15.0 INTRODUCTION

The implementation of the Proposed Actions is intended to enhance coastal resiliency along the Tottenville shoreline of the South Shore of Staten Island, NY. For a detailed review of the objectives of the Proposed Actions, see Chapter 1, “Purpose and Need and Alternatives.” Since the goals of the Breakwaters and Shoreline Projects include risk reduction strategies that would reduce wave action and coastal erosion along the coastal area in Tottenville, this chapter discusses the effect of the Proposed Actions on the surrounding area under future climate conditions affected by global climate change.

15.1 PRINCIPAL CONCLUSIONS

The Proposed Actions would not introduce any adverse impacts in terms of climate resilience. Rather, Alternatives 2, 3, and 4 would improve the resilience of the project area to coastal erosion and the impact of waves during severe coastal storm events. The Water Hub would also be designed to be resilient to future flood conditions or located outside of the potential future flood hazard area. Therefore, the Proposed Actions would be consistent with the City and State’s resilience policies. While each component (in-water breakwaters and on-shore measures) would reduce wave height on its own, for Alternatives 3 and 4, the combined benefit of both components under Alternative 2 would be larger than either component on its own.

15.2 DEVELOPMENT OF POLICY TO IMPROVE CLIMATE CHANGE RESILIENCE

In recognition of the important role that the federal government has to play to address adaptation to climate change, a federal executive order signed October 5, 2009 charged the Interagency Climate Change Adaptation Task Force, composed of representatives from more than 20 federal agencies, with recommending policies and practices that can reinforce a national climate change adaptation strategy. The 2011 progress report by the Task Force included recommendations to build resilience to climate change in communities by integrating adaptation considerations into national programs that affect communities, facilitating the incorporation of climate change risks into insurance mechanisms, and addressing additional cross-cutting issues, such as strengthening resilience of coastal, ocean, and Great Lakes communities.[1] In February 2013, federal agencies released Climate Change Adaptation Plans for the first time. The President’s Climate Action Plan[2] outlines a plan for resilience that includes building stronger and safer infrastructure through agency support in investment, developing standards, and other measures, and was

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[1] The White House Council on Environmental Quality. *Progress Report of the Interagency Climate Change Adaptation Task Force: Federal Actions for a Climate Resilient Nation*. October, 2011.

[2] Executive Office of the President. *The President’s Climate Action Plan*. June 2013.

followed by an executive order[3] directing agencies to implement the plan. In January 2015, a Presidential executive order was issued[4] requiring that federal actions use natural systems and approaches where possible when developing adaptation alternatives for consideration, and redefining the floodplain elevation as either future projected levels; the level that results from adding 2 feet (or 3 feet for critical actions) to the current base flood elevation; the "500-year" elevation (elevation of the flood with 0.2 percent probability in any given year); or the level obtained via other methods yet to be developed.

The New York State Sea Level Rise Task Force was created to assess potential impacts on the state's coastlines from rising seas and increased storm surge. The Task Force prepared a report of its findings and recommendations including protective and adaptive measures.[5] The recommendations are to provide more protective standards for coastal development, wetlands protection, shoreline armoring, and post-storm recovery; to implement adaptive measures for habitats; integrate climate change adaptation strategies into state environmental plans; and amend local and state regulations or statutes to respond to climate change. The Task Force also recommended the formal adoption of projections of sea level rise.

The New York State Climate Action Plan Interim Report identified a number of policy options and actions that could increase the climate change resilience of natural systems, the built environment, and key economic sectors—focusing on agriculture, vulnerable coastal zones, ecosystems, water resources, energy infrastructure, public health, telecommunications and information infrastructure, and transportation.[6]

New York State's Community Risk and Resiliency Act (CRRA)[7] requires that applicants for certain State programs demonstrate that they have taken into account future physical climate risks from storm surges, sea-level rise and flooding, and required the Department of Environmental conservation (NYSDEC) to establish official State sea-level rise projections. In February 2017, NYSDEC adopted a revised draft rule (Part 490) defining the existing projections for. These projections provide the basis for State adaptation decisions and are available for use by all decision makers. CRRA applies to specific State permitting, funding and regulatory decisions, including smart growth assessments; funding for wastewater treatment plants; siting of hazardous waste facilities; design and construction of petroleum and chemical bulk storage facilities; oil and gas drilling, and State acquisition of open space.

