US Army Corps of Engineers

Photo credit: U.S. Coast Guard Petty Officer 3rd Class Alexandria Preston.

CHARLESTON PENINSULA, SOUTH CAROLINA

COASTAL STORM RISK MANAGEMENT STUDY FINAL FEASIBILITY REPORT / ENVIRONMENTAL IMPACT STATEMENT

APRIL 2022

Charleston Peninsula Coastal Storm Risk Management Study
Final Integrated Feasibility Report / Environmental Impact Statement

Lead Agency: U.S. Department of the Army, Corps of Engineers – Charleston District
Cooperating Agencies: National Marine Fisheries Service; National Park Service; U.S. Coast Guard; U.S. Environmental Protection Agency; U.S. Fish and Wildlife Service; South Carolina Department of Archives and History; South Carolina Department of Health & Environmental Control; South Carolina Department of Natural Resources

Title: Charleston Peninsula Coastal Storm Risk Management Study

State Involved: South Carolina

Abstract: This final integrated Feasibility Report and Environmental Impact Statement (FR/EIS) documents the planning process and presents the findings of the study. This final FR/EIS meets the environmental review and disclosure requirements of the National Environmental Policy Act. The City of Charleston is the non-federal sponsor for this feasibility study.

The final FR/EIS identifies the No Action/Future Without Project Alternative and Alternative 2 as the final array of alternatives. Alternative 2 was developed though the USACE feasibility planning process and included scoping input and expertise from USACE, City of Charleston, cooperating agencies, and the public. Alternative 2 is comprised of a storm surge wall along the perimeter of the Charleston Peninsula, permanent and temporary pump stations, nonstructural measures, and natural and nature-based features. The FR/EIS evaluates effects to the full spectrum of cultural, social, and biological resources. The FR/EIS also documents measures to avoid, offset, or minimize impacts to resources affected by the proposed action. At the completion of the Charleston Peninsula Coastal Storm Risk Management Study, and upon approval by the Chief of Engineers of the United States Army, a plan would be recommended to Congress for authorization and funding. If authorized and/or funded by Congress, subsequent phases of the project would include: Preconstruction Engineering and Design (PED); Construction; and, Operations, Maintenance, Repair, Replacement and Rehabilitation.

For additional information, contact:
US Army Corps of Engineers
Attn: Charleston Peninsula
69A Hagood Avenue
Charleston, SC 29403
Telephone: (843) 329-8017
Email: *Chs-Peninsula-Study@usace.army.mil*

Visit the project website: https://www.sac.usace.army.mil/Missions/Civil-Works/Supplemental-Funding/Charleston-Peninsula-Study/

For additional copies of this document:
Internet – The FR/ EIS is on the Internet at: https://www.sac.usace.army.mil/Missions/Civil-Works/Supplemental-Funding/Charleston-Peninsula-Study/.

Due to the size of the document, only a limited number of hard copies will be available for pick up upon request.

Executive Summary

The Charleston Peninsula Coastal Storm Risk Management Study was initiated in October 2018 to evaluate actions that would reduce risk to the Charleston Peninsula from coastal storm surge inundation. This integrated Feasibility Report and Environmental Impact Statement (FR/EIS) documents the planning process and presents the findings of the feasibility study. This FR/EIS and the associated process also meets the environmental review, disclosure, and public involvement requirements of the National Environmental Policy Act (NEPA). The City of Charleston is the non-federal sponsor for this study, and the U.S. Army Corps of Engineers (USACE) is the lead agency under NEPA.

At the completion of this feasibility study, and upon approval by the USACE Chief of Engineers, the recommended plan will be submitted to Congress for authorization and funding. Subsequent phases of the project would include Preconstruction Engineering and Design (PED), Construction, and Operations and Maintenance as shown in Figure ES-1. PED may commence upon approval by the Chief of Engineers and the availability of funds for that purpose; however, construction may not commence without authorization and appropriate funding from Congress.

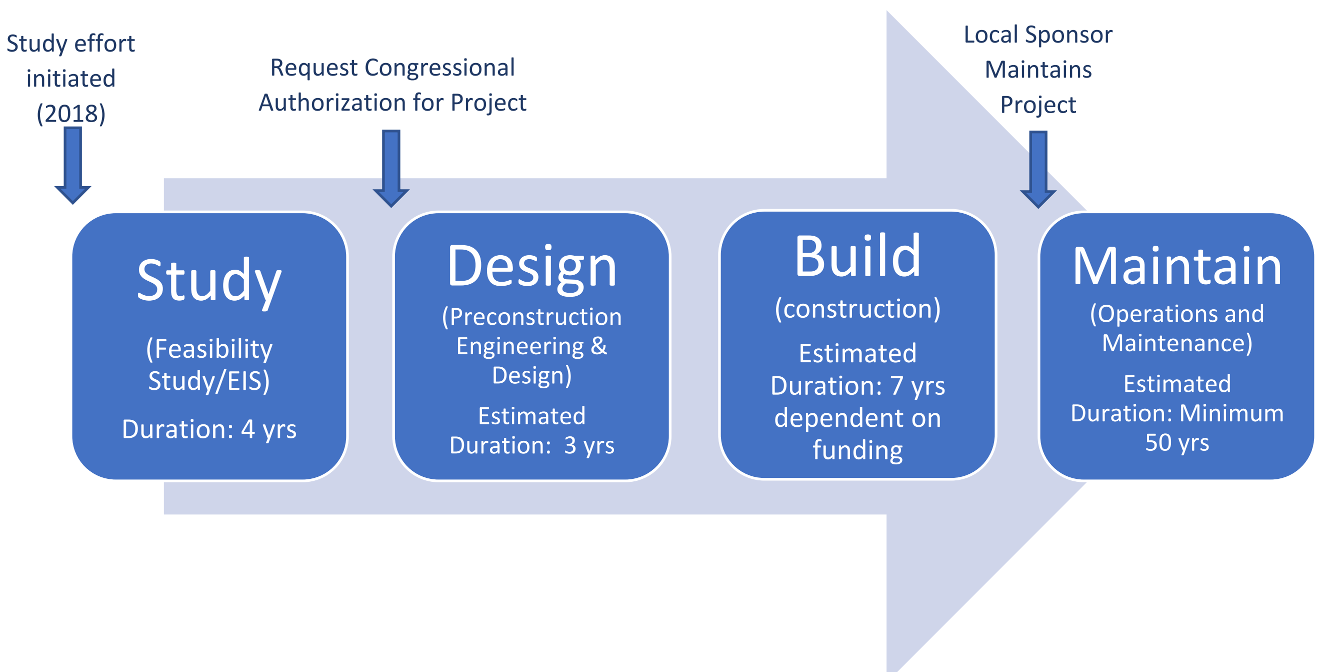

Figure ES 1. Phases of a proposed project to reduce coastal storm risk to the Charleston Peninsula.

ES.1 Purpose and Need

The Charleston Peninsula is a highly urbanized, relatively flat community with nearly all lands lower than elevation 20 feet North American Vertical Datum of 1988 (NAVD88). It is the historic core and urban center of the City of Charleston. The low elevations and tidal connections to the Ashley and Cooper Rivers and Charleston Harbor place a significant percentage of the Charleston Peninsula at risk of flooding from hurricanes and other coastal storms. While the Charleston Peninsula also experiences flooding from tides and rainfall unrelated to storm events, this study was authorized to investigate measures to reduce the risk of coastal storm surge. Tidal fluctuations, sea level rise, and precipitation are taken into account as they contribute to storm surge risk. The timing of a coastal storm event is key to the severity of potential damages. A major coastal storm making landfall at or near Charleston at high tide could be catastrophic for the community. But even coastal storms that arrive at low tide or pass by the Charleston Peninsula can have severe storm surge impacts on the community. Storm surge inundation presents a substantial risk of economic damage in the form of destruction of or physical harm to homes, businesses, and industry; impairment of access to critical facilities, emergency services, and evacuation routes; and places people at risk for loss of life and declines in public health. Exacerbating the vulnerability of the peninsula to storm surge flooding is the phenomenon of relative sea level rise (RSLR), which is the combination of rising ocean levels and land subsidence. Without a plan to enhance the peninsula's resilience to coastal storm surge inundation, the peninsula's vulnerability is expected to increase over time unabated due to a combination of RSLR and climate change. The purpose of this feasibility study for coastal storm risk management is to identify the optimal structural and non-structural solution set to reduce risk to human health and safety, to reduce the risk of economic damages, and increase resilience on the Charleston Peninsula.

ES.2 USACE Planning Process and NEPA Public Involvement

The planning and NEPA process for this study has been extensive and includes: planning charettes; release of a draft FR/EA in April 2020; EIS scoping in spring 2021; release of a draft FR/EIS in September 2021; and, numerous meetings and public outreach efforts. Commencing in the fall of 2018, the study team held two planning charrettes, or kickoff meetings to initiate the USACE planning process. The City of Charleston and key agencies and stakeholders participated in the charettes and collaborated to identify study objectives and formulate an initial array of conceptual alternatives. In accordance with the study authority, the study team over time established the following objectives to guide the planning process:

- Reduce risk to human health, safety, and emergency access from coastal storm surge inundation on the Charleston Peninsula over the 50-year period of analysis of 2032 – 2082.
- Reduce economic damages resulting from and increase resilience to coastal storm surge inundation on the Charleston Peninsula over the 50-year period of analysis of 2032 – 2082.

The study team identified and evaluated the effectiveness, constructability, cost efficiency, and policy compliance of more than 25 coastal storm risk reduction measures. Using the measures that were retained for further consideration, the study team developed an initial array of four action alternatives to meet study objectives (see Chapter 3 of the main report). Those four action alternatives were: 1) Perimeter Protection, 2) Perimeter Protection + Nonstructural, 3) Perimeter Protection + Nonstructural + Wave Attenuating Structure, and 4) Nonstructural Only.

Originally, the study team's iterative evaluation and comparison procedures resulted in the identification of Alternative 3 (Perimeter Protection + Nonstructural + Wave Attenuating Structure) as the Tentatively Selected Plan (TSP). In April 2020, a draft integrated Feasibility Report and Environmental Assessment (FR/EA) and draft Finding of No Significant Impact (mitigated) that described the process of identifying Alternative 3 as the TSP was released to the public for review and comment. In light of the importance of the proposed action and the ongoing pandemic, the draft FR/EA went out for an expanded 60-day comment period. After further agency analysis, review of substantive comments received on the draft FR/EA, and continued refinement of the study, USACE concluded that an Environmental Impact Statement (EIS) with a Record of Decision would best fulfill NEPA compliance for this study.

A Notice of Intent (NOI) to prepare an EIS for this study was published in the *Federal Register* on March 23, 2021 (86 Federal Register [FR] 15470) to begin the EIS scoping process. Among other things, the NOI informed the public that comments received in response to the draft FR/EA would be considered as part of the EIS scoping process and did not need be resubmitted. Additional announcements were made via press release and social media. A virtual public scoping meeting was held on March 30, 2021. The scoping comment period ended April 22, 2021. USACE received approximately 125 substantive comments during the scoping period.

Between the release of the draft FR/EA and the release of the draft FR/EIS, the identified TSP changed. As a result of further analysis, it was determined that the proposed wave attenuation structure (breakwater) was not justified. As a result, Alternative 2 (Perimeter Protection + Nonstructural) was identified in the draft FR/EIS as the TSP. The Notice of Availability for public review of the draft FR/EIS was published in the Federal register on September 10, 2021 (86 FR 50713). USACE hosted one virtual public meeting and nine outreach meetings during the public comment period. The 45-day review period ended October 25, 2021. USACE received approximately 209 substantive comments and has revised the final FR/EIS and/or provided a comment response, accordingly. After review of substantive comments received on the draft FR/EIS, and with consideration of agency technical reviews and an independent external peer review, the TSP was endorsed by USACE as the Recommended Plan (RP). Further refinements and optimization efforts are described in this report.

ES.3 How the Plan Has Changed

After the original TSP was presented in the April 2020 draft FR/EA, multiple refinements and optimizations were considered and evaluated to enhance performance and reduce costs and environmental impacts of the TSP. Most significantly and as previously noted, the plan no longer includes the wave attenuating structure. This feature was dropped from the plan because further analysis revealed that it did not provide inundation reduction benefits that exceeded its cost. The change from Alternative 3 (Perimeter Protection + Nonstructural + Wave Attenuating Structure) to Alternative 2 (Perimeter Protection + Nonstructural) as the TSP was presented in the September 2021 draft FR/EIS.

Another significant change included moving substantial portions of the proposed storm surge wall from the marsh on to the land. This change drastically reduced the cost of construction because it is three to four times more expensive to build a wall in marsh than it is on land. Realigning the wall on land also drastically reduced adverse wetland impacts from 111 acres estimated in the April 2020 draft FR/EA to approximately 35 acres in the September 2021 draft FR/EIS. Minimizing impacts to the marsh is preferred for the health of the ecosystem but doing so has also lowered compensatory mitigation costs.

The September 2021 draft FR/EIS incorporated aesthetic mitigation costs into the overall project cost estimate. The study team in collaboration with the City of Charleston, the Historical Charleston Foundation, and others performed a Visual Resources Assessment Procedure (VRAP). The team used the results of the assessment to develop a rough order of magnitude cost estimate (approximately $53M) because detailed project designs are not developed until the PED phase. USACE and the City have executed a Memorandum of Understanding outlining the framework for aesthetic resources assessment during the PED phase, including mitigation measures and cost-sharing considerations.

In the September 2021 draft FR/EIS, oyster reef-based living shoreline sills were presented as a feature of the TSP based on the qualitative benefits of coastal storm risk reduction services they provide. In this final FR/EIS, oyster reef-based living shoreline sills remain in the plan at the same estimated placements and quantities as previously described, but to comply with USACE policy, they have been recategorized as an environmental impact minimization measure rather than a coastal storm risk reduction feature. During the PED phase, additional consideration will be given to living shorelines or other natural and nature-based features (NNBF), either as project features if quantitative analyses demonstrate coastal storm risk reduction benefits exceeding their cost, or as mitigation where justified. Here, as elsewhere in the plan, the non-federal sponsor is responsible for 100% of costs greater than the National Economic Development plan.

The alignment of the storm surge wall along the South Carolina Ports Authority (SCPA) property has changed since the September 2021 draft FR/EIS. Following the release of the draft FR/EIS, the SCPA engaged with the study team to optimize a segment of the storm surge wall that previously paralleled portions of East Bay and Washington Streets. The storm surge wall was moved to the eastern edge of the property, closer to the shoreline. The move eliminates condemnation of private properties, provides storm surge risk reduction for any cargo stored at the port terminal, and moves the wall further from historic structures. This realignment results in lower implementation costs and higher coastal storm risk reduction benefits.

The current BCR reflects the changes described above, and the development of new and better information over time. Principal cost reductions from the original TSP have included the elimination of the breakwater (approximately $300 million), as well as the optimization of the wall alignment from salt marsh to high ground for substantial portions of the storm surge wall (reducing both construction costs and wetlands mitigation costs). The primary factors leading to an increase in the identified benefits have included: a reevaluation of storm frequency statistics following technical review of the draft 2020 FR/EA which enabled the study team to identify with greater precision the water levels which would be paired with a storm's severity so that the calculation of damages was more refined; updating price levels from 2019 to 2021; and, the addition of nonstructural benefits. These cost reductions and increased project benefits resulted in a higher benefit-to-cost ratio.

ES.4 The Recommended Plan

- **Storm surge wall along the perimeter of the Peninsula**: The storm surge wall would be constructed along the perimeter of the peninsula to reduce damages from storm surge inundation. On land, the storm surge wall would be a T-wall with traditional concrete stem walls and pile supported bases. In the marsh, the storm surge wall would be a combination wall (combo-wall), which consists of continuous vertical piles on the storm surge side and battered pipe piles on the other side, connected by a concrete cap. The length of the proposed wall is approximately 8.7 miles (7.2 miles of T-wall and 1.5 miles of combo-wall). It would be strategically aligned to minimize impacts to existing wetland habitat, cultural and aesthetic resources, and private property while allowing continued operation of all port facilities, marinas, and the Coast Guard Station. The wall would tie into high ground as appropriate, including the shoreline at the Citadel and the existing Battery Wall. Due to its age and uncertainty about the integrity of the structure, the High Battery would be reconstructed to meet USACE construction standards and raised to provide a consistent level of performance. The proposed elevation of the storm surge wall is 12 feet North American Vertical Datum of 1988 (NAVD88).

  The alignment of the wall displayed in Figure ES-2 has been optimized to minimize costs and impacts to the study area. Changes to the alignment may occur during the PED phase, as appropriate. Drivers of the potential changes include, but are not limited to, new developments in technology or construction methodologies, results of additional engineering analyses, unforeseen cultural and historic resources, the presence of buried utilities not discovered during feasibility, and real estate acquisition challenges. Also, during the PED phase, changes will occur for the purpose of aesthetic and cultural mitigation that could not be identified during the feasibility study because they inherently relate to detailed designs.

  The storm surge wall would include multiple pedestrian, vehicle, railroad, and storm (tidal flow) gates. Typically, the gates would remain open, and gate closure procedures would be initiated based on storm surge predictions from an authoritative source. When major flooding is expected, storm gates would be closed at low tide, to keep the rising tide levels from taking storage needed for associated rainfall. For the vehicular, pedestrian, and railroad gate closings, timing of the closure would be dependent on evacuation needs and the anticipated arrival of rising water levels that close transportation arteries. Gate operation procedures would be refined during the PED phase with input from the City of Charleston, emergency management experts, and weather experts. Specific responsibilities of the non-Federal sponsor regarding execution of work will be described in the Project Partnership Agreement, a legally binding document between the Federal government and the non-Federal sponsor, as well as the operations, maintenance, repair, replacement, and rehabilitation (OMRR&R) manual.

Accompanying the storm surge wall will be the following minimization or mitigation features:

- **Interior Drainage Facilities:** Five temporary and five permanent, small to medium hydraulic pump stations to mitigate interior flooding caused by the storm surge wall.
- **Natural and Nature Based Features**: Approximately 9,300 feet of oyster reef-based living shoreline sills would be constructed as a minimization measure to reduce impacts to natural shorelines and other resources seaward of the wall. The living shoreline sills would reduce marsh scour at the proposed storm surge wall and reduce erosion of the shoreline edge. The living shorelines would also provide other environmental benefits. The reef-based living shoreline materials/design would be determined during the PED phase.

- **Nonstructural measures:** In residential areas where construction of the storm surge wall would be impracticable because of issues with implementability and the risk of associated adverse impacts, nonstructural measures such as elevations and floodproofing could be applied. Neighborhoods that have been identified for nonstructural treatment include Lowndes Point on the north-western edge of the peninsula, Bridgeview Village on the north-east edge of the peninsula, and the Rosemont community in the Neck Area of the peninsula. Approximately 100 structures have been identified for nonstructural treatment and the minimum proposed design elevation is 12 ft NAVD88. Wet floodproofing measures, such as elevation of utilities, would be applied in the Lowndes Point area because residential structures are already elevated above 12 feet NAVD88. Dry floodproofing measures would be applied to Bridgeview Village, and floodproofing or elevation measures would be applied to the Rosemont neighborhood considering the nature of construction materials and techniques used in these communities. Higher design elevations will be considered during the PED phase because the nonstructural measures are not limited by the same constraints as the storm surge wall. Nonstructural measures will, incidentally, provide risk reduction for structures due to sources of flooding other than coastal storm surge.

Figure ES 2. The National Economic Development and Recommended Plan.
Official mapping product of the Management Support Branch, Charleston District, USACE.

The RP would improve the resilience of the Charleston Peninsula by reducing the risk of inevitable storm surge inundation events, and by anticipating and adapting to changing conditions associated with sea level rise and climate change. After implementation of the RP, the Charleston Peninsula would be able to withstand and recover from coastal storms more quickly. Increased resilience to coastal storm hazards means a reduction of economic damages and health/safety risk, an improved ability to maintain emergency access, and fewer disruptions to the daily life on the peninsula as the historic core and urban center of the City of Charleston.

ES.5 Performance of the Recommended Plan

A wall with top elevation 12ft NAVD88 would prevent stillwater overtopping for a 0.7% annual exceedance probability (AEP) surge event in 2032 and a 1% AEP event in 2082, assuming the USACE intermediate rate of sea level rise. Engineer Regulation 1105-2-101 requires that project performance is also described with a high degree of assurance. At the upper 90% confidence limit, the 12ft NAVD88 wall would prevent stillwater overtopping for a 2.8% AEP event in 2032 and a 3.6% AEP event in 2082, assuming an intermediate rate of sea level rise. A design elevation of 12ft NAVD88 for nonstructural measures would have the same level of performance as the storm surge wall. Figure ES-3 displays stillwater elevations assuming an intermediate rate of sea level rise for both the average AEP and the 90% confidence AEP in 2032, when the project is first estimated to be complete. Figure ES-4 displays the same information for the year 2082, which is the end of the period of analysis for this study.

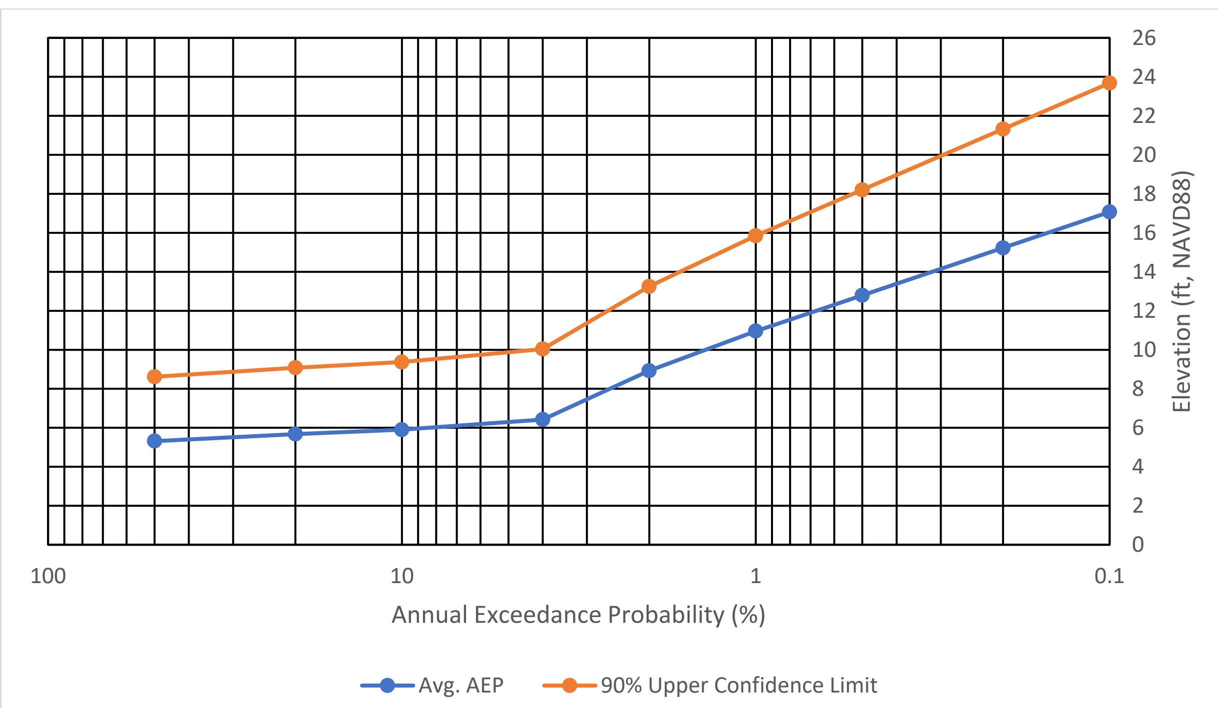

Figure ES 3. Stillwater elevations for average (most likely) annual exceedance probabilities and upper 90% confidence limits in the year 2032 assuming an intermediate rate of sea level rise.

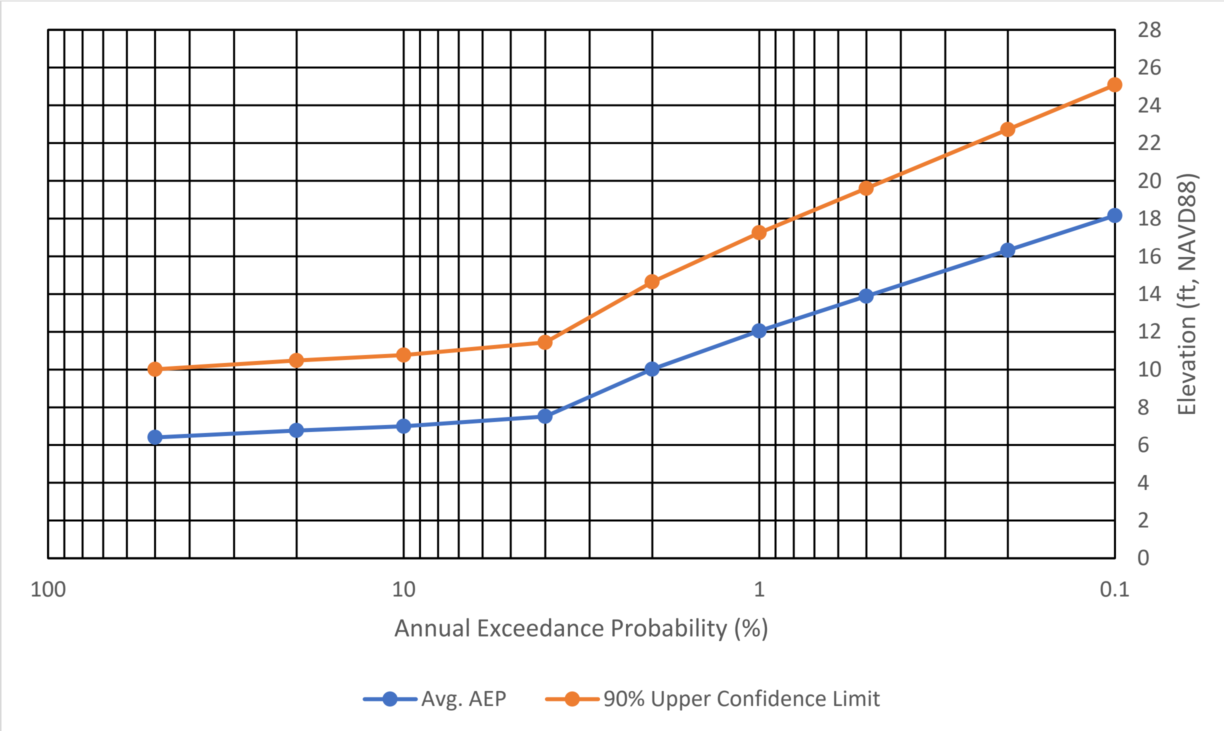

Figure ES 4. Stillwater elevations for average (most likely) annual exceedance probabilities and upper 90% confidence limit in the year 2082 assuming an intermediate rate of sea level rise.

Figures ES-5 and ES-6 depict and compare stillwater elevations of the with and without-project conditions. In the year 2082, assuming a high rate of sea level rise, a 20% AEP event would result in 9 ft NAVD88 storm surge inundation on the Charleston Peninsula. Without a project to limit storm surge inundation, economic activity, critical facilities, emergency access roads, historic structures, and archaeological sites would be damaged during the coastal storm event. With implementation of Alternative 2, the wall would block surge from inundating the peninsula and recurring damages from high frequency storms would be reduced.

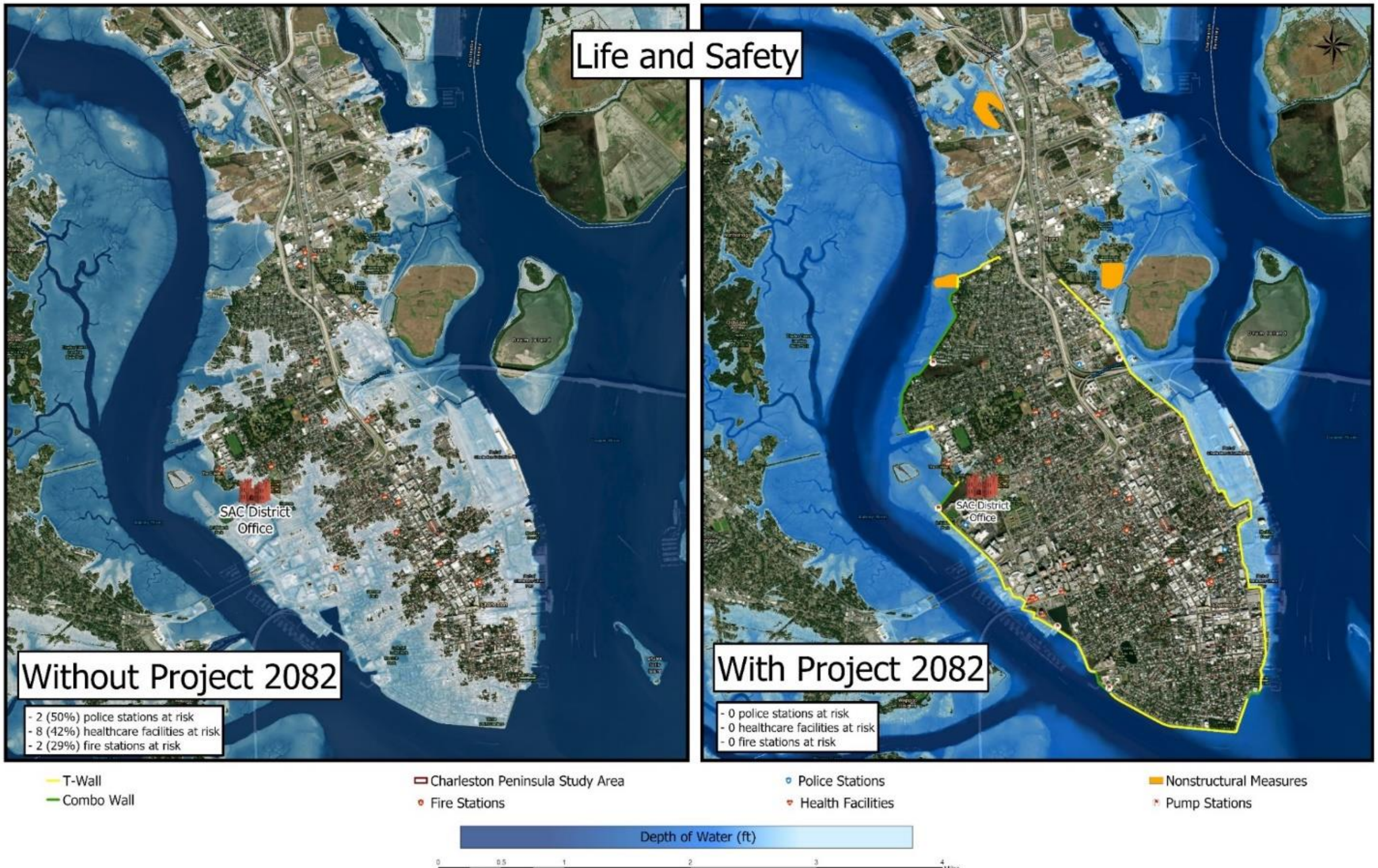

Figure ES 5. Comparison of a 20% AEP coastal storm event in 2082, assuming a high rate of SLR. With implementation of Alternative 2, damages to critical facilities and interruptions in emergency services would be limited and life safety risk would be reduced.

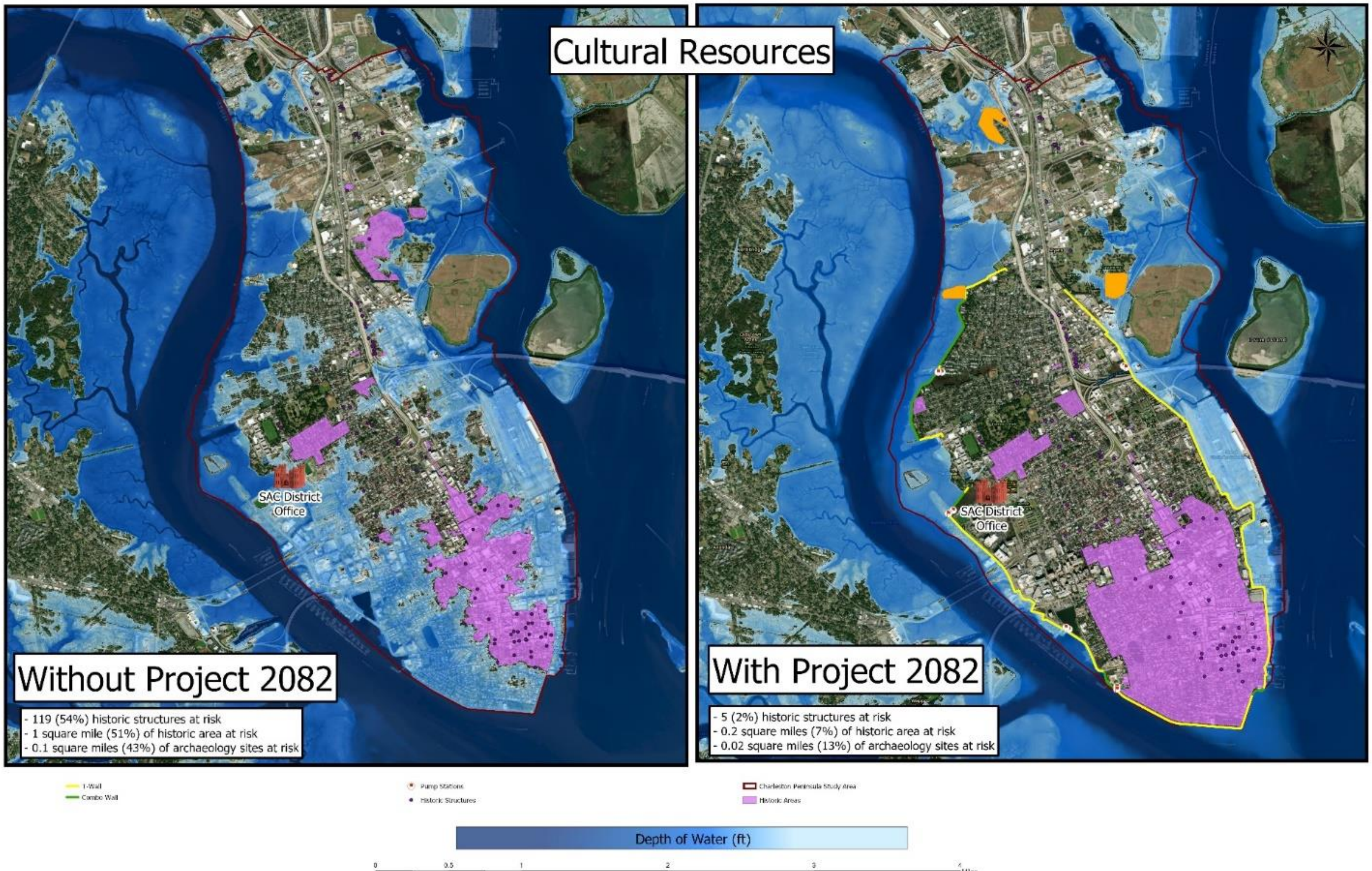

Figure ES 6. Comparison of a 20% AEP coastal storm event in 2082, assuming a high rate of SLR. With implementation of Alternative 2, damages to historic structures and cultural resources would be reduced.

ES.6 Costs and Benefits

As described in Section ES.3, study refinements resulted in lower implementation costs and higher inundation reduction benefits. The final feasibility level costs and benefits are displayed in Figure ES-1.

Table ES 1. Costs and Benefits of the Recommended Plan ($1,000).

Cost/Benefit Item	Recommended Plan
Investment Costs	–
Project First Cost	$1,133,000
Interest During Construction	$ 130,000
Total Investment Cost	$1,269,000
Average Annual Cost[1]	–
Average Annual First Cost	$42,500
Annual OMRR&R[2] Cost	$ 3,000
Average Annual Costs	$45,500
Benefits[1]	–
Average Annualized Benefits	$493,000
Net Benefits	$447,500
BCR	10.8

[1]Costs are rounded in 2022 price levels, 2.25% discount rate, and a 50-year period of analysis.
[2]Operation, Maintenance, Repair, Replacement, and Rehabilitation.

ES.7 Cost Sharing

The estimated first cost of the RP is $1,132,096,000 (Table ES-2). The cost share apportionment is 65% Federal and 35% non-Federal, therefore the Federal portion of the estimated first cost is $735,862,000 and the non-Federal sponsor portion is $396,234,000 (Table ES-3). The non-Federal sponsor would provide all lands, easements, rights-of-way, relocations, and suitable borrow and disposal areas and would also assume responsibility for OMRR&R. The estimated average annual OMRR&R cost is $3,000,000. The non-Federal sponsor will continue to participate in and comply with applicable Federal floodplain management and flood insurance programs.

Table ES 2. First Costs of the Recommended Plan ($1,000).

MCACES Account[1]	Description	Total First Cost[2]
02	Relocations	$15,230
06	Fish & Wildlife Facilities	$27,633
11	Levees & Floodwalls	$645,311
13	Pumping Plant	$48,112
18	Cultural Resource Preservation	$87,821
19	Buildings, Grounds & Utilities	$55,130
	Construction Estimate Totals	$879,237
01	Lands and Damages	$130,209
30	Planning, Engineering & Design	$61,504
31	Construction Management	$61,504
	Total First Cost	**$1,132,096**

[2]Micro Computer-Aided Cost Engineering System, 2nd Generation (MII) is the software program and associated format used by USACE in developing cost estimates. Costs are divided into various categories identified as "accounts."
[1]Costs are in 2022 price levels.

Table ES 3. Preliminary Cost-Share Responsibilities for the Recommended Plan ($1,000).[1]

	Federal (65%)	Non-Federal (35%)	Total
Initial Project Cost	$735,862	$396,234	$1,132,096
LERRD Credit	-	$145,439	-
Cash Contribution	-	$250,795	-

[1]Costs are in 2022 price levels.

ES.8 Environmental Impacts and Mitigation

Approximately 555 acres of tidal creeks, mudflats, and saltmarshes remain around the perimeter of the peninsula. All of the tidal creeks and saltmarsh wetlands on the peninsula are considered Essential Fish Habitat (EFH), meaning that commercially and recreationally important fisheries depend on them for at least part of their life. Several threatened and endangered species could be found in and around the Charleston Harbor and the Cooper and Ashley Rivers including the West Indian manatee, Atlantic and shortnose sturgeon, several species of sea turtles, the American wood stork and the Eastern black rail. Parts of the Cooper River are designated Critical Habitat for Atlantic sturgeon. The study area is not located within the Coastal Barrier Resources System.

Localized adverse effects are anticipated for saltmarsh wetlands, EFH, and water quality at locations where the storm surge wall would be placed in the marsh. Through optimization of the plan, USACE has taken considerable steps to avoid adverse effects on wetlands and the species that depend on them. Potential adverse effects on wetlands and associated habitat have been reduced from an earlier alignment of the storm surge wall by 76 acres, from 111 to 35 acres.

Construction-related activities also have the potential to result in temporary adverse effects on natural resources. Multiple minimization measures are being proposed to reduce these effects. The remaining adverse effects on saltmarsh wetlands that cannot be avoided or minimized would be offset through compensatory wetland mitigation. A Draft Mitigation Plan has been prepared and is included as an appendix to this report.

Adverse effects are anticipated for the abundant historic and cultural resources within the study area which are protected by the National Historic Preservation Act (NHPA). These effects include potential acquisition, demolition, modification of historic structures; viewshed and sight line impacts to historic districts; and disturbance of terrestrial and submerged archaeological sites. As project designs are refined and surveys are conducted in the PED phase, effects to historic and cultural resources would continue to be minimized and avoided in some cases. Due to the lack of detailed project designs during the current feasibility stage, it will not be possible to conduct fieldwork to identify and evaluate cultural resources or to determine the effects of the RP on historic properties. Consistent with applicable law, USACE has executed a Programmatic Agreement (PA) involving NHPA consulting parties to defer final identification and evaluation of historic properties until the PED phase, when additional funding becomes available, and prior to construction. The PA will allow USACE to complete the necessary archaeological surveys during the follow-on PED phase, and for any additional inventories and mitigation to be completed after structural and non-structural measures have been clearly defined and sited. The executed PA is included as an appendix to this report, having been provided to the consulting parties for review and comment prior to execution (South Carolina State Historic Preservation Officer, National Park Service, Advisory Council on Historic Preservation, City of Charleston, Historic Charleston Foundation, Preservation Society of Charleston, and Catawba Indian Nation).

Adverse effects are anticipated for aesthetics and visual resources from the proposed plan since it would be permanent and visible on land and/or water. As described in section ES.3, effects to visual resources will continue to be assessed and mitigated during the PED phase consistent with the executed MOU to preserve the city's cultural and historic nature.

The study has also identified important beneficial effects on the human environment that would result from reducing storm surge flooding on the peninsula. Reducing the risk of storm surge flooding would have beneficial effects on human health and safety, emergency access, economic activity, floodplain management, compound flooding, historic and cultural resources, transportation, recreation, and land use. Living shorelines provide immediate beneficial effects on aquatic resources by creating habitat.

In summary, some of the adverse environmental effects assessed in this FR/EIS are considered to be minor, a few are negligible, and some would be significantly adverse. However, important avoidance and minimization measures are prioritized, and compensatory mitigation measures would be taken where appropriate. These measures are documented in the Record of Decision (ROD) that accompanies the final FR/EIS.

ES.9 Areas of Known or Expected Controversy

NEPA requires identification of issues of known controversy that have been raised in the scoping process and throughout the development of the study. The following issues were identified as a result of public scoping, stakeholder engagement, and environmental review.

Impacts to Cultural and Aesthetic Resources

The Charleston Peninsula is a scenic tourist destination with a high concentration of historic and cultural resources. The construction of a storm surge wall would change views of the water from land and conversely of the cityscape from the water. The assessment of effects and potential mitigation measures will continue into the PED phase, including by implementation of the PA for historic and cultural resources discussed above, and following of the MOU framework for aesthetic resources assessment.

Opportunity for Nature Based Solutions

Public input has conveyed a preference for NNBF or green solutions to address storm surge inundation as opposed or in addition to traditional structural solutions. Environmental conditions in the study area preclude many nature-based solutions such as beaches, dunes, barrier islands and most forest types since these features don’t naturally exist in the study area. Topographical or other physical constraints, such as existing development and the federal navigation channel, also preclude some features. Some nature-based features were identified as feasible in the study area; however, none could be shown to reasonably reduce coastal storm surge inundation. Oyster reef-based living shoreline sills remain in the plan as an environmental minimization measure.

Property Acquisition

In some cases, permanent property acquisition would be needed for project construction, operation, and maintenance. Efforts have been made to maximize the use of real property interests already within the public realm. Temporary construction easements would be required for construction staging and equipment access. Temporary restrictions on access to private property may also be necessary. Specific property acquisition requirements have not been identified at this time.

Construction-Related Effects

Some portions of the storm surge wall are adjacent to tourist and residential areas. Construction activities are likely to result in temporary construction-related effects, such as noise and road closures. Public access to historic sites or recreation areas may be temporarily limited in certain places. These effects are described, together with minimization measures to reduce adverse effects, in Chapter 6. For example, construction could be limited to daytime hours to reduce noise, and detours would be made available.

Table of Contents

List of Figures

CHAPTER 1 - Study Information

The Charleston Peninsula Coastal Storm Risk Management Study is a comprehensive investigation of coastal storm risk management problems and solutions on the Charleston Peninsula. The City of Charleston, the non-Federal sponsor, and the United States Army Corps of Engineers (USACE) signed a Feasibility Cost-Sharing Agreement on October 10, 2018, to initiate the study. USACE is the lead agency under the National Environmental Policy Act (NEPA) and the USACE Coastal Storm Risk Planning Center of Expertise provided technical review of the study.

In April 2020, a draft integrated Feasibility Report and Environmental Assessment (FR/EA) was published for public review and comment. The FR/EA identified a Tentatively Selected Plan (TSP) to reduce coastal storm risk for the Charleston Peninsula. Based on resource agency and public feedback and refinement of the TSP, USACE determined that a full Environmental Impact Statement was merited to adequately assess environmental impacts of the proposed project.

Pursuant to 33 CFR 230.13, this document is an integrated Feasibility Report and Environmental Impact Statement (FR/EIS). This integrated FR/EIS documents the planning process to address coastal storm risk for the Charleston Peninsula and meets the environmental review and disclosure requirements of NEPA. This FR/EIS includes the information and prescribed content necessary for a full and fair discussion of significant environmental impacts, and to inform decision makers and the public of the reasonable alternatives that would avoid or minimize adverse impacts or enhance the quality of the human environment according to 40 CFR 1502. Prescribed NEPA content is as follows: *Chapter 2 – Planning Considerations* of this document discusses the purpose and need for the proposed action, *Chapter 3 – Conceptual Measures and Alternatives* identifies the range of alternative solutions including the proposed action, *Chapter 4 – Affected Environment* describes the existing condition of the study area that could be affected by the alternatives, *Chapter 6 – Environmental Consequences* presents the environmental impacts of the proposed action, *Chapter 9 – Environmental Compliance and Commitments* addresses Federal environmental laws, implementing regulations, and executive orders potentially applicable to the proposed action, and *Chapter 11 – List of Preparers* presents the people who were primarily responsible for preparing the FR/EIS and/or appendices. USACE is exercising its discretion to employ the 1978 CEQ NEPA regulations to this ongoing NEPA process pursuant to CEQ's Update to the Regulations Implementing the Procedural Provisions of the National Environmental Policy Act, Final Rule, 85 FR 43304, at 43339-43340 (July 16, 2020).

The Charleston Peninsula Coastal Storm Risk Management Feasibility Study is one of multiple Coastal Storm Risk Management (CSRM) studies recently completed or in process throughout the Nation, including Norfolk, the Florida Keys, Collier County, Miami-Dade Back Bay, New Jersey Back Bays, and New York and New Jersey Harbor and Tributaries Focus Area Studies.

Each study seeks to address issues associated with coastal storm risk management as appropriate to the location's distinctive coastal geography and circumstances.

1.1 Study Authority

The authority to study all of coastal South Carolina, including the Charleston Peninsula, was provided in Section 110 of the Rivers and Harbors Act of 1962, P.L. 87- 874, and a subsequent Senate Committee Resolution. Section 110 reads in part:

> *The Secretary of the Army is hereby authorized and directed to cause surveys to be made at the following named localities and subject to all applicable provisions of section 110 of the River and Harbor Act of 1950:*
>
> *Surveys of the coastal areas of the United States and its possessions, including the shores of the Great Lakes, in the interest of beach erosion control, hurricane protection and related purposes: Provided, That surveys of particular areas shall be authorized by appropriate resolutions of either the Committee on Public Works of the United States Senate or the Committee on Public Works of the House of Representatives.*

On April 22, 1988, a Senate Environment and Public Works Committee Resolution authorized the Secretary of the Army to study the entire coast of South Carolina pursuant to Section 110:

> *Resolved by the Committee on Environment and Public Works of the United States Senate, that the Secretary of the Army in accordance with the provisions of Section 110 of the River and Harbor Act of 1962, is hereby authorized to study, in cooperation with the State of South Carolina, its political subdivisions and agencies and instrumentalities thereof, the entire Coast of South Carolina in the interests of beach erosion control, hurricane protection and related purposes. Included in this study will be the development of a comprehensive body of knowledge, information, and data on coastal area changes and processes for such entire coast.*

Authority to conduct this study may also be found in Public Law 84-71 (69 Stat. 132), which authorized:

> *an examination and survey to be made of the eastern and southern seaboard of the United States with respect to hurricanes, with particular reference to areas where severe damages have occurred [to include] possible means of preventing loss of human lives and damages to property, with due consideration of the economics of proposed breakwaters, seawalls, dikes, dams, and other structures, warning services, or other measures which might be required.*

The Bipartisan Budget Act of 2018 (Public Law 115-123), Division B, Subdivision 1, Title IV (BBA 2018), appropriates funding for the study at full Federal expense. As identified under this "Supplemental Appropriation" bill, the study is subject to additional reporting requirements and is expected to be completed within three years and for $3 million dollars:

> *FLOOD CONTROL AND COASTAL EMERGENCIES For an additional amount for ''Flood Control and Coastal Emergencies'', as authorized by section 5 of the Act of August 18, 1941 (33 U.S.C. 701n), for necessary expenses to prepare for flood, hurricane and other natural disasters and support emergency operations, repairs, and other activities in response to such disasters, as authorized by law, $810,000,000, to remain available until expended: Provided, That funding utilized for authorized shore protection projects shall restore such projects to the full project profile at full Federal expense: Provided further, That such amount is designated by the Congress as being for an emergency requirement pursuant to section 251(b)(2)(A)(i) of the Balanced Budget and Emergency Deficit Control Act of 1985: Provided further, That the Assistant Secretary of the Army for Civil Works shall provide a monthly report to the Committees on Appropriations of the House of Representatives and the Senate detailing the allocation and obligation of these funds, beginning not later than 60 days after the enactment of this subdivision.*

1.2 Study Area

In 2018, USACE initiated the Charleston Peninsula Coastal Storm Risk Management Study at the request of the City of Charleston. The Charleston Peninsula was identified as the study area due to the focus on coastal areas in the legal authorities referenced in the previous section, the March 7, 2018, request from the City of Charleston for a flood risk management study of the Charleston Peninsula, and the peninsula's significant vulnerability to storm surge inundation (as described in Section 2.1).

Located between the Ashley and Cooper Rivers, the Charleston Peninsula is approximately 8 square miles (Figure 1-1). The two rivers join off the southern end of the peninsula to form the Charleston Harbor, which is a natural tidal estuary sheltered from the Atlantic Ocean by barrier islands. The Charleston Peninsula is the historic core and urban center of the City of Charleston. The peninsula has undergone dramatic shoreline changes over the course of its history, predominantly driven by landfilling of the intertidal zone. Early maps show that over one-third of the present-day peninsula has been "reclaimed." Much of the landfilling occurred on the southern and western side of the peninsula. Figure 1-2 depicts the Charleston shoreline in 1849 after construction of a bulkhead seawall and promenade known as the High (East) Battery.

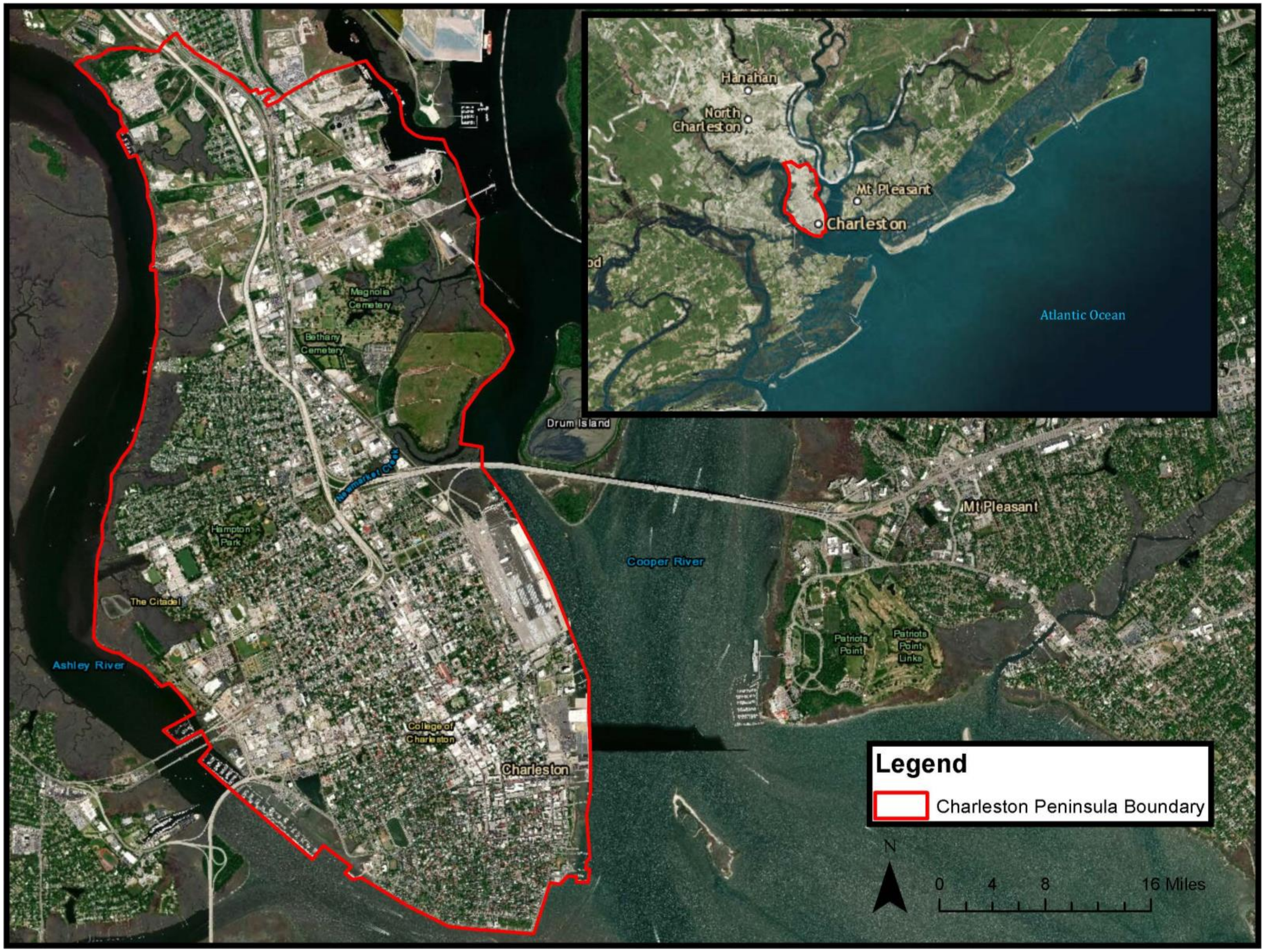

Figure 1-1. The Charleston Peninsula study area is bordered by the Ashley and Cooper Rivers, the Charleston Harbor, and barrier islands. Official mapping product of the Management Support Branch, Charleston District, USACE.

Figure 1-2. The shoreline of Charleston, South Carolina in 1849. Source: Wikimedia Commons.

1.3 Scope

Both Section 110 and Resolution 395 (see Section 1.1) limit the overall scope to “beach erosion control, hurricane protection and related purposes.” The Water Resources Development Act of 1986 (WRDA 86) had the effect of further defining the scope of Section 110 such that erosion control no longer has any separate status as a project purpose or as a project output. (USACE, 1996; ER 1105-2-100, 3-4). Similarly, P.L. 84-71 provides authority “with respect to hurricanes.”

The intent of the Charleston Peninsula Coastal Storm Risk Management Study is to investigate and recommend potential structural and nonstructural solution sets to reduce risk to human life, critical facilities and infrastructure, and reduce risk of economic damages from coastal storm surge inundation. As a low-lying peninsula in a tidal estuary, the Charleston Peninsula, South Carolina is highly vulnerable to coastal storms, a vulnerability which will be further exacerbated by a combination of sea level rise and climate change over the period of analysis. Without a plan to address the risks posed by coastal storm surge inundation, the peninsula’s vulnerability to coastal storm surge is expected to increase unabated over time.

The focus of this study is flooding due to coastal storm surge. According to the National Oceanic and Atmospheric Administration (NOAA), storm surge is produced by water being pushed toward the shore by the force of the winds moving cyclonically around a storm. The storm may be a hurricane, tropical storm, tropical depression, or nor’easter that approaches and passes the Charleston vicinity or moves on shore at or near the Charleston Peninsula. While the Charleston Peninsula also experiences flooding from tides and rainfall unrelated to coastal storm surge events, the authority for this study does not include the investigation of measures to address these aspects of flood risk management. However, the analysis does take into account tidal fluctuations, sea level rise, and precipitation to the extent that these factors combine with coastal storm surge events. Mitigation for adverse impacts to stormwater runoff has been investigated and addressed as appropriate per ER 1105-2-100, Section 3-3.b.(5).

1.4 Existing Programs, Studies and Projects

To inform the feasibility study, significant data has been collected by USACE, the City of Charleston, and other stakeholders. The following programs, studies, and projects were used to characterize existing conditions and forecast future conditions for evaluating alternatives.

City of Charleston Programs and Studies

- Charleston City Plan, 2021
    - The City of Charleston’s comprehensive plan that articulates the values and goals of the city.
    - The plan addresses existing conditions, community priorities, and recommendations for the following key elements:

        - Population
        - Natural resources
        - Cultural resources
        - Economic development
        - Transportation
        - Community facilities and priority investment
        - Housing
        - Land use
        - Resilience and equity
- Dutch Dialogues, 2019
    - This collaborative effort brought together national and international water experts to work alongside Charleston's local teams to conceptualize a future living with water through integrated planning and urban landscape design. A public Colloquium was held on May 1-2, 2019, to identify key takeaways for geographic locations in the city. The Dutch Dialogues Design Workshop was held on July 15 – 19, 2019, and the final report presentation on September 26, 2019. The process resulted in a publicly shaped conceptual road map for the city to adapt and prepare for sea level rise.
- Flooding and Sea Level Rise Strategy, 2019
    - The document provides a vision and framework to proactively protect lives and property, maintain a thriving economy, and support Charleston's quality of life by improving the city's resilience to sea level rise and recurring flooding.
    - The City recommends a 2-to-3-foot increase above Base Flood Elevation for all new and substantially improved structures.
- Vision|Community|Heritage – A Preservation Plan for Charleston, South Carolina, 2008
    - The plan provides direction for Charleston to protect and add to its layers of built history for new generations.
- Neck Area Plan, 2003
    - The purpose of the plan is to provide a framework for physical development in the Charleston Neck Area, which is defined as the area north of Mt. Pleasant Street and northeast of Morrison Drive.
    - This area was historically used for industrial purposes. A great deal of land is contaminated, brownfield sites.
    - The Neck Area is home to small, vibrant communities.

- Downtown Plan, 1999
    - Establishes parameters to guide future development and a vision for downtown Charleston that builds upon its historic armature.
- Calhoun Street-East/Cooper River Waterfront Special Area Plan, 2010
    - The purpose of the plan is to establish policies and priorities for coordinated development, land use planning, and budgetary preparation.

State of South Carolina Programs and Studies

- South Carolina Floodwater Commission
    - Created by executive order on 15 October 2018, for the purpose of state-wide flood accommodation, response, and mitigation efforts. The Commission shall serve as a vehicle for authorities to research, evaluate, share, and coordinate measures and ideas being considered. The Commission shall identify short-term and long-term recommendations to alleviate and mitigate flood impacts to the state, with special emphasis on cities, communities, and enterprises located on or near the coast and rivers.

City of Charleston Projects

- Medical District Tunnel Extension at Ehrhardt Project
    - The addition of a tunnel adit and drop shaft to extend the Spring/Fishburne project into the Charleston Medical district to reduce flooding on roads to access the Medical University of South Carolina, Roper Hospital, and the VA Medical System. Construction contract approved by the City Council in February 2022, completion expected in 2023.
- Market Street Drainage Improvement Project, Division III in construction
    - A new tunnel underneath the eastern portion of Market Street connects to the Concord Street pump station (which can pump about 7.2 million gallons of water out of the City in an hour). To date, 3 drop shafts along Market Street are connected to the tunnel and are already making a difference in the market area. This phase consists of constructing a new, larger surface collection and conveyance system and tying it to the drop shafts. The sidewalks and streetscape of Market Street will also be improved.
    - Division I completed in 2006
    - Division II completed in 2014
- Limehouse Brick Arch Retrofit Project

  - The cleaning and rehabilitation of a historic brick arch sewer system (from which sanitary sewer was previously disconnected) to provide a 5 foot by 3 foot stormwater conveyance system running from the Low Battery up Limehouse, Logan, and Coming Street. This is an ongoing construction project with the first phase planned for completion in 2022.
- US 17 Spring/Fishburne Drainage Improvement Project, Phase IV in construction, expected completion in 2022
  - This complex project includes more than 8,000 linear feet of deep underground tunnels that will all be connected to an outfall and pump station between the Ashley River bridges. This project will serve more than 500 acres of the western peninsula and will keep Highway 17 open during most rain events when complete.
  - US Hwy 17, also known as the Crosstown is a vital route for emergency response vehicles, commuters, and connecting those evacuating the city to evacuation routes in times of imminent hurricanes.
  - Phase I completed in 2013
  - Phase II completed in 2017
  - Phase III completed in 2020
  - Phase V planned completion in 2024
- The Low Battery Seawall Rehabilitation Project, Phase II in construction
  - After more than 100 years of exposure to aggressive environmental conditions, several powerful hurricanes, and numerous extreme high tides, the entire Battery wall has been left in a significantly degraded state. The High Battery at The Turn recently underwent a total reconstruction due to concerns about deteriorated foundations. As a continuation of that project, the City is now addressing the Low Battery.
  - The Low Battery wall is being restored and elevated to match the High Battery.
  - Phase I completed in 2021.
  - Phase II in construction with planned completion in 2022.
  - Phase III planned completion in 2023.
- Calhoun West/Beaufain Drainage Improvement Project
  - The Calhoun West/Beaufain basin contains the Medical University of South Carolina (MUSC), the College of Charleston, Roper Hospital, and many businesses and residences that are impacted by frequent flooding. Flooding of streets poses many problems including restricting access to hospitals, diverting

traffic around accumulated water, and damage to vehicles parked along flooded streets.

  - The City of Charleston completed a study to improve drainage in the Calhoun West/Beaufain drainage basin and alleviate many of the existing drainage problems. Ultimately, the project will increase the capacity of the stormwater collection and conveyance system as well as provide means to convey stormwater directly into the Ashley River during storms and tidal events via pumping systems.

- Calhoun Street East Drainage Improvement Project, 1999.
  - First drainage improvement project by the City of Charleston.
  - The project consisted of an 8-ft diameter tunnel under Calhoun Street from Marion Square to Concord Street, a 5.5-ft diameter tunnel under Meeting Street from Mary Street to Marion Square, large and small drop shafts along Meeting and Calhoun Streets, and a stormwater pump station on Concord Street with 3 pumps each capable of pumping water in excess of 30,000 gallons per minute.

Federal Projects

- Charleston Harbor Post 45 Deepening Project
  - The purpose of this project is to address transportation inefficiencies by deepening and widening the Charleston Harbor to allow for growth in the shipping industry with the influx of Post-Panamax ships calling on port in the Lowcountry. The South Carolina Ports Authority is the non-federal sponsor for this USACE Civil Works project.
- Charleston Harbor
  - The City of Charleston has utilized this natural harbor since the late 17th century. Over time, the harbor has been deepened as needed to adapt to the changing needs of its users. The Rivers and Harbors Act of 1852 authorized navigation improvements to Charleston Harbor.
  - The Charleston Harbor supports a vital mission in the defense of our nation and is one of the nation's 17 strategic ports. It is the 4th busiest container port on the East Coast. This project consists of 38.6 miles of channel, three turning basins, and one anchorage basin. The lower harbor requires dredging every year, the entrance channel every other year, and the upper harbor approximately every 15 – 18 months.
- Ashley River Channel
  - The Rivers and Harbors Act of 1912 and 1937 authorized navigation improvements to the Ashley River. This project is now inactive.

1.5 Public and Agency Coordination

1.5.1 Public Involvement

Public involvement is required by NEPA before a Federal agency undertakes an action affecting the environment. The purpose of public involvement is to enable citizen input regarding potential alternatives and effects of agency actions, and to bolster informed agency decision-making. During the development of the draft 2020 FR/EA for this study, USACE involved Federal, State, and local agencies, stakeholders, and the public through various meetings and the NEPA public comment period. With the transition to an EIS, USACE continued to engage in a robust NEPA public process with scoping and draft FR/EIS public comment periods, each with associated public meetings and other outreach efforts. For a more in-depth discussion of the public involvement process, see Chapter 5, *Coordination and Public Involvement Process*.

1.5.2 Agency Involvement

Early in the study process, USACE along with other Federal, State, and local agencies participated on an Interagency Coordination Team. When the study transitioned to an EIS, USACE asked Federal and State agencies to participate as cooperating agencies based on their jurisdiction by law, or their special expertise with respect to any environmental issue evaluated in this FR/EIS.

1.6 Importance of the Study Area Location

Charleston, South Carolina is important to the Nation because of 1) the well-preserved history of the community reflects the history of the Nation, 2) its economic vitality, along with the presence of key medical infrastructure and educational institutions, 3) strategic military bases in the area are critical to national security, and 4) Charleston Harbor's port facilities support the Nation's economy.

1.6.1 Historic Charleston

The history of Charleston is one of the longest and most diverse of any community in the United States. In 2020, the city celebrated 350 years since Europeans established the town as a seaport community. The Charleston Peninsula is the historic heart of the City. Charleston has a long history of Native American occupation, and the city played an important role in Colonial, Revolutionary, antebellum, and Civil War America. Early in its history, as the capital of the Carolina colony, the city was fortified with walls, cannons, and moats to protect its habitants from attack. Later, key battles of the Revolutionary and Civil War were fought within and surrounding the peninsula. Today, Charleston contains numerous buildings from the late-eighteenth century to the mid-nineteenth century reflecting the city's unique and rich history. Refer to Section 4.10 for an overview of the historical development of Charleston.

1.6.2 Charleston Peninsula

Charleston is a top tourist destination in the U.S., with the peninsula driving a significant portion of the attraction. According to the Charleston Regional Development Alliance (CRDA), over 7 million people visit the area each year, contribute over $9 billion to the local economy, and support a regional workforce of more than 47,000 employees. See Appendix C Economics, C.1.3.1. Socioeconomic Data. The peninsula is also home to critical medical facilities such as the Medical University of South Carolina, Ralph H. Johnson VA Medical Center, and Roper St. Francis Hospital. The healthcare industry in Charleston has the 14th fastest growth rate among mid-sized U.S. metropolitan areas. See Appendix C Economics, C.1.3.1. Socioeconomic Data. Key educational institutions such as The Citadel and The College of Charleston are situated on the peninsula.

1.6.3 Charleston Military Strategic Significance

The Charleston area is home to Joint Base Charleston, one of 12 Department of Defense Joint Bases. Joint Base Charleston hosts over 60 Department of Defense and Federal agencies, and supports a total force of over 90,000 Airmen, sailors, soldiers, Marines, Coast Guardsmen, civilians, dependents, and retirees across four installations including Charleston Air Force Base. Even though these facilities are not situated on the peninsula, the medical facilities and educational facilities on the peninsula directly support those bases.

The Joint Base is home to the largest C-17 Globemaster III Air Force base. The aircraft is the most flexible cargo aircraft to enter the airlift force. The C-17 is capable of rapid strategic delivery of troops and all types of cargo to main operating bases or directly to forward bases in the deployment area. The aircraft can perform tactical airlift and air drop missions and can transport litters and ambulatory patients during aeromedical evacuations. The inherent flexibility and performance of the C-17 force improves the ability of the total airlift system to fulfill the worldwide air mobility requirements of the United States. According to historian Stan Gohl, due to threats to the U.S. in recent years, the size and weight of U.S.-mechanized firepower and equipment have grown in response to the improved capabilities of potential adversaries. This trend has increased air mobility requirements and the C-17 meets the Air Force’s needs (Trimarchi, 2013).

Recently, the U.S. Coast Guard announced its plans to build a new superbase in the Charleston area. Charleston is already home to a large concentration of Coast Guard assets and personnel. Considered an enjoyable duty station, and one of only a few strategically located seaports in America that still boasts a moderate cost of living, the area is an ideal place for additional Coast Guard investment.

1.6.4 Port of Charleston

The Port of Charleston operated by the South Carolina Ports Authority (SCPA) is the 4th largest container seaport on the East Coast with two of the six port terminals located within the study area on the Charleston Peninsula (Union Pier and Columbus Street), and a third just to the north of the study area (Leatherman Terminal). The SCPA generates an annual total economic impact of $63.4 billion in South Carolina and another $12 billion in neighboring states. After completion of the Charleston Harbor Post 45 Deepening Project, the Charleston Harbor will be the deepest harbor on the U.S. East Coast.

1.7 Planning Process and Report Organization

The USACE water resources planning process consists of six major steps: (1) specification of water and related land resources problems and opportunities; (2) inventory, forecast, and analysis of water and related land resources conditions within the study area; (3) formulation of alternative plans; (4) evaluation of the effects of the alternative plans; (5) comparison of the alternative plans; and (6) selection of the recommended plan based upon the comparison of the alternative plans.

The USACE planning process parallels the NEPA process. NEPA requires that all federal agencies use a systematic, interdisciplinary approach to protect the human environment. This approach promotes the integrated use of natural and social science in planning and decision-making. The NEPA process involves a scoping phase, public involvement, and a determination of whether environmental effects of a federal action are likely to be significant. Where net environmental effects on the quality of the human environment of a major Federal action are projected to be significant, an EIS is prepared in the NEPA process to look at different action alternatives and evaluate the relative significance of the environmental effects of the alternatives. Federal agencies have been encouraged to integrate their planning processes with the NEPA process; therefore this document presents an integrated FR/EIS.

