New York Harbor Complex, fine sediments from river, marine, and shoreline sources tend to accumulate at higher rates in dredged areas of the Upper Bay, Newark Bay, and Raritan Bay. Overall, bottom sediment of the Lower New York Bay, which includes Raritan Bay, comprises mostly coarse-grained sand with only 26 percent silt-clay (Adams et al. 1998). Flood and Ferrini (1998) found highly reflective surface sediments along the southern shore of Staten Island in Raritan Bay, which can be attributed either to the presence of methane gas bubbles in fine-grained sediments, or to the presence of coarse sediment at the surface in some areas.

Typical of any urban watershed, New York Harbor sediments are contaminated due to a history of industrial uses in the area. When compared to sediments of other coastal areas on the East Coast (from Cape Cod to the mouth of the Chesapeake Bay), the Harbor Estuary appears to be heavily and extensively contaminated (Adams et al. 1998). Mean sediment contaminant concentrations for 50 of 59 chemicals measured were statistically higher in the Harbor Estuary than in other coastal areas on the East Coast (Adams et al. 1998). The Lower New York Harbor receives contaminated sediments from industrial areas upstream, both in the Hudson River and along the north and west shores of Staten Island. Trends in contamination tend to follow trends in sediment characteristics, especially grain size and organic carbon content. In general, the percentage of fine sediment is somewhat proportional to sediment contamination concentrations (USACE 1999). This relationship is due to the higher surface-area-to-volume ratio and surface charges of fine sediments that cause them to accumulate more contaminants than coarse sediments (Power and Chapman 1995 in Adams et al. 1998).

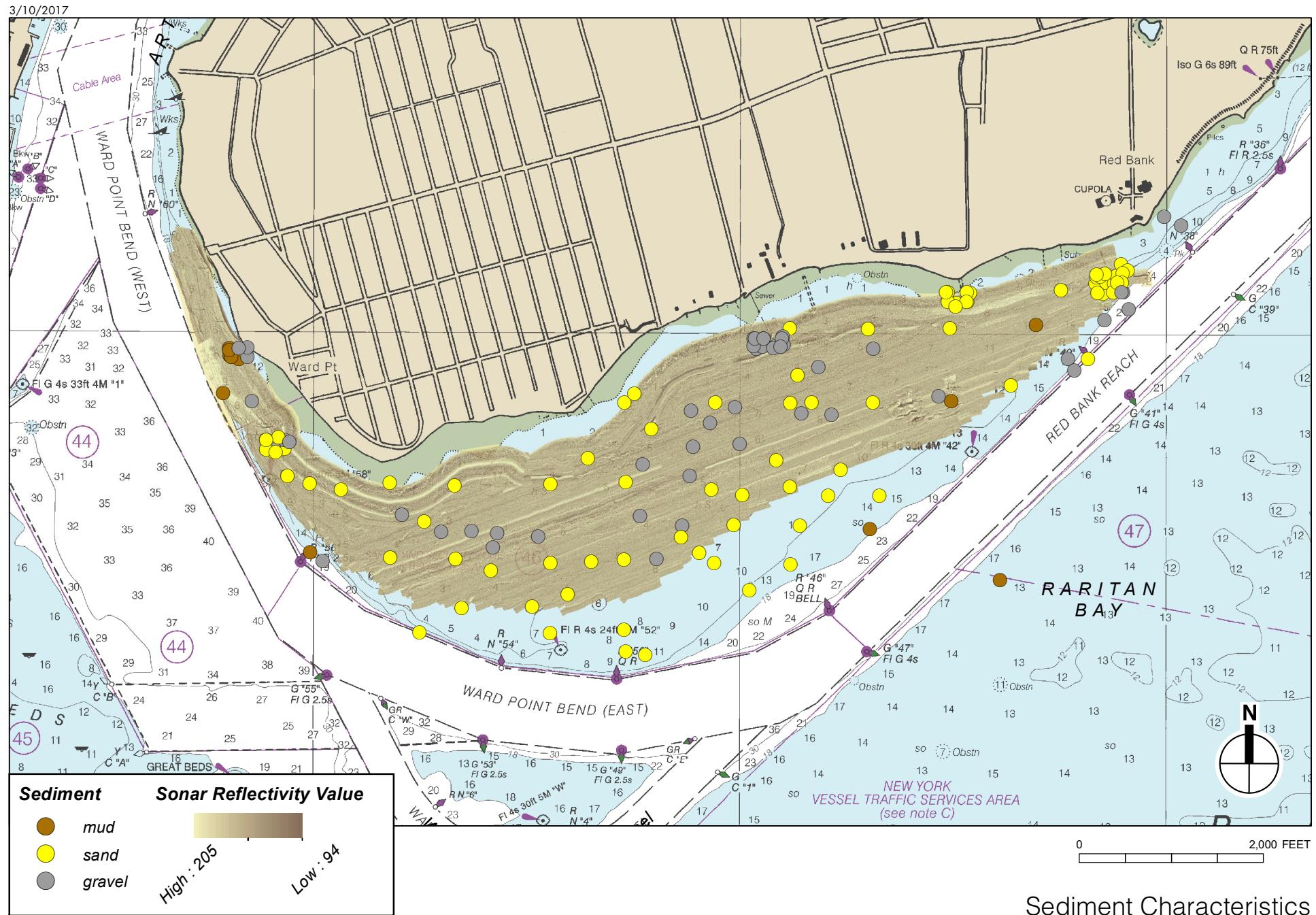
There is evidence that the level of contamination is decreasing in New York Harbor sediments, as older sediments tend to have higher contamination levels than material deposited more recently. Decreases in sediment contamination from 1960s levels have been documented in certain areas of

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the Harbor, while studies conducted in other areas have proved inconclusive (Bopp et al. 1997, NOAA 1995, USACE 1999). NOAA (1995) performed chemical analyses and reported the presence of trace elements, polycyclic aromatic hydrocarbons (PAHs), chlorinated pesticides, and other hydrocarbons. According to NOAA (1995), sediment toxicity was lower in portions of Lower New York Harbor and northern Raritan Bay and diminished southward and eastward toward the mouth of the estuary, especially in samples that were relatively high in sand content. Relatively high toxicity has been frequently observed in western Raritan Bay south of Staten Island. In western Raritan Bay, average and/or maximum concentrations of cadmium, chromium, copper, nickel, lead, and zinc exceeded Effects Range Median (ERM) values (identified as the 50th percentile of the data) (NOAA 1995). USACE (2004b) attributed sediment contamination in Raritan Bay to outflows from the Arthur Kill and Raritan River, as toxicity levels are generally highest in the western section of the Bay.

The results of the grain size and total organic carbon (TOC) content analysis conducted in conjunction with the benthic macroinvertebrate sampling within the study area in June and September of 2015 and 2017 (see **Appendix E-9**), and the side-scan sonar, hydrographic survey and grain size analysis conducted for the Breakwaters Project, indicate that sediments within the study area consist primarily of sand (small grain, 2mm [0.07 inch] to 0.063 mm [0.002 inch] diameter particles) with areas of gravel (large grain, 64mm [2.5 inch] to 2mm [0.07 inch] diameter particles) in the central portion of the study area and in the vicinity of hard-bottom features (hard/rocky bottom, greater than 64mm [2.5 inches] in size and including small cobbles to boulders and including breakwater structures and existing rock piles) (see **Figure 9-14**). Smaller areas of finer silty sand and mud (fine grain, less than 0.063 mm [0.002 inches] in diameter) also exist along the seaward edge of the study area near the navigation channel. Areas of coarse gravel exist along the western edge of the study area near the navigation channel and piles of rocks and debris occur near the shoreline. Areas of fine-grained silty sediment (i.e., mud) also occur off the southwest corner of Conference House Park and along the eastern portion of the study area. On average throughout the study area in both 2015 and 2017, more than 91 percent of the sediments were sand or gravel (i.e., small and large grain), with the remainder consisting of clay and silt (i.e., fine grain).

For the June 2015 samples, on average throughout the study area, sediments consisted mainly of coarse grained sand (28.1 percent) followed by medium-grained sand (25.5 percent), fine-grained sand (23.9 percent), gravel (16.8 percent); and silt and clay (less than 5 percent of samples). For the June 2017 survey, sediment samples showed similar results, consisting mainly of sand (82.9 percent), followed by gravel (8.0 percent), silt (7.1 percent), and clay (2.0 percent). TOC concentrations in the June 2015 and 2017 samples were generally below 1 percent. In 2015, concentrations ranged from 0.1 to 4.2 percent with a mean of 0.6 percent, and in 2017, ranged from 0.1 to 3.0 percent with a mean of 0.4 percent. For the September 2015 samples, on average throughout the study area, sediments consisted mainly of sand (total of 80.2 percent comprising coarse-grained sand [27.3 percent]] followed by medium-grained sand [26.8 percent], and fine-grained sand [26.1 percent], and gravel (12.9 percent); silt and clay together accounted for less than approximately 9 percent of samples. In September 2017, sediments consisted mainly of sand (84 percent), followed by gravel (10.5 percent), silt (4.4 percent), and clay (1.3 percent). Similar to the June 2015 sampling event, TOC in September 2015 were generally less than 1 percent, ranging from 0.1 to 3.7 percent with a mean of 0.5 percent. Two stations had TOCs of 3.7 percent and four stations had TOCs between 1 and 3 percent. In September 2017, TOC concentrations ranged from 0 to 1.7 percent with a mean of 0.3 percent. As in June, the majority of TOC samples were less than 1 percent. Only 7 stations had TOC concentrations between 1 and 1.7 percent.



Sediment Characteristics Side-Scan Sonar and Benthic Grabs

Figure 9-14

Sediment samples were collected at 30 locations (see **Figure 9-4** in 2015 where clams were collected for the purpose of contaminant analysis (see **Appendix E-4**). The results of the sediment analysis were compared to three sets of standards: NYSDEC 6 NYCRR Part 375 thresholds for unrestricted use and the protection of groundwater (see **Appendix E-9**), and Technical and Operational Guidance Series (TOGS) 5.1.9, *In-water and Riparian Management of Sediment and Dredged Material, 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 9-8**).

Table 9-8
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).

Source: NYSDEC 2004

In general, sediment samples indicated low levels of contamination that were generally at concentrations considered Class A. No Class C concentrations of contaminants were collected. Class B concentrations of arsenic, copper, lead, mercury, the sum of DDT, DDE, and DDD, and the sum of PAHs were generally concentrated at the southwest tip of Staten Island, off the southwestern portion of Conference House Park. Additionally, one sample location within Raritan Bay, south of Conference House Park, contained Class B concentrations of biphenyl, and two sample locations in Raritan Bay close to the shoreline and east of Page Avenue contained Class B concentrations of mercury. The pesticides aldrin, dieldrin, 4,4'-DDD, 4,4'-DDE, and 4,4'-DDT were not detected in the samples but when one half of the reporting limits that were achieved for each of these parameters was used as the concentration, all sites exceeded the Part 375 thresholds for unrestricted use. The contaminant 4,4'-DDD was only detected at one site west of Staten Island, and 4,4-DDE was detected at two sites west of Staten Island. Total chromium was detected at each site sampled and exceeded the Part 375 threshold for unrestricted use.

The sediment samples collected off the southwestern tip of Staten Island near Conference House Park, in the vicinity of the western terminus of Clermont Avenue, contained elevated levels of arsenic, chromium, copper, lead, mercury, zinc, and the sum of DDTs. Sediments sampled in this location during the benthic macroinvertebrate sampling generally had higher concentrations of silt and clay (approximately 50.6 percent), and lower concentrations of sand and gravel. Class B levels of arsenic were detected in samples 2014_19, HB06_11, and HB06_12; the HB06_11 sample concentration exceeded the unrestricted use threshold. In addition to the site-wide exceedances of the unrestricted use threshold for total chromium, concentrations of total chromium in samples 2014_19, HB06_11, and HB06_12 also exceeded the protection of groundwater threshold. Class B levels of copper were detected in samples 2012_19, HB06_11, and HB06_12; concentrations in each of these samples also exceeded the unrestricted use threshold. Class B levels of lead were detected in 2012_19, HB06_11, and HB06_12; the concentrations in the HB06_11 sample also exceeded the unrestricted use category. Class B levels of mercury were detected in 2012_9, 2013_28, 2014_19, 2071_12, HB06_11, and HB06_12; concentrations in each of these samples

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also exceeded the unrestricted use threshold. The unrestricted use threshold for zinc was exceeded at 2014_19, HB06_11, and HB06_12. Class B levels of the sum of DDTs were detected at HB06_11 and HB06_12. While all samples west of Staten Island indicate exceedances of the DDD and DDE thresholds, concentrations of 4,4' DDD where only detected in sample HB06_11 and concentrations of 4,4' DDE were only detected in samples HB06_11 and HB06_12.

On the southwest tip of Staten Island, off Conference House Park but farther south in the vicinity of the western terminus of Billip Avenue, sediment samples contained elevated concentrations of total chromium, copper, mercury, and total PAH were detected at one site – 1438_23. Copper, mercury, and PAH were detected at Class B levels. Mercury exceeded the unrestricted use threshold and total chromium exceeded the unrestricted use and protection of groundwater standards.

In the sediments south of Staten Island, one sample (714_40) collected off-shore of Conference House Park contained a Class B concentration of total PCBs. Two samples (HB04_6 and HB04_7) collected east of Page Avenue contained Class B concentrations of mercury. The mercury concentration of HB04_7 also exceeded the unrestricted use threshold. Sample HB04_7 also had a total chromium concentration that exceeded the unrestricted use and protection of groundwater standards. Sediments sampled in this location during the benthic macroinvertebrate sampling generally were comprised of gravel and sand (95.8 percent).

AQUATIC BIOTA

Phytoplankton, Macroalgae, and Associated Epibenthic Fauna on Hard Bottom Areas

Diatoms, dinoflagellates, green algae, and blue-green algae are the most dominant groups of phytoplankton in the New York-New Jersey Harbor area (Hazen and Sawyer 1983, Brosnan and O’Shea 1995). From 1991–2000, surveys along the shorelines of Staten Island documented 94 phytoplankton taxa; the most frequently collected were *Nannochloris atomus*, *Skeletonema costatum*, *Rhizosolenia delicatula*, and dinoflagellates (*Peridinium* spp.) (NYCDEP 2007). Six species of phytoplankton that are associated with shellfish disease are widespread in the New York-New Jersey Harbor area, including *Pseudonitzschia pungens*, *Pseudonitzschia seriata*, *Dinophysis acuta*, *Dinophysis caudate*, *Prorocentrum micans*, and *Prorocentrum minimum*. However, these species typically only affect shellfish when they occur at very high concentrations or the shellfish are stressed from highly degraded habitat conditions, and no shellfish poisoning in the harbor is known to occur (NYCDEP 2007).

Benthic macroalgae are found in shallow waters of Raritan Bay. Common species in the New York-New Jersey Harbor area include brown algae (*Fucus* sp.) and sea lettuce (*Ulva lactua*) (Perlmutter 1971). These species have a particular affinity for hard substrates within the photic zone, and are frequent colonists of pilings, rocks, bulkheads and other structures. Rubble mound channel marker foundations in the study area were found to provide habitat for 8 species of macroalgae (SeArc 2015).

Hard-bottom macroalgae composition in the study area was characterized in hard bottom surveys conducted in July and September of 2015 (see **Figures 9-2a and 9-2b**). A total of 19 macroalgal taxa were identified from the 13 destructive samples collected in July; total biomass ranged from 0.02 to 2.69 grams and averaged 1.10 grams. A total of 16 macroalgal taxa were identified in the 15 destructive samples taken in September; total biomass ranged from 0 to 8.75 grams and averaged 1.80 grams. A total of 32 macroalgal and epibenthic faunal taxa were identified in the 23 composite images taken in July. The dominant species near the mouth of the Arthur Kill at the southwestern point of Staten Island were *Agardhiella* spp., a red branching algae, and *Ulva lactuca*, a sea lettuce. *Ulva* spp. and red filamentous algae were most abundant at sites farther east

along the southern edge of Staten Island. The July 2015 photograph analysis yielded four species of gastropods (*Littorina littorea*, *Urosalpinx cinerea*, *Ilyanassa obsoleta*, and *Eupleura caudate*), two species of sponges (*Microciona prolifera* and *Halichondria bowerbanki*), a species of anemone (*Diadumene leucolena*), and tunicate (*Molgula manhattensis*). In September 2015, 26 macroalgal taxa were identified in the 26 composite images. The red branching algae *Agardhiella* spp., *Ulva* spp., and red filamentous algae were the dominant taxa observed at two of the sites. The eastern-most site was dominated by bryozoans, encrusting sponges, and hydroids. The September 2015 photograph analysis also yielded three gastropods (*Urosalpinx cinerea*, *Eupleura caudate*, and *Crepidula* spp.), a species of bivalve (the hard clam *Mercenaria mercenaria*), an anemone (*Metridium senile*), and tube worms (*Serpulidea*). Benthic macroinvertebrates species are described in greater detail under “Hard Bottom Survey” in the “Benthic Macroinvertebrates” section of this chapter.

Zooplankton

Zooplankton are an important component of the food web of the New York-New Jersey Harbor area. These organisms feed on phytoplankton and decomposed material, and are a primary food source for bait fish such as bay anchovy (*Anchoa mitchilli*) and the early life stages of commercially and recreationally important fish such as striped bass (*Morone saxatilis*) and white perch (*Morone americana*). Copepods, rotifers, barnacle larva, mysid shrimp, and amphipods are among the most common groups of zooplankton in New York-New Jersey Harbor (Perlmutter 1971, Stepien et al. 1981, Hazen and Sawyer 1983, Lonsdale and Cosper 1994). Sampling from 1991–2000 by NYCDEP found 20 zooplankton taxa offshore from Staten Island, with the most dominant taxa being *Tintinnopsis* spp., nauplius stage copepods (*Copepoda* spp.), and *Eutreptia* spp. (NYCDEP 2007).

Benthic Macroinvertebrates

Benthic macroinvertebrates inhabit sediments and the surfaces of submerged, hard substrates such as rocks, pilings, or debris and often comprise important prey of recreational and commercial fish species found in the New York-New Jersey Harbor (Steimle et al. 2000). Common groups include aquatic earthworms (oligochaetes), segmented worms (polychaetes), snails (gastropods), bivalves (e.g., soft shell clam, dwarf surf clam, blue mussel, ribbed mussel and oyster), barnacles, amphipods, isopods, crabs, and shrimp. Overall, the benthic invertebrate community of the New York-New Jersey Harbor is generally considered to be largely composed of pollution-tolerant species (Adams et al. 1998). In accordance with 6 NYCRR Part 41: Sanitary Condition of Shellfish Lands, all shellfish lands in Richmond County are in such a sanitary condition that the shellfish are not to be taken for use as food and the waters off Richmond County are designated as uncertified.

Among the several studies of benthic invertebrates that have been conducted in the Lower Bay Complex of New York-New Jersey Harbor (comprising Lower Bay, Raritan Bay, and Sandy Hook Bay), 328 total species have been documented and the dominant taxonomic groups have been found to be polychaete worms (43 percent), crustaceans (31 percent), and mollusks (17 percent) (Cerrato 2006). At the mouth of Lemon Creek, a tidal tributary to Raritan Bay on the eastern side of Staten Island and near the study area, Goto and Wallace (2009) found benthic invertebrate biomass to be dominated by polychaetes, followed by bivalves, gastropods, crustaceans, oligochaetes, and insects. This area had a lower density (11,000 individual organisms/m²) and biomass (7.8 g/m²) of benthic invertebrates than several sampling stations in the Arthur Kill and

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its tributaries, but had significantly higher species richness²⁰ and diversity.²¹ Bivalve biomass, in particular, was significantly greater at the less degraded sites at Lemon Creek, on the Raritan Bay side of Staten Island, than in the Arthur Kill. Relative to the open waters of Raritan Bay, many parts of the Arthur Kill are highly polluted by industrial uses and wastewater treatment plant discharges, and in turn, the benthic community there is dominated by a few pollution-tolerant species that proliferate as a result of a release from predator pressure and interspecific competition (Goto and Wallace 2009).

The benthic community of Raritan Bay has been characterized as indicative of a polluted and stressed system, but not without some disagreement (Studholme 1988, Steimle and Caracciolo-Ward 1989, Cerrato 2006). Benthic habitat degradation and losses of mollusks and other benthic organisms in the Raritan Bay waters off Staten Island had been noted as early as 1920 (Jacot 1920), but a series of systematic surveys conducted in Raritan Bay and the rest of the Lower Bay Complex from 1957–1960 is the earliest, formally established baseline to which surveys in more recent times can be compared. A total of 127 benthic invertebrate taxa were documented during these baseline studies, with species richness at the sampling stations off of the southeastern shoreline of Staten Island, closest to the study area, ranging from 16 to 20 species. Soft clams and ampeliscid amphipods (*Ampelisca abdita* and other *Ampelisca* spp.) were universally the most abundant throughout the survey region at the time.

Replication of the surveys in 1973 found significant reductions in richness and abundance; only 78 taxa were documented and abundance was one fourth of that found from 1957–1960. Soft clams in particular were far less abundant than before, and ampeliscid amphipods (a group that is sensitive to pollution) were nearly absent. At the stations closest to the study area, species richness ranged from 7 to 13. These findings were interpreted as an indication that water quality and other habitat characteristics in the Lower Bay Complex, which includes Raritan Bay, had further declined since the first survey in the late 1950's. However, only 4 years later, in 1977, 126 taxa were found and the relative abundance of mollusk, crustacean, and polychaete species was similar to what had been observed in the late 1950's, although the ampeliscid amphipods were still largely absent. Additionally, a reanalysis of the data from 1957–1960 and 1973 conducted by Steimle and Caracciolo-Ward (1989) concluded that the stark decline in richness and abundance between those surveys could be largely attributed to naturally high annual variation and inconsistent sampling seasons, and was questionable as evidence of a true pollution trend. Most notably, it was pointed out that the decline in total benthic invertebrate abundance was primarily driven by the ampeliscid amphipods, which are most abundant during summer and least abundant during winter; the 1957–1960 surveys were conducted only in the summer, likely leading to an overestimate of abundance, whereas the surveys in 1973 were conducted across all four seasons (Steimle and Caracciolo-Ward 1989). A more recent meta-analysis also found that decadal trends in benthic invertebrate community composition and abundance in the Lower Bay Complex since the surveys of the late 1950's are clouded by problems caused by high annual variability and inconsistencies in sampling locations, sampling seasons, gear types, and methods of taxonomic classification (Cerrato 2006).

Nonetheless, throughout the time period of the late 1950s to the mid-1990s analyzed by Cerrato (2006), many of the same benthic invertebrate species have remained consistently common and widespread in the Lower Bay Complex, and the community as a whole continues to be representative of most coastal regions of the northeastern and mid-Atlantic U.S. Recent surveys

²⁰ Species richness is the number of different species represented in an ecological community, landscape or region.

²¹ Species diversity is the number of different species that are represented in a given community (a dataset).

have supported the results of the earlier baseline and replicated surveys and have found that in recent years, *Ampelisca* amphipods have largely disappeared from Sandy Hook Bay, south of Raritan Bay; no *Ampelisca* were found in a survey completed in August 2014 (personal communication with Clyde MacKenzie, NOAA, April 24, 2015).

Overall, the benthic community of the Lower Bay Complex can be broadly categorized into a northern and southern half based on this distribution of muddy sediments to the south and sandy sediments to the north. The benthic community in the Lower Bay Complex, naturally experience large seasonal fluctuations in composition such that the relative abundance of species is often different from season to season as well as year to year. Yet, on a decadal time scale from the earliest surveys in the late 1950's to the more recent surveys in the 1990's, community composition has remained rather consistent (Cerrato 2006).

Soft Bottom Survey

Benthic grab sampling was conducted within the study area during June and September 2015 (see **Figures 9-3a and 9-3b**) and again during June and September 2017 (see **Figures 9-3c and 9-3d**) to characterize the benthic invertebrate community in Raritan Bay in the vicinity of the Breakwaters Project (see **Appendix E-4**).

2015 Survey. In 2015, a total of 184 benthic invertebrate taxa were collected from 120 grab samples, with 83 taxa representing 99 percent of all individuals. The six most abundant soft-bottom taxa represented 71 percent of all individuals. Two taxa, the amphipods *Unciola serrata* and *Grandidierella japonica*, were also found in the hard-bottom habitat. Taxonomic richness and total abundance of benthos was greater in June ($n = 157$ taxa, 109,452 individuals) than September ($n = 136$ taxa, 86,748 individuals).

In June, the majority (95 percent) of the benthic community comprised 30 taxa, largely represented by the polychaete worm *Mediomastus ambiseta* (33 percent), the amphipod *Unciola serrata* (11 percent), oligochaete worms (10 percent), and the polychaete worm *Polydora cornuta* (7 percent). Other common taxa included fifteen polychaete worms (21 percent), four gastropod snails (6 percent), four amphipods (4 percent), and three bivalve clams (2 percent). Forty-eight unique taxa were collected during the June sampling event, 18 of which were collected at abundances of 10 or more individuals.

In September, fewer taxa ($n = 23$) comprised the majority and the dominant taxa included *M. ambiseta* (40 percent), oligochaete worms (17 percent), the polychaete worm *Streblospio benedicti* (14 percent), and the amphipod *Grandidierella japonica* (4 percent). Ten polychaete worms (10 percent), six amphipods (6 percent), two gastropod snails (2 percent), and one species of bivalve clam (1 percent) were also among the majority. Twenty-seven unique taxa were collected during the September sampling event, 8 of which were collected at abundances of 10 or more individuals.

2017 Survey In 2017, a total of 193 benthic invertebrate taxa were collected from 120 grab samples, with 72 taxa representing 99 percent of all individuals sampled. The six most abundant soft-bottom taxa represented 72 percent of all individuals. Taxonomic richness of benthos was similar in June ($n = 158$ taxa) and September ($n = 155$ taxa); however total abundance was twice as great in June (126,616 individuals) compared to September (74,399 individuals).

In June, the majority (95 percent) of the benthic community comprised 21 taxa, largely represented by the polychaete worms *Streblospio benedicti* (29 percent) and *Mediomastus ambiseta* (25 percent), oligochaete worms (12 percent), the amphipod *Ampelisca abdita* (7 percent), and the polychaete worms *Hypereteone heteropoda* (4 percent) and *Polydora cornuta* (4 percent). Other common taxa included ten polychaete worms (12 percent), two amphipods (1 percent), two

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bivalve clams (1 percent), and a shrimp (0.5 percent). Thirty-eight unique taxa were collected during the June sampling event, seven of which were collected at abundances of 10 or more individuals.

In September, a greater number of taxa comprised the majority (38 taxa) and the dominant taxa included *M. ambiseta* (23 percent), oligochaete worms (21 percent), the polychaete worm *Streblospio benedicti* (8 percent), and the polychaete worm *Sabellaria vulgaris* (5 percent). Seventeen polychaete worms (18 percent), twelve amphipod taxa (14 percent), three gastropod snails (3 percent), two isopods (1 percent), and one species of bivalve clam (2 percent) were also among the majority. Thirty-five unique taxa were collected during the September sampling event, seven of which were collected at abundances of 10 or more individuals.

Seasonal differences between June and September explained the largest source of variation in the benthic invertebrate community during 2015 (Global R = 0.67, p = 0.001) and 2017 (Global R = 0.59, p = 0.001). Annual differences were also observed (Global R = 0.46, p = 0.001). In terms of benthic habitat, statistically significant differences were observed among sediment types (i.e., mud, sand, and gravel) during 2015 (Global R = 0.30; p = 0.001) and 2017 (Global R = 0.23, p = 0.004), but were less important than the seasonal and annual effects in explaining differences in community composition and abundance.

During 2015, the greatest difference in benthic community structure was observed between gravel and mud substrates (R = 0.74, p = 0.001), but significant differences were also apparent between sand and mud (R = 0.36, p = 0.001) and between sand and gravel (R = 0.24, p = 0.001). During 2017, benthic assemblages were again significantly different between sand and mud (R = 0.33, p = 0.001); the sample size for gravel substrates was too small for analysis (n = 4).

In general, gravel substrates had higher abundances of most benthic invertebrate taxa than sand and mud substrates. Sand and gravel substrates had similar species composition but benthic taxa were found at similar or lower abundance in sand compared to gravel substrate. Mud substrates had higher abundances of just a few dominant taxa compared to sand substrates; most taxa were more abundant in sand relative to mud.

Sand and gravel substrates were characterized by many of the same benthic taxa, though abundances were similar or lower in sand; these included eight polychaete worm taxa (*E. sanguinea*, *O. longocirrata*, *C. venefica*, Cirratulidae, *Polycirrus* sp., Glyceridae, *H. imbricata*, *Glycera dibranchiata*), two amphipod taxa (*U. serrata*, *G. japonica*), the bivalve mollusk *C. fornicata*, and oligochaete worms. These taxa were less abundant in mud substrates. The benthic assemblage associated with sand substrates was distinguished from that of gravel substrates by greater abundances of the bivalve clam *Gemma gemma*, and two polychaete worms (*C. venefica*, Glyceridae), which were more abundant in sand than in gravel.

Mud substrates had high abundances of four polychaete worms (*M. ambiseta*, *S. benedicti*, *P. cornuta*, *H. heteropoda*), two amphipods (*A. abdita*, *G. japonica*), and two gastropod snails (*Tritia obsoleta*, *Boonea bisuturalis*) compared to sand substrates; however, the majority of benthic taxa were found in relatively low abundance in mud substrates. In contrast, sand substrates had higher abundances of oligochaete worms and eleven polychaete worm taxa compared to mud substrates. In summary, the benthic invertebrate community in Raritan Bay in the vicinity of the project consisted of 241 taxa characterized by a diverse range of polychaete and oligochaete worms, amphipods, and gastropod and bivalve mollusks. Over the course of the two-year sampling effort, three dominant benthic taxa represented the majority (59 percent) of all individuals collected: two polychaete worms (*Mediomastus ambiseta* and *Streblospio benedicti*) and oligochaete worms

were the most abundant species collected during each sampling event. Several other dominant taxa included six species of polychaete worms (*Polydora cornuta*, *Hypereteone heteropoda*, *Eumida sanguinea*, *Caulieriella venefica*, *Sabellaria vulgaris*, *Heteromastus filiformis*) and three amphipod species (*Ampelisca abdita*, *Unciola serrata*, *Grandidierella japonica*). The species composition and abundance of the benthic community varied most between seasons and years and less among mud, sand, and gravel substrates.

Hard Bottom Survey

Hard bottom surveys were conducted in July and September of 2015, but were not repeated in 2017, (see **Figures 9-2a and 9-2b**, respectively; see **Appendix E-4**) to characterize benthic communities at five locations within the study area where the results of the hydrographic survey indicated rock piles. The surveys included sampling of algal biomass and invertebrate population density, and evaluation of photographs and underwater video where feasible; algal biomass and photograph analysis results are discussed above under “Phytoplankton, Macroalgae, and Associated Epibenthic Fauna on Hard Bottom Areas.” Sampling points in July included two sites at the southwestern tip of Staten Island (western sites) and three sites spaced at relatively even intervals off the southern coast from Joline Avenue to Butler Manor Woods to Kenny Road (eastern sites). Sampling points in September were slightly different, with a third site at the southwestern tip of Staten Island along the Arthur Kill and two points south of Butler Manor Woods and Kenny Road.

The hard substrate at the July and September sampling points were composed mainly of large rocks, though some sand, gravel, and cobble occurred at the western sites. Photographs showed high concentrations of suspended material in the western sampling points during both summer and fall sampling events. More macroinvertebrate species and individuals were found in the July compared to the September, but species abundance was more evenly distributed and a higher number of discrete taxa were found in the September. Overall, samples consisted mainly of pollution-tolerant macroinvertebrate species.

During hard-bottom sampling, 115 total epifaunal taxa and approximately 26,000 individual organisms were observed. Overall, 55 taxa represented 99 percent of all individuals and the top six most abundant hard-bottom taxa represented 72.8 percent of all individuals. Three of those taxa (yellow-highlighted) were also found in the soft-bottom habitat. *Amphibalanus improvisus* was the dominant hard-bottom species, accounting for 43 percent of all taxa observed. Nine other taxa were abundant and represented 2 percent to 9 percent of all individuals, including *Apocorophium acutum*, *Sabellaria vulgaris*, *Caprella penantis*, *Monocorophium insidiosum*, *Urosalpinx cinerea*, *Ampithoe valida*, *Petricolaria pholadiformis*, *Ilyanassa obsoleta*, *Microdeutopus gryllotalpa*. Collectively these ten taxa made up 83 percent of the hard-bottom community. Twenty-five taxa were frequently observed (i.e., in at least 50 percent of samples); those taxa represented 93 percent of the hard-bottom community and included the ten most abundant taxa. The majority of hard-bottom taxa (i.e., 72 species) were observed infrequently, in less than 25 percent of samples. A subset of 46 taxa, which composed 98.8 percent of the community, was retained for the analysis of community similarity among hard-bottom sites.