The Smart Growth Act, as amended by CRRA, prohibits state infrastructure agencies from approving, undertaking, supporting, or financing public infrastructure projects, including providing grants, awards, loans or assistance programs, unless, to the extent practicable, they are consistent the specific criteria, including the criterion "*to mitigate future physical climate risk due to sea level rise, and/or storm surges and/or flooding, based on available data predicting the likelihood of future extreme weather events, including hazard risk analysis data if applicable.*"

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[3] The White House. *Executive Order—Preparing the United States for the Impacts of Climate Change*. November 1, 2013.

[4] The White House. *Executive Order [13690]—Establishing a Federal Flood Risk Management Standard and a Process for Further Soliciting and Considering Stakeholder Input*. January 30, 2015.

[5] New York State Sea Level Rise Task Force. *Report to the Legislature*. December 2010.

[6] NYSERDA. *New York State Climate Action Plan Interim Report*. November, 2010.

[7] *Community Risk and Resiliency Act.* Chapter 355, NY Laws of 2014. April 9, 2013. Signed September 22, 2014.

In New York City, the Climate Change Adaptation Task Force is tasked with securing the city's critical infrastructure against rising seas, higher temperatures, and fluctuating water supplies projected to result from climate change. The Task Force is composed of over 35 New York City and State agencies, public authorities, and companies that operate, regulate, or maintain critical infrastructure in New York City. The approaches suggested for the City to create a city-wide adaptation program include ways to assess risks, prioritize strategies, and examine how standards and regulations may need to be adjusted in response to a changing climate.

To assist the task force, the New York City Panel on Climate Change (NPCC), has prepared a set of climate change projections for the New York City region[8] which was subsequently updated,[9] and has suggested approaches to create an effective adaptation program for critical infrastructure. The NPCC includes leading climatologists, sea-level rise specialists, adaptation experts, and engineers, as well as representatives from the insurance and legal sectors. The climate change projections include a summary of previously published baseline and projected climate conditions throughout the 21st century including heat waves and cold events, intense precipitation and droughts, sea level rise, and coastal storm levels and frequency. NPCC projected that sea levels could increase by up to 30 inches by the 2050s and up to 75 inches by the end of the century (more detailed ranges and timescales are available). In general, the probability of higher sea levels is characterized as "extremely likely," but there is uncertainty regarding the probability of the various levels projected and timescale. Intense hurricanes are characterized as "more likely than not" to increase in intensity and/or frequency, and the likelihood of changes in other large storms ("Nor'easters") are characterized as unknown. Therefore, the projections for future "100-year" (a 1-percent probability in any given year) coastal storm surge levels for New York City include only sea level rise at this time, and do not account for changes in storm frequency. NPCC also projected that annual average precipitation is likely to increase and that the number of downpours (intense precipitation events shorter than a day and often shorter than an hour) is "very likely" to increase.

While strategies and guidelines for addressing the effects of climate change are being developed on all levels of government, there are currently no specific requirements or accepted recommendations for land use planning or other potentially affected activities in New York City. However, the recently approved revisions to the Waterfront Revitalization Program (WRP) require consideration of climate change and sea level rise in planning and design of waterfront development. As set forth in more detail in the City's *City Environmental Quality Review (CEQR) Technical Manual*, the provisions of the WRP are applied by city agencies when conducting environmental review; the WRP provisions and the Proposed Action's consistency with those provisions are described in detail in Appendix B, "Coastal Management Program Assessment."

Climate change considerations and measures that would be implemented to increase climate resilience are discussed below.

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[8] New York City Panel on Climate Change. *Climate Change Adaptation in New York City: Building a Risk Management Response.* Annals of the New York Academy of Sciences, May 2010.

[9] New York City Panel on Climate Change. *New York City Panel on Climate Change 2015 Report*. Ann. N.Y. Acad. Sci. 1336. 2015.