CHAPTER 2 - Planning Considerations

This chapter states the purpose and need for the proposed action and presents the results of the first two steps of the planning process, (1) the specification of water and related land resources problems and opportunities (including constraints) in the study area and (2) inventorying and forecasting conditions (including without project conditions, risk, and uncertainties).

2.1 Purpose and Need

The Charleston Peninsula is a highly urbanized, relatively flat community with nearly all lands below elevation 20 feet North American Vertical Datum of 1988 (NAVD88). Because it is a flat, low-lying community surrounded on three sides by water, the Charleston Peninsula has faced flooding challenges since the City's founding. The peninsula faces flood risks from rainfall, tides, sea level rise, and storm surge events, or a combination of these sources of flood risk. The authority available to USACE to carry out this study (see Sections 1.1 Study Authority and 1.3 Study Scope, above) was limited to the management of flood risk posed by coastal storm surge. However, as previously noted, the study's analysis regarding the risk posed by coastal storm surge does takes into account tidal fluctuations, sea level rise, and precipitation as they contribute to storm surge risk. More than two years into this study process, Congress enacted a separate authority in Section 201(a)(22) of the Water Resources Development Act of 2020 (WRDA 2020) that would enable USACE to study the feasibility of "tidal- and inland-related flood risk management" for the City of Charleston in the event that appropriations are provided for that study authority.

The low elevations and tidal connections to the Ashley and Cooper Rivers and Charleston Harbor place a significant percentage of peninsular Charleston at risk of storm surge flooding from hurricanes, tropical storms, tropical depressions, and nor'easters. The timing of a coastal storm event is key to the severity of potential damages. A major coastal storm making landfall at or near Charleston at high tide could be catastrophic for the community. However, even coastal storms that arrive at low tide or pass by the Charleston Peninsula can have severe storm surge impacts on the community. A storm surge event can damage or destroy structures, undermine the foundations of transportation and utility infrastructure, and pose a serious threat of death by drowning. Exacerbating the vulnerability of the peninsula to storm surge flooding is the phenomenon of relative sea level rise (RSLR), which is the combination of water level rise and land subsidence. Without a plan to enhance the resilience of the peninsula to the risk of damages from coastal storm surge inundation, the peninsula's vulnerability to coastal storms is expected to increase unabated over time due to a combination of climate change and RSLR.

The purpose of this proposed action for the Charleston Peninsula is to identify the optimal structural and nonstructural solution set to reduce risk to human health and safety, reduce the risk of economic damages, and increase resilience to coastal storm surge inundation through the year 2082. The purpose statement is derived from the more detailed Problem Statements, Opportunities, and Objectives below.

2.2 Problem Statements

During planning charrettes in the Fall of 2018, the project delivery team, with input from stakeholders, identified the following problems:

1. Storm surge inundation on the Charleston Peninsula places people at risk, including the potential for loss of life and declines in public health (as described in Section 2.2.1).
2. Access to critical facilities, emergency services, and evacuation routes is limited or cut off entirely during coastal storm surge events on the Charleston Peninsula.
3. The Charleston Peninsula experiences storm surge inundation that adversely affects: the economic sustainability of Charleston, including impacts to businesses, organizations, and industry; critical facilities and infrastructure; and residents.

2.2.1 Life Loss and Impacts to Public Health

Flooding in urban areas can cause serious health and safety problems for the affected population. The most obvious threat to health and safety is the danger of drowning in flood waters. Swiftly flowing waters can easily overcome even good swimmers. When people attempt to drive through flood waters, their vehicles can be swept away in as little as two feet of water.

Workers who respond to flooded areas are at risk of illness, injury, or death. These workers include utility workers, law enforcement, emergency medical personnel, firefighters, and military and government personnel. According to the Occupational Safety and Health Administration, some of the hazards associated with working in flooded or recently flooded areas include: electrical hazards, hypothermia, structural instability, exhaustion, hazards associated with heavy equipment operation, drowning, biohazards, fire, musculoskeletal hazards, burns from fires caused by energized line contact or equipment failure, carbon monoxide, falls from heights, hazardous materials, and dehydration.

Liquified petrolem gas tanks and underground storage tanks can break away from their supports and float in flood waters, causing hazards from their released contents. Floods can damage fire protection systems, delay response times of emergency responders, and disrupt water distribution systems. All of these factors lead to increased danger from fires.

During a flood, local water systems may become contaminated. A variety of sources of contamination include animal and human waste, dead and decaying animals, or chemicals accidentally released during flooding. Water supply contamination can lead to a number of waterborne illnesses. Food exposed to floodwaters or stored without refrigeration during extended loss of power during flooding can lead to food-borne illnesses. Buildings damaged by flooding can become contaminated with mold and fungi if they do not dry out quickly enough. These molds and fungi can pose serious health risks.

After floodwaters recede, debris cleanup can be a substantial undertaking. After the flooding in New Orleans resulting from Hurricane Katrina, debris removal included general houshold trash and personal belongings, construction and demolition debris, vegetative debris, household hazardous waste, white goods (e.g. refrigerators and washing machines), and electronic waste. Curbside debris was in excess of 53 million cubic yards. There were nearly 900,000 units of white goods and over 600,000 units of electronic goods. More than 350,000 cars and 60,000 vessels were damaged or destroyed and abandoned (Luther, 2008).

Extreme weather and climate-related events can have lasting mental health consequences in affected communities, particularly if they result in degradation of livelihoods or community relocation. Populations including older adults, children, low-income communities, and some communities of color are often disproportionately affected by, and less resilient to, the health impacts of extreme weather and climate-related events. Lessons from numerous coastal storm events have made it clear that even if elderly, functionally impaired persons, and/or low-income residents wish to evacuate from areas at risk from a pending coastal storm, they may be unable to evacuate due to their physical or socioeconomic condition.

2.2.2 Impacts to Critical Facilities, Emergency Services, and Evacuation Routes

Critical facilities on the Charleston Peninsula include six fire stations, two police stations, six colleges, and twelve public schools. The Charleston Peninsula is also home to the Charleston Medical District which includes the Medical University of South Carolina (MUSC), Roper St. Francis Hospital, and Ralph H. Johnson Veterans Affairs Medical Center. The MUSC's 700-bed center has 4 hospitals: the MUSC Children's Hospital, the Institute of Psychiatry, Ashley River Tower, and University Hospital. The center also has a Level I Trauma Center and South Carolina's only transplant center. The Ralph H. Johnson VA Center serves 75,000 Veterans along the South Carolina and Georgia Coast. The Medical District is particularly vulnerable to storm surge inundation because of its location on a filled intertidal area of the western side of the peninsula. Assuming a high rate of sea level rise, in the year 2082, 50% of police stations, 42% of health care facilities, and 29% of fire stations on the peninsula would be flooded to elevation 9 feet NAVD88 during a 20% annual exceedance probability (5-year recurrence interval) storm event.

During storm surge events, the ability of first responders to reach the location of need and the ability of individuals to reach medical facilities can be limited or cut off entirely. When a hurricane threatens South Carolina's coast, residents may plan to leave voluntarily or may be ordered to evacuate. Residents on the Charleston Peninsula will use the normal west-bound lanes of Interstate 26. However, to prepare for Hurricane Dorian in 2019, the South Carolina Highway Patrol and Department of Transportation reversed eastbound lanes on Interstate 26 in response to an evacuation order. In addition to the population of 40,000 people, thousands of commuters and tourists/day users may be on the peninsula.

2.2.3 Economic Impacts

The impacts of flooding affect local industries, including tourism, commercial shipping and logistics, technology, and education, as well as residents of the peninsula. Business operations are reduced when anticipating a coastal storm, especially if evacuation orders are issued, but if the storm significantly damages property and infrastructure, operations would be impacted for a longer duration.

There are approximately 6,670 structures (out of a total of 12,095 structures) on the Charleston Peninsula in the FEMA 100-year floodplain. Property owners in high-risk flood areas with Federally-backed mortgages are required to purchase flood insurance, although flood insurance has eligibility requirements and numerous exclusions. Residents may have flood insurance to cover some damages, but they are still financially impacted by storm events. The FEMA National Flood Insurance Program does not cover additional living expenses, such as temporary housing while the building is being repaired or is unable to be occupied; loss of use or access to the insured property; financial losses caused by business interruption; property and belongings outside of an insured building such as trees, plants, wells, septic systems, walks, decks, patios, fences, seawalls, hot tubs and swimming pools; most self-propelled vehicles, such as cars, including their parts; and personal property kept in basements. Federal flood insurance coverage is also capped at $250,000 per building and $100,000 for contents.

Charleston is a top tourist destination in the United States, with the peninsula driving a significant portion of the attraction. According to the Charleston Regional Development Alliance (CRDA), 7 million people visit the area each year, contribute $8 billion to the local economy, and support a regional workforce of more than 47,000 employees. Tourism is the largest sector of the Charleston County economy, comprising nearly 25% of all sales, according to the College of Charleston Office of Tourism. Charleston lost an estimated $65 million in visitor spending during Hurricane Florence (September 2018), although it was downgraded to a tropical storm by the time it arrived, and the city avoided the storm’s most damaging effects.

Healthcare is a major industry in the region, including the medical district located on the peninsula. According to the CRDA, the healthcare industry supports a regional workforce of more than 30,000 people, including more than 2,000 physicians. The healthcare industry in Charleston has the 14th fastest growth rate among mid-sized U.S. metropolitan areas.

Commercial shipping is important to the Charleston economy. The Port of Charleston was the 9th-busiest seaport in the United States in 2020, accounting for 4 percent of the nation’s containerized cargo volume. The Port of Charleston is owned and operated by the South Carolina State Ports Authority. Two terminals, Columbus Street and Union Pier, are located on the peninsula and subject to future flood risk.

The Charleston area is also becoming a popular location for information technology jobs and corporations. A 2020 study by the South Carolina Council on Competitiveness shows that South Carolina's technology industry has doubled since 2005 and Charleston exhibits the highest annual growth in employment at 15.5%. The Lowcountry, which includes Charleston, accounts for 44.1% of all technology firms in the state.

2.3 Opportunities

Opportunities are the desirable future outcomes which address the water resource problems and improve conditions in the study area. The project delivery team, with input from stakeholders, identified the following opportunities:

- Increase resilience of the Charleston Peninsula to storm surge flooding.
- Enhance existing natural areas including open spaces and streams.
- Utilize dredged materials as productive materials not to be wasted.
- Develop new transportation modes, such as bicycle pathways or small boat transit via canals.
- Establish education and/or research programs.

The April 2020 draft FR/EA included recreation features such as a walkway along the river and river access points as opportunities; however, such recreation features were determined not to be incidental to the final array of alternatives and therefore not USACE policy compliant. Per ER 1165-2-130, Section 6a(1), "…the Corps participates in shore protection plans that include recreation facilities or generate recreation benefits if the recreation outputs are incidental (i.e., no separable construction costs are required to realize recreation outputs) and are not the primary outputs." Walkways and other features may be incorporated as part of cultural resource or visual mitigation plans during the design phase, or as betterments funded by the non-Federal sponsor, but may not be included in the National Economic Development plan to address storm surge inundation.

2.4 Objectives

An objective is a statement of what an alternative plan should achieve over the life of the project to effectuate the project purpose. To consider the impact of a plan over time, each alternative will be evaluated over a 50-year period of analysis. Assuming construction is complete in 2032, the end of the period of analysis would be 2082.

The study team has identified the following objectives to guide achievement of the study goal:

- Reduce risk to human health, safety, and emergency access from coastal storm surge inundation on the Charleston Peninsula over the 50-year period of analysis of 2032 – 2082.
- Reduce economic damages resulting from and increase resilience to coastal storm surge inundation on the Charleston Peninsula over the 50-year period of analysis of 2032 – 2082.

Risk to emergency access refers to the potential for storm surge flooding to close roads, isolate neighborhoods, and impede access to critical facilities, emergency services, and evacuation routes. Resilience refers to the ability to anticipate, prepare for, and adapt to changing conditions, and to withstand, respond to, and recover from disruptions.

2.5 Constraints

A constraint is a restriction that limits the development and selection of alternative plans. Constraints for this analysis include:

- Minimize adverse effects to historic districts and structures over the 50-year period of analysis of 2032 – 2082.
- Minimize adverse effects to threatened and endangered species and Essential Fish Habitat over the 50-year period of analysis of 2032 – 2082.
- Ensure that environmental justice considerations are incorporated and not compromised over the 50-year period of analysis of 2032 – 2082.
- Avoid high-cost modifications and installation of flood gates to Interstate 26 and U.S. Route 17 over the 50-year period of analysis of 2032 – 2082.
- Avoid encroaching on navigation channels in the Charleston Harbor and the Ashley and Cooper Rivers (see Figure 2-1) over the 50-year period of analysis of 2032 – 2082.
- Avoid adverse impacts to Coast Guard, port, and marina operations over the 50-year period of analysis of 2032 – 2082.

The first three constraints are universal constraints, in that they are based in law and policy and apply in some form to every planning study. For example, in addition to substantive legal protections for historic resources, Section 904 of WRDA 1986 requires USACE to address the preservation of cultural and historical values in the formulation and evaluation of alternative plans, and Section 112(b)(1) of WRDA 2020 (P.L. 166-260) requires the consideration of environmental justice in the formulation of water resource projects consistent with Executive Order 12898. Universal constraints may assume particular importance in an individual context, as in the case of the high concentration of historic resources present on the Charleston Peninsula. The last three constraints are specific to this study. On the Ashley River, any proposed barrier must be strategically placed to avoid impacts to operations of the U.S. Coast Guard Station at Tradd Street and the Safe Harbor Charleston City Marina, the federal navigation channel, and the Ashley River bridge. Alignment of a barrier through this area would be constrained to the height of the existing abutment of the Ashley River Bridge which is 12 feet NAVD88. Violating these constraints would be a major cost driver and limit the net benefits of a potential barrier structure.

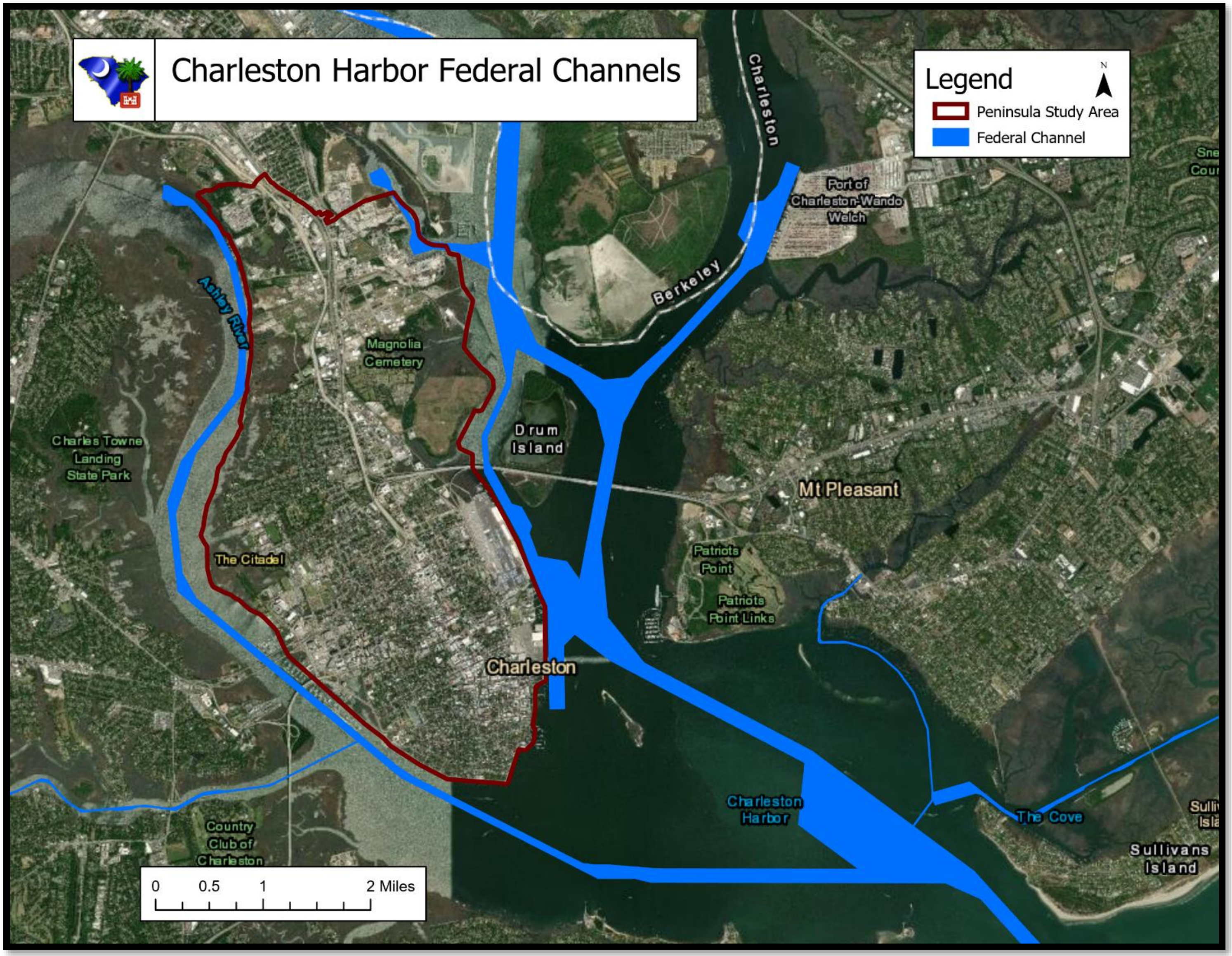

Figure 2-1. Depiction of the federal navigation channels near the study area. Official mapping product of the Management Support Branch, Charleston District, USACE.

2.6 Inventorying and Forecasting

The Charleston Peninsula has been subjected to intense coastal storm events throughout its history. Since 1851, 41 tropical cyclones have made landfall in the National Weather Service's Charleston County Warning Area – 25 of these storms were hurricanes, 9 were tropical storms, and 7 were tropical depressions. There has been a general upward trend in the number of weaker tropical cyclones making landfall and a general downward trend in the number of major (Category 3 – 5) landfalling hurricanes (NOAA, 2020a). The following paragraphs discuss recent storm events and their impacts on the people, businesses, industry, infrastructure, and critical facilities on the Charleston Peninsula.

2.6.1 Hurricane Hugo (1989)

Hurricane Hugo was a Category 4 hurricane when it made landfall just north of Charleston on September 22, 1989. Hugo produced tremendous wind and storm surge damage along the coast, however, rainfall amounts were limited due to the fast motion of the storm. Hugo produced the highest storm tides (a combination of storm surge and the astronomical tide) ever recorded on the East Coast of the United States (https://www.weather.gov/chs/HurricaneHugo-Sep1989). Historical data from the Charleston Harbor Tide gage (https://tidesandcurrents.noaa.gov/stationhome.html?id=8665530) shows that the highest water levels resulting from storm surge during that timeframe reached 12.53 ft MLLW (9.39 ft NAVD88). Water crashed over the historic seawall and flooded the first floors of homes. Approximately 30 miles to the north in Bulls Bay, South Carolina a tide gage was not active to record historic water elevations at the time of Hurricane Hugo's landfall as it was in the Charleston Harbor. A post storm survey completed by the United States Geological Survey (https://sc.water.usgs.gov/hurricane/pubs/OFR90-386.pdf) notes that the highest water elevation resulting from storm surge was 18.3ft MLLW in Bulls Bay. Since the precise location of this recording is unknown a conversion to NAVD88 is not provided. According to the National Weather Service, had the eye of Hugo struck just 20 miles further south, full Category 4 conditions would have been felt in Charleston and the damage would have been catastrophic (Townsend, NWS).

Hugo was responsible for at least 86 fatalities in the United States. Of those deaths, at least 26 occurred in South Carolina. Only one death in Charleston was directly attributable to Hugo. However, the Medical University of Southern Carolina (MUSC) lost most of its electrical power during the storm, creating conditions for indirect medical consequences.

Until Hurricane Katrina (August 2005), Hugo was the costliest storm in terms of property damage. The storm caused $8 to $10 billion in damages. This record-breaking amount of property damage was due to the intensity of the storm along highly developed areas of coastal South Carolina and the considerable distance inland the storm traveled and maintained its strength. South Carolina received Federal Emergency Management Agency payments totaling

$212 million, with Charleston County receiving the highest amount of funding per capita (Lord, 1991).

2.6.2 Hurricane Joaquin (2015)

From 2015 – 2017, Charleston experienced three historic floods in three consecutive years. In October 2015, the aftermath of Category 4 Hurricane Joaquin fed a continuous stream of precipitation into South Carolina, and the Charleston region received more than 20 inches of rainfall over 3 days. The City's harbor had the highest recorded tides since Hurricane Hugo made landfall in 1989. The water that infiltrated Charleston caused road closures, property damage, and required rescues by emergency personnel. The MUSC had to close 4 operating rooms, resulting in the cancellation of almost 200 surgeries.

2.6.3 Hurricane Matthew (2016)

In October 2016, Hurricane Matthew swept through Charleston. Though it arrived during low tide and had weakened to a Category 1 storm, Matthew delivered significant inundation from storm surge. A peak storm tide of 9.3 feet MLLW was recorded in Charleston Harbor, which was the third-highest tide to date. Flooding from the harbor along with 9 to 10 inches of rainfall took days to drain.

2.6.4 Hurricane Irma (2017)

In September 2017, Hurricane Irma produced a peak storm tide that exceeded both Hurricane Matthew and the October 2015 flood event, measuring in at 9.9 feet MLLW. Though the eye of the storm was quite a distance from Charleston, Irma brought continuous and heavy bands of rain. Throughout the entire City of Charleston, 111 roads were closed because of flooding, significantly interrupting lives and businesses. Following Hurricanes Matthew and Irma, MUSC facilities had combined damages of about $1.3 billion.

2.7 Without-Project Conditions and Assumptions

The without-project condition and forecast assumptions are critical to the planning process since they provide the baseline for the subsequent evaluation and comparison phases. The following discussion includes projections about the future of the Charleston Peninsula if the Federal government, State or local interests do not address the problems identified in this study. A more in-depth discussion covering some of the same and additional considerations is found in Chapter 6 (regarding the No Action Alternative).

2.7.1 Population and Land Use

Charleston is part of a rapidly growing metropolitan area known as the Tri-County Area (Berkeley County, Charleston County, and Dorchester County). According to census figures for 2020, about 33 people move to the Tri-County Area each day, making it one of the country's fastest growing regions (CRDA). The Tri-County Area has a population of about 787,000. Charleston is the second largest city in South Carolina, with a population of about 150,000. Approximately 34,000 people currently reside on the peninsula and more than 40,000 people are projected to reside on the peninsula in 2030.

The majority of residents on the peninsula already live in the FEMA 100-year flood zone and nearly everyone else is in the 500-year flood zone. There are several housing development projects planned and in progress to accommodate the influx of new residents on the peninsula. Despite the city's flood risk, it is assumed people will continue to move to Charleston which would increase the amount of people vulnerable to flooding. The City of Charleston's Department of Planning, Preservation & Sustainability projects that the number of residents on the peninsula could double by the year 2070 (Table 2-1).

Table 2-1. City of Charleston Estimated/Projected Population.

Year	**2020***	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**	**2060**	**2070**
Peninsula	33,644	37,396	40,857	44,317	47,778	51,238	54,699	61,619	68,540
West Ashley	67,873	71,958	76,375	80,791	85,208	89,625	94,041	102,874	111,707
James Island	21,595	22,536	23,613	24,689	25,765	26,842	27,918	30,071	32,224
Johns Island	11,884	14,215	16,306	18,397	20,488	22,579	24,670	28,852	33,034
Daniel Is/Cainhoy	15,231	18,408	21,469	24,531	27,592	30,654	33,715	39,838	45,960
Total	**150,227**	**164,514**	**178,619**	**192,725**	**206,831**	**220,937**	**235,042**	**263,254**	**291,466**

*Census 2020

Land use on the peninsula is dominated by residential, commercial, and industrial development (see Figure 2-2). Recently, the city created an incentive-based zoning district to encourage sustainable and responsible development in areas of the Upper Peninsula with lower flood risk. The city will continue to make incremental adjustments in land use by managing and directing growth to lower risk areas, but significant change will be slow since the peninsula is already highly developed.

2.7.2 Transportation

Surface streets as well as U.S. Route 17 (locally known as the Crosstown) already close during flood events, limiting movement on the peninsula. U.S. Route 17 currently floods more than 10 times per year and is expected to experience up to 180 floods annually by 2045 (Fourth National Climate Assessment). During storm events, public access to hospitals is limited. Hospitals in

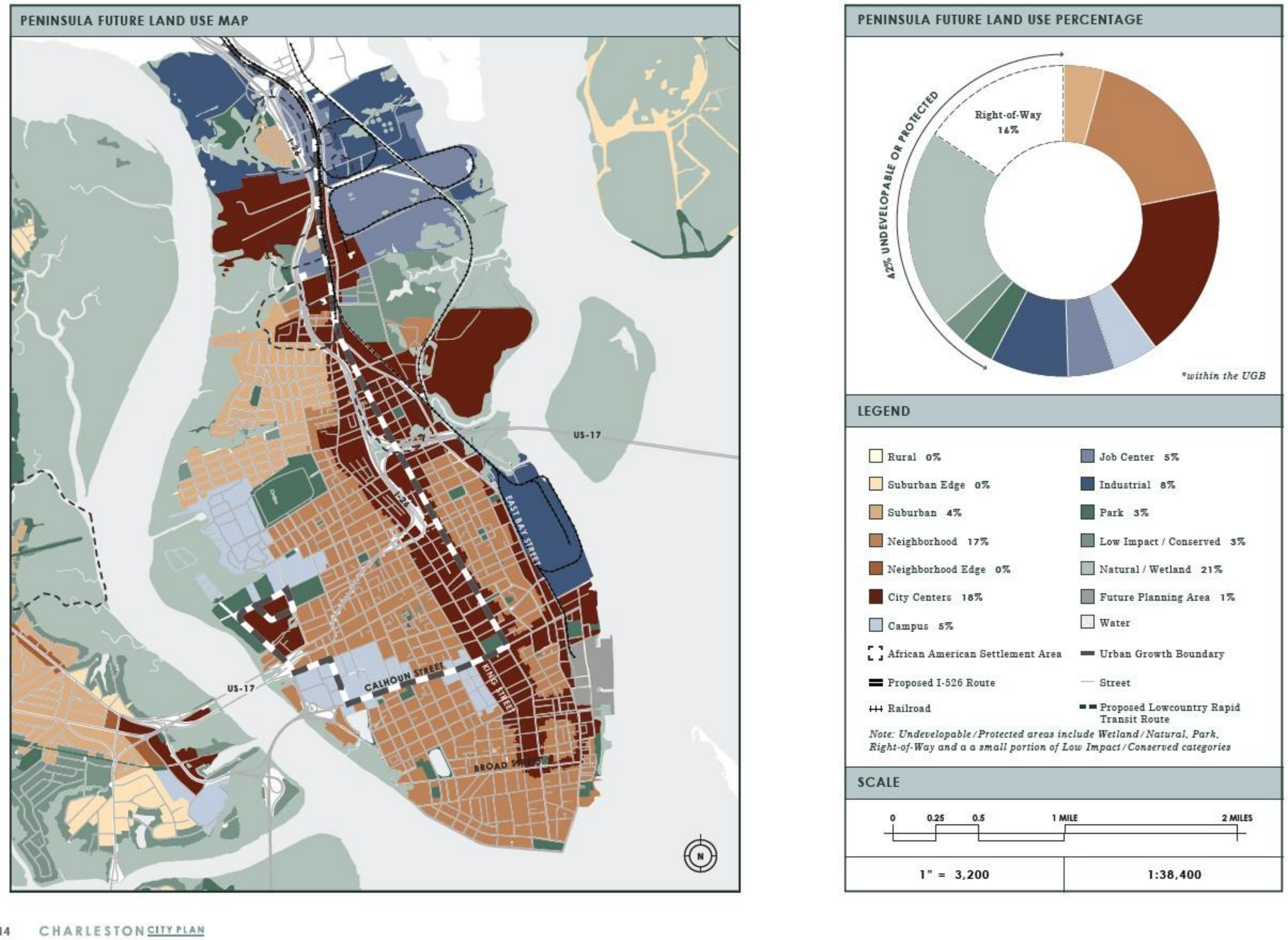

Table 2-2. Land use on the Charleston Peninsula. Source: Charleston City Plan.

the peninsula's medical district are already using johnboats and tactical vehicles to transport staff between facilities during flood events. The MUSC recently purchased a storm ready truck that can plow through four feet of water to transport doctors, nurses, and other essential employees through floodwaters on the MUSC campus. The without-project scenario assumes that flooding during coastal storm surge events will increasingly limit and/or block transportation and evacuation routes.

2.7.3 Hydrology

The City of Charleston has experienced a marked increase in the number of days of "minor coastal flooding" over time, which will increase along with rising sea levels. Similarly, the water table below Charleston will continue to rise, limiting the effectiveness of gravity drainage post-storm. Assuming an intermediate rate of sea level rise, it is estimated that water levels in the Charleston Harbor would increase 1.65 feet over the 50-year study period. Subsidence also affects RSLR as soil deposited naturally or placed by humans in the intertidal zone compacts over time.

According to an evaluation in the 1984 Master Drainage Plan, stormwater drainage facilities within the peninsula consist mainly of vitrified clay pipe or brick arches, some of which date back to the 1850s, and the majority of which are inadequate for design limits. However, since the 1990s, the City of Charleston has made major strides in addressing interior drainage issues on the peninsula. The city has been working on alleviating drainage problems since the establishment of the Stormwater Utility in 1996, using this money to fund only stormwater projects. In addition to this fund, the city has sought other funding sources to tackle large capital improvement projects and improve the quality of life on the peninsula. The city has invested over $260 million in drainage projects, with several more unfunded projects in the works.

The future without-project scenario assumes that the Low Battery Seawall project is complete, however the people and properties behind the seawall remain at risk because the Low Battery Seawall does not tie into high ground. With the exception of the Calhoun West/Beaufain Drainage Improvement Project, each local drainage project listed in Section 1.4 is also assumed to be complete in the future without-project scenario, including the check valve program on the drainage system outfalls that prevent tidal backflow into the system. The local drainage system will slowly be improved during the period of analysis subject to funding availability. These projects will address some site-specific flooding problems but leave the city vulnerable to storm surge inundation.

2.7.4 Tidal and Sea Level Rise

The Intergovernmental Panel on Climate Change (IPCC) (Fifth Assessment Report) notes that global mean sea level has risen significantly since the Industrial Revolution (ending in the mid-1800s) when accurate records regarding sea level were first kept (circa 1870s). The Charleston

Harbor tide gauge has been measuring sea level since 1899 and continuously since 1921. In that nearly 100-year time span, local sea level has risen 1.07 feet.

The IPPC Fifth Assessment Report also notes that the rate of sea level rise has not been constant from year to year. Instead, sea level rise has been accelerating at increasing rates over the last 50 years. The report projects that global sea level will rise at least 60 cm (approximately 1.97 ft) by 2100, though it may rise by significantly more than 1 m (3.28 ft) by 2100 according to some projections as sea level rise has been accelerating in recent years.

Researchers at the Virginia Institute of Marine Science identified accelerating sea level rise trends in Charleston. From 1990 to 2000, the sea level rose 1.4 inches. From 2000 to 2010, the seal level rose an additional 2 inches. From 2010 to 2020 the sea level rose 2.7 inches more. Following this curve, sea levels would rise an additional 3.2 inches by 2030 (Bartelme, 2020).

The City of Charleston has experienced a marked increase in the number of days of minor coastal flooding, commonly called nuisance, sunny day, or high tide flooding and this trend is expected to continue and accelerate. Currently, low-lying areas of the peninsula begin to flood when water levels reach 7 feet MLLW. Charleston Harbor experienced tides of 8 feet MLLW or higher only thirty-nine times throughout the past 100 years, however twenty-five of those 8-foot tides have occurred since 2015 (Diaz, 2021). Charleston experienced all-time record high tide flood occurrences in 2015 (38 days) and 2016 (50 days) (Fourth National Climate Assessment).

This study will consider the impacts that RSLR will have on the elevation of high tides under both with and without project alternatives consistent with ER 1100-2-8162, "Incorporating Sea Level Change in Civil Works Programs." Sea level rise will result in a corresponding increase in tidal and storm surge elevations. Research by climate science experts predict continued or accelerated climate change for the 21st Century and possibly beyond, which would cause a continued or accelerated rise in the sea level in the Charleston area.

2.7.5 Environmental Trends

Cities along the Eastern Seaboard of the United States, including Charleston, have witnessed seas rising faster than the global average. Researchers have zeroed in on three factors that have made this shoreline a regional hotspot of sea level rise. They include a slowing Gulf Stream, shifts in a major North Atlantic weather pattern, and the effects of El Nino climate cycles. Climate change is expected to continue into the future, potentially leading to increased ocean temperatures, ocean acidification, and changes in currents, upwelling and weather patterns.

According to the National Weather Service, there has been a general upward trend in the number of weaker tropical cyclones making landfall in the Charleston vicinity and a general downward trend in the number of major (Category 3 – 5) land falling hurricanes (NOAA, Tropical Cyclone History) (Figure 2-3). The increased frequency of minor tropical cyclones is expected to continue in the future. When major hurricanes do occur, they are expected to be more intense due to increased ocean temperatures. Additionally, tropical cyclones that do not make landfall can still cause storm surge impacts on the peninsula.

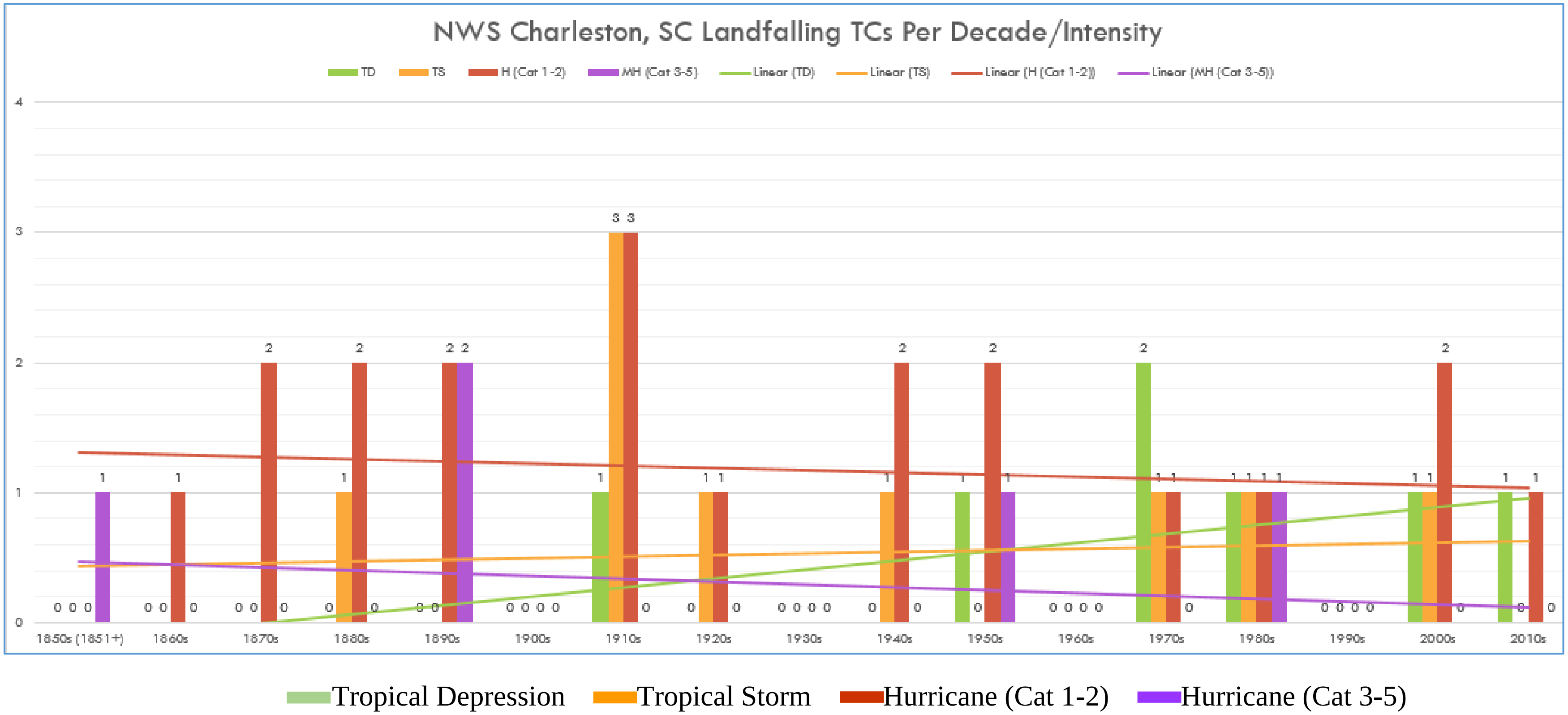

Figure 2-2. Charleston, SC, Landfalling Tropical Cyclones by Decade. Source: National Weather Service.

Habitat loss is the most important factor contributing to species decline in South Carolina (SCDNR, 2021). Historically, wetlands on the peninsula were filled to make way for development, limiting and fragmenting habitat. Current trends in shifting climate regimes and salinity profiles, rising sea levels, and increased coastal storms, combined with development pressures, will continue to impact the quantity and quality of remaining natural habitat on the peninsula. For example, while tidal marshes have adapted to fluctuating water levels and periodic inundation, there is concern regarding storm-induced erosion to existing marshes and inundation from rising sea levels. Most of the salt marshes around the perimeter of the peninsula do not have the ability to migrate inland as they erode at the edges or as water levels rise because they are restricted by roads, culverts, and other infrastructure. Salt marshes in some areas around the peninsula could be extirpated in the future due to sea level rise where there is limited ability for them to migrate or otherwise adapt. Marshes provide other benefits to people such as storing runoff and improving water quality (these are discussed more in Section 4.6 on Wetlands), and these benefits would also be lost if marshes are lost.

Historic and cultural resources will continue to be at risk from storm surge events. A major draw for tourism is the historic architecture associated with the Charleston Old and Historic District (COHD), which encompasses a large portion of the southern peninsula. The COHD contains primarily residential buildings in addition to commercial, religious, and government-related buildings. The great concentration of eighteenth and nineteenth-century buildings give the district a feeling of an earlier America. In the future without-project scenario, assuming a high rate of sea level rise in the year 2082, approximately 54% of historic structures are at risk from inundation during a 20% annual exceedance probability storm surge event.

2.8 Multiple Layers of Resiliency

Resiliency increases when there are multiple layers incorporated in any risk management project and this is especially true in coastal storm risk management planning. In this study a combination of coastal storm risk management measures – structural and nonstructural – are being investigated. Natural and nature-based features can also contribute to storm resiliency, but they must be economically justified to be included in the National Economic Development plan. In addition to this study, the City of Charleston is increasing freeboard recommendations for new facilities and infrastructure to 2 to 3 feet above base flood elevation, incentivizing private property owners to implement green infrastructure, conducting a vulnerability analysis to inform the Comprehensive Plan Update and revaluation of the City’s zoning ordinance, and creating design guidelines for retrofitting historic buildings and assisting property owners in developing resilient design solutions. In addition, the City has numerous projects either completed, underway, or planned to improve stormwater drainage on the peninsula.

2.9 Risk-Informed Decision-Making Framework

In compliance with the Director's Policy Memorandum dated May 8, 2018 (DPM 2018-05) and the Planning Manual, Part II: Risk Informed Planning (IWR 2017R03), this study follows the risk informed process for identifying a plan to address study objectives. Risk and uncertainty assessments have been incorporated into the six-step planning process to inform the decisions made during the process. One key aspect to this paradigm is that evidence gathering is limited to the information needed to make the next planning decision and that evidence gathering continues throughout the process. The assumption is that good planning decisions can be made with limited time and resources. Another important aspect of the process is to conduct multiple iterations of the six-step process throughout the study and have the team and decision-makers assess the risks identified before proceeding.

2.9.1 Key Uncertainties

There are several uncertainties that affect existing, future without and future with project conditions. For example, current and accurate data on surficial geology and the performance of the city's stormwater drainage system is not available. However, risk-informed assumptions can be made to mitigate risk and uncertainty and move forward with the six-step planning process. Key uncertainties include:

- Performance of the city's existing and reasonably foreseeable drainage system;
- Future improvements to port facilities (particularly Union Pier);
- Subsurface conditions particularly along the perimeter of the peninsula;
- The exact location of some buried utilities given the age of the city's infrastructure;
- Unknown buried archaeological resources;
- The rate of relative sea level rise on the peninsula (which takes subsidence into account); and
- Timing, duration, or frequency of storm activity.

2.9.2 Managing Risk

Using the USACE risk informed planning process, relative sea level rise (RSLR) is considered by running coastal storm scenario models using USACE derived high, low and intermediate rates for changes in RSLR to determine the sensitivity of a plan's ability to meet the objectives of the study to changes in RSLR. The future condition for the economic considerations was performed using the USACE intermediate rate for the 50-year economic life ending in 2082 as 1.65 feet for the purposes of hydraulic modeling. The 100-year adaptation range for the project into the future (year 2132) would be 3.19 feet for the intermediate rate of RSLC and 8.71 ft for the high rate. In their 2022 Sea Level Rise Technical Report, NOAA includes five possible scenarios of global sea level rise by 2100: Low (1 foot; 0.3 meters), Intermediate Low (1.6 feet; 0.5 meters), Intermediate (3.3 feet; 1.0 meter), Intermediate High (4.9 feet; 1.5 meters), and High (6.6 feet; 2.0 meters). The sensitivity analysis performed in this study allows for adaptability in the plan that covers even the High prediction in the NOAA report, buying down that risk.

Risk informed decision making affected other aspects of plan formulation. The conservative assumption that no subsurface drainage system is in place ensured that the selected plan would include pump systems that could manage all wall-induced flooding during a storm event. Once the City's plans are better developed, the performance of city stormwater drainage can be added to the model to reduce the load on, and therefore the size of, the proposed pumps. Risks such as the location of unknown archeological sites have been accounted for through the use of a Programmatic Agreement which details the monitoring and response efforts if and when such unanticipated cultural resources are encountered. Regarding the discovery of buried utilities, surveys to locate utilities and other subsurface conditions have been budgeted for completion during PED and prior to construction. Finally, because there is no way to know the timing, size, direction, or duration of a future storm, modeling included a wide array of storm types and sizes, from multiple directions, and on differing tide levels allowing for the selection of a plan that would be effective in a variety of conditions.

CHAPTER 3 - Conceptual Measures and Alternatives

This chapter describes the identification of management measures and formulation of alternative plans to address the study objectives identified in Section 2.5. Study objectives are repeated here for reference:

- Reduce risk to human health, safety, and emergency access from coastal storm surge inundation on the Charleston Peninsula over the 50-year period of analysis of 2032 – 2082.
- Reduce economic damages resulting from and increase resilience to coastal storm surge inundation on the Charleston Peninsula over the 50-year period of analysis of 2032 – 2082.

The first iteration of the six-step planning process was conducted on October 16, 2018, with study team members and staff from the City of Charleston. The primary outcome of this iteration was the identification of problems, opportunities, objectives, and constraints as described in Chapter 2. Participants also brainstormed management measures to address study objectives. More than 20 management measures were identified for consideration in formulating alternatives, which are described in Section 3.1 below. Major data gaps were also identified, such as economic inventory data sets and specific event floodplains.

A second planning iteration was conducted on November 6, 2018, with study team members, the City of Charleston, and over 20 stakeholders. This iteration resulted in validation of the problem statements, opportunities, objectives, and constraints with minor alterations. The iteration produced an array of alternatives using formulation strategies to address the planning objectives. These alternatives are described in section 3.2 below. The initial array of alternatives were formulated in spite of known data gaps, then refined throughout the planning process as information was collected and developed.

3.1 Management Measures

A management measure is a feature or activity at a site, which addresses one or more of the study objectives. Coastal storm risk management measures consist of three basic types: structural, nonstructural, and natural or nature-based features, and the initial array of alternatives consist of a variety of each type. Following USACE planning methodology, the construction and performance qualities of management measures and the dependencies and interactions among these measures are considered over both the short- and long-term. The following measures cover those identified by USACE as potential storm surge risk management measures or identified by agencies and the public in the initial planning iterations in the fall of 2018, in response to the draft FR/EA released in April 2020, and as part of the EIS scoping in the spring of 2021.

Structural measures have historically been the technique most desired by the general public, as they modify flood patterns and "move floods away from people." Structural coastal flood risk management measures are constructed features that counteract a flood event by reducing the hazard or influencing the course or probability of occurrence of the event. Structural measures are features such as levees, flood walls, and gates that are implemented to reduce risk to people and property.

Nonstructural management measures basically "remove people from floods," leaving flood waters to pass unmodified. Nonstructural measures differ from structural measures in that they focus on reducing the consequences of flooding instead of focusing on reducing the probability of flooding. Nonstructural coastal flood risk management measures are permanent or contingent measures applied to a structure and/or its contents that prevent or provide resistance to damage from flooding. Relocation, buyout/acquisition, floodproofing, home elevation, and flood warning systems are examples of nonstructural measures.

Natural or Nature-Based Features (NNBFs) refer to the use of landscape features to provide flood risk management benefits of reduced damages to people and property from flooding and erosion, including processes that contribute to these (Bridges et al., 2021). Examples of coastal NNBFs include beaches and dunes; vegetated coastal environments such as maritime and mangrove forests, salt marshes, tidal freshwater wetlands, and seagrass beds; coral and shellfish reefs; and barrier islands. For this study, NNBFs that attenuate waves and or slow and store tidal flooding such as living shorelines, raising marsh surfaces, and historic creek restoration were identified by stakeholders for consideration.

3.1.1 Professional Assessment of Management Measures

During initial iterations of the plan formulation process, no scenarios are modeled, and no new data is produced. Instead, the knowledge of the study team and the knowledge of agencies and stakeholders are used to brainstorm management measures. In addition to the initial planning iterations in the fall of 2018, the measures in the following sections also reflect comments received on the April 2020 draft FR/EA and the EIS scoping process. Existing knowledge or professional judgement is also used to assess individual measures based on a set of criteria. For this study, measures were assessed based on the measure's effectiveness of meeting study objectives, constructability (the degree of difficulty to construct or implement the measure), cost efficiency (the relative costs and outcomes of different measures), and USACE policy compliance. Sections 3.1.2 – 3.1.4 describe the study team's professional assessment for each measure in terms of whether to screen or retain the measure for further consideration, potentially in combination with other retained measures. However, measures may only be combined if they are interdependent and must function together to achieve coastal storm risk reduction benefits. Measures that are separable, or not technically interdependent, must be individually justified to be included in the National Economic Development plan. For example, the addition of salt marsh behind a breakwater would not be considered interdependent or inseparable since the salt marsh is not required for the breakwater to function and the salt marsh would not be economically justified on its own.

3.1.2 Structural Measures Considered

Charleston Harbor Storm Surge Barrier System (also referred to as Regional Storm Surge Barrier System)

The Charleston Harbor Storm Surge Barrier System would be a coastal defense system that would reduce risks from storm surge inundation for inland areas. The defining feature of this conceptual system is a large floodgate that would close across the Charleston Harbor prior to a storm and reopen to facilitate transport of goods and boats and allow natural movement of tides. A series of floodwalls or levees and additional gates would be necessary for the system to function. The primary alignment of the Charleston Harbor floodgate would be from Mt. Pleasant to James Island to minimize other flow paths, although storm surge would move inland via the Stono River and the Atlantic Intracoastal Waterway, requiring additional gates (see Figure 3-1).

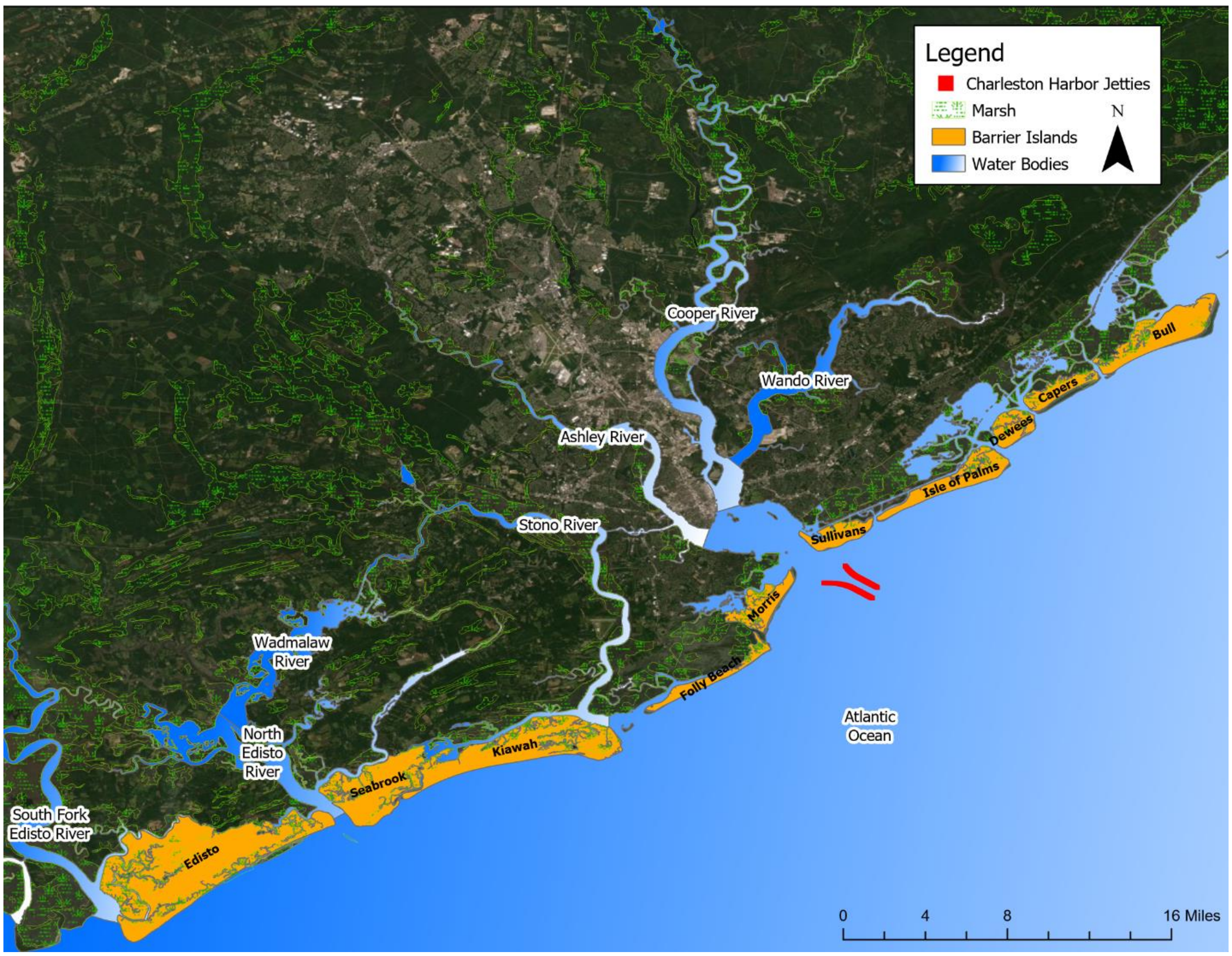

Figure 3-1. Coastal features considered for the Charleston Harbor Storm Surge Barrier System. Official mapping product of the Management Support Branch, Charleston District, USACE.

Professional assessment: The cost and maintenance of this measure would be extremely high and complicated by riverine flooding due to rainfall associated with coastal storms.

Status: Screened from consideration based on constructability and cost efficiency. For additional rationale to support this screening decision, see the excerpt from the Dutch Dialogues Charleston Final Report below.

DUTCH DIALOGUES CHARLESTON – CHALLENGES TO A REGIONAL STORM SURGE BARRIER SYSTEM
During the Dutch Dialogues Workshop, we noted [the following] important challenges: • Jetties aligning the ship channel into the Charleston Harbor negatively impact coastal geomorphology, causing erosion and land loss on the western (Morris Island) side and sand accretion on the eastern (Sullivan's Island) side. Sand nourishment / supplementation on western side would be needed to support barrier infrastructure. • The narrows between Morris Island and Sullivan's Island near Fort Sumter exceed a mile in width. Full hurricane protection for the peninsula and port would require an extended land bridge combined with a navigable storm surge barrier. Such a barrier would be comparable to the conceptual designs made for the Verrazzano Narrows in New York and for Bolivar Roads / Galveston Texas. These designs combine both vertical lift and floating sector gates. • While such barriers are feasible, designing, constructing and maintaining them would be complex and expensive. Residual stormwater and some tidal risks would remain and not all ecosystem and environmental impacts could be mitigated. • Two additional, smaller barrier structures would be needed on the Wadmalaw and Stono rivers.

Wave Attenuation Structure

A wave attenuation structure would be constructed in the Charleston Harbor to protect the peninsula from the force of waves, reduce loading on seawalls, and reduce the effect of waves overtopping seawalls during storm events. For the purposes of this study, the wave attenuating structure is assumed to be a breakwater made of granite stone or rubble mound. If this measure is incorporated into the recommended plan, other types of wave attenuating structures may be considered during the Preconstruction, Engineering, and Design (PED) phase, such as a nearshore berm made of dredged material or a manufactured breakwater.

Professional assessment: This measure may be a cost-effective way to reduce damages from coastal storm surge inundation.

Status: Retained for further consideration.

Perimeter Storm Surge Wall

A storm surge wall is designed to limit storm surge inundation behind the wall. The proposed alignment for the storm surge wall is along the perimeter of the Charleston Peninsula with the potential to incorporate the existing Low Battery and High Battery Seawall. In the early stage of the planning process, multiple types of walls were considered as a perimeter storm surge wall. An upland coastal floodwall for the Charleston Peninsula could be either I-wall or a T-wall. Per EC 1110-2-6066, *Design of I-Walls*, it was determined that any wall that is six feet or less in height could be an I-wall and any wall that was six feet or more would be a pile supported T-wall. I-walls would be concrete-capped cantilevered sheet pile walls. However, for RSLR adaptation purposes, it is assumed that T-walls would need to be used. T-Walls would be traditional concrete stem walls with pile supported bases. T-Walls would be designed in accordance with EM 1110-2-2502, *Retaining and Flood Walls*. In the marsh, the storm surge wall would be a combination wall (combo-wall), which consists of continuous vertical steel piles on the storm surge side and battered steel pipe piles on the other side, connected by a concrete cap.

Professional assessment: This measure may be a cost-effective way to reduce damages from coastal storm surge inundation.

Status: Retained for further consideration.

Rehabilitate and Raise Low Battery Wall

The Low Battery Wall is an existing concrete wall that reduces the impacts of storm surge inundation on the Charleston Peninsula. The Low Battery Wall extends approximately 0.9 miles in the general east-west direction along the left bank of the Ashley River. At its eastern end near the southeastern tip of White Point Gardens, the Low Battery intersects with the High Battery. At this location, concrete stairs provide pedestrian access up the approximately 3.5 feet from the top of the Low Battery sidewalk to the High Battery walkway. The city is currently implementing the Low Battery Seawall Project to reconstruct and raise the elevation of the Low Battery Seawall. Figure 3-2 shows the vicinity of the project.

Professional assessment: The city is already constructing this measure.

Status: This measure will be included in the future without-project condition scenario.

Figure 3-2. The Low Battery Wall is currently being rebuilt and raised by the City of Charleston.

Ringwall

Ringwalls are floodwalls or levees constructed to hold floodwaters back. The primary difference between a ringwall and a storm surge wall is scale. Whereas a storm surge wall protects a large area (e.g., a community) a ringwall is considered for individual structures or a small grouping of structures. Generally, a ringwall is located in close proximity to the building(s) it is protecting.

Professional assessment: Ringwalls around individual structures or small groupings of structures would not be an efficient or effective way to meet study objectives. A series of ringwalls throughout the study area would result in increased overall linear mileage of constructed wall and would not address accessibility of critical facilities, emergency services, and evacuation routes.

Status: Screened from consideration based on effectiveness, cost efficiency, and potentially non-compliance with USACE policy for single properties (see ER 1105-2-100, paragraph 3-3(b)(7)).

Deployable Floodwall

This type of floodwall is designed to deploy during coastal storms and limit storm surge inundation behind the wall. Deployable floodwall structures such as removeable panels, stop logs, or inflatable tubing may be temporarily erected along the banks of a river or estuary, or in the path of floodwaters. Some systems require a permanent base or footing, while others may be deployed without a base. This category includes permanently installed, deployable flood barriers/gates that rise into position during flooding, due to buoyancy of barrier material and hydrostatic pressure. Deployable floodwalls are usually used in locations where space is limited. Storage and maintenance of the equipment would be required, as well as personnel trained and available to deploy or construct the systems.

Professional assessment: The nature of these structures limits the size or level of protection possible, therefore the measure on its own would not be an effective way to meet study objectives. However, limited segments of deployable floodwall may be appropriate for mitigation purposes.

Status: Screened from consideration based on effectiveness.

Levees

Levees are earthen embankments along a channel or low-lying coastline constructed for the primary purpose of providing flood risk management.

Professional assessment: Because of their larger footprint, levees are only feasible where space allows. If a levee is located in an erosive shoreline environment, revetments may be needed on the waterfront side for more protection from erosion.

Status: Retained for further consideration.

Elevated Roads

This measure would involve raising existing roads using fill to serve as a levee that would limit storm surge inundation on the peninsula and potentially also limit flooding of evacuation routes.

Professional assessment: Assuming an earthen base, the footprint would be large and require considerable real estate. In addition to the high cost of real estate acquisition, modifications to access roads and existing structures would contribute to the complexity and high cost of this measure.

Status: Screened from consideration based on constructability and cost efficiency.

Canals / Flood Channels

Canals or flood channels would be designed to reduce water levels by sending excess water into non-risk areas. Canals range in size and length and can be constructed multiple ways. For example, canals could be created by recessing roads or walkways or constructed along the course of former waterways.

Professional assessment: Canal footprints would be large and require considerable real estate and bridges to maintain traffic flow, which are significant cost drivers. Additionally, canals would primarily address interior drainage issues and would not reasonably reduce coastal storm surge risk.

Status: Screened from consideration based on effectiveness and cost efficiency.

Lake Storage

There are two tidally influenced, man-made lakes on the Charleston Peninsula. Alberta Sottile Long Lake is separated from the Ashley River by Lockwood Drive. It is lined (on the bottom) and surrounded by green space, surface streets, and parking areas. Colonial Lake is slightly further inland and is also lined, and completely surrounded by walkways which function like retaining walls or bulkheads. The current depth of the Colonial Lake is approximately four to five feet. A single 42-inch diameter subterranean drainage pipe leads through the remnants of Cummings Creek to the Ashley River and provides for controlled flushing action with each tidal cycle. Perimeter walls could be constructed and/or raised at each lake to provide for additional floodwater storage. Pumps would be required to convey floodwater over the walls.

Professional assessment: Because the volume of the ocean is effectively unlimited, a storage facility at either lake would not reasonably reduce storm surge inundation risk. Pumping floodwaters into a lake and then back out again would create a significant operation and maintenance burden and with significant associated costs. In light of the limited efficacy of this measure, to the extent that such storage would be considered part of a "storm sewer system" within the meaning of ER 1165-2-21 or "basic drainage system" within the meaning of ER 1105-2-100, 3-3(b)(6), it would also be outside of USACE authority to construct.

Status: Screened from consideration based on effectiveness and cost efficiency, and potentially policy non-compliance.

Detention Basins

A detention basin is an excavated area installed on or adjacent to rivers, streams, lakes or bays to capture floodwaters and to reduce impacts of flood events.

Professional assessment: The developed nature of the Charleston Peninsula limits available space to construct a detention basin. To reduce real estate costs associated with acquisition of properties, this measure could be achieved by converting existing parks on the Charleston Peninsula into detention basins for short-term storage of storm water. However, parks near the shore are at low elevations with high groundwater levels, making them ineffective as detention basins. Parks on high ground would require a pumping system to move flood waters to higher elevations, which would be a major cost driver. Additionally, it would introduce risk to high elevation areas that typically do not flood. Other considerations include impacts to cultural and environmental resources such as archaeological sites and protected oak trees. Ultimately, a detention basin would not reasonably reduce storm surge inundation risk because the volume of the ocean is effectively unlimited. In light of the limited efficacy of this measure, to the extent that such detention basins would be considered part of a “storm sewer system” within the meaning of ER 1165-2-21 or “basic drainage system” within the meaning of ER 1105-2-100, 3-3(b)(6), it would also be outside of USACE authority to construct.

Status: Screened from consideration based on effectiveness and constructability, and potentially policy non-compliance.

Underground Cisterns

Underground cisterns and tanks could temporarily store floodwaters and reduce the impact of flood events. Industrial pumps would discharge the water at a controlled pace after the storm surge has receded. The underground cisterns could serve other purposes between floods, such as parking.

Professional assessment: The developed nature of the Charleston Peninsula, presence of existing subsurface drainage systems, and potential impacts to cultural and environmental resources make the construction of underground cisterns problematic. Because the volume of the ocean is effectively unlimited, cisterns would not reasonably reduce coastal storm surge risk. In light of the limited efficacy of this measure, to the extent that such cisterns would be considered part of a “storm sewer system” within the meaning of ER 1165-2-21 or “basic drainage system” within the meaning of ER 1105-2-100, 3-3(b)(6), it would also be outside of USACE authority to construct.

Status: Screened from consideration based on effectiveness and constructability, and potentially policy non-compliance.

3.1.3 Natural and Nature-Based Features (NNBF) Considered

Elevate Existing Marsh Wetland

The dense vegetation and shallow waters within coastal marshes can slow the advance of storm surge somewhat, and slightly reduce the surge landward of the wetland or slow its arrival time. Some of the benefits of restoring marshes with thin layer placement of dredged materials include increased surface elevation to keep pace with sea level rise over time, improved soil stability, and enhanced wetland functions that would preserve some of the natural flood abating functions for coastal storms.

Professional assessment: Marshes naturally adapt to sea level rise through a process called transgression, or migration. There needs to be sufficient area for marshes to migrate inland to naturally keep pace with the gradual, long-term rise in sea levels. However, for existing salt marshes along the perimeter of the peninsula, there are wide-spread barriers to inland migration including roads, structures, and embankments so that marsh migration is expected to be limited. Marshes can also adapt to rising sea levels by naturally trapping sediments and accreting, either vertically or horizontally. This process can be accelerated by adding NNBFs such as living shorelines (see below) or by intentionally placing a sediment source (e.g., dredged material of compatible grain size and quality) to existing marshes to increase the height of the marsh surface. While raising marsh surfaces through thin layer placement could help sustain marsh functions in the short-term, the existing marshes would still be restrained long term to inland migration. As such, thin layer placement may need to be continually applied over time to maintain the limited storm surge abatement benefits. Ultimately, elevating existing marsh wetlands through thin layer placement would provide some short-term coastal storm risk management benefits towards surge advancement reduction if a healthy marsh system is maintained, but would not be sustainable long term for the peninsula's limited wetlands in order to contribute considerably to coastal storm surge risk reduction. This NNBF would be more effective for adapting to sea level rise impacts than storm surge impacts and can be recommended for implementation by the City of Charleston.

Status: Screened from consideration based on effectiveness.

Living Shorelines

Open and exposed shorelines are prone to erosion due to winds and waves, which are accentuated during coastal storms. Open shorelines also transmit more wave run-up than protected shorelines. With living shoreline sills, wave action is reduced on shorelines by causing waves to break on the sill and dissipating wave energy, rather than transmitting it to the shoreline. Therefore, sills manage risk by maintaining a minimum distance between the waves and the shoreline, reducing exposure. This results in reduced erosion and shoreline loss from wave attack. Sills allow sediments and vegetation to fill in behind them, to further stabilize natural shorelines and expand coastal marshes. Sills can be constructed of a number of different materials, but for this NNBF, sills that are created by oyster reefs would be considered because this living shoreline technique is already used in South Carolina, shown to be effective, and meets new state regulations for living shorelines.

Professional assessment: Discussions with local experts suggested that reef-based living shorelines would not reasonably reduce coastal storm surge risk on their own (most storm surges would overtop the sills) but can help reduce transmission of wave energy to natural shorelines during storms, reducing shoreline erosion and reducing exposure to other resources in its lee. Oyster reefs are particularly effective at trapping sediments and promoting marsh expansion. The role of living shoreline sills in reducing erosional impacts to natural resources is notable and may be appropriate for mitigation purposes, but would not likely contribute to considerable reduced storm surge damages to structures.

Status: This was initially retained as a measure, but ultimately screened from consideration based on effectiveness; however, it is retained for mitigation purposes.

Restore Historical Creeks

The concept of uncovering and restoring buried streams or creeks in urbanized environments is typically a floodplain management technique that creates more space for fluvial flood waters to be stored in places where natural hydrologic patterns exist. As an NNBF for this study, historical tidal connections from the peninsula to the Charleston Harbor, Ashley or Cooper Rivers would be restored to re-create historical tidal creeks that could hold some tidal waters during coastal storms. These creeks would also drain and temporarily store overland flow of precipitation not collected by the City’s stormwater management system.

Professional assessment: Even existing tidal creeks on the peninsula are unsuitable for considerably mitigating damaging storm surge flooding from coastal storms, so this NNBF would need to be considered in combination with other structural and nonstructural measures to meet the study objectives. This NNBF would involve acquiring property in densely populated areas of the peninsula where historical creeks once flowed, removing those structures and roads, and restoring the channel of the previous creek bed. To maintain vehicular and pedestrian connections, bridges may be needed, and utility corridors would need to be redesigned. To produce NNBF benefits from restored salt marsh along the creek, additional land surrounding the creek channels would likely need to be acquired to create sloping banks and room for marsh vegetation to grow to create a sustainable salt marsh/tidal creek system. Since the original (historical) creeks were replaced with fill material, mitigation measures may be needed so not to reintroduce any contamination into the environment. Ultimately, extensive acquisition and relocation of historic structures and other infrastructure would need to be implemented, while restored tidal creeks would not contribute considerably to coastal storm risk reduction. This NNBF may be more effective for stormwater management and can be recommended for implementation by the NFS.

Status: Screened from consideration based on effectiveness and cost-efficiency.

Beaches, Dunes, Coral Reefs, Islands

These measures are all recognized in the International Guidelines on NNBF for Flood Risk Management (Bridges, et al, 2021) as coastal landscape NNBF. They were not proposed as potential measures in response to the April 2020 draft FR/EA or EIS scoping, which included experts familiar with local conditions and ecosystems. Had these measures been raised, substantial engineering and environmental issues would be anticipated. Feasibility concerns would arise given spatial constraints and the fact that these features do not naturally exist in the study area. Even assuming the technical feasibility obstacles in this setting could be overcome, to engineer such features from scratch into highly functioning and sustainable ecosystems that provide the desired storm risk reduction effect would require that land use and environmental conditions on and around the Peninsula be highly altered.

3.1.4 Nonstructural Measures Considered

Physical Nonstructural Measures

Elevate Structures

This nonstructural technique lifts an existing structure to an elevation which is at least equal to or greater than the 1% annual exceedance probability flood elevation to limit floodwaters from reaching living areas. In many elevation scenarios, the cost of elevating a structure an extra foot or two is less expensive than the first foot, due to the cost incurred for mobilizing equipment. Elevation can be performed using fill material, on extended foundation walls, on piers, post, piles, and columns. Elevation is also a very successful technique for slab on grade structures.

Professional assessment: This measure may be a cost-effective way to reduce damages from coastal storm surge inundation.

Status: Retained for further consideration.

Wet Floodproofing

Wet floodproofing is a nonstructural technique that allows floodwaters to enter an enclosed area of a structure without damaging the structure or its contents. This measure is applicable as either a stand-alone measure or as a measure combined with other measures such as elevation. As a stand-alone measure, all construction materials and finishing materials need to be water resistant and all utilities must be elevated above the design flood elevation. Wet floodproofing is applicable to commercial and industrial structures when combined with a flood warning system.

Professional assessment: This measure is generally not applicable to large flood depths and high velocity flows but may be a cost-effective way to reduce damages from coastal storm surge inundation.

Status: Retained for further consideration.

Dry Floodproofing

Dry floodproofing is a nonstructural technique that prevents the entry of flood waters into a structure. This can be done to residential homes as well as commercial and industrial structures. This measure achieves flood risk reduction, but it is not recognized by the National Flood Insurance Program (NFIP) for any flood insurance premium rate reduction if applied to a residential structure. Based on laboratory tests, a "conventional" built structure can generally only be dry flood proofed up to 3-feet in elevation. A structural analysis of the wall strength would be required if it was desired to achieve higher protection. A sump pump and perhaps French drain system should be installed as part of the measure. Closure panels are used at openings. This concept does not work with basements nor does it work with crawlspaces. For buildings with basements and/or crawlspaces, the only way that dry floodproofing could be considered to work is for the first floor to be made impermeable to the passage of floodwater.