A total of 21,000 macroinvertebrate organisms, classified into 81 discrete taxa from 53 families, were found in 13 quadrat samples taken during July. Abundance averaged 1,613 individuals and 27 species per sample (1/16 square meter). Species diversity was highest at the sampling point south of Butler Manor Woods on the southern coast. Of the phyla encountered at all sites, arthropods made up the greatest proportion of species, followed by mollusks, annelid worms, and all other phyla combined. Averaging across all samples, the barnacle *Amphibalanus improvisus*

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was the most abundant organisms, followed by the polychaete *Sabellaria vulgaris*, and amphipods *Caprella penantis*, *Apocorophium acutum*, and *Monocorophium insidiosum*; these five taxa accounted for at least 75 percent of the total abundance.

In September, a total of 5,000 organisms of 91 discrete taxa from 63 families were counted in 15 quadrats sampled from the hard bottom sites. Abundance averaged 327 individuals and 25 species per sample. Species diversity was highest at the western site closest to shore. As in the summer sampling event, arthropods made up the greatest proportion of species, however, annelid worms were the second most common, followed by mollusks and all other species combined. Averaging across all samples, ten dominant taxa accounted for at least 75 percent of the total abundance, with the corophiidae amphipod *Apocorophium acutum* as the most abundant, followed by the polychaete *Sabellaria vulgaris*, caprellid amphipods *Caprella penantis* and *Paracaprella tenuis*, chordates, gastropods, polychaetes, and amphipods.

Seasonal differences in the species composition and abundance of the hard-bottom community were greater than those observed among hard-bottom sites within a season (PRIMER ANOSIM Global R = 0.92, p=0.001). However, there were also differences in the hard-bottom community among sites (Global R = 0.69, p=0.001). When comparing among sites, the hard-bottom community at Joline Avenue and Butler Manor Woods, in the middle of the study area, had the greatest similarity observed at any of the sites (greater than 60 percent similarity in 5 of the 7 samples) and was not significantly different between the two sites (ANOSIM R = 0.09, p=0.37). In contrast, the hard-bottom community at the two most distantly separated sites (i.e., at the Arthur Kill and at Kenny Road had significantly different assemblages of invertebrates from one another (ANOSIM R = 0.99, p=0.003). In most cases, the hard-bottom community at these sites was approximately 40 percent to that observed at the two middle sites at Joline Avenue and Butler Manor Woods.

In terms of species richness, the two easternmost hard-bottom sites had 19 and 22 different common taxa (i.e., those that made up 90 percent of all organisms), which was the highest richness observed in hard-bottom habitat in the study area. The other eastern site at Jolene Woods had the lowest richness with 14 taxa. The two western hard-bottom sites along the Arthur Kill had 16 to 18 different taxa. The Arthur Kill site had the lowest abundances of most taxa compared to the other sites (average abundance of 2.2 organisms per sample), while the adjacent site to the south had moderate abundances (4.3 organisms per sample). Similarly, moderate abundances were observed at the two easternmost sites (3.1 to 3.9 organisms per sample, while the highest average abundances were recorded at the Jolene Woods site (8.1 organisms per sample).

In general, gastropods, amphipods and polychaete worms represented the majority of the hard-bottom assemblage at all five hard-bottom sites, though the species composition varied among sites. Amphipods were the dominant invertebrate taxon at hard-bottom sites, with nine taxa being most commonly observed. The amphipod, *Apocorophium acutum*, was found at all five hard-bottom sites. One species of barnacle was relatively more abundant at the three sites along the eastern side of the study area but not among the common taxa at the two sites along the Arthur Kill.

While the hard- and soft-bottom habitats sampled were characterized by distinct communities of benthic invertebrates, several species were found in both habitats. Co-occurrence of species in each of these habitats is not unexpected because they are both components of the benthic habitat mosaic of Raritan Bay. Overall, 26 benthic invertebrate taxa were found in both soft- and hard-bottom habitats. Amphipods, gastropod snails, and polychaete worms comprise 22 of the taxa that represented 21 percent of the soft-bottom community and 35 percent of the hard-bottom community.

SeArc Study Results

In September 2015, SeArc Ecological Marine Consulting conducted a study of structured habitat (i.e., pier piles and underwater rock piles) in the study area to better inform the design process of the Living Breakwaters project. This “Adjacent Artificial Habitats” survey (see **Appendix E-5**) established a baseline characterization of the fouling communities²² inhabiting artificial structures in the vicinity of the Proposed Actions. The survey revealed a total of 43 taxa of algae, invertebrates, fish, and birds in the vicinity of the sampling locations. Shallow areas were dominated by algae while deeper water was dominated by polychaetes. The average dry weight of fouling communities scraped from the artificial substrates surveyed was up to 1 kilogram per meter squared (kg/m^2) and consisted of 75 percent inorganic material and 25 percent organic material. These results suggest that local structured habitat attracts several species found in the survey such as barnacles, tube worms, and oysters known for their significant calcium carbonate deposition. The youngest site surveyed was only 2.5 years old and yet had comparable dry weight values to older sampling locations, suggesting that deposition rates in the study area are comparable to other temperate regions.

Clam Tissue Analysis

As part of the benthic macroinvertebrate sampling, hard clam (*Mercenaria mercenaria*) were collected in September 2015 at 30 of the 60 benthic sampling stations (see **Figure 9-4**), chosen by divers as those locations most likely to support hard clam populations. Six to twelve clams were collected at each location in order to provide sufficient tissue for contaminant analyses for metals and organics to serve as baseline tissue concentrations. A total of 231 clams were collected via diver, clam rake, and van Veen grab. An additional 63 hard clams were found in the 60 macroinvertebrate grab samples collected during the September 2015 survey. Overall, clams ranged in size from 44 to 95 mm with an average length of 73 mm. Hard clams were widely distributed in the study area with mean densities of 26.3 per square meter (see **Figure 9-15**); small specimens less than one centimeter in length were collected in higher numbers than larger specimens in macroinvertebrate grab samples. **Table 9-9** summarizes the results of the tissue analysis.

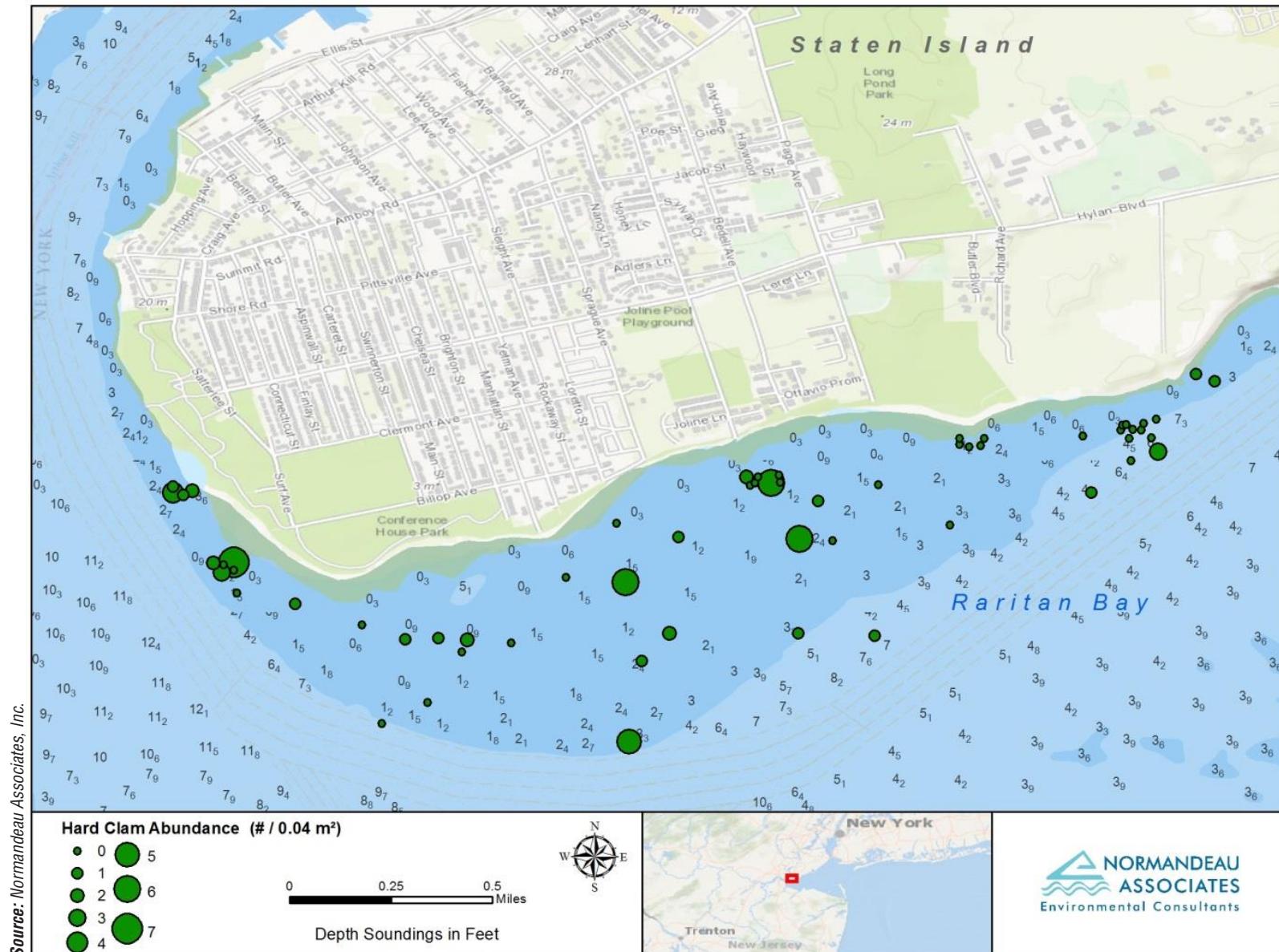
Horseshoe Crabs

Horseshoe crab eggs surveys were conducted along the beach in the study area approximately between Swinnerton Street and Page Avenue in June 2015 and July 2017 (see **Figure 9-5**). During the June 2015 survey, horseshoe crab eggs were found in only 3 of the 24 cores. The numbers of eggs in these 3 cores were highly variable at 5, 7, and 105. This extrapolates to densities of 3125, 4375, and 65625 eggs/ m^2 , respectively. Among all 24 cores, including the 21 cores with no eggs, egg density within the survey area averaged 3047 eggs/ m^2 (± 13372 SD). Three adult horseshoe crabs were observed on the beach on the day of the June survey, presumably about to lay eggs near the high tide line on the segment of beach near Swinnerton Street, near Brighton Street in between the interim dune and the current water line, and near the intersection of the Surf Avenue trail with the beach. Six dead horseshoe crabs were also observed throughout the survey area.

In June 2017, horseshoe crab eggs were found in only 4 of the 60 cores taken. The numbers of eggs in these cores were highly variable: 1, 2, 5, and 524. This extrapolates to densities of 32, 64, 159, and 16,688 eggs/ m^2 . Among all 60 cores, including the 56 cores that did not contain eggs, egg density within the survey area averaged 282 eggs/ m^2 ($\pm 2,154$ SD). The sample with the

²² Fouling communities are communities of organisms found on artificial surfaces such as the sides of docks, marinas, piers, and boats.

1.25.17



Hard Clam Abundance per Sample in Macroinvertebrate Grab Samples
September 2015

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highest number of eggs was located at the westernmost sampling point at the high tide line. All but one sample containing eggs were located approximately between Carteret Street and Brighton Street; the other was located at Joline Avenue. Beach substrate within this section of beach was primarily sandy, compared to the rockier beach substrate to the east. The beach is also wider with a gentle slope compared to areas west of Manhattan Street, where the beach is narrower with rocky substrate. No eggs were collected between Manhattan and Loretto Streets, where the one-time shoreline restoration would take place. During a visual survey at high tide on June 8, 2017, several horseshoe crab spawning pairs along with scattered males and females were seen between Swinnerton Street and Brighton Street, all at or near the high tide line; none were seen farther east during the survey. Significantly more spawning pairs were observed during a visual survey at high tide on June 7, 2017, within Conference House Park from Hylan Boulevard to Ward's Point, at the confluence of the Arthur Kill with Raritan Bay on the west-facing shore, and west of the egg sampling locations.

For comparison, horseshoe crab egg sampling on several beaches in Jamaica Bay using the same methodology found many beaches to have densities of over 4000 eggs/m², and in some cases, over 100,000 eggs/m². However, egg density was extremely spatially variable, ranging from no eggs on several beaches to a high of 287,748 eggs/m² on one beach (Botton et al. 2006). Horseshoe crab egg sampling on Long Island has also found egg density to be extremely variable both within and among beaches (Sclafani et al. 2009).

Table 9-9
Average Contaminant Concentration in Clam Tissue Samples

Parameter	Average Concentration
Dioxins / Furans (ng/Kg)	
1,2,3,4,6,7,8-HpCDD*	0.910
1,2,3,4,6,7,8-HpCDF*	0.297
1,2,3,4,7,8,9-HpCDF*	0.157
1,2,3,4,7,8-HxCDD*	0.134
1,2,3,4,7,8-HxCDF*	0.130
1,2,3,6,7,8-HxCDD*	0.186
1,2,3,6,7,8-HxCDF*	0.112
1,2,3,7,8,9-HxCDD*	0.148
1,2,3,7,8,9-HxCDF*	0.157
1,2,3,7,8-PeCDD*	0.150
1,2,3,7,8-PeCDF*	0.151
2,3,4,6,7,8-HxCDF*	0.134
2,3,4,7,8-PeCDF*	0.183
2,3,7,8-TCDD*	0.204
2,3,7,8-TCDF*	0.474
OCDD*	6.614
OCDF*	0.736
Total Hepta-Dioxins*	1.907
Total Hepta-Furans*	0.453
Total Hexa-Dioxins*	0.749
Total Hexa-Furans*	0.404
Total Penta-Dioxins*	0.348
Total Penta-Furans*	0.561
Total Tetra-Dioxins*	0.472
Total Tetra-Furans*	1.470
Metals (mg/Kg)	
Aluminum	51.333
Antimony*	0.013
Arsenic	12.664
Barium	1.640
Beryllium*	0.026
Cadmium	1.231
Calcium	7,213.667
Chromium	0.717
Cobalt	1.562
Copper	14.247
Iron	159.643
Lead	2.721
Magnesium	6,385.667
Manganese	247.980
Mercury	0.077
Nickel	5.014
Potassium	13,530.000
Selenium	2.583
Silver	3.473
Sodium	45,583.333
Strontium	93.670
Tin*	0.066
Titanium	0.725
Vanadium	0.640
Zinc	218.379
Organochloride Pesticides (µg/Kg)	
4,4'-DDD*	1.565
4,4'-DDE	-
4,4'-DDT	-

Table 9-9 (cont'd)
Average Contaminant Concentration in Clam Tissue Samples

Parameter	Average Concentration
Organochloride Pesticides ($\mu\text{g}/\text{Kg}$) (cont'd)	
Aldrin	-
alpha-BHC	-
alpha-Chlordane*	0.404
beta-BHC*	1.032
delta-BHC	-
Dieldrin	1.100
Endosulfan I	-
Endosulfan II	-
Endosulfan Sulfate	-
Endrin	-
Endrin Aldehyde	-
Endrin Ketone	-
gamma-BHC (Lindane)	-
gamma-Chlordane*	0.470
Heptachlor	-
Heptachlor Epoxide	-
Methoxychlor	-
Toxaphene	-
PCBs ($\mu\text{g}/\text{Kg}$)	
Aroclor 1016	-
Aroclor 1221	-
Aroclor 1232	-
Aroclor 1242*	6.340
Aroclor 1248	-
Aroclor 1254*	10.047
Aroclor 1260*	4.008
Semivolatile Organic Compounds / PAHs ($\mu\text{g}/\text{Kg}$)	
2-Methylphenol*	-
4-Methylphenol*	-
Acenaphthene*	1.110
Acenaphthylene*	1.160
Anthracene*	0.861
Benz(a)anthracene*	1.685
Benzo(a)pyrene*	-
Benzo(b)fluoranthene*	1.633
Benzo(g,h,i)perylene*	-
Benzo(k)fluoranthene*	-
Chrysene*	2.157
Dibenz(a,h)anthracene*	-
Dibenzofuran*	0.985
Fluoranthene*	4.131
Fluorene*	1.475
Indeno(1,2,3-cd)pyrene*	-
Naphthalene*	-
Pentachlorophenol*	8.950
Phenanthrene*	1.850
Phenol*	58.867
Pyrene*	5.762
Other (percent)	
Total Lipids	0.322
Total Solids	11.508

Notes:

* Includes estimated values

No measurements include outliers or values outside of acceptance limits

Sources: July and September 2015 Benthic Survey Results, Normandeau

Fishes

New York City is located at the convergence of several major river systems, all of which connect to the New York Bight portion of the Atlantic Ocean. This convergence has resulted in a mixture of habitats in the Harbor Estuary that supports marine fish, estuarine fish, anadromous fish (fish that migrate up rivers from the sea to breed in freshwater), and catadromous fish (fish that live in freshwater but migrate to marine waters to breed). The current fish community of Raritan Bay reflects both the diversity of habitats and historical influence of anthropogenic impacts in New York City and its surrounding aquatic and marine ecosystems. Raritan Bay is a component of a larger network of rivers, bays, sounds, and islands that collectively spans freshwater to near marine conditions known as the Hudson-Raritan Estuary (Briggs and Waldman 2002; Bain et al. 2007). The Hudson-Raritan Estuary is bounded by the mouths of the Hudson and Raritan rivers and the Atlantic Ocean off of New York and New Jersey, with Raritan Bay occupying the southwest section of the larger system. Historically, the Raritan Bay and surrounding estuarine and marine waters of coastal New York and New Jersey were spectacularly productive (Berg and Levinton 1985; MacKenzie 1990) supporting a wide variety of resident, migratory, and transitory species with at least 338 fish species from 114 families residing in the region's marine waters (Briggs and Waldman 2002). While the diversity of habitats found in the Hudson-Raritan Estuary in part contributes to the richness of the local fish community, many more species make seasonal migrations to the system from both more northern and southern waters of the Atlantic Ocean (Briggs and Waldman 2002). The Raritan Bay fish community remains highly diverse; however, the abundance of many species has declined to low levels from overfishing, contaminant pollution, and lost or degraded habitat (MacKenzie 1990).

The New York State Department of Health²³ has placed fish consumption advisories for all waters surrounding New York City, including Raritan Bay due to the presence of contaminants found within the New York-New Jersey Harbor Estuary (i.e., PCBs, dioxin, and cadmium) that resident and seasonally present fish and shellfish can accumulate in their bodies. With the exception of Long Island Sound, the Atlantic Ocean, and the Lower New York Bay, women under 50 and children under 15 should not consume fish or shellfish from the waters surrounding New York City. For the rest of the population, specific advisories are issued by species.

The fish community of the Raritan Bay and neighboring waters includes prey species (e.g., bay anchovy, Atlantic menhaden, Atlantic silverside) that provide forage for higher-level predators in the ecosystem, species that support recreational and commercial fisheries (e.g., summer flounder, striped bass, winter flounder, bluefish), and those species protected under the Endangered Species Act such as Atlantic (Berg and Levinton 1985; MacKenzie 1990; USACE 2004a, ASSRT 2007; SSSRT 2010). Several scientific surveys have documented the spatial and temporal distribution of catches of Raritan Bay fish species (e.g., Berg and Levinton 1985; Steimle et al. 2000; USACE 2004a). In addition, fish surveys were conducted within the study area in June, July and September of 2015. **Table 9-10** lists freshwater, coastal, anadromous, and catadromous fish species caught in Raritan Bay and neighboring waters on the basis of these previous surveys and the more recent surveys conducted for the Breakwaters Project in 2015 and 2017, including a visual survey of the rubble mound channel marker foundations. Species that were caught in "project baseline" survey samples in 2015 are indicated in the "Observed within the Study Area in 2015" and "Observed within the Study Area and 2017" columns with the following sampling gear codes: B = beach seine, P = fish trap, T = trawl).

²³ <https://www.health.ny.gov/publications/6532.pdf>

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Table 9-10
Finfish Species with the Potential to Occur within the Study Area

Habitat	Common Name	Scientific Name	Observed within the Study Area in 2015	Observed within the Study Area in 2017
Anadromous	Alewife	<i>Alosa pseudoharengus</i>	B	
Catadromous	American eel	<i>Anguilla rostrata</i>	B	
Coastal	American sand lance	<i>Ammodytes americanus</i>		
Anadromous	American shad	<i>Alosa sapidissima</i>		
Coastal	Atlantic cod	<i>Gadus morhua</i>		
Coastal	Atlantic croaker	<i>Micropogonias undulatus</i>		
Coastal	Atlantic herring	<i>Clupea harengus</i>		
Coastal	Atlantic mackerel	<i>Scomber scombrus</i>		
Coastal	Atlantic menhaden	<i>Brevoortia tyrannus</i>	B, T	B, T
Coastal	Atlantic moonfish	<i>Selene setapinnis</i>		
Coastal	Atlantic needlefish	<i>Strongylura marina</i>		
Coastal	Atlantic silverside	<i>Menidia menidia</i>	B, T	B, T
Anadromous	Atlantic sturgeon	<i>Acipenser oxyrinchus</i>		
Freshwater, Coastal	Banded killifish	<i>Fundulus diaphanus</i>		
Coastal	Bay anchovy	<i>Anchoa mitchilli</i>	B, T	B, T
Coastal	Black sea bass	<i>Centropristes striata</i>	B, P	P, T
Anadromous	Blueback herring	<i>Alosa aestivalis</i>		
Coastal	Bluefin tuna	<i>Thunnus thynnus</i>		
Coastal	Bluefish	<i>Pomatomus saltatrix</i>	B	B, T
Coastal	Butterfish	<i>Peprilus triacanthus</i>		T
Coastal	Clearnose skate	<i>Raja eglanteria</i>		
Coastal	Cobia	<i>Rachycentron canadum</i>		
Coastal	Conger eel	<i>Conger oceanicus</i>		
Coastal	Crevalle jack	<i>Caranx hippos</i>		
Coastal	Cunner	<i>Tautogolabrus adspersus</i>		
Coastal	Fawn cusk eel	<i>Lepophidium cervinum</i>		
Coastal	Feather blenny	<i>Hypsoblennius hentz</i>		
Coastal	Fourbeard rockling	<i>Enchelyopus cimbricus</i>		
Coastal	Fourspine stickleback	<i>Apeltes quadratus</i>	B	B
Coastal	Four-spot flounder	<i>Paralichthys oblongus</i>		
Freshwater, Coastal	Gizzard shad	<i>Dorosoma cepedianum</i>		
Coastal	Goosefish	<i>Lophius americanus</i>		
Coastal	Grey snapper	<i>Lutjanus griseus</i>		
Coastal	Grubby	<i>Myoxocephalus aenaeus</i>		B, T
Anadromous	Hickory shad	<i>Alosa mediocris</i>		
Freshwater, Coastal	Hogchoker	<i>Trinectes maculatus</i>		B
Coastal	Inland silverside	<i>Menidia beryllina</i>		
Coastal	Inshore lizardfish	<i>Synodus foetens</i>		
Coastal	King mackerel	<i>Scomberomorus cavalla</i>		
Coastal	Lined seahorse	<i>Hippocampus erectus</i>	T	B, T
Coastal	Little skate	<i>Raja erinacea</i>		
Coastal	Longhorn sculpin	<i>Myoxocephalus octodecemspinosis</i>		
Coastal	Lookdown	<i>Selene vomer</i>		
Freshwater, Coastal	Mummichog	<i>Fundulus heteroclitus</i>	B	B
Coastal	Naked goby	<i>Gobiosoma boscii</i>		B, T
Coastal	Northern kingfish	<i>Menticirrhus saxatilis</i>	B, T	

Table 9-10 (cont'd)
Finfish Species with the Potential to Occur within the Study Area

Habitat	Common Name	Scientific Name	Observed within the Study Area in 2015	Observed within the Study Area in 2017
Coastal	Northern pipefish	<i>Syngnathus fuscus</i>	B, P, T	B, T
Coastal	Northern puffer	<i>Sphoeroides maculatus</i>	B	B, T
Coastal	Northern searobin	<i>Prionotus carolinus</i>	T	T
Coastal	Northern stargazer	<i>Astroscopus guttatus</i>	B	
Coastal	Oyster toadfish	<i>Opsanus tau</i>	B, T	B, P
Coastal	Pinfish	<i>Lagodon rhomboides</i>		B
Coastal	Planehead filefish	<i>Monacanthus hispidus</i>		
Coastal	Pollock	<i>Pollachius virens</i>		
Anadromous	Rainbow smelt	<i>Osmerus mordax</i>		
Coastal	Red hake	<i>Urophycis chuss</i>		
Coastal	Rock gunnel	<i>Pholis gunnellus</i>		
Coastal	Rough scad	<i>Trachurus lathami</i>		
Coastal	Sandbar shark	<i>Carcharhinus plumbeus</i>		
Coastal	Scup	<i>Stenotomus chrysops</i>	P, T	P, T
Coastal	Seaboard goby	<i>Gobiosoma ginsburgi</i>		
Coastal	Sheepshead minnow	<i>Cyprinodon variegatus</i>	B	B
Coastal	Short bigeye	<i>Pristigenys alta</i>		
Coastal	Silver hake	<i>Merluccius bilinearis</i>		
Freshwater, Coastal	Silver perch	<i>Bairdiella chrysoura</i>		
Coastal	Smallmouth flounder	<i>Etoropis microstomus</i>		
Coastal	Smooth dogfish	<i>Mustelus canis</i>		
Coastal	Spanish mackerel	<i>Scomberomorus maculatus</i>		
Coastal	Spiny dogfish	<i>Squalus acanthias</i>		
Coastal	Spot	<i>Leiostomus xanthurus</i>	B	
Coastal	Spotfin butterflyfish	<i>Chaetodon ocellatus</i>		
Coastal	Spotted hake	<i>Urophycis regia</i>		
Coastal	Striped anchovy	<i>Anchoa hepsetus</i>		
Anadromous	Striped bass	<i>Morone saxatilis</i>	B	B, P
Coastal	Striped cusk eel	<i>Ophidion marginatum</i>		
Coastal	Striped killifish	<i>Fundulus majalis</i>	B	B
Catadromous	Striped mullet	<i>Mugil cephalus</i>		
Coastal	Striped searobin	<i>Prionotus evolans</i>	B, T	
Coastal	Summer flounder	<i>Paralichthys dentatus</i>	I	I
Coastal	Tautog	<i>Tautoga onitis</i>	B, T	B, P, T
Anadromous	Three-spine stickleback	<i>Gasterosteus aculeatus</i>		
Coastal	Tidewater silverside	<i>Menidia peninsulae</i>		
Coastal	Tomcod	<i>Microgadus tomcod</i>	I	
Coastal	Weakfish	<i>Cynoscion regalis</i>	B	
Coastal	White hake	<i>Urophycis tenuis</i>		
Coastal	White mullet	<i>Mugil curema</i>	B	
Freshwater, Anadromous	White perch	<i>Morone americana</i>		B
Coastal	Windowpane	<i>Scophthalmus aquosus</i>	B, T	I
Coastal	Winter flounder	<i>Pseudopleuronectes americanus</i>	B, T	B, T
Coastal	Winter skate	<i>Leucoraja ocellata</i>		
Coastal	Yellowtail flounder	<i>Limanda ferruginea</i>		

Notes: Sampling gear codes: B = beach seine, P = fish trap, T = trawl

Boldface indicates those species identified as having EFH in the portion of Raritan Bay near the project site, or those species identified as NOAA Trust Species.

"Coastal" indicates species that most commonly occur in estuarine and/or marine waters.

Sources: Able and Studholme 1993, AKRF et al. 1998, Berg and Levinton 1985, LMS 2003a,b, Normandeau 2015a,b NYCDEP 2007, Steimle et al. 2000, USACE 2004a, Woodhead 1990, FishBase: www.fishbase.org; Florida Museum of Natural History: <https://www.flmnh.ufl.edu>.

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Habitats play a central role in defining ecological relationships between species. The collection of prey species varies among different habitat types, thus, the presence of predators depends, in part, on the available habitat for forage species (e.g., fish and invertebrates). This habitat-based link between predators and prey (i.e., trophic linkages) helps determine the collection of fish species in particular habitats of Raritan Bay and neighboring waters. Benthic invertebrates that reside in the sediments (e.g., bivalve mollusks, polychaetes, and some amphipods) are an important group of forage species for popular commercial and recreational fish species like winter flounder, scup, and spot (see Soft Bottom Survey; Steimle et al. 2000). Other predatory fish of Raritan Bay consume small invertebrates that live on the bottom sediments like sevenspine bay shrimp (*Crangon*), hermit crabs, Atlantic rock crabs, and lady crabs. Mysid shrimp, gammarid amphipods, and copepods that may move into the water column during the night form another suite of important prey species. Surveys of the benthic invertebrate community in the Hudson-Raritan Estuary conducted during June and September of 2015 showed that several of these important prey groups were found in the study area (see Soft Bottom Survey).

In addition, some Raritan Bay fish species are themselves important prey items, especially during early life stages. Examples include bay anchovy, rock gunnel, northern searobin, smallmouth flounder, goby, northern pipefish, lined seahorse, Atlantic menhaden, Atlantic herring, river herring and shads, silversides, juvenile weakfish, butterfish, and silver hake. Habitat characteristics determine the presence of fish forage species such as cunner, a species that prefers structures like piers, bridges, rip-rap, and even shellfish and seagrass beds (Steimle et al. 2000). Although cunner orient to structures, they are preyed upon by species that forage in more open habitats (e.g., summer flounder and skates) which suggests that cunner are vulnerable when away from the shelter of structure.

In order to better characterize the fish community within the study area, fish sampling was conducted during June, July, and September of 2015 and 2017 in the nearshore area of Raritan Bay immediately south of the Staten Island shoreline (see **Appendix E-4**). Seine nets were used to collect fish along the shorelines (2015 and 2017), while beam trawls (2015 only) and otter trawls (2015 and 2017) were used to collect the benthic/demersal and water-column fish species in deeper, nearshore areas. Fish traps were also used to compare use of existing hard structure by fish relative to open water areas lacking structure.

Shoreline fishes

Seine nets. Significantly greater abundances of fishes and crabs were collected in seine nets deployed along the shoreline in Raritan Bay in 2015 (29,249 individuals) compared to 2017 (8,395 individuals). This difference was the result of high abundances of Atlantic silversides collected during July and September 2015. When Atlantic silversides are excluded, total abundances were similar between years (2015: 2,684 individuals, 2017: 2,494 individuals). A total of 46 taxa were collected over the two years; species richness was greater during 2015 (37 taxa) compared to 2017 (29 taxa). Species richness during the sampling program ranged from 12 to 26 taxa per month. In 2015, fewer taxa were observed during June and richness increased significantly in July and September; richness was relatively consistent among months during 2017.

Atlantic silversides, Atlantic menhaden, striped killifish, bluefish, and winter flounder were dominant during both years and represented the majority of the catch in shore seines (2015: 60 percent, 2017: 92 percent). Relatively high abundances of tautog, northern kingfish, bay anchovy, white mullet, mummichog, and American eel were observed during 2015 and represented an additional 31 percent of all organisms (totaling 91 percent) collected in shore seines that year. During 2017, blue crab and northern pipefish were among the numerically abundant taxa collected

in shore seines, representing 4 percent of the catch (totaling 96 percent that year). Species evenness was greater in 2015 when more taxa occurred at moderate abundance compared to 2017; among those taxa were longwrist hermit crab, blue crab, weakfish, northern puffer, northern pipefish, jack crevalle, striped bass, black drum, and lady crab.

In 2015, total abundance was greatest during July as a result of high abundances of Atlantic menhaden, striped killifish, tautog, and northern kingfish along the shoreline, but relatively low during June and September. In 2017, greatest abundances were observed during June when Atlantic menhaden and bluefish were in high abundance; decreasing abundances of these species resulted in lower total abundances in July and September 2017. In terms of fish-community similarity, monthly differences were observed for seine collections (ANOSIM: Global R=0.46, p=0.001) with the greatest dissimilarity between June and July (R=0.72, p=0.001) and between June and September (R=0.61, p=0.001). Fish collections along the shoreline were relatively similar between July and September (R=0.10, p=0.005).

Nearshore fish and crustaceans

Otter trawls. During 2015 and 2017, similar abundances and species richness of fish and crabs were collected in otter trawls deployed in deeper offshore areas of Raritan Bay (2015: 26 taxa and 1,009 individuals, 2017: 29 taxa and 1,309 individuals). A total of 34 taxa were collected in otter trawls during the sampling program. Species richness ranged from 10 to 22 taxa per month. Fewer taxa were observed during June and richness increased in July and September of both years.

Bay anchovy, scup, winter flounder, Say mud crab, and blue crab were dominant during both years and represented the majority of the catch in otter trawls (2015: 76 percent of all individuals, 2017: 88 percent of all individuals). Relatively high abundances of lady crab, portly spider crab, and tautog were observed during 2015 and represented 14 percent of all organisms collected in trawls that year; during 2017 black sea bass and summer flounder were also among the numerically abundant taxa collected in the otter trawl, representing 3 percent of the catch. These dominant taxa represented 90 percent and 91 percent of all fish and crabs collected in the otter trawl during 2015 and 2017, respectively.