15.3 EFFECTS ASSESSMENT

15.3.1 ALTERNATIVE 1—NO ACTION ALTERNATIVE

In the No Action condition, no physical changes would be introduced in the project area. Potential storm elevations, potentially affecting residential and other uses near the shoreline, would continue to increase gradually as sea level continues to rise, and shoreline erosion and accretion processes would continue to change the shoreline.

SEVERE STORM CONDITIONS

In the current condition and the near future, a severe "100-year storm" could flood areas near the coastline, potentially including residential uses as far north as approximately 50 to 450 feet north of Billop Avenue (see the current and future NPCC "high" scenarios in **Figure 15-1**).[10] The extent of that flood hazard zone will continue to extend northward as sea levels rise; based on NPCC's current projections, by the end of the century and in the "high" scenario, the northern boundary of the "100-year" flood hazard area would be between Billop Avenue and Clermont Avenue, somewhere between the mid-block area and Clermont Avenue (varies by location).

Within the above "100-year" flood hazard area, the area currently in the "Limit of Moderate Wave Action (LiMWA)" area—the area where this severe storm may cause 1.5-foot or greater breaking waves—extends just north of Billop Avenue except between Brighton Street and Rockaway Street where the LiMWA is mostly located mid-block south of Billop Avenue (see **Figure 15-1**). It is likely that the LiMWA would also be pushed somewhat northward in the future under the No Action Alternative as sea levels rise. Within this area, the area between Brighton Street and Sprague Avenue, where residential uses are located near the shoreline, is particularly at-risk.

The current "100-year" storm water elevation in these residential areas range from 13 to 15 feet NAVD88 (varies by location and distance from the shoreline). Storm water elevations would increase in the future due to sea level rise, and can be approximated by adding projected sea level rise to current storm water level estimates. NPCC projects potential sea level rise ranging up to 21 and 39 inches in the "middle" scenario range by the 2050s and 2080s, respectively, and as high as 30 and 58 inches in the "high" scenario by the 2050s and 2080s, respectively. Note that the "high" scenario is not the highest predicted range, and that additional more severe scenarios are possible, associated with more extreme climate change effects that are possible but not yet understood well enough to be incorporated into projections of probable sea level rise. NPCC will continue to update sea level rise projections in the future as better understanding of potential future conditions is attained, and the uncertainty in the ranges of possible scenarios will decrease as the target years grow closer.

COASTAL EROSION

Staten Island's South Shore was once buffered from wave action by a wide, shallow bathymetric shelf known as the "West Bank." Until the mid-19th century, oyster reefs and then leased oyster