Professional assessment: This measure has limited applicability but may be a cost-effective way to reduce damages from coastal storm surge inundation.

Status: Retained for further consideration.

Relocations

This nonstructural technique requires physically moving the at-risk structure and buying the land upon which the structure is located. It makes most sense when structures can be relocated from a high flood hazard area to an area that is located completely out of the floodplain.

Professional assessment: Relocating structures out of high flood hazard areas is an effective way to reduce risk to human health and safety and reduce economic damages. However, there are limited comparable areas that are also out of the floodplain where homes may be relocated.

Status: Screened from consideration based on constructability.

Buy-out / Acquisition

This nonstructural technique consists of buying the structure and the land. The structure is demolished, and the land is allowed to return to its natural state. Property owners would be relocated in accordance with the Uniform Relocation Assistance and Real Property Acquisitions Act of 1970 P.L. 91.646.

Professional assessment: This measure may be a cost-effective way to reduce damages from coastal storm surge inundation and might be used for highly vulnerable properties.

Status: Retained for further consideration.

Non-Physical Nonstructural Measures

Flood Warning System

A flood warning system is a way of detecting threatening events in advance in order to warn the public to take actions to reduce the adverse effects of the event. As such, the primary objective of a flood warning system is to reduce exposure to coastal flooding or remove people from the flood. Local flood warning systems are the responsibility of the local government.

Professional assessment: The National Weather Service Forecast Office in Charleston issues flood watches, warnings, and advisories. Flood warnings and evacuation notices delivered by a flood warning system are an effective way to reduce risk to human health and safety. Continued outreach and education can improve the effectiveness of the system. PB 2016-01, Clarification of Existing Policy for USACE Participation in Nonstructural Flood Risk Management and Coastal Storm Damage Reduction Measures (22 December 2015) clarifies that this measure is not within the category of nonstructural measures which meet USACE criteria for agency participation and cost-share during implementation. However, it is appropriate for further consideration by the City of Charleston.

Status: Screened from further consideration as part of a Federal plan due to policy noncompliance, but retained for further consideration by the City of Charleston.

Emergency Response Plan

An emergency response plan is a set of written procedures for dealing with emergencies that minimize the impact of the event and facilitate recovery from the event. The objective of an emergency response plan is to prevent fatalities and injuries, reduce damage to structures and content, and accelerate the resumption of normal activities. The City of Charleston currently has a Hurricane Preparedness Guide that outlines actions to take before, during, and after a coastal storm event.

Professional assessment: Emergency response plans reduce risk to human health and safety as well as property damages. Continued outreach and education can improve the effectiveness of a plan. PB 2016-01, Clarification of Existing Policy for USACE Participation in Nonstructural Flood Risk Management and Coastal Storm Damage Reduction Measures (22 December 2015) clarifies that this measure is not within the category of nonstructural measures which meet USACE criteria for agency participation and cost-share during implementation. However, it is appropriate for further consideration by the City of Charleston.

Status: Screened from further consideration as part of a Federal plan due to policy noncompliance, but retained for further consideration by the City of Charleston.

Land Use Regulations

Land use and zoning laws involve the regulation of the use and development of real estate. The basic principles of these tools are based nationally in the NFIP which requires minimum standards of floodplain regulation for those communities that participate in the NFIP. For example, land use regulations may identify where development can and cannot occur, or to what elevation structures should locate their lowest habitable floor.

Professional assessment: Land use regulations within a designated floodplain effectively reduce flood risk and flood damage. Land use regulations are the responsibility of the local government. PB 2016-01, Clarification of Existing Policy for USACE Participation in Nonstructural Flood Risk Management and Coastal Storm Damage Reduction Measures (22 December 2015) clarifies that this measure is not within the category of nonstructural measures which meet USACE criteria for agency participation and cost-share during implementation. However, it is appropriate for further consideration by the City of Charleston.

Status: Screened from further consideration as part of a Federal plan due to policy noncompliance, but retained for further consideration by the City of Charleston.

Low-Impact Development / Green Infrastructure

The term low impact development (LID) refers to systems and practices that use or mimic natural processes that result in the infiltration, evapotranspiration or use of stormwater in order to protect water quality and associated aquatic habitat. LID is an approach to land development (or re-development) that works with nature to manage stormwater as close to its source as possible and reduce the impacts of flooding. LID employs principles such as preserving and recreating natural landscape features, minimizing effective imperviousness to create functional and appealing site drainage, and treating stormwater as a resource rather than a waste product. There are many practices that have been used to adhere to these principles such as bioretention facilities, rain gardens, vegetated rooftops, rain barrels and permeable pavements.

Professional assessment: LID and green infrastructure can reduce the volume and speed of stormwater runoff, which in turn decreases property and economic damages. However, because the volume of the ocean is effectively unlimited, LID measures would not reasonably reduce coastal storm surge inundation. In addition, PB 2016-01, Clarification of Existing Policy for USACE Participation in Nonstructural Flood Risk Management and Coastal Storm Damage Reduction Measures (22 December 2015) clarifies that this measure is not within the category of nonstructural measures which meet USACE criteria for agency participation and cost-share during implementation. However, this and other aspects of stormwater management (see, e.g., ER 1165-2-21) are appropriately the responsibility of the local government and are appropriate for further consideration by the City of Charleston.

Status: Screened from consideration based on effectiveness and policy noncompliance, but retained for further consideration by the City of Charleston.

Highwater Emergency Vehicles

The purchase of high-clearance trucks to traverse highwater during storm events would support rescue efforts and bring food and water to people in need.

Professional assessment: This measure would improve access to critical facilities and emergency services. PB 2016-01, Clarification of Existing Policy for USACE Participation in Nonstructural Flood Risk Management and Coastal Storm Damage Reduction Measures (22 December 2015) clarifies that this measure is not within the category of nonstructural measures which meet USACE criteria for agency participation and cost-share during implementation. However, consistent with land use regulations and stormwater management, this measure is considered a local government responsibility and is considered appropriate for further consideration by the City of Charleston.

Status: Screened from further consideration as part of a Federal plan due to policy noncompliance, but retained for further consideration by the City of Charleston.

3.1.5 Measures Proposed in Response to the Draft FR/EIS

Certain management measures were raised in comments post-dating scoping and responding to the draft FR/EIS. None of these offered comprehensive solutions to the problem of storm surge risk reduction for the Charleston Peninsula which could serve as a stand-alone alternative. For example, in the most detailed submittal of additional measures, it is acknowledged that a storm surge wall would still be necessary in some locations (in the commenter's view), but modifications were proposed in other, sometimes specified, locations. Like other measures considered previously (see Section 3.1), these measures were assessed based on the effectiveness of meeting study objectives, constructability (the degree of difficulty to construct or implement the measure), cost efficiency (the relative costs and outcomes of different measures), and USACE policy compliance. The largely coextensive considerations relating to the Screening of Conceptual Alternatives in Section 3.4 were likewise consulted. Based upon these criteria, USACE has assessed these proposed measures or modifications of alternatives to determine whether they are reasonable in light of purpose and scope. Where applicable, overlap with previously considered measures is noted.

Vegetated Breakwater

The proposed measure would add a "living breakwater" in the area of the Battery (and potentially other locations). This would add nature-based features, such as oyster habitat and constructed marsh, into the rock barrier elements of a traditional breakwater.

Professional Assessment: As described in Section 3.4 Screening of Conceptual Alternatives, the proposed wave attenuation structure (breakwater), which was initially carried forward as a measure and as part of Alternative 3, has since been eliminated from further consideration. The "living breakwater" is essentially a variation of the previously-considered wave attenuation structure – in essence, it remains a structural measure with "green" elements added to produce environmental co-benefits. The vegetated breakwater suffers from the same basic problem as the original wave attenuation structure – it is not effective at reducing storm surge inundation, which is a primary objective and purpose of the study but would reduce such things as wave action and long-term maintenance of the storm surge wall. Breakwaters are a high-cost measure without commensurate storm surge risk reduction benefits because they would still require an adjacent wall or levee (see discussion of levees, below). This proposal may have stemmed from the inclusion earlier in the NEPA process of a breakwater off of the Battery in the tentatively selected plan. See also Appendix I Response to Comments, Table 1-4, Submittal #1.

Status: This proposal is not reasonable in light of the foregoing and considering project purpose and objectives. However, living shorelines have been carried forward as part of the Recommended Plan, and the agency has committed to further consideration of additional opportunities for these and other coastal NNBFs that are appropriate for the study area in the PED phase.

Removable Floodwall Panels

Glass panel floodwalls or removable flood panels could be added to a storm surge wall or seawall to provide additional levels of protection and prevent overtopping, while limiting viewshed disturbance and blending with the area's historic nature.

Professional Assessment: The proposal for glass or removable floodwall panels is quite similar to the Deployable Floodwall measure previously screened from further consideration in Section 3.1 due to lack of effectiveness. When considered for large sections of storm surge wall, glass or removable (a/k/a deployable) floodwall panels would be ineffective as they would present labor-intensive installation and maintenance requirements, present potential sealing issues at each joint between panels, and require storage facilities. As such, they would be risk and cost multipliers. See also Appendix I Response to Comments, Table 1-4, Submittal #1.

Status: While this proposal is accordingly not reasonable for any substantial section of storm surge wall, permanent or removable glass panels (or other deployable barriers) could be considered in the PED phase for limited portions of the wall to achieve cultural resources and/or aesthetic mitigation.

Levee and Lockwood Drive Modifications

A multi-phase proposal was submitted for the Lockwood Drive Corridor. Phase 1 consisted of what was described as a "horizontal levee" (earthen levee plus enhanced or created salt marsh), plus a series of small breakwaters. A horizontal levee is a form of levee that blends a traditional earthen levee with the restoration of tidal marshes, The horizontal levee would consist of a standard levee (impermeable core, fill, slopes, etc.), but with a gentler slope on the river side to encourage salt marsh establishment and growth over time. The horizontal levee would be constructed along the southern portion of Lockwood Drive and extend north to the City Marina. From here, an earthen berm would wrap the outer edge of the City Marina and connect to the

Corps' proposed seawall at the intersection of Lockwood Drive and the James Island Expressway. Phase 2A would construct a levee to encapsulate Lockwood Drive by cantilever or tunnel. The levee would provide storm surge risk reduction, while on top of the levee would be park space and recreation areas with views of the Ashley River. Phase 2B would eliminate Lockwood Drive altogether in favor of park or pedestrian access.

Professional Assessment: Levees, the primary recommendation of both phases of this proposal, were considered as a structural measure in Section 3.1.2. It is noted that levees are structural measures which may have some "green" elements added with environmental co-benefits, but they would not be considered NNBF. While levees were retained for further consideration, they are only feasible where space allows because of their larger footprint. This would be difficult in many areas of the heavily developed peninsula and could require otherwise unnecessary condemnation of multiple properties, possibly including historic structures. A horizontal levee would require an even larger footprint than a traditional levee in order to achieve the "gentle slope" and still reach the necessary elevation for storm surge risk reduction. In this case, a large amount of real estate would need to be acquired to accommodate a footprint for a traditional levee (potentially even larger for a horizontal levee). Since this portion of the peninsula is fill material, a levee large enough to reduce storm surge damages would likely be subject to subsidence, which would result in maintenance and performance issues, and added costs. Constructing a levee in this location would also require filling some existing wetland habitat and result in adverse impacts, which would in turn require additional mitigation cost. The destruction of saltmarsh for a co-benefit of restoring saltmarsh with the horizontal levee may not be an acceptable environmental tradeoff. The concept of a horizontal levee is also premised on there being an extensive saltmarsh seaward of the levee, when only relatively small areas of fringing saltmarsh still exist along Lockwood Drive (some of which would be filled for the levee). The proposal for Phase 1 notes that the lanes for that portion of Lockwood Drive adjacent to the levees would need to be reduced from 4 to 2 to accommodate levee size, despite Lockwood Drive having been identified as a critical transportation artery by the City. Enhancement or creation of wetlands as a management measure was screened out due to limited effectiveness at addressing storm surge (Section 3.1.3). Phase 2 would expand the already significant footprint of the levee to encapsulate or eliminate this section of Lockwood Drive. In order to encapsulate Lockwood Drive without also elevating the roadway (a measure which was screened out in Section 3.1.2 due to constructability and cost-efficiency concerns), the Phase 2A rendering indicates a lowering of the roadway which could present comparable constructability and cost-efficiency concerns. The complete removal of this section of Lockwood Drive would sever a critical transportation and evacuation artery. See also Appendix I Response to Comments, Table 1-4, Submittal #1.

Status: This two-phase proposal is not a reasonable modification of the Recommended Plan. Levee constructability is a problem in this location because of limited space and potential subsidence issues; lowering the roadway would also present constructability issues. The proposal is problematic from a cost-efficiency perspective, as it goes well beyond what is necessary to achieve the purpose of reducing risk to coastal storm surge and requires a greater footprint (not only for the levee, but due to additional features, such as breakwaters). Reducing or eliminating a section of Lockwood Drive, an identified transportation artery for evacuation, would undermine the objective of reducing risk to emergency access. To the extent that additional real estate acquisition would require the removal of or additional impacts to historic structures, this would violate a project constraint. However, levees in general are retained as a measure for consideration in PED at limited locations of the proposed alignment where sufficient space is available and environmental conditions are suitable, and potentially as an aesthetic mitigation measure.

Rosemont Resilience Measures

Among the recommendations proposed specific to Rosemont were the following: a horizontal levee and integrated earth berm or deployable barrier; develop, fund and implement a community resilience plan with community input; and construct blue/green infrastructure (a water management approach that incorporates both natural areas and engineered systems, such as permeable pavement, roadside swales, and rain gardens).

Professional Assessment: The Recommended Plan's rationale for proposing nonstructural measures for Rosemont has largely to do with the impact of constructing a wall, regardless of whether it is a storm surge wall or a levee, at this location. Upland construction of a wall would require involuntary buyouts and removal of homes in order to accommodate the footprint of the wall – something USACE has sought to avoid throughout the study area. As noted above, levees require a substantially larger footprint than a wall, which would in turn lead to an expanded requirement for involuntary buyouts or removal of homes, and likely additional wetland impacts where access to the saltmarsh is highly valued by this community. Further, given the need for a perimeter barrier to largely encapsulate the neighborhood (be it a wall or levee) coupled with the lack of subsurface drainage throughout Rosemont, a significant bathtub effect would be created which would require mitigation by large pump stations at the end of most streets, which would in turn require significant real estate acquisition or condemnation. Regarding deployable barriers, please see the discussion of Removeable Floodwall Panels, above.

Developing, funding, and implementing a community resilience plan would fit within the category of Nonphysical, Nonstructural Measures Considered in Section 3.1.4. These measures are within the responsibility of the local government and generally not within USACE criteria for agency participation and cost-share during implementation.

Blue-green infrastructure fits within a measure previously considered in the draft FR/EIS and there described as "Low-Impact Development/Green Infrastructure." While it could reduce the volume and speed of stormwater runoff, it would not reasonably reduce coastal storm surge inundation, and is within the responsibility of the local government and generally not within USACE criteria for agency participation and cost-share, and is an area specifically identified as the responsibility of the local government.

See also Appendix I Response to Comments, Table 1-4, Submittal #1.

Status: These resilience measures for the most part represent measures already considered and screened, as described above, for effectiveness and policy non-compliance. As discussed in Section 3.3, below, a perimeter barrier presents particular feasibility and implementation problems for Rosemont. Accordingly, these are collectively not considered a reasonable modification to the Recommend Plan's approach to storm surge risk reduction in Rosemont; however, both USACE and the City are committed to continuing to explore specific opportunities for mitigation and resilience measures during PED, commensurate with their respective legal authority.

3.2 Formulation of Strategies

This section describes the process for formulating alternative plans from the measures described in Section 3.1 which were retained for further consideration. A formulation strategy is a systematic way of combining measures into alternative plans based on planning objectives. No single formulation strategy will result in a diverse array of alternatives, so a variety of strategies is needed. During the first planning iteration, the study team considered that there are basically three structural strategies to control floodwater: store it, divert it from inundating a specific area, or convey it to another area. Using these three strategies, alternative plans were formulated. During the second planning iteration, spatial and historical aspects were added to the strategies to address conditions specific to the Charleston Peninsula. However, when the study team determined that measures related to storage and conveyance (including historical creek restoration) would not reasonably reduce storm surge inundation, these measures were screened from further consideration (see previous Section 3.1) and alternatives that were developed using those strategies were likewise removed from consideration.

For this study, the following strategies were used in formulating the initial array of alternatives:

- Diversion – This strategy focused on measures that would divert floodwaters from damageable property. Since the primary concern is floodwater from coastal storm surge and not riverine sources, the measures were variations of in-water and shoreline-based barriers.
- Nonstructural – This strategy focused on measures and actions that would allow the Charleston Peninsula to live with the flood waters. Nonstructural measures are permanent or contingent measures applied to a structure and/or its contents that prevent or provide resistance to damage from flooding. Nonstructural measures differ from structural measures in that they focus on reducing the consequences of flooding instead of focusing on reducing the probability of flooding.
- Spatial – This strategy focused on applying different management measures to specific areas of the peninsula. For example, nonstructural measures would be applied to areas where construction of a structural barrier is constrained by other considerations.

3.3 Initial Array of Conceptual Alternatives

No Action Alternative

The No Action Alternative assumes that no actions would be taken by the Federal Government to address the problems identified by the study. Consequently, the No Action Alternative would not reduce damages from coastal storm surge inundation. Although this alternative would not accomplish the purpose of this study, it must always be included in the analysis and can serve several purposes. The No Action Alternative will be used as a benchmark, enabling decision makers to compare the magnitude of economic, environmental, and social effects of the actionable alternatives. Additionally, the No Action Alternative leads to the future without project condition. The following paragraphs highlight key assumptions for the No Action Alternative / future without project condition.

Population growth is expected to continue over the next 50 years in the Charleston area, putting more people at risk of storm surge inundation. Effects of climate change such as rising sea levels and increased frequency and intensity of coastal storms are expected to continue and accelerate. The City of Charleston will use established planning frameworks to guide future development and will also complete multiple projects such as raising the Low Battery Wall, drainage improvement projects, and installation of check valves on existing stormwater outfalls. This will have a positive effect on shallow coastal flooding from rainfall or tidal events and on compound flooding; however economic damages and impacts to human health and safety from storm surge inundation are expected to increase in the future.

Predicted climate change impacts, such as increased ocean temperatures, ocean acidification, sea level rise, and changes in currents, upwelling, and weather patterns have the potential to affect the nature and character of estuarine and coastal ecosystems in and around the study area. Climate change and associated sea level rise have the potential to cause permanent impacts to salt marshes and local fauna with changes in salinity regimes. Wetlands surrounding the peninsula are at risk of elimination due to sea level rise when they can no longer adapt and retreat inland. Shorelines that are not protected, like Brittlebank Park, will be subject to erosion. The High Battery could become unsafe if erosion, scour, and wave attack damages the aging structure.

As sea level rises and storm surge affects the study area more frequently and with increasing intensity, the landscapes and structures at the rivers and harbors edge will increasingly experience storm surge damages. Those parts of the urbanized landscape closest to the water's edge would need to be periodically rebuilt or restored after storm surge events. If the structures are not restored, the visual quality of the landscape would progressively degrade. Tourism facilities including commercial, institutional, ecclesiastical, and other historic buildings would be closed more often and for longer periods of time due to storm surge flooding and/or recovery efforts. Individually owned residential buildings in the Charleston Old and Historic District, which is a major draw for tourism, that are not restored or repaired after a storm surge event could degrade the visual quality of the historic area. Some storm surge events, alone or in combination with others, may result in irreparable damage to historic structures.

1. Perimeter Protection Alternative

This alternative was a result of the diversion formulation strategy. This alternative consists of the following measure:

- A wall or levee along the perimeter of the Peninsula, strategically placed onshore or in marsh to reduce damages from storm surge inundation while maintaining access to property.

This wall or levee would be newly constructed and aligned to avoid or minimize impacts to existing marsh, wetland habitat, and cultural resources. The structure would be strategically located to allow for continued operation of all ports, marinas, and the Coast Guard Station. The structure would tie into the existing Battery seawall and potentially raise the seawall to provide a consistent level of performance.

A variety of different structures were considered during the early formulation process. Further analysis determined that the footprint of an earthen levee embankment was too large for the heavily developed peninsula and would require condemnation of too many properties and/or excessive salt marsh impacts. The most effective and most efficient type of structure would be a T-wall on land and a combination wall in the marsh.

Portions of the Neck Area of the peninsula would not receive perimeter protection under this alternative. In these areas, construction of a storm surge wall has generally been deemed impracticable because of challenges to its implementability and the risk of associated, excessive adverse impacts. *Implementability* means that a measure is feasible from technical, environmental, economic, financial, political, legal, institutional, and social perspectives (see ER 1105-2-100, p. E-4). Among the combination of factors considered in reaching this conclusion are topographic limitations, lack of subsurface drainage, the presence of historic landmarks, neighborhood impacts due to real estate acquisition for construction of pump stations and wall or levee, avoidance of additional wetland impacts, and the prospect of residual life/safety risk due to enclosure of certain neighborhoods.

A refined description of this alternative can be found in the Final Array of Alternatives section 3.5.

2. Perimeter Protection + Nonstructural Alternative

This alternative was formulated using a combination of formulation strategies: diversion and spatial. The management measures included in this alternative are:

- A wall or levee along the perimeter of the Peninsula
- Buyout structures

- Elevate structures
- Floodproof structures

The wall along the perimeter of the Peninsula would adhere to the same constraints and assumptions as the Perimeter Protection Alternative. For structures outside of the wall alignment, a suite of nonstructural measures including buyouts, structure elevation, or floodproofing measures could apply. In the draft FR/EIS, this alternative included an NNBF measure (+ NNBF) in the form of oyster reef-based living shoreline sills which would be constructed in appropriate locations to reduce storm impacts to natural shorelines and other resources seaward of the wall; however, upon further USACE review the living shoreline component was determined to be ineffective as a management measure in the reduction of coastal storm surge when combined with a wall, but effective in mitigating the impact of a wall on adjacent habitat.

3. Perimeter Protection + Wave Attenuating Structure + Nonstructural Alternative

This alternative was formulated using a combination of formulation strategies: diversion and spatial. The management measures included in this alternative are:

- A wall or levee along a portion of the Peninsula's perimeter
- Wave attenuating structure
- Buyout of structures
- Elevate structures
- Floodproof structures

The storm surge wall along the perimeter of the Peninsula and nonstructural measures in this alternative would adhere to the same constraints and assumptions as described in Alternative 2. A wave attenuation structure would be constructed in the Charleston Harbor to dampen waves, reduce loading on seawalls, and prevent waves from overtopping during storm events. For the purposes of this study, the wave attenuating structure is assumed to be a breakwater made of granite stone or rubble mound. If this measure was incorporated into the recommended plan, other types of wave attenuating structures would be considered during the preconstruction, engineering, and design phase, such as a nearshore berm made of dredged material or a manufactured breakwater. Additional analysis would determine the actual numbers of structures proposed for buyout, elevation, or floodproofing. In the draft FR/EIS, this alternative included an NNBF measure (+ NNBF) in the form of oyster reef-based living shoreline sills which would be constructed in appropriate locations to reduce storm impacts to natural shorelines and other resources seaward of the wall; however, upon further USACE review the living shoreline component was determined to be ineffective as a management measure in the reduction of coastal storm surge when combined with a wall, but effective in mitigating the impact of a wall on adjacent habitat.

4. Nonstructural Alternative

This alternative was formulated using the nonstructural strategy and includes both actions that can be implemented by USACE and actions that can only be implemented by the City of Charleston (shown in *italics*). This alternative would consist of the following measures:

- Buyout of structures
- Elevate structures
- Floodproof structures
- *Flood warning system*
- *Revise emergency response plan*
- *Low-impact development / green infrastructure measures*

Storm surge inundation would not be limited on the Charleston Peninsula with this alternative, but damages would be reduced due to the application of nonstructural measures to vulnerable structures. Additional analysis would determine the actual numbers of structures proposed for buyout, elevation, or floodproofing. These measures are described in greater detail above in Section 3.1.

3.4 Screening of Conceptual Alternatives

The study team performed additional planning iterations with a focus on screening alternatives that would not meet planning objectives. Without substantial data to base the screening on, professional judgment was used to assess how well alternatives met a set of criteria.

The screening criteria used in this study for the initial array of conceptual alternatives include effectiveness, efficiency, acceptability, and completeness as defined in the *Economic and Environmental Principles and Guidelines for Water and Land Related Resources Implementation Studies (Principles and Guidelines)*, by the Water Resources Council pursuant to the Water Resources Planning Act of 1965, as amended. *Effectiveness* is the ability of the measure to meet or partially meet a study objective. *Efficiency* is the extent to which an alternative plan is the most cost-effective means of alleviating the specified problems and realizing the specified opportunities, consistent with protecting the Nation's environment. *Acceptability* is the extent to which the alternative plans are acceptable in terms of laws, regulations, and public policies. *Completeness* is the extent to which a given alternative plan provides and accounts for all necessary investments or other actions to ensure the realization of the planned effects.

Study constraints were also used as a screening criterion. *Study Constraints* is the likelihood that the measure does not violate a constraint identified in Section 2.5 of this report. Table 3-1 contains an assessment of how well each alternative meets the study objectives and avoids the constraints. Table 3-2 displays how well each alternative met the four evaluation criteria as prescribed in the *Principles and Guidelines*. Table 3-2 also identifies the action alternative that was carried forward into the final array.

Each alternative in the initial array fulfills to some degree both study objectives with the exception of the Alternative 4, the Nonstructural Only Alternative, which fails to address impaired access to critical facilities, emergency services, and evacuation routes during coastal storm events, and would achieve some but not all aspects of resilience. Additionally, a buyout of vulnerable structures would violate the constraint of minimizing adverse effects to historic districts and buildings. Even widespread floodproofing and elevation of structures could have cumulative adverse impacts to historic districts on the peninsula. Although Alternative 1 addresses both study objectives, Perimeter Protection alone reduces economic damages to a lesser degree by leaving neighborhoods vulnerable to storm surge inundation where a wall is impracticable to construct. In conclusion, Alternatives 2 and 3 were assessed to be the most effective at addressing both study objectives.

Alternative 4 received an overall score of 7, which is the lowest score on the *Principles and Guidelines* evaluation criteria assessment. The alternative scored low in effectiveness because it would not adequately address risks to human health and safety as discussed in Table 3-1, and would only partially realize the opportunity to increase the resilience of the Charleston Peninsula to storm surge flooding. Alternative 4 received a low efficiency score due to the high density of high-cost structures vulnerable to storm surge inundation that would need to be treated with nonstructural measures, some of which are not susceptible to such measures (for example, medical facilities and infrastructure). Alternative 4 also received a low score in acceptability due to negative anticipated reactions from the public.

Alternative 1 also received an overall score of 9 on the P&G evaluation criteria. However, the alternative received a medium effectiveness score because while the storm surge wall is effective at reducing storm surge inundation, the neighborhoods in areas where a wall or levee is impracticable would be left vulnerable to storm surge as discussed above. Alternative 1 received a medium efficiency score because it does not capture damage reduction benefits of the nonstructural measures, and a medium acceptability score because it provides no risk reduction to certain disadvantaged neighborhoods.

Table 3-1. Assessment of How Well the Initial Array of Alternatives Meet Study Objectives and Constraints.

Alternative	Assessment	Objective: Reduce Economic Damages and Increase Resilience?	Objective: Reduce Risk to Human Health, Safety, and Emergency Access?
No Action	No action would be taken by the Federal Government to address the problems identified by the study, therefore the No Action Alternative would not reduce damages from coastal storm surge inundation or meet study objectives.	**No**	**No**
1. Perimeter Protection	The strategically placed wall or levee would reduce damages to structures by limiting storm surge inundation on the peninsula. A wall or levee would reduce risk to human life and safety by limiting road closures, thereby improving access to critical facilities, emergency services, and evacuation routes. Impacts to public health would also be reduced by limiting illness and injury associated with storm surge inundation. Perimeter protection would benefit a representative cross-section of socio-economic communities on the peninsula. However, areas where perimeter protection is impracticable would lack risk reduction.	**Yes**	**Yes**
2. Perimeter Protection + Nonstructural	Like Alternative 1, this alternative would reduce damages to structures and reduce risk to human health and safety for a representative cross-section of socio-economic communities on the peninsula, including environmental justice communities. This alternative would provide comprehensive risk reduction because nonstructural measures would be applied to residential structures in areas where a storm surge wall or levee would not be practicable.	**Yes**	**Yes**
3. Perimeter Protection + Nonstructural + Wave Attenuator	This alternative would reduce damages to structures and reduce risk to human health and safety to the same extent as Alternative 2. A wave attenuation structure in the Charleston Harbor might reduce the effect of waves from overtopping floodwalls during coastal storm events, further limiting inundation on the peninsula. The wave attenuation structure might also reduce wave loading on the Battery Wall.	**Yes**	**Yes**
4. Nonstructural Only	This alternative would reduce damages to structures by elevating, floodproofing, or otherwise acquiring vulnerable structures on the peninsula. This alternative would not address storm surge inundation that limits access to critical facilities, emergency services, and evacuation routes. It would increase some, but not all, aspects of resilience. Further, a buyout of structures vulnerable to storm surge inundation would violate the constraint of minimizing adverse effects to historic districts and buildings.	**Yes**	**No**

Table 3-2. Screening of Action Alternatives Based on Evaluation Criteria from the Principles & Guidelines (P&G).

Alternative	Completeness[1]	Effectiveness[2]	Efficiency[3]	Acceptability[4]	Score	Result
1. Perimeter Protection	High (3)	Medium (2)	Medium (2)	Medium (2)	9	Screen
2. Perimeter Protection + Nonstructural	High (3)	High (3)	High (3)	Medium (2)	11	Retain
3. Perimeter Protection + Nonstructural + Wave Attenuator	High (3)	High (3)	Low (1)	Medium (2)	9	Screen
4. Nonstructural Only	High (3)	Medium (2)	Low (1)	Low (1)	7	Screen

[1]Completeness ratings are based on the extent to which the alternative plan provides and accounts for all necessary investments or other actions to ensure the realization of the planned effects.
[2]Effectiveness ratings are based on the extent to which an alternative plan meets or partially meets a study objective.
[3]Efficiency ratings are based on the extent to which an alternative plan is the most cost-effective means of alleviating the specified problems and realizing the specified opportunities, consistent with protecting the Nation's environment.
[4]Acceptability ratings reflect the extent to which the alternative plans are acceptable in terms of laws, regulations, and public policies, and take into account anticipated reactions to project impacts from the public.

Alternative 3 received an overall score of 9 on the P&G evaluation criteria. The alternative received a high effectiveness score because the storm surge wall is effective at reducing storm surge inundation; however, after further review it was determined that the wave attenuating structure is not. Instead, the wave attenuating structure is effective at reducing impacts from wave attack and erosion, which translates to minimal inundation reduction benefits when combined with a wall. Alternative 3 received a low efficiency score because the wave attenuation measure is a high-cost measure that does not produce inundation reduction benefits in addition to the storm surge wall. The April 2020 draft FR/EA identified Alternative 3 as the plan that most reasonably maximized net benefits; however, refined engineering and economic analyses showed that the wave attenuator did not generate benefits to justify its cost, resulting in a reduced efficiency score as reflected in Table 3-2 of this report. Accordingly, since Alternative 3 without the wave attenuation structure was the same as Alternative 2, Alternative 3 was eliminated from further consideration.

In summary, Alternative 4 was screened because it did not address both study objectives and it also scored the lowest on the P&G evaluation criteria assessment. Alternative 3 was screened due to the significant inefficiency of the wave attenuator measure. Alternative 1 was screened because it did not provide a comprehensive solution for the entire study area, leaving Alternative 2 and the No Action Alternative to be carried forward to the Final Array of Conceptual Alternatives

3.5 The Final Array of Conceptual Alternatives

Based on the screening criteria and process outlined above, the final array of alternatives includes the No Action Alternative and Alternative 2 as described below. At this point in the study, additional information has been developed and incorporated into the description of each alternative.

No Action Alternative

The No Action Alternative assumes that no actions would be taken by the Federal Government to address the problems identified by the study. Consequently, the No Action Alternative would not reduce the risk of damages from coastal storm surge inundation. As noted above in Section 3.3, although this alternative would not accomplish the purpose of this study, the National Environmental Policy Act requires that it must always be included in the analysis and can serve several purposes. The No Action Alternative is used as a benchmark, enabling decision makers to compare the magnitude of economic, environmental, and social effects of the actionable alternatives. Additionally, the No Action Alternative leads to the future without-project condition, which is described in Sections 2.7 and 3.3 and each subsection of Chapter 7, under the *No Action/Future Without-Project* heading.

Alternative 2

The management measures included in this alternative are listed and shown on Figure 3-3:

- Storm surge wall along the perimeter of the Peninsula (approximately 8.7 miles)
- Nonstructural measures (approximately 100 structures)

The storm surge wall would be constructed along the perimeter of the peninsula to reduce damages from storm surge inundation. Where feasible, it would be strategically aligned to minimize impacts to existing wetland habitat, cultural resources, and private property. The wall would be strategically located to allow for continued operation of all port facilities, marinas, and the Coast Guard Station. The wall would tie into high ground as appropriate, including the shoreline near the Citadel and the existing Battery wall. Due to its age and uncertainty about the integrity of the structure, the High Battery wall would be reconstructed to meet USACE construction standards and raised to provide a consistent level of performance. This alternative would include permanent and temporary pump stations to the extent justified per USACE policy, as well as pedestrian, vehicle, railroad, boat, and storm (tidal flow) gates.

As previously noted, a storm surge wall was determined to be more appropriate than a levee due to the large amount of real estate that would need to be acquired to accommodate a significant levee footprint. Also, since much of the existing shoreline is fill material, a levee large enough to reduce storm surge damages would likely be subject to subsidence, which would result in maintenance and performance issues. On land, the storm surge wall would be a T-wall with traditional concrete stem walls and pile supported bases (Figures 3-4 and 3-4-A). In the marsh, the storm surge wall would be a combination wall (combo-wall), which consists of continuous vertical steel piles on the storm surge side and battered steel pipe piles on the other side, connected by a concrete cap (Figure 3-5). To withstand earthquakes, pilings for both wall types would be 50 to 70 feet deep to tie into the bedrock. From the center of the wall on each side, a perpetual 25-foot-wide easement is required for maintenance, plus a 10-foot-wide temporary construction easement.

To minimize erosional impacts on wetlands from the storm surge wall, oyster reef-based living shoreline sills would be constructed in appropriate locations. Pump stations would also be strategically placed to mitigate interior flooding caused by the storm surge wall.

Figure 3-3. Map showing the measures of Alternative 2 including mitigation features of hydraulic pumps and living shorelines. Official mapping product of the Management Support Branch, Charleston District, USACE.

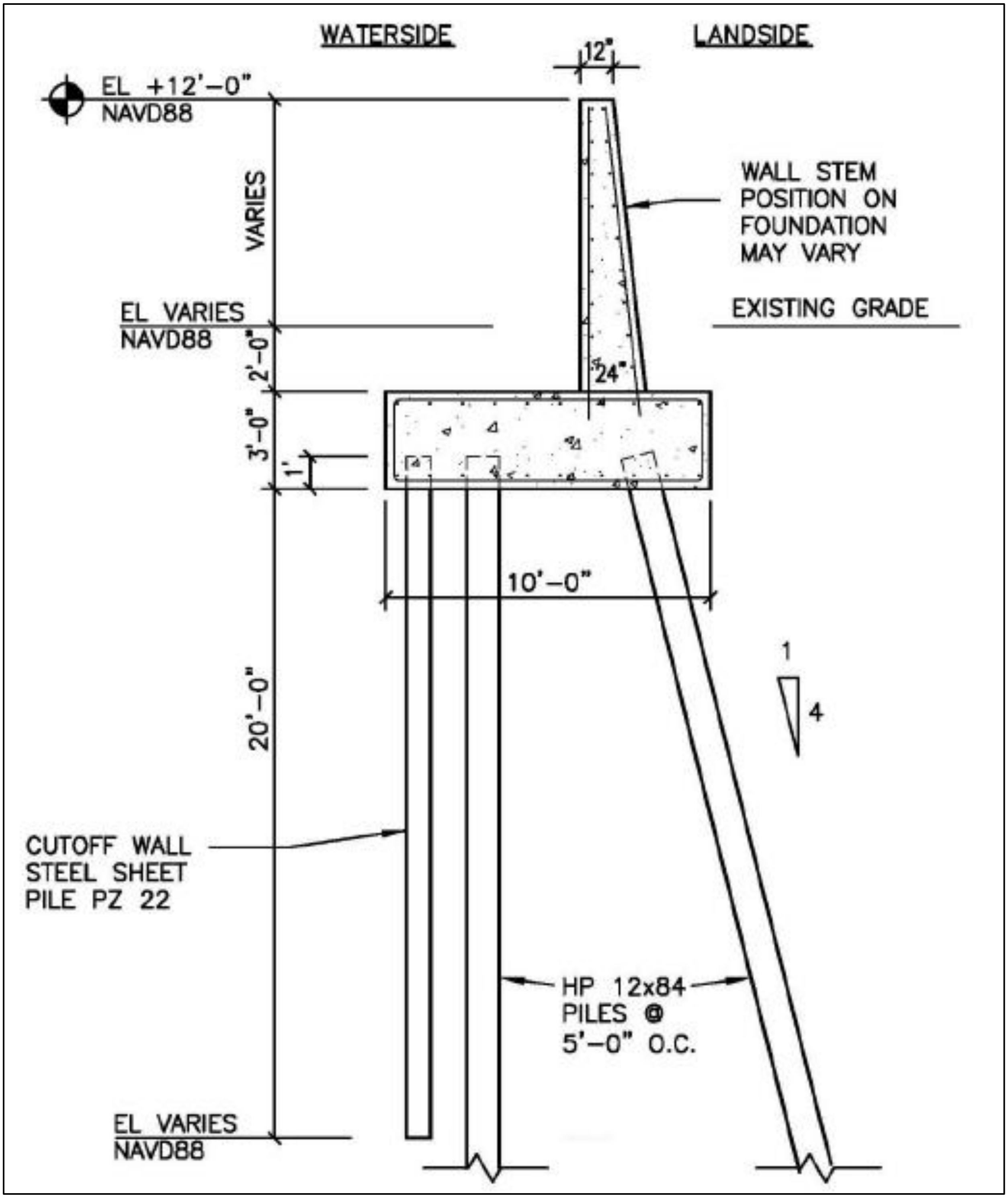

Figure 3-4. T-wall typical section.

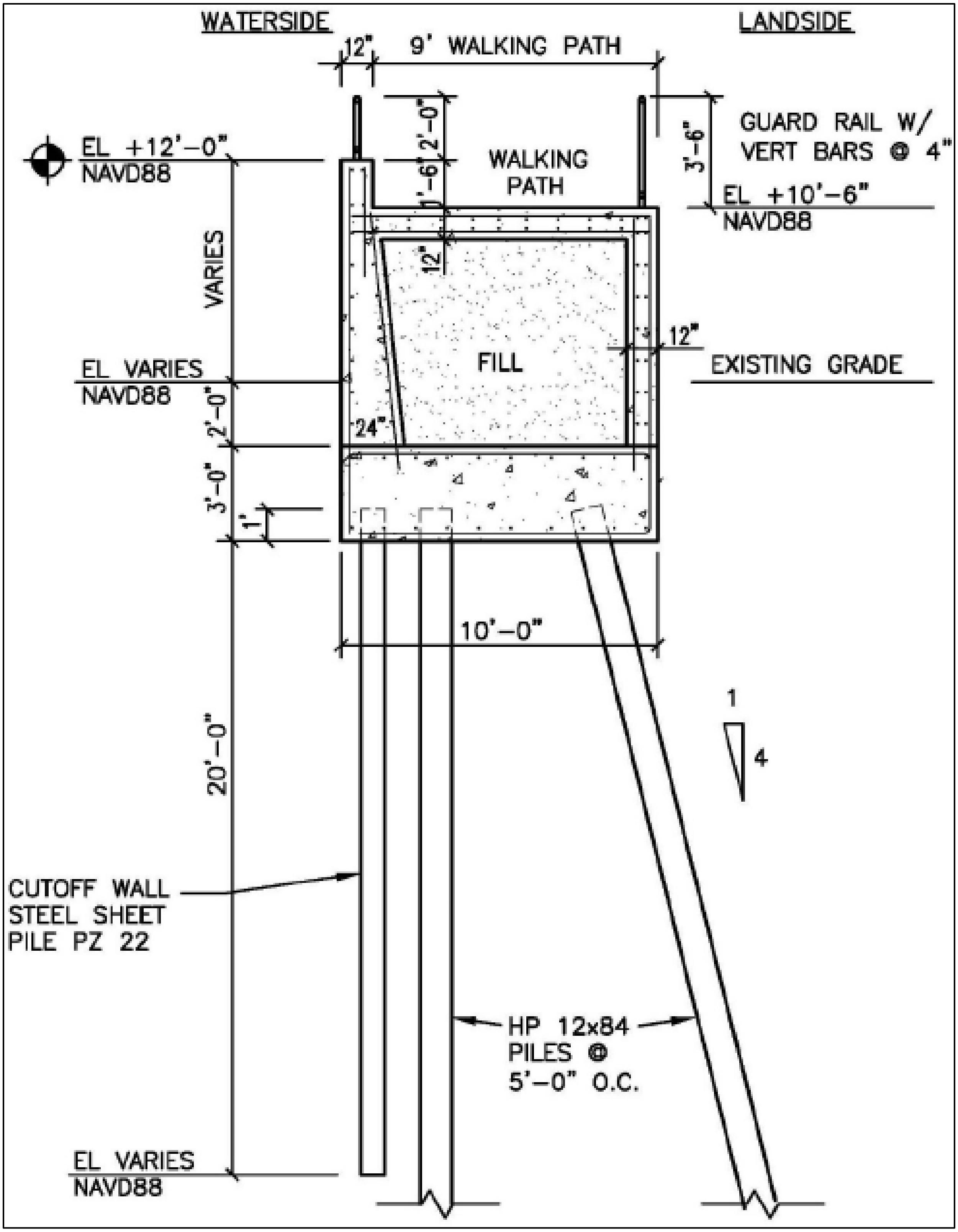

Figure 3-4-A. T-wall with walkway typical section.

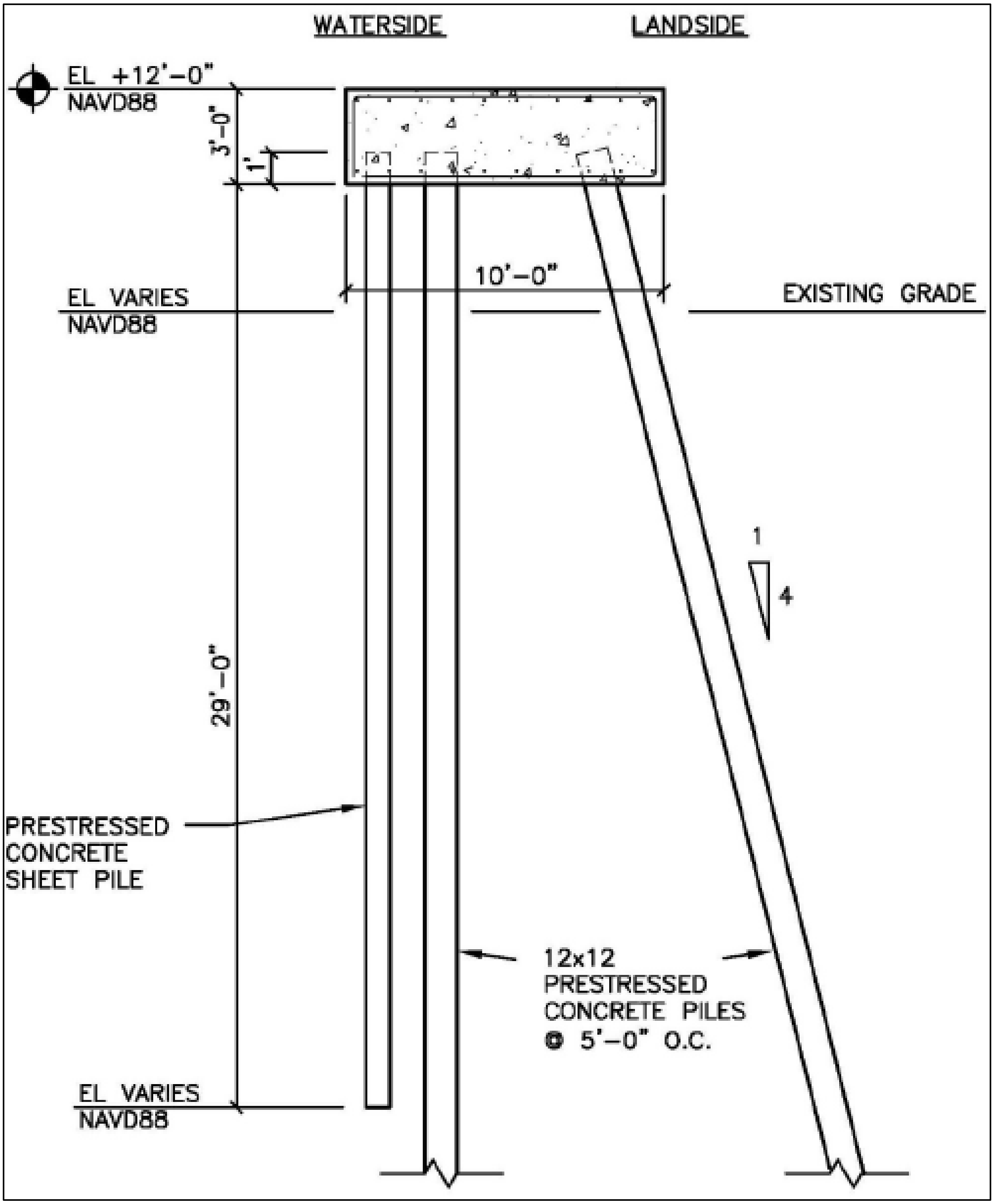

Figure 3-5. Combo-wall typical section.

3.5.1 Alternative 2 – Storm Surge Wall Considerations

Any wall lower than 12 feet NAVD88 would not reasonably maximize benefits. A preliminary analysis using rough order of magnitude costs was conducted to confirm that a smaller scale plan would not have greater net national economic development benefits. The estimated dollar figures in Table 3-3 reflect early assumptions and the best available data which have changed over the course of the study and therefore are not directly comparable to the final economic analyses presented in Chapter 8 of this report. However, the overall trend in Table 3-3 and Figure 3-6 remains valid and confirms that net benefits increase with higher design elevations. Therefore, the highest elevation feasible within topographic and infrastructure constraints (12 feet NAVD88) was selected.

Table 3-3. Preliminary net benefits were calculated to identify net benefits trends.

Elevation in Feet	Present Value Damages Reduced	First Cost	Annualized Benefits	Annualized Costs	Net Benefits	BCR
7	$1,279,621,123	$1,351,017,000	$ 47,398,343	$50,042,912	$(2,644,569)	0.95
7.5	$1,489,177,920	$1,364,205,000	$ 55,160,519	$50,531,408	$ 4,629,112	1.09
8	$1,698,734,717	$1,377,393,000	$ 62,922,696	$51,019,903	$11,902,793	1.23
8.5	$1,908,291,514	$1,390,581,000	$ 70,684,872	$51,508,399	$19,176,473	1.37
9	$2,117,848,311	$1,403,769,000	$ 78,447,049	$51,996,895	$26,450,154	1.51
9.5	$2,457,161,579	$1,456,079,500	$ 91,015,524	$53,934,524	$37,081,001	1.69
10	$2,796,474,847	$1,508,390,000	$103,584,000	$55,872,153	$47,711,847	1.85
10.5	$3,135,788,115	$1,560,700,500	$116,152,475	$57,809,782	$58,342,694	2.0
11	$3,475,101,383	$1,613,011,000	$128,720,951	$59,747,411	$68,973,540	2.15
11.5	$3,814,414,651	$1,665,321,500	$141,289,426	$61,685,040	$79,604,386	2.29
12	$4,153,727,919	$1,717,632,000	$153,857,901	$63,622,669	$90,235,233	2.42

A wall with an elevation 13 feet NAVD88 or higher was not analyzed due to topographic, infrastructure, and viewshed constraints, as well as increases in cost and impacts to the construction duration. A storm surge wall at elevation 13 feet NAVD88 or higher would require that the Low Battery Seawall, currently being repaired and elevated by the City of Charleston, would need to be demolished and replaced due to insufficient strength and stability to support higher elevations. The cost to replace the Low Battery Seawall would likely exceed $60M and would require 12 months or more to complete. Further the City's current $23M investment in rehabilitating the wall would be lost.

Along Lockwood Drive, the storm surge wall would be located beneath elevated segments of Spring Street and Cannon Street. A wall at 13 feet NAVD88 or higher would interfere with the bridge superstructures, requiring reconstruction to integrate the wall and bridges. Modifications to the bridges would likely exceed $20M. Such construction may require closing Spring Street and Cannon Street which are also US Highway 17, a major thoroughfare with high average daily

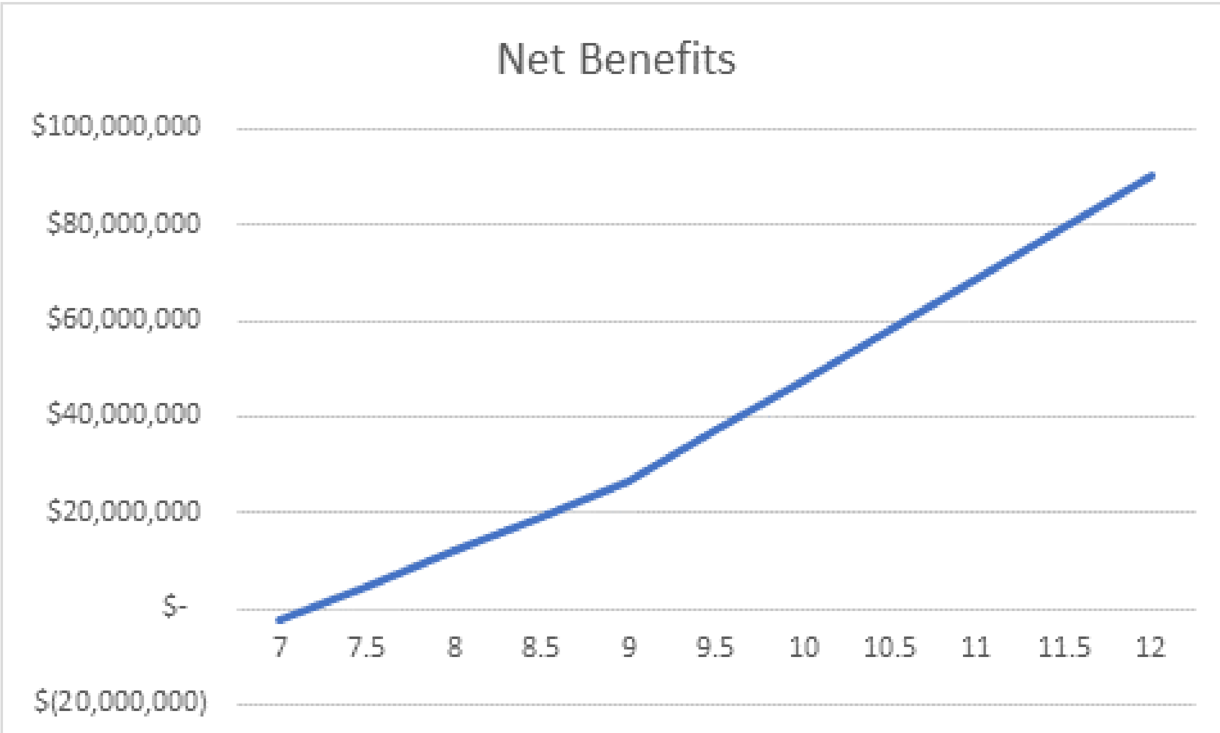

Figure 3-6. Preliminary net benefits increase with higher design elevations.

traffic and important access on and off the peninsula. Traffic disruptions would likely occur for a period of 12 months or more.

A wall with an elevation 13 feet NAVD88 or higher would eliminate opportunities to tie-in to higher ground near the Citadel Campus. This would eliminate construction phasing opportunities on the Ashley River side of the peninsula and increase the timeframe for benefits to be realized for the critical infrastructure of the medical district. The length of the wall would also increase to be able to tie into high ground or form a complete closure system. Additional vehicular gates, including a gate crossing US Highway 52, a major thoroughfare, would be required, further complicating project operations. Although not estimated, increases in cost and completion schedule would be significant.

Adding a foot of elevation to the proposed 12-feet NAVD88 wall would materially increase the construction cost along the entire length of the wall. Finally, a wall with an elevation 13 feet NAVD88 or higher would also require additional mitigation measures to compensate for increased loss of viewshed and increased length of combo-wall in the marsh. Although mitigation costs are not estimated, they are expected to be significant.

A wall with a top elevation of 13 feet NAVD88 or higher would incur the cost and completion schedule increases described above. A wall with a top elevation of 13 feet NAVD88 or higher is not likely to be incrementally justified and is considered to be impracticable due to additional costs and construction schedule impacts. The final optimized alignment of a 12 ft NAVD88 wall would be determined in PED should the alternative be selected.

3.5.2 Alternative 2 – Nonstructural Considerations

In addition to the storm surge wall, this alternative includes nonstructural measures that would be applied to residential structures in locations where it would be impracticable to construct the perimeter wall. The Rosemont neighborhood in the Neck Area of the peninsula has been identified as a nonstructural area because it is separated from the lower peninsula by higher ground, making an extension of a 12 ft NAVD88 wall impracticable (see Figure 3-7). A smaller wall system around Rosemont was also determined to be impracticable because the wall footprint and associated easements would require acquisition of a significant portion of structures, impacts to the marsh wetlands, and would create significant interior drainage issues.

The neighborhood of Bridgeview Village on the northeast edge of the peninsula has been identified as a nonstructural area because the wall would either impact the Charleston Cemetery Historic District and marsh wetlands or would require acquisition of a significant proportion of the structures in the community. Similarly, smaller wall systems encircling these neighborhoods would require significant impacts to protected cultural and natural resources and/or acquisition of a significant proportion of the community.

Nonstructural measures that were retained for further consideration include buyouts, elevations, and floodproofing. Elevations and floodproofing were determined to be the most likely nonstructural treatments because buyouts would impose disproportionately high and adverse effects on the minority or low-income areas of Rosemont and Bridgeview Village. Elevation or wet or dry floodproofing measures would be applied to the single-family homes in the Rosemont neighborhood and dry floodproofing measures would be applied to concrete apartment buildings in Bridgeview Village. Utilities in the Lowndes Point neighborhood have been identified for nonstructural measures because residential homes are already elevated to or above 12 feet NAVD88. However, since nonstructural measures are not constrained by the same considerations as the storm surge wall, elevations higher than 12 ft NAVD88 would be considered during PED with consideration of sea level rise.

The cost of elevating a single-family home was selected to develop cost estimates for the Rosemont community because elevations are more expensive than floodproofing, therefore the estimate is more conservative. The cost estimate is based on existing information sourced from local contractors. Cost estimates for dry floodproofing were developed for Bridgeview Village based on professional judgement of implementing floodproofing techniques. During the PED phase, a structure-by-structure analysis will determine the specific application of nonstructural measures should the alternative be selected.

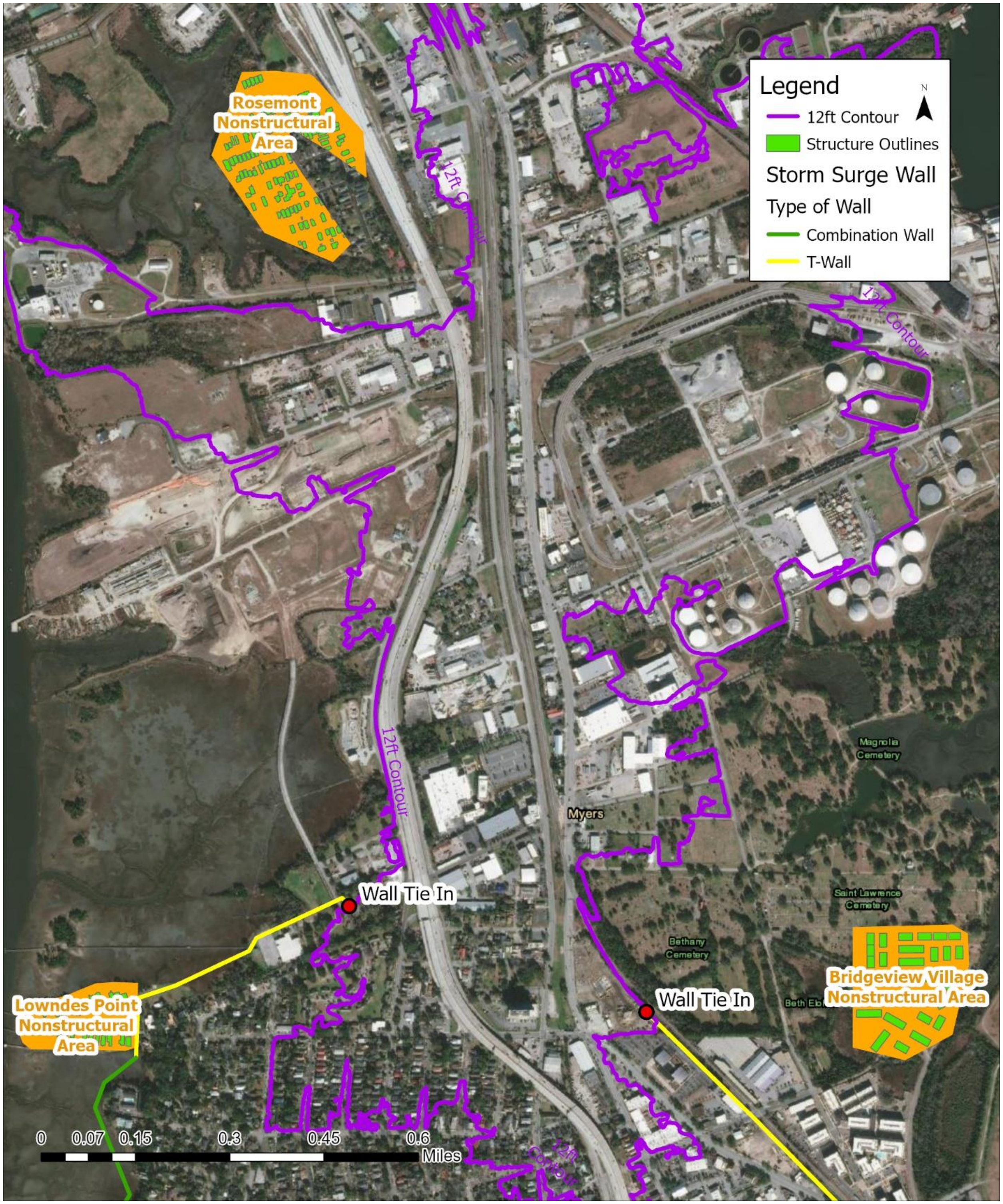

Figure 3-7. Nonstructural areas of Alternative 2 in relation to the 12-foot NAVD88 contour line. Official mapping product of the Management Support Branch, Charleston District, USACE.

CHAPTER 4 - Affected Environment

This chapter describes the affected environment, or existing conditions, of the study area that could be affected by the alternatives. For each environmental factor, a brief explanation of the factor is provided. The framework and Region of Influence (ROI) for which the alternatives will be evaluated are also provided, such as compliance with relevant laws and regulations and data sources used.

4.1 Land Use

Land use comprises the natural conditions and/or human-modified activities occurring at a particular location. Common land use categories include residential, commercial, industrial, transportation, communications and utilities, agricultural, institutional, recreational, and other developed use areas. State laws, management plans, and zoning regulations determine the type and extent of land use allowable in specific areas and are often intended to protect specially designated or environmentally sensitive areas. Zone requirements are regulations developed by the local agencies or municipalities to control potential future development. Comprehensive plans evaluate long-term demographic trends to identify how the region should be developed. Where zoning focuses on immediate trends in development, comprehensive plans are generally less regulatory in nature and often serve as guidance when the local planning department is evaluating application requests for development.

The ROI for land use includes all of the land on the Charleston Peninsula within the study area boundary. Because of its proximity, land areas of the North Charleston Neck area are also part of the ROI.

Affected Environment

The City of Charleston's local zoning ordinance was put in place in 1931 and has grown in scope and complexity over the years to respond to various development and land use issues. The City's zoning ordinance, which covers more than just the study area, has base zoning districts, overlay zoning districts, old city height districts, neighborhood districts, many planned unit developments and neighborhood districts, and preservation and design districts.

The City has finalized its new comprehensive plan, Charleston City Plan in October 2021 (City of Charleston, 2021a). According to the 2021 Charleston City Plan, commercial, institutional, and industrial uses comprise approximately 66% of the developed area within the approximately 8 square mile area on the Charleston Peninsula while residential uses (33%) makes up most of the remaining land uses. The commercial lands largely represent the City's downtown business district, while there is an indication that the industrial lands are declining with a smaller port presence than in the past, and with development of Brownfield projects. The peninsula also includes multiple college campuses, a medical district, and many residential neighborhoods. Under the Charleston City Plan (2021a), the primary land use designation used by the City of Charleston on the Peninsula include (also see Figure 4-1):

- Suburban: Low density, suburban-style areas, adjacent to higher zones that include some mixed-use. Limited mixed-use is allowed at key crossroads. Densities range from four to eight dwelling units per acre (4 du/a to 8 du/a). An example on the Charleston Peninsula is the Wagener Terrace neighborhood.

- Neighborhood: Mixed-use, but primarily residential areas with a wide range of building types and setbacks. Densities range from 5 du/a to 12 du/a. Examples on the Peninsula include Ansonborough and Hampton Park Terrace neighborhoods.

- City Centers: The densest, most mixed-use portions of the City. The tallest buildings would occur here along with the most buildings of regional significance. Blocks may be smaller, streets have steady street tree planting, and buildings are set close to wide sidewalks. Densities would range from ten dwelling units per acre and up. The Central Business District of Charleston (portions of King, Calhoun, Meeting, and East Bay Streets) is an example of this category on the Charleston Peninsula.

- Campus: The campus areas would primarily house school or office uses that do not conform to traditional urban block patterns. Residential uses, other than those associated with a school or a large assisted living facility, would not be allowed. Examples on the Charleston Peninsula include The Citadel, the College of Charleston, and the Peninsula medical district.

- Industrial: The industrial areas would primarily included more intensive manufacturing, warehousing and distribution involving heavy truck traffic and potential emissions that would not be found in lighter manufacturing operations. Residential uses would not be allowed, in an effort to preserve these areas for job generation and reduce conflicts from industrial traffic, emissions, and noise. On the Charleston Peninsula, examples include the east side of the Charleston Neck area and the Columbus Street Terminal.

Land use on the peninsula continues to evolve, primarily through redevelopment. More recent planned development projects on the Charleston Peninsula include development of the approximate 180-acre Magnolia Tract in the Charleston Neck area where approximately 3500 units are planned, and the WestEdge development project that is currently partially built out.

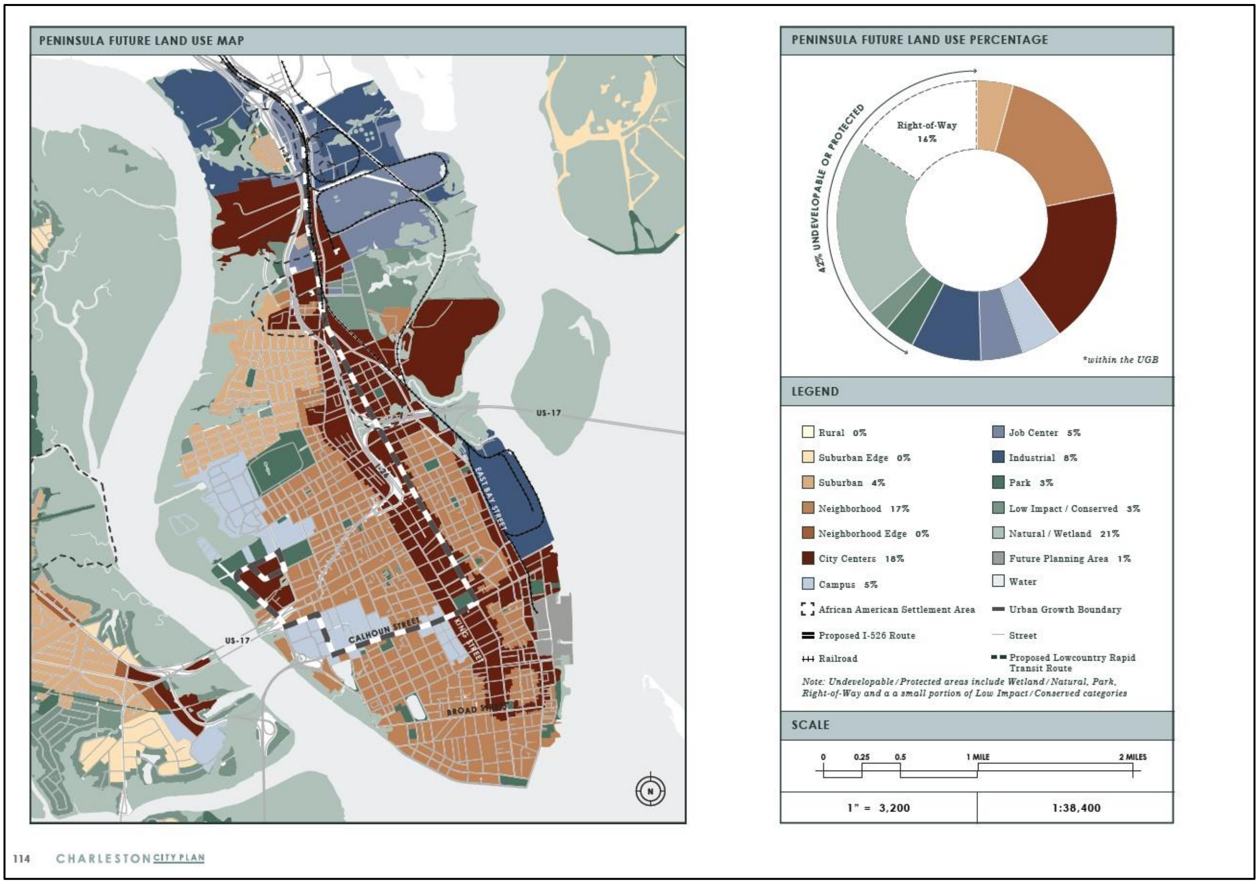

Figure 4-1. Map of land use designations on the Charleston Peninsula.

Source: Charleston City Plan, 2021a

4.2 Geology and Soils

Geologic resources are defined as the topography, geology, soils, and mining of a given area. Topography describes the physical characteristics of the land, such as slope, elevation, and general surface features. The geology of an area includes the bedrock materials and mineral deposits. Soil refers to unconsolidated earthen materials overlaying bedrock or other parent material. Mining refers to the extraction of resources (e.g., gravel). Geology and soils are generally regulated on their potential to affect other resources, such as air and water quality. There are geologic factors that also influence the stability of structures, such as soils stability, depth of bedrock, and seismic properties.

This section briefly describes the geotechnical conditions of the Charleston Peninsula. The ROI includes the Charleston Peninsula, perimeter salt marsh wetlands and immediate nearshore areas along the existing High Battery and Low Battery seawalls. A more detailed description of the geotechnical conditions can be found in Sub-Appendix B2 - Geologic and Geotechnical. For this study, no new geotechnical data were collected. Existing and available geotechnical data from various sources were used. Additional geotechnical information would be collected during the Preconstruction, Engineering, and Design (PED) phase in proposed construction areas to complete structural analyses, including subsurface exploration to verify stratigraphy and the presences of any man-made construction fill or debris.

Affected Environment

The ROI is located within the Sea Islands/Coastal Marsh ecoregion of the Southern Coastal Plain. It is a subsiding depositional basin which contains Cretaceous and Tertiary sediments. The stratigraphy of the South Carolina Coastal Plain consists of partially consolidated, unconformity bound, southeast dipping estuarine-marine shelf Tertiary deposits, which are overlain by unconsolidated Quaternary barrier and nearshore deposits. The stratigraphy also includes escarpments and terraces that were carved into the strata as a result of interglacial sea-level fluctuation that began as early as 240,000 years ago. The development of the modern barrier islands, inlets, and intertidal waters was strongly influenced by the geology and topography of resistant strata (Harris et al., 2005). The stratigraphic units that occur in the ROI are the Black Mingo Group, Santee Limestone, Cooper Marl Formation, Edisto Formation, and Marks Head Formation (Park, 1985). They are described in detail in the Sub-Appendix B2 - Geologic and Geotechnical; also see Figure 4-2. Soils in the ROI are generally soft. The distinct soil types found here include Galveston clay, Norfolk fine sand, Norfolk fine sandy loam, Portsmouth fine sandy loam, Galveston fine sand, and Norfolk sand. Surficial geology information extracted from Weems et al. 2014 suggests that most of the perimeter of the Charleston Peninsula is composed of artificial fill (see Figure 4-3). There are no geologically significant features in the ROI.