Total abundance was lowest during June of both years but increased significantly during September 2015 and during July and September 2017. In 2015, the increased abundances later in the summer were a result of higher abundances of bay anchovy, scup, and Say mud crab. In 2017, higher abundances of bay anchovy, winter flounder, and scup resulted in increased abundances later in the summer.

Fish traps. During 2015 and 2017, similar abundances of fish and crabs were collected in fish traps deployed in Raritan Bay (2015: 428 individuals, 2017: 352 individuals). A total of 12 taxa were collected over the two years and similar species richness was observed during both years (2015: 8 taxa, 2017: 9 taxa). Species richness during the sampling program ranged from 4 to 6 taxa per month and was consistent among months and between years.

Portly spider crab, blue crab, and Say mud crab were dominant during both years and represented the majority of the catch in fish traps (2015: 99 percent of all individuals, 2017: 87 percent of all individuals). Relatively high abundance of scup and tautog were observed during 2017 and represented an additional 11 percent of all organisms collected in traps that year (totaling 98 percent of all individuals in traps during 2017). Total abundance each month ranged from 55 to 208 individuals; there were no obvious trends in abundance between the two years.

In terms of faunal-community similarity, monthly differences were observed for otter trawl collections (ANOSIM: Global R=0.39, p=0.001). September was significantly different from June

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(R=0.45, p=0.001) and July (R=0.44, p=0.001). June and July were less dissimilar from one another (R=0.25, p=0.004).

Essential Fish Habitat

The NMFS collaborates with regional fishery management councils (New England Council and Mid-Atlantic Council) to designate EFH within 10' x 10' squares identified by latitude and longitude coordinates. Raritan Bay is within a portion of Atlantic Ocean waters within the Hudson River estuary EFH that is situated in the NMFS 10' x 10' square with coordinates (North) 40°50.0' N, (East) 74°00.0' W, (South) 40°30.0' N, (West) 74°20.0' W. This square includes the following waters: Staten Island, from Port Richmond, NY on the north, east to Great Kills South Harbor of Great Kills, NY and south of Bayonne, NJ. **Table 9-11** lists the species and life stages of fish identified as having EFH in the portion of Raritan Bay near the project site (NOAA 2016). Consultation with NMFS regarding EFH in the study area was completed on May 8, 2018, and the Preferred Alternative incorporates NMFS's EFH conservation recommendations.

Marine Mammals

Marine mammals occur throughout the New York Bight and occasionally come into New York-New Jersey Harbor. The harbor seal (*Phoca vitulina*) is the most commonly observed marine mammal in the harbor and can be found hauling out along the Staten Island shoreline. The grey seal (*Halichoerus grypus*) is less common in the harbor, but occurs in similar locations as the harbor seal. Harp seals (*Pagophilus groenlandicus*) and ringed seals commonly occur on Sandy Hook, NJ, approximately 10 miles across Raritan Bay from the study area. Sightings of cetaceans (e.g., porpoises and whales) in the harbor occasionally occur, but are usually of individuals that are expected to be unhealthy and/or disoriented.

9.4.4 TERRESTRIAL RESOURCES

Ecological communities available to wildlife for habitat within the study area consist primarily of sand and cobble beach (maritime beach), coastal scrub/shrub (maritime dune) and early successional forest (southern successional forest), described below, freshwater and brackish marshes, a freshwater stream and pond, described previously under Section 9.4.2 "Wetlands," and the open, marine waters of Raritan Bay. Within Conference House Park, the beach transitions quickly from a narrow band of maritime dune into upland southern successional forest that contains a pond and freshwater marsh that is fed by the Twin Streams of the Lenape, mapped as NYSDEC freshwater wetland AR-22 (see Section 9.4.2 "Wetlands"). These streams originate beneath a residential neighborhood to the north and then converge and pass through a culvert under Clermont Avenue. From Clermont Avenue, the stream passes through southern successional forest and then opens into a *Phragmites*-dominated marsh and a pond known as Wards Point Pond before draining into Raritan Bay. A very narrow channel at the tributary's mouth likely minimizes tidal influences from the bay and limits brackish conditions to the lower end of the marsh.

Table 9-11
Essential Fish Habitat Designations – Raritan Bay

<u>Species</u>	<u>Eggs</u>	<u>Larvae</u>	<u>Juveniles</u>	<u>Adults</u>	<u>Spawning Adults</u>
Red hake (<i>Urophycis chuss</i>)		M,S	M,S	M,S	
Redfish (<i>Sebastes fasciatus</i>)	n/a				
Winter flounder (<i>Pleuronectes americanus</i>)	M,S	M,S	M,S	M,S	M,S
Windowpane flounder (<i>Scophthalmus aquosus</i>)	M,S	M,S	M,S	M,S	M,S
Atlantic sea herring (<i>Clupea harengus</i>)		M,S	M,S	M,S	
Bluefish (<i>Pomatomus saltatrix</i>)			M,S	M,S	
Long finned squid (<i>Loligo pealei</i>)	n/a	n/a	-	-	
Short finned squid (<i>Illlex illecebrosus</i>)	n/a	n/a			
Atlantic butterfish (<i>Peprilus triacanthus</i>)		M	M,S	M,S	
Atlantic mackerel (<i>Scomber scombrus</i>)			S	S	
Summer flounder (<i>Paralichthys dentatus</i>)		F,M,S	M,S	M,S	
Scup (<i>Stenotomus chrysops</i>)	S	S	S	S	
Black sea bass (<i>Centropristes striata</i>)	n/a		M,S	M,S	
Surf clam (<i>Spisula solidissima</i>)	n/a	n/a			
Ocean quahog (<i>Arctica islandica</i>)	n/a	n/a			
Spiny dogfish (<i>Squalus acanthias</i>)	n/a	n/a			
King mackerel (<i>Scomberomorus cavalla</i>)	X	X	X	X	
Spanish mackerel (<i>Scomberomorus maculatus</i>)	X	X	X	X	
Cobia (<i>Rachycentron canadum</i>)	X	X	X	X	
Bluefin Tuna (<i>Thunnus thynnus</i>)			X		
Sandbar shark (<i>Carcharhinus plumbeus</i>)		X ⁽¹⁾		X	
Clearnose skate (<i>Raja eglanteria</i>)			X	X	
Little skate (<i>Leucoraja erinacea</i>)			X	X	
Winter skate (<i>Leucoraja ocellata</i>)			X	X	

Notes:

S: EFH designation includes seawater salinity zone (salinity > 25 percent)

M: EFH designation includes mixing water / brackish salinity zone (0.5 percent < salinity < 25 percent)

F: EFH designation includes tidal freshwater salinity zone (0 percent < salinity < 0.5 percent)

X: EFH has been designated within the square for a given species and life stage.

n/a = Either there is no data available on the designated life stages for that species or those life stages are not present in the species' reproductive cycle.

⁽¹⁾ This species does not have a free-swimming larval stage; rather they are live bearers that give birth to fully formed juveniles. For the purpose of this table, "larvae" for sandbar shark refers to neonates and early juveniles.

Sources: "Summary of Essential Fish Habitat (EFH) Designations" fromhttp://www.greateratlantic.fisheries.noaa.gov/hcd/STATES4/new_jersey/40307410.html;<http://www.greateratlanticfisheries.noaa.gov/hcd/nj4.html>; <http://www.nero.noaa.gov/hcd/skateefhmmaps.htm>; and NMFS EFH Mapper at <http://www.habitat.noaa.gov/protection/efh/habitatmapper/index.html>

Conference House Park is a 265-acre New York City Park that covers much of the southern point of Staten Island and supports numerous species of wildlife associated with coastal, marsh, stream, and woodland habitats. The park is bordered to the north and east by residential development where there is minimal habitat for native wildlife other than urban-adapted generalists. The park is widest at the southern end, and then tapers to the east, including only a narrow band of maritime beach and maritime dune before widening to the north again at Page Avenue where it connects to the habitats in Butler Manor Woods within the Mount Loretto Unique Area. The Mount Loretto Unique Area (see **Figure 9-7**) is a 241-acre NYSDEC preserve that contains a mix of tidal wetlands, freshwater wetlands and ponds, meadow, hardwood forest, and coastal scrub/shrub.

Coastal and Social Resiliency Initiatives for Tottenville Shoreline FEIS

The Shoreline Project would be located in the successional southern hardwood portion of Conference House Park west of Brighton Street and south of Billop Street, continuing eastward into the narrow portion of Conference House Park where the open space between the water's edge and the residential development to the north is approximately 300 feet wide at its widest point. The exception is a wooded area between Sprague Avenue and Bruno Lane that is part of an approximately 30-acre contiguous woodland that extends north to Hylan Boulevard and encompasses Hybrid Oak Woods Park (see **Figure 9-7**). This area represents additional habitat to support the woodland wildlife species that are expected to occur in the wooded areas at the southern end of Conference House Park. A temporary man-made dune that was constructed following Superstorm Sandy is located along the shoreline from approximately Swinnerton Street to Sprague Avenue. During high tide, the waterline reaches the base of the temporary dune in many places, and at its widest, the amount of exposed beach between the base of the temporary dune and the water at high tide is roughly 20 feet. This prohibits this area of the beach from providing nesting habitat for beach-nesting bird species that nest on wider beaches in New York City.

ECOLOGICAL COMMUNITIES

Ecological communities within the study area are characteristic of maritime beach, maritime dune, mowed lawn with trees, and successional southern hardwoods as defined in accordance with Edinger et al. (2014). These communities are described below. **Table 9-12** lists the vegetation species observed during the May 26, 2015, September 1, 2015, August 8, 2016, and August 10, 2016, reconnaissance investigations. **Appendix E-10** presents representative photographs of the ecological communities described below. The ecological communities within the study area have been disturbed by human activity as evidenced by soil disturbance, litter, and the prevalence of invasive, non-native vegetation.

Maritime Beach

Edinger et al. (2014) define the maritime beach community as “a community with extremely sparse vegetation that occurs on unstable sand, gravel, or cobble ocean shores above mean high tide, where the shore is modified by storm waves and wind erosion. The upper margin of a maritime beach often grades into the base of a primary maritime dune, or other maritime community, such as maritime shrubland or one of the maritime forests.” This community occurs primarily along the shoreline of Conference House Park. It is sparsely vegetated, with common reed (*Phragmites australis*) and American beachgrass (*Ammophila breviligulata*) scattered across the landscape.

Maritime Dunes

The maritime dunes community, as defined by Edinger et al. (2014), is “a community dominated by grasses and low shrubs that occurs on active and stabilized dunes along the Atlantic coast. This community consists of a mosaic of vegetation patches. This mosaic reflects past disturbances such as sand deposition, erosion, and dune migration. The composition and structure of the vegetation is variable depending on stability of the dunes, amounts of sand deposition and erosion, and dune distance from the ocean.” Herbaceous species predominant in the dunes of Conference House Park include seaside goldenrod (*Solidago sempervirens*), poison ivy (*Toxicodendron radicans*), common reed, and Japanese knotweed (*Polygonum cuspidatum*). The shrub layer consists of northern bayberry (*Myrica pensylvanica*).

Table 9-12
Vegetation Identified within the Project Site and Study Area

Common Name	Scientific Name	Stratum
Box elder	<i>Acer negundo</i>	Tree
Norway maple	<i>Acer platanoides</i>	Tree
Red maple	<i>Acer rubrum</i>	Tree
Silver maple	<i>Acer saccharinum</i>	Tree
Yellow giant-hyssop	<i>Agastache nepetoides</i>	Herb
Tree of heaven	<i>Ailanthus altissima</i>	Tree
Garlic mustard	<i>Alliaria petiolata</i>	Herb
Tumbleweed	<i>Amaranthus albus</i>	Herb
American beachgrass	<i>Ammophila breviligulata</i>	Herb
False indigo	<i>Amorpha fruticosa</i>	Shrub
Common mugwort	<i>Artemisia vulgaris</i>	Herb
Common milkweed	<i>Asclepias syriaca</i>	Herb
Gray birch	<i>Betula populifolia</i>	Tree
Sea rocket	<i>Cakile edentula</i>	Herb
Hedge bindweed	<i>Calystegia sepium</i>	Herb
Asiatic bittersweet	<i>Celastrus orbiculatus</i>	Vine
American hackberry	<i>Celtis occidentalis</i>	Tree
Dune sandspur	<i>Cenchrus tribuloides</i>	Herb
Lamb's quarters	<i>Chenopodium album</i>	Herb
Field thistle	<i>Cirsium discolor</i>	Herb
Flowering dogwood	<i>Cornus florida</i>	Tree
Jimsonweed	<i>Datura stramonium</i>	Herb
Bush honeysuckle	<i>Dierilla lonicera</i>	Shrub
Saltgrass	<i>Distichlis spicata</i>	Herb
Autumn olive	<i>Elaeagnus umbellata</i>	Shrub
Common fleabane	<i>Erigeron philadelphicus</i>	Herb
Green ash	<i>Fraxinus pennsylvanica</i>	Tree
Spotted jewelweed	<i>Impatiens capensis</i>	Herb
Sweetgum	<i>Liquidambar styraciflua</i>	Tree
Tulip tree	<i>Liriodendron tulipifera</i>	Tree
Crabapple	<i>Malus sp</i>	Tree
White mulberry	<i>Morus alba</i>	Tree
Northern bayberry	<i>Myrica pensylvanica</i>	Shrub
Common evening primrose	<i>Oenothera biennis</i>	Herb
Prickly pear	<i>Opuntia humifusa</i>	Herb
Princess tree	<i>Paulownia tomentosa</i>	Tree
Virginia creeper	<i>Parthenocissus quinquefolia</i>	Vine
Common reed	<i>Phragmites australis</i>	Herb
Pokeweed	<i>Phytolacca americana</i>	Herb
English plantain	<i>Plantago lanceolata</i>	Herb
Common plantain	<i>Plantago major</i>	Herb
London plane tree	<i>Platanus acerifolia</i>	Tree
Japanese knotweed	<i>Polygonum cuspidatum</i>	Herb
Eastern cottonwood	<i>Populus deltoides</i>	Tree
Black cherry	<i>Prunus serotina</i>	Tree
Callery pear	<i>Pyrus calleryana</i>	Tree
Pin oak	<i>Quercus palustris</i>	Tree
Smooth sumac	<i>Rhus glabra</i>	Shrub
Black locust	<i>Robinia pseudoacacia</i>	Tree
Multiflora rose	<i>Rosa multiflora</i>	Shrub
Wineberry	<i>Rubus phoenicolasius</i>	Shrub
Curly dock	<i>Rumex crispus</i>	Herb
Bitter dock	<i>Rumex obtusifolius</i>	Herb
Sassafras	<i>Sassafras albidum</i>	Tree
Tall goldenrod	<i>Solidago altissima</i>	Herb
Seaside goldenrod	<i>Solidago sempervirens</i>	Herb
Common dandelion	<i>Taraxacum officinale</i>	Herb
Poison ivy	<i>Toxicodendron radicans</i>	Vine
Red clover	<i>Trifolium pratense</i>	Herb
White clover	<i>Trifolium repens</i>	Herb
Northern gamma grass	<i>Tripsacum dactyloides</i>	Herb
Slippery elm	<i>Ulmus rubra</i>	Tree
Common mullein	<i>Verbascum thapsus</i>	Herb
Arrowwood viburnum	<i>Viburnum dentatum</i>	Shrub
Grape	<i>Vitis sp</i>	Vine
Wisteria	<i>Wisteria sp</i>	Vine
Beach clotbur	<i>Xanthium strumarium</i>	Herb

Note: Boldface denotes NYS-listed threatened species.

Source: AKRF reconnaissance investigations on May 26, 2015, and September 1, 2015.

Coastal and Social Resiliency Initiatives for Tottenville Shoreline FEIS

MOWED LAWN WITH TREES

The mowed lawn with trees community, as defined by Edinger et al. (2014), is “residential, recreational, or commercial land in which the groundcover is dominated by clipped grasses and forbs, and it is shaded by at least 30 percent cover of trees. Ornamental and/or native shrubs may be present, usually with less than 50 percent cover. The groundcover is maintained by mowing and broadleaf herbicide application.” This community occurs primarily in the vicinity of buildings within Conference House Park (e.g., Biddle House and Rutan-Beckett House). Herbaceous species common to the mowed lawn with trees community include Kentucky bluegrass (*Poa pratensis*), white clover (*Trifolium repens*), red clover (*Trifolium pratense*), crabgrass (*Digitaria* sp), common plantain (*Plantago major*), and English plantain (*Plantago lanceolata*).

Successional Southern Hardwoods

The forested communities located inland from the beach and dunes (e.g., where the raised edge, on-shore Water Hub locations, earthen berm, and eco-revetments are proposed) are considered “forested uplands.” This community has “more than 60 percent canopy cover of trees” and occurs “on substrates with less than 50 percent rock outcrop or shallow soil over bedrock” (Edinger et al., 2014). The forested uplands community within the study area is best described as a successional southern hardwood forest. Edinger et al. (2014) define the successional southern hardwoods as “a hardwood or mixed forest that occurs on sites that have been cleared or otherwise disturbed” and which is located primarily “in the southern half of New York, south of the Adirondacks.”

The successional southern hardwoods community is relatively narrow at the eastern end of the study area, with a denser shrub layer, higher prevalence of invasive/non-native species, and more indications of disturbance. In contrast, the successional southern hardwoods community in the western portion of the study area, particularly within Conference House Park, is wider, has a more open understory, a higher proportion of native species, and fewer signs of disturbance.

Dominant species within the successional southern hardwoods community throughout the study area include eastern cottonwood (*Populus deltoids*), American hackberry (*Celtis occidentalis*), black cherry (*Prunus serotina*), pin oak (*Quercus palustris*), gray birch (*Betula populifolia*), black locust (*Robinia pseudoacacia*), and tree of heaven (*Ailanthus altissima*) within the tree layer. False indigo (*Amorpha fruticosa*) is dominant within the shrub layer. The herbaceous layer includes Japanese knotweed, common mugwort (*Artemisa vulgaris*), and seaside goldenrod.

WILDLIFE

Birds

The New York State Breeding Bird Atlas is a periodic census of the distribution of the State’s breeding birds. The most recent census was conducted from 2000 to 2005 and documented 39 species as confirmed or probable/possible breeders within the census block in which the project site is located (Block 5548D) (see **Table 9-13**). The study area contains suitable breeding habitat for each of these species, and each species is therefore considered to have the potential to nest in the area. Two additional species that are known to nest in the area and are noteworthy for New York City include Chuck-will’s-widow (*Antrostomus carolinensis*) and eastern screech owl (*Megascops asio*) (Fowle and Kerlinger 2001, DeCandido 2005). These are woodland birds that would have the potential to occur in the successional southern forest sections of the study area. Although oceanfront beach habitat is present within the study area, beach-nesting birds such as the piping plover, least tern, common tern, and American oystercatcher are not known to nest in

Conference House Park or the other segments of beach that exist within the study area, possibly because the beach is too narrow and/or levels of human activity are too high.

The following birds were observed within the study area during the June 9, 2015, wildlife survey, which coincided with the nesting period for most bird species in the New York City region: house wren, wood thrush, American robin, gray catbird, eastern towhee, northern cardinal, Baltimore oriole, blue jay, common yellowthroat, red-winged blackbird, northern mockingbird, common grackle, American goldfinch, eastern kingbird, barn swallow, tree swallow, cedar waxwing, willow flycatcher, yellow warbler, tufted titmouse, European starling, song sparrow, mallard, ring-billed gull, great black-backed gull, warbling vireo, fish crow, common yellowthroat, mourning dove, house sparrow, osprey (flying high overhead), and snowy egret (flying high overhead).

During spring and fall migration, shorebirds such as the sanderling (*Calidris alba*), semipalmated plover (*Charadrius semipalmatus*), semipalmated sandpiper (*Calidris pusilla*), and ruddy turnstone (*Arenaria interpres*) are known to often occur on the study area's beaches to briefly rest and refuel before continuing north or south (USFWS 1997, Fowle and Kerlinger 2001). Birds of prey, such as Cooper's hawk (*Accipiter cooperii*), sharp-shinned hawk (*Accipiter striatus*), and merlin (*Falco columbarius*) are also apt to pass through the study area during migration, particularly during autumn (Fowle and Kerlinger 2001). Several species of migratory songbirds occur within the wooded portions of the study area during spring and fall stopovers, and can be particularly abundant around the stream and Wards Point Pond in Conference House Park (Fowle and Kerlinger 2001). Examples include eastern kingbird (*Tyrannus tyrannus*), northern flicker (*Colaptes auratus*), purple finch (*Haemorhous purpureus*), Baltimore oriole (*Icterus galbula*), common yellowthroat (*Geothlypis trichas*), red-eyed vireo (*Vireo olivaceus*), American redstart (*Setophaga ruticilla*), and yellow-rumped warbler (*Setophaga coronata*), among many others. The following bird species were observed within the study area during the May 18, 2015, wildlife survey, which coincided with the spring migration period for many species through the New York City region: blue jay, Baltimore oriole, American robin, cedar waxwing, wood thrush, blackpoll warbler, scarlet tanager, great-crested flycatcher, gray catbird, northern cardinal, tufted titmouse, northern parula, red-winged blackbird, red-bellied woodpecker, warbling vireo, eastern wood peewee, American redstart, common yellowthroat, American goldfinch, European starling, brant, yellow warbler, double-crested cormorant, ring-billed gull, northern mockingbird, common tern (offshore, in flight north), osprey (in flight overhead), American crow, mallard, black-crowned night heron, common grackle, eastern towhee, and song sparrow.

The bird community in the study area is most sparse during winter, particularly on the areas of open beach, where non-migratory gulls, such as great black-backed gull (*Larus marinus*), are likely among the only species present. Examples of birds that can likely be found wintering in the areas of maritime dune, successional southern hardwood forest, and wetlands that are adjacent to the beach, or the area's residential neighborhoods to the north and east include European starling (*Sturnus vulgaris*), rock dove (*Columba livia*), white-throated sparrow (*Zonotrichia albicollis*), dark-eyed junco (*Junco hyemalis*), northern cardinal (*Cardinalis cardinalis*), house sparrow (*Passer domesticus*), house finch (*Carpodacus mexicanus*), American goldfinch (*Spinus tristis*), and yellow-rumped warbler (*Setophaga coronata*).

Table 9-13
Birds Documented During the 2000–2005 Breeding
Bird Atlas in Block 5548D

Common name	Scientific name
Canada Goose	<i>Branta canadensis</i>
Mallard	<i>Anas platyrhynchos</i>
Ring-necked Pheasant	<i>Phasianus colchicus</i>
Double-crested Cormorant	<i>Phalacrocorax auritus</i>
Killdeer	<i>Charadrius vociferus</i>
Rock Pigeon	<i>Columba livia</i>
Mourning Dove	<i>Zenaida macroura</i>
Chimney Swift	<i>Chaetura pelagica</i>
Red-bellied Woodpecker	<i>Melanerpes carolinus</i>
Downy Woodpecker	<i>Picoides pubescens</i>
Northern Flicker	<i>Colaptes auratus</i>
Willow Flycatcher	<i>Empidonax traillii</i>
White-eyed Vireo	<i>Vireo griseus</i>
Blue Jay	<i>Cyanocitta cristata</i>
American Crow	<i>Corvus brachyrhynchos</i>
Black-capped Chickadee	<i>Poecile atricapillus</i>
Tufted Titmouse	<i>Baeolophus bicolor</i>
Carolina Wren	<i>Thryothorus ludovicianus</i>
House Wren	<i>Troglodytes aedon</i>
Blue-gray Gnatcatcher	<i>Polioptila caerulea</i>
Wood Thrush	<i>Hylocichla mustelina</i>
American Robin	<i>Turdus migratorius</i>
Gray Catbird	<i>Dumetella carolinensis</i>
Northern Mockingbird	<i>Mimus polyglottos</i>
Brown Thrasher	<i>Toxostoma rufum</i>
European Starling	<i>Sturnus vulgaris</i>
Cedar Waxwing	<i>Bombycilla cedrorum</i>
Yellow Warbler	<i>Dendroica petechia</i>
Common Yellowthroat	<i>Geothlypis trichas</i>
Eastern Towhee	<i>Pipilo erythrrophthalmus</i>
Scarlet Tanager	<i>Piranga olivacea</i>
Northern Cardinal	<i>Cardinalis cardinalis</i>
Red-winged Blackbird	<i>Agelaius phoeniceus</i>
Common Grackle	<i>Quiscalus quiscula</i>
Orchard Oriole	<i>Icterus spurius</i>
Baltimore Oriole	<i>Icterus galbula</i>
House Finch	<i>Carpodacus mexicanus</i>
American Goldfinch	<i>Spinus tristis</i>
House Sparrow	<i>Passer domesticus</i>

Source: 2000–2005 New York State Breeding Bird Atlas

Several species of waterfowl and other waterbirds are commonly found in the waters surrounding New York City during fall and winter. Waterbirds that are often observed in Raritan Bay, offshore from Conference House Park, include canvasback (*Aythya valisneria*), red-throated loon, common loon, redhead, common goldeneye (*Bucephala clangula*), horned grebe, brant (*Branta bernicla*), greater scaup (*Aythya marila*), long-tailed duck (*Clangula hyemalis*), and bufflehead (*Bucephala albeola*) (Fowle and Kerlinger 2001). Other waterbirds that are known or expected to occur in Raritan Bay in high abundance include herring gull (*Larus argentatus*), ring-billed gull (*Larus*

delawarensis), double-crested cormorant (*Phalacrocorax auritus*), Canada goose (*Branta canadensis*), American black duck (*Anas rubripes*), mallard (*Anas platyrhynchos*), red-breasted merganser (*Mergus serrator*), and American widgeon (*Anas americana*) (USFWS 1997).

Mammals

Mammals that are typical of coastal shrublands, dunes, and woodlands within New York City (e.g., Bourque 2007, Ekernas and Mertes 2007), and therefore considered to have the potential to occur within the study area, include house mouse (*Mus musculus*), meadow vole (*Microtus Pennsylvanicus*), woodland vole (*Microtus pinetorum*), white-footed mouse (*Peromyscus leucopus*), raccoon (*Procyon lotor*), Norway rat (*Rattus norvegicus*), gray squirrel (*Sciurus carolinensis*), eastern cottontail (*Sylvilagus florianus*), and domestic cat (*Felis catus*). Muskrats (*Ondatra zibethicus*) are likely to occur in the freshwater pond and wetlands within Conference House Park. Silver-haired, (*Lasionycteris noctivagans*), eastern red (*Lasiurus borealis*), tri-colored (*Perimyotis subflavus*) and hoary bats (*Lasiurus cinereus*) may pass through the study area during their long-distance migrations, and little brown bats (*Myotis lucifugus*) and big brown bats (*Eptesicus fuscus*) may inhabit the study area's woodlands during the breeding season. The only mammals that would be expected to occur in the residential neighborhoods outside of Conference House Park are Norway rat, domestic cat, gray squirrel, house mouse, and raccoon. White-tailed deer and gray squirrel were the mammals observed within the study area during the May 18 and June 9, 2015, wildlife surveys.

Reptiles and Amphibians

The NYSDEC Herp Atlas Project, a survey conducted from 1990 to 1999 to document the geographic distribution of New York's reptile and amphibian species, recorded 24 species in the census block in which the project site is located (Arthur Kill USGS quadrangle; see **Table 9-14**). Although this census block covers much of Staten Island and its many different natural areas and habitat types, the maritime dune, successional southern hardwood forest, and freshwater streams and pond that occur within the study area are suitable habitats for many of these species. On the basis of their habitat associations (Mitchell et al. 2006, Gibbs et al. 2007) and status on Staten Island (Gibbs et al. 2007, Pehek 2007), the reptiles and amphibians that are considered to have the potential to occur within the non-marine portion of the study area include gray treefrog (*Hyla versicolor*), spring peeper (*Pseudacris c. crucifer*), Fowler's toad (*Bufo fowleri*), northern brown snake (*Storeria d. dekayi*), red-backed salamander (*Plethodon cinereus*), northern two-lined salamander (*Eurycea bislineata*), red-spotted newt (*Notophthalmus viridescens*), bullfrog (*Rana catesbeiana*), green frog (*R. clamitans*), snapping turtle (*Chelydra serpentina*), spotted turtle (*Clemmys guttata*), eastern box turtle (*Terrapene carolina*), eastern mud turtle (*Kinosternon subrubrum*; NYS endangered), northern diamondback terrapin (*Malaclemys terrapin*), red-eared slider (*Trachemys scripta elegans*), painted turtle (*Chrysemys picta*), northern water snake (*Nerodia sipedon*), northern ring-neck snake (*Diadophis punctatus edwardsii*), northern brown snake (*Storeria dekayi*), common garter snake (*Thamnophis sirtalis*), northern black racer (*Coluber constrictor*), and eastern fence lizard (*Sceloporus undulatus*). The newly described southern leopard frog species (*Rana kauffeldi*; formerly classified as *Rana sphenocephala utricularius*) that is endemic to the New York metropolitan area and inhabits coastal freshwater and brackish wetlands on Staten Island (Newman et al. 2012, Feinberg et al. 2014) also has the potential to occur within the study area.

Table 9-14
Reptiles and Amphibians Documented by the NYSDEC
Herp Atlas Project in the Arthur Kill Census Quadrant

Common Name	Scientific Name
Spotted salamander	<i>Ambystoma maculatum</i>
Red-spotted newt	<i>Notophthalmus viridescens</i>
Red-backed salamander	<i>Plethodon cinereus</i>
Northern two-lined salamander	<i>Eurycea bislineata</i>
Fowler's toad	<i>Bufo fowleri</i>
Spring peeper	<i>Pseudacris crucifer</i>
Bullfrog	<i>Rana catesbeiana</i>
Green frog	<i>Rana clamitans</i>
Southern leopard frog	<i>Rana sphenocephala</i>
Pickerel frog	<i>Rana palustris</i>
Snapping turtle	<i>Chelydra serpentina</i>
Musk turtle	<i>Sternotherus odoratus</i>
Eastern mud turtle	<i>Kinosternon subrubrum</i>
Spotted turtle	<i>Clemmys guttata</i>
Eastern box turtle	<i>Terrapene carolina</i>
Northern diamondback terrapin	<i>Malaclemys terrapin</i>
Red-eared slider	<i>Trachemys scripta</i>
Painted turtle	<i>Chrysemys picta</i>
Eastern fence lizard	<i>Sceloporus undulatus</i>
Northern water snake	<i>Nerodia sipedon</i>
Northern brown snake	<i>Storeria dekayi</i>
Common garter snake	<i>Thamnophis sirtalis</i>
Northern ringneck snake	<i>Diadophis punctatus</i>
Northern black racer	<i>Coluber constrictor</i>
Note: Boldface indicates the subset of species that are considered to have the potential to occur in the study area on the basis of their habitat requirements and status on Staten Island (Mitchell et al. 2006, Gibbs et al. 2007, Pehek 2007, NYCParks 2015).	

Green frog, bullfrog, common snapping turtle, and red-eared slider were the species of reptiles and amphibians observed within the study area during the May 18 and June 9, 2015, wildlife surveys. Search methods for reptiles and amphibians included visual encounter and cover object surveys (Parris 1999, Manley et al. 2006), including thorough searches under rocks and other cover objects along the stream's edges and riparian zone for two-lined salamanders and other stream salamanders (Strain et al. 2012) that occur on Staten Island (Pehek 2007).

9.4.5 TERRESTRIAL AND AQUATIC THREATENED, ENDANGERED, AND SPECIAL CONCERN SPECIES

Federally endangered, threatened, candidate, or proposed species listed by the USFWS IPaC System (see **Appendix E-2**) as occurring in Richmond County near the project site include the piping plover (*Charadrius melanotos*; threatened) and roseate tern (*Sterna dougalli*; endangered). Additional consultation with USFWS indicated that red knots (*Calidris canutus rufa*) have been documented on other beaches and coastal areas on Staten Island and Jamaica Bay, New York, and would therefore have the potential to occur within the study area as occasional transient individuals. Federally-listed aquatic species that are considered by NMFS (see **Appendix E-2**) to have the potential to occur in Raritan Bay, near the project site, include Atlantic sturgeon (*Acipenser oxyrinchus*), loggerhead sea turtle (*Caretta caretta*; threatened), green sea turtle (*Chelonia mydas*; threatened), and Kemp's ridley sea turtle (*Lepidochelys kempii*; endangered)

(NMFS 2015, see **Appendix E-2**). The Governor's Office of Storm Recovery (GOSR) completed consultation with NMFS and USFWS under Section 7 of the Endangered Species Act following publication of the DEIS, as discussed below.

In response to a request for information on state-listed species and significant natural communities, NYNHP (see **Appendix E-2**) provided the following non-historical records from within 0.5 miles of the project site: sweetbay magnolia (*Magnolia virginiana*; endangered), northern gama grass (*Tripsacum dactyloides*; endangered), willow oak (*Quercus phellos*; endangered), wild potato vine (*Ipomoea pandurata*; endangered), yellow giant-hyssop (*Agastache nepetoides*; threatened), white-bracted boneset (*Eupatorium leucolepis* var. *leucolepis*; endangered), persimmon (*Diospyros virginiana*; threatened), and dune sandspur (*Cenchrus tribuloides*; threatened).