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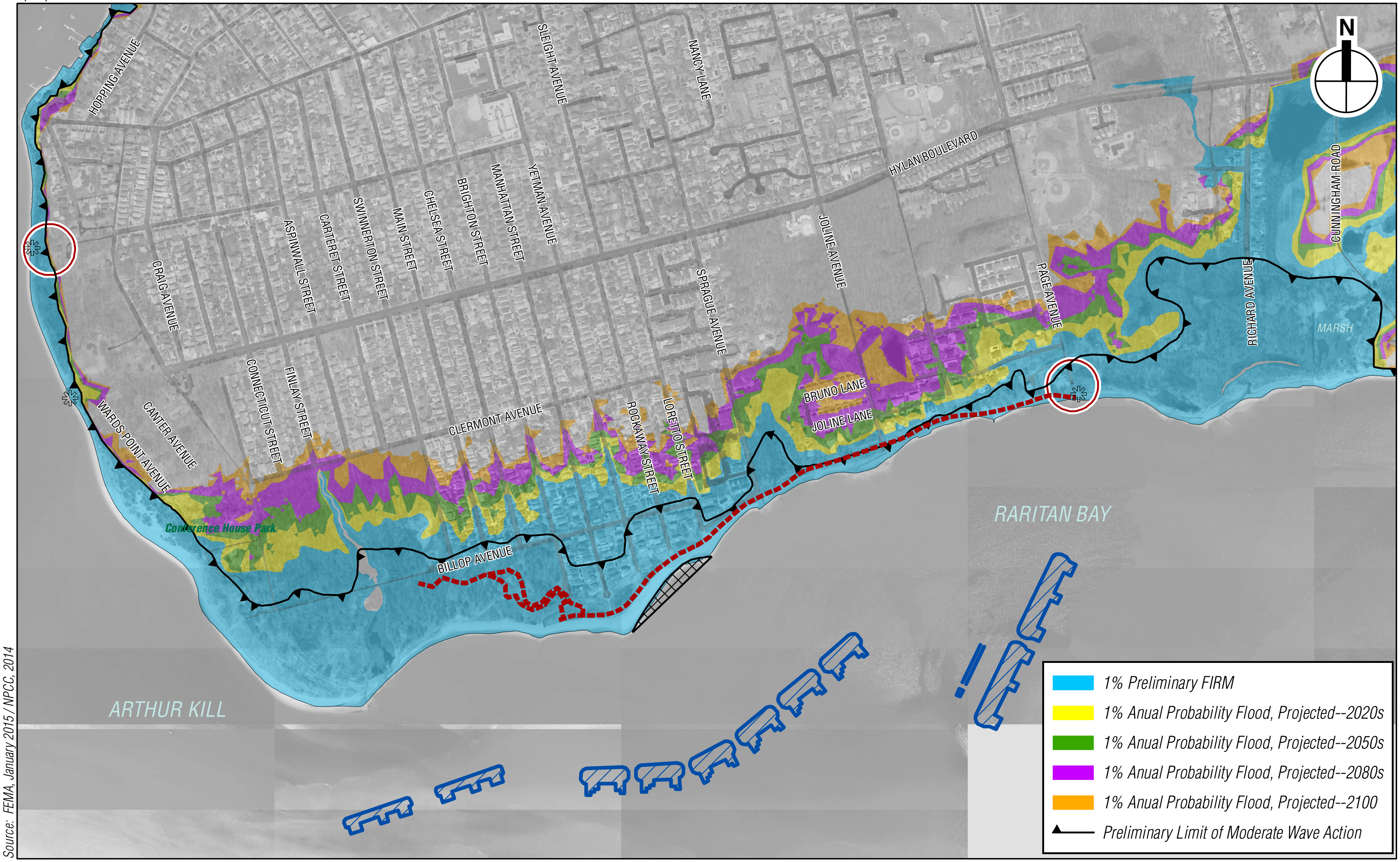
[10] Federal Emergency Management Agency (FEMA) released revised preliminary FIRMs on January 30, 2015 that precede the future publication of new, duly adopted, final FIRMs. The revised preliminary maps represent the Best Available Flood Hazard Data at this time. FEMA, and the Federal Government as a whole, requires communities to use the preliminary maps or the current effective maps, whichever is more restrictive, per the Federal Uniform Flood Risk Reduction Standard for Sandy Rebuilding and the FEMA Best Available Data memo, both from 2013.

3/10/2017



Source: FEMA, January 2015 / NPCC, 2014

Proposed Breakwater Features
Proposed Shoreline Project Elements
Proposed Shoreline Restoration Area
Potential Location of Proposed Water Hub (exact location to be determined)
Potential Water Access
Proposed Floating Dock and Oyster Nursery
0 1,000 FEET

Projected Potential Future Flood Zones
Figure 15-1

Coastal and Social Resiliency Initiatives for Tottenville Shoreline

beds extended across the shallow waters of Raritan Bay, filtering water, enhancing the biodiversity and quality of the fisheries in the lower harbor and buffering the south shore from erosion-causing wave action. In the 19th and 20th centuries, changes in land use and populations drove widespread decline in water quality, habitat extents and beach widths across the bay, decreasing the quality of the Bay ecosystem and increasing coastal risk to inhabitants and assets along its shoreline. The project area has experienced dramatic net erosion between 1978 and 2012. The greatest historic erosion rates were seen in the southern part of the project area in Conference House Park, just north of Wards Point where the erosion rate was over 3 feet per year. In general, while some small areas showed accretion, and some areas eroded less, large parts of the shoreline within the project area were eroded at rates ranging from 1 foot to over 3 feet per year (from 1978 to 2012). Some areas of accretion were observed, usually updrift of shoreline structures such as groins or storm sewer outfalls, but higher rates of erosion were generally observed down-drift of such structures. Overall, beaches in the project area have experienced an annual net loss of sediment. Narrow beaches lead to less protection for on-shore assets from wave action and coastal erosion, as well as less space for residents and visitors to enjoy the shoreline experience, and access the shoreline and nearshore waters.