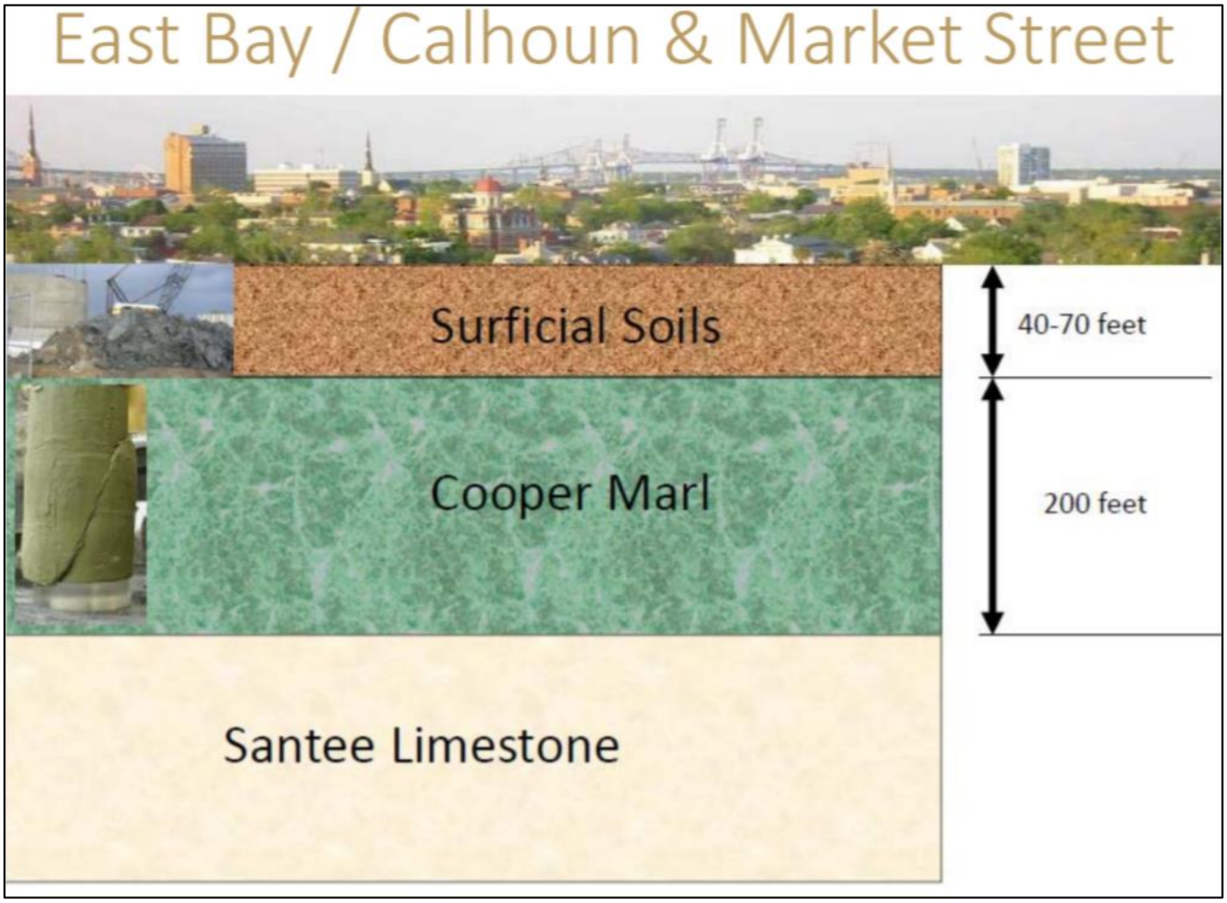

Figure 4-2. Graphical representation of the stratigraphy in the area near East Bay Street, Calhoun Street, and Market Street.

Source: City of Charleston

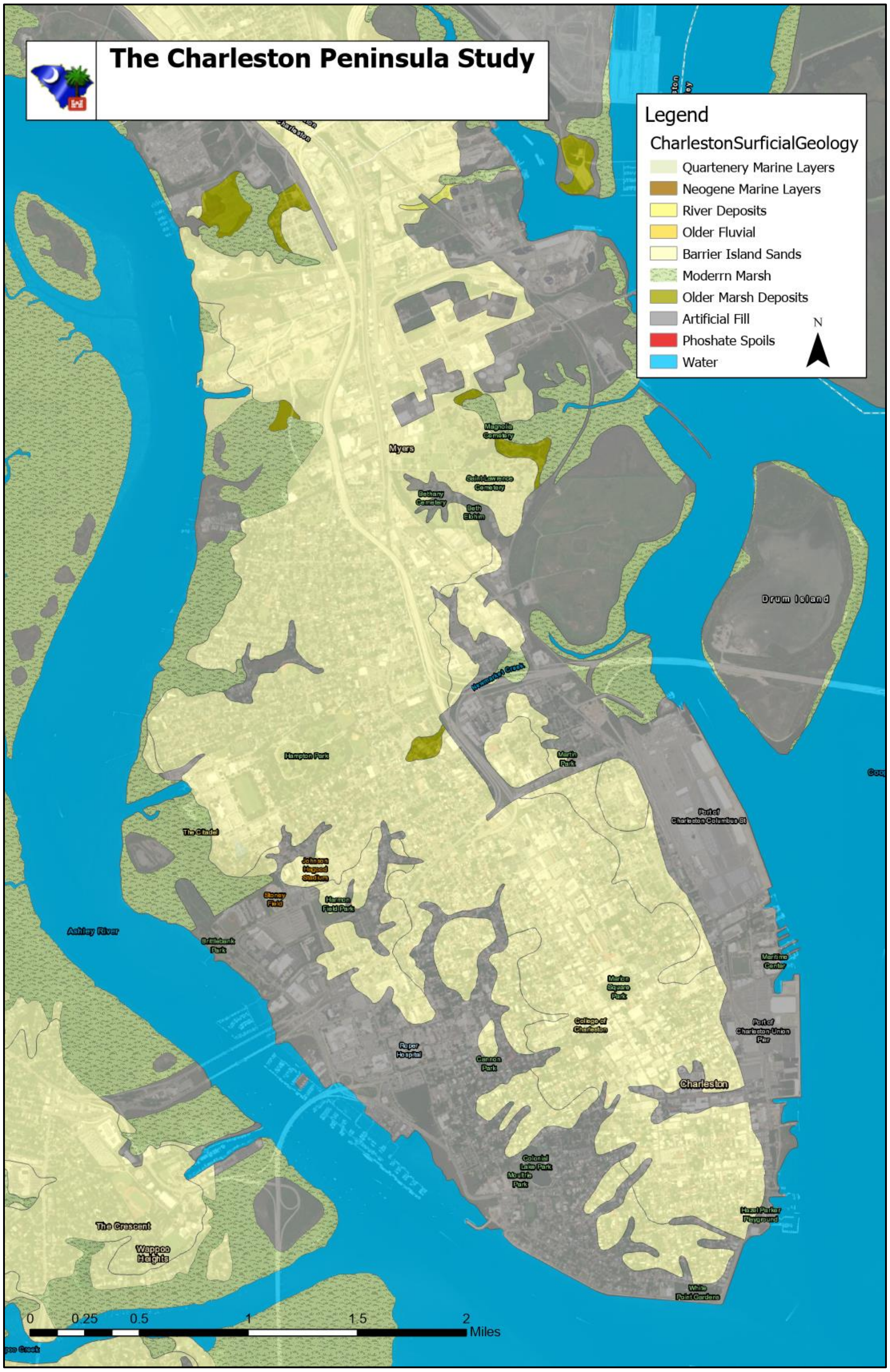

Figure 4-3. Surficial geology of the Charleston Peninsula.

Source: Weems et al. 2014

Cooper Marl consists of medium dense silty sand to firm silty clay and provides sufficient bearing capacity to support all structures. The top of Cooper Marl varies across the peninsula. Using existing subsurface information, estimates of the top of Cooper Marl elevations range from -55 feet to -75 feet NAVD88. Many existing structures on the Charleston Peninsula are founded on piles (either steel H-piles or square pre-stressed concrete piles, either of 12" or 14" in size), which are driven to bear within the Cooper Marl formation.

Seismic Activity

Earthquakes are a concern in the ROI. Charleston is the site of the largest earthquake known to have occurred in the southeastern United States, which occurred in 1886. As defined in ER 1110-2-1806, the Charleston Peninsula is located within a high seismic hazard zone. As such, a seismic evaluation has been completed as part of this feasibility study and the details are presented in Sub-Appendix B2 - Geologic and Geotechnical. The Charleston Peninsula has a High Hazard Potential Project rating, due to the presence of a residential population at risk. USACE guidance (ER 1110-2-1806 and ECB 1110-2-6000) states that projects having a "High Hazard Potential Project" shall have a Maximum Design Earthquake (MDE) that equals the Maximum Credible Earthquake (MCE).

Erosion

Shoreline erosion is caused by winds and wave action. Manmade structures, such as docks, jetties, groins, revetments, and bulkheads, can also contribute to shoreline change. Erosion can leave upland bluffs exposed and that slump into adjacent tidal creeks, leading to loss of vegetation and marsh shorelines (Jackson, 2017). Estuarine shoreline erosion is a growing concern for residential and commercial properties. The South Carolina Department of Health and Environmental Control Office for Ocean and Coastal Resource Management (SCDHEC-OCRM) has led an effort to assess estuarine, oceanfront, and inlet shoreline positions, calculate shoreline change rates, and identify erosion hotspots across the state. Their results have identified some high erosional areas along the Charleston Peninsula, while some areas are experiencing more gradual shoreline change (see Figure 4-4).

Subsidence

The three main causes of subsidence are crustal deformation, groundwater extraction, and soil compaction/compression. Various research (see the Sub-Appendix B2 - Geologic and Geotechnical) indicates that over the last 100-years, subsidence in Charleston has contributed around 5 inches, or 40%, to the 12 inches of sea level rise. This subsidence rate is expected to remain constant. Subsidence in the study area is not believed to be caused by crustal deformation or groundwater extraction (although groundwater withdrawal has occurred in the greater tri-county Charleston area). The past glaciation did not advance far enough towards Charleston to influence the mantle. Additionally, groundwater extraction around the study area is not great enough to lower the groundwater table here. Given this, subsidence has to be attributed to the compaction/compression of the surrounding soils. It is estimated that 1/3 of the Peninsula's land areas are wetlands that were filled to extend the Charleston Peninsula out to the current shoreline. This fill in the low areas is likely contributing attributing to compaction of the soils beneath it.

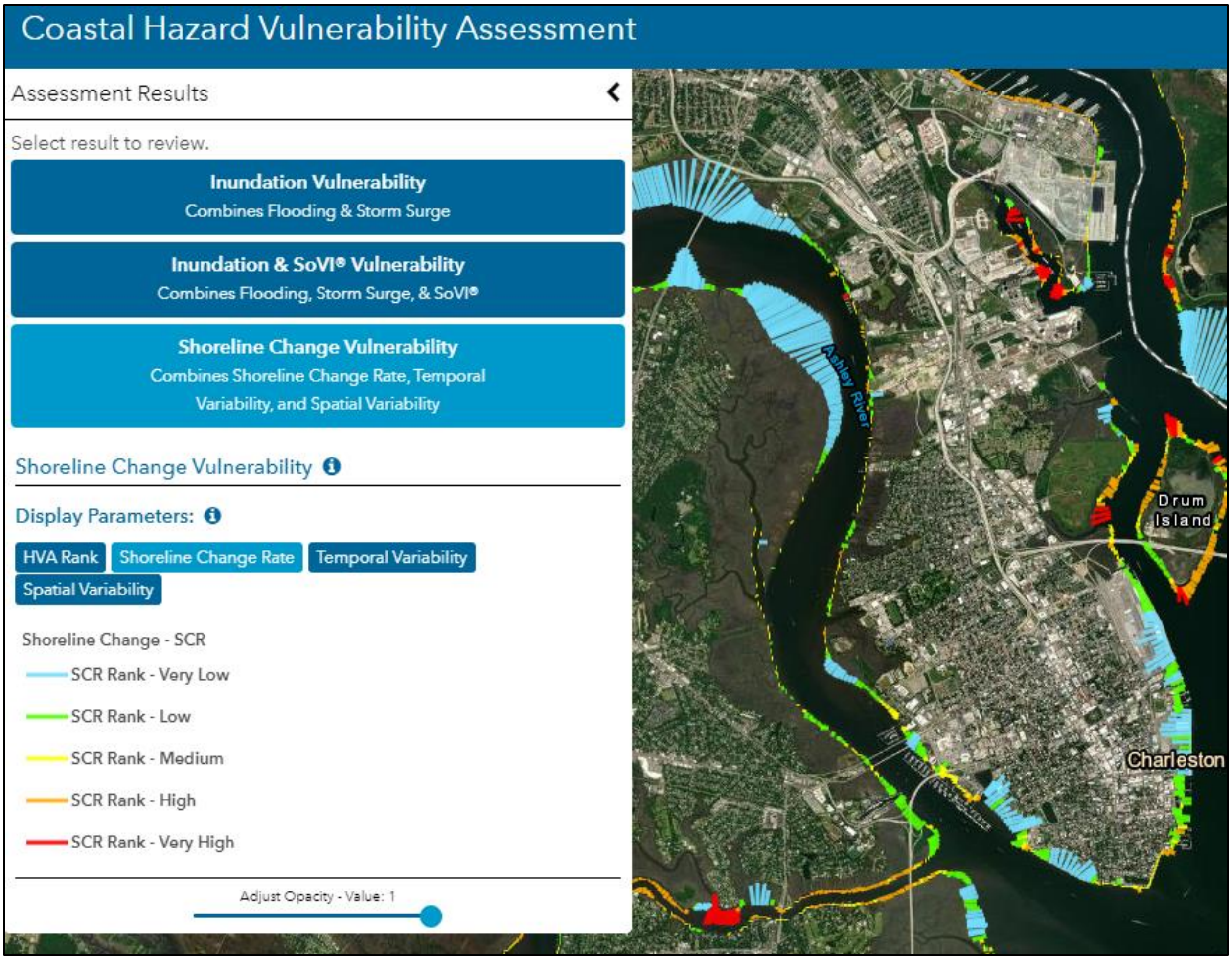

Figure 4-4. Map of shoreline change rates around the Charleston Peninsula from the Coastal Hazard Vulnerability Assessment Tool.

Source: SCDHEC-OCRM

<u>Scouring</u>

Scouring is a process by which water passes around an obstruction in the water column, causing it to change direction and accelerate. Sediments may be suspended by this process causing it to redistribute. As flow velocity and turbulence increase, so does the effect of scouring. Scouring effects are generally localized and can lead to small to large deep depressions around or next to the object, including dislodging rooted vegetation. Scouring along the seaward-facing side of the

Low Battery Seawall on the Charleston peninsula has resulted in exposure of the wall's foundation that was originally buried, contributing to the wall's deterioration over time and the need for the City of Charleston to take on their current battery seawall rehabilitation project (JMT 2015). A universal countermeasure for scouring is rip rap.

4.3 Coastal Hydrodynamics, Hydrology, and Hydraulics

Coastal hydrodynamics is the science that addresses the fundamental principles of wave theory and ocean wave generation through the process of wave transformation as the wave form approaches and reacts with the shore, including water level variations and currents. Hydrology is the science that deals with the properties, circulation, and distribution of water on and under the surface of the earth, and in the atmosphere from the moment of precipitation until it returns to the atmosphere through evapotranspiration or is discharged into the ocean. Hydraulics is the science that deals with the practical applications of water flowing through a channel. Collectively, hydrology and hydraulics are referred to as "H&H."

For the purpose of assessing environmental impacts, there are no specific regulations regarding H&H, though these factors are closely tied to flooding impacts, as well as water quality and coastal habitat which are discussed in subsequent sections of this report. Coastal and H&H numeric models used for this study include ADvanced CIRCulation (ADCIRC), Steady-State Spectral Wave (STWAVE) and related products provided by SCDNR, and Hydrologic Engineering Center's River Analysis System (HEC-RAS) 2-dimensional modeling provided by the City of Charleston, both which were expanded or modified by USACE as appropriate. More information on the coastal hydrodynamics and H&H analyses performed for this study can be found in Sub-Appendix B3 – Hydraulics, Hydrology, and Coastal and B4 - Coastal. This section of the report also uses information from literature and similar studies/projects, and builds on information from the Floodplains and Water Quality sections of this report, to characterize coastal hydrodynamics and H&H.

The coastal hydrodynamic and H&H conditions of the Charleston Peninsula and adjacent waterways, including the Charleston Harbor, lower Ashley River, and lower Cooper River are all part of the ROI. The Atlantic Intracoastal Waterway is not in the ROI.

Affected Environment

The study area lies within two 12-Digit Hydrologic Unit Code (HUC) Watersheds – the Lower Ashley River Watershed and the Lower Cooper River Watershed, the latter of which extends out into the Charleston Harbor. A HUC is an identification given to each hydrologic unit throughout the United States and the Caribbean as delineated by the U.S. Geological Survey using a national standard hierarchical system based on surface hydrologic features. The Ashley River is to the west of the Charleston Peninsula and the Cooper River is to the east of the peninsula, and both drain (along with the nearby Wando River) into the Charleston Harbor tidal estuary. The waters immediately offshore of the Battery seawalls are considered to be part of Charleston Harbor. Charleston Harbor extends about four miles to the Atlantic Ocean and is sheltered by barrier islands at the entrance and is outside of the ROI.

Historically, the Ashley, Cooper, and Wando Rivers were all tidal sloughs with limited freshwater inflows and extensive tidal marshes. Alterations, principally the construction of upstream reservoirs and canals, changed historic freshwater discharge in the Cooper River. The Cooper River now contributes controlled freshwater inflow into the system from Lake Moultrie. It is limited to a 4500 cubic feet per second (cfs) daily average by week. The Federal navigation channel in the Cooper River and Charleston Harbor is regularly dredged to support marine commerce. The Federal navigation channel on the Ashley River is still authorized but is not regularly dredged.

Intertidal wetlands in the estuary have been lost over time to development and diking for rice cultivation. Two historic creeks that have been filled and completely lost are Major Daniel’s Creek near the current Waterfront Park and Vanderhorst’s Creek in the Battery area. The remaining tidal creeks in the study area are shown in Figure 4-5. They include Belvidere Creek, New Market Creek, Vardell’s Creek, Koppers Creek, Diesel Creek, Halsey Creek, Gadsden Creek, Cummings Creek, and the Citadel Boat Landing channel. All of the remaining tidal creeks have been either partially filled or tidal flow is restricted by berms or embankments, and/or roads with culverts, with the exception of Koppers Creek which currently has no barriers to tidal flow. Due to the shallowness of these creeks, it is likely that the tides control flushing.

Figure 4-5. Present-day tidal creeks on the Charleston Peninsula.

Official mapping product of the Management Support Branch, Charleston District, USACE

Water Levels

NOAA maintains a tide gage in the Charleston Harbor. It has been measuring water levels continuously since 1921. The Charleston area has a semidiurnal tide cycle, with a tide range of almost 6 feet. In the past 100 years, local sea level has risen 1.07 ft (see Section 4.21 for more on sea level change in the study area).

Flooding from elevated tide levels in Charleston is increasing. In 1950, tidal flooding in the Charleston area occurred about 2 days annually for a total of 4 hours. In 2014, tidal flooding occurred 25 days annually for a total of 42 hours (Sweet and Park, 2014). More recently, Charleston has experienced 8 of the top 15 tides ever recorded in a recent four-year period, some associated with storms. The National Weather Service indicates major flooding occurs in Charleston when water levels are at 8 ft. (MLLW) which equates to 4.86 ft. at the Charleston Harbor tide gauge (NAVD88). At present day, 4.86 ft. NAVD88 is equivalent to approximately a 50% annual exceedance probability (AEP) Still Water Level (without rainfall included). The National Weather Service describes major tidal flooding impacts at this level as widespread flooding on the Charleston Peninsula with numerous roads flooded and impassable, and some impact to structures. At this level, impacts become more extensive all along the southeast South Carolina coast including erosion at area beaches, with limited or no access to docks, piers, and some islands.

According to NOAA, "Storm surge is an abnormal rise of water generated by a storm, over and above astronomical tides" (NOAA, n.d.). When water is pushed toward the shore by the force of storm winds, it "piles up" creating storm surge. Storm surge is a complex phenomenon and the surge potential at a particular location is dependent on many different factors. It can cause devastating damage and loss of life, as experienced with past hurricanes.

Storm tide is the water level rise that results due to the combination of storm surge and the astronomical tide (NOAA, n.d.). Therefore, storm tides and peak surge elevations will be greater if the storm surge coincides with high tide. Since Charleston has such a large tidal range, surge levels produced by a tropical storm would be significantly influenced by the tide phase at the time of landfall. For the height of a wave, this is dependent upon wind speed and duration, . and length of fetch (distance that wind and waves travel across open water), but is also a direct function of water depth. As the water depth increases, larger waves are able to form. Waves can also regenerate if they go over a sizable body of water, and they dissipate as they pass over land.

Compound flooding is also an issue for the Charleston Peninsula. Compound flooding occurs when a combination of storm-induced inundation, precipitation, king tides, and high groundwater table elevations occur simultaneously, resulting in potentially greater impacts. Recent coastal storms and hurricanes have resulted in widespread heavy rains across South Carolina, compounded by storm surge on the coast. The low topography of South Carolina contributes to the compounding effect.

Groundwater

Groundwater is the water found underground that fills the spaces between soil, sand, and rock. Normally it is stored and slowly moves through underground aquifers. Ground water typically recharges waterbodies such as lakes or wetlands, supplies drinking water, and provides for irrigation for agriculture.

Historically, the greater Charleston area was supplied with groundwater from the Middendorf aquifer (of the Coastal Plain). In the 1920s, the groundwater levels and production declined, so surface water was used to supply water to the Charleston area. The City of Charleston, which covers more than the peninsula, currently receives its drinking water from Bushy Park and Edisto River. As groundwater levels have continued to decline in the greater Charleston area, which includes the counties of Charleston, Berkeley, Dorchester, the area was designated as a capacity-use area to regulate groundwater withdrawals due to 180-ft drawdowns in the Middendorf, or Queens Branch Aquifer (SCDHEC, 2019). Coastal drought in South Carolina has also exacerbated the reduction in water levels (USGS, 2010).

Currently, groundwater occurs at water-table depths of 3-15 feet in the Charleston area, with annual fluctuations between one to six feet. Recharge is usually through local rainfall, although some water is contributed by the underlying Santee Limestone where the Cooper Formation is thin or absent. On the Charleston Peninsula, the groundwater levels in the surficial aquifer are especially shallow, and fluctuate with the tides, seasons, and precipitation. Considering local tides in the Charleston Harbor, the groundwater encountered near the perimeter of the Peninsula would be at or near the elevation of the tide elevation.

Wave Attack

Wave attack is the impact of waves on shoreline and is considered one of the main coastal damage mechanisms. The repeated pounding of waves on shorelines or structures can create damage over time under normal wave conditions and is exacerbated during storm conditions when waves become larger and more frequent. In general, due to deeper water and long fetch, the eastern and southern parts of the Charleston Harbor experience more wave energy.

Wave attack can damage or destroy engineered structures such as seawalls, revetments, or bulkheads through direct wave impacts on a structure or by scouring the foot of the structure and undermining it. In addition to frontal erosion, wave attack can lead to wave run-up and overtop coastal structures which can scour the backside of structures and cause them to fail.

Wave attack also damages natural shorelines such as beaches and marshes by causing erosion of the sediment that make up these coastal environments. It can damage or destroy coastal vegetation, which anchors their respective systems in place, and leave the remaining system more vulnerable to additional erosion.

4.4 Water Quality

Water quality describes the chemical and physical composition of water affected by natural conditions and human activities. Water quality conditions can influence other issues such as land use, biological resources, socioeconomics, public safety, and environmental justice. The ROI for water quality includes the two 12-Digit HUC Watersheds of the Lower Ashley River and the Lower Cooper River that encompass the Charleston Peninsula and include the adjacent waters of the Charleston Harbor.

This section focuses on existing water quality conditions. Information from public agencies, literature and similar studies have been used. The water quality regulations that have been considered include the Clean Water Act and S.C. Regulations 61-68 and 61-699.

The Clean Water Act (CWA) of 1972 (as amended, 33 USC 1251 et seq.), is the primary Federal law that protects the nation's waters, including lakes, rivers, and coastal areas. The CWA prohibits all unpermitted discharges of pollution into any jurisdictional waters of the U.S. The US Environmental Protection Agency (USEPA) is responsible for administering the water quality requirements of the CWA. Section 303(d) of the CWA requires all states to identify waters that do not meet or are not expected to meet, applicable water quality standards. States must develop a total maximum daily load (TMDL) for each pollutant that contributes to the impairment of a listed water body. The South Carolina Department of Health and Environmental Control (SCDHEC) is responsible for ensuring that TDMLs are developed for impaired surface waters in South Carolina.

The CWA Section 401 requires a state water quality certification for discharges into waters of the United States. SCDHEC administers the state's Section 401 Water Quality Certification Process. The pre-certification process has been initiated for this study (see Appendix F – Environmental).

SC Regulation 61-68 *Water Classifications and Standards* establishes classifications and water quality standards for South Carolina's waters that define how waters are used, protected and maintained, and regulated for against degradation. SC Regulation 61-69 *Classified Waters* includes the list of State waters, their location, classification, designation, description of the waterbody, and site-specific numeric criteria. All waters of the state are classified even if they do not appear on the list. Any unlisted water is assigned the classification of the waterbody that it is a tributary to.

Affected Environment

Water Quality Classifications

Water quality standards provide an indication of current conditions. The provisional classifications for waters in the ROI are shown in Figure 4-6. For the lower Ashley River, there are two classifications found: "Class Saltwater A" (SA), and SA with special site-specific conditions for some of the tributaries. Class Saltwater A water bodies are tidal saltwaters suitable for primary and secondary contact recreation, crabbing, and fishing, except for harvesting of clams, mussels or oysters for market purposes or human consumption. They are considered suitable for the survival and propagation of a balanced indigenous aquatic community of marine fauna and flora (SCDHEC, 2014). There are six water quality monitoring stations on the lower Ashley River (listed by responsible entity):

- Charleston Environmental Quality Control (EQC) office - ambient surface random (Devereaux Ave)
- Charleston EQC office - ambient surface fixed (at Salrr Bridge, Citadel boat landing)
- Charleston EQC office - ambient surface random (Citadel disposal area)
- Charleston Water Keeper - special study/QAPP (Brittlebank Park floating dock)
- Charleston Water Keeper - special study/QAPP (City Marina and JI Connector)
- Charleston EQC office - shellfish (JI and CG station)

The state classifies the Cooper River from the juncture of the east and west branches of the river to the confluence with the Ashley River as a "Class Saltwater B" (SB) water body. This same class applies to the Charleston Harbor. The difference between Class SA and SB waters relates to the dissolved oxygen limitations. Class SA waters must maintain daily dissolved oxygen (DO) averages not less than 5.0 mg/L, with a minimum of 4.0 mg/L, while SB waters maintain DO levels not less than 4.0mg/L. More information on DO can be found below. There are five water quality monitoring stations on the lower Cooper River and Charleston Harbor off the Battery (listed by responsible party):

- Charleston EQC office - ambient surface random (Columbus St terminal)
- Two Charleston EQC office - shellfish (off Battery)
- Charleston EQC office - ambient surface random (off Battery)
- Charleston EQC office – shellfish (pilot station)

There are a few small tributaries of the Cooper and Ashley Rivers that have a provisional classification of Freshwater. Freshwaters are defined as suitable for primary and secondary contact recreation and drinking water supplies after conventional treatment, and for industrial uses, agriculture, fishing, and propagation of a balanced indigenous aquatic community of fauna and flora (SCDHEC, 2014).

There are no state Public Water Supply Wells or Intakes in the ROI, and shellfish harvesting is prohibited in all waterways of the ROI. There are also no federal nor state groundwater level monitoring sites in the area.

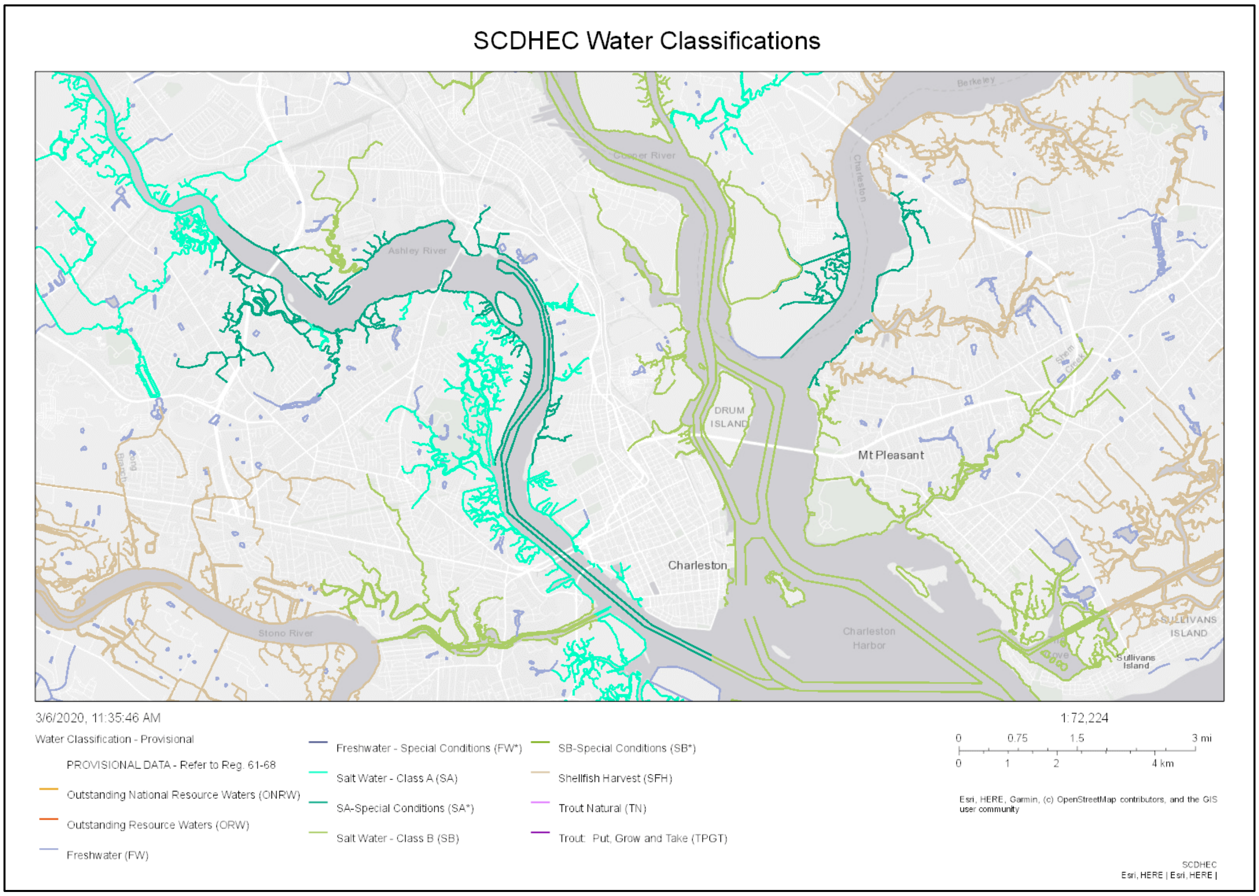

Figure 4-6. Provisional classifications for waters in the ROI.

Source: SCDHEC

There are four areas in the ROI in close proximity to the study area that have been identified by SCDHEC under Section 303(d) of the CWA in their 2018 updated list as impaired waters (see Figure 4-7). All are listed as impaired for recreational use based on enterococci, which are a bacteria that indicate the presence of fecal material in the water. As noted above, shellfish harvesting is already restricted in all areas. One of the sites is located along Brittlebank Park.

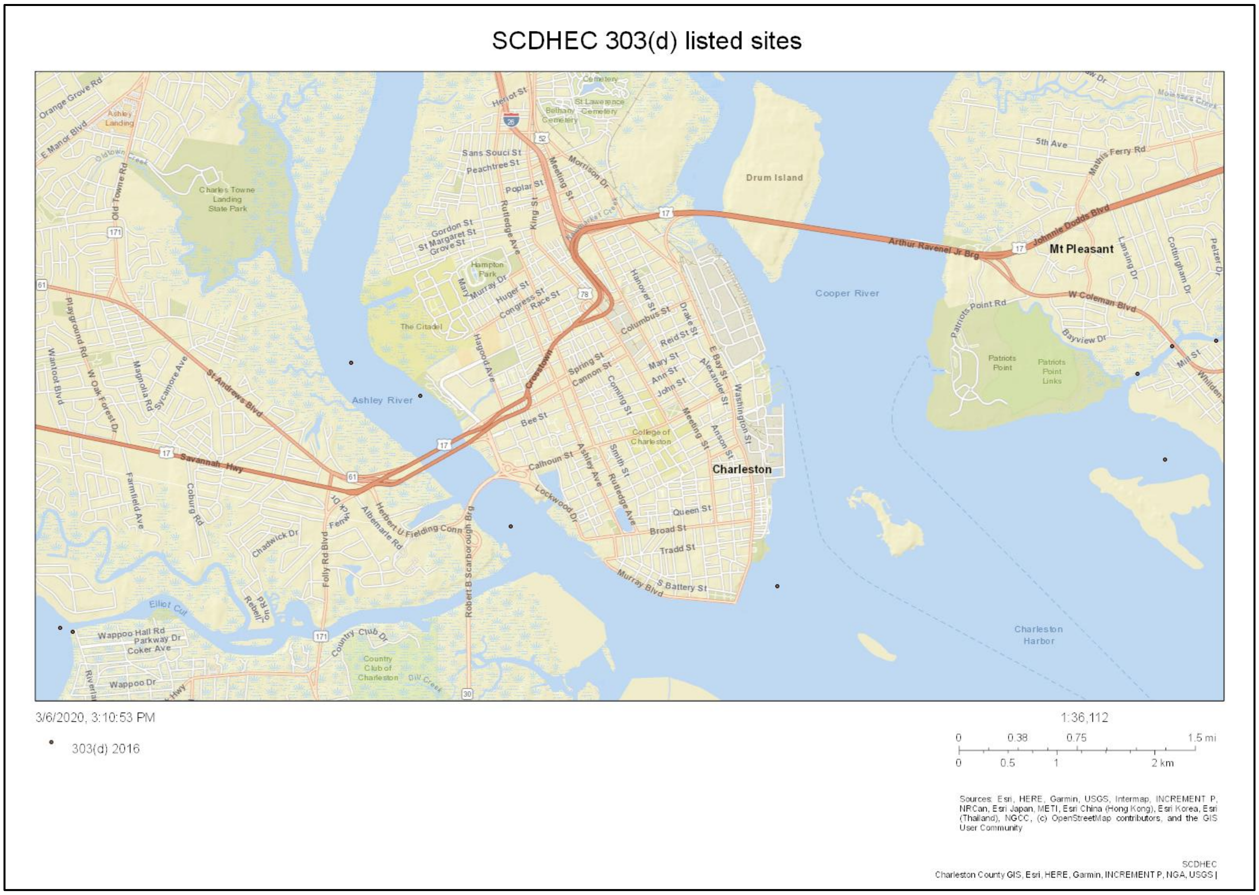

Figure 4-7. Impaired water quality sites in the ROI. The sites closest to the peninsula are impaired due to fecal matter.

Source: SCDHEC

<u>Dissolved Oxygen</u>

The State has set a total maximum daily load (TMDL) for the Cooper River, Wando River, Ashley River and Charleston Harbor combined, known as the "Charleston Harbor TMDL" for DO (SCDHEC, 2013). The TMDL allocates the amount of oxygen demanding substances that an industry can discharge into the water body or system. The Charleston Harbor TMDL covers an area much larger than the ROI.

According to SCDHEC, many of the waters in the Charleston Harbor area are known to experience naturally low DO levels that do not attain established numeric criteria. Under such circumstances where DO concentrations are naturally low, state water quality standards (S.C. R.61-68.D.4.a.) allow an additional lowering of DO of no more than 0.1 mg/L due to point sources and other activities. Therefore, the water quality target for this TMDL is the allowable DO impact of 0.1 mg/L. The SCDHEC instantaneous and daily average water quality standards for DO are 4 and 5 mg/L, respectively.

DO concentrations are dependent on a number of factors such as temperature, salinity, wind, turbulence, atmospheric pressure, and pollutants. DO is important to the survival of aquatic organisms, and often serves as a general indicator of the overall health of coastal habitats. As such, SCDNR monitors water quality across the state's estuaries through the South Carolina Estuarine and Coastal Assessment Program (SCECAP), including a few locations within the ROI of this study (Sanger et al., 2020). Two sites sampled in the Lower Ashley River, one near the Wagener Terrace neighborhood and one near the Citadel, showed summer daily-average DO concentrations of 5.9 mg/L and 5.6 mg/L respectively, which is considered "good." Salinity concentrations measured at the sites were 26.4 ppt and 25.0 ppt, respectively. Temperature, pH, nitrogen, phosphorous, chlorophyll, eutrophication, and bacterial levels were also measured. Summary data for these sites can be found in Appendix F – Environmental. With all metrics considered together, the water quality at the Ashley River site near Wagener Terrace was considered to be "fair" driven by lower scores for phosphorous, eutrophication and chlorophyll , and at the Ashley River site near the Citadel water quality was considered to be "good."

In the Cooper River, the diversion of freshwater flow into the River from Lake Moultrie starting in the 1940s and then modified by rediversion has caused the Cooper River to shift from vertically well-mixed, to a more stratified condition that has influenced DO and salinity. The SCECAP has also sampled in two locations in the ROI in the Lower Cooper River, one near the Columbus Street Terminal and one near the Charleston Maritime Center, and a site in the Charleston Harbor near the High Battery. Summer daily-average DO concentrations were 5.7, 5.3, and 5.4 mg/L respectively, which were all considered "good." Salinity concentrations measured at the sites were 28.4, 30.7, and 28.8 ppt, respectively. Combined with data on temperature, pH, nitrogen, phosphorous, chlorophyll, eutrophication, and bacterial levels at each of the sites (see Appendix F – Environmental), the water quality overall in these areas of the Lower Cooper River and of the Charleston Harbor were all considered to be "good."

For this study, activities that disturb sediments are of interest to water quality because they can reduce DO, depending on the volume and duration of sediment resuspension, the oxygen demand of the sediment, and other factors (Arora et al., 2017). Fine sediments high in organic matter have greater potential oxygen demand than sandy sediments. DO reduction is generally associated with near bottom waters adjacent to the disturbance, while DO decreases towards the surface and with increasing distances.

Total Suspended Solids and Turbidity

Total suspended solids (TSS) are the suspended organic and inorganic particulate matter in water. Although increasing TSS can also be an indication of increased runoff from land, TSS differs from turbidity in that it is a measure of the mass of material in, rather than light transmittance through, a water sample. High TSS can adversely impact fish and fish food populations and damage invertebrate populations. There are no explicit state standards for TSS.

However, the state standard for turbidity in the Charleston Harbor system is 25 nephlometric turbidity units (NTU).

<u>Salinity</u>

Salinity concentrations in estuaries can affect habitat and the distribution of marine/estuarine species, including in sediment pore water. Along with tidal inundation/water elevation, salinity generally determines the marsh vegetation species, and influences fish, crustacean, and bivalve populations. Salinity in the Charleston Harbor is typically between 33 and 36 ppt, although the SCECAP shows it to be lower than this in some locations (see Dissolved Oxygen discussion above). Salinity concentrations in the Cooper River and the Ashley River can range from 5 to 18 ppt, although the SCECAP suggests it may be higher than this in the lower reaches (see Dissolved oxygen discussion above). Vegetated shorelines are dominated by estuarine emergent marshes with cordgrasses and black needlerush (see more in Section 4.6 - Wetlands section). The diversion of the Santee River into the Cooper River mentioned above, had a pronounced effect on salinity regimes in the Charleston Harbor. Since salinity influences DO concentrations, and event-driven salinity intrusion into freshwater can be a concern for water usage farther up the watershed, there are now several monitoring stations throughout the Cooper River Watershed to help inform management of freshwater flow from Lake Moultrie into the Cooper River.

4.5 Floodplains

The Federal Emergency Management Agency (FEMA) is responsible for identifying floodplain areas and producing Flood Insurance Rate Maps. Floodplains are designated by the frequency of the flood that is large enough to cover them. The resulting maps show all locations near major water bodies and the base flood elevations and floodplain boundaries, such as the 100-year floodplain boundary. A 100-year flood event has a 1% probability of occurring in a given year.

Executive Order 11988 Floodplain Management requires Federal agencies to evaluate all proposed actions within the 1% annual chance exceedance (100-year) floodplain. In addition, the 0.2% annual chance exceedance (500-year) floodplain should be evaluated for critical actions or facilities. The Executive Order provides an eight-step process to evaluate activities in the floodplain. If the proposed alternatives have limited impacts, then the eight-step process may vary or be reduced in application.

Section 202(c) of the Water Resources Development Act of 1996 requires that before the construction of any project for local flood damage reduction or hurricane or storm damage reduction that involves assistance from the Secretary of the Army, the non-Federal interest must agree to participate in and comply with applicable Federal floodplain management and flood insurance programs. It also requires non-Federal interests to prepare a Floodplain Management Plan designed to reduce the impacts of future flood events in the project area within one year of signing a Project Partnership Agreement and to implement the Plan not later than one year after completion of construction of the project.

More specifically, Section 202 (c) requires that the non-Federal sponsor shall prepare a Floodplain Management Plan designed to reduce the impacts of future flooding in the project area. It should be based on post-project floodplain conditions. The primary focus of the Plan should be to address potential measures from this study, practices and policies which will reduce the impacts of future residual flooding, help preserve levels of risk reduction provided by the USACE project and preserve and enhance natural floodplain values. In addition, the Plan should address the risk of future flood damages to structures within the post-project floodplain and internal drainage issues related to USACE's coastal storm risk management measures. Since actions within the floodplain upstream and downstream from the study area can affect the performance of a USACE project, the Plan developed by the non-Federal sponsor should not be limited to addressing measures solely within the immediate study area boundary. The non-Federal sponsor usually develops the Plan during the PED phase of a project.

For the purpose of this study, floodplain is defined as any land area susceptible to being inundated by floodwaters from any source. Since the entire Charleston Peninsula is in either the 500-year or 100-year FEMA floodplain, it makes up the ROI. Since riverine flooding is generally not a factor for the Charleston Peninsula, only the lower Ashley and Cooper Rivers are part of the ROI.

Affected Environment

Since the Charleston Peninsula is highly urbanized, relatively flat with nearly all ground elevations below elevation 20 feet NAVD88, and has tidal connections to the Ashley and Cooper Rivers and the Charleston Harbor, it has either experienced past flooding or has the potential to be flooded. It is at risk of being impacted by tidal, rainfall, and storm surge event-driven flooding, including from nor'easters, tropical storms, hurricanes, and other storms. In fact, most of the Charleston Peninsula is in the 100-year floodplain, with the remainder within the 500-year floodplain. The majority of residents on the Peninsula live in that 100-year floodplain, or FEMA 1% annual chance exceedance flood zone. In addition to residents, numerous business, historic sites, the medical district and other critical infrastructure, port infrastructure, and tourist attractions are located in the 100-year floodplain. In total, there are approximately 6,670 structures (out of 12,095) in the study area that are in the 100-year floodplain. Nearly everyone else on the Peninsula is in the 500-year floodplain, or FEMA 0.2% annual chance exceedance flood zone (see Appendix C - Economics for more information). Structures are not only at risk of economic structural damages from flooding, but flooding in urban areas can also cause serious health and safety problems for the affected populations (see Section 4.18).

Flooding in the ROI is caused by several factors, which often combine to form a complex, multi-faceted challenge. Figure 4-8 demonstrates some of the causes of flooding in the Charleston area.

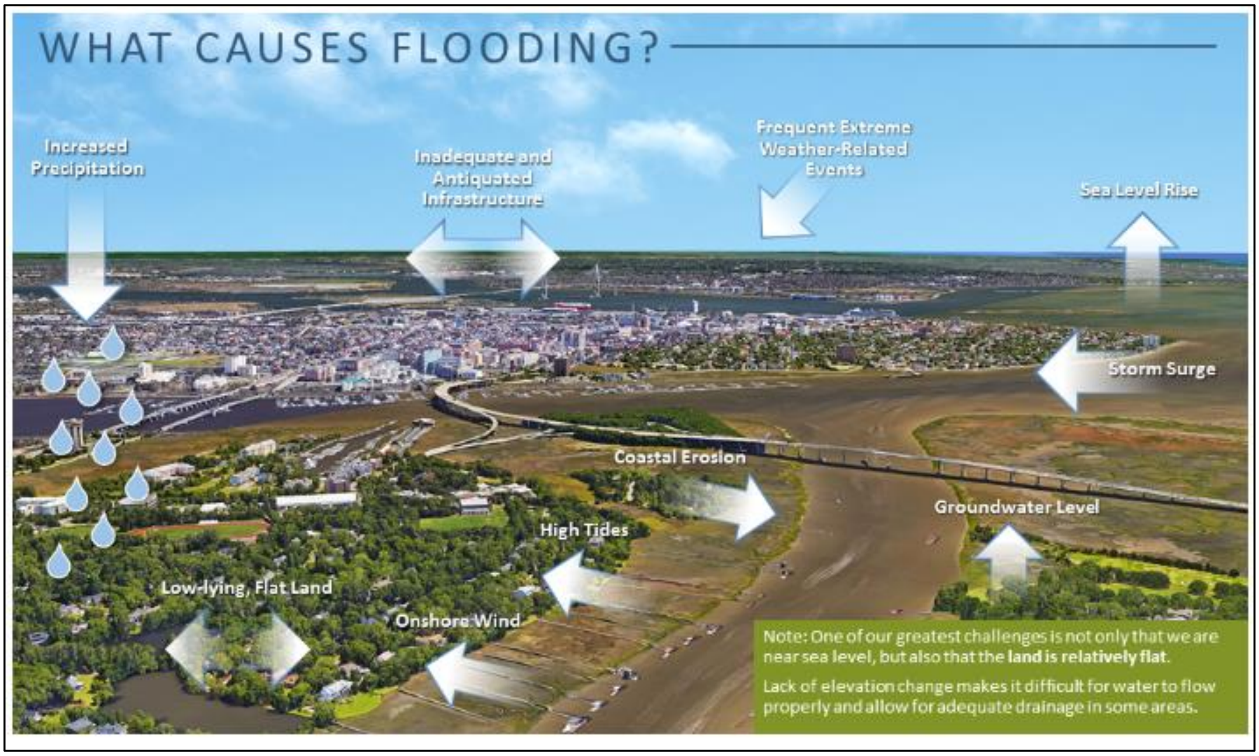

Figure 4-8. Local factors that contribute to flooding in the Charleston area.

Source: City of Charleston

<u>Rainfall Flooding</u>

Localized flooding is currently being addressed on the Charleston Peninsula through several new and planned municipal projects that have included installation of hydraulic pumps of various sizes to alleviate interior flooding when the subsurface drainage system is overwhelmed. Several municipal projects have been undertaken to improve interior drainage on the Peninsula during heavy flooding from rainfall including.

- Market Street Drainage Improvement Project, with previous phases that installed a pump station at Concord Street with the total capacity of pumping 282 cubic feet per second (cfs).
- US 17 Spring/Fishburne (Septima Clark) Drainage Improvement Project, with a medium-sized pump installed in previous phases completed and current construction of a large pumping station with a total capacity of 900 cfs.
- Calhoun West/Beaufain Drainage Improvement Project that will result in a new pump station around King and Huger Streets with an approximate capacity of 156 cfs.
- MUSC Pump Station, with a total capacity of 114 cfs.

Tidal and Compound Flooding

Current high tides are influencing the effectiveness of the old drainage system that the City of Charleston is trying to address with the projects listed above. Most of the stormwater outfalls in the City drain to water bodies that are tidally influenced. At high tides, the stormwater collection system is already inundated from tidal waters, so there is little capacity for the stormwater runoff. Thus, the stormwater has no place to go, and flooding results. This is exacerbated when the high tide stays inland longer than usual, such as due to wind and on King Tides cycles, which usually last a number of days before they return to normal tide levels. While the City has added check valves and berms to a number of locations, this still does not allow for enough flow out of the existing drainage system's undersized pipes and provides for very little opportunity for storage of stormwater.

Coastal Storm Flooding

The City of Charleston already has two existing structures that help to reduce coastal storm flood risks in the ROI, the Low Battery and High Battery Walls, although they are seawalls with the original intent "to retain the landside fill." The Low and High Battery Walls are located on the west and south sides of the peninsula, respectively. They are reinforced at the base of the structure, or toe, with rip rap. The City of Charleston undergoing a project to rehabilitate and modify the Low Battery Wall to raise it to elevation 9 feet NAVD88, which is the height of the High Battery Wall. However, the age and condition of the High Battery Wall does not meet current USACE standards for design and performance for coastal storm risk management. Currently, flood hazard transmission into the floodplain is somewhat mediated by the Battery seawalls. The walls prevent transmission of the flood hazard until it exceeds the top elevation of the walls. Several past tropical storms that have impacted the Charleston area have not only overtopped the walls, but also flanked it at its terminus by the U.S. Coast Guard Station on Tradd Street where the ground elevation is lower than the height of the Battery Wall.

Floodplain Management

The City of Charleston's Bluebelt program is a Floodplain Management initiative to guide strategic flood mitigation decisions. The goal of the Bluebelt program is to reduce the risk of flood hazards to life and property by promoting and restoring natural floodplain functions. This may be achieved by creating connected areas for flood storage or conveyance. These projects can provide additional community benefits such as recreation, habitat restoration, and improved water quality. Projects undertaken to meet these goals include property acquisition and demolition, relocation, and easement acquisition. While the Bluebelt program is applicable city-wide, there have only been a few projects in the historic district because of the preservation restrictions. There are, however, over two dozen homes that have been elevated or are currently in the review/approval process to be elevated in the historic district under this program.

The City of Charleston has applied for and received property acquisition grants through the FEMA Hazard Mitigation Grant Program (HMGP) and Flood Mitigation Assistance (FMA) program since 2015, with additional grant applications currently pending. City funds are used as matching dollars to purchase severe repetitive loss and repetitive loss properties. Including both City funds and Grant funds, more than $12 million has been allocated for this work since 2015 (city-wide, not just in the study area). The structures are demolished by the City and owned by the City as green space in perpetuity.

4.6 Wetlands

Wetlands are defined by the Clean Water Act (CWA) as, "those areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas" (33 CFR 328.3(b)). The two major categories of wetlands are tidal (subject to the ebb and flow of tide), and nontidal (freshwater).

There are a number of laws and regulations that govern coastal wetlands. The CWA of 1972**,** as amended (33 USC Section 1251 et seq), is the primary federal law that regulates the nation's waters, including lakes, rivers, and coastal areas. It prohibits all unpermitted discharge of any pollutant into any jurisdictional waters of the U.S. As described in the Water Quality section, Section 404 of the CWA (33 USC 1344) regulates the discharge of dredged or fill material into jurisdictional waters of the U.S. - this includes wetlands. Wetlands regulated under the CWA are delineated pursuant to the 1987 USACE Wetland Delineation Manual, along with the appropriate regional supplement manual. For this study, the Atlantic and Gulf Coast Plain Region Regional Supplement to the Corps of Engineers Wetland Delineation Manual: (Version 2.0) applies. USACE does not issue 404 permits to itself; however, a Section 404 evaluation has been completed for this study and can be found in Appendix F - Environmental.

Section 10 of the Rivers and Harbors Act of 1899 (as amended; 33 USC 403) regulates structures or work that would affect navigable waters of the U.S. All wetlands subject to the ebb and flow of the tide are, by definition, navigable waters (33 CFR 328). The definition of structures under Section 10 would include any storm surge wall, gates, and pump intakes or outlets that might be built as a result of recommendations of this study. The definition of work under Section 10 includes dredging, filling, excavation, or other modifications to navigable waters of the U.S. Although USACE does not issue Section 10 permits to itself, the public interest factors that are considered for Section 10 permits, including effects on navigation, are addressed in this report.

There are also state regulations that govern wetlands, specifically the South Carolina Coastal Tidelands and Wetland Act of 1977 (Statutory Code Ann. Section 48-39-10 et seq.). The Act defines "tidelands" as all areas which are at or below mean high tide and coastal wetlands, mudflats, and similar areas that are contiguous or adjacent to coastal waters and are an integral part of the estuarine systems involved. Coastal wetlands include marshes, mudflats, and shallows and means those areas periodically inundated by saline water courses and those areas that are normally characterized by the prevalence of saline water vegetation capable of growth and reproduction. Mitigation is required for projects impacting tidelands. The Act states that mitigation shall be performed at a ratio of 1:1 wetland created to wetland altered, for projects deemed in the public interest.

Wetland information and quantities for this study were estimated from literature, field reconnaissance, and the U.S. Fish and Wildlife Services' (USFWS) National Wetlands Inventory, which is based on the classification system of Cowardin et al. (1979) dated 2011 for the Charleston area. More recent high-resolution land cover mapping from NOAA's Coastal Change Analysis Program and Google Earth imagery were also used to verify wetland distribution. An official delineation of impacted wetlands would be completed in the PED phase of the project in accordance with the Corps of Engineers Wetland Delineation Manual, which USACE uses pursuant to Section 404 of the CWA. H&H modeling to support this section can be found in Appendix B - Engineering.

The ROI for wetlands includes perimeter tidal wetlands, primarily but not exclusively on the Ashley River side of the Peninsula, that will be directly filled, dredged, excavated or otherwise converted to another use as a result of construction, or indirectly affected through such factors as tidal flushing, sedimentation, water chemistry, and erosion. Tidal wetlands along shorelines directly across waterways of the Charleston Peninsula (the Charleston Harbor, Ashley River, and Cooper River) that could be indirectly affected are also in the ROI.

Affected Environment

Wetland distribution is influenced primarily by water elevation, which fluctuates in response to daily tides, rainfall and freshwater drainage, and winds. Figure 4-9 shows the general distribution of wetlands within the study area, with most of the wetlands found around the perimeter of the peninsula. While most of the 8 square miles of the Charleston Peninsula is developed, high-resolution landcover data from 2016 shows that approximately 555 acres of estuarine emergent wetlands, or salt marsh, remain in the study area. These wetlands are polyhaline, meaning they have a salinity range between 18 and 30 ppt, and are characterized by smooth cordgrass (*Spartina alternaflora*) and black rush (*Juncus roemerianus*). High marsh is limited in the study area, but typically includes sea oxeye (*Borrichia frutescens*), salt grass (*Distinchlis spicata*) and salt meadow hay (*Spartina patens*), along with estuarine scrub shrub wetlands that support wax myrtle (*Myrica cerifera*), salt marsh elder (*Iva frutescens*) and groundsel tree (*Baccharis halimifolia*) (Sanger and Parker, 2016).

Only small areas of freshwater emergent, scrub-shrub and forested wetlands can be found on the Charleston Peninsula (see Figure 4-9). Approximately 20 acres of freshwater emergent and forested wetlands can be found in upper Belvidere Creek around Magnolia Cemetery. Due to multiple tidal restrictions, approximately 8 acres of upper New Market Creek are freshwater wetlands. The 8.5-acre dredge spoil area by the Citadel Boat Channel is classified as a freshwater emergent wetland, but it is actively used for placement of dredge material and is not managed for habitat.

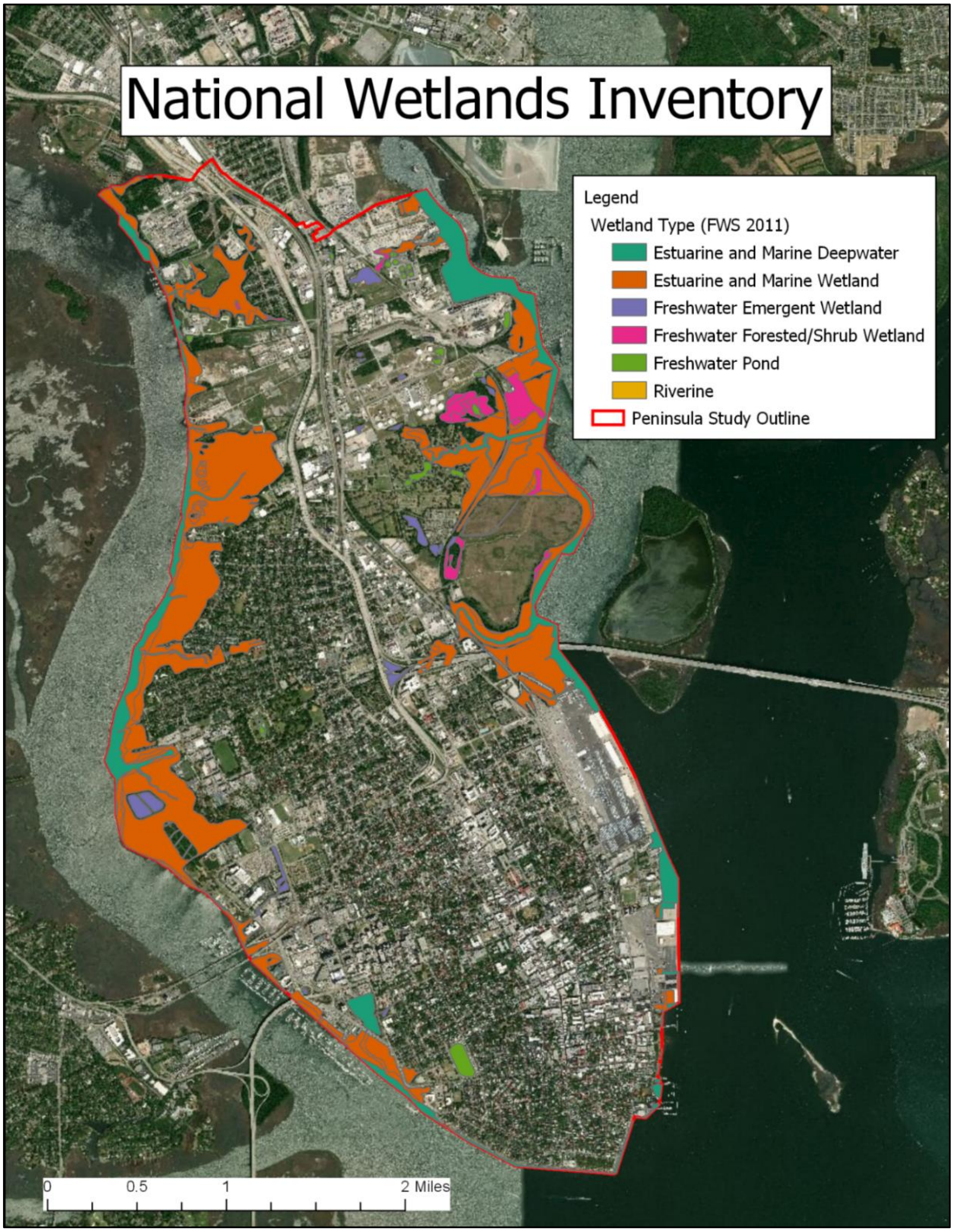

Figure 4-9. Distribution of wetland types in the study area.

Data source: USFWS NWI 2011.
Official mapping product of the Management Support Branch, Charleston District, USACE

Since the majority of the wetlands on the Charleston Peninsula are characterized as estuarine emergent wetlands (approximately 555 acres), the term salt marsh will be used throughout the remainder of this section to refer to the wetlands of interest. Salt marshes provide habitat and support biodiversity, as well as a number of valuable ecosystem services. Ecosystem services are benefits that people gain from natural (or nature-based) resources. In addition to habitat, some of the ecosystem services of salt marshes include water storage, wave attenuation, reduced coastal erosion, improved water quality, and improved aesthetics and access to “nature” that can increase tourism and recreation (Sanger and Parker, 2016). Figure 4-10 shows one of the salt marsh tidal creek systems in the study area.

Figure 4-10. Halsey Creek is one of the salt marsh tidal creek systems found on the Charleston Peninsula, shown here at low tide facing out to the Ashley River.

Source: USACE

Another part of tidal creek-salt marsh systems is the tidal flats. Tidal flats are the foundation for coastal wetlands because they accumulate sediments on gently sloping beds in estuaries or other low energy marine environments. Tidal flats are important to the intertidal chemistry since they recycle organic matter and nutrients from both terrestrial and marine sources. They are also areas of high primary productivity and can support an abundance of microorganisms, benthic organisms, fin fish, shellfish, and wading birds. Tidal flats can be differentiated by tidal elevation zones. Supratidal flats are found in the supratidal elevation zone. This is the tidal zone above high tide. Intertidal flats are found in the intertidal elevation zone. This is the tidal zone between high and low tides. The intertidal flats are non-vegetated, soft sediment habitats composed of fine-grained sediments (e.g., mud). Subtidal flats are found in the subtidal elevation zone. This is the tidal zone that is below low tide and is rarely exposed to the atmosphere. The subtidal flats are generally made up of larger grained sediments such as sand and are found lower in the tidal zone. The submerged ocean floor of Charleston Harbor is made up of unconsolidated sediments and is considered deep water habitat, which extends beyond the ROI and is not a focus for this study.

As discussed in Chapter 1, the Peninsula has undergone dramatic shoreline changes since the first European settlers arrived in Charleston around 1670, predominantly by landfilling of the intertidal zone on the southern and western side of the peninsula. Marshes and creeks that have not been filled or partially filled, have all been altered to varying degrees. Two historic tidal creeks (Major Daniel's Creek and Vanderhorst's Creek) have been completely lost to development. Belvidere Creek and New Market Creek are each restricted by multiple road crossings with culverts as well as a railroad berm. Tidal flow is also restricted in Vardells Creek and Gadsden Creek by multiple road crossings and culverts, and in Halsey Creek by one culvert. At Koppers Creek, tidal restrictions include embankments and one road culvert. The Citadel Boat Channel is dredged for boat access while a berm and dredge spoil area have been constructed within the marsh next to the Citadel Channel. A stormwater culvert and drainage channel currently connects the interior marsh and the Ashley River. Alberta Long Lake is a tidally influenced lake on artificial fill with a primary connection to the Ashley River through a culvert under Lockwood Blvd. Cummings Creek is also restricted by a culvert under Lockwood Blvd. The emerged creek then flows through an underground pipe network to Colonial Lake, where a water control device keeps the lake from draining. Colonial Lake is approximately 7 acres and is classified as a freshwater pond.

The peninsula's creeks and marshes are also impaired by indirect impacts of development. According to Sanger et. al, 2015, tidal creeks in small coastal watersheds, like those on the peninsula, are especially sensitive to changes in land use. When these small watersheds are characterized by 20-30% impervious surface (indicative of development), then ecological processes in tidal creeks are impaired. For example, New Market Creek is considered impaired because 70% of its 199 hectare (ha) watershed is impervious cover. In the Lower Cooper River, sites monitored by the SCECAP (see Section 4.4) have an overall habitat quality score of "good," while in the Lower Ashley River, the sites have an overall habitat quality score of only "fair" (Sanger et al., 2020; also see Appendix F – Environmental).

In addition to filling wetlands for development or altering for roads, shorelines have been hardened. Most notable is the approximately 1.2 miles of shoreline along the Battery where the current seawalls exist. Other notable armored areas of shoreline in the study area can be found near the Carolina Yacht Club (see Figure 4-11); by the Bristol Condominiums; along the hotels off of Lockwood Blvd; along the U.S. Coast Guard Station off Tradd Street; and along the City Marina.

Figure 4-11. Seawall by the Carolina Yacht Club along the Charleston Harbor. It is reinforced at the toe with rip rap, which continues around the corner along the east side of the yacht club (out of view in this photo).

Source: USACE

Perimeter salt marshes are also currently vulnerable to erosion from wave attack (see Section 4.2), with the exception of some marsh shorelines behind man-made structures that serve to break waves, such as marinas. For marshes that are not able to migrate inland because of roads and other infrastructure, erosion will continue to reduce the size of the marshes. Many of the perimeter salt marshes directly align upland development, leaving those structures vulnerable to encroachment of high tides as the capacity of marshes to store water decreases with erosion and rising sea levels.

4.7 Special Status Species

“Special status species” usually refers to animals and plants listed as endangered or threatened and protected under the Endangered Species Act (ESA) of 1973, as amended (16 USC §1531). The ESA provides for the conservation of species that are endangered or threatened throughout all or a significant portion of their range and the conservation of habitats upon which they depend. The law also prohibits any action that causes a "taking" of any listed species of endangered fish or wildlife unless otherwise authorized by the USFWS or NOAA. The term “take” per the ESA means to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct. Section 7 of the ESA requires that Federal agencies consult with USFWS and NOAA to ensure that their actions do not jeopardize the existence of any listed species. The ESA also designates “critical habitat” (per 50 CFR parts 17 or 226) and defines those habitats that are essential for the conservation of a federally threatened or endangered species, and that may require special management and protection.

This section also covers species that are afforded protections under the Marine Mammal Protection Act (MMPA) of 1972, as amended (16 USC 1461). This Act prohibits, with certain exceptions, the “take” of marine mammals in U.S. waters and by U.S. citizens on the high seas, and the importation of marine mammals and marine mammal products into the U.S. All marine mammals in the U.S. are afforded protection under the MMPA. The term “take” per the MMPA is defined as harass, hunt, capture, or kill, or attempt to harass, hunt, capture or kill any marine mammal.

Additionally, consideration is given to species protected by the Migratory Bird Treaty Act of 1918 (16 USC 703-712) and Executive Order 13186, Responsibilities of Federal Agencies to Protect Migratory Birds. This Act prohibits the take (including killing, capturing, selling, trading and transport) of protected migratory bird species without prior authorization by the USFWS. Only migratory bird species that are native to the United States and U.S. territories are applicable.

The ROI for special status species includes the study area and the estuarine tidal creeks and marshes in the study area that any of these species may rely on, and the surrounding waterways of the Charleston Harbor and lower Ashley and lower Cooper Rivers.

Affected Environment

There are a few species protected by the ESA and under the jurisdiction of the USFWS and/or NOAA that can be found in the ROI, in varying proximity to the study area. These are shown in Table 4-1. There are also five species of whales listed as endangered, the endangered hawksbill sea turtle, the threatened giant manta ray, and the threatened oceanic white tip shark that can be found in offshore waters of South Carolina but are not likely to be in the ROI of this study. There are no Federally-listed plant species in the ROI.

Table 4-1. Federally-listed Threatened and Endangered Species in the Region of Influence.

Species Common Name	Scientific Name	Status
Atlantic sturgeon*	*Acipenser oxyrinchus*	E, CH
Shortnose sturgeon*	*Acipenser brevirostrum*	E
American wood stork**	*Mycteria americana*	T
Eastern black rail**	*Laterallus jamaicensis jamaicensis*	T
West Indian manatee	*Trichechus manatus*	E
Green sea turtle	*Chelonia mydas*	T
Kemp's ridley sea turtle	*Lepidochelys kempii*	E
Leatherback sea turtle	*Dermochelys coriacea*	E
Loggerhead sea turtle	*Caretta caretta*	T, CH
Key: E - Endangered T – Threatened CH - Critical Habitat * These species are under the sole jurisdiction of National Marine Fisheries Service ** These species are under the sole jurisdiction of US Fish and Wildlife Service Sources: NOAA 2020b; USFWS IPaC (n.d.)		

<u>Fish</u>

Two federally protected fish species commonly occur in the Charleston Harbor and the Cooper River. As noted in Table 4-1, they include the shortnose sturgeon (*Acipenser brevirostrum*) and the Atlantic sturgeon (*Acipenser oxyrhynchus*). Shortnose sturgeon spend most of their time as adults in fresh and brackish water but do venture into lower coastal reaches and the ocean on rare occasions. Atlantic sturgeon is a subtropical, anadromous species that typically migrates up rivers in the spring and fall in this region to spawn. Both are bottom feeders. Historically, over-fishing affected sturgeon populations. Current prominent threats to these species include habitat loss or fragmentation, dredging, migration/passage barriers, decreased water quality, and entanglement in fishing gear, as well as vessel strikes for Atlantic sturgeon. Shortnose sturgeon are currently found in the Cooper River, and the Carolina Distinct Population of Atlantic sturgeon is found throughout the Charleston Harbor, with portions of the Cooper River designated at Critical Habitat for the Atlantic sturgeon (NOAA, n.d.).