None of the birds documented by the 2000–2005 Breeding Bird Atlas in the census block in which the project site is located are federally or state-listed. Four species of reptiles and amphibians that were documented by the Herp Atlas Project and are considered to have the potential to occur within the study area on the basis of their habitat associations are state-listed: eastern mud turtle (endangered), eastern box turtle (species of special concern), eastern fence lizard (threatened), and southern leopard frog (species of special concern).

The only listed wildlife species that were observed within the study area during the May 18 and June 9, 2015, wildlife surveys were the osprey (special concern) and common tern (threatened), which were both seen passing overhead or offshore from the project site.

ATLANTIC STURGEON

Atlantic sturgeon is an anadromous species that spawns in freshwater habitats. Atlantic sturgeon is a bottom-dwelling fish that inhabits large freshwater rivers when spawning and primarily marine waters when not breeding; they can also be found in bays, river mouths, and estuaries. NMFS (2015) notes that individuals from any of the five distinct population segments of Atlantic sturgeon may be present in Raritan Bay. While Atlantic sturgeon are not expected to occur in significant numbers within the study area, transient sub-adults may be present as they move through shallower marine waters along the Atlantic coast; adults are more likely found in deeper offshore waters of the continental shelf. Early life stages (i.e., eggs, larvae, and smaller juveniles) are relatively intolerant of salinity, young-of-year Atlantic sturgeon exhibit poor survival at salinities ranging from 5 to 10 ppt, and slightly older sturgeon (Age-1 and Age-2) may tolerate salinities up to 12 ppt (Kynard and Horgan 2002, ASMFC 2012).

In the New York Harbor, Atlantic sturgeon typically occur in deeper waters than those in the study area. According to recent surveys conducted by NMFS and multiple state agencies in the region, the majority of Atlantic sturgeon occurred in waters between 10 and 15 meters (32 to 49 feet) in depth; many of these sturgeon were found off the west coast of Long Island (Dunton et al. 2010). Atlantic sturgeon from this congregation could potentially be found in Raritan Bay as transient individuals.

SEA TURTLES

NMFS (2015) indicates that New York and New Jersey waters may be warm enough to support loggerhead (*Caretta Caretta*) and Kemp's ridley turtles (*Lepidochelys kempi*) from May through mid-November, and green sea turtles (*Chelonia mydas*) from June through October; those that do occur in these waters are typically small juveniles. Leatherback sea turtles (*Dermochelys coriacea*) may be found in the waters off New York and New Jersey during the warmer months, but this species generally prefers deep, pelagic waters over shallow, nearshore waters, and would not be

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expected in the vicinity of the Raritan Bay shoreline where the proposed breakwater would be located. Loggerhead, green, and Kemp's ridley sea turtles in New York waters are uncommon as far west as New York Harbor. Mark-recapture and satellite tracking studies of these species documented extensive usage of eastern Long Island Sound, the Atlantic Ocean off of eastern Long Island's south shore, and eastern Long Island's Peconic Bay, but did not record any sea turtles in inshore waters west of Suffolk County (Morreale and Standora 1994, 1998). The New York-New Jersey Harbor complex of which Raritan Bay is a part is considered to be of marginal or lower quality as sea turtle habitat, and observations of sea turtles in these waters are infrequent despite extensive monitoring and surveying efforts (Ruben and Morreale 1999, USACE 2001). However, the USFWS (1997) notes that loggerhead and Kemp's ridley sea turtles occur off of Sandy Hook, NJ, approximately 10 miles from the study area. Additionally, a dead, unidentified sea turtle was observed washed up on the beach within Conference House Park during the September 1, 2015, vegetation survey. Overall, sea turtles are considered to have the potential to occur within the study area on rare occasions, and only as transients rather than for long-term occupation for breeding, wintering, or growth and development.

WHALES

NMFS (2015) indicates that, although a number of endangered whales occur seasonally off the coast of New York and New Jersey, the listed species would likely not occur in the study area due to its shallow depths and nearshore location. North Atlantic right whales (*Eubalaena glacialis*) can occur in the vicinity from September through March, and humpback whales (*Megaptera novaeangliae*) can be found from February through April and again from September through November. Fin (*Balaenoptera physalus*), sei (*Balaenoptera borealis*), and sperm (*Physeter macrocephalus*) whales can also be found off the coast of New Jersey and New York, and all are typically found in deeper offshore waters.

PIPING PLOVER

The breeding range of the piping plover within New York State is limited to the coastlines of Long Island, where plovers nest from Queens to eastern Suffolk County (Wasilco 2008). Nesting of piping plovers within New York City is limited to a colony on Rockaway Peninsula in Queens County (Boretti et al. 2007) and a few individual pairs that have sporadically nested within the Jamaica Bay Unit of the Gateway National Recreational Area in Queens and Kings Counties on isolated occasions (Wells 1996, Wasilco 2008). Piping plovers also nest within the Sandy Hook Unit of the Gateway National Recreational Area in New Jersey, more than 10 miles west of the study area. Piping plovers do not nest on Staten Island, and any potential occurrences of piping plovers within the study area would be limited to migrants associated with breeding populations elsewhere briefly passing through en route to their nesting or wintering areas.

ROSEATE TERN

The breeding range of the roseate tern within New York State is limited to the coastlines of Long Island and more than 90 percent of the population is made up by a single colony on Great Gull Island, off Long Island's eastern end. The remainder occurs in small groups of often just one or two breeding pairs in variable locations along Long Island's south shore (Mitra 2008). Roseate terns have sporadically nested towards the western end of Long Island in the past (e.g., 2 pairs in Jamaica Bay in 1996; Wells 1996), but during the most recent New York State Breeding Bird Atlas (2000–2005), they were not documented anywhere west of Suffolk County (Mitra 2008), and no roseate terns were found nesting anywhere on western Long Island during the most recent NYSDEC Long Island Colonial Waterbird Census for which data are available (NYSDEC 2013).

Roseate terns are migratory and overwinter in the southern hemisphere. Therefore, any potential occurrences of roseate terns within the study area would be limited to migrants briefly passing through on their way to their breeding or wintering grounds.

RED KNOT

The *rufa* subspecies of the red knot migrates up to 30,000 miles round trip between primary wintering grounds in South America and breeding grounds in the high arctic, with conditions for refueling at staging areas along the Atlantic coast being critical determinants of migration and reproductive success and overall survival (Baker et al. 2004, Morrison et al. 2007). Delaware Bay is the most significant migration staging area for *rufa* red knots, which time their springtime arrival in the bay to coincide with the peak horseshoe crab spawning period (Baker et al. 2004, Niles et al. 2009). Red knots are dependent on a superabundance of horseshoe crab eggs as a food source in order to almost double their body mass and fuel the remaining leg of their migration to the high arctic (Baker et al. 2004, Morrison and Hobson 2004). Delaware Bay is the only place in the Western Hemisphere where horseshoe crabs spawn in numbers that enable red knots to do so (Niles 1999). Steep declines in the number of horseshoe crabs spawning in Delaware Bay in recent decades, despite stricter harvest restrictions, has significantly hindered the ability of red knots to refuel at sufficient rates, and in turn, led to rapid population declines (Niles et al. 2008, 2009). Monomoy National Wildlife Refuge in Cape Cod, Massachusetts appears to be among the most significant staging areas for red knots during their southbound autumn migration (Harrington et al. 2010, Burger et al. 2012). In addition to these primary staging areas in Delaware Bay and Cape Cod, migrating red knots may commonly stage, albeit in much lower densities, elsewhere along the Atlantic coast (Harrington 2010, Burger et al. 2012). Therefore, any potential occurrences of red knots within the study area would likely be limited to migrants briefly passing through on their way to their breeding or wintering grounds.

EASTERN MUD TURTLE

The eastern mud turtle is a New York State endangered species whose distribution within the state is limited to Staten Island and the south shore and south fork of Suffolk County, Long Island (Gibbs et al. 2007). The NYSDEC Herp Atlas Project documented the eastern mud turtle in the census block in which the project site is located. Eastern mud turtles inhabit freshwater and brackish wetlands, including small ponds and marshes often dominated by *Phragmites australis* (Gibbs et al. 2007, NYNHP 2013d). Their wetlands are usually surrounded by vegetated, sandy, upland habitat that the turtles use for nesting and overwintering (NYNHP 2013d). The mix of freshwater and brackish wetlands associated with the Twin Streams of the Lenape in Conference House Park, and the surrounding scrub/shrub and oak forest uplands represent the habitat types that are preferred by the eastern mud turtle, and as such, this species is considered to have the potential to occur within the study area.

EASTERN BOX TURTLE

The eastern box turtle is still relatively common in New York State, but populations are in decline and the species is listed as a species of special concern (Gibbs et al. 2007). The NYSDEC Herp Atlas Project documented the eastern box turtle in the census block in which the project site is located. Eastern box turtles are found in forests and a variety of open or successional habitats, usually near ponds or streams, and prefer habitats with sandy, well-drained soils (Mitchell et al. 2006, Gibbs et al. 2007). As such, appropriate habitat for eastern box turtles is present throughout Conference House Park and eastern box turtles are considered to have the potential to within the study area.

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EASTERN FENCE LIZARD

The eastern fence lizard is uncommon and listed as threatened in New York State, which is the northernmost extent of its range, but can be abundant in more southern regions (Gibbs et al. 2007). The eastern fence lizard was documented by the NYSDEC Herp Atlas Project in the census block in which the project site is located, and suitable habitat for the species is present within the study area. Eastern fence lizards inhabit dry, open woodlands, including oak forest (Gibbs et al. 2007), such as that which occurs within Conference House Park. Eastern fence lizards are considered to have the potential to occur within these wooded portions of the study area.

SOUTHERN LEOPARD FROG

Recent molecular evidence suggests that southern leopard frogs occurring in the New York-New Jersey-Connecticut tri-state area are genetically distinct from southern leopard frogs in adjacent regions (Newman et al. 2012, Feinberg et al. 2014) and should be recognized as a separate, newly described species of southern leopard frog, *Rana kauffeldi* (Feinberg et al. 2014). Current populations of southern leopard frogs (all species within the complex) in New York State are limited to Long Island, Staten Island, and the lower Hudson Valley (Gibbs et al. 2007, Feinberg et al. 2014). The newly described *Rana kauffeldi*, known as the Atlantic coast leopard frog, occurs in a number of locations in Staten Island where it is found in coastal freshwater and brackish wetlands, often dominated by *Phragmites australis* (Feinberg et al. 2014). As such, suitable habitat for Atlantic coast leopard frogs occurs in the freshwater and brackish wetlands within and around Wards Point Pond and the Twin Streams of the Lenape in Conference House Park, and this species has the potential to occur within these portions of the study area.

SWEETBAY MAGNOLIA

Sweetbay magnolia (*Magnolia virginiana*) is a tall shrub or slender tree predominantly found in red maple hardwood swamps and red maple sweetgum swamps in either wet or saturated soils. Sweetbay magnolia can also be found nearer to development in drier soils. Current distribution within New York State includes small natural areas on Staten Island and southern Long Island (NYNHP 2013g). Sweetbay magnolia was not observed during the May 26, 2015, or September 1, 2015, reconnaissance investigations. Based on habitat requirements, sweetbay magnolia is not considered to have the potential to occur in the study area.

NORTHERN GAMA GRASS

Northern gama grass (*Tripsacum dactyloides*) is found near the coast in high salt marsh, wet meadows, oak forests, old fields, roadsides, and maritime dunes. Northern gama grass may also be planted as cattle forage (NYNHP 2013i). Based on habitat requirements, northern gama grass is considered to have the potential to occur within the study area. Two populations of northern gama grass was observed within the maritime dunes and successional southern hardwoods communities within the study area during the September 1, 2015, and August 10, 2016, reconnaissance investigations.

WILLOW OAK

Willow oak (*Quercus phellos*) is a long-lived overstory tree which can be found in swamps and moist soils, including floodplain forests, maritime grasslands, woodlands, and roadside forests. There are a few native populations on Staten Island and Nassau County, Long Island. It is common for willow oak to be planted as a street tree in New York City (NYNHP 2013h). Based on habitat requirements, willow oak is not considered to have the potential to occur within the study area.

During the May 26, 2015, and September 1, 2015, reconnaissance investigations willow oak was not observed.

WILD POTATO-VINE

Wild potato-vine (*Ipomoea pandurata*) is a perennial, herbaceous vine similar to the common morning-glory. In New York State, there is scattered distribution of the vine with one population near Rochester and one population on Staten Island. Typically, wild potato-vine occurs in disturbed habitats, such as old field and road margins, hedgerows, and quarry edges, which are dominated by shrubs and vines (NYNHP 2013f). Based on habitat requirements, wild-potato vine is not considered to have the potential to occur within the study area, and was not observed during the May 26, 2015, or September 1, 2015, reconnaissance investigations.

YELLOW GIANT-HYSSOP

Yellow giant-hyssop (*Agastache nepetoides*) is a tall herb found near roadsides, railroads, and thickets often in areas with limestone derived soils. Distribution is widespread across New York State with particular emphasis on areas near New York City, Buffalo/Niagara Falls, and Ithaca on sites with rich soil (NYNHP 2013a). Based on habitat requirements, yellow giant-hyssop is considered to have the potential to occur within the study area. One population of yellow giant-hyssop was observed within the successional southern hardwoods community within the study area during the September 1, 2015, reconnaissance investigation.

WHITE-BRACTED BONESET

White-bracted boneset (*Eupatorium leucolepis* var. *leucolepis*) is a perennial herb located primarily in sandy soils along the weedy or shrubby margins of pond shores. In New York State, its current distribution is in Suffolk County, Long Island (NYNHP 2013e). During the May 26, 2015, and September 1, 2015, reconnaissance investigations, white-bracted boneset was not observed. Based on habitat requirements, white-bracted boneset is not considered to have the potential to occur within the study area.

PERSIMMON

Persimmon (*Diospyros virginiana*) is a small tree with edible fruit. Current distribution includes Long Island, Staten Island, and New York City. Persimmon has been found in a variety of dry forests, in swampy woods, and along the margin of coastal ponds. Most often, persimmon is found in small natural areas surrounded by development (NYNHPc). During the May 26, 2015, and September 1, 2015, reconnaissance investigations, persimmon was not observed. Based on habitat requirements, persimmon is not considered to have the potential to occur within the study area.

DUNE SANDSPUR

Dune sandspur (*Cenchrus tribuloides*) is an annual grass found on maritime sand dunes and beaches on Long Island and Staten Island. Dune sandspur thrives in disturbed sands (NYNHP 2013b). Based on habitat requirements, dune sandspur does have the potential to occur within the study area. Four populations of dune sandspur were observed within the maritime beach and maritime dunes communities within the study area during the September 1, 2015, and August 10, 2016, reconnaissance investigations.

9.5 EFFECTS ASSESSMENT

9.5.1 ALTERNATIVE 1—NO ACTION ALTERNATIVE

The No Action alternative assumes that no new structural risk reduction or marine habitat restoration projects will be implemented in the study area. This alternative also assumes that current trends with respect to coastal conditions at Tottenville—i.e., relating to erosion, wave action, ecosystems, and water quality—will continue. Under the No Action Alternative, the existing man-made temporary dune system would remain in 2020. These dunes and the Tottenville shoreline would remain vulnerable to intense wave energy and thus continue to be at risk from storm wave damage. Under the No Action condition, the Tottenville shoreline is expected to continue to erode in certain locations. Numeric simulation of shoreline changes revealed that in the southwestern portions of the site (south of Sprague Avenue) both the overall pattern and rates of shoreline erosion and accretion are likely to continue into the future, including erosion rates of 1 to 2 feet per year between Loretto Street and Manhattan Street, and between 2.0 and 3.5 feet per year in Conference House Park between Main Street and Wards Point. North of Sprague Avenue, modeling indicates that the general pattern of erosion and accretion will remain the same as those observed historically, though the simulation shows future rates of change slightly lower than those historically observed.

The No Action Alternative also presumes that existing strategies to educate New Yorkers and the general public on the risks posed by climate change will remain the same in the study area.

GROUNDWATER

Under the No Action Alternative, groundwater conditions on Staten Island would not be expected to change and drinking water would continue to be provided by New York City's system of upstate reservoirs.

WETLANDS

Under the No Action Alternative, no changes to existing NWI or NYSDEC wetland classifications or boundaries in the study area would be expected. NYC Parks has ongoing or proposed projects in Conference House Park, including wetland restoration, that are independent of the Proposed Actions and would continue under the No Action Alternative. Under the No Action alternative, the 0.8-acre Phragmites-dominated delineated wetland near the shoreline within Conference House Park would not receive any enhancement measures.

AQUATIC RESOURCES

Several of the 296 sites selected for inclusion in the HRE-CRP are located along the southern shore of Staten Island and northern shore of New Jersey, and have the potential to benefit the aquatic resources of Raritan Bay in such ways as improving the quality of water entering the bay as runoff or from tributaries, maintaining or enhancing natural shorelines, restoring salt marshes and other coastal and estuarine habitats, reestablishing oyster reefs, and removing contaminants. The HRE-CRP within the Lower Bay Planning Area aims to “develop a mosaic of habitats that provides society with renewed and increased benefits from the estuary environment” and represents the results of a large scale effort to coordinate the several completed, ongoing and planned conservation and restoration programs in the area in order to strategically address specific objectives in this most urban section of the Estuary (USACE 2016, Bain et al. 2007). Within the lower Hudson River estuary, the Lower Bay Planning Region contains relatively abundant habitat for oyster restoration—one of the HRE-CRPs key Target Ecosystem Characteristics (TECs).

HRE-CRP sites that are closest to the proposed Breakwaters and Shoreline Projects and would provide direct or indirect benefits to the overall aquatic resources of the area include Mt. Loretto Unique Area, Butler Manor Woods, Paw-paw Hybrid Oak Coastal Woods, and Lemon Creek in Staten Island, and Treasure Lake, Whale Creek/Long Neck Creek, and Marquis Creek in New Jersey. HRE-CRP projects at these sites typically include one or more of the following activities: coastal and upland land acquisition and protection, coastal habitat restoration, restoration of tidal connections of tributaries, restoration and protection of riparian and upland areas around the bay's tributaries, debris removal, and/or contaminated sediment removal. The HRE-CRP also includes oyster reef restoration off of the Great Kills Park peninsula's shoreline in Staten Island, a few miles northeast from the study area. Aquatic resources in Raritan Bay are also expected to continue to gradually improve in the future without the Proposed Actions as a result of other city-wide initiatives, including New York City's Green Infrastructure Plan, PlaNYC, and OneNYC. Focal areas of these plans include expanded usage of green infrastructure throughout the city, reduced pollution from stormwater runoff, improved flushing of constrained water bodies, and optimization of existing sewer systems through improvements to drainage, interceptors, and tide gates. Another initiative of PlaNYC and Vision 2020 is to increase public access to the city's waterfronts, including in the Tottenville section of Staten Island. The PlaNYC Special Initiative for Rebuilding and Resiliency includes several storm protection strategies that are being contemplated for the southern shore of Staten Island and involve beach renourishment, expansion of the borough's Bluebelt storm water management system, protection of coastal forests, and construction of living breakwaters.

Coastal restoration efforts in the Hudson-Raritan Estuary would continue under the No Action Alternative and would be expected to improve habitat for aquatic biota. The USACE's South Shore of Staten Island Coastal Storm Risk Management Project (CSRMP) spans approximately 5.3 miles from Fort Wadsworth to Oakwood Beach on the eastern side of the south shore of Staten Island. The CSRMP includes a Line of Protection (LOP) consisting of a buried seawall/armored levee along 80 percent of the Fort Wadsworth to Oakwood Beach reach that would protect the coast against severe coastal surge flooding and wave forces. The remaining 20 percent of the reach would include a vertical floodwall, levee, and a mosaic of tidal wetland, maritime forest/scrub/shrub, low marsh, and high marsh improvements.

The gradual improvements in water quality in Raritan Bay that are expected as a result of these and other initiatives should improve living conditions for aquatic biota and potentially allow for more pollution-intolerant species to occur in the bay. Other living breakwaters and shellfish restoration projects planned for the future in Raritan Bay including efforts undertaken by the New York Harbor Foundation's Billion Oyster Project and New York/New Jersey Baykeeper, with the objective of replenishing New York and New Jersey bays with healthy oyster populations and reef habitats (USACE 2016) would enhance the diversity of aquatic biota and further improve water quality.

Many aquatic species in the region have active commercial and/or recreational fisheries, and either have active management plans or harvest regulations that have been implemented to promote the long-term productivity of these resources and sustainability of the fisheries in New York's coastal waters and along the Atlantic coast. Under the No Action Alternative, these protective measures would continue to benefit their focal species and the ecosystems where they live. Management plans and/or harvest regulations for certain species found in Raritan Bay are developed by the Mid-Atlantic Fisheries Management Council, the New England Fisheries Management Council, and the Atlantic States Marine Fisheries Commission. The United States Food and Drug Administration sets strict industry standards for States' shellfish industries. These plans and

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regulations would continue to be developed and implemented under the No Action Alternative to protect and manage certain species found in the area.

Sediment Quality

Under the No Action Alternative, sediment quality would continue to improve throughout the New York Harbor as new sediment is deposited over older sediment, which typically has higher contamination levels than recently deposited material (i.e., Class A sediment deposited over Class B sediment). Sediments in Raritan Bay would continue to consist mainly of coarse- and medium-grained sand and gravel, and sedimentation rates would likewise remain unaltered in the Bay and along the shoreline.

TERRESTRIAL RESOURCES

Ecological Communities and Wildlife

Because the majority of the study area is protected parkland, habitat availability and conditions for wildlife in the future under the No Action Alternative are expected to remain much the same as at present. NYC Parks has ongoing or proposed projects in Conference House Park that are independent of the Proposed Actions that would benefit ecological communities and may benefit wildlife. Examples include wetland restoration, invasive plant removal, coastal grassland and wet meadow creation, and maritime forest restoration. These projects are expected to improve ecological communities and habitat quality for native wildlife, but overall, wildlife community composition in the study area is not expected to substantively change, and the same species are expected to continue to inhabit the area.

NYC Parks will be reconstructing the Pavilion, located along the shoreline within Conference House Park, which has been closed to the public since 2011 due to weather damage to the roof and deck. Reconstruction is anticipated to start in spring 2017 and is expected to extend into the fall of 2018. The Pavilion will be reconstructed within the existing footprint and elevated 5 feet above the 100-year flood elevation (i.e., Base Flood Elevation). Noise and increased human activity associated with these reconstruction activities may result in temporary avoidance of the successional woodland and lawn habitat adjacent to the structure by some wildlife individuals. Given the amount of comparable habitat within the park nearby to the Pavilion location, any displaced wildlife individuals would not be expected to have difficulty temporarily relocating nearby. Any such temporary displacement from proximity to the Pavilion during reconstruction activities would not significantly impact wildlife at the individual or population level. Similarly, any waterfowl or other waterbirds that have the potential to be temporarily displaced from nearshore waters adjacent to the shoreline where the Pavilion is located would be expected to easily utilize alternative open-water habitat that is abundant elsewhere along the Raritan Bay shoreline. Upon completion of the reconstruction, the same species of terrestrial wildlife and waterbirds would be expected to return to the area.

TERRESTRIAL AND AQUATIC THREATENED ENDANGERED, AND SPECIAL CONCERN SPECIES

Given that the majority of the study area consists of protected parkland, habitat availability and conditions for listed species of wildlife in the future under the No Action Alternative are expected to remain much the same as at present. Any listed wildlife species currently inhabiting the area would be expected to continue to occur with the same likelihood and in the same abundance, but would not receive the risk reduction benefits that would be achieved by Alternative 2. NYC Parks has ongoing or proposed projects in Conference House Park that are independent of the Proposed

Actions and may benefit listed species of wildlife. Examples include wetland restoration, invasive plant removal, coastal grassland and wet meadow creation, and maritime forest restoration. These projects are expected to improve habitat quality, but overall, wildlife community composition in the study area is not expected to substantively change, and the same listed species are expected to continue to have the same potential to inhabit the area.

9.5.2 ALTERNATIVE 2 (PREFERRED ALTERNATIVE)—THE LAYERED TOTTENVILLE SHORELINE RESILIENCY STRATEGY: LIVING BREAKWATERS AND TOTTENVILLE SHORELINE PROTECTION PROJECT (LAYERED STRATEGY)

As described in Chapter 1, “Purpose and Need and Alternatives,” Alternative 2 consists of the implementation of two individual projects: the Living Breakwaters Project and the Tottenville Shoreline Protection Project, as described below, as a strategy that would increase the overall resiliency of the Tottenville shoreline. The preferred layout of the breakwaters would attenuate wave energy and reduce shoreline erosion at the water’s edge, effectively holding, or in some locations increasing, beach width, while increasing the diversity of aquatic habitats, fostering community education on coastal resiliency, increasing physical and visual access to the water’s edge, enhancing community stewardship of on-shore and in-water ecosystems, and increasing access to recreational opportunities. The Shoreline Project would reduce or delay flooding of inland areas during certain storm events, and reduce damage to inland structures. It is expected that during coastal storm events, in cases where over-topping from storm surge does not occur, some level of risk reduction from coastal flooding would be provided by the Shoreline Project.

BREAKWATERS PROJECT

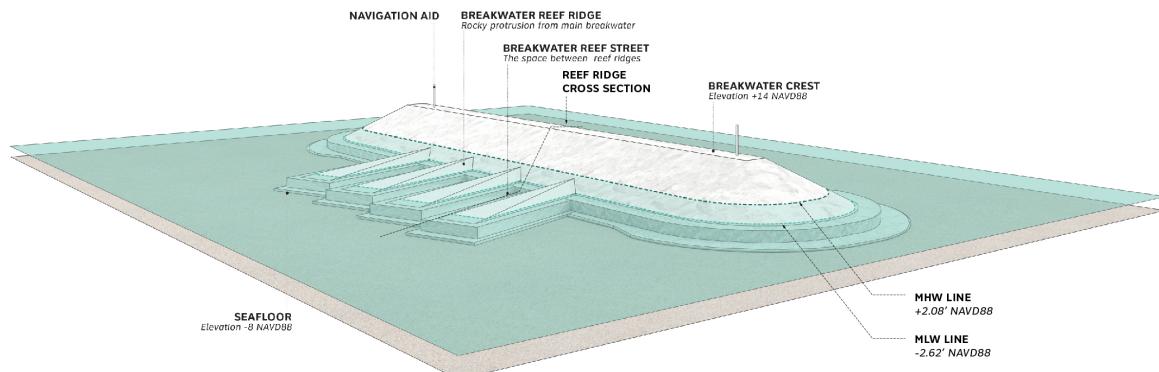
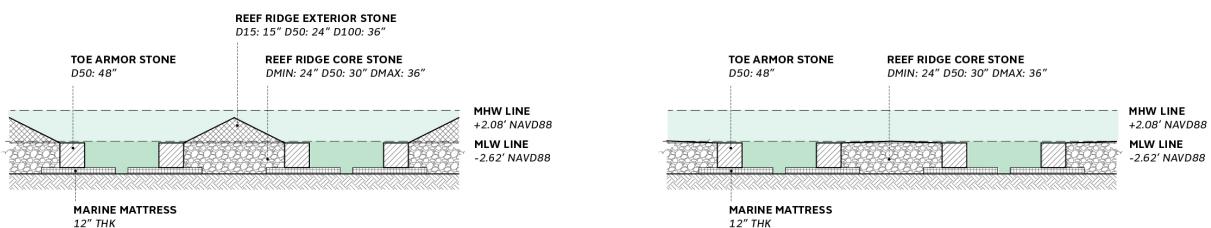
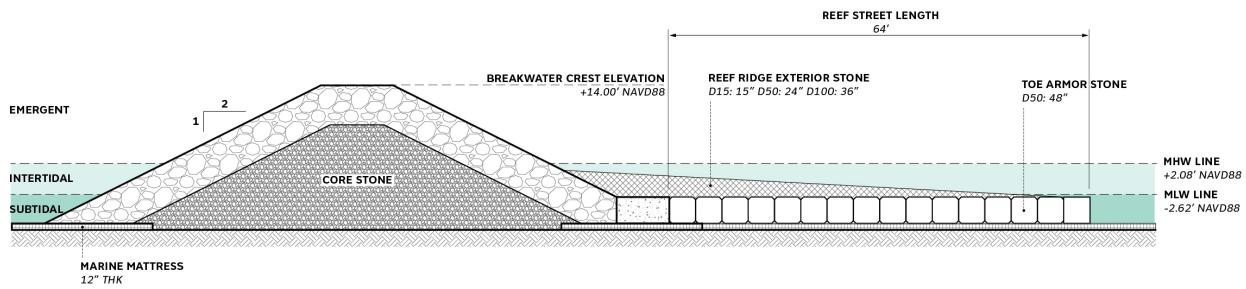
The Breakwaters Project (see Figure 9-16) comprises:

- an ecologically enhanced breakwater system, consisting of 9 breakwater segments of varying size;
- an area of one-time shoreline restoration;
- a proposed seasonally placed floating dock; and
- a proposed Water Hub and possible accessory seasonal boat launch.

The proposed breakwaters would have a total length of approximately 3,200 linear feet (0.6 miles) within Raritan Bay and would be located between 790 and 1,200 feet from the shoreline. Additionally, the vast majority of the breakwater structures would be located more than 1,700 feet from the Federal Navigation Channel with the closest breakwater segment located more than 700 feet from the channel. The breakwater structures would occupy approximately 495,900 square feet (11.4 acres) on the bottom of Raritan Bay and result in the placement of 151,780 CY of rock and ecologically enhanced concrete within Raritan Bay; approximately 117,880 CY of which would be below MHW, and 115,990 CY of which would be below MLW. Approximately 7.1 acres of the breakwaters would be located within NYSDEC littoral zone tidal wetlands (waters less than 6 feet at MLW) (see Table 9-15). The breakwaters would incorporate ecological enhancements that include rocky protrusions (reef ridges) and the narrow spaces between them (reef streets) to create additional complex hard/rocky structured habitat extending out on the ocean-facing side of the breakwaters (see Figure 9-17). The breakwaters would be positioned to optimize reductions in both wave height and shoreline erosion, minimize scour at the structures, and ensure flushing of the reef streets while enhancing habitat and minimizing habitat displacement and navigational impacts. The Type A breakwaters, farthest west in the study area, would have crest crenellations



Components of the Proposed Breakwaters Project

BREAKWATER AXON**BREAKWATER SECTION**
VARIES BASED ON WATER DEPTH AND ELEVATION

Source: SCAPE / Landscape Architecture PLLC

Proposed Breakwater Reef Streets and Ridges
Coastal and Social Resiliency Initiatives for Tottenville Shoreline

Figure 9-17

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in order to increase the surface area of intertidal habitat and create a water column connection at high tide between both sides of the breakwaters. The crenels would form areas with the same conditions found on low crested biogenic structures such as reefs, mussel beds, and tidal flats, where the crest is submerged during high tide and storm events. Effective flushing of water through these areas is typically associated with high biodiversity and biomass.

Three types of breakwaters, defined largely by their differences in crest elevation (in NAVD88) and overall height, are proposed: Type A, Type B, and Type C (see **Figure 9-18**), all of which would extend some height above MHW. Two segments of Type A breakwaters would be installed in the western portion of the project site near Ward's Point. These breakwaters would have crenels along the tops and have a crest elevation of 5 feet NAVD88, with an overall height of 11 feet. Both Type A segments would have 12 reef ridges on the ocean side. Together the two segments would be approximately 900 feet long, and result in the placement of 19,940 CY of rock and other breakwater material in the bay, of which 19,020 CY would be below MHWS, and 18,840 CY would be below MHW. The two segments would occupy 2.8 acres of bay bottom, all of which would be within NYSDEC littoral zone tidal wetlands (waters with depths of 6 feet or less at MLW) (see **Table 9-15**).

In the middle portion of the project site, offshore of the shoreline restoration area, five segments of Type B breakwaters would be installed; four Type B breakwater segments would each include 4 reef ridges and streets, and one would not. Together these segments would be approximately 1,500 feet long, with a crest elevation of 14 feet NAVD88, an overall height of 20 feet, and result in the placement of approximately 79,870 CY in the bay, of which 58,620 CY would be below MHWS, and 57,520 CY would be below MHW. The five segments would occupy 5.7 acres of bay bottom, of which approximately 4.4 acres would be in waters with depths of 6 feet or less at MHW and mapped by NYSDEC as littoral zone tidal wetlands (waters with depths of 6 feet or less at MLW) (see **Table 9-15**).

Two Type C breakwaters, C1 and C2, would be installed offshore from the terminus of Page Avenue in the eastern portion of the project site; the Type C2 breakwater segment would include 4 reef ridges and streets and a lee-side intertidal shelf, and the Type C1 segment would not. Together, these segments would be approximately 800 feet long, with a crest elevation of 14 feet NAVD88, an overall height of 24 feet, and result in the placement of approximately 51,970 CY within the bay, of which approximately 40,240 CY would be below MHWS, and 39,630 CY would be below MHW. The two segments would occupy 3.0 acres of bay bottom, all of which would be in waters with depths greater than 6 feet at MLW, and thus not within a NYSDEC littoral zone tidal wetland (see **Table 9-15**).