These processes would continue in the future under the No Action Alternative, and may increase due to sea level rise and changes in storm frequency and/or intensity. Numeric simulation of shoreline changes using a shoreline response numerical modeling system revealed that in the southwestern portions of the site (southwest 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 1.0 to 2.0 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. Northeast of Sprague Avenue, the general pattern of erosion and accretion appear to remain the same, though rates of change simulated are slightly lower in the future than those historically observed.

These erosion rates, combined with projected sea level rise, could eliminate some beach sections and leave others completely inaccessible at high tide, reducing the protective beach berm which is the first line of defense against erosion and waves, and limit public access.

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

Alternative 2 would introduce both the Breakwaters and Shoreline Projects, as described in Chapter 1, “Purpose and Need and Alternatives.” The following sections describe the effect of Alternative 2 on potential severe storm conditions and coastal erosion under projected future climate conditions as sea level continues to rise.

SEVERE STORM CONDITIONS

Alternative 2 would provide severe storm wave risk reduction, particularly in the at-risk location between Brighton Street and Sprague Avenue where residential uses are located near the shoreline. While each component (in-water breakwaters and on-shore measures) would reduce wave height on its own, as described in detail below for Alternatives 3 and 4, the combined benefit of both components would be larger than either component on its own. Although specific projections of the combined effect are not yet available, as described below for the breakwaters, substantial wave height reduction would be achieved reducing the potential impact of waves during severe storms at least up to the “100-year” level including future conditions accounting for sea level rise of up to 30 inches, which may occur sometime between the 2050s and the 2080s. Further design refinement of the breakwaters to optimize the net storm wave reduction benefits provided by the two combined projects would be carefully coordinated in future phases of design and may impact the final design, particularly the selection of breakwater crest elevations. The breakwaters would attenuate waves with more than 30 inches of sea level rise, but the attenuation would be less. 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 and at a minimum would need to consider the following:

- Results of regular monitoring of wave attenuation and shoreline resilience being achieved by the Living Breakwaters and Shoreline Project working in tandem, as will be required by NYSDEC and USACE as a permit condition;
- Potential impacts to sediment transport and other secondary impacts to the shoreline that would have the potential to result from modifications made to the breakwater system; and
- Potential direct and indirect impacts to aquatic biota associated with habitat loss and modification that would result from the expansion of the breakwater footprint that would be required to raise the heights of the breakwater structures.

In addition, the Water Hub would be designed to be resilient to potential future severe storm conditions including higher future flood elevations. The Water Hub building would be either elevated at least 3 feet above the current Base Flood Elevation at Potential Location 1, which would protect the facility from flooding at least through the 2060s and possibly through 2100 (based on the above NPCC projections), or would be located outside of the potential future flood hazard area, well above any current or future potential flood elevations, at Potential Location 2.

COASTAL EROSION

Alternative 2 would provide substantial protection against shoreline erosion.

The breakwaters system is designed to reduce or reverse the long-term historic erosion observed across the site, and to encourage shoreline growth, or accretion, where the beach is most narrow and where erosion risk threatens to increase the exposure of vulnerable assets to erosion and limit future access to the beach. The project is also designed to reverse the pattern of historic land loss, promoting the stabilization or accretion of beach in areas of the greatest observed historic land loss. As there is a limited amount of sediment in the system, it is not feasible to grow the shoreline throughout the project area. The project aims to minimize the potential for down-drift erosion. Therefore, the focus for beach accretion is targeted at these priority zones while ensuring the beach is stabilized in other areas.