Tagging and tracking by the SCDNR of shortnose and Atlantic sturgeon confirm movement throughout the Charleston Harbor, and in the Cooper River with the highest usage of the Cooper River by shortnose sturgeon roughly between river km 30 and 45 where the freshwater-to-saltwater interface occurs. This is well upstream of the study area. Adult and sub-adult Atlantic sturgeon in the Cooper River are believed to be transient populations from other river systems. Both species of sturgeon have been detected in the Ashley River. The Ashley River is not used for spawning, so SCDNR believes sturgeon detections are most likely from juveniles or transient adults (personal communication, Bill Post SCDNR Diadromous Fish Coordinator). While it's possible for sturgeon to enter small, shallow tidal creeks of the Peninsula to forage, this would not be common.

Marine Mammals

Marine mammals known in the ROI include bottlenose dolphin (*Tursiops truncates*) and West Indian manatee (*Trichechus manatus*). Both are afforded Federal protection under the MMPA.

There are two recognized subspecies of the West Indian manatee; the Antillean manatee (*Trichechus manatus manatus*) and the Florida manatee (*Trichechus manatus latirostris*). The Florida manatee inhabits the Southeastern coast of the United States, however both subspecies are commonly referred to as the West Indian manatee. As noted in Table 4-1, the West Indian manatee is a federally-listed threatened species. Manatees can inhabit both salt and fresh waters and are found at shallow depths (5-20'). In the waters of the continental US, they are most abundant in the warm waters of peninsular Florida. During the summer months manatees on the eastern coast of Florida have been reported to travel as far north as Cape Cod, Massachusetts (USFWS, 2008). Manatees that inhabit and travel through South Carolina waters during the warmer months will feed on salt marsh grasses at high tide and submerged algae beds at low tide. Manatees have been sited near the Charleston Peninsula in the Cooper River, the Ashley River, the Atlantic Intracoastal Water Way, and Shem Creek; a tidally influenced saltwater creek that drains directly into Charleston Harbor before draining into the Atlantic Ocean.

While common bottlenose dolphins can be found in nearshore coastal waters and estuaries of the Atlantic Coast from New York to Florida, a resident single-stock of bottlenose dolphins inhabits the Charleston Harbor and main channels of the Ashley, Cooper, and Wando Rivers. The Charleston Estuarine System (CES) Stock spans the estuarine waters and tributaries from Price Inlet (near Capers Island) to the Stono River. The stock is threatened by entanglement with blue crab traps/pots and other fishing gear, disease, and urban pollution, especially in the tidal rivers more so than in the open waters of the Charleston Harbor (NOAA, 2016). Bottlenose dolphins, who fall into the mid-frequency generalized hearing range for cetaceans of 150 Hz to 160 kHz, are susceptible to hearing impacts from underwater noise (NOAA, 2018). The size of the CES Stock is currently unknown, but it is considered to be a "strategic stock under the MMPA" (NOAA, 2016).

Sea Turtles

There are four species of sea turtles known to occur in or near waters of Charleston, SC, all of which are federally-listed as threatened or endangered species (see Table 4-1): Kemp's ridley (*Lepidochelys kempii*), leatherback (*Dermochelys coriacea*), loggerhead (*Caretta caretta*) and green (*Chelonia mydas*). Leatherback sea turtles, found in offshore waters, and Kemp's ridley sea turtles, found in nearshore waters, could be but are less likely to be, in the ROI. Loggerhead and green sea turtles are the most common species in South Carolina waters, and their distribution at different life stages varies including offshore waters, bays, inlets, river mouths, salt marshes, creeks, ship channels, and sandy beaches for nesting. Subadult and adult loggerheads move into coastal waters, such as Charleston Harbor, to prey on mollusks, crustaceans, and fish (USFWS, 2015). Studies done in Virginia and Delaware show loggerhead sea turtle eating preference to be horseshoe crab, then blue crab, then finfish. Ultimately, reduction of salt marsh acreage could lead to alteration of the loggerhead sea turtle food web (Boutin & Targett, 2013; Seney & Musick, 2007).

A trawling study conducted within the Charleston Harbor shipping channel between 2004-2007 showed that loggerhead sea turtles are present in the channel in increased numbers, and are of increased size, compared to the early 1990s (Arendt et. al, 2012). Although loggerheads and greens could be found in the Cooper and Ashley Rivers, they are unlikely to wander into the shallow, altered tidal creeks of the peninsula.

Threats to sea turtles include vessel strikes, dredging, fishing by-catch and entanglement, degradation of foraging habitat, pollution, and disease. They are also threatened by various natural and anthropogenic impacts to their nesting habitat, such as beach erosion, beach armoring, artificial lighting, and nest predation. In the Charleston area, Critical Habitat for nesting loggerhead sea turtles has been federally-designated for Folly Beach and Morris Island, but these are well outside of the ROI.

Birds

There are two avian species that are listed as threatened under the ESA (see Table 4-1) that are of interest for this study: the American wood stork and eastern black rail (BLRA). The BLRA was officially listed in 2020.

The American wood stork is a long-legged water bird species that uses freshwater and estuarine wetlands as feeding, nesting, and roosting sites. The stork constructs nests in trees, usually in gregarious colonies (called rookeries). Often the rookeries and roosting areas are in association with herons, egrets, and other species. Stork feeding behavior is typically along the marsh vegetation and open water interface seeking small fish and macroinvertebrates (USFWS, 1990). According to the USFWS South Carolina Field Office, the existing tidal wetlands on the Peninsula could serve as potential foraging habitat for the wood stork, but there are no known roosting areas or rookeries.

While wood storks are habitat generalists, foraging and reproductive grounds are decreasing due to encroaching development. Additionally, storks are especially sensitive to environmental conditions at breeding sites and may fly relatively long distances either daily or between regions annually seeking adequate food resources (USFWS, 1990).

The BLRA is a wetland dependent bird found in a variety of salt, brackish, and freshwater wetland habitats that can be tidally or non-tidally influenced requiring dense overhead cover and soils that are moist to saturated (occasionally dry) and interspersed with or adjacent to very shallow water. The BLRA nests within dense clumps of vegetation over moist soil or shallow water to provide shelter from the elements and protection from predators. The primary threats to the eastern black rail included habitat degradation through marsh draining and ditching as well as fragmentation from conversion of habitat to agricultural lands or urban areas (USFWS, 2019). Presence of BLRA in the study area is questionable since the marsh habitat has varying tidal fluctuations, but the possibility remains for this recently-listed species (M. Caldwell, USFWS personal communication).

There are many migratory songbirds, waterfowl, seabirds, and wading birds that stopover in coastal South Carolina. In addition to the wood stork and black rail discussed above, sparrows, pelicans, herons, and common coastal migratory species could be in the ROI, but their presence for nesting, resting, or foraging would be limited to the extent that suitable habitat is available, similar to that for the stork and black rail. Given their more recent adaptation to urban landscapes, least terns (*Sternula antillarum*) are one of the more likely migratory birds of interest to be found on the Charleston Peninsula. Due to lack of suitable beach nesting habitat and other factors, least terns began nesting on pebble-covered roofs in South Carolina in the last few decades, including some locations around Charleston. Not all nest sites are used every year, while new sites may arise in any nesting season. There is only one known rooftop nesting site in the study area, at the northern end in an industrial area. The last recorded use was in 1992 (M. Caldwell, USFWS personal communication).

4.8 Aquatic Resources

This section focuses primarily on aquatic invertebrates and fishery resources and their habitat dependencies. The Fish and Wildlife Coordination Act requires USACE to coordinate with USFWS and NOAA on water resources related projects to obtain their views toward preservation of fish and wildlife resources and mitigation of unavoidable impacts. A Fish and Wildlife Coordination Act Report has been prepared for this study and has helped to inform this FR/EIS. It can be found in Appendix F – Environmental.

When important recreational and commercial fisheries are present, the Magnuson-Stevens Fishery Conservation and Management Act of 1994 (MSA) must be considered. The MSA applies to Federally managed species and requires Federal agencies to identify and describe Essential Fish Habitat (EFH) for fisheries that may be impacted by a potential project. Essential Fish Habitat is defined as “those waters and substrates necessary to fish for spawning, breeding, feeding, or growing to maturity.” The MSA applies to federally managed species under the management of regional fishery management councils, who must develop fishery management plans that identify and describe EFH for the fishery, minimize adverse effects from fishing on the fishery, and sustainably manage the resource. “Adverse effect” includes “any impact which reduces quality and/or quantity of EFH, through direct impacts (e.g., contamination or disruption), indirect impacts (e.g., loss of prey, reduction in fecundity), or individual, cumulative, or synergistic impacts. An Essential Fish Habitat Assessment has been prepared for this study, as required by the MSA. It can be found in Appendix F – Environmental.

The invertebrate and fish species that may be found in estuarine tidal creeks of the Charleston Peninsula, as well as in adjacent waterways of the Charleston Harbor, lower Ashley River, and lower Cooper River make up the ROI. Benthic macrofauna are addressed in the next section, Benthic Resources.

Affected Environment

Common aquatic invertebrates found in waterways and salt marshes in the ROI include penaeid shrimp, grass shrimp (*Palaemonetes vulgaris*), blue crabs (*Callinectes sapidus*), horseshoe crabs (*Limulus polyphemus*), knobbed whelk (*Busycon carica*), eastern oysters (*Crassostrea virginica*), ribbed mussels (*Geukensia demissa*), hard clams (*Mercenaria mercenaria*), Eastern mud snails (*Ilyanassa obsolete*) and marsh periwinkles (*Littoraria irrorata*) (Sanger and Parker, 2016). Some of these organisms rely entirely on salt marsh-tidal creek systems, while others such as penaeid shrimp and blue crabs are transient and use them as nursery grounds. Many of these species are economically important in South Carolina.

Cartilaginous fishes, such as the Atlantic stingray (*Dasyatis sabina*) and the bonnethead shark (*Sphyrna tiburo*), can be found in the ROI, including Essential Fish Habitat for some shark species. Sharks move into estuaries in the spring, and then head offshore in the fall. Common demersal fish that can be found in waters of the ROI include Atlantic croaker (*Micropogonias undulates*), bay anchovy (*Anchoa mitchilli*), mummichog (*Fundulus heteroclitus*), red drum (*Sciaenops ocellatus*), black drum (*Pogonias cromis*), silver perch (*Bairdiella chrysoura*), spot (*Leiostomus xanthurus*), spotted seatrout (*Cynoscion nebulosus*), Atlantic menhaden (*Brevoortia tyrannus*), blackcheek tonguefish (*Symphurus plagiusa*), and southern flounder (*Paralichthys lethostigma*) (Sanger and Parker, 2016). Several of these species, such as red and black drum, flounder, spot, and spotted sea trout have commercial and/or recreational value.

SCDNR monitors biological communities throughout the state's coastal habitats, including through the SCECAP (Sanger et. Al., 2020). Data from the SCECAP sites in the ROI (see Section 4.4) verify that recreationally and commercially important species of spot, flounder, white shrimp, brown shrimp, and blue crabs are present, with white shrimp being the most abundant, especially within tidal creeks.

All of the tidal creeks and tributaries, along with their adjacent saltmarshes (estuarine emergent vegetation), tidal flats, and oyster reefs, along the lower Ashley and Cooper Rivers are designated as Essential Fish Habitat under the MSA because they provide nursery habitat for juvenile development of penaeid shrimp, specifically white and brown shrimp. They are also a Habitat Area of Particular Concern for penaeid shrimp and for fishes in the snapper-grouper complex. The snapper-grouper complex includes ten families of fishes containing 73 managed species. The Habitat Area of Particular Concern includes the areas of depth inshore of the 100-foot contour in Charleston Harbor which includes salt and brackish marshes, tidal creeks, and soft subtidal sediments. The habitat designation is specific to nearshore snapper-grouper species and target life stages that are estuarine dependent (NOAA, 2020c).

Subtidal flats in the study area (see Section 4.6) are considered EFH. These areas are designated EFH to protect marine benthic macroinvertebrates in support of economically important aquatic resources. The water column of the Charleston Harbor, the lower Ashley River, and lower Cooper River are also EFH, because they serve as the connecting water bodies between inshore estuarine nursery grounds and offshore marine habitats used for spawning and growth to maturity. A more detailed description of how the habitats in the ROI support federally-managed fisheries is included in the Essential Fish Habitat Assessment found in Appendix F – Environmental.

A major threat to current aquatic resources comes from the hundreds of years of development and marine commerce in the Charleston area. Development within coastal watersheds leads to increased salinity ranges, increased nutrient loading, bacteria and pathogens, and contaminants in tidal creeks that impair oyster health, reduce biological productivity, and alter the food web (Sanger et al., 2015). All waterways in the ROI are currently closed to shellfish harvesting due to reduced water quality. As described in Section 4.6, estuarine habitat has been lost due to filling of tidal wetlands and armoring of shorelines – most notably the current Battery seawalls. Roads with culverts and other tidal restriction impact almost all of the salt marsh tidal creek habitats on the Peninsula, affecting flow and likely fish passage to varying degrees. Other threats to aquatic resources include over-fishing, invasive species, and climate change.

4.9 Benthic Resources

The benthic (bottom-dwelling) resources focused on in this section include the macroinvertebrates found living on the bottom of the tidal creeks and tributaries, and in the tidal flats found around and nearshore of the Charleston Peninsula (this is the ROI). These small invertebrates can usually be seen without a microscope. Marine benthic macroinvertebrates fall into two benthic communities. Epifaunal communities live attached to surfaces such as rocks, pilings, or on the surface of the bottom. Infauna communities burrow and live within benthic sediments.

These benthic resources have an important role in the food web, and their size, abundance, and species diversity in a given area serve as a valuable indicator of the surrounding environmental conditions. Since these benthic resources serve as a primary food source for larger, economically important crustaceans and fish in the ROI, their environment is considered Essential Fish Habitat and is regulated under the Magnuson-Stevens Fishery Conservation and Management Act.

Affected Environment

Intertidal and subtidal flats (unconsolidated bottom) surround portions of the Charleston Peninsula. Intertidal flats are unvegetated bottoms of estuaries that lie between high and low tide lines, usually along mainland or barrier island shorelines. Mudflats can be extensive where the tide range is greatest.

Tidal flats can be differentiated by tidal elevation zones. Supratidal flats are found in the supratidal elevation zone. This is the tidal zone above high tide. Intertidal flats are found in the intertidal elevation zone. This is the tidal zone between high and low tides. The Intertidal flats are non-vegetated, soft sediment habitats composed of fine-grained sediments (e.g., mud). Subtidal flats are found in the subtidal elevation zone. This is the tidal zone that is below low tide and is rarely exposed to the atmosphere. The subtidal flats are generally made up of larger grained sediments such as sand and are found lower in the tidal zone. Tidal flats are areas of high primary productivity and support an abundance of benthic organisms.

Typical benthic macroinvertebrates that could be found in the ROI include snails, marine worms, and small shrimp-like crustaceans. Macroinvertebrates sort within the tidal zones by habitat stressors such as benthic sediment size, soil salinity and wave energy (Sanger and Parker, 2016). Most species are sedentary and are sensitive to sediment conditions and changing environmental conditions. SCDNR monitors macrobenthic communities throughout the state's coastal habitats, including through the SCECAP which assesses benthic integrity (Sanger et al. 2020). For all of the SCECAP sites in the ROI (see Section 4.4 and Appendix F - Environmental), the benthic quality score was "good" except for the Lower Ashley River site near the Citadel where the benthic quality was considered "fair." At this site, high concentrations of polyaromatic hydrocarbons, or PAHs, were detected in the sediments.

4.10 Terrestrial Wildlife and Upland Vegetation

This section focuses on upland plants and terrestrial species of invertebrates, amphibians, reptiles, birds, and mammals. Special status wildlife species are already discussed in Section 4.7 above. The ROI for terrestrial wildlife and plants includes the upland portions of the Charleston Peninsula study area.

Affected Environment

Tidal marshes and flats such as those found in the ROI harbor many species of birds including larger wading birds such as herons and egrets, as well as smaller birds like redwing black birds and sparrows. Marshes serve as nesting and foraging grounds for these and other birds. Foraging may occur at various tidal stages with birds seeking small fish and crabs, the marsh periwinkle, and other macroinvertebrates as described in Section 4.9. Over time, development on the Charleston Peninsula has eliminated or fragmented many of the salt marsh-tidal creek systems; very little unaltered estuarine habitat remains.

There are a number of At-Risk-Species (ARS) in Charleston County, which are also State-listed species, but the Charleston Peninsula does not support suitable habitats for most of them. The At-Risk-Species that could be found on the peninsula based on their habitat preferences include saltmarsh sparrow (*Ammospiza caudacuta*) and monarch butterflies (*Danaus plexippus*). The saltmarsh sparrows live only in salt marshes and are found along the East and Gulf Coasts but are not known to breed as far south as South Carolina. Their population is at risk as salt marshes are lost since they currently use no other habitats. The monarch butterfly is a highly recognizable butterfly, but its population is declining. They feed on a wide range of flowering plants, and they can be found in urban parks and gardens. They require milkweed for breeding. At-Risk-Species are not afforded any Federal protections.

Other terrestrial wildlife that could be in the ROI include diamondback terrapins, river otters, marsh rabbits, muskrats, marsh rice rats, beavers, and mink because they are dependent on estuarine areas for foraging, cover, and/or nesting. Urban development and other human disturbances have already limited their habitat.

Most of the terrestrial plant species on the Peninsula are ornamental and nonnative trees, grasses, and shrubs that are regularly maintained. The City of Charleston has an ordinance to protect trees that are classified as a “grand tree” which is any tree 24 inches or greater in diameter above the grade diameter at breast height (D.B.H.) excluding pine trees or sweet gums, and a “protected tree” which is any tree eight inches or greater D.B.H except multi-stem crepe myrtles.

4.11 Cultural Resources

Numerous laws require Federal agencies to consider effects on cultural resources. The Council on Environmental Quality’s regulations implementing National Environmental Policy Act (NEPA) require that Federal agencies consider the “[u]nique characteristics of the geographic area such as proximity to historic or cultural resources, park lands, prime farmlands, wetlands, wild and scenic rivers, or ecologically critical areas” and “[t]he degree to which the [proposed] action may adversely affect districts, sites, highways, structures, or objects listed in or eligible for listing in the National Register of Historic Places (NRHP) or may cause loss or destruction of significant scientific, cultural, or historical resources” (40 CFR §1508.27(b)(3), (8)). In addition to a consideration of cultural resources, USACE must also take into account the effects of its undertaking on historic properties as defined in 54 U.S.C. §300308 of the National Historic Preservation Act (NHPA). The NHPA (54 U.S.C. §300101 et. seq.) characterizes historic properties as any prehistoric or historic district, sites, building, structure, artifacts, or object included in, or eligible for inclusion in, the NRHP. Several Federal laws and regulations protect these resources, including the NHPA, the Archaeological and Historic Preservation Act of 1974 (54 U.S.C. §§312501- 312508), and the Archaeological Resources Protection Act of 1979 (16 U.S.C. §§470aa-470mm). These Federal laws, specifically Section 106 and Section 110 of the NHPA, require Federal agencies to consider the effects of their actions on cultural resources and historic properties, including districts, sites, buildings, structures, and objects included or eligible for inclusion in the NRHP. Documentation of cultural resources and historic properties is particularly important for this project as Charleston is nationally significant for its role in the development of the Untitled States. This history is visually represented by the dense concentration of architecturally significant structures that characterize the Peninsula.

Section 106 of the NHPA (54 U.S.C. § 306108) and its implementing regulations (36 CFR Part 800) requires an assessment of the potential impact of an undertaking on historic properties that are within the proposed project's area of potential effects (APE), which is defined as the geographic area(s) "within which an undertaking may directly or indirectly cause alterations in the character or use of historic properties, if any such properties exist" (36 CFR 800.16(d)). Additionally, Section 110(f) of the NHPA (54 U.S.C. § 306107) requires USACE to minimize harm to all National Historic Landmarks (NHL) within the APE to the maximum extent possible. The APE for cultural resources extends beyond the study area and is defined as the areas where structural measures are implemented (to include construction, demolition, vibration, and auditory effects), where non-structural measures are applied to historic properties, and where structural or non-structural measures have the potential to affect the viewshed of historic properties. An effect is an alteration to the characteristics of a historic property qualifying it for inclusion in or eligibility for the NRHP (36 CFR 800.16(i)). Examples of effects include visual intrusions, alterations of setting, noise, vibrations, viewsheds, and physical impacts. Effects may be direct, indirect, or cumulative. Indirect effects to historic properties are those caused by the undertaking that are later in time or farther removed in distance but are still reasonably foreseeable. Cumulative effects are those which result from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions. For purposes of the *Affected Environment* analysis below, historic properties and cultural resources are broadly discussed within the study area. Effects to historic properties based on the APE are discussed in more detail within Chapter 7. Information on historic properties within the study area relies on existing information primarily from South Carolina's ArchSite database and the South Carolina Department of Archives and History (SC DAH).

Affected Environment

<u>Precontact and Early Settlement</u>

Modern day South Carolina has been inhabited by humans for over 12,000 years. Evidence of some of the earliest human occupation has been found at the Topper site along the Savannah River in Allendale County (Goodyear, 2005). Radiocarbon samples from the site have produced dates that range from 50,300 B.P. and 51,700 B.P., thousands of years prior to the well-established and documented Paleoindian Period (12,000 B.P. – 10,000 B.P.); however, dates from the Topper site have been disputed. The Paleoindian period is typically marked by the presence of a series of fluted, lanceolate projectile points and common types in South Carolina include the Suwannee, Cumberland, Clovis and Quad. The population of this period are generally considered nomadic, band level hunter-gatherer societies with low population density that increased at the end of the period. Paleoindian sites are found in major river systems where food sources would have been the most abundant and are generally limited to surface finds. In Charleston County, there have been seven Paleoindian projectile points reported.

The Archaic Period (10,000 B.P. – 3,000 B.P.) represents a time of adaptation to warming climates and rising sea levels and is divided into the Early, Middle and Late Periods. During the Archaic period populations grew and became less mobile towards the end of the period as technological innovations and a more varied artifact assemblage appear in the archaeological record. Late Archaic sites have produced some of the earliest pottery sherds as well as the first evidence of freshwater shellfish procurement.

During the Woodland Period (3,000 B.P. – 850 B.P.) pottery became more widespread and semi-permanent villages were formed. Elaborate mortuary practices were common and large earthen or sand mounds were constructed for ceremonial purposes. These practices continued to evolve in the Mississippian period (850-310 B.P.) as hierarchical social, political and ceremonial systems continue to develop. The Protohistoric period follows the Mississippian Period and is interpreted as a transitional period between the end of the Prehistoric period and the beginning of the Historic period. This cultural elaboration is seen along the lower Ashley River, including the Charles Towne Landing site (38CH1) on the southern side of the present-day Charles Towne Landing State Park. The site is of noted for the presence of wooden palisades and mortuary and ceremonial structures. The end of the period is marked by the founding of Charles Town in 1670 and subsequent expansion of the British into the Southeast.

The Charleston area was part of the Carolina colony, both named in honor of King Charles II, and included most of present-day North and South Carolina and Georgia. King Charles II issued a charter in 1663 to eight Lords Proprietors, and in 1670 a group of roughly 200 colonists from Barbados arrived in Carolina to found Charles Town on the west bank of the Ashley River. Each family member was allotted 150 acres, which helped give rise to settlement by large plantation owners. To grow the colony, the Lords Proprietors projected religious tolerance as a tenant as part of the *Fundamental Constitutions of Caroline*, although much of the property rights established were modeled on feudalism (Navin, 2020). This promise attracted numerous religious groups to Charles Town with the hope of experiencing religious freedom. As a result of these migrations, Charles Town became home to one of the largest Jewish communities in North America. By 1681, the settlement had grown and was moved across the river to the Peninsula. Although Native American populations were already moving inland due to Spanish colonization, numerous tribes resided in the area when the British arrived. This displacement continued with the founding and subsequent expansion to the Peninsula, but some Native American populations remained and were a focus of early efforts by the Lords Proprietors and colonial government to establish and control trade (Zierden and Reitz, 2016). The effort culminated in the establishment of a trade alliance with the Creek in 1685.

<u>History of the Charleston Peninsula</u>

Early settlement of the peninsula was concentrated along the Cooper River. In response to Queen Anne's War in 1703, a network of fortifications, including walls, cannon, and moats, were constructed to encircle the town (Figure 4-12). In addition to timber and cattle production, the early deerskin trade with the nearby Indians helped Charles Town develop into a major port of the Carolina Colony. Through this early era, Charles Town would begin to be known on maps and in writing as Charleston. Enslaved laborers composed the majority of the population by 1708 due to the early establishment of a plantation economy by the Lords Proprietors. The population of enslaved people increased sharply in Charleston and the Carolina Colony with the introduction of rice production in the early eighteenth century (Butler, 2020; Navin, 2020). As inland swamp rice production became the primary regional industry, the annual production of rice went from 8,000 barrels in 1715 to 40,000 in the 1730s (Zierden and Reitz, 2016). Indigo also became a major commercial export, as it was highly desired on the British market and preferred upland settings, which did not conflict with rice. Production of this scale and the resultant demand for labor in the form of chattel slavery greatly increased the focus of Charles Town as a hub of export and import. In 1729 the Carolina Colony was divided into North and South, and Georgia was separated as its own colony in 1731.

By 1750 Charles Town was the fourth largest city in Colonial America and the largest, as well as one of the wealthiest cities south of Philadelphia. Following the American Revolution, when indigo demand waned, cotton became the primary upland product. Coupled with the introduction of the cotton gin, production increased steadily and further demands on shipping activity resulted in the expansion of harbor development along the Cooper River and the expansion of Charles Town to the north and west (Figure 4-13). This growth also led to a doubling of the enslaved population from the 1760s to 1780 (Zeirden and Reitz, 2020). Through this growth, the city would be incorporated and formally renamed Charleston in 1783.

Figure 4-12. Early Charles Town as shown on excerpt from "Complete Description of the Province of Carolina in 3 parts," Edw. Crip 1711 (Library of Congress).

Source: Library of Congress, https://www.loc.gov/item/2004626926/

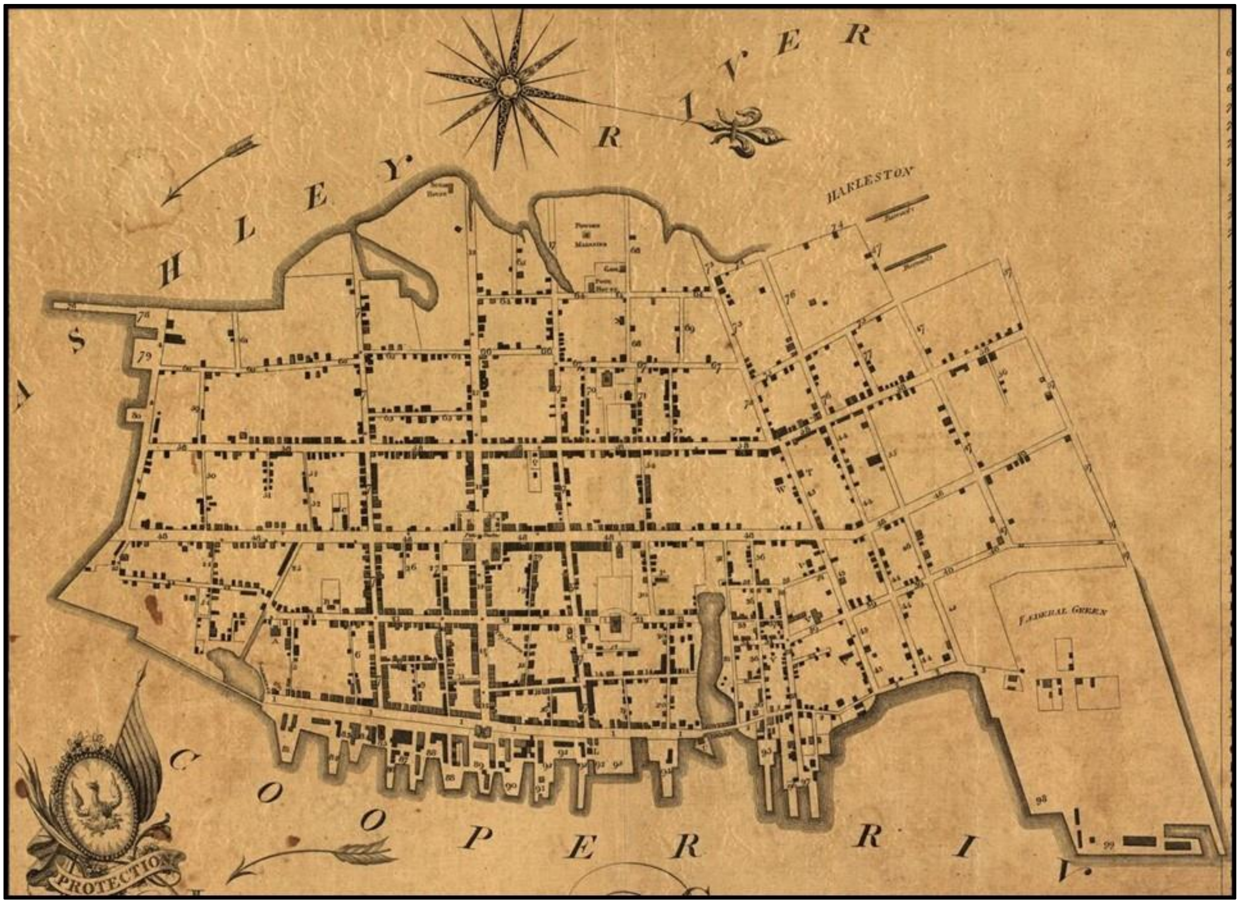

Figure 4-13. Portion of "Ichnography of Charleston, South-Carolina: at the request of Adam Tunno, Esq., for the use of the Phoenix Fire-Company of London, taken from actual survey, 2d August 1788," E. Petrie, 1790, showing growth of the lower peninsula.

Source: Library of Congress, https://www.loc.gov/item/80692362/

As the city's population and wealth grew, the community added resources that would offer the plantation owners and merchants opportunities for cultural and social events. The first theater building in America, the Dock Street Theatre, was built in Charleston in 1736. The building was likely destroyed by a fire in 1740 and rebuilt as a hotel in 1809. Horse racing was also popular, and in 1734 the first jockey club in America was founded in Charleston. The racecourse at New Market held its first race in 1760 and closed in 1792 after the Washington Race Course opened at Hampton Park. Other cultural institutions that were founded include the first publicly supported library (1698), the College of Charleston (1770), and the Charleston Museum (1773). Although later destroyed by fire, the Old Bethel United Methodist Church was established by both free and enslaved residents in 1797. The congregation of the Emanuel African Methodist Episcopal (AME) Church stems from a religious group organized solely by free and enslaved African Americans in 1791.

According to U.S. Census data, Charleston was the twenty-second largest city in 1860, with a population just over 40,500, the majority of which were enslaved persons. Shortly after the election of Abraham Lincoln in 1860 the state of South Carolina seceded from the Union, and in April 1861 the first shots of the Civil War were fired at Fort Sumter, approximately 3.5 miles east of Charleston. The city remained under siege by Union forces from 1863 until 1865, which caused considerable damage to the city (Figure 4-14). The greatest damage to the city, however, was caused by a fire that burned through portions of the lower peninsula in 1861. The fire was unrelated to the war and destroyed around 540 acres of land and numerous buildings.

Figure 4-14. “Charleston, S.C. Houses on the Battery damaged by shell-fire.” Photographed by George N. Barnard, 1865.

Source: Library of Congress, https://www.loc.gov/item/2018666910/.

After the Civil War many structures were never rebuilt, and more were demolished as the city went through periods of economic growth and social changes. Preservation efforts in the early twentieth century by the city, local organizations, and citizens helped prevent razing of many historic structures, and today the peninsula has one of the largest and most diverse assemblages of eighteenth through twentieth-century architecture in South Carolina.

In the decades following the Civil War, Charleston continued to grow as a vital port along the Atlantic coast for trade within the states and internationally. This was bolstered by the repair and expansion of multiple rail lines, including the Northeastern and Savannah & Charleston railways, which connected the two port cities and provided the shortest route from New York to Florida (Fraser, 1989). Despite this boom, transportation within the city was plagued by flooding and poor drainage leading to roadways and sidewalks described as “dangerous to life and limb” (Fraser, 1989). By the late 1870s, only about one third of the city’s 53.5 miles of streets were paved in some form (Fraser, 1989). This became a focus of municipal development, as approximately 94,000 square yards of granite block was laid along the principal streets from 1880 to 1883 and crews made daily work of clearing waste. Much of this waste was then repurposed as fill for reclamation of marshes around the peninsula and road fill on the neck of the peninsula, resulting in overall expansion of the city.

This economic growth did not continue into the twentieth century due to earthquakes and hurricanes, increased competition from surrounding states, and shifting rail patterns left Charleston out of major railroad routes. In the early- to mid-twentieth century, a recurring strategy to combat this downturn was to renovate the city’s roadways, particularly along the waterfront. One of the first large shoreline improvements was the installation of the Low Battery Seawall between 1900 and 1912 and development of the roadway along it, now Murray Boulevard. The Low Battery Seawall construction also led to the filling of 47 acres of mud flats, which were then surveyed and platted for residential development. A second phase of this expansion was initiated in 1917 and included improvements to the seawall surrounding White Point Gardens. The expansion was plagued by delays, partially due to labor and material shortages during World War I and ongoing engineering issues (Butler, 2020). The project was slated to take a year; however, it was not complete until late 1920. Continuous focus on these efforts fluctuated with the political climate but gained added support through the 1930s and 1940s. This was largely due to federal funds becoming more available during the Great Depression and the development of the Navy Yard in support of World War II. The Navy Yard was situated along the Cooper River north of the city and contained an ammunition depot, housing, and shipbuilding facilities, resulting in the production of 12 destroyers (Fraser, 1989). This led to an associated influx of naval and support personnel and an increased demand for city expansion and infrastructure development.

Like much of the country, World War II ushered in a boom time for Charleston. Population swelled, driving the demand for housing and infrastructure throughout the city. This led to renewed interest in the road development and expansion of marsh reclamation along the Ashley

River (Butler, 2020). This effort would lead to completion of Lockwood Drive and the associated backfilling in 1951. Though not tied to a specific road expansion, similar reclamation was also conducted to the north of the city along the Cooper River, particularly in the vicinity of Vardell's Creek near the on ramp for the Grace Bridge (Butler, 2020).

Inventory of Cultural Resources in Study Area

As of July 6, 2021, there are approximately 373 cultural resources listed on the South Carolina database (ArchSite) within the study area. Archsite is an online geographic information system (GIS) maintained by the South Carolina Department of Archives and History (SC DAH) and the South Carolina Institute of Archaeology and Anthropology (SCIAA) that combines data from the state's archaeological and built heritage (Figure 4-15). The database includes recorded cultural resources regardless of NRHP eligibility status, including archaeological sites, historic structures, historic districts, historic areas, and civil war earthworks.

Cultural resources are distributed throughout the peninsula, but the largest concentration of historic properties is found in the Charleston Old and Historic District (COHD) (Figure 4-16). The district spans the southern portion of the peninsula. The NRHP-listed COHD was also designated a NHL in 1960 and consists of an assemblage of eighteenth- and nineteenth-century buildings and structures. Collectively the structures represent the historic development of the city across multiple architectural styles, including the Georgian, Regency, Federal, Adamesque, Classical Revival, Greek Revival, Italianate, Gothic Revival, and Queen Anne styles. Subsequent NRHP nomination updates in the 1970s and 1980s expanded the boundary and extended the period of significance to 1941. The COHD contains primarily residential buildings, but also includes institutional resources, such as churches and government-related buildings. Many buildings are significant both for associations with historic events or persons and for architecture. The SC DAH maintains a list of historic properties that have been determined to be contributing elements to the COHD; however, there is not a comprehensive inventory of contributing properties. As of November 2019, the list contained at least 760 contributing elements. According to staff at the SC DAH the list is derived from what has been entered into the SC DAH database throughout the years, rather than the product of a systematic survey (John Sylvest, personal communication, November 2019). The COHD covers approximately 2 square miles. The NHL boundary for the COHD does not include more recent boundary expansions, so is smaller than what is shown in the ArchSite database (Ellen Rankin, personal communication October 2019). The COHD includes several historic neighborhoods, the King Street/Meeting Street commercial corridor, and the Low and High Battery Seawalls, whose construction facilitated the creation of Murray Boulevard and East Battery Street, respectively. The High Battery Seawall also facilitated the development of East Battery Street and White Point Garden. Other notable historic districts within the study area include the French Quarter District, Charleston Cemeteries Historic District, and the Hampton Park Terrace Historic District. The Mount Pleasant Historic District and the Moultrieville Historic District are located outside of the study area, across the Cooper River, but within the viewshed of the project.

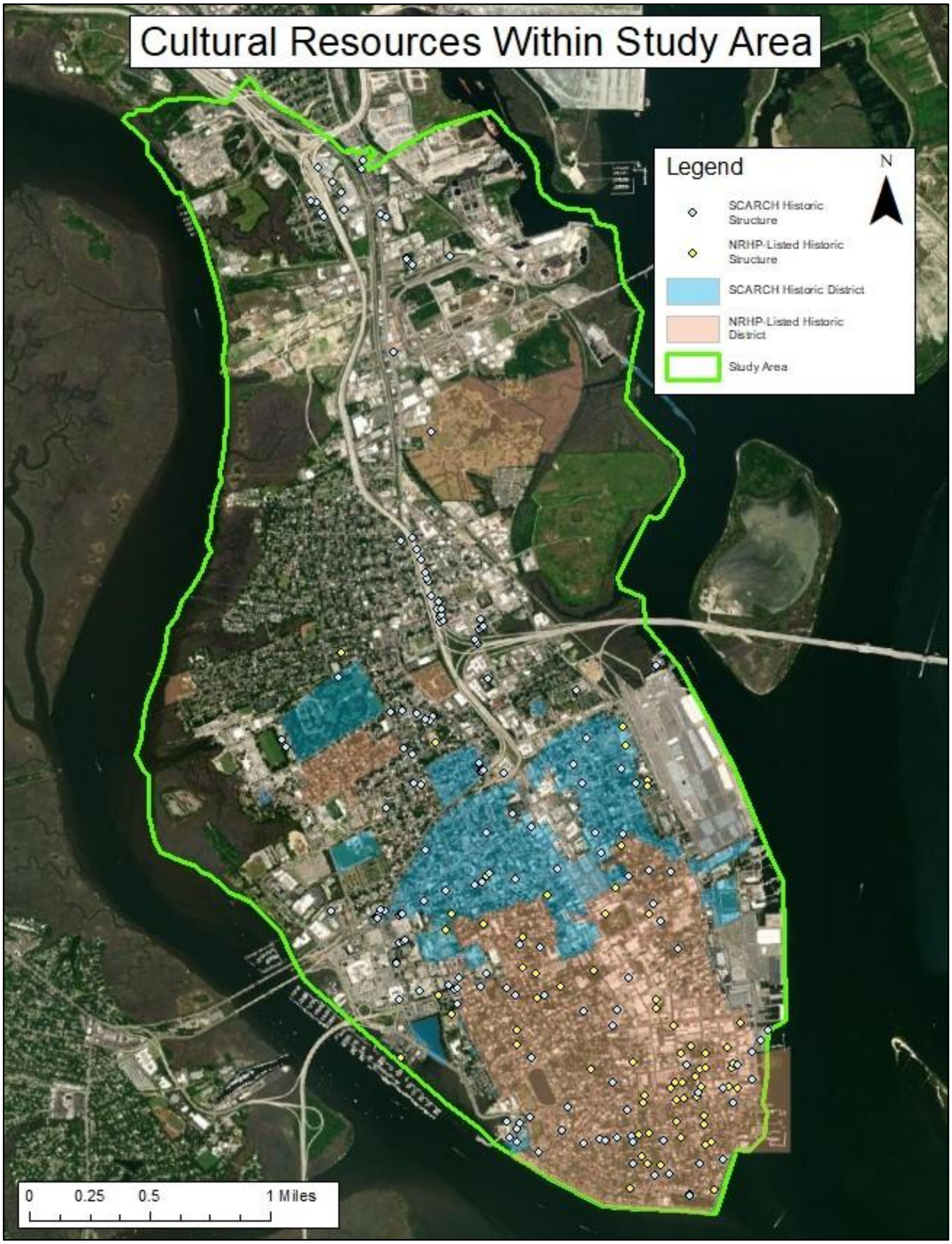

Figure 4-15. Cultural resources located on the peninsula within the Study Area. Archaeological sites are not depicted due to sensitivity of information.

Data source: SC ArchSite

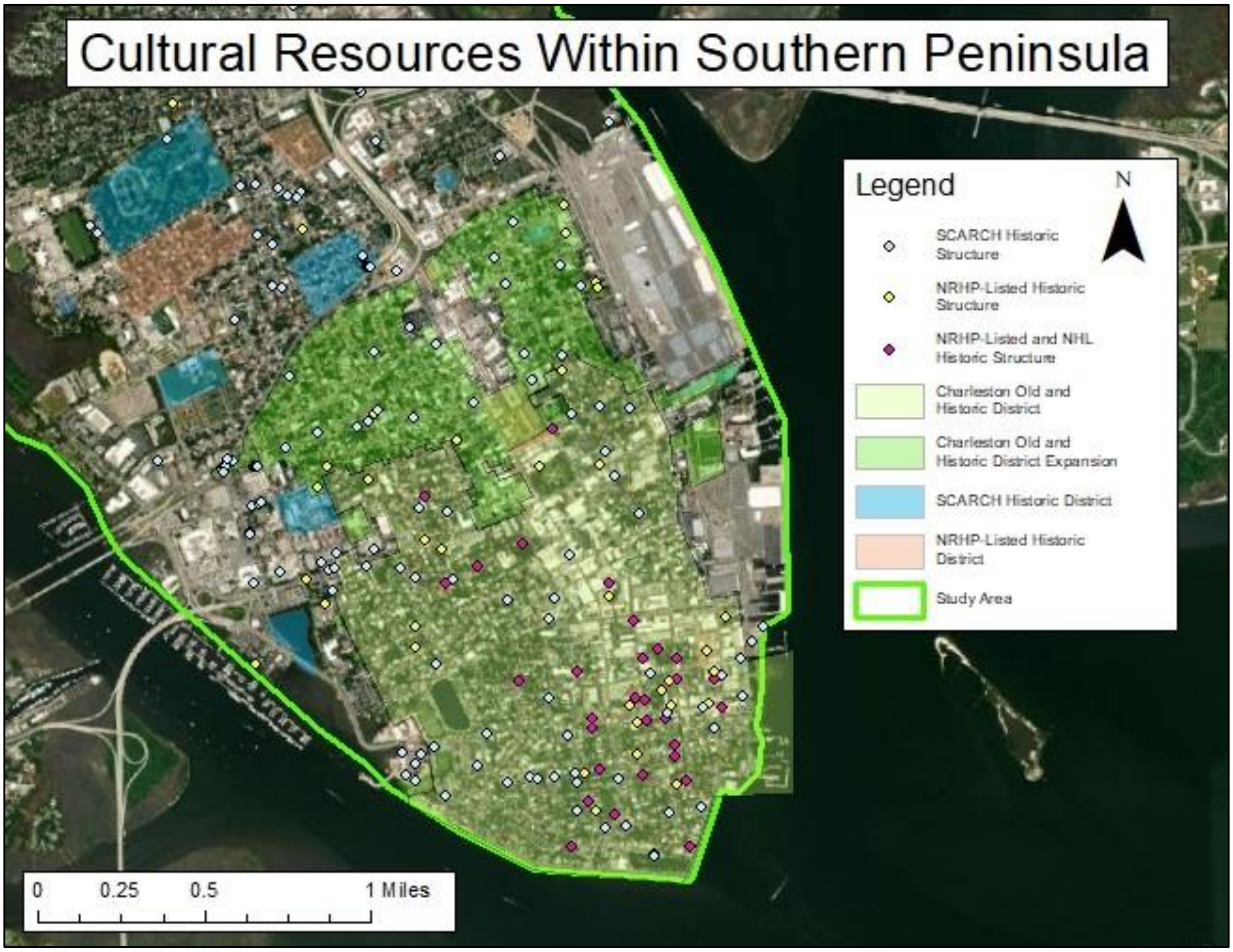

Figure 4-16. Southern portion of study area with a focus on the National Historic Landmark districts and structures.

Data source: SC ArchSite

Of the 373 cultural resources identified within the study area, 79 are individually listed in the NRHP, including 32 which are also designated as NHLs. NHLs within the study area generally consist of historic structures. The structures are concentrated towards the southern end for the peninsula within the COHD and span the late eighteenth through early twentieth century. Examples of these resources include the Exchange and Provost, the Robert William Robert House, and the Market Hall and Sheds. The Exchange and Provost, also known as the Custom House and Half-Moon Battery, was listed in the NRHP in 1969 and designated a NHL in 1973. The building was constructed from 1767 to 1771 and has served numerous key roles through the development of Charleston. In the eighteenth century alone, the building served as a customhouse, public market, public meeting place, military prison, and barracks. Significant historical events tied to the building include hosting state legislative meetings in 1788 when the state house had been razed by British forces, hosting the meeting to ratify the state's 1790 constitution, and the city's welcoming of President George Washington during his southern tour of 1791. The Robert William Roper House was listed in the NRHP and designated a NHL in 1973. The house was constructed in 1838 and the first to be built on the East Battery. Having survived the 1886 earthquake relatively unscathed, the house represents an unaltered example of the Greek Revival style. The Market Hall and Sheds National Historic Landmark is significant as one of Charleston's best examples of the Greek Revival architectural style and is one of the few remaining nineteenth-century market complexes in the United States. The current configuration of the Market Hall and sheds were constructed in 1841; however, these buildings replaced the original market which was built ca. 1788 and were destroyed in the 1838 Charleston fire.

Fort Sumter and Fort Moultrie National Historic Park are two historic fortifications located outside of the study area but within the viewshed of the study. Fort Sumter is located at the mouth of Charleston Harbor on man-made land. Construction on the Fort began in 1829 and the first attack on Fort Sumter on April 12, 1861 is generally considered the beginning of the Civil War. Fort Sumter was established as a National Monument in 1948 and listed on the NRHP in 1966. Fort Moultrie consists of fortifications on Sullivan's Island and is associated with the Revolutionary and Civil Wars. The site of the original palmetto log and sand fortification played an important role in the Revolutionary War and was rebuilt ca. 1794 on top of the original location. The Fort was rebuilt for a third time in 1811 and played a significant role during the Civil War. Fort Moultrie was added to the Fort Sumter National Monument in 1960 and listed individually in the NRHP in 1966.

Additional historic properties listed on the National Register within the study area include residential structures, churches, theatres, industrial buildings, schools, cemeteries, and various other government buildings. Examples of these include the West Point Rice Mill (ca. 1861-63), U.S. Customhouse (ca. 1853-79), and the Josiah Smith Tennent House (ca. 1859). The West Point Rice Mill is significant as one of the few remaining antebellum commercial rice mill buildings and was listed in the NRHP in 1995. The Customhouse is architecturally important as an outstanding example of Classical design and historically important in the commercial development of the Port of Charleston. The Customhouse is both part of the COHD and individually listed in the NRHP in 1974. The Tennent House is significant as an example of the detached Charleston single house, constructed in the Greek Revival style. This residential structure survived the 1886 Charleston earthquake and was listed in the NRHP in 1979.

A total of 125 archeological sites are recorded within the study area. Prehistoric deposits include a record of human activity from the Late Archaic through Middle Woodland periods and historic deposits span the eighteenth through twentieth centuries. Due to the urban environment of Charleston, the majority of archaeological sites within the study area were identified as a result of construction activity. Although none of the sites are listed in the NRHP, a number of these sites are associated with NRHP-listed structures and have the potential to be determined eligible pending additional testing.

Potential for Unidentified Cultural Resources.

In spite of the number of recorded archaeological sites on the peninsula, limited archaeological investigations have been conducted to date. Twelve cultural resource surveys and investigations are on record within the study area (Figure 4-17). Cultural resource surveys for South Carolina Department of Transportation and other infrastructure projects are the most prevalent. These survey areas are located on the east and west sides of the peninsula and were conducted for bridge renovation and replacement projects. In addition to general cultural resource surveys, the Charleston Museum initiated a historic archaeological research program in the 1970s. These investigations have contributed to Charleston's historic archaeological record and generally focused on historic house sites, including multiple studies associated with the development of Charleston's waterfront. Archaeological work has also been conducted by the *Mayor's Walled City Task Force*. Established in 2005, the organization is composed of volunteers from multiple disciplines, including archaeologists, historians, and curators and prioritizes education and research activities focusing on the development of Charleston. Task Force led initiatives included excavations within the study area along South Adgers Wharf.

Due to the peninsula's long history of human occupation, there is a high potential for encountering previously unidentified cultural resources. A review of historic maps indicates that buried archaeological deposits are likely to be identified in areas on the Cooper River side of the peninsula where Colonial settlement and growth occurred. There have also been limited comprehensive historic structure inventories within the study area. Few of the historic structures within the study area have been formally evaluated for their eligibility for inclusion in the NRHP on an individual basis. There is a high potential to identify additional historic properties, including structures and archaeological sites within the study area as a result of future cultural resources surveys. Depending on the final project features, ground disturbing activities have the potential to adversely affect the integrity of archaeological sites and installation of above-ground features has the potential to diminish the characteristics of historic structures that make them eligible for inclusion in the NRHP. Additional cultural resources surveys and evaluation of NRHP eligibility will be necessary once project design is finalized to assess effects from the project on historic properties.

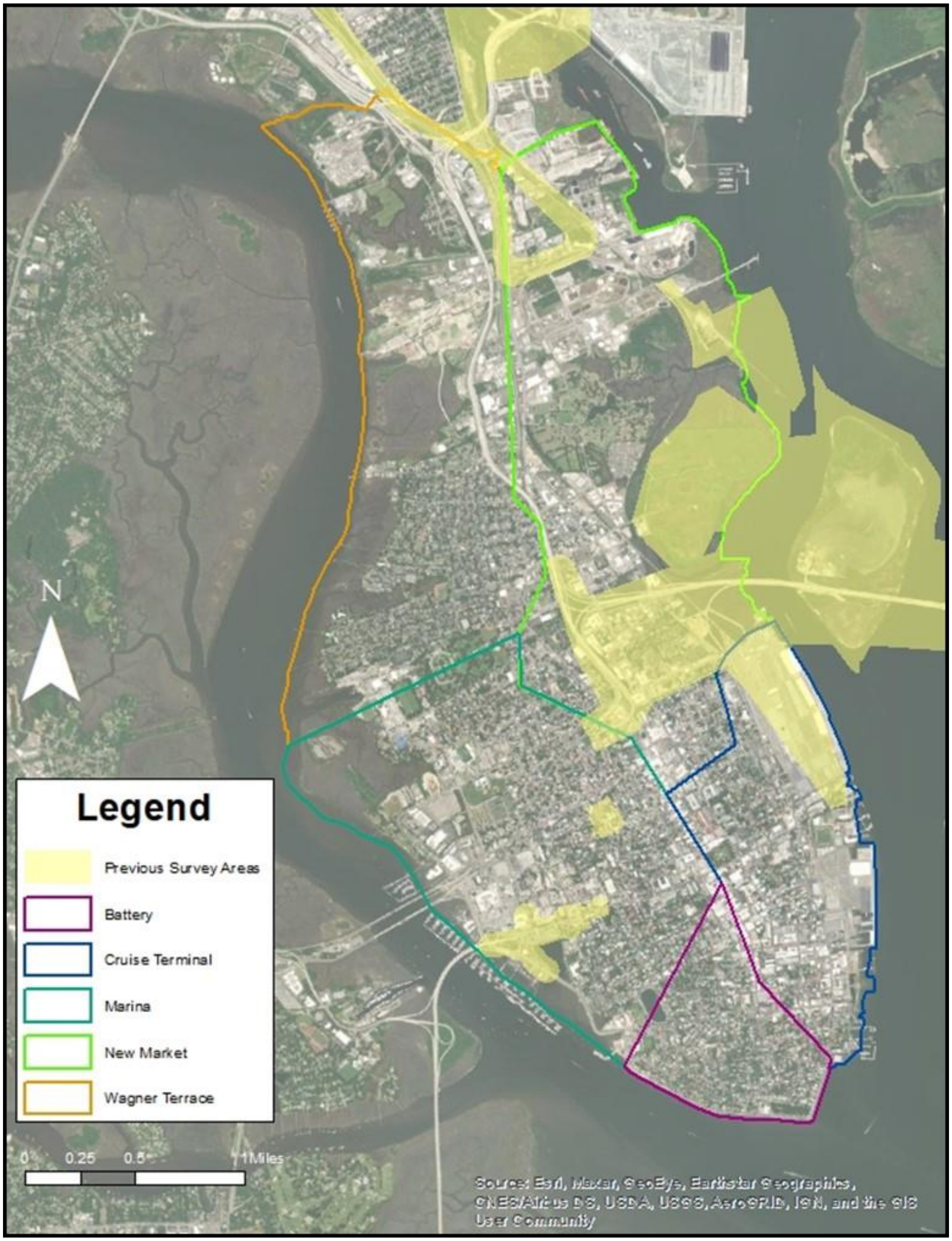

Figure 4-17. Archaeological surveys in the study area.

Data source: SC ArchSite

4.12 Recreation

Recreational facilities are defined as those amenities that provide for relaxation, rest, exercise, activity, enjoyment, education, or opportunities for leisure and community support that enrich the quality of life. These include, but are not limited to, parks, trails, boat ramps, piers, marinas, athletic fields, playgrounds, and community centers. Recreational areas may include any type of activity in which residents or visitors may participate, such as hiking, bike riding, boating, fishing, swimming, picnicking, playground use, or participation in sports.

The ROI is defined as all recreational areas and facilities within the study area boundary on the Peninsula, and the surrounding waterways, that would be affected either directly or indirectly by where a structure or other measure is being placed.

Affected Environment

In July 2021, the City of Charleston (2021b) finalized a comprehensive Parks and Recreation Master Plan that assesses current facilities and programs and provides a detailed framework and action steps for future improvement. Enhancing parks and recreation facilities is a top priority, including increasing park assets to expand the system and increasing connectivity between green spaces and public access to waterways.

There are numerous parks managed by the City of Charleston on the Peninsula, as shown in Figure 4-18. Notable parks include the 67-acre Hampton Park, which serves the neighborhoods it borders including Wagener Terrace, as well as residents throughout the City. Mall Park, Hampstead, and E. Hampstead Parks are within blocks of most homes in the Eastside neighborhood. Brittlebank Park, which is next to Joseph P. Riley Ballpark, gives residents and visitors a place to view the Ashley River and fish from the recreational pier. Waterfront Park includes waterfront walking paths, a pier, and the distinctive pineapple fountain. Colonial Lake Park is near the hospital district and includes walking paths around this man-made lake. Tiedemann Park, off of Meeting Street, has an onsite nature center with reptile and amphibian displays. Marion Square is a 10-acre area rich in history that is used for many local events. Another historically significant park is White Point Gardens at the tip of the Peninsula that provides access to the promenade along the existing Battery seawalls, which is popular with visitors.

Figure 4-18. Map of parks managed by City of Charleston on the peninsula.

Official mapping product of the Management Support Branch, Charleston District, USACE

Other recreational features on the Peninsula include several community centers, sports fields, playgrounds, and a water taxi at Waterfront Park. Many large to small arts, historical, and special events are held on the Charleston Peninsula – too numerous to list them all. Most notable are the Spoleto Festival USA and the Southeast Wildlife Expo, which are held annually and utilize multiple venues across the Charleston Peninsula.

Recreational boating is very popular in the Charleston area. There are two public marinas located on the Peninsula. The Charleston City Marina is located on the Ashley River-side. It includes 19,000 linear feet of dock space, extends 1,500 feet, and covers 40 acres of water. The Maritime Center is on the Cooper River side and is part of the City's vision to revitalize the historic waterfront. It includes a deep-water, full-service marina. There are also several small private marinas located around the peninsula. The Citadel operates a boat landing off of the Ashley River, which is accessed through a channel that is periodically dredged. According to The Citadel, the channel was originally a small creek surrounded by marsh, and the current access channel was constructed in 1955 (http://www.citadel.edu/root/ofe-boating-center).

According to the City of Charleston (City of Charleston, 2016) there has been a surge in bicycling and walking in the City for health reasons and commuting interest, and the City along with Charleston County and the South Carolina Department of Transportation, have taken on a large number of bicycle and pedestrian improvement projects since 2000.

4.13 Visuals and Aesthetics

The visual resources assessment for this study was conducted according to USACE guidance ER 1105-2-100 (22 Apr 2000), Appendix C Environmental Evaluation & Compliance, section C-5 "Aesthetic Resources". As stated in the referenced ER, "The purpose of using a procedure is to have a systematic approach to consider aesthetic resources. Advantages of a systematic and quantifiable approach include the ability to assign a visual resource value to all of the landscape units within a study area, identify important aesthetic resources, and to determine causes of [significant] impact[s]. Such a procedure provides a clear, tractable basis for including aesthetics in plan formulation, design, reformulation, and mitigation planning."

Aesthetic resources can briefly be defined as those natural and man-made features of the environment that can be perceived by all the senses, not just sight. Aesthetic resources include the unified combination of water resources, landforms, vegetation, and user characteristics at a site. An aesthetic resource may be a particular landscape, viewshed, or view as perceived with all the senses. Visual resources are defined as those natural and cultural features of the environment that can be potentially viewed. For the purposes of this analysis, the terms visual resources and aesthetic resources are used interchangeably.

The procedure recommended in ER 1105-2-100 (22 Apr 2000), Appendix C Environmental Evaluation & Compliance, section C-5 “Aesthetic Resources” is the Visual Resources Assessment Procedure (VRAP) as described in the Waterways Experiment Station (WES) Instructional Report EL-88-1. The VRAP Procedure was developed for USACE water resource projects and is consistent with USACE planning and environmental policies. The level of detail used in the draft FR/EIS is an abbreviated Management Classification System (MCS), and the Visual Impact Assessment (VIA) Basic Procedure.

The intent of the MCS and the VIA Basic Procedure, as related to describing the affected environment, is to describe the existing visual resources focusing on the elements that unify the Charleston Peninsula. The ROI for visual resources includes all portions of the study area where temporary or permanent visual changes could occur, and also extends into the viewshed of the Charleston Harbor, the lower Cooper River, and the lower Ashley River. Per the VRAP method, the emphasis is on the visual characteristics of the following elements: water, landform, vegetation, land use, and user activity.

For a study of this extent, several viewpoints from and of the Charleston Peninsula were inventoried in order to be able to aggregate to the study area as a whole. Presented here are the aggregated findings of the visual characteristics of the elements of water, landform, vegetation, land use and user activity. For more information on the VRAP Procedure, or the site inventories that led to this description of the affected environment, see Appendix A – Visual/Aesthetic Resources Assessment.

Affected Environment

This is a summary description of existing conditions for aesthetic resources in the study area, in NEPA terms known as the Affected Environment. Organized by the five landscape components of water, landform, vegetation, land use, and user activity, the unifying visual elements within each of these components, are the following:

<u>Water</u>

The type, movement and scale of water resources contribute to the general landscape composition, for example, by providing a feature that can be a focal. Large bodies of swiftly moving water are present, including the Charleston Harbor and the Ashley and Cooper rivers. In the places observed, these water bodies are often visually dominant and aesthetically pleasing.

<u>Landform</u>

The type of landform present in an area contributes to the general landscape composition by enclosing space, defining viewing distances, and creating opportunities for different viewer positions. The Charleston Peninsula is a coastal landform. The relatively flat nature of the coastal landform here means that the contribution the landform makes to the landscape composition is to not provide enclosure or define viewing distances. Further, vertical changes to viewer positions are not opportunities the landform here typically provides. What the coastal landform here does provide in many cases, especially near the water, is open views into the distance. In the places observed these views, when present, are aesthetically pleasing.

Vegetation

The cover and diversity of vegetation existing in the study area can determine the visual boundaries of a view, provide canopy cover, or screen particular project components. Percent vegetation cover varies widely depending on location and view. When present, the type of vegetation also varies from forested wetlands and marshes to park trees and other urban plantings. Seasonal change was not perceptible but, for vegetation around the Peninsula, change is subtle (relative to other parts of the nation) with plants here predominantly being green and leafed most of the year.

User Activity

User activity consists of the number of participating people using a place, the kinds of activities, and the frequency of the activities. User activity was very place specific and varied accordingly. Some observed uses included sidewalks with people using them to walk, run, or bike. The numbers of people observed were dependent upon location, with some locations more heavily used than others. People were also present on piers, in some cases fishing.

On the water were boats of various sizes and purposes, including small boats such as sailboats and motorboats, as well as large ships such as cruise ships and container ships. Roads in the vicinity of the inventoried sites had people driving cars, as well as other types of traffic such as busses and commercial vehicles, and sometimes these were audible at the site visits. Traffic was generally an unattractive activity. Construction cranes were another unattractive activity present, visible on the skyline.

Land Use

For the purposes of aesthetic assessment, land use refers to the observable characteristics of how land is used to support various human activities. Examples of land use types are industrial, commercial, residential, agricultural, recreational, and undeveloped. Note that this is based on what is observable in the field, not what may be present in land use plans.

Land uses in the areas observed were primarily either commercial and institutional or had commercial and institutional substantially interspersed with some residential. The study area has other land use types, but they were not observed during this assessment. Dependent on location, docks, small boat marinas, or other uses associated with connecting with the water were present. Scenery across the water bodies in the distance often consisted of a generally urbanized landscape, though with vegetation often visible.

Distinct attractive land uses included parks and recreational areas as well as historic steeples visible on the skyline from some locations. Parks important to the area’s tourism, as well as historic neighborhoods/sites on the National or State Register of Historic Places, were perceptible and are part of visual resources in the study area. Unattractive land uses included industrial buildings and unsightly infrastructure in the skyline such as cell phone towers and directional highway signs.

Management Classification System (MCS) Assessment Framework, a professional assessment framework, is developed that determines existing visual quality and puts the study area, into a management class. The management class provides general guidelines as to the degree and nature of visual change acceptable in a landscape. As such, it provides goals and constraints to be considered in the planning and design of a water resources project.

Table 4-2, below, documents the MCS scoring for each resource, and the resulting management class for the study area. The columns in Table 4-2 have specific definitions provided by the VRAP, as given here.

> Distinct – something that is considered unique and is an asset to the area. It is typically recognized as a visual/aesthetic asset and may have many positive attributes. Diversity and variety are characteristics in such a resource.
>
> Average – something that is common in the area and not known for its uniqueness, but rather is representative of the typical landscape of the area.
>
> Minimal – something that may be looked upon as a liability in the area. It is basically lacking any positive aesthetic attributes and may actually diminish the visual quality of surrounding areas.

The below presentation of the MCS assessment framework is preliminary based on the analysis conducted during this feasibility study and will be refined during the PED phase.

Table 4-2. Preliminary MCS Assessment Framework.

–	**Distinct 3**	**Average 2**	**Minimal 1**
Water Resources	x	Large bodies of swiftly moving water, such as the Charleston Harbor and the Ashley and Cooper Rivers.	x
Landform	x	Coastal.	x

	Distinct 3	Average 2	Minimal 1
Vegetation	x	Percent cover varies from close to 0% to close to 100% depending on location and view. Type varies from marshes and forested wetlands to park trees and other urban plantings.	x
Land use	Parks and recreational areas, historic steeples visible on skyline	Commercial buildings	Industrial buildings, infrastructure
User Activity	Park events, historic tours	General river and harbor viewing, land-based recreation, fishing off of piers, boating	Construction activities
Subtotals	6	10	2
Total	18		

As can be seen in Table 4-2, above, the MCS assessment framework total score is 18. Management classes and Total Assessment Values include: Preservation (17 or greater), Retention (14 to 16), Partial Retention (11 to 13), Modification (8 to 10), and Rehabilitation (less than 8). Therefore, the Charleston Peninsula overall, based on the sites inventoried in the MCS, is preliminarily found to be in the Preservation Class.

The VRAP defines Preservation Class as the following: These areas are considered to be unique and to have the most distinct visual quality in the region. They are highly valued and are often protected by Federal and State policies and laws. These areas include wilderness areas, some natural areas, portions of wild and scenic rivers, historic sites and districts, and similar situations where changes to existing resources are restricted. While limited project activity is not precluded, it should not be readily evident. Structures, operations, and use activities should appear to be extensions of the protected resource and should faithfully represent, repeat, or reinforce the visual character of that resource.

4.14 Air Quality

For this study, the ROI for air quality is defined by the administrative/regulatory boundary of Charleston County, within the Berkeley-Charleston-Dorchester (BCD) Air Quality Coalition Region, one of seven regional groups in South Carolina dedicated to improving the state's air quality.

Air quality in a given location is described by the concentration of various pollutants in the atmosphere. A region's air quality is influenced by many factors including the type and amount of pollutants emitted into the atmosphere, the size and topography of the air basin, and the prevailing meteorological conditions. The significance of the pollutant concentration is determined by comparing it to the federal and state ambient air quality standards. The Clean Air Act (CAA) and its subsequent amendments (CAAA) established the National Ambient Air Quality Standards (NAAQS) for six principal air pollutants, also known as "criteria air pollutants." Those air pollutants considered for the proposed action are sulfur dioxide (SO_2) and other related compounds (i.e., oxides of sulfur or SOx); volatile organic compounds (VOCs), which are precursors to ozone (O_3); nitrogen oxides (NOx), which are also precursors to ozone (O_3) and other compounds; carbon monoxide (CO); and particulate matter (PM2.5 and PM10). These criteria pollutants are generated by the activities (e.g., construction and mobile source operations) associated with the proposed action.

A locality's air quality status and the stringency of air pollution standards and regulations depend on whether monitored pollutant concentrations attain the levels defined in the NAAQS. To ensure the NAAQS are achieved and/or maintained, the CAAA requires each state to develop a State Implementation Plan (SIP). The South Carolina Department of Health and Environmental Control (SC DHEC) air program oversees the state's air agendas, including the SIP. The state and national ambient air quality standards that have been set are presented in Table 4-2 below. They represent the maximum allowable atmospheric concentrations that may occur while ensuring protection of public health and welfare, with a reasonable margin of safety. Short-term standards (1, 8, and 24-hour periods) are established for pollutants contributing to acute health effects, while long-term standards (quarterly and annual averages) are established for pollutants contributing to chronic health effects.

The EPA published *Determining Conformity of General Federal Actions to State or Federal Implementation Plans; Final Rule* in the November 30, 1993 Federal Register (40 CFR Parts 6, 51, and 93). This publication provides implementing guidance to document the CAA Conformity Determination requirements. Federal regulations state that no department, agency, or instrumentality of the Federal Government shall engage in, support in any way or provide financial assistance for, license to permit, or approve any activity that does not conform to an applicable implementation plan. It is the responsibility of the Federal agency to determine whether a federal action conforms to the applicable implementation plan before the action is taken (40 CFR Part 1 51.850[a]). The general conformity rule applies to Federal actions proposed within areas which are designated as either nonattainment or maintenance areas for the NAAQS for any of the criteria pollutants. Former nonattainment areas that have attained the NAAQS are designated as maintenance areas. Emissions of pollutants for which an area is in attainment are exempt from conformity analyses.

Affected Environment

The Bureau of Air Quality (BAQ), under SCDHEC, maintains a network of air quality monitoring stations located throughout the state. There are two primary continuous monitoring stations in the ROI: one at the Jenkins Avenue Fire Station in North Charleston, and one at the Cape Romain National Wildlife Refuge in Awendaw). The Jenkins Ave station currently monitors nitrogen oxides, sulfur dioxide, and particulate matter. The Cape Romain station monitors nitrogen oxides, sulfur dioxide, particulate matter, and ozone. A temporary monitoring station operates at Irving Street in North Charleston to monitor activities related to port expansion over approximately two years. It monitors for nitrogen oxides, sulfur dioxide, and particulate matter. There is an additional station on the Charleston Peninsula (in the study area) at the Charleston Public Works on Fishburne Street that records particulate matter but has recently been approved to be relocated to the Jenkins Avenue Station.

Currently, Charleston County and the other counties in the airshed, are considered by EPA to be in attainment for all principal air quality pollutants in the CAA and its amendments. Included are the standards for emissions of CO, SO_2, NO_2, $PM_{2.5}$, PM_{10}, Pb and the 8-hr standard for ozone. The South Carolina ambient air quality standards are shown in Table 4-3.

Table 4-3. South Carolina Ambient Air Quality Standards.