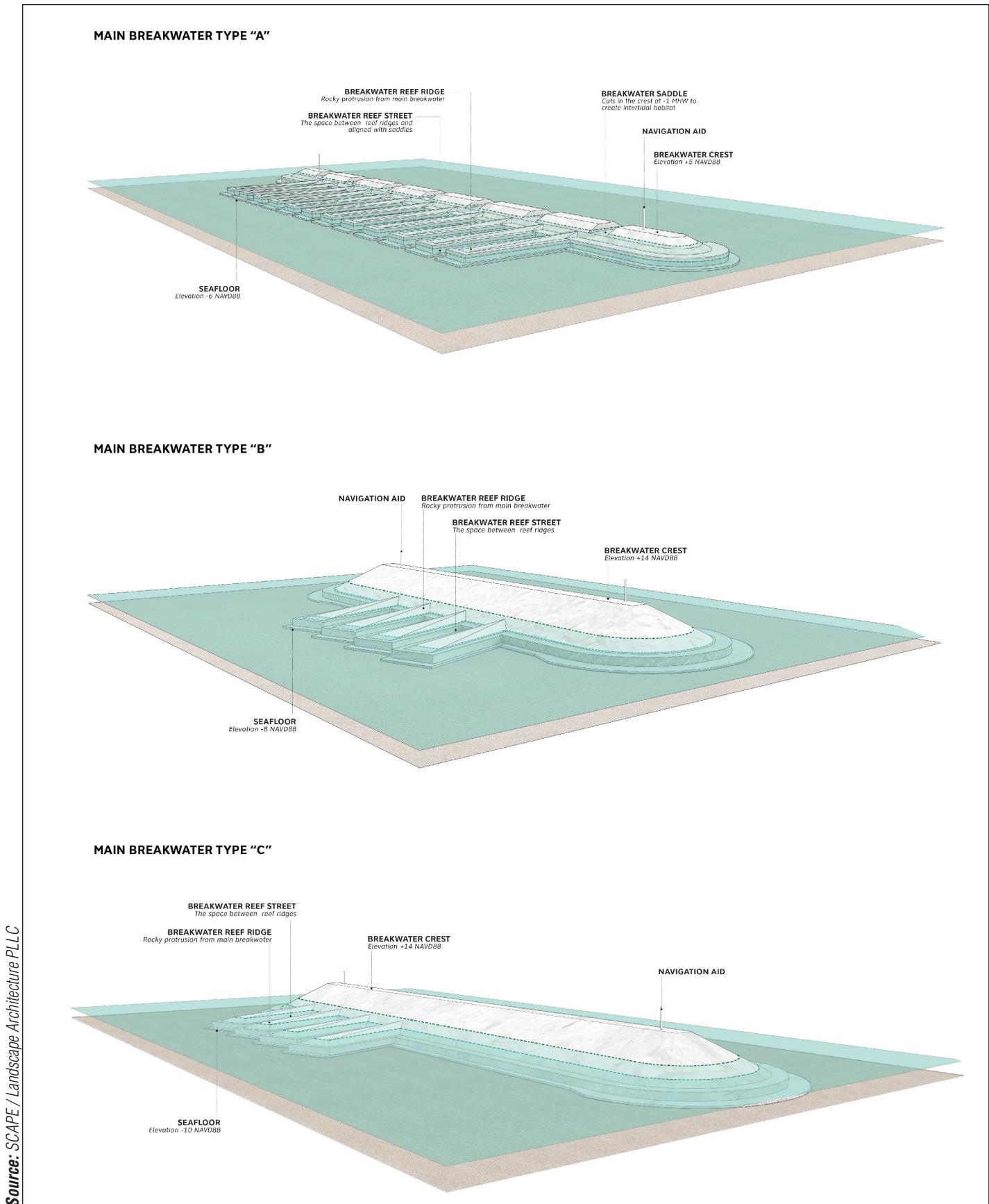


Table 9-15
Breakwater Type Areas and Volumes

<u>Breakwater Type</u>	<u>Total Length (feet)</u>	<u>Total Footprint (square feet)</u>	<u>Total Footprint (acres)</u>	<u>Footprint Below -6' MLW (acres)</u> ¹	<u>Total Volume (cubic yards)</u>	<u>Total Volume Below MHW (cubic yards)</u>	<u>Total Volume Below MHWS (cubic yards)</u>
A1	450	59,600	1.4	1.4	9,970	9,420	9,510
A2	450	59,600	1.4	1.4	9,970	9,420	9,510
B1	300	39,000	0.9	0.9	14,630	10,160	10,380
B2	300	51,500	1.2	1.2	16,310	11,840	12,060
B3	300	51,500	1.2	1.1	16,310	11,840	12,060
B4	300	51,500	1.2	0.8	16,310	11,840	12,060
B5	300	51,500	1.2	0.4	16,310	11,840	12,060
C1	350	49,000	1.1	0.0	20,230	14,900	15,170
C2	450	82,700	1.9	0.0	31,740	24,730	25,070
Type A Total	900	119,200	2.8	2.8	19,940	18,840	19,020
Type B Total	1,500	245,000	5.7	4.4	79,870	57,520	58,620
Type C Total	800	131,700	3.0	0.0	51,970	39,630	40,240
Total	3,200	495,500	11.4	7.1	151,780	115,990	117,880

Notes: Total footprint in acres is a rounded conversion of the footprint in square feet.

¹ NYSDEC littoral zone tidal wetland

Breakwater crest elevations and locations were based on the relative need for storm wave attenuation along the shoreline, the intent to stabilize shoreline change across the project area and to promote shoreline accretion (reverse erosion) in key locations. Type B and C breakwaters, which each have a crest elevation of 14 feet NAVD88. Considering up to 30 inches sea level rise, these breakwaters are designed to reduce wave heights to less than 3 feet in a 100-year storm event (with 30 inches of sea level rise), thereby reducing wave energy at the shoreline and structural damage to on-shore assets previously exposed to storm wave action. The Type A breakwaters, with crest elevations of 5 feet, would be placed where erosion of the shoreline needs to be reduced but less wave attenuation is needed. The crenels on the tops of these breakwaters would allow water to flow through the top of the segments at MHW, reducing the flow around the structures, and thus reducing scour at their edges. The Type A breakwaters would still remain above MHW with up to 30 inches of sea level rise, and thus would still reduce or reverse long term erosion.

Wave attenuation provided by the breakwaters on a day-to-day basis would help maintain beach conditions by reducing long term beach erosion rates, reducing exposure of shoreline structures to erosion, and encouraging accretion in priority beach zones (where the existing beach is narrow and/or projected rates of erosion are high). The breakwater system is designed and located to maintain and restore the beach while minimizing down-drift impacts. The breakwaters would attenuate waves and alter the sediment transport along the shore for this purpose. Local sediment transport rates and accretion would be altered but the natural processes would not be blocked as there would still be sediment transport along the shore and tidal circulation around the breakwaters. At the western tip of the study area near Ward's Point, the breakwaters would likely reduce sand migration from the northeast into the Federal Navigation Channel. The breakwaters were also designed to encourage shoreline growth, or accretion, in places where the beach is most narrow and/or projected erosion rates are high. One-time shoreline restoration proposed for the narrow section of shoreline between Loretto Street and Manhattan Street would augment the accretion potential that could be provided by the breakwaters.

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To construct the breakwater segments, geotextile fabric would be installed on the bottom in a manner that minimizes sediment resuspension. The geotextile would be prefabricated offsite in large panels and spooled onto a roller that may be floated out to the installation location. Sheets would be cut to the required length and lowered to the bottom using temporary framing or pinning and held in place permanently using rocks for the breakwater construction. The rock would be placed on top of the geotextile in various configurations (see **Figure 9-19**). Rocks used for armoring and to construct the breakwaters would be made of “clean” material to further minimize the potential for release of suspended material into the water column. They would be regionally sourced from an existing quarry and directly barged to the project area. Crane barges would be moved during construction as needed to construct the breakwater segments, and vessels carrying construction materials would make an average of less than one trip per day over the entire construction period. Construction vessels would maintain a separation of at least 2 feet from the bottom of the Bay during all tide phases. Construction would last approximately 6 months in the first year and 5 months in the second year, or 11 months in total.

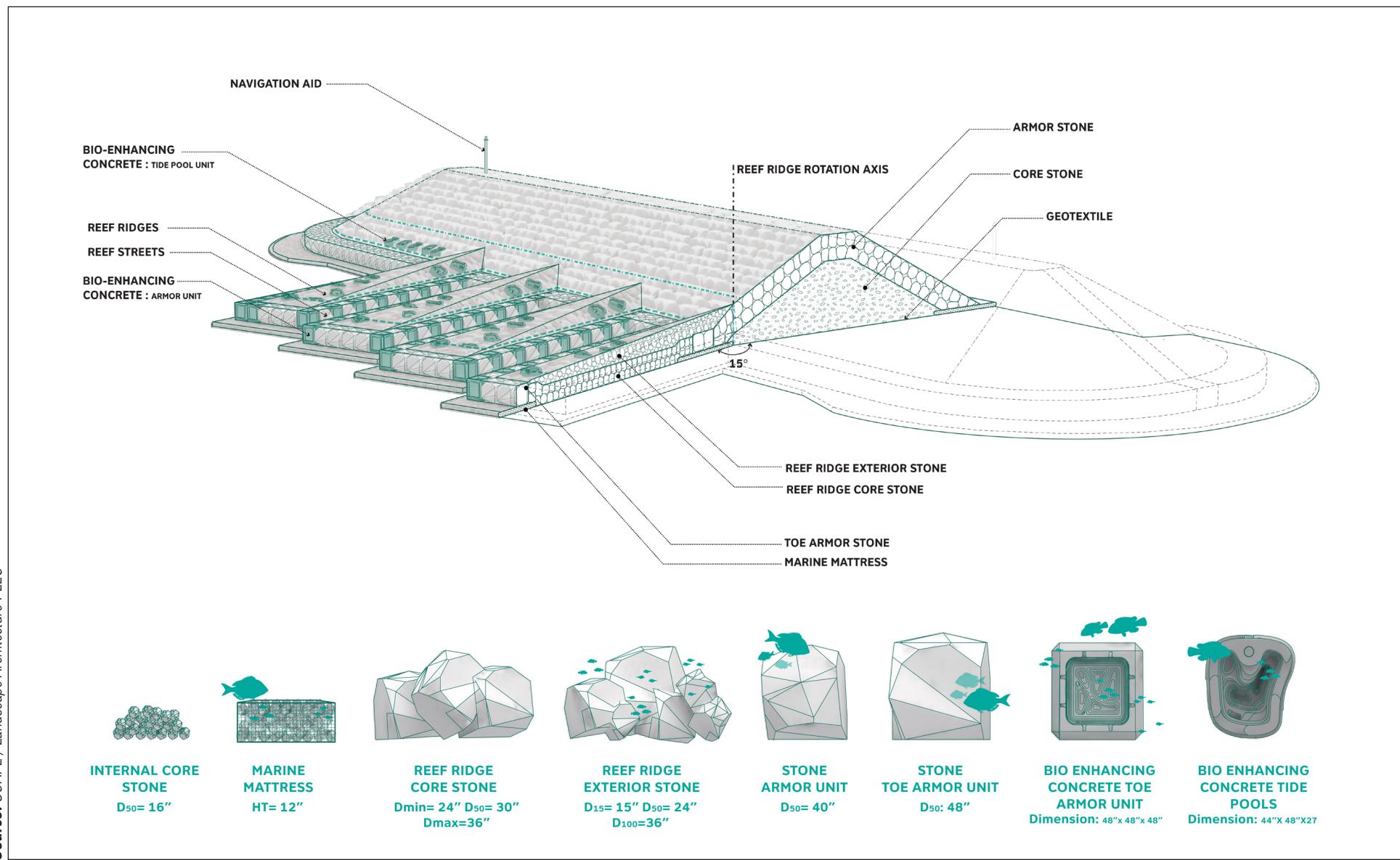
The proposed area of one-time shoreline restoration would include placement of approximately 17,404 CY of sand over approximately 136,100 square feet (3.1 acres), of which 12,341 CY would occupy 117,700 square feet (2.7 acres) below MHWS, and 11,637 CY would occupy 114,500 square feet (2.6 acres) below MHW (see **Table 9-16**). The proposed shoreline restoration would extend along approximately 806 feet of shoreline between Manhattan Street and Loretto Street to establish a wider beach in what is currently a narrow and erosion-prone section of the beach. Following its initial placement profile, the sand is expected to shift down the beach over time as it reaches the anticipated equilibrium configuration projected on the basis of modeling and design efforts. The shoreline restoration would extend the beach waterward at an elevation of +5.0 feet NAVD88 to a width of 50 feet and then slope downward to meet the existing bathymetry.

Table 9-16
Shoreline Restoration Area and Volume of Sand Placed

	<u>Area (square feet)</u>	<u>Area (acres)</u>	<u>Volume (cubic yards)</u>
Total Shoreline Restoration	<u>136,100</u>	<u>3.1</u>	<u>17,404</u>
Below MHW	<u>114,500</u>	<u>2.6</u>	<u>11,637</u>
Below MHWS	<u>117,700</u>	<u>2.7</u>	<u>12,341</u>
Note: Shoreline restoration would be completed over 806 linear feet of shoreline between Manhattan Street and Loretto Street.			

This 3.1-acre area was selected for one-time shoreline restoration between Manhattan and Loretto Streets to reduce erosion and grow the beach within this portion of Conference House Park. The results of modeling indicate that this section of the beach would be slow to respond to the breakwaters and may not achieve the necessary width for risk reduction and maintaining public access. Under equilibrium conditions, this one-time shoreline restoration would approximate the historic 1978 shoreline position, augment the accretion potential that can be provided by the breakwaters and add sediment to the overall system, particularly contributing to one of the narrowest and most erosion-prone areas of beach in the site and generally enhancing overall beach growth potential. With the shoreline restoration, the Breakwaters Project would allow the beach to gain approximately 50 feet in width over 20 years; without the added sand, beach width would only gain approximately 15 feet over this same time period.

Installation of breakwater segments occupying 11.4 acres in Raritan Bay comprising a total of 117,880 CY of rock and bio-enhancing concrete placed below MHWS and the placement of



Proposed Breakwater Stone Configuration

Figure 9-19

12,341 CY of clean sand over 2.7 acres below MHWS to be used for a one-time shoreline restoration would require a permit from the USACE under Section 10 of the Rivers and Harbors Act and Section 404 of the Clean Water Act, and from the NYSDEC under Articles 15 and 25 of the New York ECL.

One of three potential locations under consideration will be selected for siting the Water Hub within Conference House Park—Potential Location 1 would be in the vicinity of the southern terminus of Page Avenue (involving the construction of a new structure). Potential Location 2 would be in the northwestern portion of Conference House Park (involving the rehabilitation and adaptive reuse of an existing NYC Parks building). Potential Location 3 is a water-based Water Hub Option. It would involve a “floating” Water Hub or vessel operated by a non-profit organization (e.g., BOP). The vessel would visit the breakwater project area periodically for education and monitoring and would be docked at existing facilities in the City (serving local groups and community members when docked locally) (see Figures 1-4, and 1-10 through 1-16).

Potential Location 1 (On-Shore)—Potential Location 1 is in the vicinity of the southern terminus of Page Avenue (see Figures 1-4, and 1-10 through 1-13). At this location, there are two options for the construction of the Water Hub. The first, Page East Option, would locate the proposed Water Hub in an existing Conference House Park parking lot and surrounding wooded area immediately east of Page Avenue. The second, Page West Option, would use a grassy site west of Page Avenue that has previously contained a two-story NYC Parks building (which was demolished in 2016 due to substantial damage caused by Superstorm Sandy). The proposed Water Hub facility is expected to include an enclosed 5,000-square-foot building and approximately 35,500 square feet of site improvements that would include landscaping, parking and utility spaces and designated space for the use of NYC Parks vehicles and equipment. An approximately 210-foot-long by 8-foot wide accessory seasonal boat launch would extend from about 1 foot above MHW to water depths sufficient for docking of a shallow draft research vessel in water depths between 4 and 5 feet at MLW. The proposed Water Hub would provide direct on-site waterfront access and would include parking for visitors, as well as several on-shore and near-shore landscape elements. It is anticipated that the facility would be used by the New York Harbor Foundation, NYC Parks, and local schools and community groups. Should Water Hub programming be located at Potential Location 2 or Potential Location 3 (see below), a small facility would be located at Potential Location 1 to provide seating, wayfinding and interpretive elements and potential storage for kayaks and beach cleaning equipment. This structure would be a small pavilion, shed, or other light structure (approximately 400 feet), and may be connected to the City's water supply but would not require sanitation sewer connections. The existing parking facilities at the terminus of Page Avenue would be used to access this facility.

Potential Location 2 (On-Shore)—Potential Location 2 is in the northwestern portion of Conference House Park (see Figures 1-1, and 1-14 to 1-16). At this location, there are two options for the adaptive reuse of existing NYC Parks buildings for Water Hub programming: the Henry Hogg Biddle House (Biddle House); and the Rutan-Beckett House. Water access would be provided in the vicinity of the NYC Parks building selected for adaptive reuse. Water access would be provided by ADA accessible pathways and ramps leading to the beach in the vicinity of a seasonally deployed temporary floating boat launch. Parking for Water Hub activities at Potential Location 2 would be accommodated at the existing Conference House Park Visitor's Center. A small facility to provide seating, wayfinding, interpretive elements, and potential storage for kayaks and beach cleaning equipment would be constructed near the terminus of Page Avenue. This structure would be a small pavilion, shed, or other light structure as described above under Potential Location 1. The existing parking facilities at the terminus of Page Avenue would be used

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to access this facility. Additional wayfinding, interpretive signage, and monitoring locations would be integrated along the length of the shoreline as part of the Water Hub's educational programming.

Potential Location 3—Potential Location 3 would involve a “floating” Water Hub, or vessel operated by a non-profit organization (e.g., BOP). The vessel is anticipated to be between 54 and 100 feet long by 24 feet wide, with a draft of 4 feet. The vessel would be docked at existing facilities in the City (serving local groups and community members when docked locally) and would visit the project area approximately once per week from April through November for student based teaching events, and host community events approximately twice per month. When in the project area, the vessel would anchor near the breakwater structures for observation/monitoring and education activities. Each trip would accommodate approximately 30 to 75 students/community members and instructors/presenters depending on the size of the vessel ultimately acquired. The vessel would be anchored off the breakwater for less than one day each time. It would only operate where the bottom of the vessel can maintain a 2-foot separation from the mudline. Should Water Hub programming be located at Potential Location 3, wayfinding, interpretive elements, and potential storage for kayaks would be constructed near the terminus of Page Avenue. Additional wayfinding, interpretive signage and monitoring locations would be integrated along the length of the shoreline as part of the Water Hub's educational programming. No additional parking facilities would be required with this option. Also, because this option does not include an onshore facility, a seasonally deployed temporary floating boat launch would not be included as part of the project.

Should Water Hub programming be located at Potential Location 1 or 2, a temporary seasonal floating dock measuring about 30 feet by 50 feet, with a total area of 1,500 square feet, would be installed near the Type C eastern breakwater segments for observations, monitoring, maintenance, and stewardship, including specifically, for vessels operated by project stewards. The floating dock would not be required for Potential Location 3, because education and monitoring activities could occur directly from the vessel or “floating” Water Hub.

SHORELINE PROJECT

The proposed Shoreline Project would consist of a series of shoreline protection measures that would include an earthen berm, hybrid dune/revetment system, two sections of eco-revetments, and a raised edge with a revetment, along with wetland enhancements and landscaping with coastal plant species, as described in greater detail below. It would extend from approximately west of the intersection of Swinnerton Street and Billop Avenue to Page Avenue (see **Figure 9-20**). The proposed earthen berm would be located from approximately Carteret Street to Brighton Street where it would tie into an eco-revetment that would run along the northern edge of a 0.8-acre delineated tidal wetland and end at Manhattan Street, at the start of a reinforced, planted dune/revetment system (hybrid dune/revetment). The hybrid dune/revetment would extend to Loretto Street and transition to another eco-revetment along Surf Avenue that would extend to approximately Sprague Avenue, where a stretch of raised edge with a revetment would continue the rest of the length of the Shoreline Project to Page Avenue (near the site of the proposed Water Hub Potential Location 1). Two transition nodes, comprising approximately 358 square feet in total with landscaping, would connect the hybrid dune/revetment and eco-revetment and the eco-revetment to the raised edge; these would consist of concrete pavers connected to sidewalks or trails and stairways to allow shoreline access.

The Shoreline Project would be well above MHW (+2.08 NAVD88), but would occur within the NYSDEC TWAA and a delineated tidal wetland, and would require a permit under Articles 15

Source: Stantec / RACE Coastal Engineering



Proposed Shoreline Project

Figure 9-20

and 25 of the ECL. Along the length of the Shoreline Project, additional shoreline treatments would be implemented, such as wetland enhancements and additional shoreline plantings. Green infrastructure would be implemented wherever possible. The Shoreline Project has been designed to withstand storm wave action and overtopping of the shoreline structures, and to be resilient to sea level rise of 30 inches and provide some level of risk reduction from coastal flooding.

The Shoreline Project includes the following:

- *Earthen Berm*—The proposed earthen berm would be stabilized with a 12” thick layer of stone and would be approximately 25 feet wide, range from 1 foot to 7.5 feet high and extend approximately 948 linear feet between Carteret Street and Brighton Street, for a total footprint of 0.5 acres (see **Figure 9-21**). The earthen berm would run through a section of Conference House Park consisting mainly of successional hardwood forest and connect to an eco-revetment south of Brighton Street. The crest of the berm would be 8-ft wide and contain either habitat-specific native plant species or a pathway comprised of pervious material, depending on the location. The angled sides of the berm would be planted with a mix of native habitat-specific species from **Table 9-14** that will be coordinated with NYC Parks and the Greenbelt Native Plant Center. Most of the earthen berm would be vegetated.
- *Eco-Revetment between Brighton Street and Manhattan Street*—The proposed eco-revetment in this area (see **Figure 9-20**) would be 46 feet wide and extend approximately 338 linear feet between Brighton Street (at the eastern terminus of the earthen berm) to Manhattan Street (where the hybrid dune/revetment begins). This project element would bring the risk reduction system upland of the western portion of the hybrid dune/revetment system described above, along the northern edge of a 0.8-acre delineated wetland. The eco-revetment would comprise a pathway and rip rap with joint plantings, providing continuous access along this stretch of the project area (see **Figure 9-23**).
- *Hybrid Dune/Revetment System*—The proposed hybrid dune/revetment would be at an elevation of approximately 14 feet (approximately 1 foot higher than the existing temporary dune system), with a 70 foot to 90 foot width, and extend approximately 937 linear feet between Manhattan and Loretto Streets (see **Figure 9-22**). The temporary dune between Brighton and Loretto Streets (approximately 16,270 CY of material) would be removed. The hybrid dune/revetment would consist of 12,000 CY of material, including armor stone, bedding stone, and earthen fill. The crest of the dune would be 10 feet wide and higher than the current grade, providing a more gradual transition from upland elements to the shoreline. The proposed hybrid dune/revetment would be stabilized with armor core stone, capped with sand, and planted with American beach grass (*Ammophila breviligulata*) over an approximately 1.9-acre area.
- *Eco-Revetment between Loretto Street and Sprague Avenue*—The proposed eco-revetment in this area would be approximately 60 feet wide and extend approximately 396 feet from Loretto Street to Sprague Avenue for a total footprint of approximately 0.55 acres and comprise a bioswale, sloped plantings, a pathway, and rip rap or concrete steps, depending on the location along the shoreline (see **Figure 9-23**). A concrete sidewalk along Surf Avenue would border a 5-foot-wide bioswale, separated by a 6 inch curb. The bioswale would be planted with a mix of native habitat-specific species from **Table 9-14**. Approximately 0.09 acres of the eco-revetment would be vegetated. A narrow concrete wall would separate the bioswale and the upward-sloped section of the eco-revetment, which would be planted with perennials, ornamental grasses, and groundcover. The top of the eco-revetment would consist of an 8-foot-wide pathway that would transition to downward-sloped sections, varying in size, of



Source: Stantec / RACE Coastal Engineering



FOR ILLUSTRATIVE PURPOSES ONLY



Coastal and Social Resiliency Initiatives for Tottenville Shoreline

Proposed Eco-Revetment
(between Loretto Street and Sprague Avenue)

Figure 9-23

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American beach grass and other habitat appropriate coastal plantings, concrete steps, or rip rap, depending on the location along the shoreline.

- *Raised Edge (Revetment with Trail)*—The proposed 8-foot-wide raised edge would begin at Sprague Avenue and extend approximately 2,536 feet to Page Avenue with an approximate total footprint of 5.3 acres (see **Figure 9-24**), all of which would be within the NYSDEC TWAA. Approximately 60 percent of the footprint, or 3.8 acres, would comprise seaward revetment. The trail would be bordered upland by an approximately 5-foot-wide bioswale and shoreward by a stone revetment cresting at either 8 feet (same elevation as the proposed pathway) or 12.5 feet, depending on the location, and would comprise a top layer of either concrete or asphalt. Approximately 1.7 acres of native coastal vegetation would be planted as part of the raised edge, comprising about 17 percent of the raised edge footprint. The segment of the raised edge parallel to Tricia Way would include the removal of approximately 2,290 CY of unpermitted fill and wall within approximately 17,370 square feet located along of the shoreline. Approximately 5,470 square feet and 280 CY of unpermitted fill below MHW (NYSDEC littoral zone), and 2,010 CY over 11,900 square feet within the NYSDEC TWAA would be removed. Some of this material would be re-used as part of Alternative 2 in accordance with a BUD prepared for the Proposed Actions. After the unpermitted fill is removed and the components of Alternative 2 are constructed, there would be an approximately 320 CY reduction in fill occupying the NYSDEC littoral zone (area below MHW) and the NYSDEC TWAA than at present.

Construction of the Shoreline Project would be conducted landside and proceed from west to east. Materials for the Shoreline Project are anticipated to be delivered to the project site via trucks to construction staging areas. Water-based delivery of material is unlikely for the Shoreline Project but would be explored as design progresses. Site preparation would be conducted first, followed by excavation, then placement of bedding stone, armor stone, and revetment stone to construct the various Shoreline Project structures. Sand placement final grading and planting would be done following stone placement. An estimated 4 to 12 feet of excavation would be required for construction of the Shoreline Project. Excavated soil suitable for reuse would be stockpiled adjacent to the excavation for use as backfill. Soil unsuitable for reuse or in excess of what is needed for construction of the proposed structure, would be transferred to construction staging areas before being hauled off-site to a licensed facility. Removal of the existing man-made temporary dune comprising sand-filled barrier bags would likely occur following the placement of the earthen berm fill so that some measure of shoreline protection would remain in place when the barrier bags are removed. Work in and around the wetland would be conducted within a demarcated, fenced area to limit construction activities and traffic within the wetland area. Construction of the Shoreline Project would take approximately 15 months—4 months for the earthen berm, 5 months for the hybrid dune/revetment, 3 months each for the eco-revetments and transition nodes, and 6 months for the raised edge.

The following sections discuss the potential for natural resource impacts to occur under the Alternative 2, the Layered Strategy, during construction and operation.

GROUNDWATER

Construction

Excavation of soils during construction of the Shoreline Project and proposed Water Hub at Potential Location 1, including the removal and re-use of the unpermitted fill material at Tricia Way, would vary between depths of 4 and 12 feet. Depth to groundwater within the upland portion



of the study area along the shoreline ranges from 4 to 6 feet, varying with season, precipitation and tides. Sampling of the southernmost portion of the unpermitted fill that would be removed south of Tricia Way for construction of the raised edge indicated that these samples met the NYSDEC SCOs for residential use and for protection of groundwater (6 NYCRR Part 375-6.4[b][1] and 375-6.5), with the exception of acetone in some of the samples, which exceeded the protection of groundwater SCO, but which is a typical laboratory contaminant and thus may have not actually been present in the samples. In addition to this exceedance, there were also exceedances of the more restrictive “Unrestricted SCOs” for the metals lead and nickel, and for the pesticide DDT and its metabolites DDE and DDD. As such, the removal of this material (and, assuming testing of the remaining soil indicates similar findings, the remaining soil to be removed from within the Surf Avenue right-of-way) would not have the potential to adversely affect groundwater resources. Excavation of soils along the other portions of the Shoreline Project and any shallow excavation that would occur at the Water Hub Potential Location 1, and at Potential Location 2 for the construction of a pathway or ramp from one of the repurposed NYC Parks buildings is not anticipated to encounter widespread or significant soil or groundwater contamination (see Chapter 8: Hazardous Materials). Should evidence of contaminated soil/or sand, creosote-treated wood or other contaminants be encountered, these materials would be segregated and disposed of in accordance with applicable federal, state and local regulations. Groundwater recovered during dewatering, if any, would be tested and treated in accordance with NYSDEC requirements prior to discharge to Raritan Bay. With these measures in place the construction of Alternative 2 would not result in significant adverse impacts to groundwater resources.

Operation

Operation of Alternative 2 would not adversely affect either the confined (i.e., artesian) or unconfined (i.e., water-table) groundwater underlying the project site. The Shoreline Project and Water Hub component of the Breakwaters Project have incorporated bioswales and other green infrastructure stormwater management measures where possible to allow infiltration of runoff and recharge to groundwater. Additionally, all of the shoreline elements are porous and would allow seepage of bay and groundwater through the structures. The landscaped areas within the Shoreline Project and at both Water Hub Potential Locations would be maintained using IPM techniques thereby substantially diminishing the need for the use of pesticides and other chemicals. Therefore, the discharge of stormwater runoff from the shoreline portions of Alternative 2 would not result in significant adverse impacts to groundwater quality.

Groundwater is not used as a potable water supply in the area (Rosenberg 2013) and Alternative 2 would not result in groundwater withdrawal. Therefore, Alternative 2 would not have the potential to adversely affect groundwater resources on or in the vicinity of the study area, and would be compliant with Section 1424(e) of the U.S. Safe Drinking Water Act.

WETLANDS

NWI-mapped wetlands (E1UBL, E2US2N, E2US2P, E2EM5P6, E1UBL6, and PUB/SS1T), NYSDEC-mapped freshwater wetlands (AR-22 and AR-15) and NYSDEC littoral zone tidal wetlands occur within the study area. In addition, a 0.8-acre tidal wetland meeting the three USACE wetland criteria (hydric soils, hydrophytic vegetation, and wetland hydrology), was delineated within the study area on August 10, 2016, east of the location of the earthen berm, south of a portion of the eco-revetment, and west of the proposed hybrid dune/revetment. Currently, there is limited connectivity between this phragmites-dominated wetland and the open waters of Raritan Bay due to the presence of the temporary dune and sand clogged inlet structure. The marsh

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is currently split by a section of unpermitted fill forming a sand bridge that further restricts tidal flow to the eastern end of the wetland. The Proposed Actions would include removal of these obstructions to improve tidal exchange between the wetland and Raritan Bay, allowing access for fish that may move through the Bay and connected waters. Phragmites would also be removed, and native saltmarsh plants would be planted. These enhancements may also improve foraging habitat for waterbirds that occur in the wetlands.

Construction

Construction of the shoreline restoration and the off-shore component of Alternative 2 would result in temporary impacts to NYSDEC littoral zone tidal wetlands and mapped NWI estuarine wetlands due to sediment resuspension (placement of sand for shoreline restoration, placement of breakwater materials, and movement of construction barges and vessels). Increases in suspended sediment would be temporary, localized, and would dissipate upon cessation of sediment disturbing activities. Construction of the breakwater segments would result in the unavoidable permanent loss of NYSDEC littoral zone tidal wetlands within the footprint of the Type A and Type B breakwater segments (approximately 7.1 acres) located in water depths of 6 feet or less at MLW, and within the portion of the shoreline restoration below MHW (2.6 acres), for a total loss of NYSDEC littoral zone tidal wetlands of approximately 9.7 acres. This loss of NYSDEC littoral zone tidal wetlands would be small when considered in context of the unaffected NYSDEC littoral zone tidal wetlands within the study area and Raritan Bay as a whole. Approximately 1.8 acres of NYSDEC TWAA would be modified due to the shoreline restoration. This placement of additional sand would not adversely affect this portion of the TWAA or the function it serves in protecting NYSDEC littoral zone tidal wetlands.