Beach accretion will have the most benefit between Brighton Street and Sprague Avenue where the beach width is currently narrow, subject to erosion, and the proposed Shoreline Project may encroach further onto the beach. The project includes a targeted area of shoreline restoration along approximately 806 feet of shoreline between Manhattan Street and Loretto Street. This one-time shoreline restoration would approximate the historic 1978 shoreline position, augment the accretion potential that can be provided by the breakwaters to add sediment to the overall system, and generally enhance the overall beach growth potential of the project. This would also serve to reduce the risk of the proposed hybrid dune from eroding beginning at the outset of the project. The shoreline at this location would change somewhat over time, but the breakwater system is intended to hold the newly established shoreline, generating a net increase in beach width from the current condition. Much of the beach north of this stretch within the project area is also characterized as narrow, and additional beach width, generated through accretion over time, will improve public access and provide additional wave attenuation and erosion protection for onshore structures and natural features.

At the western tip of the project area near Wards Point, the breakwaters will help hold sand in the system and reduce sand migration into the Federal Navigation Channel. In other areas of the project site, the goals of the project are to maintain the existing shoreline by preventing or reducing the ongoing erosion, while minimizing the potential for down-drift erosion.

Shoreline modeling completed to date has indicated that achieving a good balance of these various goals is possible and practicable. Current modeling of the effectiveness of the proposed breakwaters system alone estimated that over a 20-year timeframe, including potential sea level rise of up to 30 inches, the beach adjacent to the shoreline protection elements could grow while still maintaining the shoreline within other parts of the project area. The results are greatly improved with the inclusion of the targeted shoreline restoration. The inclusion of the Shoreline Project would not reduce this effectiveness. The reduction in coastal erosion at sea-level rise greater than 30 inches would still occur but would be somewhat less. Implementation of a Monitoring Plan and Adaptive Management Plan would ensure that the potential effectiveness of the project would be monitored and managed in the future.

In addition, the Shoreline Project has been designed to maintain its structure during severe storms of up to the “100-year” level including 30 inches of sea level rise (likely to occur sometime between the 2050s and 2080s). Under those conditions, the rock-core of the hybrid dune, the eco-revetment and the rip-rap path would create an inland limit to erosion, and coastal erosion landward of the structures themselves would not occur.

15.3.3 ALTERNATIVE 3—BREAKWATERS WITHOUT SHORELINE PROTECTION SYSTEM

Alternative 3 would introduce the Breakwaters Project as described in Chapter 1, “Purpose and Need and Alternatives.” The following sections describe the effect of Alternative 3 on potential severe storm conditions and coastal erosion under projected future climate conditions as sea level continues to rise.

SEVERE STORM CONDITIONS

The breakwaters system is designed to reduce wave heights and energy within the project area where buildings and infrastructure vulnerabilities to storm wave action have been identified. For the 30 percent design, a crest elevation of 14 NAVD88 was selected as the design crest elevation so as to effectively prevent transmission of waves greater than three feet in a storm event up to the “100-year” event with 30 inches of sea level rise. According to the above mentioned NPCC projections, 30 inches of sea level rise may occur as early as 2050, and is more likely to occur by the 2080s.

Although the breakwaters would perform as a system to attenuate waves, in general, the eastern and central breakwater segments would be aligned to attenuate easterly and southeasterly waves (the predominant storm wave direction) and thus are designed with a crest elevation of 14 NAVD88. The southwestern breakwater segments would not need to be designed to attenuate storm waves and thus have been designed with a lower crest elevation of 5 feet NAVD88 (see **Figure 15-1**).

The breakwaters system would provide effective wave attenuation for “100-year” storm waves. Modeling of select wave conditions for 30 percent design show the breakwaters would be capable of reducing “100-year” wave heights by 50 percent or more which will support the goal of reducing storm wave exposure to the structures (e.g., homes) between Brighton Street and Sprague Avenue—the area where vulnerable buildings and infrastructure are exposed to storm wave action (and potentially reduce the limits of the FEMA V Zone and LiMWA, subject to FEMA's review and approval). The breakwaters would attenuate waves with more than 30 inches of sea level rise, but the attenuation would be less. 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.