Pollutant	Reference	Measuring Interval	Standard Level			
			mg/m^3	**$\mu g/m^3$**	**ppm**	**ppb**
Sulfur Dioxide	40 CFR 50.4 40 CFR 50.5	3 hour (secondary)	-	1300	0.5	-
	40 CFR 50.17	1-hour (primary)	-	-	-	75
PM_{10}	40 CFR 50.6	24 hour	-	150	-	-
$PM_{2.5}$	40 CFR 50.18	24 hour (primary)	-	35	-	-
	40 CFR 50.18	Annual (primary)	-	12	-	-
	40 CFR 50.13	24 hour (secondary)	-	35	-	-
	40 CFR 50.13	Annual (secondary)	-	15	-	-
Carbon Monoxide	40 CFR 50.8	1 hour (no secondary)	40	-	35	-
		8 hour (no secondary)	10	-	9	-
Ozone	40 CFR 50.15	8 hour (2008)	-	-	0.075	-
	40 CFR 50.19	8 hour (2015)	-	-	0.07	-
Nitrogen Dioxide	40 CFR 50.11	Annual	-	100	0.053	53
		1-hour				100
Lead	40 CFR 50.16	Rolling 3-month average	-	0.15	-	-

South Carolina Department of Health and Environmental Control Air Pollution Control Regulations and Standards, Regulation 61-62.5 Air Pollution Control Standards, Standard No. 2, Ambient Air Quality Standards.

Since the air quality within the airshed is in attainment for all criteria air quality contaminants, the BCD coalition is exempt from CAA Conformity Determination requirements. However, emissions of nitrogen oxides (NOx) and volatile organic compounds (VOC), which are precursors to ozone formation and are caused primarily by motor vehicle traffic and other mobile sources such as aircrafts, are of continuing interest in Charleston County, as well as the state of South Carolina.

According to the American Lung Association's 2017 Air Quality Report, the Charleston-North Charleston area (which is in the ROI) is one of eight cities in the Southeast that reached the lowest level-in-year for recorded ozone and long-term particle pollution in the air. Charleston's prevailing sea breezes contribute to sweeping the coastal air, keeping it cleaner than inland areas.

4.15 Noise

Section 4(b) of the Noise Control Act of 1972 directs Federal agencies to comply with applicable Federal, state and local noise requirements with respect to the control and abatement of environmental noise. Congress defined environmental noise in the Noise Control Act of 1972 to include the intensity, duration, and character of sounds from all sources. Applicable Federal guidelines for noise regulation are derived from the U.S. Department of Transportation (USDOT) or, more specifically, the Federal Transit Administration and the Federal Highways Administration.

Sound becomes noise when it is considered undesirable because it interferes with communication, results in health effects such as sleep disorder or hearing damage if intense enough, and it diminishes the quality of the environment. Responses to noise vary depending on the type and the characteristics of the noise source, distance from the source, receptor sensitivity, and time of day. Noise can be intermittent or continuous, steady or impulsive, and it may be generated by stationary or mobile sources. Noise is described by a weighted sound intensity (or level), which represents sound heard by the human ear and is measured in units called decibels (A-weighted decibels [dBA]). The EPA recommends an average 24-hr exposure limit of 70 dBA to protect against hearing damage, and a limit of 55 dBA in outdoor areas to protect public health and welfare (USEPA 1978).

Noise sensitive receptors are of particular interest. These are buildings or parks where quiet forms a basic element of their purpose; residences and buildings where people normally sleep (e.g., homes, hotels, hospitals), where nighttime noise is most annoying; and institutional land uses (e.g., schools, libraries, parks, churches) with primarily daytime and evening use. Because noise levels at sensitive receptors are reduced by obstructions (such as sound walls, buildings, vegetation) lying between them and the noise source, special emphasis is placed on sensitive receptors having a direct line of sight to the construction sites.

Many fish and wildlife resources are susceptible to noise because they use sound for communication or predation (Tyack, 2008). This is especially true for aquatic resources because sound travels three times faster in water than it does through the air. For example, bottlenose dolphins, who fall into a mid-frequency generalized hearing range of 150 Hz to 160 kHz for class of animals, are susceptible to hearing impacts from underwater noise. However, if the frequency of a sound source is outside of the hearing range of a species, then the likelihood of hearing loss caused by that sound source is low (NOAA, 2018).

The City of Charleston currently has a noise ordinance that includes provisions for "building construction operation noise" (Section 21-17). It specifies allowable days and times for operations that "cause loud and repetitive noises in the city" as 7:00 a.m. to 7:00 p.m. on weekdays, and 9:00 a.m. to 7:00 p.m. on Saturdays. Sundays and certain holidays are prohibited. The ordinance does list a number of exemptions, including "projects whose timely completion is deemed key to public interest."

The ROI for the noise consists of the entire study area, and the communities closest to the study area including the North Charleston Neck and West Ashley along the river from Albemarle Point to the foot of the Ashley River Bridge. Waters of the lower Ashley River, lower Cooper River, and Charleston Harbor nearshore of the Battery seawalls are also part of the ROI.

Affected Environment

Primary sources of noise in the United States include road and rail traffic, air transportation, and occupational and industrial activities (National Academy of Engineering (NAE) 2010). Typical high-density urban areas can average up to 78 dBA while average density urban areas can average up to 65 dBA during the day and early evening (USEPA 1978). Other sources of noise exposure at the individual-level include amplified music, recreational activities (including concerts and sporting events), firearms, and personal music players.

Existing sources of noise on the Charleston Peninsula are primarily from traffic and industry, such as dock side port operations and rail operations. The City's hydraulic pumps also generate noise. There are also low levels of noise from residential and recreational areas. Currently there are a number of construction projects taking place on the Peninsula, which generate noise. However, construction noise is usually limited to daytime hours and Saturdays per the City's noise ordinance described above. Typical noise form the Charleston Harbor includes large commercial vessels, dredging vessels, cruise ships, smaller recreational boats, and rescue vessels (e.g., Coast Guard ships). There are also several passenger ferries and water taxis. Airplanes going to/from the Charleston Airport and Joint Base Charleston (the airport and base are physically outside of the ROI) are also a source of noise.

4.16 Hazardous Materials and Waste

Hazardous materials include, but are not limited to, hazardous and toxic substances (biological, chemical, and/or physical) and waste, and any materials that pose a potential hazard to human health and the environment due to their quantity, concentration, or physical and chemical properties. Hazardous waste is characterized by its ignitability, corrosivity, reactivity, and toxicity. Hazardous materials and wastes, if not controlled, may either (1) cause or significantly contribute to an increase in mortality, serious irreversible illness, or incapacitating reversible illness, or (2) pose a substantial threat to human health or the environment. The primary relevant federal regulations for hazardous material and waste include those promulgated under the

Resource Conservation and Recovery Act (RCRA) of 1974 and the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) of 1980 (commonly known as Superfund), which are administered by the USEPA.

South Carolina regulations that apply include the SC Pollution Control Act, the SC Hazardous Waste Management Act, and the SC Oil and Gas Act. Essentially, any company, business, government agency, warehouse, or other facility that uses, produces, or stores any of the extremely hazardous substances identified by USEPA is required to notify the state.

The ROI for hazardous materials and wastes includes the study area and adjacent waterways of the Ashley River and Charleston Harbor where measures are being considered. This section uses existing information gathered from USEPA and state databases, including the following:

- Superfund Enterprise Management System (SEMS). This database lists hazardous waste sites under the Superfund Program, a federal program to clean up the most hazardous sites throughout the U.S (current as of November 2019). Sites include abandoned warehouses, manufacturing facilities, processing plants, and landfills.
- Resource Conservation and Recovery Act Information (RCRAInfo). This is a national program management and inventory system about hazardous waste handlers (current as of February 2020)
- Toxics Release Inventory (TRI). This is an information system about toxic chemicals that are being used, manufactured, treated, transported, or released into the environment (current as of November 2019).
- SCDHEC Solid Waste Facilities. List of solid waste facilities in South Carolina, sorted by county.

Affected Environment

There are a number of known hazardous waste sites and facilities in the ROI of varying proximity and priority. They are described below. Additionally, portions of the Charleston Peninsula were used as a municipal landfill from the early to mid-1900s. Those areas have since been developed over, including construction of major buildings, the Joseph R. Riley Ballpark, and Brittlebank Park. Hazardous materials are not known to be a concern, but underground debris may be present.

<u>CERCLA/Superfund Sites</u>

The National Priorities List (NPL) includes those sites in the Superfund program that are listed as a national priority among the hazardous waste sites and receive funding from the Trust Fund for remedial action. There is currently one NPL site in the ROI. The Koppers Co., Inc. (Charleston Plant) Superfund site is located on 102 acres in the Charleston Neck area. Wood treatment operations started here in the 1940s, and phosphate and fertilizer production took place from the 1900s until 1978. The site also includes a barge canal excavated off of the Ashley River by Southern Dredging in 1984. The site was placed on the NPL in 1994 due to contaminated groundwater, sediment, soil and surface water from the past facility operations. Industrial remediation has been completed. The USEPA states "the remedy at the Site protects human health and the environment because contaminated soils and sediments have been excavated, treated, and/or stabilized/solidified." Creosote and groundwater recovery systems continue to operate at the site. The site is currently undergoing an updated remedy to support mixed-use development, including residential use. The site was purchased by Ashley LLC, who plans to redevelop the site; it is the location of the future Magnolia Tract described in Section 4.1 Land Use.

There are several other CERCLA-listed sites that are not on the NPL in the study area. They are listed in Table 4-4 with their status for non-listing on the NPL. The Calhoun Park Area sites is an 18-acre waterfront area that has undergone remediation and redevelopment. The site was formerly used for wood-treatment in the early 1800s before a manufactured gas plant operated on the site starting in the mid-1800s. Contaminated soils, sediment, and groundwater from the manufactured gas plant were discovered in 1991, when South Carolina Electric & Gas Company (SCE&G, a wholly owned subsidiary of Dominion Energy, Inc.) owned the site. The USEPA worked with SCDHEC, the City of Charleston and SCE&G to clean up the site in phases to support reuse interests. The Calhoun Park Area site now supports the South Carolina Aquarium and new International African American Museum, shops, a parking garage, several parks, an electrical substation, and mixed-use development. In 2019, the USEPA conducted a review and determined the site remedy is protective in the short term, while several recovery efforts continue with groundwater monitoring and with institutional controls to protect the remedy long term to prevent exposure to contamination (USEPA, 2020a).

Table 4-4. CERCLA Sites on the Charleston Peninsula That Are Not Listed on the NPL.

Source: USEPA

SITE NAME	ADDRESS	NON-NPL STATUS
Ambrose Alley Mercury	6 Ambrose Alley CHARLESTON, SC 29401	Removal Only Site (No Site Assessment Work Needed)
Calhoun Park Area	Calhoun at Concord Street CHARLESTON, SC 29401	Remedial Activities Under EPA Enforcement
US Coast Guard Charleston	196 Tradd Street CHARLESTON, SC 29401-1800	Fed Fac Preliminary Assessment Review Start Needed
USDOI Charleston Harbor Site	Concord Street at end of Calhoun Street	Addressed as Part of Another non-NPL Site

SITE NAME	ADDRESS	NON-NPL STATUS
	CHARLESTON, SC 29401	
VA (Veterans Administration) Medical Center Research	109 Bee Street CHARLESTON, SC 29401-5703	Fed Fac Preliminary Assessment Review Start Needed
Virginia Carolina Chemical (VCC) Macmurphy	186 Concord Street CHARLESTON, SC 29401	Removal Only Site (No Site Assessment Work Needed)
Ashapoo Phosphate/Fertilizer Works	Braswell Street CHARLESTON, SC 29405	Referred to Removal - NFRAP
Atlantic Phosphate Works	2200 Hagood Road CHARLESTON, SC 29405	Referred to Removal - NFRAP
Columbia Nitrogen	West end of Milford St at Ashley River CHARLESTON, SC 29405	Remedial Activities Under EPA Enforcement
Etiwan Phosphate Company	Milford Street CHARLESTON, SC 29405	(no status provided)
Pacifico Guano	1505 King Street Extension CHARLESTON, SC 29405	Referred to Removal - Needs Further Remedial Assessment
Stono Phosphate Works	2079 Austin Avenue CHARLESTON, SC 29405-9368	Referred to Removal - NFRAP
Swift Agri-Chem Corp	2750 Speissegger Drive CHARLESTON, SC 29405-8701	Referred to Removal - NFRAP
WR Grace Co.	1820 Harmon Street CHARLESTON, SC 29405	Other Cleanup Activity: State-Lead Cleanup

RCRA Sites

Facilities that generate, transport, treat, store, or dispose of hazardous waste are required to report their activities under the RCRA. There are 14 RCRA sites on the lower peninsula in the study area (see Figure 4-19). They range from pharmacies and dry cleaners to the SC Ports Authority and local hospitals. Seventeen RCRA sites can be found in the middle peninsula (see Figure 4-20) that range from local utilities to small manufacturing operations. There are 21

RCRA sites in the Charleston Neck area of the peninsula (see Figure 4-21). These range from various marine contractors to autobody shops to petrochemical companies.

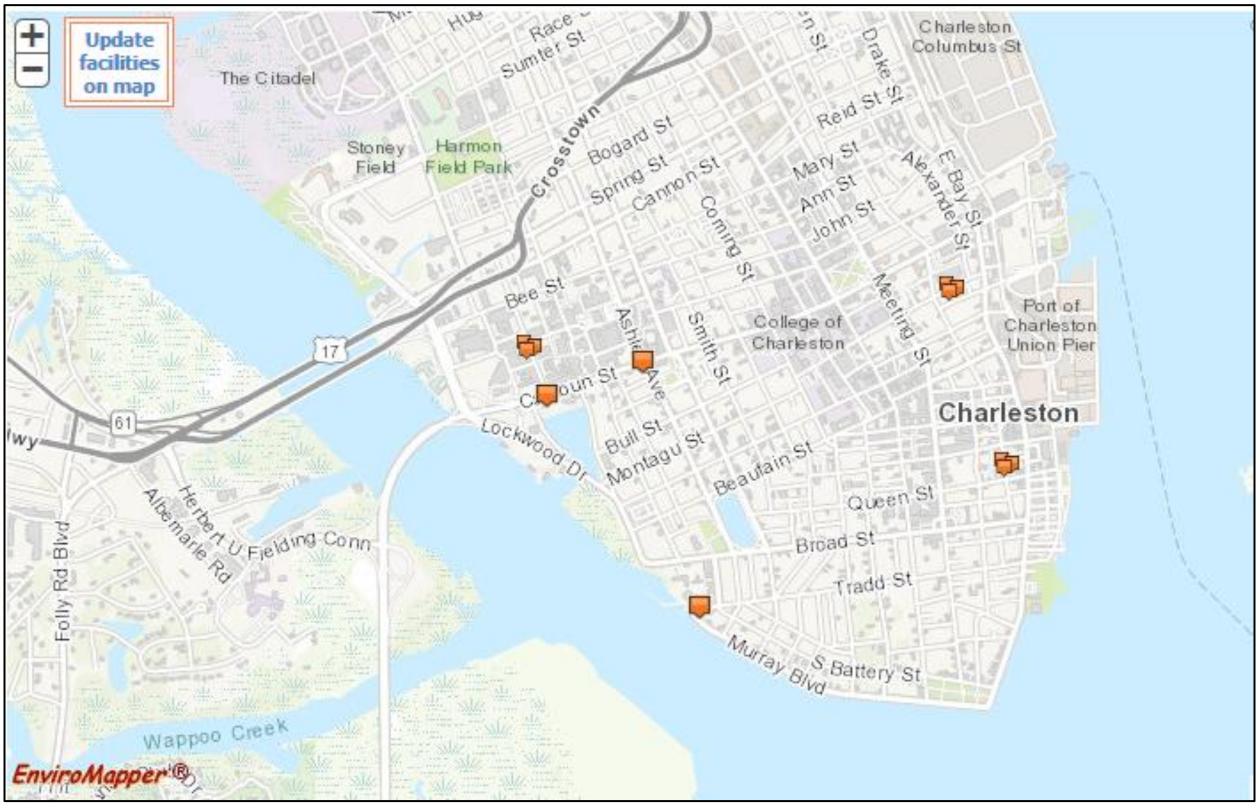

Figure 4-19. RCRA sites on the lower Charleston Peninsula.

Source: USEPA

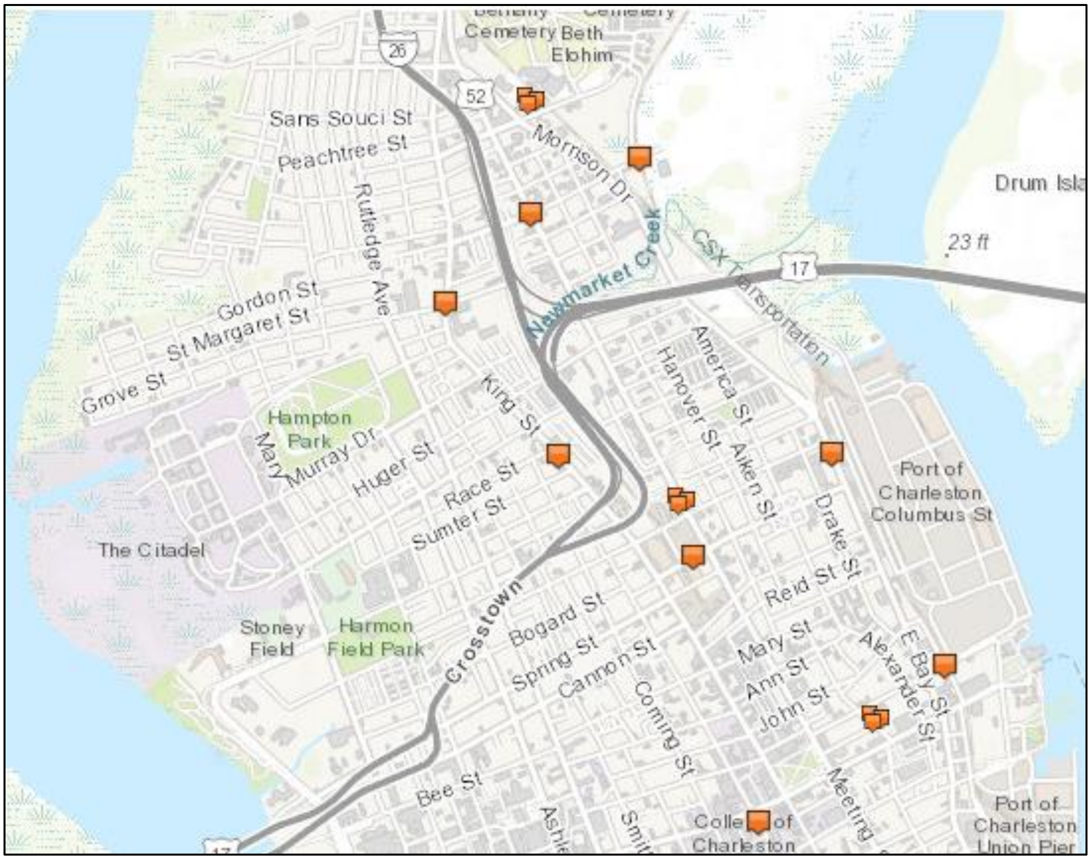

Figure 4-20. RCRA sites on the middle area of the Charleston Peninsula.

Source: USEPA

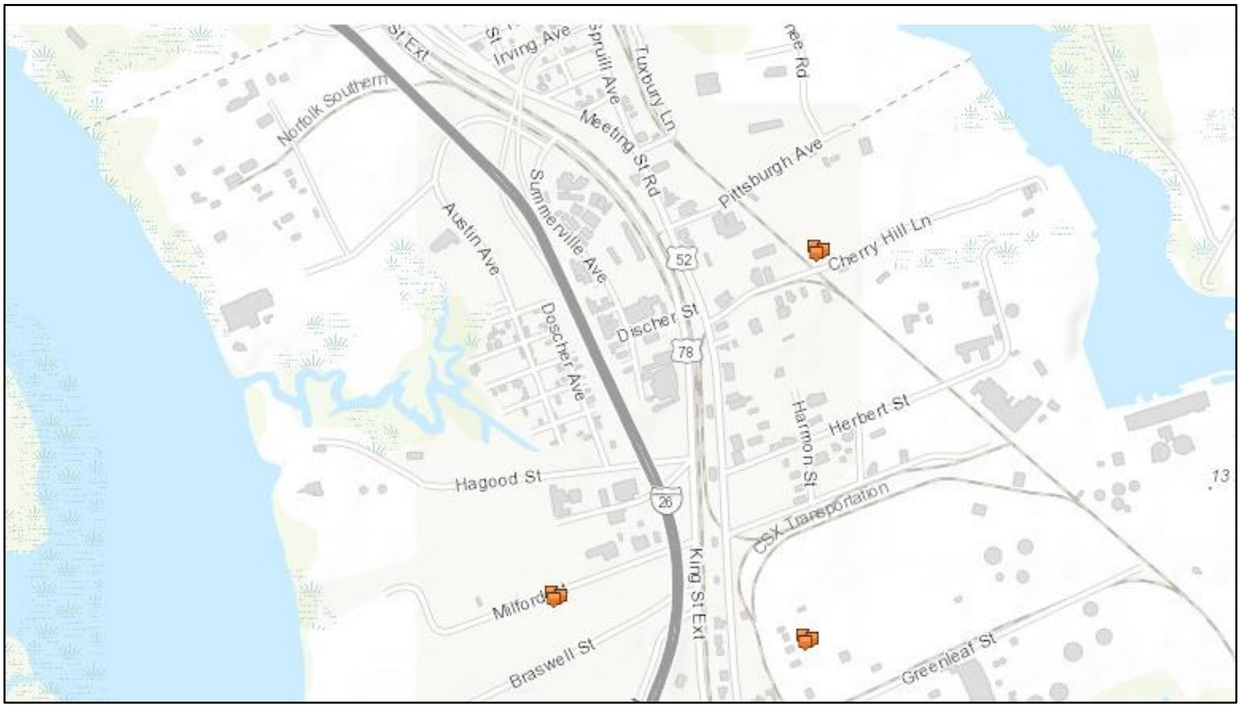

Figure 4-21. RCRA sites in the Charleston Neck area of the Peninsula.

Source: USEPA

<u>TRI</u>

Two facilities in the study area have had toxic releases reported to the TRI in the last 10 years. Both are in the Charleston Neck area of the Peninsula. They include Chevron Texaco Global Lubricants located at 1882 Milford St and the Lanxess Corp./Solvay located at 2151 King Street Extension. The Chevron facility is described a petroleum lubricating oil and grease manufacturer and the releases were reported as zinc compounds. The Lanxess Corp. site is also a RCRA facility that is described as producing phosphorous derivatives -based products, for which their generated waste is shipped to offsite facilities. They do not manage their waste on site, nor do they receive waste from offsite facilities. Lanxess Corp.'s TRI Facility Report shows that all releases of TRI chemicals were via air emissions, and that no land or surface water releases, or underground injections, have been reported in the last 20 years.

<u>Solid Waste Facilities</u>

According to SCDHEC, there are no solid waste facilities in the study area.

<u>Brownfields Sites</u>

Brownfields is a term used to describe land formerly used for industrial or commercial purposes. Expansion, redevelopment or reuse of these properties may be complicated by the presence of potential hazardous substances, pollutants, or contaminants, but don't rise to the level of a Superfund site. The EPA runs a program to clean up these sites for reinvestment. There are a number of Brownsfield Cleanup Sites in the study area. They are shown in Figure 4-22.

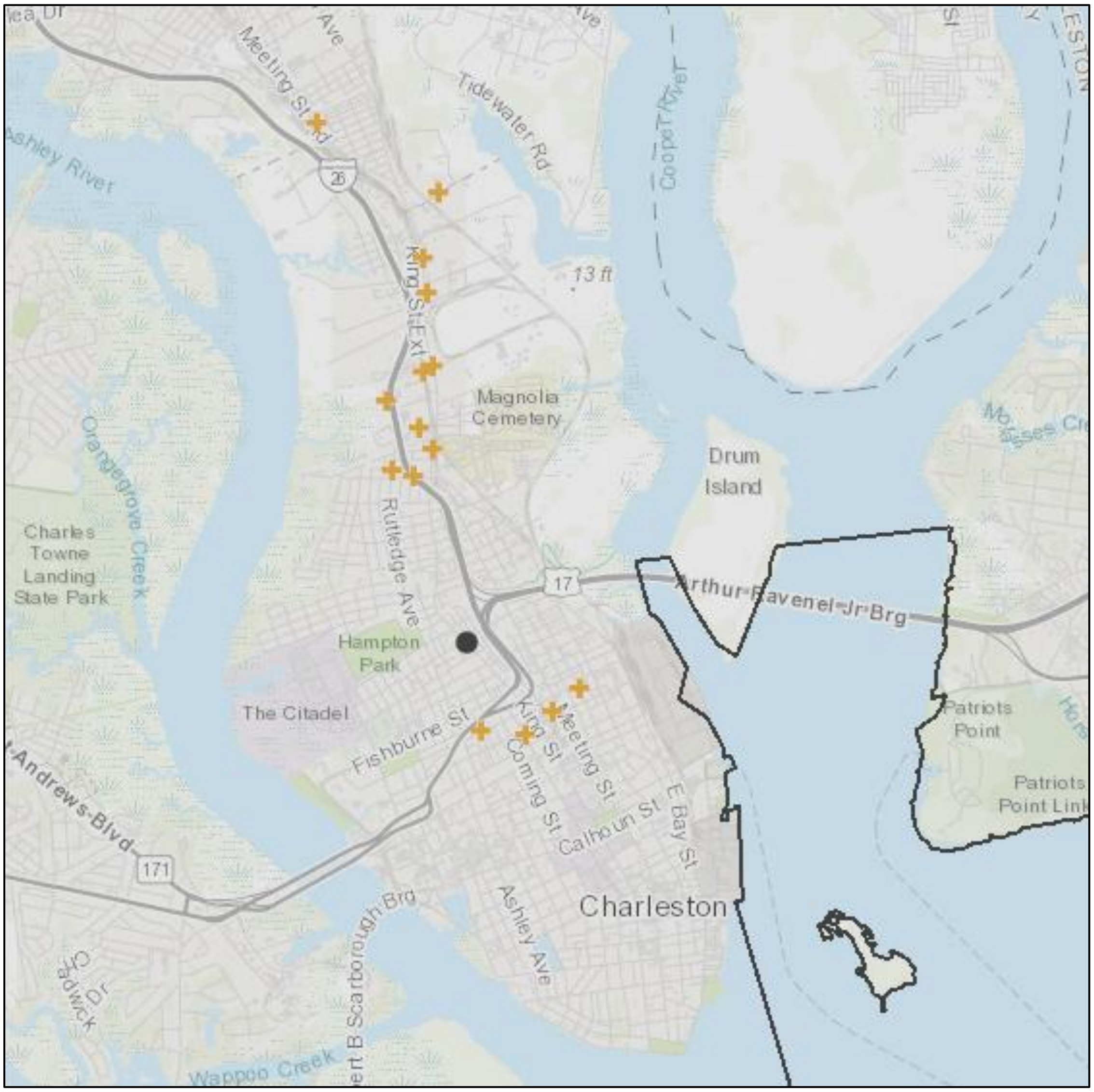

Figure 4-22. Brownfield Cleanup Sites in the study area are shown as gold "+" symbols.

Source: USEPA

4.17 Transportation

Transportation refers to the operational characteristics of the land transportation network, including the network's capacity to accommodate existing and projected future travel demand.

Transportation networks may encompass many different types of facilities that serve a variety of transportation modes, such as vehicular traffic, public transit, and non-motorized travel. Access to, within, and from the Charleston Peninsula is provided via state and federal highways, bridges, arterial and connector streets, freight rail lines, bus service, and non-motorized transportation including bicycle lanes and sidewalks. All of these sources on the Charleston Peninsula, and leading on/off the Peninsula, are in the ROI.

The ROI for waterborne transportation includes the Federal navigation channels in the Charleston Harbor and lower Cooper and Ashley Rivers, and encompasses private transportation (e.g, boat tours and taxis), marine commerce transportation, and water-based emergency response. Recreational boating is also prevalent but is discussed in the Recreation section.

The intention of this section is not to describe in detail all of the many transportation corridors on and connecting the Charleston Peninsula, but rather provide an overview of the major transportation networks.

Affected Environment

The only Federal Interstate in the ROI is Interstate 26. U.S. highways in the ROI include Highway 17 (known as the Crosstown on the Peninsula), Highway 52 (Meeting Street), Highway 78 (King Street), and Highway 30 (known as the James Island Connector). Highway 17 connects the Peninsula to surrounding communities over two major bridges – the Ashley Bridge which crosses the Ashley River, and the Arthur Ravenel Jr. Bridge that crosses the Cooper River to the Town of Mount Pleasant. U.S. Highway 30 is a causeway that connects the Charleston Peninsula with James Island. In the event of a hurricane, the South Carolina Department of Transportation (SCDOT) has designated Interstate 26 as the only official evacuation route from the Charleston Peninsula. U.S. Highway 17 from the Ravenel Bridge serves as an evacuation route from Mount Pleasant, which connects with the Interstate 26 evacuation route on the Charleston Peninsula. As such, Interstate 26 serves as a very important artery in the event of a hurricane evacuation.

Most of the road network on the Peninsula is a grid. Major roadways that generally run east-west (aside from highways) include Calhoun Street, Broad Street, Spring Street, Cannon Street, Columbus Street, Congress Street, Huger Street, and Murray Blvd at the Battery. Major roads that run north-south on the Peninsula (aside from highways) include East Bay Street, Meeting Street, King Street, Morrison Drive, Rutledge Avenue, Ashley Avenue, and Lockwood Blvd. Aside from these major roadways, much of the city grid is made up of short blocks, intended to be easily walkable and bikeable.

Three rail companies operate in the ROI – CSX, Norfolk Southern, and Palmetto Railways. CSX and Norfolk Southern provide intermodal and merchandise rail services for the Port of Charleston on class I railroads. Palmetto Railways is an enterprise agency of the state, and a division of the South Carolina Department of Commerce that operates class III railways that moves freight. Locations of the three railways can be seen in Figure 4-23. Palmetto Railways handles approximately 25,000 rail cars per year running seven days a week though the Columbus Street Terminal. During an emergency such as a hurricane, all three railways coordinate together to move rail cars out of the Columbus Street Terminal. CSX and Norfolk Southern tend to coordinate the national and state emergency management level while Palmetto Railways closely coordinates with the local emergency management offices. Palmetto Railways begins taking action when the State and County Emergency Operations Centers are partially activated. As the threat of the storm becomes more certain and a significant threat, Palmetto Railways begins to move the rail cars to a safe location (Palmetto Railways, 2021).

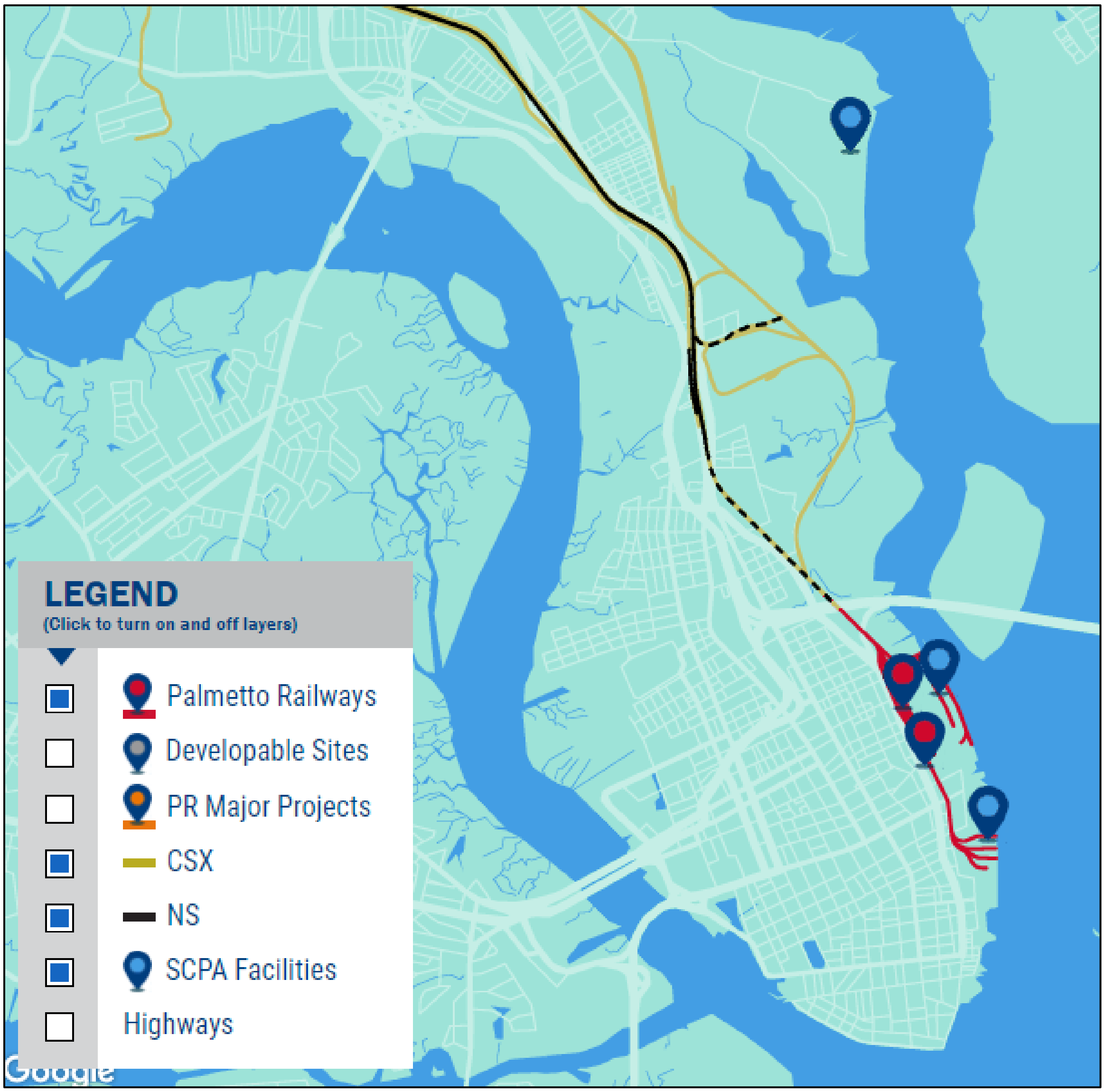

Figure 4-23. Locations of railways operated by Palmetto Railways, CSX, and Norfolk Southern on the Charleston Peninsula.

Source: Palmetto Railways

In 2018, the City of Charleston updated their Citywide Transportation Plan (City of Charleston, 2018) in preparation for an influx of people and businesses. It provides local solutions as well as a long-range vision for Charleston's transportation system. For the Peninsula, the focus of the plan is on preparing for new residential and commercial growth and making more effort to serve the multi-modal needs of residents and tourists. According to the plan, commute times are expected to increase in the future as workers find more affordable housing farther away. Ridership on the Charleston Area Regional Transportation Authority (CARTA) transit has increased tremendously in the last 10 years, and more people are also walking and biking to work. The Citywide Transportation Plan makes recommendations for bicycle and pedestrian physical improvements. Walking and biking have an important transportation role on the Peninsula in supporting tourists that come to Charleston to explore its neighborhoods, patronize its businesses and recreate at the Battery. The promenade that aligns the top of the Battery seawalls is one of the most iconic walking and biking areas on the Peninsula.

Some of the same challenges that the City of Charleston faces with improving transportation in confined spaces on the Charleston Peninsula, also apply to implementing storm protection on the Peninsula. The Citywide Transportation Plan states, "Rivers, historic districts, buildings and trees abutting existing roads – all make road widening and better connections problematic. What might work elsewhere has limited applicability here, so innovation, technology, and alternative modes have to rise to meet the challenge."

There are several sources of waterborne transportation in the ROI. The Charleston Water Taxi runs between Mount Pleasant and the Waterfront Park and the Aquarium Wharf on the Peninsula. Also, at the Aquarium Wharf, there is a ferry service that operates tours to Fort Sumter National Historic Landmark (the only way to access this national park), as well as harbor tours and cruises. Marine commerce is served on the Peninsula by the Federal navigation channels in the Charleston Harbor to the Columbus Street Terminal, operated by the South Carolina Ports Authority. The Charleston Harbor Pilots Association also supports marine commerce through safe navigation. Their operations are on the Cooper River-side of the Peninsula, off of Concord Street. Cruise ships port in Charleston at the "cruise terminal" at the Ports Authority's Union Pier. Finally, the US Coast Guard Sector Charleston station on Tradd Street is responsible for maritime accidents, incident response, and other local logistics. They have three cutters that port at this location, which is on the Ashley River-side of the Peninsula, not far from the current Battery wall.

4.18 Utilities

This section focuses on the following major utilities within the study area and their conditions: electricity, gas, and stormwater management. There is no potable drinking water source on the Charleston Peninsula, nor wastewater treatment facilities, so there is less focus on these. No information about the telecommunications network on the peninsula is readily available, so assumptions have been made.

The ROI for utilities is the study area, although it is generally recognized that transmission lines or stations on the peninsula may serve areas beyond the peninsula (into the North Charleston Neck area, for example). This type of information is not publicly available (see more below). The ROI does include the bordering lower Cooper River, lower Ashley River and Charleston Harbor as they relate to stormwater management.

Affected Environment

The City of Charleston's Department of Public Safety is responsible for enforcing utility construction standards. They also offer ditch piping services. The Department of Stormwater Management administers the Stormwater Regulatory Program, Stormwater Capital Project Management, and Floodplain Management, as well as maintains the City's drainage system. Major utilities in the study area include buried and aboveground electrical transmission lines, buried gas lines, buried water main lines, buried sewage lines, stormwater outfalls, and stormwater pumping stations. However, locations of most of the utilities on the peninsula are not well documented over the City's long history. Telecommunications cables may be above ground or buried, but this has not been verified.

Electric and Gas

Dominion Energy provides electric and natural gas services to homes and business across portions of South Carolina, including the Charleston area. Due to confidentiality concerns, detailed information on locations of the electrical and gas distribution system is limited, and only maps of transmission-level substations and power lines are available. Many of these on the peninsula would be vulnerable to flooding. Above ground power lines are more susceptible to storm damage than underground lines. The City of Charleston has two specific underground utility districts on the peninsula: King Street Neighborhood and Orange Street Neighborhood.

Telecommunications

Multiple carriers serve the City of Charleston, including Comcast, Time Warner Cable, DIRECTV, and AT&T. Communications are usually directed through wire centers, which are physical locations that contain telecommunication switches, including mobile services. Wire centers in a flood zone could be at risk. It is unknown if/where these are located on the Charleston Peninsula.

Stormwater

The City of Charleston has numerous stormwater outfalls around the peninsula, although the subsurface drainage system has not been fully mapped. A Stormwater Management Plan is in place to ensure that the stormwater that is discharged into public water bodies complies with water quality regulations. An effort is currently underway to install check valves onto existing stormwater outfalls.

The City also has a comprehensive Master Drainage Plan to tackle large capital projects that will improve drainage due to heavy flooding from rainfall. Projects that are underway or planned to improve interior drainage on the peninsula include:

- Medical District Tunnel Extension to Ehrhardt Project, approved February 2022
- Market Street Drainage Improvement Project, Division III in construction, (two previous phases have already been completed)
- Limehouse Brick Arch Retrofit Project, in construction
- US 17 Spring/Fishburne (Septima Clark) Drainage Improvement Project, Phase IV in construction (three previous phases have been completed, and one more are planned after this one)
- Calhoun West/Beaufain Drainage Improvement Project, Preliminary Engineering Report completed in early 2020
- Calhoun Street East Drainage Improvement Project (first modern drainage improvement project started by the City in 1999)

Since most of the stormwater outfalls in the City drain to water bodies that are tidally influenced, current high tides are influencing the effectiveness of the drainage system. At high tides, the stormwater collection system is already inundated from tidal waters, so there is little capacity for the stormwater runoff. Thus, the stormwater has no place to go, and flooding results. This is exacerbated when the high tide stays inland longer than usual, such as due to wind and on King Tides cycles, which usually last a number of days before they return to normal tide levels. The check valves and pumping stations are intended to address some of these flooding issues.

Water and Wastewater

The Charleston Water System is a public water and wastewater utility that services the greater Charleston area. They provide drinking water to the City of Charleston, including the peninsula, from their Hanahan Water Treatment Plant (outside of the ROI). Their extensive sewer system includes collection mains, pump stations, and deep tunnels that carry wastewater to the Plum Island Wastewater Treatment Plant, across the Charleston Harbor from the peninsula.

4.19 Safety

Safety of the public on the Charleston Peninsula can be evaluated in terms of flood risk to life and property, and the effectiveness of the emergency response services to respond to such events. Coastal storm surge, intense, heavy rainfall and tidal flooding have the ability to cause property damage and destruction, life-threatening injuries, and the possibility of loss of life for those affected. This section considers flood extents and considers the community potentially affected by a major storm surge event on the Charleston Peninsula (the ROI). Safety is evaluated in terms of initial risk, emergency response, and communication of emergency procedures to the potentially affected populations. The potentially affected population consists of the public at risk of harm from flooding, including the personnel that will be constructing, operating, and maintaining this project.

Federal regulations that are considered for safety include:

- FEMA Disaster Operations Legal Reference Version 2.0. The second Edition of the Disaster Operations Legal Reference describes the legal authorities for FEMA's readiness, response, and recovery activities.

- Robert T. Stafford Disaster Relief and Emergency Assistance Act, PL 100-707, signed into law November 23, 1988; amended the Disaster Relief Act of 1974, PL 93-288. This Act constitutes the statutory authority for most Federal disaster response activities especially as they pertain to FEMA and FEMA programs (Stafford).

- Presidential Policy Directive 8 is aimed at strengthening the security and resilience of the United States through systematic preparation for the threats that pose the greatest risk to the security of the nation, including acts of terrorism, cyber-attacks, pandemics, and catastrophic natural disasters.

South Carolina Regulations 58-1 and 58-101, both passed in 1982, govern emergency preparedness in South Carolina. The former defines the standards for emergency preparedness at the county level. The latter details the emergency preparedness standards for the state. Under this regulation, county governments are responsible for the conduct of operations within their jurisdictions with the state providing support as needed.

Action agencies must also ensure worker safety through the Occupational Safety and Health Act (OSHA) of 1970 that require the assurance of safe and healthful working conditions for working men and women by setting and enforcing standards and by providing training, outreach, education, and assistance.

Affected Environment

Flooding in urban areas can cause serious health and safety problems for the affected population. The most obvious threat to health and safety is the danger of drowning in flood waters. Swiftly flowing waters can easily overcome even good swimmers. When people attempt to drive through flood waters, their vehicles can be swept away in as little as two feet of water.

Water levels at coastal locations are an important public concern and a factor in coastal hazard assessment, navigation safety, and ecosystem management. The NOAA National Weather Service has established thresholds for flooding in the Charleston area:

- Action Stage (6.5 ft MLLW)
- Minor Flooding (7.0 ft MLLW)

- Moderate Flooding (7.5 ft MLLW)
- Major Flooding (8.0 ft MLLW)

The Action Stage equates with King Tide levels for Charleston. King Tides are those especially high tide events when there is alignment of the gravitational pull between the sun and moon. The SCDHEC-OCRM issues a King Tide warning once tide height reaches 6.6 feet (MLLW), equating to 3.46 feet (NAVD88). Some low-lying areas in the ROI will experience tidal flooding when water surface elevations reach the level of King Tides, which often leads to road closures. In areas where there is critical infrastructure, such as in the Medical District, there is a risk to life safety if access is restricted. For example, surface streets as well as U.S. Route 17 (locally known as the Crosstown) already close during flood events, limiting movement on the peninsula. U.S. Route 17 currently floods more than 10 times per year and is expected to experience up to 180 floods annually by 2045 (Fourth National Climate Assessment). In addition to the population of approximately 40,000 people on the peninsula, thousands of commuters and tourists/day users may be on the peninsula. During storm surge events, the ability of first responders to reach the location of need and the ability of individuals to reach medical facilities can be limited or cut off entirely.

The Charleston area can experience inundation from all three types of tropical cyclones (hurricanes, tropical storms and tropical depressions), and nor'easters. When a hurricane threatens South Carolina's coast, residents are expected to leave the peninsula for their safety, if evacuation orders are issued. Residents may plan to leave voluntarily even if not ordered to evacuate. Storms do not have to make landfall to have a flooding and safety impact. Twenty-two storms passed within 100 nautical miles of Charleston between 2000 and 2019 (NOAA Historical Hurricane Tracks) (https://oceanservice.noaa.gov/news/historical-hurricanes/). Some examples of storms that greatly impacted the Charleston area with wind and inundation include Hurricane Hazel, a Category 4 storm that made landfall near Little River, S.C. in 1954 with 106-miles per hour winds and a 16.9-foot storm surge. One person was killed and damage was estimated at $27 million. Hurricane Hugo, a Category 5 storm, made landfall near Sullivan's Island as a Category 4 storm with 120 knot winds in 1989. It continued on a northwest track at 25-30 miles per hour and maintained hurricane force winds as far inland as Sumter, SC. The hurricane caused 13 directly related deaths and 22 indirectly related deaths, and it injured several hundred people in South Carolina. Damage in the State was estimated to exceed $7 billion, including $2 billion in crop damage (South Carolina Water Resources Commission 1990). Tide level reached 9.39 ft NAVD88. In 1999 Hurricane Floyd, a very large storm, came very close to the South Carolina coast, then made landfall near Cape Fear, North Carolina. Hurricane Floyd triggered mandatory evacuations along the South Carolina coast. More information about historic tropical storms can be found in Appendix B - Engineering.

The City of Charleston has a number of initiatives underway to address flooding safety for its citizens. It is currently working on developing a new Hazard Mitigation Plan specifically for the City. It will include actions that can be taken to help reduce or eliminate long-term risks caused by hazards and disasters, including flooding. The City has also established a Flood Condition Awareness Program (FLOODCON) to guide users in making informed decisions to avoid flooding that can help protect public safety. The City is also taking steps to improve the drainage system so it will reduce rainfall flooding (see Section 4.8).

Emergency Services:

There are a number of emergency services in the study area that may be impacted by coastal flooding and need to be considered, for their safety, and the safety of community.

Police protection for citizens and visitors in the study area is provided by the City of Charleston Police Department, which is made up of 458 sworn police officers and 117 civilians. They perform basic duties of promoting safety, protecting human life, preserving the streets and highways, and more. They have a Disaster Response Team that assists locally and throughout the southeast in natural disaster situations. The Charleston Police Department also has a Marine Patrol Unit that provides services to citizens on waterways surrounding the City of Charleston.

The Charleston Fire Department provides fire suppression, rescue and emergency medical services, hazardous materials mitigation, fire inspection, and risk reduction education for the City of Charleston. It was founded in 1882 and is currently made up of 390 uniformed and non-uniformed personnel. They operate six stations on the Peninsula, including their headquarters.

There are two efforts underway in the Charleston area that relate to emergency response. The Charleston County’s Regional Hazard Mitigation Plan from 2016-2017 is in effect, while the City of Charleston is in the process of developing a new plan that will focus only on the city and is intended to highlight various projects that can help to reduce risks through proper mitigation planning. This includes risks caused by flooding, as well as earthquakes and wildfires. It will align and be synergistic with Charleston County's Regional Hazard Mitigation Plan. Additionally, an All Hazards Vulnerability and Risk Assessment was initiated in 2019 and completed in November 2020. The assessment identifies populations and assets (e.g., economic, cultural, historical, critical facilities and ecosystem services) that are vulnerable to various physical threats such as sea level rise, extreme precipitation, extreme heat, etc. The assessment highlights the most critical areas and assets at risk from these various physical threats, including flooding sources, the consequences associated with each and potential adaptation measures that could be implemented.

The U.S. Coast Guard also provides waterborne emergency services in waterways of the ROI. The U.S. Coast Guard Sector Charleston has a station on Tradd Street on the Peninsula and is responsible for maritime accidents, incident response, and other local logistics.

4.20 Environmental Justice

Socioeconomics are the basic attributes and resources associated with the human environment, particularly population, demographics, and economic development. Environmental justice is described by the USEPA as the fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income with respect to the development, implementation and enforcement of environmental laws, regulations, and policies (USEPA, 2010). Fair treatment means that no group of people, including racial, ethnic, or socioeconomic should bear a disproportionate share of the negative environmental consequences resulting from the execution of federal, state, local, and tribal programs and policies. The goal of fair treatment is not to shift risks among populations but to identify potential disproportionately high and adverse effects and identify alternatives that may mitigate these effects.

In accordance with Executive Order 12898, Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations, federal agencies must assess whether disproportionately high and adverse effects would be imposed on minority or low-income areas by federal actions. In addition, Executive Order 13045, Protection of Children from Environmental Health Risks and Safety Risks, requires Federal agencies to assess the environmental health and safety risk of their actions on children. Section 112(b)(1) of WRDA 2020 (P.L. 166-260) requires the formulation of water resource projects to comply with "any existing Executive Order regarding environmental justice." Moreover, Executive Order 14008, Tackling the Climate Crisis at Home and Abroad, Section 219 directs federal agencies to "[develop] programs, policies, and activities to address the disproportionately high and adverse human health, environmental, climate-related and other cumulative impacts on disadvantaged communities".

This section assesses socioeconomics to understand environmental justice in relation to the study alternatives. The ROI is defined by those census tracts that are on the Charleston Peninsula, some of which extend outside of the jurisdictional limits of the City of Charleston.

Affected Environment

The Charleston Peninsula study area overlaps with 16 census tracts (45019005400, 45019004400, 45019001600, 45019001500, 45019005200, 45019005300, 45019001100, 45019001000, 45019000900, 45019000600, 45019000700, 45019005100, 45019000500, 45019000400, 45019000100,45019000200). Figure 4-24 shows the census tract boundaries on the Charleston Peninsula and surrounding areas.

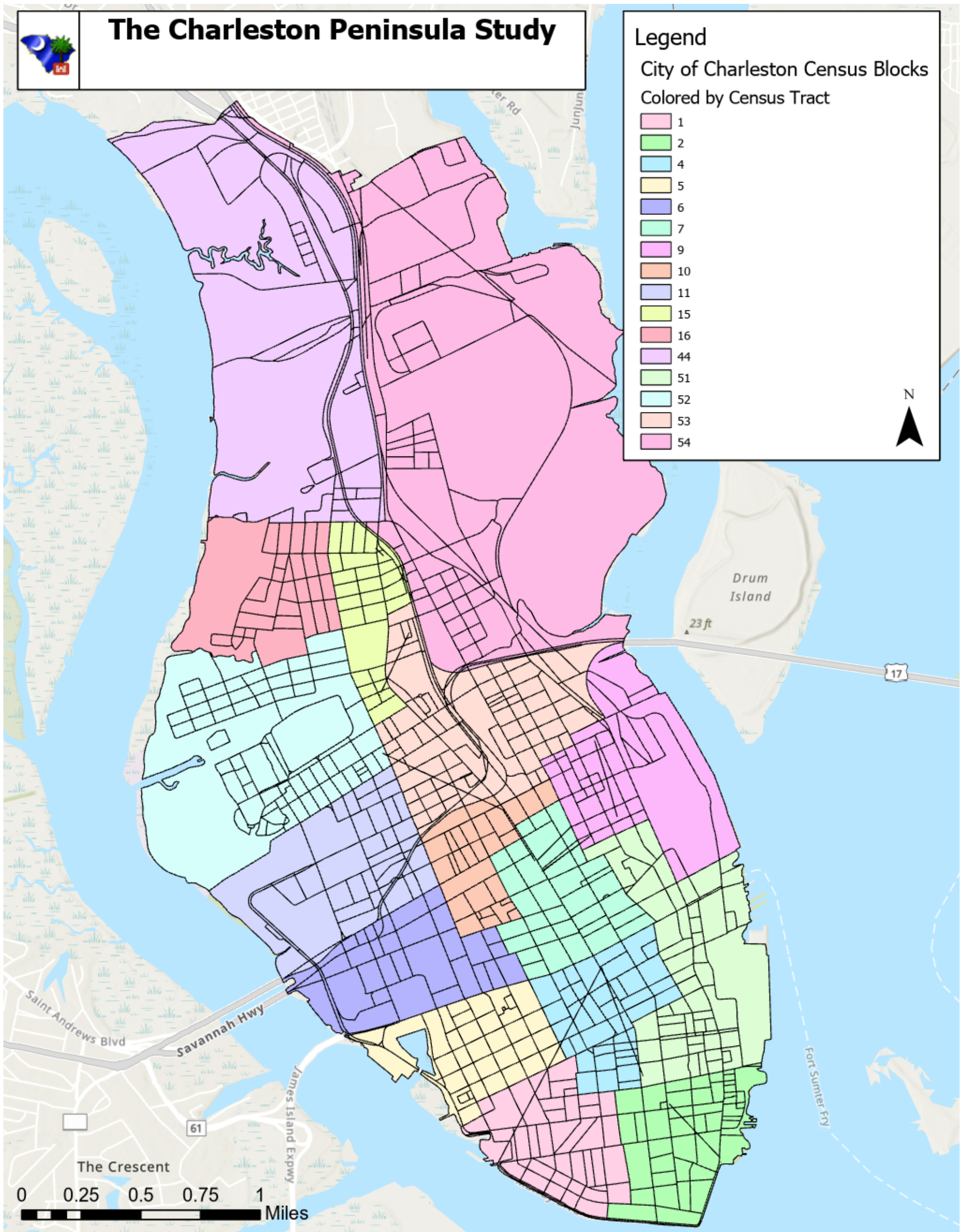

Figure 4-24. Map of US Census Tract boundaries. There are 16 census tracts on the Charleston Peninsula that overlap with the study area.

Source: USEPA EJ Screen Tool

The Charleston Neck is the area at the northern end of the Peninsula boundary, north of Mt. Pleasant Street and northeast of Morrison Drive. The area is primarily industrial but targeted for economic redevelopment (City of Charleston, 2003). The City of North Charleston Neck lies to the north.

The USEPA's EJ Screen Tool was used to identify census communities that are susceptible to key environmental factors in the ROI, based on the 2010 census (USEPA, 2020b). The key environmental and demographic variables are presented in Tables 4-5 and 4-6, keeping in mind that some of the census tracts represent areas that extend beyond the study area.

Table 4-5. Environmental Exposure Indicators for Study Area.
Source: EJ Screen Tool

Environmental Indicator	Value per Indicator	State Average	Percentile in State	USA Average	Percentile in USA
Particulate Matter (PM 2.5 in μg/m^3)	7.65	8.84	12	8.3	30
Ozone (ppb)	36.3	40.8	14	43	15
NATA* Diesel PM (μg/m^3)	0.675	0.308	14	0.479	80-90th
NATA* Cancer Risk (lifetime risk per million)	41	38	84	32	80-90th
NATA* Respiratory Hazard Index	0.5	0.53	30	0.44	60-70th
Traffic Proximity and Volume (daily traffic count/distance to road)	1300	180	98	750	86
Lead Paint Indicator (%Pre-1960 Housing)	0.62	0.14	97	0.28	83
Superfund Proximity (facility count/km distance)	0.47	0.092	97	0.13	94
Hazardous Waste Proximity (facility count/km distance)	1.7	0.56	91	4	74
Wastewater Discharge Indicator (toxicity-weighted concentration/m distance)	0.18	0.24	95	14	91

*The National-Scale Air Toxics Assessment (NATA) is EPA's ongoing, comprehensive evaluation of air toxics in the United States. EPA developed the NATA to prioritize air toxics, emission sources, and locations of interest for further study. It is important to remember that NATA provides broad estimates of health risks over geographic areas of the country, not definitive risks to specific individuals or locations. More information on the NATA analysis can be found at https://www.epa.gov/national-air-toxics-assessment.

Table 4-6. Demographic Susceptibility Indicators for the Study Area.

Source: EJ Screen Tool

Demographic Indicators	Percentage	State Average	Percentile in State	USA Average	Percentile in USA
Demographic Index	42%	37%	65	36%	65
Minority Population	39%	36%	61	39%	58
Low Income Population	45%	37%	66	33%	73
Linguistically Isolated Population	1%	2%	65	4%	47
Population w/ Less Than High School Education	9%	13%	42	13%	49
Population Under 5 Years of Age	4%	6%	36	6%	34
Population Over 64 Years of Age	12%	16%	34	15%	42

Additionally, the US Census Bureau's American Community Survey (ACS), also available from EJ Screen, provides more recent demographic information for 2013-2017. The ACS indicates that the population for the census tracts that fall within or partially within the study area is 35,275 from the 2010 Census. Thirteen percent of that population is classified as minority. Only 3% of the population in the study area census tracts has less than a high school education, and 96% of the population speaks English.

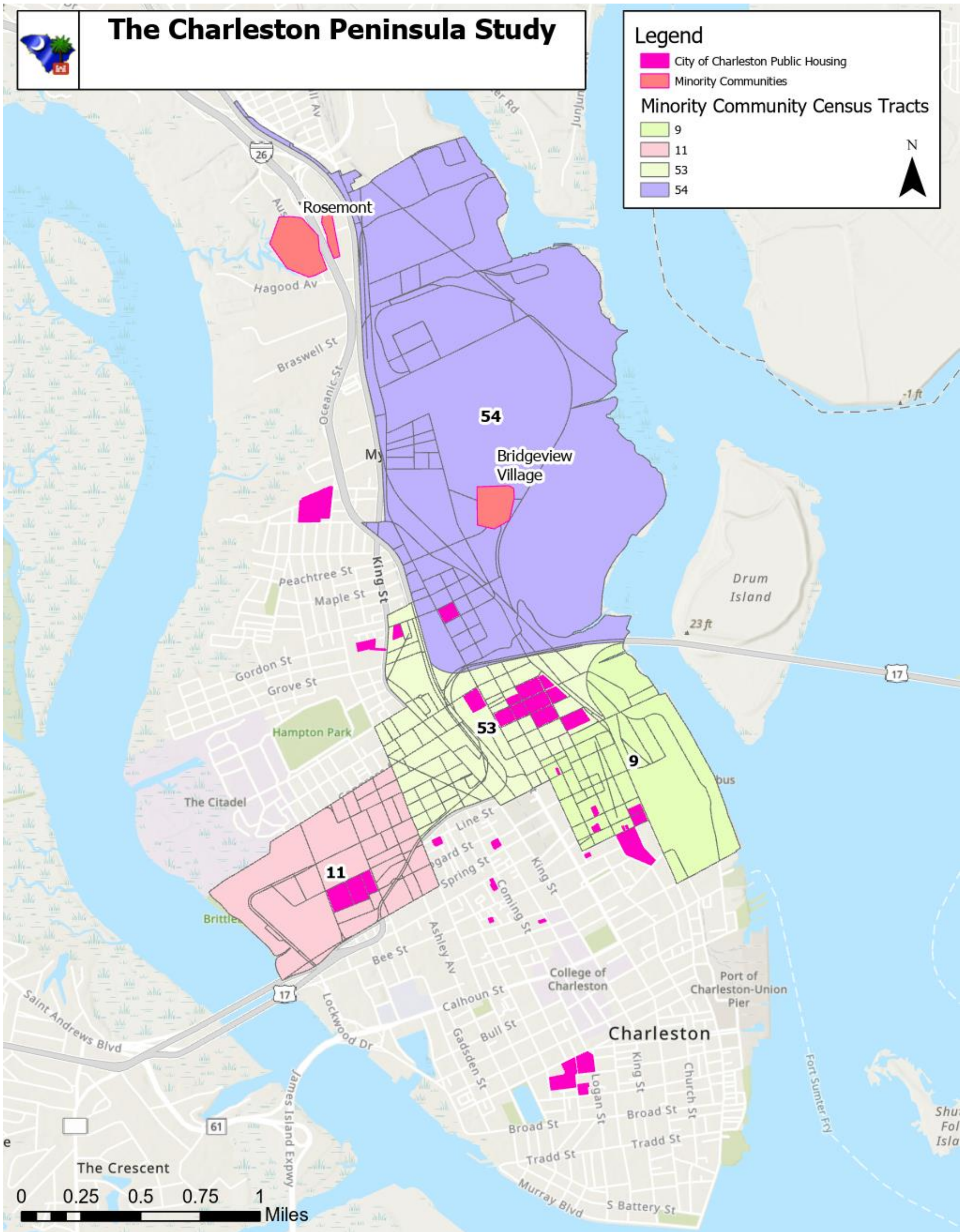

Figure 4-25. Map showing distribution of households below the poverty level (by census tract) in relation to the Charleston Peninsula.

Source: EJ Screen Tool

The ROI contains a number of populations of minority communities at the 2010 Census Tract level, within Charleston County, when compared to the surrounding areas. In particular, this is observed in Census Tract 9 where 1,075 people of 1,439 identified as Black or African American, Census Tract 11 (encompassing the Public Housing Community known as Gadsden Green) where 1,738 people of 2,584 identified as Black or African American, Census Tract 53 where 2,813 people of 3,580 identified as Black or African American and Census Tract 54 where 1,997 people of 2,166 identified as Black or African American. Moreover, as reported from the American Community Survey estimates for 2010, 57% of households, with children under 18 years old, were below the poverty level in Census Tract 11, 71.4% in Census Tract 53, and 61.5% in Census Tracts 54, respectively. Zooming down to the 2010 Census Block level, data within the study area for Census Tracts 53 and 54 reveals the Rosemont Neighborhood, and Bridgeview Village can be described as minority communities also, in addition to other Public Housing communities on Charleston Peninsula.

According to the 2010 Census, the Rosemont Neighborhood falls within Tract 44 on Charleston Peninsula, and is covered by Census Blocks 1002, 1003, 1013, 1014, 1015 and 1021 for a total population of 103, 101 of which identified as Black or African American. Bridgeview Village falls within the 2010 Census Tract 54 on Charleston Peninsula and is covered by Census Blocks 2028, 2029, and 2031 for a total population of 550, 547 of which identified as Black or African American.

The Public Housing communities of Cooper River Court and Meeting Street Manor fall within the 2010 Census Tract 53 within Charleston County and is covered by Census Blocks 3007, 3009, 3013, 3014, and 3015 for a total population of 727, 699 of which identified as Black or African American (note however, these totals do not include data for Census Block 3007; none are available). The Public Housing community known as Robert Mills Manor which falls within the 2010 Census Tract 1 within Charleston County and covered by Census Blocks 1000 and 1003 for a total population of 370, 279 of which identified as Black or African American.

4.21 Climate Change

Climate change is defined as a change in global or regional climate patterns. It is measured by changes in temperature, wind patterns, and precipitation. Emission of greenhouse gases above natural levels is suggested to be a significant contributor to global climate change. Greenhouse gases are known to trap heat in the atmosphere and regulate the Earth’s temperature. These gases include water vapor, carbon dioxide, methane, nitrous oxide, ground-level ozone, and fluorinated gases such as chlorofluorocarbons, and hydrochlorofluorocarbons.

According to the Intergovernmental Panel on Climate Change (IPCC), global warming and climate change have been observed since the mid-20th century and are expected to continue into the future which would contribute to a continued or possibly accelerated sea level rise. Climate change and sea level rise is largely attributed to human activities that increase atmospheric concentrations of carbon dioxide and other greenhouse gases. Executive Order 13693 Planning for Federal Sustainability in the Next Decade was issued on March 19, 2015, with a goal of maintaining Federal leadership and sustainability in greenhouse gas emission reductions. Executive Order 13834 Efficient Federal Operations was signed on May 22, 2018 and is intended to eliminate unnecessary use of resources and protect the environment. Executive Order 14008 Tackling the Climate Crises at Home and Abroad, effective January 27, 2021 directs Federal agencies to increase resilience to the impacts of climate change; to protect public health and to conserve our lands, waters, and biodiversity, in addition to the other directives of this Order.

This section focuses primarily on the climate change conditions related to increasing water levels and sea level rise as they relate to coastal flooding and tropical storm trends. The Department of the Army Engineering Regulation 1100-2-8162 (31 Dec 2013) also requires that future Relative Sea Level Rise (RSLR) projections be incorporated into the planning, engineering design, construction and operation of all civil works projects. To do this, consideration is given to "low," "intermediate," and "high" potential rates of future RSLR. The range of potential rates of RSLR is based on the findings of the National Research Council and the Intergovernmental Panel for Climate Change. According to these sources, NOAA, and using USACE Sea-Level Change Curve Calculator (Version 2017.55) for the Charleston Gage 8665530, the sea level change in 2100 for the low rate is 1.12 feet, intermediate rate is 2.15 feet and for high rate is 5.44 (see Figure 4-26). Values are also tabulated in Table 4-7 relative to the current National Tidal Datum Epoch (NTDE) of 1992 for the year that the project is constructed (2032), the end of the period of analysis (2082), and the end of the adaptation horizon (2132) for each USACE sea level change curve. Details of the sea level rise analysis conducted for this study can be found in the Appendix B Engineering, Sub-Appendix - Coastal.

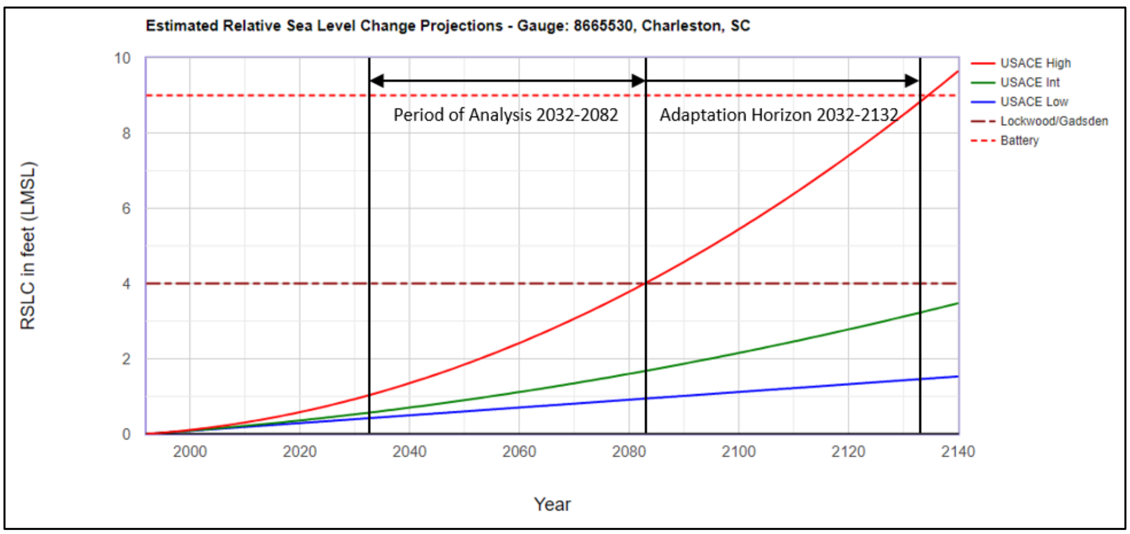

Figure 4-26. Estimated relative sea level change based on projected low, intermediate, and high rates at the Charleston Harbor gage over the 50-year period of analysis and 100 year adaptation horizon from 2032.

Source: USACE

Table 4-7. Estimated relative sea level change relative to the NTDE 1992.

Year	USACE Low (ft)	USACE Int (ft)	USACE High (ft)
2032	0.41	0.56	1.01
2082	0.93	1.65	3.93
2132	1.45	3.19	8.71

Climate change is also increasing temperatures with implications for human health and species distributions, as well as altering precipitation trends, water quality and increasing ocean acidity, but these are not expanded on in this section. Alternatively, Table 4-8 is provided as overview of a suite of impacts from climate change and the consequences to natural resources in South Carolina.

The ROI for considering climate change includes the entire study area and the surrounding waters of the Charleston Harbor, lower Ashley River, and lower Cooper River.

Table 4-8. Climate Change Impacts, and Consequences as Identified by the SCDNR Climate Change Technical Working Group

Source: SCDNR, 2021

Potential Impacts	Potential Consequences
• Changes in precipitation cycles increasing evapotranspiration (e.g., frequency and duration of droughts) • More problems with invasive species • Spatial changes in species' ranges • Changes in timing of aquatic organism migration and competition for available resources as food chains are altered • Increased coastal flooding • Increased coastal erosion • Rising water tables • Saltwater intrusion • Increased nonpoint source pollution • Increases in toxic substances flowing from upstream to coastal areas • Increases in numbers of threatened and endangered species	• Decline in water quality and quantity • Surface and sea-water pH changes • Decline in productivity and availability of fish and other aquatic species • Economic losses directed toward business associated with natural resource management in coastal zones • Loss of beaches • Increased storm surge flooding • Impacts to coastal infrastructure • Salt marsh conversion to open water • Freshwater marsh conversion to salt marsh • Loss of important recreational and commercial fishing and shell fishing habitats • Extinction of threatened and endangered species

Affected Environment

The effects of climate change are already being observed in the ROI with the increase in minor coastal flooding, also known as tidal flooding or "nuisance" flooding. The Cooper River Entrance Tidal Gage (8665530), also called the Charleston Harbor or Custom's House gage, is the most extensive and continuous record of tides for the City of Charleston. It has been measuring sea level continuously since 1921. In that nearly 100-year time span, local sea level has risen 1.07 ft. The National Weather Service has defined that when the tide reaches a height of 7.0 ft MLLW in the Charleston Harbor, minor coastal flooding occurs. Note that this is based on tide levels, not surge levels. NOAA refers to this flooding as "nuisance" flooding because it leads to public inconveniences, such as road closures. Nuisance flooding is becoming increasingly common as sea levels rise.