Approximately 5,640 square feet (0.13 acres) of the eco-revetment would be constructed within the northern limit of the 0.8-acre delineated tidal wetland (see **Figure 9-10**). An approximately 630 square-foot section (0.01 acres) of the hybrid dune/revetment would also be constructed in this wetland at its eastern limit. In total, approximately 6,270 square feet (0.14 acres) of this wetland would be impacted. An existing sand bridge comprising unpermitted fill (approximately 595 square feet and 44 CY) that runs north to south currently divides the delineated wetland and would be removed in order to construct the eco-revetment. The removal of this sand bridge would remove an impediment to tidal exchange within the eastern portion of the wetland, and result in a net change in fill within the wetland of approximately 5,675 square feet (0.13 acres), and 1,176 CY. Permanent impacts to the tidal wetland would be primarily within the portion of the wetland dominated by common reed and while the loss of a portion of the wetland would be an adverse effect, it would be offset by the enhancement of the tidal wetland plant community that would include improved tidal exchange through modification of the inlet to Raritan Bay. Temporary impacts would be minimized through the use of measures such as marsh mats or low ground-pressure equipment within the wetland, and installation of erosion and sediment control measures in accordance with the SWPPP prepared as required under the SPDES General Permit GP-0-15-002 for Stormwater Discharges from Construction Activity. Portions of the wetland disturbed during dune/revetment and eco-revetment construction would be restored as necessary (e.g., repair of ruts, stabilization of soil). Wetland vegetation would be planted to replace vegetation temporarily disturbed during construction. Phragmites would be removed from the wetland, and native saltmarsh plants would be re-established through seeding or planting plugs to supplement the native saltmarsh vegetation that already occurs in the wetland. The existing native salt marsh vegetation would be retained to the extent possible, and individual plants and seeds would be collected for preservation and replanting as part of wetland enhancement activities. With these measures in place, temporary impacts to wetlands during construction and the permanent loss of

a small portion of the wetland due to the eco-revetment and hybrid dune/revetment would not result in significant adverse impacts to wetland resources.

Other elements of the shoreline component of Alternative 2 would be built within the NYSDEC-regulated TWAA (i.e., the hybrid dune/revetment, eco-revetment, raised edge, parking lot for the Water Hub at Potential Location 1, and the small facility near the terminus of Page Avenue that would be developed at Water Hub Potential Location 1 should the Water Hub program be sited at Potential Location 2 or Potential Location 3). The area of unpermitted fill in the vicinity of Tricia Way would fall within NYSDEC littoral zone tidal wetlands and TWAA, where a total of 2,290 CY of unpermitted fill would be removed, approximately 280 CY of which would be below MHW. After the unpermitted fill is removed and the components of Alternative 2 are constructed, there would be an approximately 320 CY reduction in fill occupying the NYSDEC littoral zone (area below MHW) and the NYSDEC TWAA than at present. Erosion and sediment control measures (e.g., silt fencing and hay bales) would be implemented in accordance with the SWPPP prepared for the project as required by the General Permit and would minimize discharges of sediment to Raritan Bay during construction of these project elements. Therefore, construction of Alternative 2 would not adversely affect wetlands.

Operation

The operation of the Breakwaters Project would not adversely affect NYSDEC littoral zone tidal wetlands within the study area. The Breakwaters Project has been designed to reduce wave energy at the shoreline and prevent or reverse shoreline erosion without adversely affecting tidal flushing within the study area or resulting in down-drift impacts within the NYSDEC littoral zone tidal wetland. The breakwater alignment, segment length and distance from shore are designed to promote beach accretion, but avoid the creation of tombolos (a sand spit connecting the shore and breakwater created through deposition, which would act like a terminal groin extending into the water from the beach, encroaching on NYSDEC littoral zone tidal wetlands). This was tested through modeling the shoreline change impacts of various breakwater alignments using the GENESIS shoreline change model (for scenarios modeled and modeling results, see **Appendix E-6**) The layout of the breakwaters would result in containment of greater amounts of sediment and stabilization of the shoreline throughout the system.

The enhancement of the delineated wetland adjacent to the section of eco-revetment and hybrid dune/revetment system due to removal of the sand bridge and increased tidal exchange (e.g., tidal sluice gates) would benefit wetland resources within the study area. Increased tidal exchange between Raritan Bay and the delineated tidal wetland would increase the frequency and extent of inundation and increase the salinity of the water inundating the wetland. Increased flooding and salinity within the wetland would provide more suitable conditions for native vegetation (e.g., saltmarsh cordgrass [*Spartina alterniflora*], spike grass [*Distichlis spicata*], and salt hay grass [*Spartina patens*]), and limit or reverse the spread of common reed, an invasive species, within the wetland. Biological benchmarks (i.e., elevations at which desirable plants typically grow in the immediate vicinity of the project site) would be established in consultation with NYC Parks to help determine the range of design elevations that would be established for the wetland enhancements following the removal of common reed. Onsite and offsite biological benchmark locations would be identified for survey, and hydrologic data would be collected in order to inform the design of the enhancement. The existing native salt marsh plants would be preserved to the extent possible during construction for re-use at the site. Phragmites, or common reed, would be removed from the wetland, and native saltmarsh plants would be re-established through seeding or planting plugs to supplement the native saltmarsh vegetation that already occurs in the wetland.

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Monitoring activities would be conducted following the completion of wetland enhancement measures, in accordance with a monitoring plan developed in consultation with the appropriate agencies.

Onshore components of Alternative 2 that would be within the NYSDEC TWAA and would require a permit from NYSDEC under Article 25 of the ECL include the hybrid dune/revetment, eco-revetment (between Loretto Street and Sprague Avenue), raised edge, shoreline restoration, portions of the parking area (Potential Location 1), seasonal boat launch (Potential Locations 1 and 2), wayfinding, interpretive signage, and monitoring elements (Water Hub Potential Locations 2 and 3), and the small facility near the terminus of Page Avenue for kayak storage (Potential Locations 2 and 3). The hybrid dune/revetment would enhance the function of the TWAA in protecting the NYSDEC littoral zone tidal wetlands within Raritan Bay by stabilizing the shoreline. In addition to stabilizing the shoreline using a gradual riprap slope designed to minimize erosion of the beach at the toe of the structure, the raised edge would include stormwater management measures such as bioswales to maintain the protective function of the NYSDEC TWAA. While the walkways would be impermeable, stormwater management measures such as bioswales would be installed adjacent to the eco-revetments and raised edge to allow treatment of runoff, and the planted portions of the revetment would also allow some infiltration. The landscaping with native coastal species of the hybrid dune/revetment, eco-revetment, and raised edge would also enhance the native coastal habitats available within the NYSDEC TWAA.

The Water Hub building (both potential onshore locations) would be outside the NYSDEC TWAA, but the parking area (Potential Location 1) and seasonal boat launch (Potential Locations 1 and 2) would be within the TWAA. The parking area would be designed as a pervious surface and would be designed to manage any net runoff generated by the parking area. Therefore, the parking area associated with the Water Hub at Potential Location 1 would not adversely affect the protective function of the NYSDEC TWAA. The seasonal deployment of the floating boat launch would occupy a small portion of the TWAA and would not adversely affect this resource.

In summary, Alternative 2 would stabilize the shoreline while minimizing the potential for erosion of the beach, would enhance the habitats through the establishment of native dune vegetation and other native coastal plant species throughout the Shoreline Project, and would not adversely affect the function of the TWAA to protect NYSDEC littoral zone tidal wetlands. The modification to 1.8 acres of the TWAA due to the shoreline restoration would not adversely affect the TWAA. The loss of approximately 7.1 acres of NYSDEC littoral zone tidal wetlands due to the installation of the Type A and Type B breakwater segments, and approximately 2.6 acres due to shoreline restoration would not result in a significant adverse impact to NYSDEC tidal wetlands within this portion of Raritan Bay.

AQUATIC RESOURCES

Water Quality

Construction

In-water construction activities for Alternative 2 would not result in significant adverse impacts to water quality. All in-water construction work would be done using barge-based crews and materials. Construction of the Breakwater Project in-water components would have the potential to result in temporary impacts to water quality resulting from sediment resuspension during placement of the breakwater materials, movement of construction barges and vessels, and one-time shoreline restoration. Increases in suspended sediment would be minor, temporary, localized, and would dissipate upon cessation of sediment disturbing activities.

To construct the breakwater segments, geotextile fabric would be installed on the bottom in a manner that minimizes sediment resuspension. The geotextile fabric underlying the breakwater structures would be prefabricated offsite in large panels and spooled onto a roller that may be floated to the installation location. Sheets would be cut to the required length and lowered to the bottom using temporary framing or pinning and held in place permanently using rocks for the breakwater construction. The rock would be placed on the geotextile in a manner that limits sediment resuspension. Rocks used for armoring and to construct the breakwaters would be made of “clean” material, further minimizing the potential for release of suspended material into the water column. Crane barges would be moved during construction as needed to construct the breakwater segments, and vessels carrying construction materials would make an average of less than one trip per day over the entire construction period, minimizing the potential for sediment disturbance by vessel movement. Construction vessels would maintain at least 2 feet of clearance from the bottom of the Bay during all tide phases in order to further minimize sediment disturbance.

Construction activities associated with shoreline improvements, including the placement of sand for the shoreline restoration, would be conducted entirely landside. Materials for the Shoreline Project and shoreline restoration are anticipated to be delivered to the project site via construction trucks. Water-based delivery of material is unlikely for the Shoreline Project but would be explored as design progresses. Should construction materials be delivered via barge for offloading by crane, the vessels would not make contact with the bottom or the shoreline. Movement of these vessels, the tugs that would move them into place, and mooring of the material delivery barge may result in temporary increases in suspended sediment and localized turbidity. As with in-water activities for the breakwaters, sediments mobilized by vessels would be expected to settle quickly and would not result in adverse impacts to water quality. Shoreline improvements would be undertaken in accordance with erosion and sediment control plans and best management practices incorporated into the SWPPP prepared for the Proposed Actions and would not result in adverse impacts to water quality from stormwater discharge during construction. This would include all staging areas, and any areas used for the temporary storage of excavated material.

Overall, in-water construction activities for Alternative 2 would not result in significant adverse impacts to water quality.

Operation

If they impound waters and restrict flushing or water circulation, in-water structures can lead to stagnant water conditions, which is one of the major potential contributors to degraded water quality. Stagnant waters tend to encourage accumulation of nutrients and fine sediments, and promote overproduction of phytoplankton and algae, which can lead to anaerobic conditions (Goodwin 1991). Stagnant waters can also have higher bacterial content. The Breakwaters Project has been designed to maintain sufficient flushing conditions in the study area to avoid these potential effects. The results of the hydrodynamic modeling (using DELFT 3D) project negligible changes in tidal flushing would result from the breakwater alignment in Alternative 2 (see **Appendix E-6**). Changes in residence times (time water remains in the area shoreward of the breakwater segments) were modeled as less than a few hours, consistent with tidal exchange. Thus, modeling confirmed that the Breakwaters Project would have negligible, if any, impact on water circulation and flushing and thus water quality within the study area. The use of multiple, shorter structures with sufficient spacing between them, rather than one continuous breakwater, along with their placement at least 200 feet from the shoreline would allow for continuous water exchange through the study area with little obstruction. The breakwaters would create small changes in flow directly surrounding the structures, but would not significantly disrupt existing

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currents in Raritan Bay, or result in increased erosion of bay bottom at the toe of the breakwater segments. Flow3D modeling completed for the Breakwaters Project indicated that water would approach the breakwater and accelerate as it passes around the edges; in the lee of the breakwater, eddies would be formed. This would occur on the ocean side of the structures during flood tide, and on the landward side during ebb tide, resulting in continuous circulation of the water. According to DELFT 3D water circulation modeling completed for the Breakwaters Project, the breakwaters would have little to no impact on flushing times in the project area, and therefore would have no significant impact on water quality. The individual breakwater segments have wide gaps (typically approximately 200 feet) between them, allowing for water movement and flushing between the ocean side and landward side of the structures. The crenulated crest of the Type A breakwaters would also allow water to flow over the breakwater (through the crenels) at MHW, which would allow exchange of water between both sides of the breakwater.

The project area for the breakwaters is currently subject to dynamic wave action and tidal currents on a daily basis. As offshore waves travel to the beach, they can cause resuspension of sediment as they pass over shallow water areas and break; larger waves generally re-suspend more sediment. Tidal currents can also re-suspend finer sediment during peak ebb and flood flows. With the Breakwaters Project, wave energy inshore of the breakwaters would be reduced, potentially resulting in less resuspension of sediments by wave action in the near-shore area. Since the breakwaters would dissipate wave energy, increases in suspended sediment directly adjacent to the breakwaters due to wave action are likewise anticipated to be insignificant. The alignment of the reef ridges has been designed to minimize scour effects and related sediment resuspension. While some scour may occur around the ends of the breakwaters, the associated resuspension of sediment would be localized and would not result in a significant adverse impact to water quality.

FLOW 3D modeling of localized currents and sediment movement around individual breakwater structures completed for the project indicates the potential for scour / deposition patterns to develop at the breakwater perimeter under ebb and flood tidal flows. The scour and deposition depths are modest, estimated as 0.05 to 0.15 feet of scour and 0.1 to 0.3 feet of deposition under normal tidal and wave conditions. There is indication of reversal of the trends between flood and ebb conditions for most areas. For fixed structures in tidal currents, scour and scour related deposition typically reach quasi-equilibrium states, including potentially some change in grain size to scour resistant diameters. The modeling results indicate that scour will be localized, within 15 feet of the ends of the breakwater.

The Breakwaters Project has been designed to maintain and restore the existing shoreline within the study area without significantly altering sedimentation rates outside of the study area. Shoreline modeling results indicate that the MHW line would move offshore in response to the lower wave energy in the lee of the breakwaters. Limited localized resuspension of sediment is possible on a seasonal basis, as the seasonal floating dock and seasonal boat launch are installed and removed but these increases in suspended sediment would be localized, would be of short duration and would be expected to dissipate quickly. Sediment resuspension adjacent to the breakwaters would be localized, only occurring within about 15 feet of the ends of the structures. The minimal sediment resuspension would not result in significant increases in turbidity, and would not have an impact on water quality. The breakwaters have been designed to: minimize sediment transport within reef streets; minimize scour along reef ridges; minimize changes to the reef ridge and street habitats between flood and ebb cycles, and ensure adequate flushing of reef ridges and reef streets.

Elements of the shoreline protection actions associated with Alternative 2 have been designed to mitigate the potential effects of stormwater runoff on water quality in Raritan Bay. The Shoreline Project has integrated green infrastructure measures such as bioswales into the design for the eco-revetment and the raised edge to minimize potential impacts to storm sewers from Alternative 2. Similarly, the parking lot design for the Water Hub at Potential Location 1 would incorporate green infrastructure measures. With these measures in place, runoff resulting from Alternative 2 would not adversely affect water quality of Raritan Bay.

In summary Alternative 2 would not result in significant adverse impacts to water quality of Raritan Bay.

Sediment Quality

Construction

Movement of construction vessels and placement of sand for the shoreline restoration and the breakwater structures may result in temporary increases in suspended sediment containing low to moderate levels of contamination. Generally, sediments in the study area were found to contain low levels of contamination (i.e., Class A concentrations) with some exceedances of Part 375 unrestricted use concentrations. Any sediments resuspended during construction activities would be expected to be localized and to dissipate quickly. Redeposited sediment would be expected to settle out on sediment with similar levels of contamination. Erosion and sediment control measures implemented in accordance with the SWPPP prepared for Alternative 2 would minimize the discharge of sediment to Raritan Bay during construction activities and would not result in significant adverse impacts to sediments in Raritan Bay.

Operation

Alternative 2 would alter sediment characteristics in the footprint of the breakwaters from sand and gravel to hard/rocky bottom. It is anticipated that coarse-grained and sandy material similar to that already found in Raritan Bay would accumulate around the breakwaters consistent with tide and current patterns in the area. Some finer material could settle out in areas of reduced wave energy in the lee of the breakwaters, resulting in minimal deposition behind the structures. Increased deposition is only anticipated to occur at the shoreline. Materials used for construction of the breakwaters would be free of contaminants and would not result in leaching or deposition that could impact sediment quality. Sedimentation rates would be altered, with areas of increased deposition expected along the shoreline within the project site. The breakwaters are designed to dissipate wave energy, so an increase in suspended sediment directly adjacent to the breakwaters is not anticipated to be significant. The breakwaters have also been designed to minimize scour at the base of the structures. Three-dimensional hydraulic modeling indicated that some scour may occur, especially around the ends of the breakwaters. However, any resuspension of sediment would be localized, occurring within about 15 feet from the ends of the breakwaters. Additionally, scour and associated deposition around fixed structures in tidal currents typically reach quasi-equilibrium states, with some change in grain size to scour resistant diameters. As sediments in the study area were found to contain only Class A or Class B contamination levels, the change in sedimentation would not be expected to impact sediment quality either in areas of accretion or scour. Shoreline improvement elements of Alternative 2 would not result in significant adverse impacts to sediment quality or characteristics in Raritan Bay.

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Aquatic Biota

Construction

The in-water construction activities described above under “Water Quality,” have the potential to result in temporary adverse impacts to fish and macroinvertebrates due to the following:

- Sand placement associated with the one-time shoreline restoration;
- Loss of soft-bottom benthic habitat within the area of proposed shoreline restoration below MHW;
- Temporary increases in suspended sediment; and
- Other impacts associated with construction such as vessel movement, movement of breakwater material and construction equipment through the water column, and associated underwater noise.

The proposed one-time shoreline restoration over 2.7 acres below MHWS (2.6 acres of which would be below MHW) between Manhattan Street and Loretto Street would result in a permanent loss of benthic macroinvertebrates unable to move upward through the placed sand. Shoreline restoration would comply with construction windows recommended by NMFS (2018) to protect horseshoe crab spawning activities (April 15 through July 15). Placement of the 12,341 CY of sand that would fall below MHWS (11,637 CY of which would be below MHW) would also be restricted during the spawning season for winter flounder (January 1 through May 31), which has some overlap with the timing of horseshoe crab spawning. The material used for restoration would be similar in composition to the existing sand substrate within the beach at Conference House Park, and macroinvertebrate populations would be expected to re-establish upon completion of sand placement.

Installation of the breakwater segments of the Breakwaters Project would result in the conversion of approximately 11.4 acres of existing sand/gravel substrate and the loss of any benthic invertebrates associated with this habitat that are unable to move from within the footprint. As discussed in “Existing Conditions,” the benthic invertebrate communities occupying sand and gravel substrates consisted of similar taxa, with higher densities found in gravel substrates relative to sand substrates. Sand and gravel substrates are the most common substrate in the approximately 33,500 acres of nearshore habitat in the Raritan Bay-Sandy Hook Bay complex (USFWS 1997) and the 11.4 acres impacted by construction of the breakwaters would constitute just 0.03 percent of the sandy substrate within this complex, and 2 percent of nearshore habitat present within the approximately 610-acre study area within Raritan Bay (the open water area bounded to the north by the shoreline of Staten Island and to the south by the navigation channel). Placement of the geotextile over 11.4 acres would cause a temporary reduction in the availability of benthic prey for various fish species. This 2 percent loss of foraging habitat would occur sequentially over the 11-month construction period (6 months in the first year and 5 months in the second year) as the breakwater segments are installed, rather than all at once. Benthic prey species are expected to recolonize the sand and gravel among the breakwaters, as well as the breakwaters themselves, following construction. The loss of non-motile invertebrates within this area and the temporary loss of sand/gravel substrate foraging habitat for fish and epibenthic invertebrates would not result in a significant adverse impact to these organisms, as similar foraging habitat would be available adjacent to areas undergoing construction, and benthic prey species would become available to predators when they recolonize the area following construction.

Temporary increases in suspended sediment during construction of the Breakwaters Project would be below thresholds that would adversely impact vulnerable life stages of susceptible benthic

invertebrates and fish. As discussed above under “Water Quality,” measures would be implemented to minimize sediment resuspension during placement of sand for the shoreline restoration and of the geotextile and the breakwater materials. Vessels would operate such that there is a minimum of 2 feet between the bottom of vessels and the bay bottom, minimizing the potential for sediment resuspension by construction vessels.

Estuarine organisms experience relatively high levels of suspended sediment as a result of natural processes, but at excessive levels behaviors like filter feeding or physiological mechanisms may be impaired. Mobile fish and benthic invertebrates would be expected to avoid unsuitable conditions such as significant increases in suspended sediment (Clarke and Wilber 2001). As discussed in “Existing Conditions,” suspended sediment concentrations in the vicinity of the study area (stations K5A, K5, and K6) averaged between 13.8 and 15.5 milligrams per liter (mg/L) from 1999 to 2014, with peaks between 90.4 and 117.4 mg/L. Average and maximum observed suspended sediment concentrations in the vicinity of the study area fall below levels that could interfere with upstream fish migrations (350 mg/L, NOAA 2001). Expected increases in suspended sediment concentrations related to vessel activity during construction would likely be minimal relative to those background levels and would be well below established criteria for harming benthic organisms (<390 mg/L: no anticipated adverse impacts to benthos, USEPA 1986; and deleterious effects of TSS on oyster eggs occurred at 188 mg/L and 1,000 mg/L for clam eggs, Clarke and Wilber 2001). Because fish are motile they would likely avoid areas with unsuitable levels of suspended sediment (Clarke and Wilber 2001). The maximum expected suspended sediment concentrations are well-below lethal levels of suspended sediment estimated for white perch (*Morone americana*), spot (*Leiostomus xanthurus*), silversides (Atherinopsidae), bay anchovy (*Anchoa mitchilli*), and menhaden (*Brevoortia* spp.) adults, which range from 580 mg/L to 24,500 mg/L (Shrek et al. 1975 as cited in NMFS 2003). These species represent members of the aquatic finfish community likely to be found at the project site. Additionally, sublethal suspended sediment thresholds for fish, which could lead to gill membrane abrasion, reduced dissolved oxygen availability or consumption, and impaired predator avoidance, are also well-above expected levels of suspended sediment that could result from the construction of the Breakwaters Project portion of Alternative 2. Additionally, suspended sediments would dissipate via dispersion by tidal currents of Raritan Bay and would not result in long term adverse impacts to fish or benthic macroinvertebrates.

Construction of the in-water components of Alternative 2 would require additional vessel traffic and associated vessel noise in the study area. Raritan Bay is a region of high commercial vessel traffic in the New York-New Jersey Harbor, with an estimated 26,459 commercial trips made in 2014 (approximately 72.5 trips/day) from the ship channel near Sandy Hook to Raritan Bay and upriver through Arthur Kill and Kill Van Kull to Upper New York Bay (USACE 2014). Recreational fishermen made 630 fishing trips in Raritan Bay between 2012 and 2016, averaging 126 trips per year. Thus, it is unlikely that the benthic invertebrate or fish communities in the study area would be adversely impacted by the expected additional vessel traffic or associated underwater noise.

Construction of the breakwaters would require the use of various barges to transport materials and equipment to construction locations. Two types of barges could be used, either spud and anchor or jack-up type barges. One barge would be used as a crane barge used to install breakwaters materials, while additional barges would be cycled continuously to deliver materials. A typical crane barge covers 7,500 feet squared and material barges would likely be of similar size. The anchored barge would initially shade benthic habitat for three to six weeks, but the shaded area is small, would only be shaded a single time, and the impacted habitat would be expected to recover

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quickly from the temporary impact. The material barges would be moved off-site after materials are unloaded and installed; any shading of benthic habitat is on the order of hours to days. Fish and motile benthic invertebrates would likely avoid the construction area where breakwater materials are being placed on the bottom, and would not experience any adverse impacts from the lowering of these materials through the water column.

Operation

Alternative 2 would result in minimal large scale long-term changes to water circulation and water quality, would stop or reverse shoreline erosion, and would modify local sediment transport to grow the beach while minimizing down-drift impacts. The breakwaters would attenuate waves and alter the sediment transport along the shore for this purpose. Local sediment transport rates and accretion would be altered but the natural processes would not be blocked as there would still be sediment transport along the shore and tidal circulation around the breakwaters. Based on observed wave conditions, the primary direction of sand movement is from northeast to southwest, past Ward Point and into the Arthur Kill. As such, there is little potential for down-drift impacts from the altered sediment transport and accretion, with the possible exception of reducing the amount of sediment entering the Arthur Kill channel, which would be considered a positive effect. The increased shoreline stability provided by the Proposed Actions, including the shoreline restoration, would likely benefit spawning horseshoe crabs and other organisms that use beach habitat. The shoreline restoration would alter the slope at varying levels between Manhattan Street and Loretto Street, potentially affecting horseshoe crab spawning areas. Long-term changes in the vicinity of the breakwater segments would likely include the accumulation of broken shells and other calcium carbonate materials originating from sessile and encrusting marine organisms that encrust the structure. Such “halos” of biogenic material were observed in the survey of existing artificial habitats in the study area, and observations suggest that the breakwaters will provide the conditions to support the creation of similar “halos” of coarse, biogenic material, which could provide additional habitat heterogeneity (see Appendix E-5, SeArc 2015).

The introduction of hard substrate in an area of sand and gravel would likely lead to colonization by mollusks and other filter-feeding organisms, which could in turn lead to general small-scale improvements in water quality. Local, small-scale changes in water circulation, water quality, and sediment transport could increase local retention of planktonic invertebrates and fish larvae and their subsequent recruitment to the breakwaters (Vogel 1994; Mann and Lazier 1996; Lenihan and Peterson 1998), influencing the local fish community and its forage base. These effects would largely be confined to waters adjacent to the breakwaters in front of and behind the breakwaters (i.e., wave and lee sides). Zooplankton and fish larvae are important prey for the early life stages of many fish species; thus, increasing their retention to the breakwaters could increase the forage supply and, concomitantly, could enrich the ecological community colonizing the breakwaters.

Installation of the breakwater segments of the Breakwaters Project would convert approximately 11.4 acres of existing sand/gravel substrate to complex hard structure. As discussed in “Existing Conditions,” the benthic invertebrate communities occupying sand and gravel substrates consisted of similar taxa, with higher densities found in gravel substrates relative to sand substrates. Sand and gravel substrates are the most common substrate in the approximately 33,500 acres of nearshore habitat in the Raritan Bay-Sandy Hook Bay complex (USFWS 1997) and the 11.4 acres that would be converted to hard bottom habitat through construction of the breakwaters would constitute just 0.03 percent of the sandy substrate within this complex, and 2 percent of nearshore habitat present within the approximately 610-acre study area within Raritan Bay (the open water area bounded to the north by the shoreline of Staten Island and to the south by the navigation channel). Benthic prey species are expected to recolonize the sand and gravel among the

breakwaters, as well as the breakwaters themselves, following construction. The breakwater structures would also convert 115,990 CY of open water habitat below MHW overlying the breakwater footprint to subtidal, intertidal, and emergent hard/rocky habitat (a habitat that was historically present but currently scarce in Raritan Bay) composed of rock and bio-enhancing concrete of varying sizes.

The Breakwaters Project would result in a loss of approximately 3.6 acres of Waters of the U.S. and associated habitat that would no longer be available to aquatic organisms due to the portion of the breakwater structures above MHW. This loss would result in adverse impacts to aquatic resources and would be mitigated pursuant to the Clean Water Act through measures that may include available credits from an approved mitigation bank, and restoration/enhancement of Waters of the US within the Raritan Bay watershed in New York.

One-time sand placement and long-term accretion would also result in the loss of shallow water habitat. Accretion would occur gradually over a period of years to decades, allowing aquatic biota to adjust to slowly changing depths and beach slopes near the shoreline over time. As a result of the one-time shoreline restoration, there would be an initial loss of some habitat below MHWS of approximately 2.7 acres, of which approximately 2.6 acres would be below MHW. Over time, no net difference in the quantity of available habitat below MHWS or MHW would be expected, as sand initially placed above MHWS would be distributed to areas below MHWS. However, there would be differences in the types of habitat available. The shoreline restoration over time would result in a net gain of intertidal habitat of approximately 0.5 acres and a net loss of subtidal (open water) habitat of approximately 0.5 acres. The conversion of open water habitat would represent a small reduction in this type of habitat in the study area within Raritan Bay, and similar habitat at equivalent water depths would continue to be available in the vicinity. While the breakwaters would convert open water to structured habitat, the structures would not hinder the movement of fish and other aquatic biota through the water column, nor would they disrupt water circulation in Raritan Bay. Fish and other aquatic biota, including anadromous species and early life stages, would be able to pass (either actively or passively) around the individual breakwater segments at any given time.

The sand and gravel habitat that would be converted to complex hard structure in the 11.4-acre footprint of the breakwaters is common in the study area and throughout Raritan Bay and the larger Hudson-Raritan Estuary. Alternative 2 would not adversely affect the functionality of soft bottom habitat in Raritan Bay on a whole, as only a small portion of the study area (2 percent) would be converted to hard bottom habitat. Historically, Raritan Bay supported a large area of hard substrate habitat composed mainly of oyster reefs (Bain et al. 2007). The loss of these areas has altered the structure and function of the Hudson-Raritan Estuary's benthic ecosystem, and eliminated a significant habitat resource for estuarine fish and invertebrate species which rely on spatially complex submerged hard structures. The high-relief rocky habitat provided by the breakwaters would be designed to attract and retain habitat-forming benthic invertebrates, shellfish, and bivalves, and return some of this structure and function to the Bay. Reduced wave energy near the breakwaters would provide suitable habitat for zooplankton and planktonic larvae. Increasing the retention of zooplankton and fish larvae could increase the forage supply and, concomitantly, could enrich the ecological community that is expected to colonize the breakwaters.

The potential for any localized increases in suspended material at the breakwater structures and at the shoreline would result in increased food supply for filter-feeding bivalves that feed on suspended particles like organic matter and plankton (SMS 2002). Fluctuations in suspended

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sediment concentrations and sediment grain size are common in coastal environments (Norkko et al. 2001). As such, estuarine species, including clams, are well-adapted to fluctuating levels of suspended sediments and deposition, and would be expected to adjust to the gradually changing conditions on the landward side of the breakwaters. Filter feeding bivalves, in particular, may benefit from small additions of fine sediment, which can be used as a food source (Anderson et al. 2004). Deposition of sediments along the shoreline would occur gradually, allowing time for infaunal organisms (e.g., clams) to adjust to appropriate depths in the substrate. Hard clams, for example, which occur in the study area, can escape up to 50 centimeters of overburden if the deposited sediment is similar to its surroundings (Stanley and DeWitt 1983), and would easily adjust to gradually changing conditions.

While Alternative 2 would result in the loss of some shallow open water habitat, the addition of complex substrate would serve as habitat for foraging and sheltering for a number of species, including those that primarily occupy open water environments. The breakwater structures were designed to include varying levels of elevation and inclination, along with bio-enhancing materials, and varying textures and rock gradation in order to create complex habitat attractive to a wide range of aquatic biota. The complex habitat associated with the breakwater structures would provide increased complexity resulting from the rock and bio-enhancing concrete units that would be available to target species groups.

The Breakwaters Project has incorporated a variety of design modifications and techniques to create a set of ecological niches typically absent from standard rubble-mound breakwater structures, which are intended to enhance habitat for the target species functional groups described in Appendix E-7. These design measures include: incorporation of bio-enhancing concrete material, reef ridges, and streets, inclusion of water retaining features in the intertidal zone, integration of varying levels of elevation and inclination, and creation of a wide range of structural complexity. As such, the Breakwaters Project is anticipated to increase the diversity of aquatic habitat in the study area, and encourage overall higher diversity and species richness of both flora and fauna.

Large-scale design features, such as the number, size, shape, spatial distribution, and orientation of the breakwaters, would contribute, in part, to the diversity of habitats created by the Breakwaters Project portion of Alternative 2 and to the connectivity between the breakwaters and to the Hudson Raritan Estuary (e.g., how free-swimming and planktonic organisms move to and from breakwaters and other estuarine habitats). All but two of the breakwater segments would have a series of four to twelve rocky protrusions or reef ridges that extend approximately 65 feet (at MSL NAVD88) seaward, roughly perpendicularly to the main breakwater. These reef ridges and the narrow spaces between them (reef streets) would add to the diversity and complexity of available habitat within the intertidal and subtidal zones, including interstitial spaces between armor units, and could generate additional opportunities for ecological enhancement. Non-uniformity of niches and crevice/void sizes generally enhances the heterogeneity of habitat provided by rocky structures (Musetta-Lambert et al. 2015). The ecological enhancements to the study area resulting from the Breakwaters Project (e.g., approximately 1,000 to 1,200 bio-enhancing concrete armor units and approximately 850 to 1,200 tide pools) would create a mosaic of high-relief habitat across different elevations, inclinations, and orientations, expanding the niche space for all colonizing organisms and in particular taxa described under the *Target Species Rationale* (see Appendix E-7). The reduced energy shoreward of the breakwater structures would also provide refuge for aquatic species along an otherwise exposed shoreline where wave energy can currently be relatively high.

The pore spaces and crevices that would result from placement of the armor units (stone and bio-enhancing concrete) within the breakwaters would provide subtidal and intertidal habitat below MHW available to encrusting habitat forming organisms,²⁴ which were observed on and near the rocky substrates sampled within the study area and on adjacent artificial rocky habitat. Approximately 11.4 acres of open water and low-relief sand and gravel habitat would be converted into diverse, high-relief, reef-like habitat in the subtidal and intertidal zones, including crevices, that would be available for use by aquatic biota. Thus, the structural complexity resulting from the breakwater segments would provide greater habitat diversity when compared to the sand and gravel area and open water habitat replaced by the breakwaters.