Note that the intended goal of the breakwaters system does not include flood protection and would not affect flooding levels or the areas affected by potential flooding.

In addition, as described above for Alternative 2, the Water Hub would be either designed to be resilient to potential future severe storm conditions including higher future flood elevations at Potential Location 1, or located outside of the potential future flood hazard area, well above any current or future potential flood elevations at Potential Location 2.

COASTAL EROSION

As described above for Alternative 2, the breakwaters system on its own would provide substantial protection against shoreline erosion. The breakwaters system is designed to reduce or reverse the long-term historic erosion observed across the site, and to encourage shoreline growth where the beach is most narrow and where the exposure of vulnerable assets to erosion is likely to increase and erosion is likely to limit future access to the beach. The project is also designed to reverse the pattern of historic land loss, promoting the stabilization or accretion of beach in areas of the greatest observed historic land loss. The reduction in coastal erosion at sea-level rise greater than 30 inches would still occur but would be somewhat less. Implementation of a Monitoring Plan and Adaptive Management Plan would ensure that the potential effectiveness of the project would be monitored and managed in the future.

15.3.4 ALTERNATIVE 4—SHORELINE PROTECTION SYSTEM WITHOUT BREAKWATERS

Alternative 4 would introduce the Shoreline Project, as described in Chapter 1, "Purpose and Need and Alternatives." The following sections describe the effect of Alternative 4 on potential severe storm conditions and coastal erosion under projected future climate conditions as sea level continues to rise.

SEVERE STORM CONDITIONS

The proposed raised edge component of the Shoreline Project (revetment and trail) is projected to reduce wave heights by approximately 5 to 10 percent 30 feet inland of the raised edge during the "100-year" and "50-year" severe storm events and by approximately 20 to 35 percent for the "25-year" and "10-year" events when including future sea level rise of 30 inches.

For the more frequent "10-year" and "25-year" events with 30 inches of sea level rise, the water level was projected to be intersected by the proposed earthen berm and eco-revetment indicating that these structures would greatly reduce wave heights during these events. The earthen berm was projected to reduce wave heights by approximately 10 and 15 percent for the "100-year" and "50-year" events, respectively, and the eco-revetment was projected to reduce wave heights by approximately 25 percent for both the "100-year" and "50-year" events. Due to its higher crest elevation, the proposed hybrid dune is projected to reduce wave height during the "100-year" event with 30 inches of sea level rise by approximately 45 percent. The water level would be intersected by the hybrid dune during the "50-year", "25-year", and "10-year" events, indicating that the hybrid dune would greatly reduce wave heights during these events. Note that the hybrid dune's reduction percentage assumes a fully intact dune. As sand erodes from the hybrid dune, the crest elevation will be decreased by up to 1.5 feet (to the top of the rock core), and the reduction percentage in that condition would be similar to that of the proposed eco-revetment.

While the Shoreline Project is not designed to avoid flooding caused by severe storms, it will 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 project. While the risk reduction measures would be porous in nature, seepage through the system (earthen berm, hybrid dune and eco-revetment) is likely to be slowed and of lower volume than with free flowing water entering the land without the project.

While the Shoreline Project would address the impacts of coastal flooding, during extreme surge events, stormwater outfalls along the coastline may experience backflow inundation leading to flooding of inland catch basins. Backflow flooding along the shoreline would be experienced with or without the Shoreline Project.

COASTAL EROSION

The shoreline protection system has been designed to maintain its structure during severe storms of up to the "100-year" level including 30 inches of sea level rise (likely to occur sometime between the 2050s and 2080s). Under those conditions, coastal erosion landward of the structures themselves would not occur.

15.4 MINIMIZATION AND MITIGATION OF IMPACTS

The proposed alternatives would not introduce any adverse impacts in terms of climate resilience, and Alternatives 2, 3, and 4 would improve the resilience of the project area to coastal erosion and the impact of waves during severe coastal storm events. Therefore, no mitigation is required or proposed. ✷