Tidal flooding occurs now with high tides in many locations in the ROI due to climate-related sea level rise and the loss of wetlands to development. For example, Lockwood Blvd begins to flood with water levels at 7.2 ft MLLW (or 4.06 ft. NAVD88). In addition to road closures, storm drains on the Peninsula become overwhelmed with high tide or nuisance flooding, and infrastructure and historical sites on the peninsula are compromised. The City is already taking steps to address the tidal filling of storm drains by adding check valves on some of the city's storm drainage pipelines.

This trend is expected into the future. According to the City of Charleston (2019a), a significant increase in minor coastal flooding is expected in Charleston (and along the entire South Carolina Coast) for decades to come (see Figure 4-27).

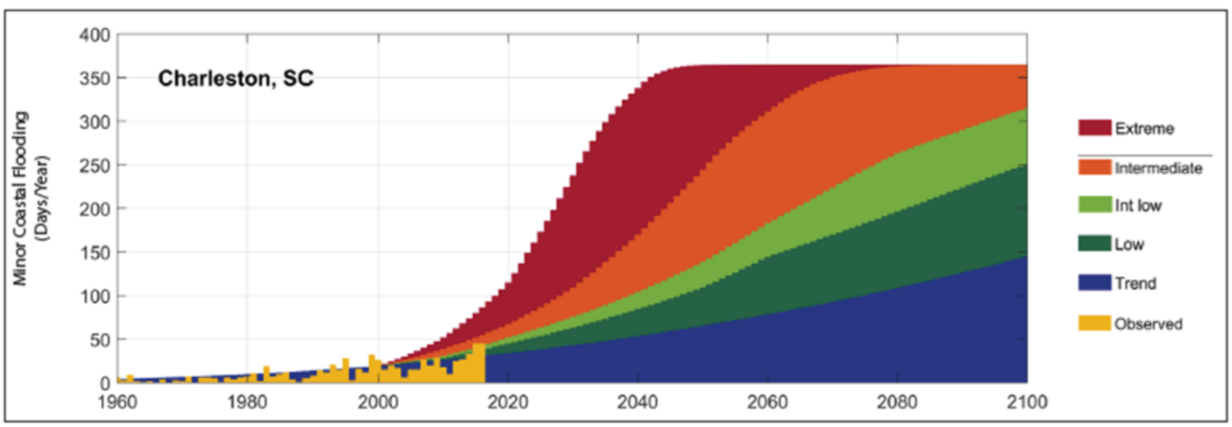

Figure 4-27. Observed and predicted "minor coastal flooding" in Charleston, SC since 1960 through 2100.

Source: City of Charleston

Subsidence can be a contributor to sea level rise and is included when referring to relative sea level rise; however, it is difficult to define for the Charleston area because subsidence studies are limited (see Section 4.2).

Salt marsh wetlands around the perimeter of the peninsula are already vulnerable to erosion from wave action from storms. Most of the salt marshes do not have the ability to migrate inland with changes in water elevations because they are restricted by roads and other infrastructure and may eventually be lost to sea level rise. Fringing salt marshes around the perimeter of the Charleston Peninsula already become over inundated on extreme high tides and are unable to retain coastal waters, allowing them to spill over and flood local roadways (see Figure 4-28).

Climate change is also contributing to increased flooding from coastal storms. South Carolina is located in an area of significant tropical storm and hurricane activity. The National Hurricane Center reports that 187 storms have impacted the state from 1852 (when official records began) to 2019. NOAA has reported a trend in increased frequency of minor tropical cyclones, likely attributed to climate change (see Section 2.5.5). When major hurricanes do occur, they are expected to be more intense due to increased ocean temperatures. During tropical storms, waves erode sediments from shorelines. Storm surge can flood coastal and inland properties. The higher the storm surge elevation, the more flooding (and subsequently more erosion, wave, and flood damage) is expected to occur.

A study by Dai et al. (2011), for a climate station in South Carolina (at the Santee Experimental Forest), identified a generally increasing, but not statistically significant, pattern in the number of extreme storm events over the past 60 years. Similarly, they demonstrated a generally increasing trend in total annual precipitation at their study site, but without statistical significance. While the Santee watershed is a different watershed that does not impact Charleston, it provides a general characterization of the precipitation trends in the local region. The report notes that projections of precipitation in that study area are less certain than those associated with air temperature; however, there is moderate consensus that future rainfall events in the region will be more intense and more frequent compared to the recent past.

Figure 4-28. Inundation on Lockwood Blvd/Broad Street and the perimeter saltmarsh by the U.S. Coast Guard station at high tide during a storm in December 2019.

Source: City of Charleston

CHAPTER 5 - Coordination and Public Involvement Process

5.1 NEPA Public Involvement

5.1.1 Public Involvement on the Draft April 2020 FR/EA

During the development of the draft 2020 Feasibility Report / Environmental Assessment (FR/EA) for this study, USACE engaged Federal, State, and local agencies, stakeholders, and the public through various meetings and the NEPA public comment period. A project information meeting for the public was held at the Citadel Alumni Center on January 31, 2019 where the public was informed on the results of the first two planning iterations and input was solicited both in person and via an internet app. There were 17 persons who provided comments during the January 31, 2019 public information meeting. Comments were submitted through an internet application and e-mail. Public comments were taken into account during the third iteration of the planning process in the development of the draft April 2020 FR/EA.

USACE solicited public comments on the draft April 2020 FR/EA during a 60-day public review period, April 20 – June 20, 2020. Due to the COVID pandemic, USACE and the City provided a number of virtual public and social media outreach efforts to inform the public/stakeholders of public review of the draft April 2020 FR/EA and solicit comments. Approximately 450 comments were received from the public and agencies. Common themes of these comments were, as follows:

- greater potential for significant adverse effects on aesthetic/visual resources;
- continued concern about cultural/historical resources and the need for a more detailed Programmatic Agreement to address those impacts;
- lack of details and confidence in the proposed plan for compensatory wetland mitigation; and
- the need for additional evaluation of socioeconomic impacts.

These common themes have been considered as part of the scoping process for the FR/EIS and during the refinement of the study design. After further agency analysis, review of substantive comments received on the draft April 2020 FR/EA, and continued refinement of the study, USACE concluded that an FR/EIS with a Record of Decision (ROD) would fulfill NEPA compliance for the study.

5.1.2 Public Scoping on the Draft FR/EIS

To ensure an appropriate scope for the FR/EIS, USACE engaged in a public scoping process. The Notice of Intent (NOI) for this study was published in the *Federal Register* on March 23, 2021 (86 Federal Register [FR] 15470); the scoping comment period ended April 22, 2021. A virtual public scoping meeting was held on March 30, 2021. In addition, a press release and social media announced the scoping comment period and virtual meeting. The NOI sought comments concerning the scope of the alternatives and identification of relevant information, studies, and analyses, stated that USACE was exercising its discretion to employ the 1978 CEQ NEPA regulations to the process, and informed the public that comments received during the draft FR/EA public comment period would be considered as part of the scoping process for the FR/EIS and did not need be resubmitted.

USACE received approximately 125 substantive comments during the scoping period. The scoping comments primarily sought additional analysis or detail, and generally fell into several themes, as follows:

- the need for further analysis of wetland, ecosystem, visual, environmental justice, interior drainage, and climate change impacts;
- more detail on risk management measures such as nonstructural, and natural and nature-based features;
- the need for additional analysis of induced flood risk, meaning shifting the flooding from the project area to another location; and
- concerns regarding city planning efforts to address development and flood risk.

5.1.3 Public Involvement and Comment on the Draft FR/EIS

The public comment period, during which any person or organization may comment on the draft FR/EIS, is governed by Federal regulation. The Notice of Availability for this study was published in the *Federal Register* on September 10, 2021 (86 FR 50713); on the same date, a Joint Public Notice was issued by USACE and SCDHEC regarding availability of the draft FR/EIS for review and comment. For this FR/EIS, the public comment period was open for 45 days. The draft FR/EIS informed the public that while public comments received on the draft FR/EA of April 2020 were considered in developing the content of the draft FR/EIS, these comments would not be further considered as comments on the draft FR/EIS. The draft FR/EIS stated that persons desiring to provide public comment on the draft FR/EIS would need to respond to the draft FR/EIS and submit their comment within the 45-day comment period, and not rely on or reference previous input or public comment on the draft April 2020 FR/EA.

Comments were accepted via email, phone, mail, or electronic comment form on the study’s website. The purpose of the public comment period is to seek input on the alternatives considered, effects of the alternatives, and associated mitigation. USACE hosted one virtual public meeting during the public comment period; no comments were received at the meeting. In addition, USACE participated in the nine outreach meetings, in person and virtual during the public comment period. These meetings were with stakeholders, public, and the City.

Public comments submitted and received within the 45-day comment period on the draft FR/EIS were considered in the agency's NEPA analysis and development of the final FR/EIS, including the Response to Public Comments in Appendix I.

5.1.4 Response to Public Comments on the Draft FR/EIS

During the comment period, approximately 102 pieces of submittals were received on the draft FR/EIS. Of the total number of submittals, approximately 65% were from the public, and 35% were from local, state, and federal agencies, and other stakeholders (such as NGOs). Approximately 400 total comments were submitted and of those, approximately 209 substantive comments were derived. Some of those comments were combined for response based upon submitter and topic in Table 1 – Substantive Comments and Responses in Appendix I – Response to Public Comments. USACE has considered all substantive comments received and has revised the final FR/EIS, accordingly.

The Appendix I – Response to Public Comments includes substantive comments received on the draft FR/EIS and USACE's responses. In addition, similar substantive comments were grouped together to develop a "comment theme". The comment theme summarizes the main points or common topics expressed across one or more substantive comments. Master responses have been prepared for each of the following comment themes and are found in Appendix I:

- Non-Storm Surge Flooding
- Climate Change and Sea Level Rise
- Interior Drainage
- Natural and Nature-Based Features
- Environmental Justice
- Induced Flood Risk to Surrounding Communities
- Wall Alignment
- Operation and Maintenance Procedures
- Public Outreach
- Visual / Aesthetics
- Historic and Cultural Resources

5.2 Other Public Involvement

The study team held two planning charrettes in the Fall of 2018 and completed an iteration of the planning process each time. As part of the risk-informed decision-making process, key agencies and stakeholders were invited to participate in the second planning iteration which resulted in the formulation of the initial array of conceptual alternatives. Representatives from the agencies and organizations in Table 5-1 participated in the second planning charrette. City of Charleston technical staff have regularly attended team meetings and provided key input into the plan formulation process.

Table 5-1. Agencies and organizations that participated in the second planning iteration.

City of Charleston	College of Charleston
Historic Charleston Foundation	South Carolina Ports Authority
Medical University of South Carolina	South Carolina Department of Natural Resources
AECOM	South Carolina Department of Health and Environmental Control, Ocean and Coastal Resource Management
Davis & Floyd, Inc.	South Carolina Department of Transportation
South Carolina Sea Grant/Carolinas Integrated Sciences and Assessments	National Oceanic & Atmospheric Administration
The Nature Conservancy	United States Coast Guard

On March 12, 2019 the study team briefed the Groundswell organization on the study. The City of Charleston also presented different initiatives to address flooding in the short and long term. Groundswell is a grassroots community organization dedicated to combating floods that threaten homes in the Charlestowne and Harleston Village neighborhoods. The meeting was attended by approximately 75 homeowners from the southwest corner of the peninsula.

On May 2, 2019 USACE, the City of Charleston, and the Historic Charleston Foundation briefed the Trident CEO council on flood risk reduction efforts within the Charleston Peninsula. The Trident CEO council is two dozen of the top CEOs in the region. The group stands for progress in the Charleston Region and wanted to know how they can support responsible progress.

On July 28, 2019, members of the study team organized a booth for local Eastside peninsula residents at the “Be Flood Ready” event hosted by Charleston Sea Grant. The study team members discussed the Charleston Peninsula Study and the 3x3x3 timeline. Several other organizations were present at the event and approximately 50 homeowners attended. The Eastside encompasses minority and low-income communities, including Bridgeview Village, Cooper River Terrace and Meeting Street Manor.

The study team has also met with the Dutch Dialogues, CSX Railroad, South Carolina State Port Authority, the South Carolina Department of Transportation, Charleston Chamber of Commerce, Charleston Medical District, and the Citadel Military College to discuss the project.

On July 23, 2021, members of the study team met at the Freddie Whaley Community Center in Rosemont to discuss the proposed 3x3x3 Charleston Peninsula study. The study team discussed the proposed non-structural action for the Rosemont community and any potential impacts. Based on the initial community feedback, they were supportive of the proposed action. The meeting was also attended by the local Council member, City of Charleston staff and other study stakeholders.

During the draft FR/EIS public comment period, another meeting was held on October 23, 2021 at the Freddie Whaley Community Center to discuss the proposed nonstructural measures and topographic and drainage constraints in the Rosemont neighborhood. Attendees, mostly residents, local Council member, and an NGO, had the opportunity to ask questions. USACE also provided question and answer handouts and study brochures.

5.2.1 Institutional Involvement

Interagency Coordination Team

The Project Delivery Team has also participated in briefings with the Mayor of Charleston and provided input into briefings to the Charleston City Council. The study team formed an Interagency Coordination Team (ICT), consisting of a number of regulatory agencies and other agencies (Table 5-2). The first meeting of the ICT was held in December 2018 and additional meetings have occurred throughout the study process.

Table 5-2. Agencies and organizations that participate in the ICT.

City of Charleston	U.S. Fish and Wildlife Service
Charleston County	National Park Service
South Carolina Department of Natural Resources	U.S. Environmental Protection Agency
South Carolina Health and Environmental Control, Ocean and Coastal Resource Management	U.S. Coast Guard
South Carolina State Historic Preservation Office (SHPO)	NOAA National Marine Fisheries Service
South Carolina Institute of Archeology and Anthropology	Advisory Council on Historic Preservation
South Carolina Department of Transportation	South Carolina Geodetic Survey

Cooperating Agency Involvement

USACE asked Federal and State agencies to participate as cooperating agencies based on their jurisdiction by law, or their special expertise with respect to any environmental issue evaluated in this FR/EIS. The cooperating agencies contributed to the draft and final FR/EIS by providing information or data, and by reviewing draft documents. The cooperating agencies are as follows:

- National Marine Fisheries Service
- National Parks

- U.S. Coast Guard
- U.S. Environmental Protection Agency
- U.S. Fish and Wildlife Service
- South Carolina Department of Archives and History
- South Carolina Department Health & Environmental Control
- South Carolina Department of Natural Resources

5.2.2 Agency and Public Coordination of Historic/Cultural Resource Impacts

Between August 2019 and April 2020, letters to interested parties with a concern for cultural resources potentially affected by the Charleston Peninsula study were sent out inviting these stakeholders to consult and participate in the development of a Programmatic Agreement (PA) for compliance with Section 106 of the National Historic Preservation Act (Appendix D). Those agencies/groups contacted included the South Carolina Department of Archives and History (SC DAH) as the State Historic Preservation Officer (SHPO); the National Park Service (NPS); the Advisory Council on Historic Preservation (ACHP); the Naval History and Heritage Command (NHHC); the City of Charleston and Charleston County Planning; Preservation groups including Preservation Society of Charleston, Historic Charleston Foundation, and the South Carolina Institute of Archeology and Anthropology (SCIAA); interested Native American Tribes including the Absentee-Shawnee Tribe of Indians of Oklahoma, the Alabama-Quassarte Tribal Town, the Catawba Indian Nation, the Chickasaw Nation, the Delaware Tribe of Indians, the Eastern Band of the Cherokee Indians, the Eastern Shawnee Tribe of Oklahoma, the Kialegee Tribal Town, the Muscogee (Creek) Nation, the Shawnee Tribe, the Thlopthlocco Tribal Town, and the Poarch Band of Creek Indians; and stewards of National Historic Landmarks (NHL) including Robert Barnwell Rhett House, Circular Congregational Church and Parish House, Clark Mills Studio, College of Charleston, Denmark Vesey House, Dubose Heyward House, Edward Rutledge House, Exchange and Provost, Farmers' and Exchange Bank, Fireproof Building, Williams Gibbes House, Heyward-Washington House, Joseph Manigault House, Hibernian Hall, Huguenot Church, John Rutledge House, Kahal Kadosh Beth Elohim Synagogue, Market Hall and Sheds, Miles Brewton House, Nathaniel Russell House, USS Yorktown, USS Laffey, USS Clamagore, Powder Magazine, Robert Brewton House, Robert William Roper House, Simmons-Edwards House, St. Michael's Episcopal Church, St. Philip's Episcopal Church, Old Marine Hospital, Unitarian Church in Charleston, William Blacklock House, and William Aiken House.

Those stakeholders that confirmed interest in serving as a concurring party or signatory to the PA and provided comments on the initial draft of the Environmental Assessment and PA were further invited to meet regularly with USACE to revise the PA as a Cultural Resources Stakeholders Group. This group includes signatories to the PA (USACE, SHPO, ACHP, and the City of Charleston), invited signatories (NPS), concurring parties (Catawba Indian Nation, Historic Charleston Foundation, and Preservation Society of Charleston), and other interested agencies (SC DHEC). Meetings with the Cultural Resources Stakeholders Group were held on

October 19, 2020, January 22, 2021, February 22, 2021, and July 13, 2021 in order to develop the PA (Appendix D).

CHAPTER 6 - Environmental Consequences

The National Environmental Policy Act (NEPA) requires that Federal agencies evaluate the effects of their actions on the human environment prior to deciding on an action alternative. The environmental effects of a federal action are evaluated with respect to what the environmental conditions would be in the future if no action is taken. Both adverse and beneficial effects of an action must be considered. This chapter of the integrated FR/EIS provides that evaluation of potential effects of the final array of alternatives on the environment. As described in the previous chapter, the final array of alternatives includes the No Action Alternative and Alternative 2 (perimeter structure + nonstructural).

Since the No Action Alternative represents a continuation of existing conditions together with a forecast of future conditions reasonably expected to occur over the 50-year period of analysis if an action alternative is not implemented, it is often referred to as the Future Without Project condition (see Section 2.7 – Without Project Conditions and Assumptions). The No Action/Future Without Project Alternative for this study would involve no action by USACE to address coastal storm surge risks on the Charleston Peninsula. Construction of structural measures and related features and implementation of non-structural measures by USACE would not take place.

Alternative 2 includes a storm surge wall of 12 ft elevation NAVD88 along portions of the perimeter of the peninsula. Approximately 7.2 non-continuous miles of the perimeter storm surge wall would be constructed on land; approximately 1.5 non-continuous miles would be constructed through saltmarsh wetlands. The wall would be constructed of concrete, and on land it would be a T-wall design and in the marsh, it would be a combination design (see Appendix B - Engineering for more information). Other features related to the storm surge wall include plans for five permanent and five temporary pump stations of low to moderate size, ranging from 20 to 90 cfs. The pumps are proposed as a mitigation feature, as described later in this chapter. There is also a series of access gates in the wall for pedestrians and transportation (tentatively 78 gates) and 11 storm surge gates in the form of sluice gates to allow for tidal exchange at creeks that intersect with the proposed wall. Natural and nature-based features include approximately 9,300 linear feet of reef-based living shoreline sills in association with the storm surge wall as a minimization measure. Detailed descriptions of the features can be found in Appendix B – Engineering.

Alternative 2 also includes nonstructural measures in the form of elevating or flood proofing for approximately 100 structures in the study area where a wall is not practicable.

6.1 Land Use

6.1.1 No Action/Future Without Project Alternative

Climatic changes such as rising sea levels and increasing coastal storms, along with human use patterns such as population growth, are expected to continue over the next 50 years in the Charleston area, putting more people at risk of coastal inundation. King tides, causing nuisance flooding, have already increased in frequency. This trend is expected to continue into the future. The City would use its most current comprehensive plan, Charleston Green Plan (City of Charleston, 2010), and Sea Level Strategy (City of Charleston, 2019a) to guide land use decisions that support adaptation to shallow coastal flooding. New development on the Peninsula must be built to base flood elevation. The City of Charleston is currently raising the existing Low Battery seawall, which will provide some reduction in storm surge damages in the Battery area Land uses that involve residences, businesses, and critical infrastructure across the rest of the Peninsula are still at risk of storm surge damages because there are no comprehensive risk reduction measures in place. Under the No Action Alternative, it is expected that these land uses would be at even greater risk of storm surge impacts in the future. Future projected yearly damages from coastal storms (with forecasted sea level rise) are expected to reach as much as $773 million in the study area.

6.1.2 Alternative 2 (perimeter structure + nonstructural)

Under Alternative 2, the City of Charleston's initiatives mentioned in the No Action Alternative above are assumed to occur. Measures in Alternative 2 are consistent with the City's goals of future development, and with recommendations from the Dutch Dialogues. Most land uses on the Charleston Peninsula would experience a continuing beneficial effect from the reduction in storm surge risk provided by this Alternative.

Implementation of a storm surge wall under this Alternative would result in a permanent landscape feature. In most locations, it is not expected to result in a permanent change to the land use, except at the footprint of the wall. Access to use of those lands in the manner in which they are currently utilized (e.g., recreation, transportation) would be maintained through such features as access gates for pedestrians or cars.

The storm surge wall and pump stations would be aligned with public property, where feasible, of various land uses. It would likely cross a limited number of private properties. Figure 6-1 shows the conceptual location of the storm surge wall in relation to current land/water parcels. Purchase of property and/or temporary construction and permanent easements would need to be acquired from those property owners along the alignment of the wall, altering the use in some locations. The wall alignment would be further refined during the design phase based on engineering and other specifications, so specific properties that could be affected would be identified at that time. Land use at some properties (private and public) that intersect the wall and its permanent easements would permanently be changed, and for those properties, this could be an adverse effect to land use.

Construction and maintenance may temporarily limit land uses in the immediate vicinity of the storm surge wall, such as closed roads, but this would be a temporary effect. Construction is planned to be phased, which would reduce the effect of those temporary disruptions in land uses. All work would be conducted in compliance with environmental laws and regulations applicable to land use in coastal areas, including the Coastal Zone Management Act and the City of Charleston’s land use regulations.

The proposed non-structural measures and living shoreline feature would have no effect on the underlying land use.

Areas that are not aligned with the structural measures or planned for non-structural measures, would not receive the long-term, positive effects from reduced storm damages. The current land uses in those areas may be adversely affected in the future by storm surge flooding with sea level rise, as in the No Action Alternative, but it is assumed they adhere to local zoning requirements and would benefit from other flood and resilience efforts by the City of Charleston.

Figure 6-1. Map showing real estate potentially impacted by the current conceptual footprint of the storm surge wall and construction buffer.

Official mapping product of the Management Support Branch, Charleston District, USACE

6.2 Geology and Soils

6.2.1 No Action/Future Without Project Alternative

Current trends in estuarine shoreline change as reported by Jackson (2017) and described in Section 4.2 are expected to continue with low erosion occurring in some locations, and with high erosion in other locations around the Charleston Peninsula, unless management measures are put into place to reduce the effects of erosion. Climatic changes such as rising sea levels and increasing coastal storms would contribute to increased erosion of shorelines into the future as a result of wave attack, storm surge, and higher water levels.

It is expected that the City of Charleston would use its most current comprehensive plan and Sea Level Strategy (City of Charleston, 2019a) to guide development decisions that support adaptation to tidal flooding. However, human use patterns including increased population growth on the coast increases the risk of altered shorelines and drainage patterns that come from development that affect erosion and disturb subsurface conditions. The risk of earthquakes in the Charleston area would continue to dictate how major infrastructure is designed and constructed into the future. Wave energy from boats will continue to impact shorelines.

Under the No Action Alternative, the subsurface conditions of the ROI would largely go unchanged, but surficial soils and shoreline sediments of the peninsula would continue to be at risk from human activities and long term sea level rise. Shoreline erosion may dramatically accelerate due to wave attack and surge from future storm events.

6.2.2 Alternative 2 (perimeter structure + nonstructural)

Construction-Related Effects

Construction of the storm surge wall and associated gates and hydraulic pumps for Alternative 2 would result in the temporary, short-term effect of soil and sediment disturbance around the area of construction, which could also run off from the site into nearby waterways. If sediments are disturbed during construction, either on land or in water, they can create environmental problems through turbidity, or through the release of harmful contaminants if present. Similar soil and sediment disturbance could also result from upland construction activities related to raising or floodproofing homes, and during the process of installing living shorelines sills along fringing salt marshes.

To minimize this, best management practices (BMPs) would be implemented during construction to control soil erosion and sedimentation, such as erosion blankets/covers, silt fences, and other sediment traps (see the Draft Mitigation Plan in Appendix F - Environmental for more on construction BMPs). Construction areas would be returned to pre-construction surface conditions upon completion.

There is only one registered hazardous waste site by the EPA that is in close proximity to the planned location of the storm surge wall (Calhoun Park/Concord Street; see Hazardous Waste section). It has been fully remediated; however, a Phase I and II soil/sediment chemical analysis could be performed during the PED phase if needed. If contamination were to be discovered, the area of contamination would be avoided by attempting to relocate the wall.

Adverse effects from construction-related soil and sediment disturbance are expected to be temporary and minor. Construction for the nonstructural measures would not occur in the same locations as the structural measures, and therefore not result in cumulative or additive effects on soils and sediments. Construction of the oyster reef-based living shorelines sills would occur during low-tide (in order for proper placement in the intertidal zone) and would not involve use of heavy equipment. Sediment disturbance would be minor.

Subsurface Effects

Implementation of the storm surge wall would involve approximately five feet of embedment into the subsurface of the Charleston Peninsula. Permanent piles would be driven to bear within the Cooper Formation due to the requirements for seismic activity in the area. This is a common practice, as many structures on the peninsula are currently founded on piles driven to the Cooper Formation. Geotechnical surveys would be conducted in the Preconstruction Engineering and Design (PED) phase to verify stratigraphy and determine if there is subsurface debris that would pose construction challenges and require location modifications. Construction of the pump stations and of elevating homes as part of proposed nonstructural measures may also involve embedment into the subsurface. These potential effects on the subsurface geology would be permanent but considered to be minor based on other common residential or commercial construction projects in the area. The reef-based living shoreline sills would be placed on the surface of the sloped bank of the intertidal zone, and while they may settle slightly depending on the consistency of the sediments, they would not affect the subsurface geology based on other living shoreline sill projects.

Erosion and Scouring Effects

Nonstructural measures in this alternative would have no effect on erosion. Since portions of the storm surge wall would be constructed in the marsh and come into contact with tides, waves, and storm surge, the adverse effect of sediment scouring is likely to occur. Traditional seawalls reflect wave energy seaward. The reflection can create turbulence, capable of suspending sediments, leading to increased erosion, or scour, at the foot of the wall (Bush et al 2001; Walton and Sensabaugh 1979). The scouring would impact the tidal mudflat habitat and reduce water clarity. The impact on the outer edge of the marsh may be even greater (Burdick, 2018). It is expected that the proposed storm surge wall in the marsh would induce scouring similar to seawalls that have been studied. Scouring effects on the inside/landward side of the wall from wave overtopping of the wall are expected to be minimal, based on the overtopping assessment performed as part of the Life Safety Risk Assessment (see Appendix B - Engineering).

To minimize this effect, oyster-reef based living shoreline sills would be placed in the intertidal zone along the edge of the marsh in front of portions of the wall to minimize the scouring effect seaward of the wall. The vertical relief of the oyster reef sills would reduce wave energy between the sill and the wall, leading to reduced marsh scour, while trapping sediments to stabilize and enhance marshes. By reducing wave attack, the living shoreline sills would also have the beneficial effect of reducing erosion at the shoreline edge from coastal storms.

6.3 Coastal Hydrodynamics, Hydrology, and Hydraulics

6.3.1 No Action/Future Without Project Alternative

Under the No Action Alternative, coastal and H&H conditions in the ROI would likely change as a result of climatological changes such as rising sea levels and increasing coastal storms into the future. As described in Chapter 4, the local water level has already risen 1.07 ft over the past 100 years, as measured at the Charleston Harbor Tidal Gage. It is predicted that Charleston would experience an increase in sea level of 0.56 feet based on USACE's intermediate rate of sea level rise in the year 2032, and in the year 2082 (50 years out) a change of 1.65 feet using the same rate (see Appendix B - Engineering). Impacts from increases in water levels have already been documented through observed increases in minor coastal flooding, also called nuisance, sunny day, or high tide flooding on the Charleston Peninsula. This kind of flooding has an adverse effect on the local economy, transportation, safety, and recreation through road closures, outdoor event cancellations, etc. and on natural shorelines and habitats. This is expected to worsen into the future. As sea levels rise, wave attack may be exacerbated in some areas. Structures that are able to withstand current water level conditions may no longer be able to withstand future wave conditions and may need to be replaced or more frequently repaired. As sea levels rise and coastal storms increase, storm surge impacts may be more significant and extend farther inland and deeper. These effects are likely to become more frequent and significant into the future with current climate change trends.

Currently, groundwater from the surficial aquifer in Charleston is acceptable for general use, but its inconsistent yield, along with saltwater intrusion, has limited the municipal use of this aquifer (Park, 1985). As sea levels continue to rise into the future, saltwater will continue to infiltrate the shallow subsurface groundwater aquifer of the peninsula.

Effects from some sources of flooding would be expected to be reduced under the No Action Alternative through non-Federal actions. It is expected that the City of Charleston would use its Sea Level Rise Strategy (City of Charleston, 2019a) and Stormwater Management Plan (City of Charleston, 2014) to guide decisions into the future that affect hydrology on the peninsula. Under the No Action Alternative, the City of Charleston has raised the current Low Battery seawall to a 9ft elevation NAVD88, which provides some reduction in storm surge impacts in the Battery area, but would not address storm surge that flanks the ends of the seawall. It is assumed that current pumping stations on the Peninsula would continue to operate and that the City's future phases of the Market Street Drainage Improvement Project, US 17 Spring/Fishburne Drainage Improvement Project, and various other interior drainage projects would be completed to improve stormwater management and interior flooding from rainfall in the future (see Section 1.4, Existing Programs, Studies and Projects for more information). The City of Charleston would continue to install check valves on their existing stormwater outfalls over time. These local actions would contribute to reduced rainfall and compound flooding, having a beneficial effect.

If the No Action Alternative is selected, storm surge would still be a significant threat to life safety, emergency access, structural damages and economic loss caused by the flooding, and to shoreline erosion across the study area. Without any comprehensive solution to address coastal storm surge risk, storm surge would also continue to contribute to compound flooding largely unabated, even with the City's improvements to stormwater management.

6.3.2 Alternative 2 (perimeter structure + nonstructural)

<u>Effects on Water Levels Inside the Study Area</u>
With respect to rainfall flooding and management of stormwater runoff on the Charleston Peninsula, this alternative assumes that the City of Charleston would implement the same initiatives identified in the No Action Alternative since they are not dependent on the proposed Federal action. The City's initiatives would contribute to reduced water levels and lessen impacts from rainfall flooding to communities and structures within the interior of the study area.

With respect to storm surge, coastal and H&H modeling conducted for this study (see Appendix B - Engineering) demonstrates that the proposed storm surge wall would be effective at reducing water levels inside of the study area from a storm surge event up to an elevation 12 ft. NAVD88, when compared to water levels without the wall in place. The reduction in water levels within the wall was shown to be significant and depends upon the topography of the peninsula. The wall, in addition to the nonstructural measures in this alternative, would have a significant beneficial effect on reducing flooding damages to structures in the study area with first floor elevation of12 ft. NAVD88. This is considered significant due to the estimated reduction in economic damages associated with such flooding (See Appendix C - Economics). The wall would also have the additional positive effect of reducing flooding to other infrastructure on the peninsula such as roads and parking lots in many locations and emergency access. The Life Safety Risk Assessment conducted for this study of incremental life loss suggests that Alternative 2 would effectively reduce life safety risk associated with storm surge inundation compared to the No Action Alternative (see Section 7.2.1)., which would also be a critical beneficial effect of Alternative 2.

The storm surge wall as proposed in Alternative 2 does have the potential to adversely affect rainfall flooding within the study area, including in conjunction with a storm surge event. Currently, most of the rainfall on the Peninsula is collected by the subsurface pipe network system, which outfalls directly into the Cooper River, Ashley River and Charleston Harbor, or into some of the tidal creeks and perimeter salt marshes before entering the larger waterbodies. Rainfall that is not collected by the subsurface system flows over land and streets and runs off naturally into the tidal creeks and surrounding rivers. The storm surge wall would prohibit this overland flow, potentially causing water to “pond” in the interior of the wall if it is not drained or otherwise diverted. To verify this, USACE modeled changes in water levels in the interior of the peninsula for various rainfall frequencies without the wall, and with the wall in place (see updated Sub-Appendix B3 – Hydraulics, Hydrology, and Coastal). The wall was modeled as a closed-system. Changes in interior water levels when the wall was present with any gates closed were different enough in some locations to potentially induce additional flood damages to nearby structures than without the wall that warrant mitigation.

To mitigate for rainfall flooding induced by the wall on the interior of the wall so that Alternative 2 does not have an adverse effect on water levels within the study area, the use of hydraulic pumps has been proposed. The modeling of rainfall water levels with and without the wall was used to assess different pumping alternatives for addressing residual and induced flooding. The modeling helped to inform feasibility-level planning decisions about locations and sizes of the pumps. Not all locations with increased water levels warranted mitigation by hydraulic pumps; it was dependent on whether the water level change with the wall would potentially induce flooding impacts to structures at that location or not.

The results indicated that at ten different locations around the study area, hydraulic pumps would be needed to mitigate for interior flooding that could be induced by the wall when the storm gates would be closed during a storm event. It was determined that five of the locations would each need a pumping capacity of 60-90 cubic feet/second (cfs), which is considered to be a medium-sized pump station and should be permanent stations. Permanent pump stations would consist of a wet well installed in a low-lying area where water naturally flows, such as near marshes and tidal creeks. The wet well would consist of a concrete inlet box with mesh screens for debris and wildlife protection, hinged lid for pump removal for maintenance, etc. The outlet from the wet well would be routed to the wall and would either pass over the wall or through it with a check valve to prevent inflow from the river side. The wet well connects to a pump house. The pump house would be elevated and would hold the electrical infrastructure and other operating equipment, and a backup generator to minimize pump failure in the event of power disruption. At each permanent pump station, rather than having one large pump, three smaller pumps would be installed, if one fails then there is 2/3 pumping capacity. More information and diagrams of such a pump station can be found in Appendix B - Engineering.

The tentative locations and capacity of the five permanent pump stations are (also see Figure 6-2):

- By Halsey Creek (3 pumps @ 30 cfs each)
- Behind Joe Riley Stadium (marsh side) (3 pumps @ 30 cfs each)
- By Alberta Long Lake (3 pumps @ 20 cfs each)

- Next to the US Coast Guard Station (Tradd Street side) (3 pumps @ 20 cfs each)
- By New Market Creek (3 pumps @ 30 cfs each)

The other five pump locations would each need less pumping capacity and would be temporary stations. These are locations where there is not a low-lying natural feature such as a marsh wetland, and where existing roads, houses, and other infrastructure are not conducive to installation of permanent stations (see Figure 6-2). At these locations, an inlet pipe would be installed which would tap into the existing storm drainage system for the peninsula, and an outlet pipe that goes over or through the wall. For storm events, a portable pump would be brought to the location and hooked up to the inlet and outlet pipes to efficiently move the rainfall in that area over the wall to avoid the "ponding" effect that the new wall would otherwise induce. The temporary pumps would have built-in backup diesel generators to allow them to function even if grid power fails and would be trailer-mounted and portable to move and store off site when not being used.

Figure 6-2. Approximate locations of proposed permanent and temporary pump stations.

The proposed pumps are sized based on modeling of rainfall for storm events to ensure there is adequate capacity to handle the projected flow from rainfall and wave overwash. The pumps are designed to mitigate for all modeled interior rainfall flooding without having to rely on the operation of storm gates to assist in the drainage, even though the gates would be expected to open once water levels have gone down. However, the modeling and analysis was based on assumptions about numbers and locations of storm gates, and when these gates would be opened and closed. The assumptions about gates are currently being refined and the interior hydrology analysis would be adjusted in the Preconstruction Engineering and Design (PED) phase. The precise size of the pump stations needed could change, but not likely in order of magnitude. In other words, a specific station could change from needing 60 cfs to 90 cfs but would still be a medium sized pump station. The current modeling was also based on an extremely conservative assumption that all rainfall flowed overland, because the model that does not account for subsurface drainage, and because information on the City of Charleston's subsurface pipe network system is not sufficient for this level of modeling. As a result, the modeling may be overestimating actual interior water levels, and thus flooding potential. The City's subsurface network would be used in the PED phase to refine uncertainty in the current model and may suggest that less pumping capacity is needed.

The proposed nonstructural measures in this alternative would have no effect on interior water levels. The vertical relief and friction of the reef-based living shoreline sills would have a beneficial effect of reducing wave energy that contributes to wave run-up during coastal storm events.

<u>Effects on Water Levels Outside of the Study Area</u>

As described in Section 4.3, the ROI for assessing effects of the final array of alternatives on coastal and H&H conditions includes other communities that are on or across the Lower Cooper and Ashley Rivers and the Charleston Harbor. Therefore, USACE examined the potential for the storm surge wall that would be constructed on the Charleston Peninsula as part of this alternative to affect water levels outside of the study area in these surrounding communities. Modeling conducted for this evaluation is described in detail in Sub-Appendix B4 - Coastal and was based on storm surge simulations completed with the wall in place, and without the wall. The significance of the potential changes in water levels in the communities outside of the study area was based on whether the change in flood level would increase damages to structures, or increase risk to life safety, above the flooding impacts expected from storm surge in those communities without a wall on the Charleston Peninsula.

The study modeled "severe" (i.e., those with a storm surge equal to or in excess of the perimeter storm surge wall height) "synthetic" (i.e., generated by FEMA as opposed to historic events to facilitate modeling of a broad range of storm characteristics such as wind speed, storm path, size and overall intensity and based on their probable alignment to Charleston's climate and hurricane history) storm events.

The results (see Sub Appendix B4 - Coastal) showed negligible change in water surface elevation (less than one inch, which is within the accuracy limit of the model) across almost all of the ROI when the wall was present compared to without. Some simulations did show a small increase in surface water elevation up to two inches in a few surrounding locations during larger storms, where the results also indicated that the Peninsula storm surge wall would also be overtopped with a 12+ ft storm surge. A one-to-two-inch increase in water surface elevation during these large surge-producing events would have a negligible effect, if any, on the flooding impacts that would otherwise be experienced in those communities without the presence of the wall. These results are also discussed and displayed in Chapter 7.

With respect to natural shorelines outside of the study area that may be affected by waves with and without the storm surge wall, modeling of wave action (see Sub Appendix B4 - Coastal) supports that reflection and refraction of waves encountering the proposed wall on the Charleston Peninsula would have no effect on shorelines outside of the study area. Under normal conditions, wave heights vary around the Charleston Peninsula depending on location, such as sheltered vs. exposed areas. Aside from these variations, the results did not show a difference in wave height in the surrounding communities with the wall present, compared to without the wall. This is consistent with the understanding that local wind waves within the surrounding rivers and Charleston Harbor nearshore area would be limited in wave height and period during a storm surge event by the limited fetches. Waves would be dissipated by marshes and shallow foreshore areas before encountering the wall which would scatter the remaining waves (except closest to the wall), causing them to dissipate within a few wavelengths. Scattering is due to directional/frequency spread of the short-period waves, irregularities in the wall, adverse wind (wind from the coastal storm blowing against the reflected waves), and the underwater depth near the wall and in the nearshore and river channels.

The nonstructural measures in this alternative would have no effect on water levels outside of the study area. Any effects that living shorelines would have on reducing water levels or wave height during the process of breaking waves would be considered beneficial and would also be localized and not affect areas outside of the study area. Therefore, Alternative 2 would have no significant adverse effects on areas outside of the study area.

Effects on Creek Hydrodynamics

Where the storm surge wall would be constructed in the marsh and across Halsey Creek (a small tidal creek in the study area), there is the potential to adversely affect the local hydrodynamics of salt marsh-tidal creek systems. The effects of traditional flood walls in coastal environments, such as the proposed storm surge wall in this alternative, are not well studied. However, the effects on salt marsh-tidal creek systems may be similar to other hard structures like seawalls, which are well studied. Seawalls reflect wave energy seaward. The reflection can create turbulence, capable of suspending sediments, leading to increased erosion, or scour, at the foot of the wall (Bush et al 2001; Walton and Sensabaugh 1979). The scouring can impact the tidal mudflat habitat and reduce water clarity. The impact on the outer edge of the marsh may be even greater (Burdick 2018)

To minimize the effects of the wall at the marsh edge and near the base of the wall from the altered hydrodynamics, the living shorelines sills would be implemented, as discussed in Section 6.2.

The storm surge wall in this alternative also has the potential to adversely affect hydrodynamics in Halsey Creek behind, or landward, of the wall. It is expected that the wall would have similar effects of intersecting tidal creeks as roads and culverts do. Road networks, including culverts, are the primary mechanism for changing the volume and timing of peak flows in a watershed. Roads and ditches transport water through systems more quickly concentrating flow, and culverts and dikes constrict the flow. The result is increased stream power that erodes channel beds and banks. Incising or aggrading of the channel can occur around the culverts (Castro, 2003). While this effect would be adverse, it is a common effect seen from road projects and would be considered a minor effect on hydrodynamics.

To confirm this, hydrodynamic modeling conducted for similar coastal storm risk management measures in the Norfolk, VA area (Moffet & Nichol, 2017) was reviewed. That modeling effort showed that constraining the opening of a tidal creek with a storm surge wall and gate (under normal conditions with the gate open) increased the velocity near the mouth of the creek compared to without the wall and gate. This change in hydrodynamics was determined to be minor, and not significant. Hydrodynamic modeling of Halsey Creek has not been conducted but effects on hydrodynamics would be expected to be similar. Halsey Creek is a small order creek. Approximately 0.5 ft. in depth at low tide and approximately 6 ft. in depth at high tide based on field observation. Approximately 1,800 feet from where the storm surge wall would be constructed, the creek channel is already restricted by a 3 ft. diameter culvert that currently disrupts the volume and timing of flow in the creek. While the storm surge wall would have an additive effect, it is still expected to be a minor change in the hydrodynamics from the current conditions because the tidal opening (gates) in the proposed wall is 25 times greater, and thus less restrictive that the existing culvert.

Upon gate closure during a major storm event, water velocities in the tidal creeks behind the sluice gates would drop to zero. This effect would occur at Halsey Creek and the six creeks where gates would be placed at existing tidal restrictions (from roads) at Gadsden Creek, the channel behind Joe Riley Baseball Stadium, Alberta Long Lake, Cummings Creek, Vardells Creek, and New Market Creek. During the duration of gate closure, there would be a temporary effect on tidal exchange. Once gates reopened, velocities would quickly return to normal. The change in velocity during the time the gates are closed could be noticeable but would be temporary. Fluctuations that occur once the gates are re-opened would be temporary and minor. Indirect effects could occur from the change in hydrodynamics on water quality and aquatic resources; these are evaluated and discussed in Sections 6.4 and 6.8.

The proposed living shoreline sills for erosion minimization would have a beneficial effect of moderately altering coastal and overland flow in the marsh where the sills are located. The sills would reduce wave energy that comes with coastal storms, disrupting and slowing the hydrologic flow so that suspension of sediments at the shorelines behind the sills would be reduced. Likewise, the sills would potentially disrupt and slow receding tidal waters, as well as overland flow from rainfall, that would allow suspended sediments in the water to be deposited behind the sill. Over time the sediments could build up and enhance the marsh surface allowing for growth of marsh vegetation and greater utilization by fish and wildlife resources.

The nonstructural measures proposed in this alternative would have no effect on creek hydrodynamics. Overall, adverse effects on creek hydrodynamics would be temporary or minor, and not considered significant.

Groundwater Effects

None of the measures or features in Alternative 2 involve extraction or withdrawals of groundwater, which is not suitable for drinking water and would require a permit since the greater Charleston (tri-county) area is designated a Capacity Use Area, as described in Section 4.3.2. Even though continued growth in the area would place additional demands on potable water, Charleston draws its water supply from areas far outside of the ROI so there is no likelihood of cumulative impacts to groundwater. Since groundwater in the subsurface aquifer is already shallow within the Charleston Peninsula and fluctuates with the tides, seasons, and precipitation, the interaction of the proposed storm surge wall with groundwater would be highly dependent on the tides. It is anticipated that the groundwater table would be encountered at or near the elevation of the tide elevation. Dewatering may be required during construction of the T-wall foundations of the storm surge wall but this would be a temporary effect, and the use of concrete materials may be needed to reduce corrosion. Any potential effects of Alternative 2 from the nonstructural measures or NNBF on groundwater would be negligible.

6.4 Water Quality

6.4.1 No Action/Future Without Project Alternative

The water quality status and classifications of existing water bodies as described in Section 4.4, are not expected to change considerably under the No Action Alternative. Development pressures may continue to threaten and degrade water quality, but it is assumed that the City of Charleston would use its most current comprehensive plan and Stormwater Management Plan (City of Charleston, 2014) to guide decisions that could affect local water quality into the future.

Climate change does have the potential to influence future water quality conditions in the ROI that are important for fish and wildlife. Salinity profiles in estuaries are expected to change as a result of both sea level rise and changes in precipitation patterns. Saltwater would move further up the rivers and tidal creeks as sea level rises. Sea level rise accompanied by drought would also push salinity regimes up estuaries and landward compressing available habitat. Changes in the location of the saltwater/freshwater interface would affect many freshwater and diadromous fish species, and lead to long-term changes in composition of aquatic communities (SCDNR, 2021).

Hypoxia occurs when there are too many nutrients in the water which reduce the availability of oxygen in the water (dissolved oxygen) for fish and aquatic invertebrates, like shrimp and crabs. Increased temperatures that are expected to come with climate change and saltwater intrusion from sea level rise which would also contribute to lowering oxygen levels in the water (SCDNR, 2021). This could lead to a long-term change in water quality conditions over time. Increased occurrences of coastal hypoxia could also result from climate-induced changes in ocean and wind circulation patterns (SCDNR, 2021).

With increased coastal storm events and changes in precipitation patterns, hypoxic conditions could result more often. During storm events, there is often increased stormwater runoff so more nutrients from sources like fertilizers may be present. Organic matter from debris caused by strong winds (leaves and branches) during storms could end up in tidal creeks and rivers in the ROI. These nutrients could create hypoxic conditions during a storm that results not only in impairment, but mortality of aquatic resources. Altered water quality conditions from coastal storms such decreased salinity, increased dissolved oxygen and increased suspended solids in estuaries can last from one to several weeks following a storm

6.4.2 Alternative 2 (perimeter structure + nonstructural)

Under Alternative 2, water quality impacts from climate change are still expected to occur. Coastal storms would continue to produce degraded water quality conditions following storms, possibly creating hypoxic conditions more often. Potential adverse effects of Alternative 2 on local water quality could range from temporary to permanent but would be localized. Permanent effects would be mitigated. With best management practices (BMPs) to protect water quality and implementation of minimization measures, most effects would be temporary and minor when compared with the No Action Alternative.

<u>Construction Related Effects</u>
Construction of the storm surge wall and related features, and of nonstructural measures like home-raising do have the potential disturb soils and sediments or create debris that could run off into local waterways and have an adverse effect. Turbidity and an increase in total suspended solids could occur in shallow open water, which could contribute to other effects like changes in pH and dissolved oxygen.

To minimize the potential effects of construction on water quality typical BMPs that are used in construction projects to reduce and contain the movement of soils and sediments would be applied. These may include silt curtains, settling basins, cofferdams, and other operational modifications. Construction would be monitored to ensure that erosion and stormwater BMPs are adequate in preventing sediment and debris migration into nearby waters. The BMPs would be detailed in an erosion and sediment/soil control plan for construction. Therefore, construction-related effects on water quality would be temporary and localized, and not significant.

For the NNBF, based on past construction of oyster reef based living shoreline sills in South Carolina estuaries performed by others, construction is considered low-impact and has not required use of best management practices for water quality. While some sediment disturbance is expected during construction (see Section 6.2.2), turbidity and total suspended solid concentrations would be low since construction would occur during low tide (for proper placement in the intertidal zone which can't be determined if it is underwater).

<u>Tidal Restriction Effects</u>

There is the potential for localized water quality to be permanently affected within salt marsh wetlands behind where the storm surge wall would be placed under Alternative 2. The wall would serve as a barrier to incoming tidal waters, and to overland flow of rainfall from draining on the interior. Without the influx of tidal waters, and receiving of only freshwater, the water quality regime would dramatically shift including salinity, dissolved oxygen, nutrients, temperature and pH. The change in water quality would lead to an indirect change in biological composition behind the wall (this is discussed in Sections 6.6 -6.9). The locations where this effect would occur from the storm surge wall include small portions of fringing marsh along the Ashley River by Wagener Terrace, in the Citadel marsh behind Joe Riley Stadium, and by the US Coast Guard Station on Tradd Street (see Section 6.6). The tidal alteration created by the storm surge wall is not expected to have effects on water quality seaward of structure.

There is also the potential for localized water quality to be adversely affected within salt marsh wetland behind the planned storm surge wall at Halsey Creek, the only tidal creek on the peninsula that the proposed wall would directly intersect. Because of the relative importance of this salt marsh tidal creek system, which serves as essential fish habitat, storm gates would be installed in the wall to allow for daily tidal flow and minimize adverse effects on water quality with only a partial tidal restriction rather than a complete loss of tidal exchange. As discussed in the Ritter et al. (2008) study of water control structures in estuarine habitats in California, a partial, or muted, tidal flow structure showed that temperature, salinity and dissolved oxygen levels varied relative to sites with full tidal exchange. Dissolved oxygen changes were of particular concern, with cycling between supersaturated oxygen and hypoxic conditions (Ritter et al., 2008). While the tidal regime is different in California than South Carolina, the muted tidal exchange, as described in the Ritter et al. study, would be similarly classified as muted tidal exchange for the proposed storm surge wall and sluice gates in this study and could show similar trends. Dissolved oxygen levels are already impaired in the Ashley River (Sanger et al, 2020), which could be assumed to extend into small tributaries of the Ashley River like Halsey Creek. The proposed storm surge wall and gates (muted tidal flow) could compound impairment of dissolved oxygen behind the wall. With the potential changes in water quality behind the wall at

Halsey Creek, adverse effects on aquatic resources and salt marsh functions would indirectly occur as described in Section 6.8.2. The estuarine water column in considered Essential Fish Habitat (EFH) for commercial and recreational fisheries, such as white shrimp. To offset the impacts on EFH at Halsey Creek, including on the estuarine water column, 90% of the loss of essential fish habitat function provided by existing salt marsh wetlands would be mitigated for as part of the overall wetland acreage calculated for compensatory wetland mitigation at Halsey Creek. The mitigation requirement and habitat functional analysis is described in Section 6.6 and in the Draft Mitigation Plan in Appendix F - Environmental.

The storm gates that are a feature of the perimeter structure in Alternative 2, are themselves also water control structures. In addition to the storm gates that would be included in the wall where it intersects with Halsey Creek (described above), storm gates would also be installed at five existing culverts around the Peninsula where tidal waters connect from the perimeter of the Peninsula to the interior, and at one small road bridge. The locations of these storm gates are shown in Figure 6-3 and includes:

- culvert at the channel behind Joe Riley Stadium from the Citadel marsh
- culvert at Gadsden Creek under Lockwood Blvd
- culvert at Alberta Long Lake under Lockwood Blvd
- culvert at Cummings Creek under Lockwood Blvd
- bridge on Johnson Street at Vardell's Creek
- culvert at New Market Creek under Morrison Drive

While the storm gates would be open at all times to avoid effects on daily tidal flow and existing water quality at those road locations (impacts at Halsey Creek already described above), all of the storm gates would need to be closed during storm surge events to provide the coastal storm risk reduction proposed by this alternative. This could have a temporary adverse effect on water quality behind the gates by further concentrating the degraded stormwater runoff that would collect behind the closed gate. Modeling conducted for similar coastal storm risk management measures (storm surge wall with gates) in the Norfolk, VA area (Moffet & Nichol, 2017) looked at the potential effect on salinity levels when gates are closed for up to five days during a storm surge event. As might be expected, results showed that a decrease in salinity would occur due to the closure, as freshwater input from the storm event is unable to flow out, while additional high-salinity water is unable to flow in. Substantial decreases in salinity were predicted for polyhaline (higher salinity) areas, but in the next reach of the waterway, the salinity dropped but stayed in the mesohaline (5 to 18 ppt) range, which is the range for tidal creeks of Charleston Peninsula. The salinity changes that resulted during temporary closure of the storm gates were not considered great enough to induce mortality of benthic (bottom dwelling) organisms. Salinity levels would fluctuate for several days once the gates reopened after the storm but would return to pre-closure conditions. This temporary change in salinity was considered to be minor and not significant in that study. The Moffet & Nichol (2017) study for Norfolk, VA did not model for changes in dissolved oxygen.

While similar minor temporary effects on salinity may be assumed for gate closures in this study, the potential for adverse effects on dissolved oxygen levels during a temporary closure of the gates could be reasonably expected at Halsey Creek and at the locations of the five culverted creeks/channels. The extent of indirect effects on aquatic resources from the altered dissolved oxygen levels may vary depending on the existing conditions and quality of the affected creeks/channels (see Section 6.7). For example, some of these culverts lead to areas that are already adapted to lower salinity and other water quality conditions due to human modifications (e.g., upper reaches of New Market Creek and Alberta Long Lake). The potential for impacts would also be influenced by the quality of the existing/future condition stormwater runoff that would be the same with and without Alternative 2, by the infrequency of gate closure, and duration of gate closure dictated by any given storm. Once the gates are re-opened, it is expected that the water quality behind the wall would equilibrate with the water quality outside of the gates, which could be even more degraded due to the coastal storm impacts on water quality described in the No Action Alternative that would exist even with the implementation of Alternative 2. With the use of minimization measures, the effect on water quality from the storm gates, when compared to the No Action Alternative, would be considered minor.

Figure 6-3. Locations of planned storm surge gates.

To minimize the effects on water quality from closing of the storm surge gates during a surge event, the time that the gates would be closed would be reduced to the greatest degree that is feasible and practicable to safely operate them before and after a storm surge event. Currently, storm surge forecasts for a tropical storm event are not issued by the National Hurricane Center until 48 hours prior to the onset of impacts, so storm gates would not be closed any earlier than that. Once a decision is made to close the gates, storm gates would be closed on the last low-tide before the onset of storm impacts, as long as it is safe for personnel to do so. Real-time local water level and other meteorological information from the National Weather Service's Charleston Weather Forecast Office or other experts would also be used to inform decisions about gate timing.

Gate closure/opening protocols will be prescribed in the Operations & Maintenance (O&M) Manual that will be developed by USACE for the City of Charleston to implement. The O&M Manual would be a binding condition of the Project Partnership Agreement between USACE and the City of Charleston. While the precise provisions of the O&M Manual would be developed in the PED phase, storm gates and pump stations must be operated consistent with the project purpose. Operation of storm gates would be in response to an authoritative forecast of storm surge inundation on the Charleston Peninsula. Tidal and precipitation flooding unrelated to coastal storm events would not be a basis for operation of the storm gates. Further modeling and analysis of storm gate and pump operations would be conducted as part of the PED phase.

<u>Stormwater Quality Effects</u>
Regular movement of stormwater through the existing subsurface drainage system would be unaffected by the measures in Alternative 2 since stormwater pipes/outfalls would be incorporated through the wall at the same locations where the existing outfall was already discharging. Check valves would be added/replaced to the outfall if needed (not already added by the City of Charleston). The living shoreline NNBF would not have any adverse effects on stormwater but could provide a minor improvement in local water quality since they would be oyster reef-based and oysters naturally remove particles form the water column.

For the other features, the hydraulic pumps would operate temporarily during a storm surge event as described in Section 6.3. Their primary purpose would be to minimize rainfall and stormwater flooding impacts to structures on the interior of the wall. The five proposed temporary pump stations would collect street-level stormwater to avoid ponding induced by the wall that exceeds the capacity of the current drainage system during a storm surge event and discharge it to the other side of the wall as it would have during overland flow. The five permanent pump stations are intended to collect rainfall and stormwater runoff that is not collected by the subsurface drainage system as it naturally flows to low-lying areas. The runoff would be pumped over/through the wall before water levels elevate to a level of inducing flooding to nearby structures. The pumps would not redirect the runoff; they would move it where it would have drained without the wall.

When operating, the pumps serve as a point source of stormwater discharge. The proposed pumps would be similar to the small and medium sized pumps that the City of Charleston already operates on a regular basis on the Peninsula but would only be operated occasionally (during a coastal storm event) and temporarily. The proposed pumps would be expected to be compliant with state water quality standards. For the permanent pump stations, a small, manufactured treatment device or sediment settling basin would be installed. Therefore, the hydraulic pumps that would be used if Alternative 2 is selected could have an effect on the quality of stormwater runoff, but it would be temporary, minor, and not significant.

6.5 Floodplains

6.5.1 No Action/Future Without Project Alternative

As described in Chapter 4, Section 4.5, everyone in the study area is in a flood zone. The majority of homes, critical infrastructure, and businesses on the Peninsula are in the 100-year floodplain, or FEMA 1% annual chance exceedance flood zone, while most of the remainder are in the 500-year floodplain, or 2% annual chance exceedance flood zone. While more people may move into the floodplain on the Peninsula as trends in population growth on the coast continue, under the No Action Alternative new development on the Peninsula would be built to 2 feet above base flood elevation so the number of structures at risk of flood damages would not be expected to increase. It is assumed the City's stormwater management and interior drainage projects, as described in Section 4.5, would be completed, resulting in a significant beneficial effect on reducing rainfall flooding on the Peninsula.

The No Action Alternative also assumes that current floodplain management initiatives, such as the Bluebelt program and FEMA Hazard Mitigation Grant Program and Flood Mitigation Assistance programs would continue into the future and would guide flood mitigation planning decisions that would reduce flood risks to some people and property. However, this would not be widespread across the study area. The Low Battery seawall is currently being raised, which will provide some additional reduction in storm surge damages in the Battery area in the future. Many homes and businesses across the rest of the Peninsula (not in the Battery) would still remain at risk to storm surge impacts that are not addressed by City initiatives. Under the No Action Alternative, it is expected that these residents and structures in the floodplain would be at even greater risk of storm surge impacts in the future as current trends in sea level rise and increased coastal storms continue. For example, assuming a high rate of sea level rise, in the year 2082, 50% of police stations, 42% of health care facilities, and 29% of fire stations on the peninsula would be flooded to elevation 9 feet NAVD88 during a 20% annual exceedance probability (5-year recurrence interval) storm event. Additionally, U.S. Route 17, which is a major artery through the peninsula, would increase from 10+ times per year of flooding to 180 times per year of flooding by 2045 (National Climate Assessment 4). Future projected yearly damages from coastal storms (with forecasted sea level rise) without a Federal project are expected to reach as much as $842 million in the study area (see the Appendix C - Economics).

6.5.2 Alternative 2 (perimeter structure + nonstructural)

Precipitation in the Floodplain

It is assumed that the City of Charleston's projects and initiatives described under the No Action Alternative would be implemented under Alternative 2 having a beneficial effect on precipitation impacts in the floodplain flooding. As discussed in the Coastal Hydrodynamics, Hydrology, and Hydraulics Section 6.3, the storm surge wall does have the potential to contribute an adverse effect of increased rainfall flooding inside of the wall, but that would be mitigated by the inclusion of the hydraulic pumps feature, and not considered significant. While designed to reduce risks from storm surge inundation, the nonstructural measures would provide some reduced risk for those structures from rainfall flooding in the floodplain as well. The NNBF would not affect precipitation impacts in the floodplain.

Coastal Flooding Effects and Implications for Floodplain Management

With implementation of the structural and nonstructural measures, and the related features including gates, pumps, and living shorelines, no direct change to the FEMA-defined floodplains is expected, but they would reduce flooding impacts from coastal storms for many more people and structures in the floodplain of the ROI compared to the No Action Alternative. This would have a significant beneficial effect on floodplain management that would be permanent through the life of the project. Nonstructural measures would help reduce flood insurance premiums and keep neighborhoods and communities sustainable and resilient after a flood, which is a beneficial effect for those living and working in the floodplain and to the City of Charleston. Nonstructural measures also have the ability to be sustainable over the long term with minimal costs for operation, maintenance, repair, rehabilitation, and replacement. There is no practicable alternative to locating Alternative 2 within the floodplain.

If Alternative 2 is implemented, then the City of Charleston would produce and execute a Floodplain Management Plan, as required by Section 402 of the Water Resources Development Act of 1986, as amended (33 USC §701b-12) and in alignment with Executive Order 11988, Floodplain Management Plan.

This would have a long-term beneficial effect on floodplain management in the ROI. The Plan would be designed to reduce the impacts of future flooding in the project area for the post-project floodplain conditions. The Plan would focus on the potential measures from this study and practices and policies that would reduce the impacts of future residual flooding, help preserve levels of risk reduction provided by the Federal project and preserve and enhance natural floodplain values.

The cost of Alternative 2 also reflects the size and complexity of the floodplain management system, including the length of storm surge wall, number of gates, need for elevating and floodproofing, construction considerations, number of hydraulic pumps, real estate needs including easements and rights-of-way, engineering and design, implementation of conservation measures, etc. However, the benefits of flood reduction on life safety, emergency access and structural damages are apparent. After a community experiences several flood events, the impacts prevented can easily justify the costs for such an action. If properly inspected, maintained, and operated, then the storm surge risk reduction system can last and function as designed and provide a beneficial effect into the future.

Therefore, Alternative 2 would have beneficial effects on floodplains.

6.6 Wetlands

6.6.1 No Action/Future Without Project Alternative

With the No Action Alternative, salt marsh wetlands could continue to be lost if remaining marshes on the Charleston Peninsula are filled to support new development. New development could also contribute to greater impairment of the existing salt marsh-tidal creek systems on the Peninsula. It is assumed that the City of Charleston would use their most current comprehensive plan to guide decisions that support protection of natural resources. One of the City's land use recommendations is to protect and improve natural resources, and maintain a lush, green environment in urban and suburban areas of the City. If the City takes these actions, this could have a beneficial effect on marshes in the future.

It is likely that rising sea levels and increased coastal storms would adversely affect salt marsh wetlands into the future if the No Action Alternative is selected. Sea level rise and storm surge would increase erosion of marsh shorelines. Sea level rise would also result in long term saltwater intrusion and inundation of marsh surfaces causing them to be permanently lost if they cannot retreat inland or otherwise keep up with increased water depths and salinity regimes. All of the peninsula's salt marshes have a limited inland migration potential due to roads and other development.

To visualize trends in wetland changes from sea level rise that could result if no action is taken, NOAA's Marsh Migration mapping tool in their Sea Level Rise Viewer (https://coast.noaa.gov/digitalcoast/tools/slr.html) was used. This tool is appropriate for understanding trends and planning considerations but is not intended to be used alone for decision making. The outputs show the potential for dramatic changes to the peninsula's existing salt marshes along the Ashley River (see Figures 6-4 and 6-5). Figure 6-4 shows the baseline wetlands (primarily vegetated salt marshes in dark purple) in the ROI as of 2000. Since for this feasibility study, the future condition for economic consideration has focused on using USACE's intermediate rate of sea level rise for the 50-year period of analysis ending in 2082 as 1.65 feet, Figure 6-5 shows the wetland distribution in 2080 with 1.5 ft of sea level rise from baseline, which is the closest calculation the tool displays to the future condition of interest. The tool shows that vegetated salt marshes along Lockwood Blvd would convert to unconsolidated shore (mudflats) or lost to open water. Vegetated salt marshes along the shorelines of the Ashley River near the Citadel and the Wagener Terrace neighborhood are also shown to convert to unconsolidated shore. Note that there is very little transitional change predicted for these marsh wetlands from salt to brackish marsh (medium pink color), but rather they are shown to be completely lost. However, it is assumed under the no action alternative that the City of Charleston would use their Sea Level Strategy (City of Charleston, 2019a) to guide decisions that support adaptation to shallow coastal flooding and sea level rise which may result in some beneficial effects on salt marshes on the Peninsula.

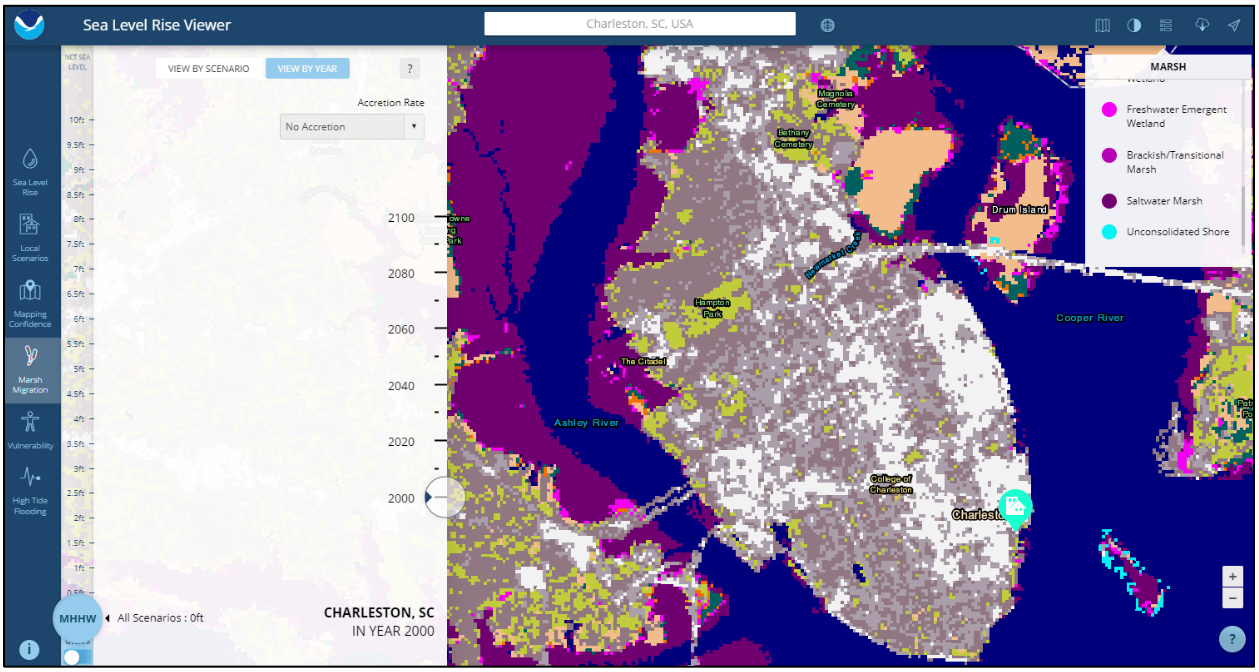

Figure 6-4. Distribution of coastal wetlands in the year 2000 in the Charleston Peninsula area.

Source: NOAA Sea Level Rise Viewer.

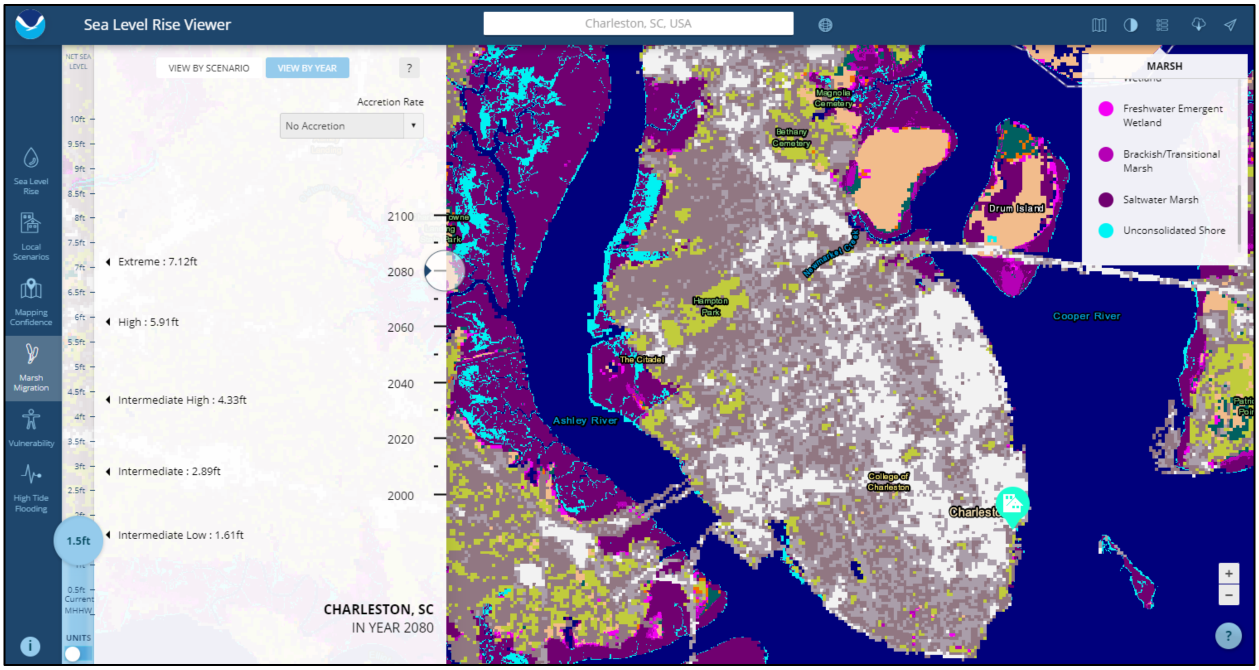

Figure 6-5. Predicted distribution of coastal wetlands in the Charleston Peninsula area based on a sea level rise of 1.5 ft in the year 2080.