The 11.4-acre area of sand/gravel substrate and open water habitat below MHW within the volume occupied by the breakwaters would be converted to breakwater structures designed to increase the diversity of available habitats, as described above. The breakwater system is expected to benefit the target species groups identified for the project (see Appendix 9-7). The newly created habitat would be designed to attract habitat forming and augmenting invertebrates and algae that would further facilitate development of a rich and diverse aquatic community. The incorporation of bio-enhancing concrete units would increase the potential for establishment of a benthic community anchored by a healthy population of habitat forming species that includes mussels, native oysters, hard clams, macro algae, barnacles, bryozoans, tunicates, tubeworms, and sponges. Additionally, porous rock structures have been shown to provide effective habitat for many species, especially juvenile fish (Beck et al. 2001, Duffy-Anderson et al. 2003, USACE 1986, Lindquist et al. 1985).

Reef-like structures incorporating ecological considerations in their design attract a diverse and productive suite of organisms that includes colonizing habitat forming invertebrates and algae, macroinvertebrates, and fish. Rubble-mound jetties, rock features similar to the proposed breakwaters in composition and structure, have been shown to provide food resources (i.e., encrusting organisms like mussels and algae, and interstitial organisms like amphipods and polychaetes) that were not available over adjacent sand substrates (Lindquist et al. 1985). Algal colonizers and macrozoobenthos establish first on the surface of the rocks (LaSalle et al. 1991) and provide surface area for epiphytic organisms, which in turn provide forage for invertebrate grazers and large fish.

There would be a brief period of time when the breakwaters are first constructed during which the structures would not be available as foraging habitat, as they would not yet be colonized by habitat forming invertebrates and algae, and macroinvertebrates that provide forage. However, studies have shown that invertebrates and algae rapidly colonize the surfaces of these porous rock structures (Knott et al. 2004, Perkol-Finkel and Sella 2014, Perkol-Finkel and Sella 2015, Van Dolah et al. 1984). Van Dolah et al. (1984) recorded early settling and rapid colonization of rubble mound jetties by blue-green algae and barnacles in the intertidal zone, mussels in the subtidal zone, and motile macroinvertebrates (e.g., amphipods and isopods) at all tidal levels within the first year of construction. Eco-enhancing concrete deployed at the Brooklyn Bridge Park waterfront in the New York Harbor was found to have live cover of 70 to 100 percent within 3 months of construction; mating blue crabs were also observed at this time. Filter-feeding species and habitat formers (e.g., tunicates, barnacles, sessile polychaetes, sponges, and bivalves) were dominant 10 months after deployment (Perkol-Finkel and Sella 2015). Two years after its deployment at Brooklyn Bridge Park, eco-enhancing concrete showed 90-100% coverage by

²⁴ Eastern oyster, blue mussel, hard clams, barnacles, bryozoans, tunicates, tubeworms, sponges, etc.

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coralline algae, sponges, gastropods, barnacles, colonial and solitary tunicates, bryozoans, and sessile polychaetes (Perkol-Finkel and Sella 2015).

The types and abundances of organisms found on or under rock structures are influenced by features of the rocks themselves or by features of the available substratum, and colonizers can be recruited by drifting through the water column or crawling up through the substratum (Chapman 2002). In general, benthic communities found in environments with a great deal of variability or frequent disturbance, such as estuaries, have higher rates of recovery following disturbance (Newell et al. 1998, LaSalle et al. 1991). Recovery rates and the nature of the recolonizing community depends on the availability of individuals from adjacent benthic habitats, the ability to reach the disturbed area, and chance. Early colonizers usually inhabit surface environments, where they provide food for other invertebrates and fish (LaSalle et al. 1991). On the basis of these studies, and the presence of hard bottom habitat and associated macroinvertebrates in the vicinity which could serve as a source for colonization, the period following construction of a particular breakwater segment, during which the sand and gravel habitat within the footprint of the breakwater segment would be lost and that breakwater would provide shelter but not forage habitat, would be expected to be limited to a few months. Additionally, the sequential construction of the breakwaters would allow colonization to begin at the first completed segments while the rest are being constructed, minimizing the period during which sand and gravel foraging habitat would be lost and prey species would not be available on any of the structures. Foraging opportunities would also continue to be available in the surrounding soft-bottom habitat during this time. Therefore, temporal loss of foraging habitat would not result in significant adverse impacts to macroinvertebrates and fish within Raritan Bay.

Given the potential for rapid colonization by sessile communities, the Breakwaters Project would likely enhance foraging and refuge habitat for several target groups of benthic invertebrates and fish affected by the project (Perkol-Finkel and Sella 2014, Sella and Perkol-Finkel 2015) (see Appendix E-7). Fish species with strong associations to structured habitats (i.e., cryptic fish and structure oriented fish) and those that may only use the structure for foraging or in passing (i.e., pelagic forage fish and higher trophic level species), would likely benefit from ecological enhancements resulting from construction of the breakwaters and the rocky, reef-like habitat. Porous structures provide higher habitat complexity in areas where such habitat is not already present, and in turn can enhance biomass and production of fish species associated with artificial structures (Bohnsack et al. 1997, Carr and Hison 1997, Pickering and Whitmarsh 1997). The highly porous layers of armor stone and riprap on the main breakwater segments and reef ridges, and the void spaces between these features, would allow water flow in and around the structures and provide habitat for motile benthic invertebrates known as cryptofauna, or those organisms which exist in protected or concealed microhabitats.

Features of the breakwaters that would enhance the abundance of small forage species include the maximized vertical relief and surface area in the littoral zone, both of which would allow greater development of attached flora and fauna that serve as food resources for forage species. The Breakwaters Project would create foraging, refuge, and potential spawning habitat well-suited to small, structure-oriented, “cryptic” fish species like tautog, black sea bass, cunner, gobies, blennies, rock gunnel, skilletfish, and oyster toadfish. With the exception of tautog, these taxa were either absent or found in low abundance in the existing conditions surveys, and would likely experience benefits in both forage and shelter from the presence of the breakwaters. Because cryptic fish serve as prey for several fish species, blue crabs, and other invertebrates, their presence would not only indicate increased local diversity, but also add complexity to the existing food web (Mann and Harding 1997, 1998). These cryptic fish also feed on many of the small benthic

invertebrates (e.g., tube worms, amphipods, isopods) expected to be attracted to the breakwater structures. Fish species with strong associations to structured habitat (i.e., cryptic fish and structure-oriented fish) and those that may only use the structure for foraging or in passing (i.e., transient/pelagic forage fish and upper trophic-level transient fish) would likely benefit from the establishment of assemblages of benthic invertebrates and macroalgae, which serve as food resources for forage fish, on the breakwaters. They would also benefit from the habitat complexity and availability of crevices and void space for sheltering.

Transient/pelagic forage fish like anchovies, silversides, and herring are ubiquitous prey for fish and other predators in the coastal zone. Many of these forage species are filter feeders, a mechanism often associated with the potential for improving water quality via the net uptake of excess nutrients. They generally consume phytoplankton, zooplankton, and small benthic invertebrates. Benthic invertebrates that establish assemblages on and among the breakwaters would periodically release planktonic larvae, and phytoplankton and zooplankton would congregate in the reef streets and on the lee side of the breakwaters where wave energy is reduced. The colonization of the breakwaters by these prey species, which would in turn attract species in the upper trophic-level group that feed on forage fish. Numerous species, including black sea bass (*Centropristes striata*) and skates, as well as recreational and commercial species like striped bass (*Morone saxatilis*), bluefish (*Pomatomus saltatrix*), weakfish (*Cynoscion regalis*), red hake (*Urophycis chuss*), summer flounder (*Paralichthys dentatus*), windowpane flounder (*Scophthalmus aquosus*), and winter flounder (*Pseudopleuronectes americanus*), derive trophic support either directly from the encrusting organisms, or indirectly by preying upon smaller forage fish that congregate around rocky structures (USACE 1986). Bluefish and black sea bass, in particular, are known to occur over rubble-mound structures similar to the proposed breakwaters (Lindquist et al. 1985). Flounder and bluefish also continue to use sandy substrates surrounding rocky structure for forage opportunities (USACE 1986). While the Breakwaters Project would result in the loss of a small fraction (2 percent) of sand and gravel substrate from nearshore waters of Raritan Bay within the study area, the increased availability of forage fish and benthic invertebrates attracted to the breakwaters would enhance foraging opportunities for upper trophic-level transient species.

Artificial structures have been shown to encourage recruitment and settlement of larvae. Depending on the position of reef-like structures with respect to other hard substrate and on the amount of larval supply, artificial structures may receive recruits that otherwise would not have found suitable habitat for settlement (Carr and Hixon 1997). Since the study area consists almost entirely of sand/gravel substrate with few structured areas, the breakwaters would likely serve as a settlement area for larval fish. The establishment of a fish community on structures like the proposed breakwaters could boost larval production onsite (Stephens and Pondella 2002). Breakwater structures that alter water circulation can act as “fish producers,” in that they encourage establishment of a fish community which results in larval abundance, rather than attracting larvae from other areas (Cenci et al. 2011, Burt et al. 2009). Breakwaters may especially act as fish producers if the availability of similar habitat in an area is limited (Cenci et al. 2011, Stephens and Pondella 2002).

It is likely that the Breakwaters Project would provide enhanced nursery habitat and predatory refugia for species that utilize structure during their early life stages. Predation on certain juvenile fish has been found to be lower in more structurally complex seagrass beds, suggesting that complexity may lead to better nursery habitat for many species because it increases survivorship (Beck et al. 2001). Early life stages and small fish, which tend to prefer calmer waters, may find refuge in areas where wave energy is reduced (Mikami et al. 2012), like the reef streets and on the

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lee side of the breakwater structures. Filter feeders, in particular, would benefit from the reduced wave energy, as the availability of detritus, macrophytes, and zooplankton would be greater in these areas (Mikami et al. 2012, Lanford 1981). They may also use shelter provided by the crevices and void space among the rocks to hide from predators.

It has been suggested that juvenile fish aggregate near complex reef-like structures, instead of in open water habitats, for both protection from predation and the availability of fouling prey resources like benthic invertebrates and algae (Duffy-Anderson et al. 2003). USACE (1986) determined that rubble-mound structures serve as nursery habitat for a variety of fish, especially juvenile black sea bass and other structure-oriented species. In a study of fish utilization of rubble-mound jetties in North Carolina, Lindquist et al. (1985) also found that young fish were rapidly attracted to a new jetty during its construction phase, suggesting that juveniles may be attracted to the breakwater structures soon after they are placed on the bottom in the study area. Utilization of the breakwater habitat by juveniles would lead to higher survival rates in the study area for structure-oriented species. Given the potential of the Breakwaters Project to provide increased foraging and nursery habitat for recreational species, it is likely that more would occur in the study area, and more would be caught through recreational fishing. The additional habitat provided by the breakwaters would lead to higher survival of juveniles, and the added fishing pressure would not be expected to deplete populations of these species in the study area.

The sand and gravel habitat (11.4 acres) and open water habitat converted to high-relief, complex, rocky reef-like habitat of the breakwater structures designed to increase the diversity of available habitats is common in the study area and throughout Raritan Bay and the larger Hudson Raritan Estuary. Alternative 2 would be expected to provide long-term benefits in the form of increased ecosystem productivity and diversity, consistent with the HRE CRP goal for the Lower Bay Planning Area to “develop a mosaic of habitats that provides society with renewed and increased benefits from the estuary environment,” while also addressing the primary storm wave attenuation and reducing shoreline erosion. The breakwater segments of the Layered Strategy have a target functional design life of 50 years, after which they would require additional work to upgrade or adapt the structures to increase the functional life span. The design of the breakwaters has incorporated a projected 30-inch rise in sea level rise, consistent with both New York City Panel on Climate Change mid-range projections for the 2080s and with 90th percentile estimates for 2050. This assumption ensures that the design accounts for sea level rise during the first half of the project’s designed life.

If the Water Hub is located on-shore (Potential Locations 1 or 2), the Proposed Actions would include the placement of floating structures within Raritan Bay that would include: an approximately 210-foot-long and 8-foot-wide seasonal boat launch within Raritan Bay at the Water Hub at Potential Locations 1 and 2 to facilitate research activities at the breakwaters; and a 30 by 50-foot-wide seasonal floating dock near the breakwater segments to facilitate monitoring and research activities. Water access at the Water Hub at Potential Location 2 would be provided by a seasonal floating boat launch similar to Location 1 near one of the NYC Parks buildings that would be adaptively reused. NYSDEC usually considers aquatic habitat under an overwater structure to be shade-impacted beyond 15 feet inward from the structure’s edges. This is consistent with recent studies that found shading from Hudson River piers to affect the behavior and abundance of fishes under the pier, approximately 15 or more feet from the nearest pier edge (Able and Grouthues 2011, Able et al. 2013). Shading from piers in the Hudson River has also been found to only minimally influence fish utilization of nearshore habitats (PANYNJ 2015). In a study evaluating the effects of floating structures relative to open water on fish communities, PANYNJ (2015) found that shading effects varied by type of fish and the presence or absence of

other shading sources; when the floating structure is the only shade source, fish are more likely to occur in its shadows. In the study area, the surrounding nearshore waters are relatively unshaded, and thus, fish may utilize the shaded area beneath the floating boat launch and floating dock during the day. Based on its limited presence in the study area (once per week for less than one day between April and November), the floating Water Hub (Potential Location 3) would not result in adverse impacts due to shading. All of these seasonal structures are narrow enough to allow some light to penetrate to the aquatic habitat beneath them during some portion of the day and would not result in significant adverse effects to aquatic habitat and biota due to shading.

The Breakwaters Project would result in a loss of approximately 3.6 acres of Waters of the U.S. and associated habitat that would no longer be available to aquatic organisms due to the portion of the breakwater structures above MHW. This loss would result in adverse impacts to aquatic resources and would be mitigated pursuant to the Clean Water Act through measures that may include the purchase of available credits from an approved mitigation bank, and restoration/enhancement of Waters of the U.S. within the Raritan Bay watershed in New York.

In summary, the construction and operation of Alternative 2 is expected to benefit the target species groups identified for the project within the Hudson Raritan Estuary and could potentially improve the productivity and diversity of the local ecosystem. In addition to the ecological enhancements, the Proposed Actions have incorporated other measures to minimize adverse effects to aquatic biota. These include timing the shoreline restoration activities and breakwater construction activities to be outside spawning windows specified by NMFS (e.g., horseshoe crab and winter flounder); maintaining at least 2 feet of clearance between the bay bottom and construction vessels or working when tide levels are sufficient to keep construction barges and vessels off the bottom; constructing breakwater segments sequentially such that the habitat conversion occurs gradually.

EFH

Appendix E-12 provides a detailed evaluation of the potential for the Alternative 2 to adversely affect EFH. For reasons discussed above under “Aquatic Biota” Alternative 2 would result in temporary effects on EFH during in-water construction activities that would not result in significant adverse impacts. Alternative 2 would convert soft bottom sandy substrate and the open water habitat overlying this substrate to complex rocky habitat of the breakwaters. Alternative 2 would result in temporary increases in suspended sediment from placement of sand for the shoreline restoration, breakwater materials and movement of construction vessels, loss of benthic habitat within the 11.4-acre footprint of the breakwaters, and increased vessel activity and associated underwater noise. The 11.4-acre footprint of the breakwaters represents only 2 percent of the available inshore habitat within the approximately 610 acres of similar habitat in Raritan Bay within the study area for the project. This 2 percent conversion of sand/gravel habitat to complex rocky habitat will occur sequentially over the 11-month construction period for the breakwaters, rather than all at one time. As the breakwaters are constructed, designated species and prey items would be temporarily displaced to other suitable habitat in the area, but would be expected to return to the project site upon completion of the breakwater installation. There may be a temporary increase in vessel traffic and noise during the construction period, along with shading by anchored barges, but these actions would not be outside the range of typical vessel activity within the study area in Raritan Bay, which is a region of high commercial vessel traffic. This temporary increase in vessel traffic would not result in significant adverse impacts on EFH or the prey of designated species in the study area. Seasonal shading by the temporary floating dock and temporary shading by construction barges would not result in significant impacts to EFH

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because the size of these vessels and structures would allow some light to penetrate to the aquatic habitat beneath during periods of the day. Construction is expected to last approximately 11 months (6 months in the first year and 5 months in the second year).

Placement of the breakwater structures would result in the conversion of 11.4 acres of existing sandy/gravel bottom and overlying open water habitat below MHW to complex hard structure. By design, the breakwater system would incorporate ecological enhancements expected to benefit the target species groups identified for the project. The high-relief rocky habitat provided by the breakwaters would be designed to attract and retain habitat-creating benthic invertebrates and shellfish, including bivalves. Ecological design features of the breakwaters (i.e., varying levels of elevation, inclination, bio-enhancing materials, textures, interstitial spaces, water retaining elements, reef streets and rock size variations) would facilitate the recruitment of a rich benthic community of habitat-forming encrusting invertebrates and algae, while also providing suitable sheltering and foraging habitat for fish and benthic invertebrates and would provide EFH for structure-oriented species. Species that require soft-bottom habitat for foraging (e.g., flounder and skates) would continue to forage over substrate that would be available among and in the vicinity of the breakwaters. Additionally, macroinvertebrates and small structure-oriented fish species expected to colonize the breakwaters would provide added foraging opportunities. The breakwater segments have been designed to have varying levels of elevation and inclination, along with bio-enhancing materials, and varying textures and rock gradation in order to create a diversity of habitat characteristics and sheltering opportunities for aquatic biota. Reef ridges and reef streets incorporated into the breakwater layout would create interspaces of narrow rocky conditions, providing niche spaces for sheltering fish. Aquatic species would have sheltering opportunities within the spaces created by these features over the entirety of the breakwater structures and among the segments themselves. Additional long-term beneficial effects would likely accrue to the local benthic invertebrate and fish community from the increased habitat diversity and water quality improvements from the establishment of a self-sustaining, viable mollusk population on the hard substrate of the breakwater system.

All shoreline improvement construction activities undertaken as part of the Shoreline Project would be done in accordance with a SWPPP as required by the SPDES General Permit and would minimize the potential for stormwater runoff to affect EFH. As described above for “Aquatic Biota,” the Alternative 2 would convert sandy bottom substrate to complex high-relief rocky habitat and expand on the niche space for colonizing and structure-oriented designated species and the forage species on which they feed. Shoreline improvement activities associated with the Shoreline Project, including the use of green infrastructure where possible, would also minimize the potential effects of runoff on water quality and subsequently EFH.

GOSR initiated consultation with NMFS for EFH on April 11, 2017. As per NOAA’s final EFH consultation letter dated May 8, 2018, NOAA/NMFS has concluded that “the revised EFH assessment adequately evaluates how the project components, both individually and cumulatively, will affect federally managed species, their EFH, and the ecology of Raritan Bay.”

TERRESTRIAL RESOURCES

Ecological Communities

Maritime beach, maritime dunes, mowed lawn with trees, and successional southern hardwoods comprise the ecological communities within the onshore portion of the study area. The Shoreline Project’s hybrid dune/revetment, eco-revetments, and raised edge would be located in a portion of the study area currently occupied by maritime beach and maritime dunes communities. The Water

Hub at Potential Location 1 would be located in a portion of the study area currently occupied by a gravel parking lot, vacant lot, and the successional southern hardwoods community. The Water Hub at Potential Location 2 would be located in a portion of the study area currently occupied by the mowed lawn with trees and successional southern hardwoods communities.

Construction

The proposed earthen berm, hybrid dune/revetment, raised edge and Water Hub would be located in portions of the study area currently occupied by successional southern hardwoods communities. The Water Hub at Potential Location 2 would also be located in portions of the study area currently occupied by mowed lawn with trees communities. Elements of Alternative 2 would affect about 5.4 acres of a combination of the maritime beach and maritime dunes communities, approximately 0.6 acres of successional southern hardwoods community, and a small area of successional southern hardwood for the construction of an ADA accessible ramp from one of the repurposed NYC Parks buildings at Water Hub Potential Location 2. The successional southern hardwoods and mowed lawn with trees communities are relatively common ecological communities within the region and the negligible loss of this habitat would not have a measurable effect on these ecological communities as a whole. Therefore, construction of Alternative 2 would not adversely affect ecological communities within the study area.

Only a few trees would be removed as a result of the Shoreline Project, and 12 to 19 for the Water Hub at Potential Location 1 as a result of the Breakwaters Project. Some trees would be removed for the construction of a potential ADA accessible ramp leading from the selected repurposed NYC Parks building to the shoreline for the Water Hub at Potential Location 2, should this water access option be chosen. To the extent feasible, the potential ramp would be sited to minimize tree loss. The earthen berm has been sited to minimize tree removal and other disturbances to the woodland of Conference House Park. Should construction activities require tree clearing between April 1st and August 31st when active bird nests, eggs, or young in trees may be present, GOSR will coordinate with the USFWS with respect to conducting active nest surveys that may support tree cutting during this period. These surveys would be focused on the presence of active nests, eggs, or young in trees targeted for removal. In the event that active nests, eggs, or young are not present, GOSR will inform USFWS of the results before commencing any tree cutting. All work would be performed in compliance with Local Law 3 of 2010 and NYC Park's Tree Protection Protocol, to minimize potential adverse impacts. In addition, all required replacement and/or restitution for removed trees would be provided in compliance with Local Law 3 and Chapter 5 of Title 56 of the Rules of the City of New York.

Operation

Native coastal vegetation (see **Table 9-17**) would be planted on the earthen berm, the hybrid dune, and within portions of the eco-revetments and raised edge, resulting in approximately 4.6 acres of native plantings. These landscaped areas would create habitat heterogeneity that would be utilized by wildlife within the study area. Therefore, operation of Alternative 2 would not adversely affect ecological communities within the study area.

Table 9-17
Planting Palette for the Planting Plan

Common Name	Scientific Name
Trees	
Box elder	<i>Acer negundo</i>
Red maple	<i>Acer rubrum</i>
Silver maple	<i>Acer saccharinum</i>
Common serviceberry	<i>Amelanchier arborea</i>
Canadian serviceberry	<i>Amelanchier canadensis</i>
Sweet birch	<i>Betula lenta</i>
Grey birch	<i>Betula populifolia</i>
Common hackberry	<i>Celtis occidentalis</i>
Eastern redbud	<i>Ceris canadensis</i>
Persimmon	<i>Diospyros virginiana</i>
Eastern black walnut	<i>Juglans nigra</i>
Easter red cedar	<i>Juniperus virginiana</i>
Sweetgum	<i>Liquidambar styraciflua</i>
Tulip tree	<i>Liriodendron tulipifera</i>
Black tupelo	<i>Nyssa sylvatica</i>
Pitch pine	<i>Pinus rigida</i>
American sycamore	<i>Platanus occidentalis</i>
Beach plum	<i>Prunus maritima</i>
Black cherry	<i>Prunus serotina</i>
White oak	<i>Quercus alba</i>
Swamp white oak	<i>Quercus bicolor</i>
Scarlet oak	<i>Quercus coccinea</i>
Pin oak	<i>Quercus palustris</i>
Willow oak	<i>Quercus phellos</i>
Red oak	<i>Quercus rubra</i>
Sassafras	<i>Sassafras albidum</i>
Shrubs	
Black chokeberry	<i>Aronia melanocarpa</i>
Purple chokeberry	<i>Aronia prunifolia</i>
Eastern baccharis	<i>Baccharis halimifolia</i>
Summersweet clethra	<i>Clethra alnifolia</i>
Strawberry bush	<i>Euonymus americanus</i>
American holly	<i>Ilex opaca</i>
Maleberry	<i>Lyonia ligustrina</i>
Northern bayberry	<i>Myrica pensylvanica</i>
Winged sumac	<i>Rhus copallina</i>
Smooth sumac	<i>Rhus glabra</i>
Swamp rose	<i>Rosa palustris</i>
Virginia rose	<i>Rosa virginiana</i>
Allegheny blackberry	<i>Rubus allegheniensis</i>
American elder	<i>Sambucus canadensis</i>
Northern highbush blueberry	<i>Vaccinium corymbosum</i>
Arrowwood viburnum	<i>Viburnum dentatum</i>
Perennials	
Common milkweed	<i>Asclepias syriaca</i>
Butterfly milkweed	<i>Asclepias tuberosa</i>
American searocket	<i>Cakile edentula</i>
White thoroughwort	<i>Eupatorium album</i>
Tall thoroughwort	<i>Eupatorium altissimum</i>
Hysspleaf thoroughwort	<i>Eupatorium hyssopifolium</i>
Flat-top goldentop	<i>Euthamia graminifolia</i>
Sand heather	<i>Hudsonia tomentosa</i>
Round-headed Bush Clover	<i>Lespedeza capitata</i>
False Solomon's seal	<i>Maianthemum stellatum</i>
Common evening primrose	<i>Oenothera biennis</i>
Canada goldenrod	<i>Solidago canadensis</i>
Seaside goldenrod	<i>Solidago sempervirens</i>
White heath aster	<i>Symphytum ericoides</i>

Table 9-17 (cont'd)
Planting Palette for the Planting Plan

Common Name	Scientific Name
Grasses	
American beachgrass	<i>Ammophila brevigulata</i>
Whiskey grass	<i>Andropogon virginicus</i>
Pennsylvania sedge	<i>Carex pensylvanica</i>
Poverty grass	<i>Danthonia spicata</i>
Crinkled hair grass	<i>Deschampsia flexuosa</i>
Greene's rush	<i>Juncus greenei</i>
Red switch grass	<i>Panicum virgatum</i>
Little bluestem	<i>Schizachyrium scoparium</i>
Indian grass	<i>Sorghastrum nutans</i>

Source: Tottenville Shoreline Protection Project – 30 Percent Schematic Design

Wildlife

Construction

During the construction of the earthen berm of the Shoreline Project for Alternative 2, which would be expected to last 6 months, and shoreline restoration, breeding birds and other wildlife occurring within or adjacent to the limits of disturbance would likely be displaced by the activity. Given the amount of contiguous woodland habitat in Conference House Park to the west and north that would be distant from and unaffected by the activity, any displaced wildlife would not be expected to have difficulty temporarily relocating nearby. In order to minimize impacts to birds with the potential to breed within the portion of Conference House Park where the earthen berm would be constructed, construction activities would avoid the early May through July primary bird breeding season to the extent practicable. Temporary displacement from the vicinity of the earthen berm during construction would not significantly impact wildlife at the individual or population level.

Construction of the hybrid dune/revetment system would be expected to take approximately 6 months and the shoreline restoration approximately one month. During construction, any birds or other wildlife occurring within or immediately adjacent to the limits of disturbance would likely be displaced from the area. Given the amount of comparable habitat along the shoreline of Staten Island to the east and north that would be distant from and unaffected by the activity, any displaced wildlife would not be expected to have difficulty temporarily relocating nearby. Any such temporary displacement from the project site during construction would not significantly impact wildlife at the individual or population level. Similarly, any waterfowl or other waterbirds that have the potential to be temporarily displaced from nearshore waters adjacent to the shoreline where the hybrid dune/revetment system would be constructed would be expected to easily utilize alternative open-water habitat that is abundant elsewhere along the Raritan Bay shoreline. Upon completion of the construction, the same species of terrestrial wildlife and waterbirds would be expected to return to the area and in the same abundance as at present.

Construction of the eco-revetment between Loretto Street and Sprague Avenue would disturb a sparsely vegetated area. During the 2 months of anticipated construction activity for this section of eco-revetment, wildlife occurring within and adjacent to the limits of disturbance, possibly including some waterbirds in the nearshore areas, would be displaced. Given that only disturbance-tolerant species that are ubiquitous to urban waterways in the region are expected to occur in the area and comparable habitat is abundant nearby, temporary displacement during construction would not have significant or long-lasting adverse impacts.

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Construction of the raised edge in this area would not eliminate high quality or uncommon habitat for wildlife, and would not alter the composition of the wildlife community from the present state. Displacement of wildlife from the area during the 5-month construction period would be temporary and would not have significant or permanent impacts on wildlife. Comparable roadside and forest edge habitat to which wildlife could temporarily relocate is highly abundant in the surrounding area.

Construction of the Water Hub at Potential Location 1 would require clearing of successional southern hardwoods within the 5,000-square-foot building footprint and another 35,500 square feet of site improvements (landscaped area, parking, and utility spaces, and designated space for the use of NYC Parks vehicles and equipment), including the removal of between 12 and 19 trees. This area is near the southern end of the Butler Manor Woods section of the Mount Loretto Unique Area. Whereas interior portions of the Mount Loretto Unique Area may support a diverse assemblage of wildlife species, the wildlife expected to occur around the site of the proposed Water Hub at Potential Location 1, which is largely clear and disturbed, and adjacent to a paved street and residential development, is limited to urban-adapted generalists. Roadside habitat is of low quality to native wildlife, and clearing of these areas would not eliminate rare or high quality habitat.

Construction of the Water Hub at Potential Location 2 would require clearing of successional southern hardwoods and possible disturbance of mowed lawn with trees communities to provide a potential ADA accessible ramp from the repurposed building and the shoreline. This area is near the northwestern corner of Conference House Park in an area that supports species typical of suburban areas (maintained lawn, shade trees, buildings and paved areas). All work at Water Hub Potential Location 2 would be performed in compliance with Local Law 3 of 2010 and NYC Park's Tree Protection Protocol, to minimize potential adverse impacts. In addition, all required replacement and/or restitution for removed trees would be provided in compliance with Local Law 3 and Chapter 5 of Title 56 of the Rules of the City of New York.

The Water Hub at Potential Location 3 would be implemented almost entirely off-shore in Raritan Bay. The small facility proposed on-shore near the terminus of Page Avenue for the Water Hub at Potential Location 3 would not require any tree clearing and would be placed in a location which is largely clear and already disturbed.

As discussed for the other components of the Shoreline Project, temporary displacement of wildlife during construction of the Water Hub (Potential Locations 1 and 2) would not have significant adverse impacts given that the area is already subjected to high levels of human disturbance and similar habitat is abundant in the area and contiguous with the project site.

Operation

The proposed earthen berm of Alternative 2 would be approximately 948 linear feet, located approximately between Carteret Street and Brighton Street. It would be approximately 25 feet wide at its base, tapering upward to an 8-foot crest at elevation of 12.5 feet, and run through an area of successional southern hardwoods in Conference House Park before connecting to an eco-revetment south of Brighton Street. The total footprint of the earthen berm would be approximately 0.5 acres. The top of the berm would contain habitat-specific plant species; the angled sides would be planted with a mix of native habitat-specific plant species selected in coordination with the NYC Parks and the Greenbelt Native Plant Center. Planting the berm with native vegetation would be expected to improve habitat conditions for woodland wildlife species inhabiting the area. However, no appreciable change in wildlife community composition would be

expected to occur and the same species would be expected to inhabit the area, in about the same abundance.

The earthen berm would transition to an eco-revetment between Brighton Street and Manhattan Street that would comprise a pathway and rip rap with joint plantings. This section of eco-revetment would transition to a hybrid dune/revetment system planted with American beach grass near Manhattan Street that would then extend east to Loretto Street. The hybrid dune/revetment system would be at an elevation of approximately 14 feet, with 70 feet to 90 feet width, and extend approximately 937 linear feet through the maritime beach and maritime dunes communities along the shoreline. It would occupy approximately 2.3 acres of which are already occupied by the temporary dune comprising sand filled barrier bags. The crest of the hybrid dune/revetment system would be 10 feet wide and higher than the current grade, providing a gradual transition from upland elements to the shoreline. It would be stabilized with armor core stone, capped with sand, and planted with American beach grass.

The beach along which the hybrid dune/revetment system would be constructed is narrow and does not appear to support beach-nesting birds or many other wildlife species that inhabit beaches. Along the temporary dune in particular, the waterline reaches the base of the barrier bag system in many places during high tide, and at its widest, the amount of exposed beach between the base of the temporary dune and the water at high tide is roughly 20 feet. This prohibits the area from providing nesting habitat for beach-nesting bird species that nest on wider beaches elsewhere. At lower tide levels, the rest of the beach and intertidal zone is likely used as foraging habitat by shorebirds during spring and fall migration, and by gulls and other waterbirds for foraging and/or loafing year-round.

No mammals, reptiles, or amphibians are expected to occur on the narrow beach that currently exists in between the temporary dune and the water. Replacement of the temporary dune with the hybrid dune/revetment system in this area would result in a negligible change in the amount of habitat available to coastal wildlife. Because the hybrid dune/revetment system would be located further inland than the temporary dune and create a more gradual transition between the shoreline and the uplands, the beach would be wider than at present and more suitable for wildlife species that breed or forage on beaches. Unlike the temporary dune, the hybrid dune/revetment system would be planted with American beach grass and further soften the transition between the beach and the inland scrub/shrub and maritime forest relative to the existing condition. In addition, approximately 3.1 acres of shoreline restoration between Manhattan Street and Loretto Street would further widen the beach and increase habitat availability for coastal wildlife.

The hybrid dune/revetment system would transition to another section of eco-revetment at Loretto Street that would extend along Surf Avenue to approximately Sprague Avenue. This section of eco-revetment would extend approximately 396 feet and consist of a bioswale, sloped plantings, a pathway, and rip rap or concrete steps, depending on the location along the shoreline (see **Figure 9-23**). A concrete sidewalk would be constructed along Surf Avenue and border a 5-foot-wide wide bioswale. The bioswale would be planted with a mix of native habitat-specific coastal species from **Table 9-17**. A narrow concrete wall would separate the bioswale and the upward-sloped section of the eco-revetment, which would be planted with perennials, ornamental grasses, and groundcover. The top of the eco-revetment would consist of an 8-foot-wide concrete pathway that would transition to downward-sloped sections varying in size of American beach grass and other habitat appropriate coastal plantings, concrete steps, or rip rap, depending on the location along the shoreline. The area in which the eco-revetment would be located currently consists of a narrow segment of beach that is armored with rip-rap on the landward side and closely bounded by Surf

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Avenue and residential development to the north. Habitat available to wildlife in this area is minimal and degraded. Levels of disturbance are high due to the close proximity of roads and residential development. Only disturbance-tolerant, generalist species of wildlife, such as ring-billed and herring gulls are likely to occur.

The eco-revetment between Loretto Street and Sprague Avenue would buffer the beach from disturbances from the nearby streets and homes to the north. This would be expected to slightly improve habitat quality for wildlife and possibly attract some additional species to the area. This eco-revetment would transition to a raised edge at Sprague Avenue that would extend approximately 2,536 feet to Page Avenue (see **Figure 9-24**). The trail would be bordered on the landward side by an approximately 5-foot-wide bioswale and on the shoreward side by a stone revetment cresting at either 8 feet (same elevation as the pathway) or 12.5 feet, depending on its location. The far western end of the proposed raised edge would be located along the southern edge of Hybrid Oak Woods Park, where the southern successional hardwood forest transitions to sandy beach. The remainder of the alignment would be located in an area that generally consists of narrow beach, armored with rip-rap and closely bounded to the north by residential development. Because of the beach's armoring and narrow width, and the close proximity of streets and residential development to the north, wildlife occurring in this area is likely limited to disturbance-tolerant, generalist species, such as ring-billed and herring gulls. Similarly, the narrow fragment of woodland at the southern end of Hybrid Oak Woods Park, which has sharp edges with beach or development to the east, west, and south, is expected to support only synanthropic, urban-adapted birds and other wildlife that are tolerant of the fragmentation and human activity associated with roadside habitat. The landscaped areas of the raised edge would continue to support these species.

The raised edge would end at near the terminus of Page Avenue. The area surrounding the proposed Water Hub at Potential Location 1 would be landscaped and would be expected to support urban adapted wildlife similar to the existing condition and No Action Alternative.

TERRESTRIAL AND AQUATIC THREATENED, ENDANGERED, AND SPECIAL CONCERN SPECIES

Terrestrial endangered, threatened, and special concern species that are considered to have the potential to occur in the vicinity of the Shoreline Project area include the piping plover, roseate tern, red knot, eastern mud turtle, eastern box turtle, eastern fence lizard, and southern leopard frog/Atlantic coast leopard frog. Federally and state-listed aquatic species that are considered to occur in the vicinity of the Breakwaters Project of Alternative 2, as transients and on rare occasions, include Atlantic sturgeon, loggerhead sea turtle, Kemp's ridley sea turtle, and green sea turtle. Informal consultation with NMFS under Section 7 of the ESA was initiated on April 19, 2017. This consultation process was completed on May 19, 2017, with a concurrence from NMFS with GOSR's conclusion that the Proposed Actions are not likely to adversely affect the ESA-listed species and/or designated critical habitat under NMFS jurisdiction (see Appendix E-2). Consultation with USFWS was initiated on April 17, 2017, and was completed on January 17, 2018 with a concurrence from USFWS with GOSR's conclusion that the Proposed Actions are not likely to adversely affect ESA-listed species under USFWS jurisdiction (see **Appendix E-2**).

Atlantic Sturgeon

Construction

Given the limited potential for Atlantic sturgeon to occur within the study area except as transient sub-adults or adults, the 11.4 acres of converted nearshore habitat may affect but is unlikely to

adversely affect this species. Any individual Atlantic sturgeon that may be within the study area during construction of the Breakwaters Project portion of Alternative 2 would avoid increases in suspended sediment and underwater activities, and would therefore not be adversely affected by these activities. Because impacts to water quality in the study area, such as increases in suspended sediment and vessel noise, would be temporary and localized and confined to shallow habitat, minimizing the potential to adversely affect Atlantic sturgeon during construction of the shoreline restoration and breakwater segments of Alternative 2. Additional vessel traffic associated with breakwaters construction would be minimal compared to recent levels in the area (i.e., less than one materials barge trip per/day versus approximately 72.5 trips/day; USACE 2014).

Operation

Two species of sturgeon found in the Hudson Raritan Estuary are protected under the federal Endangered Species Act: shortnose sturgeon (*Acipenser brevirostrum*) and Atlantic sturgeon (*Acipenser oxyrinchus*). While both sturgeon species are present in the Hudson River Estuary, only Atlantic sturgeon may occur in the study area as shortnose sturgeon have not been observed in Raritan Bay (NMFS 2015). NMFS (2015) notes that individuals from any of the five distinct population segments of Atlantic sturgeon could be present in Raritan Bay. While Atlantic sturgeon are not expected to occur in significant numbers within the study area, transient individuals may use shallower marine waters along the Atlantic coast. Adults are more likely to occupy deeper, offshore waters of the continental shelf and the deeper waters of the Hudson River channel than the relatively shallow, nearshore waters close to the shorelines. The principal spawning grounds of Atlantic sturgeon are in the freshwater reaches of the Hudson River well outside the study area. Early life stages (i.e., eggs, larvae, and smaller juveniles) are relatively intolerant of salinity and, therefore, are found at locations upriver with fresh to low salinity levels. For example, young-of-year Atlantic sturgeon exhibit low survival rates at salinities ranging from 5 to 10 ppt, while age-1 and age-2 fish may tolerate salinities up to 12 ppt (Kynard and Horgan 2002; ASMFC 2012). Juvenile Atlantic sturgeon remain in these fresh to low salinity waters upstream of the study area until reaching 70 centimeters at about 3 years of age, when they begin their migration to marine waters. Thus, the Breakwaters Project would not affect the spawning or nursery habitat for Atlantic sturgeon nor would it directly interfere with these critical processes.

Atlantic sturgeons are benthic oriented fish that primarily feed on benthic invertebrates and fish like sand lance. Atlantic sturgeon typically use deep-water channel habitat in the Hudson River (e.g., Bain 1997, Sweka et al. 2007), but may make foraging forays into shallow waters over unstructured benthic habitat (Dadswell 1979). The Breakwaters Project would convert 11.4 acres of existing benthic habitat that could be used by Atlantic sturgeon to forage for benthic fish and invertebrates, to complex hard structure. However, there is no indication that the study area could provide unique ecological opportunities; thus, the loss of this specific bottom forage habitat would represent only 0.05 percent of the available nearshore habitat in the New York and New Jersey waters of Raritan Bay (and 2 percent of existing benthic habitat in the study area, which would not be lost all at once, but rather sequentially over the 11 month construction period). In addition, subadult and adult Atlantic sturgeons consume a greater proportion of fish in their diets compared to younger life stages. Thus, the operation of the Breakwaters Project may affect, but is not likely to adversely affect, sub-adult or adult Atlantic sturgeon from occurring in the study area.

Sea Turtles

NMFS (2015) indicates that New York and New Jersey waters may be warm enough to support loggerhead and Kemp's ridley turtles from May through mid-November, and green sea turtles from June through October. While Loggerhead, green, and Kemp's ridley sea turtles in New York

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may be present in Long Island Sound and in coastal waters off the Long Island coast, they are uncommon in waters as far west as New York Harbor (Morreale and Standora 1994, 1998). Individuals found in New York Harbor are typically juveniles. Leatherback sea turtles may be found in the waters off New York and New Jersey during the warmer months, but this species is unlikely to occur in the study area because of its preference for deep, pelagic waters. The New York-New Jersey Harbor complex is considered marginal to lower quality sea turtle habitat, and observations of sea turtles in these waters are infrequent despite extensive monitoring and surveying efforts (Ruben and Morreale 1999, USACE 2001), although loggerhead and Kemp's ridley sea turtles occur off of Sandy Hook, NJ, approximately 10 miles from the study area (USFWS 1997). Overall, sea turtles are considered to have the potential to occur within the study area as occasional transient individuals, and do not depend on habitats in the region for breeding, wintering, or growth. Project construction is not expected to cause a significant adverse impact to these species. Therefore, construction and operation of Alternative 2 may affect but is unlikely to adversely affect sea turtles.

Eastern Mud Turtle

The mix of freshwater and brackish wetlands associated with the Twin Streams of the Lenape in Conference House Park, and the surrounding scrub/shrub and oak forest uplands represent habitat types that can support eastern mud turtles, although no eastern mud turtles have been confirmed to occur in the area. These wetlands in which eastern mud turtles could potentially occur are associated with the Twin Streams of the Lenape, which is approximately 250 feet west of the Shoreline Project's limits of disturbance at the closest point, and would not be directly impacted by Alternative 2. The hydrological and physical connection of these areas to Raritan Bay would not be impeded by Alternative 2. Given the distance between the wetlands and the beginning of the proposed earthen berm, no noise or other indirect disturbances to eastern mud turtles would be expected to occur during construction. Eastern mud turtles typically stay within approximately 200 feet of their wetland basin when hibernating in upland areas (Steen et al. 2007), and given the expanse of southern hardwood forest extending to the east, west, and north of the wetlands associated with the Twin Streams of the Lenape in Conference House Park, construction and operation of the earthen berm approximately 250 feet away would not be expected to interfere with the migration or overwintering of eastern mud turtles. The 0.8-acre delineated wetland is not considered likely to support mud turtles because of its small size and lack of open water.

Overall, the construction and operation of Alternative 2 would not adversely affect any population of eastern mud turtles potentially occurring in the area.

Eastern Box Turtle

Eastern box turtles have the potential to occur in the scrub/shrub and forested portions of Conference House Park, particularly around the streams. As such, eastern box turtles may occur in the vicinity of the location of the proposed earthen berm, but are not expected to occur near any other Shoreline Project elements. During the anticipated 4-month construction period, the project site would be fenced off with silt fencing that would prevent any eastern box turtles from entering the area of disturbance. While some individuals would potentially be displaced from the location of the earthen berm during construction, they would be expected to easily distance themselves from the disturbance because expansive areas of similar habitat are fully contiguous with the site of the proposed berm. On the rare chance that eastern box turtles are encountered in the area of disturbance prior to or during the construction activity, they would be relocated beyond the fencing to avoid any direct impacts. The earthen berm, which would range in height from 1 to 7.5 feet and have sloped and vegetated sides, would not affect the movements of eastern box turtle, as this

species would be capable of crossing the berm. The Shoreline Project would not result in any change in habitat availability for eastern box turtles or any barrier to their movement, and following its construction, eastern box turtles would be expected to occur in the area with the same likelihood and in the same abundance as at present. With these measures in place, construction and operation of Alternative 2 would not adversely affect any eastern box turtle population potentially occurring in the area.

Eastern Fence Lizard

Eastern fence lizards inhabit dry, open woodlands, including oak forest like that which occurs within Conference House Park. Eastern fence lizards are considered to have the potential to occur in the vicinity of the location of the proposed earthen berm of Alternative 2, but have not been confirmed occurring anywhere within Conference House Park. Eastern fence lizards are not expected to occur near any other Shoreline Project elements of Alternative 2. During the anticipated 4-month construction period, any eastern fence lizards potentially inhabiting the area would likely be temporarily displaced by the activity, but would be expected to easily move away from the disturbance into other areas of similar habitat that are fully contiguous with the site of the proposed earthen berm. The earthen berm, which would range in height from 1 to 7.5 feet and have sloped and vegetated sides, would not affect the movements of eastern box turtle, as this species would be capable of crossing the berm. The berm would be planted with native coastal vegetation and would reduce the degree of forest fragmentation currently caused by the trail. The earthen berm would not result in any change in habitat availability for eastern fence lizards or any barrier to their movement, and following its construction, eastern fence lizards would be expected to occur in the area with the same likelihood and in the same abundance as at present. Therefore, construction and operation of Alternative 2 would not adversely affect any population of eastern fence lizard potentially occurring in the area.

Southern Leopard Frog

Southern leopard frogs (including Atlantic coast leopard frogs) have the potential to occur within the freshwater and brackish wetlands within and around Wards Point Pond and the Twin Streams of the Lenape in Conference House Park, which are at least 250 feet away from the limits of disturbance of the Shoreline Project. Nowhere else in the study area is there suitable habitat for southern leopard frogs. The Shoreline Project of Alternative 2 would begin approximately 250 feet to the west of, and have no direct or indirect impacts on, these wetlands in which southern leopard frogs may occur. The hydrological and physical connection of these areas to Raritan Bay would not be impeded by Alternative 2. Therefore, construction and operation of Alternative 2 would not adversely affect any southern leopard frogs potentially occurring in the area.

Northern Gama Grass

Two populations of northern gama grass were observed within the study area. These populations are located within the approximate area of disturbance of the proposed hybrid dune/revetment system. Thus, both northern gama grass populations are likely to be adversely affected by construction of Alternative 2. A protection program for northern gama grass would be developed in coordination with NYC Parks and/or NYSDEC/NYNHP. Because northern gama grass is a perennial species, any individuals within the footprint of disturbance would be transplanted when practical as part of the protection program. The protection program may also include seed collection and propagation. The propagation efforts and implementation of the protection program that would be developed in coordination with NYC Parks and/or NYSDEC/NYNHP would maintain the northern gama grass population in the study area after construction. Therefore,

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construction and operation of Alternative 2 would not have a significant adverse impact on northern gama grass populations within the study area.

Yellow Giant-hyssop

One population of yellow giant-hyssop was observed within the study area. This population is not located within or adjacent to the approximate area of disturbance of Alternative 2. Therefore, construction and operation of Alternative 2 would not adversely affect yellow giant-hyssop populations within the study area.

Dune Sandspur

Four populations of dune sandspur were observed within the study area. These populations are located within the approximate area of disturbance of the proposed hybrid dune/revetment system, eco-revetment between Loretto Street and Sprague Avenue, raised edge, and shoreline restoration area. Thus, dune sandspur populations are likely to be adversely affected by construction of Alternative 2. A protection program for dune sandspur would be developed in coordination with NYC Parks and/or NYSDEC/NYNHP. Because dune sandspur is an annual species the projection program may include seed collection from dune sandspur within the area of disturbance. Collected dune sandspur seeds would be directly seeded in the disturbed locations in the autumn following completion of construction activities. The propagation efforts and implementation of the protection program would maintain the dune sandspur population in the study area. Therefore, construction and operation of Alternative 2 would not adversely affect dune sandspur populations within the study area.

Piping Plover, Roseate Tern, and Red Knot

Although the breakwater alignment, segment length and distance from shore are designed to promote beach accretion, but avoid the creation of tombolos, the beach would likely remain too narrow to support nesting piping plovers or other beach-nesting waterbirds. Maslo et al. (2011) concluded that beaches less than 80 meters wide (262 feet), for example, are considered narrow for piping plovers. In the same study, piping plovers in New Jersey were not found to nest less than 10 meters (32 feet) away from the high tide line (Maslo et al. 2011). The hybrid dune/revetment would be too high and too steeply sloped for piping plovers to nest on, and the margin between the base of the hybrid dune/revetment and the high tide line may not be sufficient for nesting. It is therefore unlikely that piping plovers as well as other beach-nesting birds would nest on the beach. However, in the event that any such species are found to nest on the beach, NYC Parks would enact the required management and protection protocols for each species in consultation with regulatory agencies. It is expected that red knots and other shorebirds may occur on the beach during spring and fall migration with the same likelihood as at present. The shoreline restoration and breakwaters may improve benthic invertebrate communities as well as horseshoe crab nesting habitat, and in turn, improve refueling conditions for migrating shorebirds. In the event that Alternative 2 results in an increase in red knot along the beach within Conference House Park in response to greater horseshoe crab spawning activity, NYC Parks would enact management and protection protocols in consultation with USFWS and any other relevant regulatory agencies.

9.5.3 ALTERNATIVE 3—BREAKWATERS WITHOUT SHORELINE PROTECTION SYSTEM

Alternative 3 would develop the Breakwaters Project components as described in Alternative 2, including the in-water breakwaters, shoreline restoration and the Water Hub. None of the Shoreline Protection Project components would be developed under Alternative 3.

GROUNDWATER

Construction and operation of Alternative 3 would not adversely affect groundwater. Excavation of soils during construction of the Water Hub would be limited and would not have the potential to adversely affect groundwater quality or require dewatering. There would be no appreciable difference in the impacts or benefits to groundwater as a result of Alternative 3 as compared with Alternative 2.

WETLANDS

As discussed under “Wetlands” in Alternative 2, Construction of the Breakwaters Project would result in temporary and permanent impacts to NYSDEC littoral zone tidal wetlands and mapped NWI estuarine wetlands in the vicinity of the breakwater segments and the shoreline restoration. The same impacts described for the Breakwaters Project in Alternative 2 would apply for Alternative 3, comprising the permanent loss of 7.1 acres of NYSDEC littoral zone tidal wetlands. Alternative 3 would reduce wave energy at the shoreline and reduce or reverse shoreline erosion. However, without the Shoreline Project, the barrier bags that comprise the temporary man-made dune would remain the only shoreline risk reduction feature. The barrier bags would not provide the same level of shoreline resilience as Alternative 2 and the remaining portions of the shoreline within the study area would remain in their current condition of being subject to wave energy and erosion and would not protect the NYSDEC TWAA. Additionally, the 0.8-acre delineated wetland located on the shoreline would not be enhanced through improved tidal flushing. Therefore, Alternative 3 would result in the same impact to NYSDEC tidal wetlands as Alternative 2 but would not provide the same level of coastal resiliency and protection of the NYSDEC TWAA and would leave these resources with the same vulnerabilities as Alternative 1.

AQUATIC RESOURCES

Water Quality

As described for Alternative 2, the Breakwaters Project would not result in significant adverse impacts to water quality. The same impacts to water quality described for the Breakwaters Project under Alternative 2 would apply to Alternative 3, including temporary sediment resuspension and increased turbidity during construction and seasonal movement of the temporary boat launch. Similarly, the same benefits provided by the Breakwaters Project would apply to Alternative 3, including reduced erosion along the shoreline throughout the study area.

Sediment Quality

As described for Alternative 2, Alternative 3 would not result in significant adverse impacts to sediment quality. The same impacts to sediment quality described for the Breakwaters Project under Alternative 2 would apply to Alternative 3, including alteration of sediment characteristics in the footprint of the breakwaters and temporary resuspension of sediments and any associated contaminants.

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Aquatic Biota and EFH

The same construction-related impacts to the aquatic community described for the Breakwaters Project under Alternative 2 would apply to Alternative 3, including temporary increases in suspended sediment, loss of 11.4 acres of benthic habitat within the breakwater footprints and 2.6 acres below MHW within the area of proposed shoreline restoration, and increased vessel activity, movement of materials through the water, and associated underwater noise. Similarly, the same long-term benefits provided by the Breakwaters Project portion of Alternative 2 would apply to Alternative 3. Approximately 11.4 acres of open water and low relief sand/gravel habitat and overlying open water habitat within the footprint of the breakwaters would be converted into diverse high-relief habitat in the subtidal and intertidal zones, including the creation of interstitial habitat, crevices, and other usable surface area that would be available for use by aquatic biota. The structural complexity resulting from the breakwater segments would provide increased habitat diversity when compared to the sand and gravel area and open water habitat replaced by the breakwaters. The Breakwaters Project would enhance foraging and refuge habitat for several target groups of benthic invertebrates and fish affected by the project. The converted sand and gravel habitat is common in the study area and throughout the Bay and would be replaced by structures designed to increase the diversity of available habitats. The Breakwaters Project would be expected to benefit the target species groups identified for the project and could potentially improve the productivity and diversity of the local ecosystem.

TERRESTRIAL RESOURCES

Ecological Communities

As described for Alternative 2, under Alternative 3, the Water Hub would result in the loss of between 12 to 19 trees and clearing of vegetation within the successional southern hardwoods ecological community within the building footprint (approximately 5,000 square feet) and associated site improvements (35,500 square feet) at Potential Location 1, or the loss of trees and clearing of vegetation within the successional southern hardwoods and mowed lawn with trees communities associated with the potential ADA accessible ramp at Potential Location 2, should this water access option be chosen. The successional southern hardwoods and mowed lawn with trees communities are relatively common ecological communities within the region and the negligible loss of a small area of these communities would not have a measurable effect on these ecological communities as a whole. In addition, landscaping for the Water Hub would use native plant species. Therefore, construction and operation of the Water Hub under Alternative 3 would not adversely affect ecological communities within the study area. However, without the Shoreline Project and the proposed native coastal plantings, there would be minimal enhancement of vegetation and ecological communities. Therefore, Alternative 3 would not result in significant adverse impacts to ecological communities, but as in Alternative 1, would not obtain the same level of coastal resiliency as Alternative 2.

Wildlife

Under Alternative 3, only the Water Hub and shoreline restoration would have the potential to affect wildlife. As discussed under “Wildlife” in Alternative 2, wildlife in the vicinity of the Water Hub are expected to be urban-adapted generalists that would not be adversely affected by the construction or operation of the Water Hub. The area of shoreline restoration would widen the beach and increase habitat availability for coastal wildlife. Without the Shoreline Project of Alternative 2, and the resulting, gradual transition between the shoreline and the uplands that would be created by the hybrid dune/revetment, habitat along the shoreline in this area under

Alternative 3 would be the same as under Alternative 1; fragmented and less suitable for wildlife species that breed or forage on beaches. Therefore, Alternative 3 would not obtain the same level of coastal resiliency.

TERRESTRIAL AND AQUATIC THREATENED, ENDANGERED, AND SPECIAL CONCERN SPECIES

Under Alternative 3, the types and amount of terrestrial habitat in the study area would be similar to the No Action Alternative with the exception of the Water Hub and site improvements, and would continue to support the same terrestrial endangered, threatened, and special concern species with the same likelihood. This alternative would not have the potential to adversely affect conditions for eastern mud turtles, eastern box turtles, eastern fence lizards, southern leopard frogs, northern gama grass, dune sandspur, or yellow giant-hyssop, and each of these species would continue to have the same potential to occur in the area. Alternative 3 would result in the same impacts to Atlantic sturgeon and sea turtles as described under Alternative 2, and would implement the same management and protection protocols for nesting and migrating shorebirds (e.g., piping plover and red knot) as necessary as Alternative 2. Therefore, as described under Alternative 2, Alternative 3 would not have the potential to result in significant adverse impacts to terrestrial and aquatic threatened, endangered, and special concern species.

ALTERNATIVE 4—SHORELINE PROTECTION SYSTEM WITHOUT BREAKWATERS

Alternative 4 would develop the Shoreline Project components as described in Alternative 2, including the earthen berm, hybrid dune/revetment system, wetland enhancement, eco-revetment, and raised edge. None of the Breakwaters Project components would be developed under Alternative 4.

GROUNDWATER

Alternative 4 would result in the development of the Shoreline Project as evaluated under Alternative 2. As with Alternative 2, the construction and operation of the Shoreline Project would not result in significant adverse impacts to groundwater resources.

WETLANDS

Alternative 4 would result in the development of the Shoreline Project within the NYSDEC TWAA as evaluated under Alternative 2. As with Alternative 2, the construction and operation of the Shoreline Project would not result in adverse impacts to the NYSDEC TWAA, or to the delineated wetland, and increased tidal exchange would enhance the delineated wetland by improving conditions for native vegetation. This alternative would not result in the development of the Water Hub with water access at Potential Locations 1 or 2, the parking area or the placement of sand for the shoreline restoration within the NYSDEC TWAA, or the placement of a breakwater segment within NYSDEC littoral zone tidal wetlands.

Under this alternative, the Shoreline Project would stabilize the upland shoreline, minimize the introduction of impervious surfaces within the NYSDEC TWAA, and enhance habitats in the study area through the establishment of native dune vegetation and other native coastal plant species. However, without the Breakwaters Project, NYSDEC littoral zone tidal wetlands and NYSDEC TWAA within the beach under Alternative 4 would, as in Alternative 1, remain vulnerable to coastal storm surges, wave action and erosion. Therefore, Alternative 4 would not obtain the same level of coastal resiliency and protection of NYSDEC tidal wetlands as compared with Alternative 2.

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AQUATIC RESOURCES

Water Quality

As described under Alternative 2, construction and operation of the Shoreline Project for Alternative 4 would not result in significant adverse impacts to water quality of Raritan Bay. Benefits to water quality under Alternative 4 would be the same as those described for the Shoreline Project under Alternative 2, including improvements to stormwater runoff through the use of green infrastructure measures such bioswales and the implementation of IPM to manage landscaped areas. This alternative would have no potential to affect tidal flushing or water quality of Raritan Bay which would remain as described under Alternative 1.

Sediment Quality

As described under Alternative 2, construction and operation of the Shoreline Project for Alternative 4 would not result in significant adverse impacts to sediment quality. Erosion and sediment control measures implemented under the SWPPP prepared for the Shoreline Project under Alternative 4 would minimize the discharge of sediment to Raritan Bay. This alternative would not result in any in-water construction activities within Raritan Bay that would have the potential to resuspend bottom sediment or have the potential to affect sediment characteristics.

Aquatic Biota and EFH

As described under Alternative 2, the Shoreline Project would not result in significant adverse impacts to aquatic biota of Raritan Bay. The same measures described for the Shoreline Project under Alternative 2 for minimizing potential impacts to water quality apply to Alternative 4, including minimizing potential impacts of stormwater runoff through the use of green infrastructure and landscaping with native coastal vegetation to improve infiltration.

However, this alternative would not result in protection of beach areas used for spawning by horseshoe crabs, nor would it result in increased habitat area and diversity through the introduction of the rock and bio-enhancing concrete breakwater segments that would result from Alternative 2. Under Alternative 4, the aquatic biota and EFH of Raritan Bay within the study area would be as described for Alternative 1.

TERRESTRIAL RESOURCES

Ecological Communities

As discussed under Alternative 2, the Shoreline Project would enhance and stabilize the upland shoreline, enhance the ecological communities along the shoreline through the introduction of native coastal species, prevent erosion of the upland shoreline, and create habitat heterogeneity that would be utilized by wildlife within the study area. However, without the Breakwaters Project component of Alternative 2, terrestrial and ecological communities under Alternative 4 would remain vulnerable to coastal storm surges and the beach communities would be subject to loss due to erosion as in Alternative 1.

Wildlife

Potential effects on terrestrial wildlife from Alternative 4 would be the same as those described under Alternative 2 for the Shoreline Project. Overall, the Shoreline Project under Alternative 4 would result in minimal habitat loss and disturbance, and temporary, indirect disturbances to wildlife that would not result in significant adverse impacts or alter wildlife community composition in the study area. However, without the Breakwaters Project, the beach area would

be vulnerable to erosion and beach areas used by horseshoe crabs for egg laying would remain vulnerable as under Alternative 1.

TERRESTRIAL AND AQUATIC THREATENED, ENDANGERED, AND SPECIAL CONCERN SPECIES

Potential impacts to terrestrial threatened or endangered species from Alternative 4 would be the same as described for the Shoreline Project under Alternative 2. Alternative 4 would not result in any activities within Raritan Bay and would, therefore, have not potential to adversely affect aquatic threatened or endangered species.

9.6 MINIMIZATION AND MITIGATION OF IMPACTS

The Proposed Actions would not result in significant adverse impacts to terrestrial natural resources within the study area. The Proposed Actions would result in the conversion of soft bottom sandy substrate to complex rocky habitat within the study area, and by design, would be expected to benefit the target species groups identified for the project. The loss of approximately 3.6 acres of Waters of the U.S. and associated habitat due to the portion of the breakwaters above MHW would result in adverse impacts Measures incorporated into the Proposed Actions to minimize, avoid or mitigate adverse impacts to natural resources include the following:

- Segregating any contaminated soil/or sand, creosote-treated wood or other contaminants encountered during construction and disposing of these materials in accordance with applicable federal, state and local regulations.
- Groundwater recovered during dewatering would be tested and treated in accordance with NYSDEC requirements prior to discharge to Raritan Bay.
- Implementing erosion and sediment control measures and stormwater management measures in accordance with the SWPPP prepared as required under the SPDES General Permit GP-0-15-002 for Stormwater Discharges from Construction Activity.
- Incorporating bioswales and other green infrastructure stormwater management measures to allow infiltration of runoff and recharge to groundwater.
- Relocating any eastern box turtles encountered in the area of disturbance prior to or during the construction of earthen berm to an area beyond the silt fencing to avoid direct impacts.
- Scheduling the construction of the project elements requiring tree clearing outside the early May through July primary bird breeding season, to the extent practicable. Should construction activities requiring tree clearing be necessary during April or August (i.e., the beginning and end of the breeding period), GOSR will coordinate with the USFWS with respect to conducting active nest surveys that may support tree cutting during this period. These surveys would be focused on the presence of active nests, eggs, or young in trees targeted for removal. In the event that active nests, eggs, or young are not present, GOSR will inform USFWS of the results before commencing any tree cutting.
- Maintaining landscaped areas within the Shoreline Project and at the Water Hub using IPM techniques.
- In the event that piping plovers or other beach-nesting birds are found to nest on the beach, NYC Parks would enact appropriate management and protection protocols.
- In the event that the Proposed Actions result in an increase in red knot along the beach within Conference House Park in response to greater horseshoe crab spawning activity, NYC Parks

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would enact management and protection protocols in consultation with USFWS and any other relevant regulatory agencies.

- Employing measures to minimize impacts to the 0.8-acre tidal wetland during construction of the Shoreline Project such as marsh mats or low ground-pressure equipment, and installation of erosion and sediment control measures in accordance with the SWPPP.
- In consultation with NYSDEC and USACE, designing the portion of the eco-revetment that crosses through the 0.8-acre tidal wetland to allow access across the wetland while minimizing adverse effects to the tidal wetland.
- Enhance the remaining 0.66-acre portion of the 0.8-acre tidal wetland through increased tidal exchange with Raritan Bay, removal of the unpermitted sand bridge, removal of phragmites, and re-establishment of native saltmarsh plant species. Existing native saltmarsh vegetation that is currently within the wetland would be retained to the extent possible, and individual plants and seeds would be collected for preservation and replanting. Additional native saltmarsh plants would be re-established through seeding or planting plugs to supplement the native saltmarsh vegetation that already occurs in the wetland. Post-construction monitoring would be conducted in accordance with the New York State Salt Marsh Restoration and Monitoring Guidelines.
- Planting native coastal plant species within the Shoreline Project and Water Hub (if located on-shore).
- Developing protection programs (e.g., transplant, and seed collection and propagation) in coordination with NYC Parks and NYSNHP for populations of the state-listed plant species that would have the potential to be affected by construction of the Shoreline Project: northern gamma grass (endangered), and dune sandspur (threatened).
- Designing the Breakwaters Project to reduce wave energy at the shoreline, and reduce, prevent, or reverse shoreline erosion, without adversely affecting tidal flushing along the shoreline within the NYSDEC littoral zone tidal wetland.
- Incorporating ecological enhancements into the design of the breakwater segments through the creation of three-dimensional hard/rocky structured reef-like habitat with reef streets and eco-enhanced concrete units that would increase the quantity and diversity of the aquatic habitats available for habitat forming plants and invertebrates found in Raritan Bay.
- Maintaining at least 2 feet of clearance from the bottom of the Bay, or work only at tide levels sufficient to keep construction barges and vessels off the bay.
- Mitigating for the loss of approximately 3.6 acres of Waters of the U.S. and associated habitat due to the portion of the breakwaters above MHW through measures that may include the purchase of available credits from an approved mitigation bank, and restoration/enhancement of Waters of the U.S. within the Raritan Bay watershed in New York.
- Use of best management practices to minimize the release of suspended sediments during sand placement, including placement of the material above MHWS at low tide where possible and using turbidity barriers where feasible.
- Timing the placement of sand for the shoreline restoration to avoid the spawning season for horseshoe crabs (restricted from April 15 through July 15). The material used for restoration would be similar in composition to existing sand substrate at the beach and within Conference House Park.

- Timing the construction of the breakwaters and shoreline restoration to minimize adverse effects to winter flounder early life stages and EFH (restricted from January 1 through May 31).
- Construction of the breakwater segments sequentially, such that only a small footprint of the Bay is affected at a time. As each segment is completed, habitat forming organisms would begin to colonize the structure, providing foraging opportunities for predator species.
- Development of a post-construction monitoring plan and adaptive management plan in consultation with NYSDEC, NMFS and USACE to assess use of breakwaters segments by target species groups and fish and benthic communities adjacent to the breakwaters structures.
- Development of a post-construction monitoring and adaptive management plan to assess the structural integrity and condition of breakwater structures, their effectiveness at attenuating storm waves and reducing shoreline erosion, along with establishing what corrective measures may be needed should an issue arise and when such corrective measures should be implemented. Future determination of any need for modification(s) to the breakwater structures would be in accordance with the Adaptive Management Plan developed for the project.
- To minimize human sea mammal interaction, signage indicating that such interaction is prohibited will be installed near the breakwaters in consultation with State and Federal Agencies.

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