Source: NOAA Sea Level Rise Viewer.

6.6.2 Alternative 2 (perimeter structure + nonstructural)

<u>Construction Related Effects</u>

Adverse effects on wetlands will occur during construction of the storm surge wall where it takes place in salt marsh wetlands. Construction of the wall in the marsh would need to occur mostly from the water-side. The use of heavy equipment could disturb sediments and destroy marsh vegetation if minimization measures are not used.

To minimize the potential for adverse effects on marshes during construction, several measures would be implemented. A temporary work trestle would be used so that heavy equipment does not operate directly on the marsh surface (see Appendix B - Engineering). The City of Charleston is currently using such a trestle for other construction projects. Dredging an access channel was considered but rejected because it would create additional adverse effects to existing salt marshes seaward of the where the wall would be constructed. Staging areas for construction would be identified on land. Once construction is completed, any areas of minor disturbance in the marsh (from the trestle for example) would be restored, included planting of native marsh grass as needed.

The construction techniques used for creating reef-based living shoreline sills are generally considered low-impact (no heavy equipment and use of small, shallow boats). Based on other projects, only minor disturbance to marshes is expected which have shown to quickly recover. Construction access to the living shoreline sills would be planned from the water-side where possible to minimize disturbance to marsh vegetation.

Construction of the pump stations and the nonstructural measures implemented to structures on the upland would have no direct effect on marsh wetlands.

Wetland Loss Effects

The proposed storm surge wall in Alternative 2 has the potential to induce adverse effects on wetlands in the ROI. Approximately 1.5 miles of the 8.7-mile-long storm surge wall would be constructed in salt marsh wetlands, resulting in complete loss of the wetland and wetland functions along the footprint of the wall. Areas of marsh in between the storm surge wall and upland would be restricted from tidal flow due to the wall and permanently affected. Without inundation of tidal waters, these areas would be expected to no longer function as salt marsh systems over time, resulting in a permanent, direct impacts to the salt marsh in those locations. Figure 6-6 shows the areas of fringing marsh that would potentially be affected by this alternative. They include:

- ~11 acres of salt marsh along the Ashley River near the Wagener Terrace neighborhood (to the north and south of Halsey Creek)
- ~1 acre of salt marsh along the inland shoreline of Diesel Creek
- ~11.5 acres in the Citadel marsh behind Joe Riley Stadium
- ~3.5 acres by the US Coast Guard Station on Tradd Street.

The storm surge wall would also have the potential to adversely affect about 13 acres of salt marsh wetlands in Halsey Creek. This is the only tidal creek on the peninsula that would be directly intersected by the proposed wall. Halsey Creek is currently altered by one partial tidal restriction and would likely be considered impaired if similar criteria were applied by Sanger et al. 2015. Despite this, it has relative importance as one of the few remaining salt marsh tidal creek systems in the study area, and serves as essential fish habitat. Storm surge gates would be installed in the wall to minimize adverse effects. The gates would allow for daily tidal flow and preserve some salt marsh functions, producing only a partial tidal restriction rather than a full restriction. It is estimated that five sluice gates of 15 ft wide would be installed in the wall where it intersects with Halsey Creek, in order to maintain minimum function as essential fish habitat. Since some salt marsh functions would still be lost or degraded due to the partial restriction but not all, only about 7.5 acres of salt marsh habitat function would need to be mitigated through wetland compensation (see more information below).

In total, implementation of the storm surge wall in Alternative 2 has the potential to adversely affect approximately 35 acres of salt marsh wetland function, out of the 555 acres of salt marsh wetlands currently existing on the Charleston Peninsula. As noted above, the nonstructural measures and the living shoreline sills and pump station features would not contribute to any direct wetland loss.

Steps have already been taken to avoid adverse effects of the storm surge wall on salt marsh wetlands by placing it on land to the extent that this is feasible. A previous conceptualization of the storm surge wall had about two more miles of the storm surge wall planned in the marsh, but after optimization of this alternative, a considerable portion of the storm surge wall was moved from the marsh to the land, avoiding adverse effects to the marsh in those areas. This optimization of wall location to avoid marsh impacts where practicable resulted in a considerable reduction of over 70 acres of wetlands potentially impacted from the previous conceptualization of the wall in the draft FR/EA of April 2020. To minimize effects where the wall is planned in the marsh, it would be located as close as feasible to the upland. This reduces the extent of salt marsh lost behind the wall. A distance of at least 35 feet from the shoreline is expected to be needed to feasibly implement the wall. Permanent impacts to salt marsh and marsh function in the footprint and buffer of the wall, and behind the wall, that cannot be avoided or minimized would be offset through compensatory wetland mitigation (see the Draft Mitigation Plan in Appendix F - Environmental for more information). Therefore, after avoidance and minimization, remaining adverse effects on wetlands from Alternative 2 would be mitigated to compensate for non-negligible impacts to the extent incrementally justified.

Wetland Gain Effects

Implementation of the living shoreline sills have the potential to beneficially affect wetlands through the co-benefits of this NNBF. They would create oyster reef habitat and saltmarsh habitat for fish and invertebrates (Peterson et al., 2003). If planting of marsh grass is involved with the living shoreline design (this would be determined in PED phase) then that would result in an immediate increase in salt marsh wetland acreage. The living shoreline sills also have the potential to reduce impacts to wetlands potentially associated with sea level rise and storm surge that may occur under the No Action Alternative. As the living shoreline sills reduce wave action, and sediments fill in behind the sill, the existing marsh is expected to expand in the living shoreline sill locations.

Figure 6-6. Map showing the approximate locations of marsh that could potentially be impacted by the conceptual footprint of the storm surge wall.

Official mapping product of the Management Support Branch, Charleston District, USACE

6.7 Special Status Species

6.7.1 No Action/Future Without Project Alternative

With the No Action Alternative, current trends in coastal development and climate change would likely continue into the future, and special status species in the ROI could be adversely affected. Over the past several decades, habitats that fish and wildlife rely on within South Carolina have already become increasingly fragmented. Habitat loss is the most important factor contributing to species decline (SCDNR, 2021), and this is even more important for species whose populations are threatened or endangered of extinction. In addition to habitat loss, other threats to special status species discussed in Section 4.7 would reasonably be expected to occur under the No Action Alternative, such as degraded water quality, dredging, vessel strikes, marine debris, and disease that may limit recovery of special status species.

Climate change has the greatest potential to change the nature and character of the estuarine and coastal ecosystems in South Carolina. Sea level rise may result in an increase in salinity in upstream areas that could affect spawning areas and survival of early life stages of fish, such as sturgeon. There could be shifts in spawning habitat availability and timing. The shifts in salinity, temperature, and sea level rise all have the potential to result in shifts in prey species availability for special status species.

6.7.2 Alternative 2 (perimeter structure + nonstructural)

As required by Section 7 of the Endangered Species Act (ESA) of 1973, as amended (16 USC §1531) an evaluation of the effects of the proposed measures and features in this alternative on listed species has been performed, and USFWS and NMFS have been consulted. ESA consultation documentation can be found in Appendix F - Environmental. With respect to NEPA, the potential for adverse effects from Alternative 2 on special status species are summarized below; they range from no effect to may affect but not likely to adversely affect, depending on the species, and are considered minor. Additionally, any minor effects on these species would be localized, and are not expected to have a compounding effect with other threats. Regardless, common minimization measures would be implemented, and are described below as they relate to each group of species.

Fish (shortnose sturgeon, Atlantic sturgeon, and Atlantic sturgeon critical habitat)
Potential effects from Alternative 2 on Atlantic and shortnose sturgeon would be minimal. The proposed storm surge wall with sluice gates only intersects one tidal creek on the Peninsula, Halsey Creek. While sturgeon are known to use small tidal creeks for foraging, the conditions and relatively shallow depths (few inches to few feet) here are not supportive of typical migrating, rearing, or spawning habitat used by sturgeon. Passage at Halsey Creek for any foraging sturgeon would be possible through any of several 15 ft-wide opening in the wall. There is a rare possibility that a foraging sturgeon could become “trapped” in Halsey Creek in the

instance when the storm gates in the wall are closed during a storm surge event. This possibility would be further minimized by closing the storm gates during low tide when most fish species would migrate from Halsey Creek into the deeper Ashley River.

It is also possible that sturgeon could be "trapped" during the same situation in the creeks or drainage channels where gates would be placed on existing culverts; however, sturgeon passage into these highly altered and restricted systems to forage would be considered highly unlikely.

Potential construction related effects from the storm surge wall and gate feature on sturgeon would include increased turbidity and reduced water quality from sediment disturbance during construction in the marsh or from soil disturbance on land during construction that runs off to nearby waterways. Noise from pile driving in the marsh could affect sturgeon when it travels through the water, but this is less likely because of the shallow depths (6 inches to a few feet) at most of the in-water construction locations. To minimize the potential for adverse construction related effects on sturgeon, BMPs as described in Section 6.4 would be used to reduce runoff and sedimentation that could affect water quality conditions. Noise effects would be minimized by driving piles only at low tide when constructing the wall in the nearshore environment by the US Coast Guard Station. The potential for vessel strikes with sturgeon during waterside construction of the wall would be avoided by the use of a workload trestle over the marsh that would be accessed from the landside. No vessel traffic related to construction of the wall or gates is expected. With mitigation measures, construction-related effects on sturgeon would be minor and not likely to adversely affect the species.

Water quality effects from temporary use of the hydraulic pumps in Alternative 2 would not adversely affect Atlantic or shortnose sturgeon. Discharges from pumping stations would be compliant with state water quality standards. Small, manufactured treatment devices or sediment settling basins would be installed at the permanent pump stations. Pumps would be primarily collecting rainfall and stormwater as it flows overland towards low-lying marsh areas, but not within the marsh platform or creek channel. Due to the pump intake locations and screens, entrapment by fish should not occur. Stormwater would not be redirected by the pump stations to different locations; the water would be moved through or over the wall where it would naturally drain without the wall. The quality of the stormwater is not expected to be significantly different than the quality of the stormwater without the project. Additionally, pumps would only be used during storm surge events. Any effects would be occasional and temporary, and discharged water is assumed to immediately mix with the turbulent waters of the storm surge event, so that hot spots or plumes would not result.

Since none of the nonstructural measures occur in the water, no direct effects on sturgeon would occur and any indirect effects from altered water quality as a result of runoff from upland construction would be minimal, although BMPs would be utilized.

The proposed living shoreline feature would not have any direct adverse effects on sturgeon, while contributing to improved estuarine shoreline conditions that may have an indirect beneficial effect on sturgeon. Construction access to the living shoreline sills would likely occur from the water-side, including the use of small, shallow boats to access the intertidal areas of the shoreline. A harmful boat strike to sturgeon is extremely unlikely given these considerations. Likewise, any indirect effects from sediment and water quality disturbance during construction would be minimal since construction would occur during low tide and BMPs would be implemented to minimize water quality effects. While the construction could limit sturgeon access to the marsh edge at the site of construction, this would be temporary, and it is expected that sturgeon would instinctively avoid the area of activity.

None of the physical and biological factors of Atlantic sturgeon critical habitat in the Cooper River would be adversely affected by Alternative 2. The storm surge wall would not be constructed in the Cooper River or any tributaries or fringing marsh of it. There would be one permanent pump station utilized in this alternative that would discharge into a tributary – New Market Creek – of the Cooper River. The pump station would be located by one of the two culverts on the creek, but not within the marsh or the creek. New Market Creek is a tidal creek that drains a small subwatershed (199 ha) with 70% impervious cover, and is considered impaired (Sanger et al, 2015). From the point of discharge from the pump, the stormwater discharge would travel about ¾ miles downstream, through another tidal restriction at a railroad embankment, to the confluence with the Cooper River. Considering the distance from critical habitat, the potential mixing of discharged water with storm surge, the possibility that sturgeon may be displaced during a hurricane event, and that the discharge would be treated to comply with state water quality standards, it is not expected that Atlantic sturgeon critical habitat would be significantly affected by the hydraulic pump during its limited operation.

<u>Marine Mammals (West Indian manatee, bottlenose dolphin)</u>
Alternative 2 is not likely to have an adverse effect on populations of the West Indian manatee or bottlenose dolphins from the Charleston Estuarine System stock. The proposed nonstructural measures and living shoreline feature would not likely adversely affect marine mammals for the same reasons described above for not adversely affecting special status fish species.

With respect to the storm surge wall, potential construction-related effects on marine mammals include underwater noise from pile driving and increased sedimentation and total suspended solids around the location of construction that could impair water quality, but these are not likely to adversely affect populations of marine mammals. For manatees, construction effects would be minimized through implementation of the Standard Manatee Conditions for In-Water Work published by the Florida Fish and Wildlife Commission, which would also serve to benefit bottlenose dolphins. Noise associated with pile driving is primarily a concern for marine mammals when the sound travels through water. The majority of pile driving for the wall would occur on the marsh platform surface where water depths range from a few inches to a few feet across the tidal cycle, which limits noise exposure for marine mammals. In areas where pile driving would occur along the nearshore of the Charleston Harbor, pile driving would be limited to low tide, when water depths would likely be a few feet. This would apply to construction of the combination wall by the current U.S. Coast Guard Station on Tradd Street. Nearshore elevation data would be used to help define a low-tide construction window prior to construction. Construction effects would also be minimized by use of a workload trestle over the marsh that would eliminate the need to use waterborne vessels to mobilize construction equipment on the waterside. There would be no risk of vessels strikes to marine mammals from construction of the storm surge wall and gate features.

Pumps that would be temporarily used as part of Alternative 2 are not expected to have adverse effects on manatee or dolphin populations. Direct interference with the pumps would not occur since the pumps would be located in low lying land areas behind the storm surge wall. Rain and storm water that are discharged from temporary pumping operations during occasional storm surge events would be treated to meet state water quality standards and immediately dispersed when discharged into storm surge and wave action on the seaward side of the wall (see the "Fish" section above for more information about operations of the pumps).

There is also the potential for the storm surge wall to have some permanent effects on manatees and dolphins, but these would be insignificant and discountable. The storm surge wall in the marsh would result in a permanent adverse effect on approximately 35 acres of salt marsh wetland habitat. While this would limit to some degree potential foraging habitat and food sources, it is noted that South Carolina is at the northern edge of the manatees' range and that most of the salt marsh wetlands in question regularly lack sufficient depth to provide for manatee or dolphin access. In addition, the loss of these salt marsh wetlands would be offset through compensatory mitigation. Finally, while there is also the potential for marine mammals to be injured, or killed, during closure of one of the five water control structures (sluice gates) currently planned in the storm surge wall at Halsey Creek, this is not anticipated to occur. At this location, water depths range from a few inches to a few feet, so the presence of manatees or dolphins at this depth is unlikely. Also, since the gates would be manually closed on the limited occasions of a storm surge event, the likelihood of injury would be further reduced by making visual observations for clearance of any marine mammals by the gate operators. This requirement would be included in the O&M Manual for the project. Closure, or entrapment behind, the sluice gates where they are located on culverts would not put marine mammals at risk because all of these culverts are too small for manatee or dolphin passage, with the exception of the existing box culvert at the Citadel Marsh, but this is a stormwater drainage channel.

<u>Sea Turtles (Kemp's ridley, leatherback, loggerhead, green)</u>

Alternative 2 is not expected to have an effect on leatherback and Kemp's ridley sea turtle populations because their presence in the ROI is rare. For loggerhead and green sea turtles, any effects would be considered minimal and not adversely affect their populations. While loggerhead sea turtles and green sea turtles are common in the Charleston Harbor, and to some degree in the deeper areas of the Cooper and Ashley Rivers, they are less likely to be found in small tidal creeks of the Peninsula where the tide ranges from several inches to several feet. While unlikely to be found in Halsey Creek or Vardells Creek, there is a rare possibility that a loggerhead or green sea turtle could become "trapped" in the creek in the instance when the storm gates are closed during a storm surge event. This possibility would be further minimized by closing the storm gates during low tide when any sea turtles would migrate from Halsey Creek into the deeper Ashley River or Vardells Creek into the deeper Cooper River. Sea turtle populations would not be affected by the storm gates on culverts for the same reasons described above for marine mammals.

Potential construction-related effects on water quality from the storm surge wall and nonstructural measures would be localized and would be reduced with the use of BMPs so that any effects on loggerhead and green sea turtles would be minimal. Potential noise effects from pile driving would be minimal where most of the storm surge wall is constructed in the marsh with shallow depths for sound to travel through and reach sea turtles. The potential for adverse noise effects during pile driving in the nearshore Charleston Harbor by the US Coast Guard station would be minimized by restricting construction to low tide, which is estimated to be a few feet and would be verified with high resolution bathymetry prior to construction.

Birds (American wood stork, eastern black rail, and other migratory birds)
Adverse effects on populations of the wood stork and eastern black rail from Alternative 2 are not likely to occur. The existing tidal wetlands on the Peninsula could serve as potential foraging habitat for the wood stork, but there are no known roosting areas or rookies. The presence of eastern black rails in the study area is questionable since the marsh habitat has varying tidal fluctuations, but the possibility remains. As described in Section 6.6, the planned storm surge wall in this alternative would permanently affect approximately 35 acres of salt marsh wetland habitat, limiting potential foraging habitat for wood storks and eastern black rails if they are present. However, the loss of these salt marsh wetlands would be offset through planned compensatory mitigation. Considering lack of known presence of the species in the study area and planned mitigation, no adverse effects would be expected to occur. For the proposed nonstructural measures and living shoreline feature, there would also not likely be adverse effects on special status bird species for the same considerations described above for special-status fish species.

No permanent effects on migratory birds are expected to occur. There are no least tern rooftop nesting sites at the locations of the any of the proposed measures. Temporary minor effects could result from construction activities, such as noise and nighttime lighting. To minimize light disruptions to migratory birds, shields would be used to direct lighting downward.

6.8 Aquatic Resources

6.8.1 No Action/Future Without Project Alternative

With the No Action Alternative, current trends in land use and climate change would likely continue into the future, and aquatic resources in the ROI could be adversely affected. Over the past several decades, habitats that aquatic resources rely on within South Carolina have already become increasingly fragmented. Habitat loss is the most important factor contributing to species decline (SCDNR, 2021). Climate change has the greatest potential to alter the nature and character of estuarine and coastal ecosystems in South Carolina. Sea level rise would lead to an increase in salinity in upstream areas that could affect spawning areas and survival of early life stages of fish and invertebrates. The shifts in salinity, temperature, and sea level rise all have the potential to impact availability of prey species, which could also cause detrimental effects to fish, as well as wildlife. Coastal storms would also continue to create temporary altered water quality conditions during and following storm events that indirectly affect aquatic resources, which could increase in frequency and duration with climate change.

Under this alternative, it is expected that the City of Charleston would use its most current comprehensive plan, Charleston Green Plan (City of Charleston, 2010), and Sea Level Strategy (City of Charleston, 2019a) to guide future development and conservation decisions that support adaptation to climate change and sustainable land use. These could have some positive effect in reducing impacts to aquatic resources.

6.8.2 Alternative 2 (perimeter structure + nonstructural)

Under Alternative 2, the City of Charleston's initiatives mentioned in the No Action Alternative above are assumed to occur. Climate change and coastal storms would continue to impact habitats and environmental conditions that indirectly adversely affect aquatic resources.

<u>Construction Related Effects</u>
Construction of the storm surge wall and gate features in salt marsh wetlands could have temporary adverse effects on aquatic resources. Construction equipment can cause disturbances such as turbidity that can degrade localized water quality conditions for aquatic resources and affect their foraging behavior. When construction equipment is in the marsh or water, it could cause entrainment and/or siltation of eggs, larvae, and demersal and/or slow-moving fish species. Upland construction of the wall, pump stations, and of nonstructural measures could also disturb soils that runoff into local waterways and affect water quality conditions for aquatic resources (see Section 6.4).

Noise produced during battering of the concrete piles for the storm surge wall in the tidal creek-salt marsh environment has the potential to affect aquatic resources. Sound propagation in shallow waters is complicated by multiple reflections, refractions, and by sound wave scattering, but studies that assess impacts of multi-pulse sound associated with pile installation using hydraulic impact hammers show mostly negative effects on marine mammals. The extent of the damage to these mammals depends on noise frequency, duration, and auditory characteristics of the species (Middel & Verones, 2017; Tsouvalas, 2020). The type and intensity of underwater sound associated with pile driving depends on the type and size of the pile, the firmness of the substrate and water depth, and the type and size of the pile-driving hammer and material. The pressure waves generated from wood or concrete driving are generally considered less harmful than driving steel piles. For reference, vibratory driving of a 30-inch battered steel pile during a ferry dock construction resulted in an underwater average Root Mean Square of 168 dB, and sound exposure level (SEL) of 210 dB (DOT, 2012). This occurred at a 37-foot depth. For Alternative 2, the locations where pile driving would take place in marshes at relatively shallow water depths that range from a few inches to a few feet across the tidal cycle, which would limit noise exposure to aquatic resources. Additionally, the pilings that would be used in this alternative would be constructed of concrete, not steel.

Construction activities related to installing reef-based living shorelines are generally considered low impact to the environment and would not be expected to have an adverse effect on aquatic resources. While some sediment and water quality disturbance may occur, this would have a minimal effect on aquatic resources since construction would occur at low tide, and construction permits have not required the use of typical BMPs in other projects.

To minimize the potential for adverse effects of the storm surge wall and gate construction on aquatic resources, construction BMPs as described in Section 6.4 would be implemented to reduce sedimentation and runoff that may affect water quality conditions. Direct effects between construction equipment and aquatic resources would be avoided through the use of an elevated work trestle over the marsh (see Appendix B - Engineering) and staging of equipment on land. Noise associated with pile driving is primarily a concern for aquatic resources when the sound travels through water. In areas where pile driving would occur along the nearshore of the Charleston Harbor and not on the shallow marsh surface, pile driving would be limited to low tide, when water depths would likely be a few feet. This would limit pile driving to two times within a 24-hour period. This condition would primarily apply to construction of the storm surge wall by the U.S. Coast Guard Station on Tradd Street, and likely not by Battery Beach where the water depth is only 2-3 ft (see Section 6.8 for more information about this location). Nearshore elevation (topobathy) data would be used to help define a low-tide construction window prior to construction. Therefore, through avoidance and minimization measures, potential adverse construction effects on aquatic resources would be minor and temporary.

<u>Hydraulic Pump Effects</u>

Temporary use of the hydraulic pumps in Alternative 2 are not expected to significantly affect aquatic resources. Based on current modeling results, pumps would only need to be used during storm surge events when gates are closed. During PED, additional engineering analysis will be conducted, and the pumps would be sized based on refined modeling of rainfall and more information about the current drainage system to ensure there is adequate capacity to handle the projected flow. Discharges from pumping stations would be compliant with state water quality standards. Small, manufactured treatment devices or sediment settling basins would be installed at permanent pump station locations to further address water quality. Pumps would receive rainfall and stormwater during storm surge events as it flows overland towards low-lying areas, but not within the marsh platform or creek channel. Due to the pump intake locations, entrapment by fish should not occur. Storm water would not be redirected by the pump stations to different locations; the water would be moved through or over the wall where it would naturally drain without the wall. The discharged storm water would not be expected to adversely affect aquatic resources on the outside of the wall since the quality of the stormwater collected by the pumps would be the same as the quality of the stormwater in the No Action Alternative. Discharged water from the permanent pump stations would be treated, so would actually improve the water quality conditions compared to the No Action Alternative. Discharged water from the small, temporary pumps is of the same quality of the No Action Alternative and is assumed to immediately mix with the turbulent waters of the storm surge event, so that hot spots or plumes that could affect aquatic resources during a storm event would not reasonably result.

<u>Habitat Effects</u>
All of the salt marsh-tidal creek systems (including the water column and tidal flats) in the study area are designated by NOAA as Essential Fish Habitat, meaning that commercially and recreationally important fish or crustaceans rely on these habitats in the study area for at least part of the life cycle. As stated above, habitat loss is the most important factor contributing to species decline (SCDNR, 2021). Therefore, there is the potential for the storm surge wall to have an adverse effect on aquatic resources by contributing to habitat loss, or habitat degradation.

Where the storm surge wall would be constructed in the marsh, habitat that is currently available for aquatic resources would be permanently lost in the footprint of the wall. Small areas of fringing salt marshes that are in between the wall and the upland where tidal flow would be completely restricted, would be altered and lost over time due to the lack of saltwater inundation. This would result in a direct and indirect permanent loss of available salt marsh habitat distributed in a few locations along the Ashley River (refer back to Figure 6-6).

The storm surge wall also has the potential to adversely affect aquatic resources through direct and indirect changes to salt marsh habitat in Halsey Creek, the only tidal creek on the peninsula that the proposed wall would directly intersect. Because of the relative importance of this salt marsh tidal creek system as Essential Fish Habitat and as one of the larger remaining tidal creeks on the Peninsula, storm surge gates (in the form of sluice gates) would be installed in the wall to allow for daily tidal flow and preserve some salt marsh habitat functions, producing only a partial tidal restriction rather than a full restriction. A study of water control structures in estuaries in California (Ritter et al., 2008), looked at how partial, or muted, tidal flow structures (similar to the proposed storm surge wall and gates in this alternative) affected community composition, community structure, and species richness. Most of the differences were minimal or not significant between the muted tidal exchange and the full tidal exchange sites, although species richness within each community was lowest with muted tidal exchange. Ritter, et.al. (2008) concluded that tidal restrictions accentuate the natural sea-to-land gradient of key physical factors, and that water control structures can affect environmental conditions leading to differences in habitat structure and water quality. Turner and Brody (1983) report that when in-water structures allow for 10% or less physical hydrologic connection between offshore habitat for shrimp and estuarine habitat for shrimp, then the estuarine habitat would not be suitable for supporting life requisites for juvenile shrimp. This is important because shrimp are the most valuable commercial fishery in the US (Turner and Brody, 1983) and also abundant in tidal creeks of South Carolina, as described in Section 4.8. So, while salt marsh habitat would not be fully lost in Halsey Creek due to the presence of the gates, it is assumed that some habitat functions would be permanently lost, or significantly degraded. In total, the areas of salt marsh wetlands that would be directly and indirectly affected by the storm surge wall is equivalent to 35 acres of salt marsh habitat function for white shrimp, a representative species for aquatic resources in the study area.

Alternative 2 has the potential to adversely affect aquatic resources infrequently and temporarily from water quality changes when the storm gates would close during a storm surge event. There is the possibility that larval, juvenile, or small species of fish and invertebrates could become “trapped” in the instance when the storm gates in the wall are closed during a storm surge event. As described in Section 6.4, salinity levels would lower as the influx of tidal water would cease. Dissolved oxygen levels are expected to vary considerably during gate closure, from supersaturated to hypoxic conditions (Ritter et al. 2008). Even though the effect on water quality would be temporary, if hypoxia resulted it could have an adverse effect on aquatic resources including mortality. The extent of effects of gate closures on aquatic resources would vary depending on the conditions and quality of habitat and aquatic resources compared to the No Action Alternative, duration of closure and other factors, but would be minor with minimization measures (see below).

To avoid adverse effects on aquatic resources, the storm surge wall would be constructed on land to the extent that this is feasible. A previous conceptualization of the storm surge wall had approximately 3 miles of the storm surge wall planned in the marsh, but after optimization of this alternative, half of that storm surge wall length was moved from the marsh along the Ashley River to upland along Lockwood Blvd, avoiding effects on the aquatic resources in those locations. To minimize effects where the wall is planned in the marsh, it would be placed as close as possible to the upland to reduce the extent of salt marsh habitat lost behind the wall. To minimize adverse effects to aquatic resources at Halsey Creek, the storm gates would be numbered and sized to maintain a >10% hydrologic connection needed to maintain Essential Fish Habitat suitable for white shrimp, which is an important fishery in South Carolina.

Effects on aquatic resources from gate closures at Halsey Creek and the six other locations under road restrictions would also be minimized by reducing the time that the gates would be closed to the greatest degree that is feasible and practicable to safely operate the gates before and after a storm surge event. This is described in Section 6.4. The gates would also be closed upon low tide to reduce the abundance of mobile aquatic resources behind the wall when the gates would be closed. The depth at low tide in Halsey Creek, for example, where the wall would be placed is roughly six inches, so many aquatic resources would naturally move out with the tide to deeper waters. Finally, permanent direct and indirect losses of salt marsh and habitat functions from the storm surge wall that cannot be avoided or minimized would be offset through compensatory mitigation (more information on compensatory wetland mitigation can be found in the Draft Mitigation Plan in Appendix F - Environmental). This includes Halsey Creek where 90% of degraded fish habitat function would be compensated for.

The proposed nonstructural measures occurring on the uplands would not have direct effects on aquatic habitat. The living shoreline sills would not have any direct adverse effects on aquatic resources but would have a beneficial effect. Because the sills would be reef-based, meaning they would support the growth of oyster resources and form into oyster reef habitat, they would enhance existing Essential Fish Habitat in the salt marsh-tidal creek systems where they are located.

Therefore, potential effects to aquatic resources from Alternative 2 would include permanent beneficial effects, and permanent and temporary adverse effects. Mitigation efforts (including the avoidance and minimization actions detailed above) will appreciably reduce the overall impact. Temporary adverse effects to aquatic resources that could result in some locations during temporary closure of the storm gates will be minimized to the extent practicable, and would be minor when compared to the No Action Alternative.

6.9 Benthic Resources

6.9.1 No Action/Future Without Project Alternative

Under the No Action Alternative, benthic habitats (aquatic bottom-dwelling habitats) that are degraded in the ROI would be expected to continue in that state, and new areas could be disturbed by future land use changes. Benthic organisms are sensitive to changes in environmental conditions. Changes in salinity, temperatures, and ocean acidification from climate change could also adversely affect benthic macrofauna in the future; however, an analysis of this range of alteration is beyond the scope of this feasibility study.

6.9.2 Alternative 2 (perimeter structure + nonstructural)

Potential effects on benthic resources from Alternative 2 would be similar to those described for aquatic resources in Section 6.8. Minor adverse effects could result from construction of the storm surge wall and gate features in the marsh and on land, and indirectly from construction of nonstructural measures and pump stations. Oyster reef-based living shoreline sills minimization feature would have a potential beneficial effect on salt marsh tidal creek systems where benthic resources are found.

Permanent and temporary effects on habitat loss and degradation of function in salt marsh-tidal creek systems, along with tidal flats, from the storm surge wall would lead to potentially adverse effects to benthic resources. Benthic resources are sensitive to changes in sediment composition and water quality, including salinity and oxygen exchange that occurs at the sediment-water interface. In an environmental baseline study of benthic habitat conducted by SCDNR for USACE's Charleston Harbor Deepening Post 45 Project (Sanger et al., 2013), macrobenthic communities in the Ashley River were found to be influenced by salinity concentrations but the communities were similar when compared to data from a 1980's study, indicating no long-term change. It is reasonable to expect that permanent changes in water quality induced by the storm surge wall could produce adverse effects on benthic resources in those locations.

Additionally, there is a small sandy tidal flat in the study area that would be intersected by the storm surge wall cutting off tidal flow over the flat (see Figure 6-7). This area is locally called "Battery Beach" although it is an estuarine feature with 1-2 feet water depth, not a surf zone habitat. The proposed wall would have an adverse effect on the benthic resources that utilize the area since it would lose tidal flow and no longer function as an estuarine tidal flat. The potentially affected area of the tidal flat is roughly half an acre.

Actions described in Section 6.8 to avoid, minimize and mitigate for adverse effects of habitat for aquatic resources would also reduce potential effects on benthic resources found in salt marsh/tidal creek systems. Temporary construction effects would be minimized through use of BMPs for reducing water quality impacts, elevating heavy equipment from the marsh, and others described in the section above. The salt marsh wetland areas that would be lost, along with the benthic resources, at the footprint of the wall and behind the wall as described in Section 6.6 would be offset through compensatory salt marsh wetland mitigation. Potential loss of the sandy tidal flat at "Battery Beach" would also be offset through compensatory salt marsh wetland mitigation, since intertidal flats are a subsystem of the estuarine wetland system according to Cowardin et al (1979) (see the Draft Mitigation Plan in Appendix F – Environmental). Therefore, potential effects to benthic resources from Alternative 2 would include permanent and temporary adverse effects that, after appropriate avoidance and minimization, would be mitigated for to compensate for remaining non-negligible impacts to the extent incrementally justified.

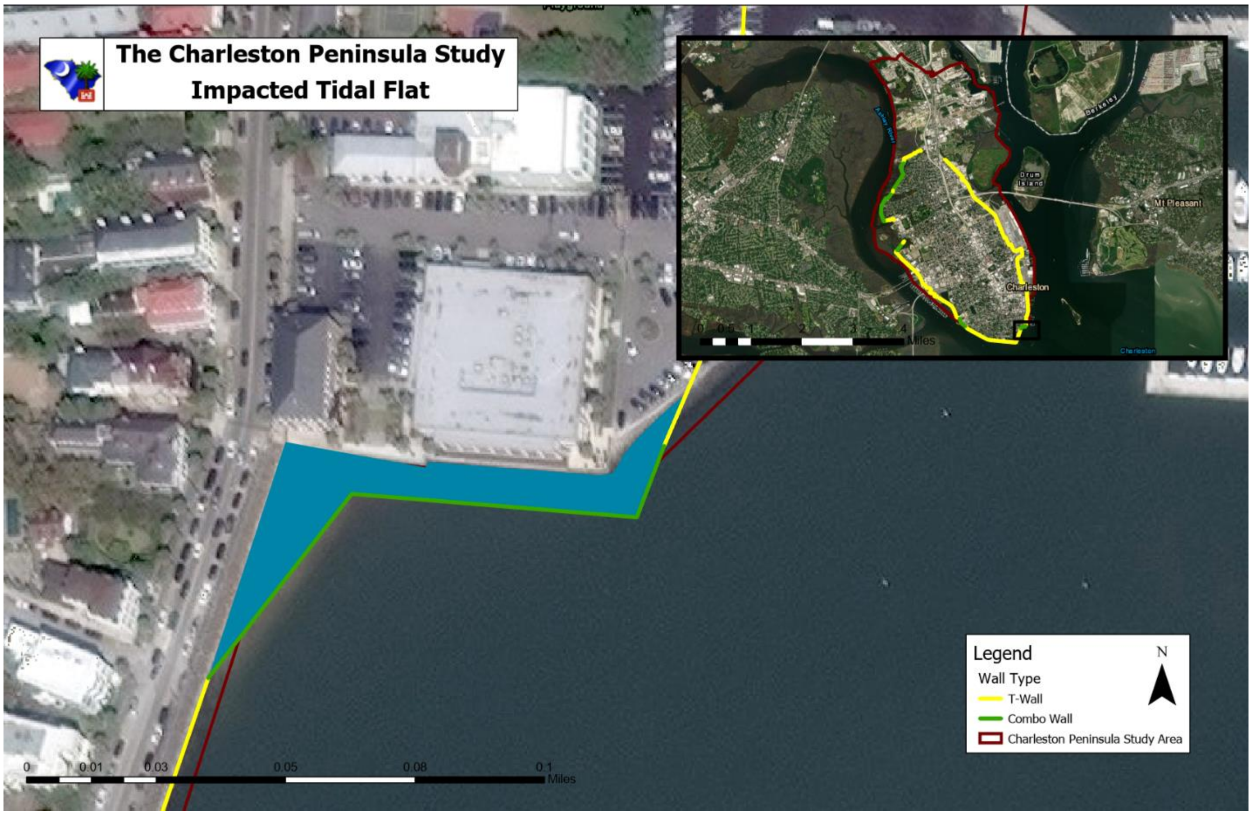

Figure 6-7. Map of “Battery Beach” tidal flat potentially affected by the storm surge wall.

6.10 Terrestrial Wildlife and Upland Vegetation

6.10.1 No Action/Future Without Project Alternative

With the No Action Alternative, current trends in land use and climate change would likely continue into the future, so that plants and wildlife in the ROI could be adversely affected. Over the past several decades, habitats that wildlife rely on within South Carolina have already become increasingly fragmented. Habitat loss is the most important factor contributing to species decline (SCDNR, 2021). Climate change has the greatest potential to change the nature and character of the estuarine and coastal ecosystems in South Carolina. This is compounded with habitat loss due to development. Habitat decline, increases in invasive species, shifting climate regimes and salinity profiles, increasing development in coastal areas, and rising sea levels represent constraints and barriers to dispersal and migration of wildlife and plant species. Migratory corridors are essential for the ability of wildlife to find suitable habitat and for population maintenance. With increased coastal storms, terrestrial habitats would flood more often due to storm surge, temporarily displacing terrestrial wildlife to higher ground. These factors would have an adverse effect on terrestrial wildlife in the future if no action is taken.

6.10.2 Alternative 2 (perimeter structure + nonstructural)

Potential effects on wildlife and vegetation from implementation of Alternative 2 would include permanent and temporary minor effects, and beneficial effects.

The storm surge wall in Alternative 2 could have a permanent effect by creating a physical barrier to movement of some wildlife species, but many would be able to fly over or could move through openings (gates) in the wall. The location of the wall could also displace existing vegetation, including mature trees. Overall, this would be expected to be minor permanent effect on terrestrial species which would be partially offset by a reduction in the threat which storm surge inundation poses to some of these terrestrial species.

Permanent effects of the creation of living shoreline sills would be beneficial for wading and other birds that utilize oyster reef and salt marsh for foraging by creating new habitat.

<u>Construction Related Effects</u>
Upland construction of the storm surge wall, nonstructural measures, and pump features in Alternative 2 has the potential to affect wildlife by disturbing upland vegetation or disturbing soils that may run off and affect water quality in marshes and tidal flats where birds feed. Use of the worksite trestle for construction of the wall in the marsh could result in minor disturbance of sediments and vegetation, as could construction of the living shoreline sill feature in the marsh. Construction would generate noise and human activity that may induce a fleeing response that temporarily displaces wildlife. These effects would be temporary and minor.

To minimize the structural and nonstructural effects on terrestrial species during construction, BMPs as described in Section 6.4 would be implemented to minimize the migration of sediments to waterways, and safety measures would be implemented to prevent the release of oil, tar, trash, debris and other pollutants. Trees that would need to be removed would be replaced in a nearby location after construction is completed (but not within the buffer zone of the wall). Any marsh vegetation lost during construction would be replaced.

6.11 Cultural Resources

6.11.1 No Action/Future Without Project Alternative

Under the No Action/Future Without Project Alternative, effects of climate change such as rising sea levels and increasing coastal storms, along with human use patterns such as population growth, are expected to continue over the next 50 years in the Charleston area. These trends are expected to continue and have the potential to adversely affect cultural resources within the study area.

Section 2.3 contains a summary of intense coastal storms that have impacted the Charleston Peninsula since 1950, as well as predictions on the effects of sea level rise. Flooding effects from storm surge are expected to continue in the future. Many archaeological resources, historic structures, and historic districts on the peninsula have been affected to varying degrees during past storm events due to the area's relatively flat topography, fill of marshes and creeks, and low elevation (<20 feet NAVD88). Based on information gathered from the SC ArchSite database of previously identified cultural resources, a coastal storm in the No Action/Future Without Project conditions in 2082 show that approximately 50 percent of the historic structures located on the Charleston Peninsula are situated in areas that would be at risk of flood damage in a 25-year flood event (Figure 6-8). These areas are primarily on the outer edges of the COHD. Portions of the COHD located near King and Meeting Streets, and historic districts north of the COHD near Hampton Park are at higher elevations and would not be affected. These areas of higher elevation correlate roughly with the peninsula's landform at the time of initial settlement in the late 1600s (Figure 6-9).

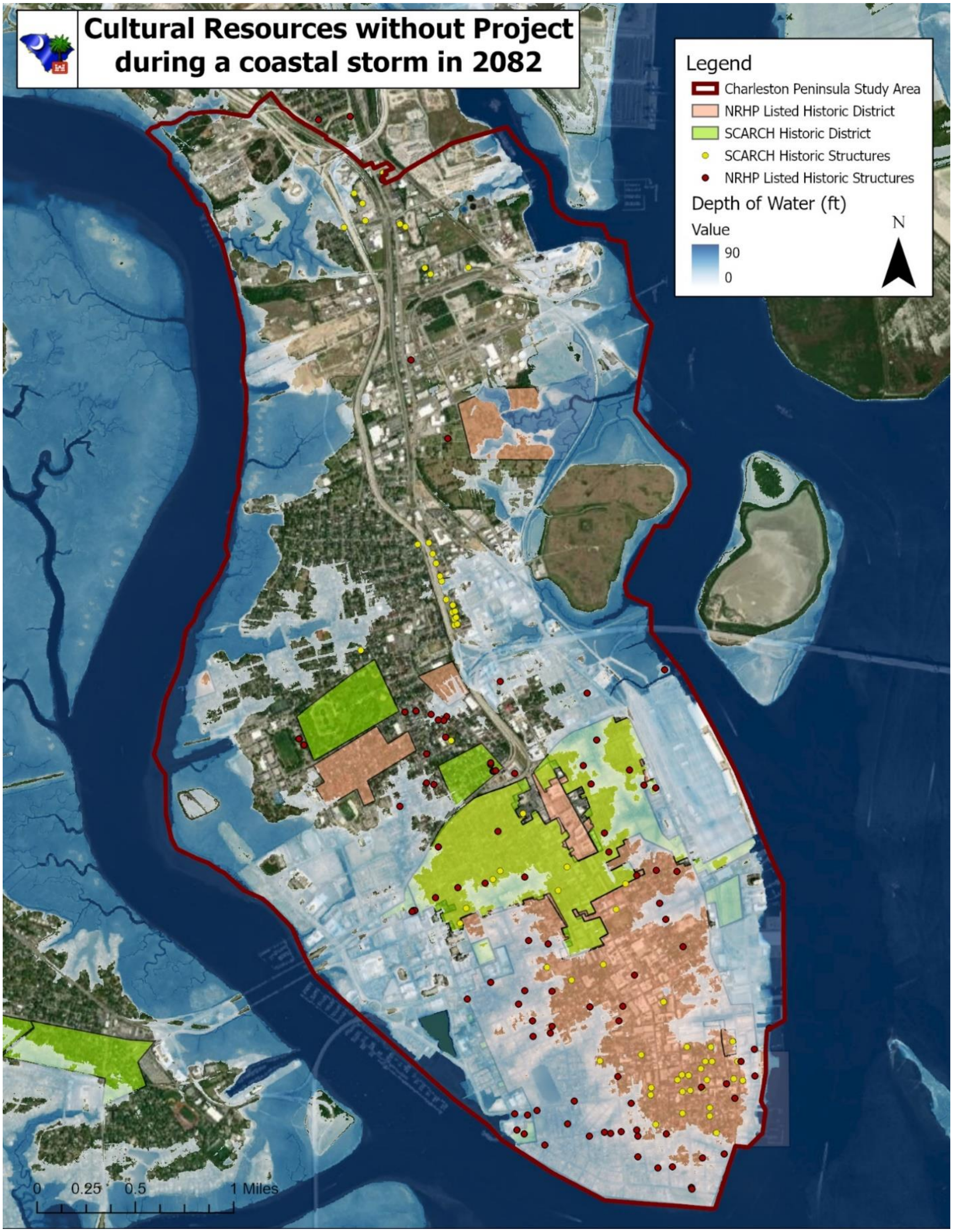

Figure 6-8. Projected conditions for a 9 ft NAVD88 storm surge inundation.

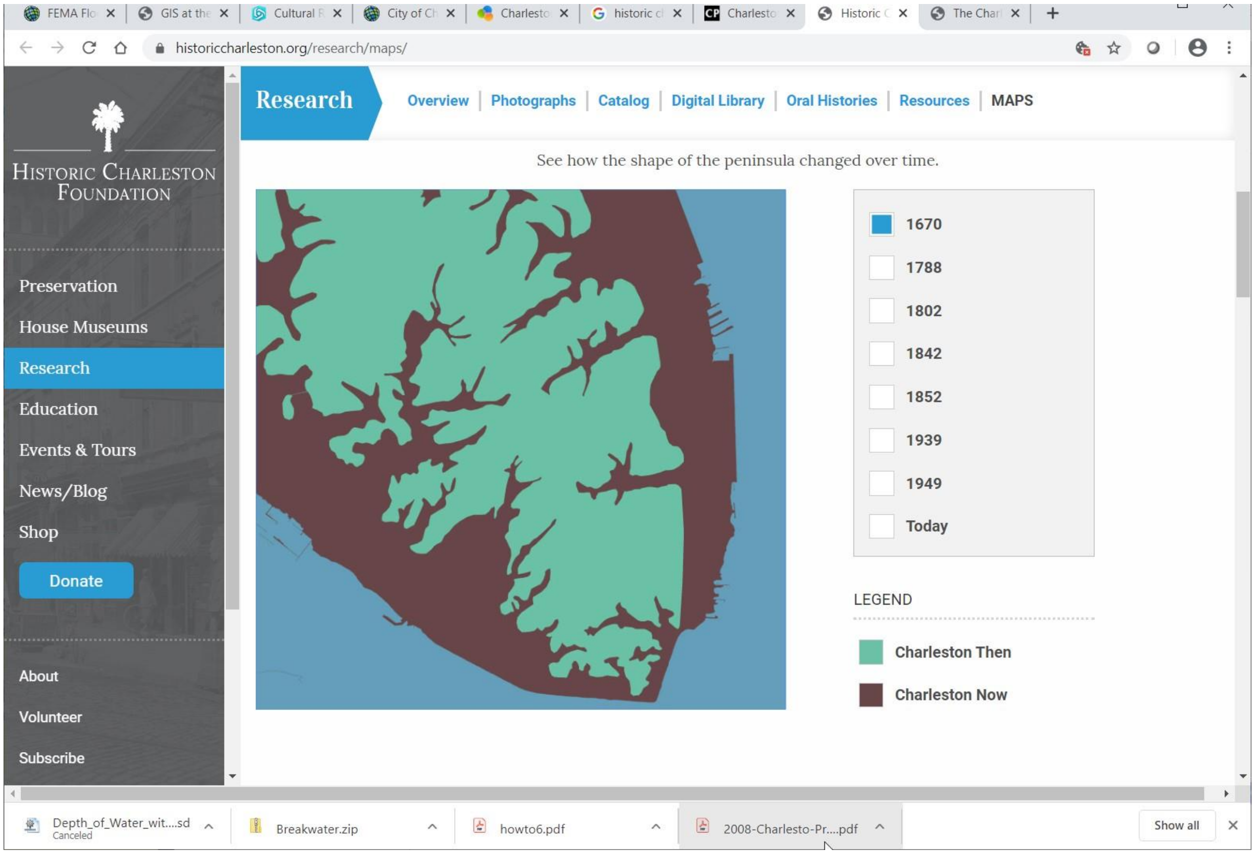

Figure 6-9. Outline of the peninsula in 1670.

Source: Historic Charleston Foundation; https://www.historiccharleston.org/research/maps/

It is expected that cultural resources, especially historic architectural resources, will continue to be added to the historic property inventory as they become 50 years of age or older and meet the criteria for inclusion in the NRHP. The South Carolina State Historic Preservation Office (SHPO) oversees the Statewide Survey of Historic Properties Program, which systematically identifies historic properties within a specific geographical area. These surveys are expected to continue and will add to Charleston’s historic resources inventory. The results of these surveys may expand the boundaries of existing historic districts and create new historic districts. These surveys will also identify resources that are individually eligible for the NRHP, particularly resources constructed in the mid- to late-twentieth century. As a result, the number of historic properties exposed to storm surge and flood waters would increase through time under the No Action/Future Without Project Alternative.

Individual property owners would continue to elevate or floodproof historic structures to combat sea level rise and flooding under the No Action/Future Without Project Alternative. The City of Charleston formalized a process in 2019 for elevating historic structures in historic districts to protect them from flood waters and damage. This process is expected to continue without implementation of the Study. The Board of Architectural Review (BAR), housed within the City of Charleston Department of Planning, Preservation, and Sustainability, reviews and approves requests. The Design Guidelines for Elevating Historic Buildings (City of Charleston, 2019b) provides design considerations to ensure historic structures retain their character and historic significance. In addition to properties within historic districts, the BAR has jurisdiction over any external changes to historic properties included on the Landmark Overlay Properties list (https://www.charleston-sc.gov/DocumentCenter/View/1261/Landmark-Overlay-properties---list--details?bidId=). These regulations ensure the protection of historic properties under the No Action/Future Without Project Alternative; however, owners of historic buildings and structures are not required to elevate, as the cost of elevating a historic structure is the responsibility of the property owner and can be quite expensive. Historic properties that remain at their original elevation may be subject to repeated damages and deterioration from inundation under the No Action/Future Without Project Alternative. In addition to damage to the foundations of historic structures, flood waters can cause damage to interior systems such as electrical wiring, ductwork, heating and air systems, and interior finishes. Repeated flooding may also adversely impact historic landscaping and plants. Archaeological deposits associated with historic structures could potentially be impacted through measures taken by historic structure owners to protect personal property.

6.11.2 Alternative 2 (perimeter structure + nonstructural)

Under NEPA, it is the federal agency's responsibility to consider effects from the study on historic and cultural resources. Section 106 of the NHPA also requires federal agencies to take into account the effects of their undertakings on historic properties, and Section 110(f) of the NHPA further requires federal agencies to exercise a higher standard of care when considering undertakings that may directly and adversely affect NHLs. Due to the high density of cultural resources and specifically historic properties listed in or eligible for inclusion in the NRHP, NHLs, National Monuments, and NRHP-listed historic districts within the study area, the consideration of effects from Alternative 2 is particularly critical in the evaluation of alternatives. Management measures included in Alternative 2 that have the potential to adversely affect historic properties include the construction of an approximately 8.7-mile-long storm surge wall surrounding the peninsula of Charleston, raising the elevation of the Low Battery Wall, reconstruction of the High Battery Wall, construction of multiple pedestrian, vehicle, railroad, and storm (tidal flow) gates, construction of interior drainage facilities including permanent and temporary pump stations, installation of approximately 9,300 linear feet of oyster reef-based living shoreline, and non-structural measures which include raising buildings and floodproofing.

Based on the above stated management measures and through consultation with cultural resources stakeholders, including the South Carolina SHPO, the NPS, the ACHP, the City of Charleston, the Catawba Indian Nation, Historic Charleston Foundation, and the Preservation Society of Charleston, USACE has determined the area of potential effects (APE) of Alternative

2 to include four separate areas based on effects of the feasibility-level design and analysis. Once features of Alternative 2 are further refined in the PED phase of this study, the APEs may be subject to change through continued consultation with these agencies/groups. The four areas are shown in Figures 6-10 through 6-13 and defined as the Construction, Non-structural, Interior Peninsula, and Exterior Peninsula APEs. The Construction APE considers demolition, vibration, and auditory effects within 200-foot of either side of the proposed storm surge wall, the living shoreline, and other constructed features (e.g., pump stations and gates). The Non-structural APE takes into account the effects of non-structural measures at three locations on the north end of the peninsula. Due to the location of the storm surge wall on the periphery of the peninsula and the nature of the city layout, potential visual effects are considered from the perspective of two different viewsheds consisting of the exterior peninsula viewshed (historic properties that view the peninsula from across the Ashley and Cooper rivers or Charleston Harbor), and the interior peninsula viewshed (historic properties located on the peninsula with a view of the storm surge wall). A list of previously identified historic properties within the APEs is presented in Table 6-1.

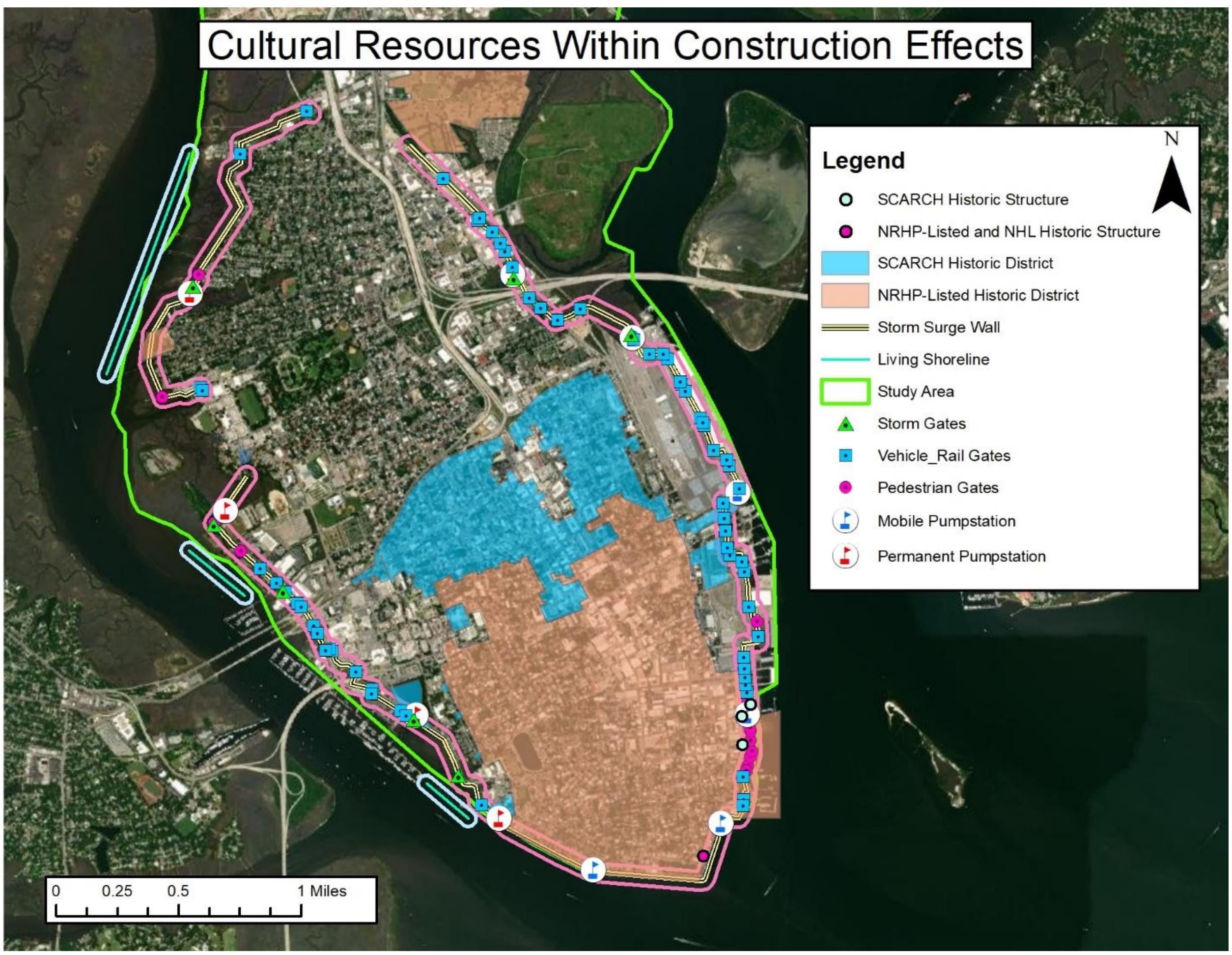

Figure 6-10. Cultural resources within the construction areas of potential effects. Note archaeological sites have not been included due to sensitivity.

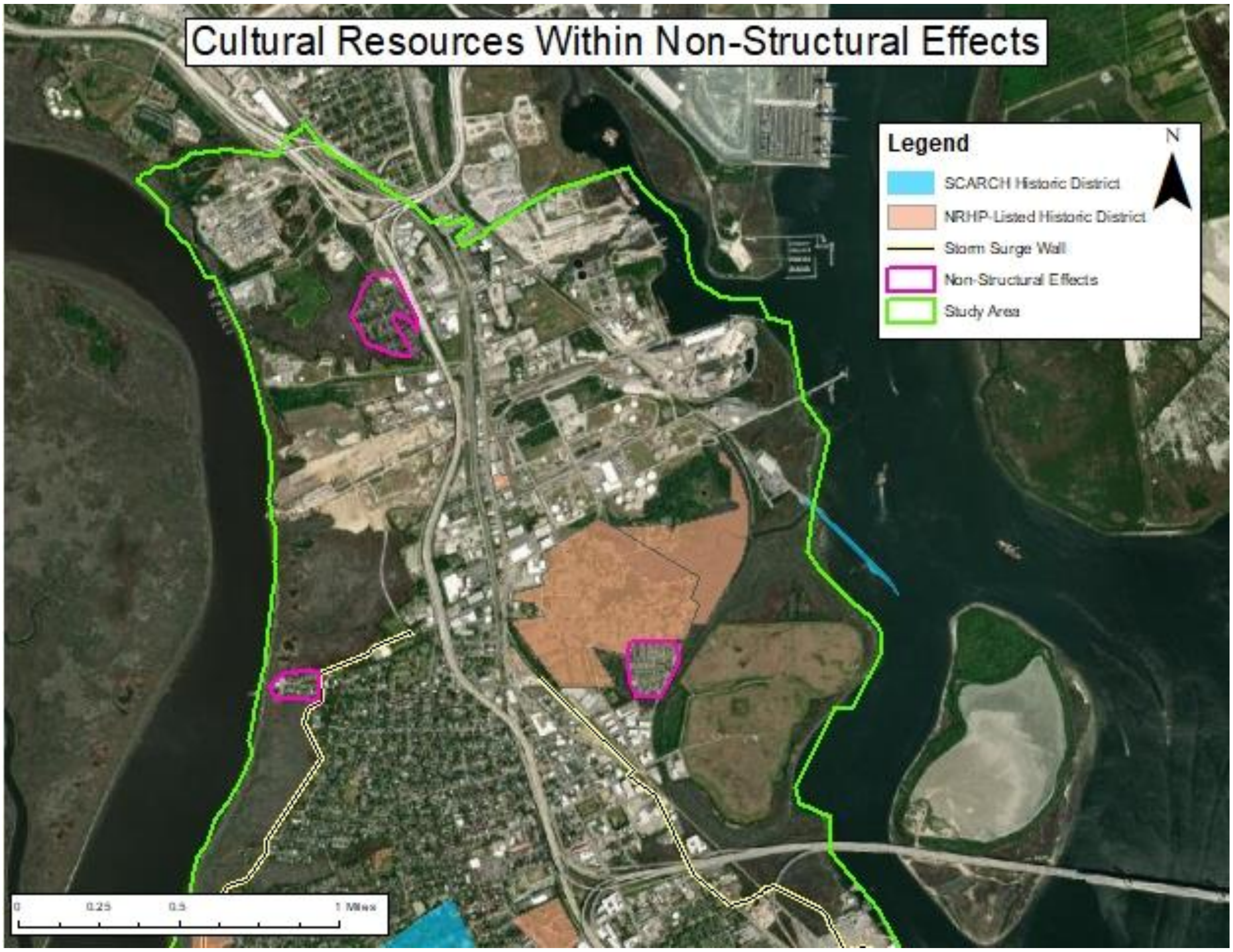

Figure 6-11. Non-structural areas of potential effects.

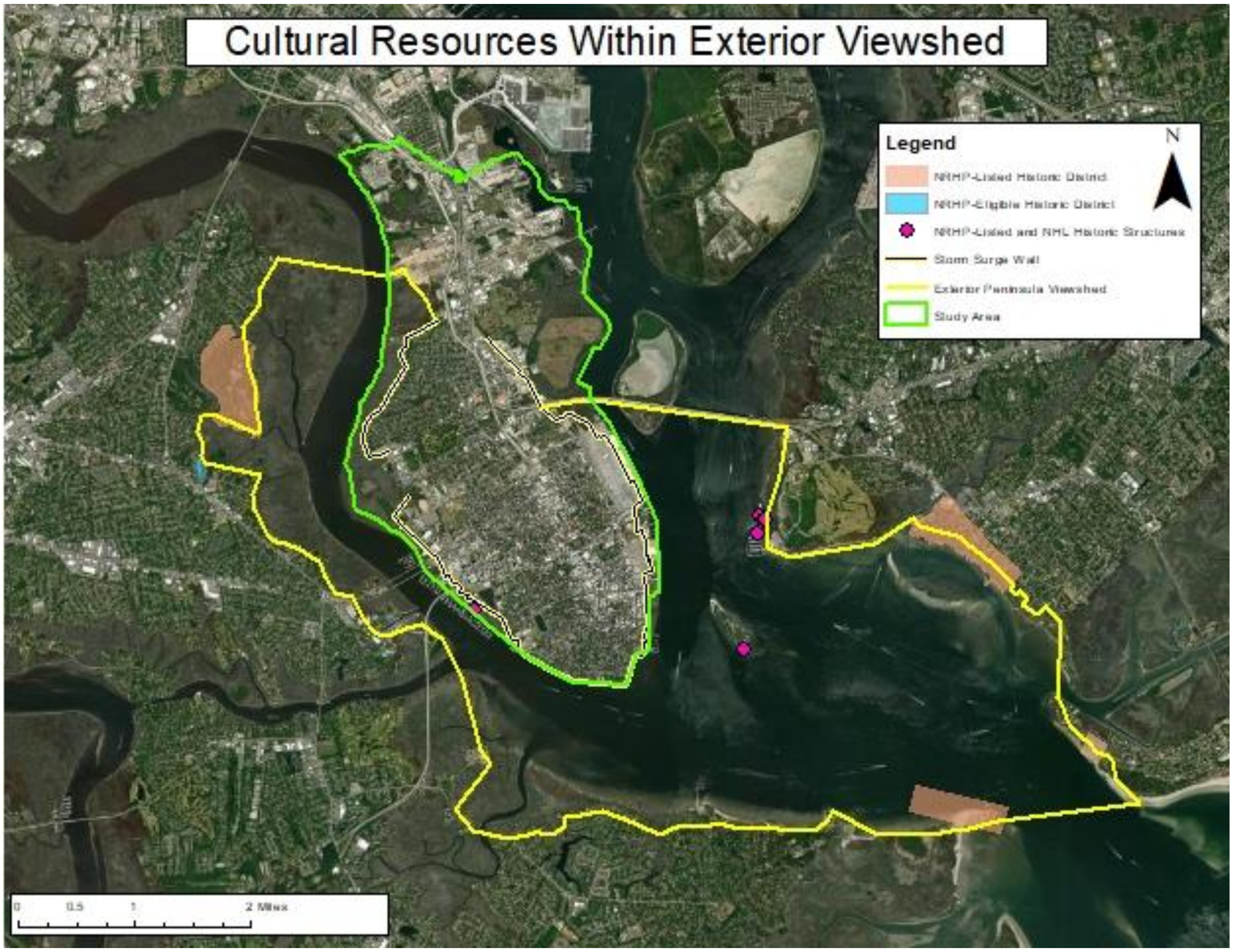

Figure 6-12. Exterior viewshed area of potential effects.

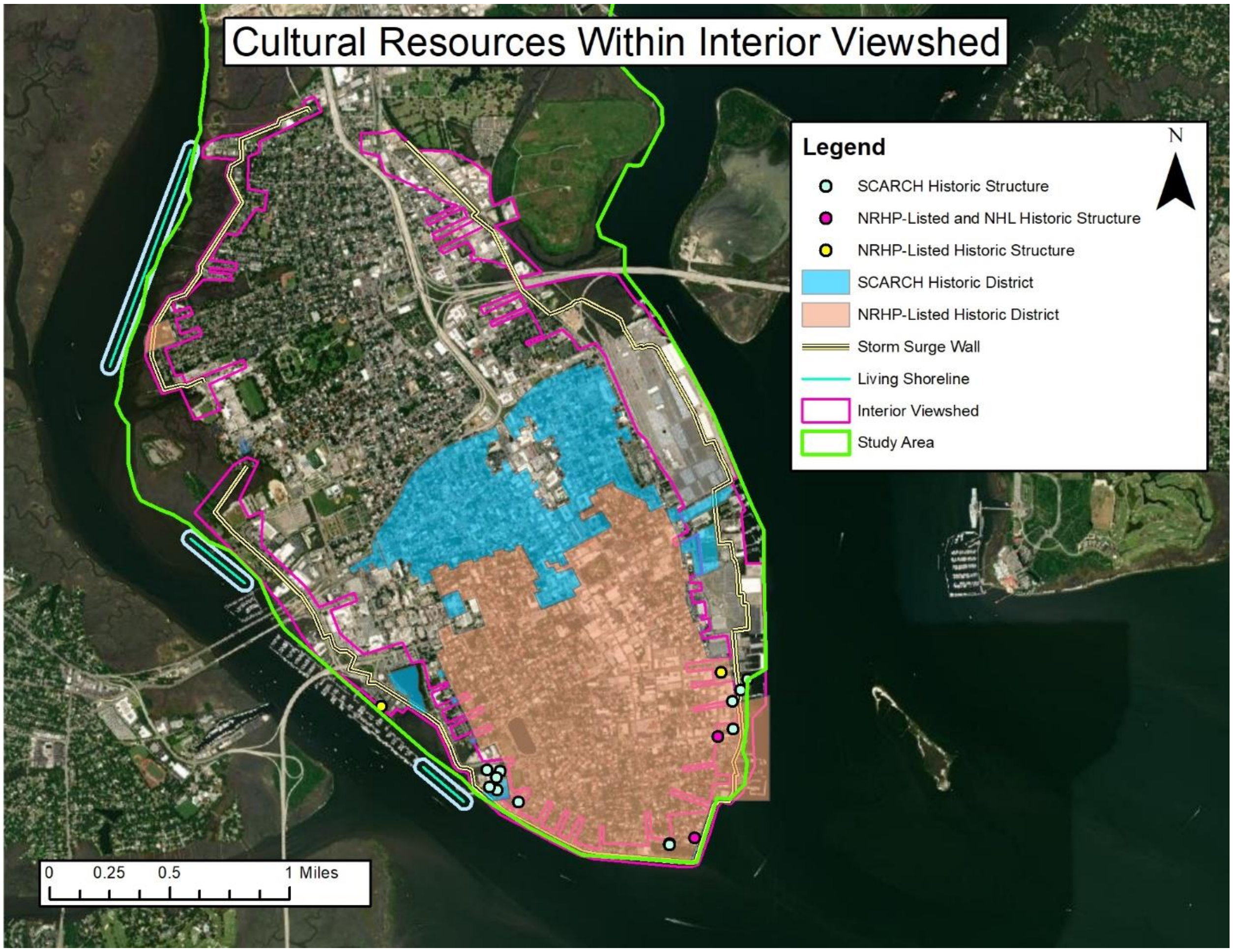

Figure 6-13. Cultural resources within the interior viewshed areas of potential effects. Note archaeological sites have not been included due to sensitivity.

The lack of detailed engineering and design of the features of Alternative 2 during the feasibility phase, in addition to time and budgetary constraints, precludes USACE from conducting all of the necessary surveys to sufficiently identify and evaluate cultural resources, fully determine adverse effects of Alternative 2 on historic properties, or establish methods to avoid, minimize, or mitigate those adverse effects, prior to completion of this feasibility study. As such, USACE is deferring final identification and evaluation of historic properties until after study approval, additional funding becomes available, and prior to construction by executing a Programmatic Agreement (PA) with the South Carolina SHPO, the NPS, the ACHP, the City of Charleston, the Catawba Indian Nation, Historic Charleston Foundation, and the Preservation Society of Charleston pursuant to 36 CFR § 800.4(b)(2). This PA details additional historic property inventories necessary in PED to identify and assess the eligibility of historic properties and determine effects of the study on these properties. The PA further outlines levels of design review necessary to avoid and minimize adverse effects to historic properties, and if necessary, mitigate adverse indirect or direct effects that USACE is unable to avoid through study design or construction for compliance with Section 106 and Section 110 of the NHPA. The discussion of effects below is preliminary based on the feasibility level design and placement of management measures and should not be considered final. In accordance with the PA presented in Appendix D, the study design would be modified where possible to avoid adverse effects to historic properties.

Table 6-1. Historic Properties within the Areas of Potential Effects.

Resource	APE	Site Type	Eligibility
38CH0701	Construction Effects, Interior Peninsula Viewshed	Archaeology Site	Unevaluated
38CH0700	Construction Effects, Interior Peninsula Viewshed	Archaeology Site	Unevaluated
Lowndes Grove	Construction Effects, Interior Peninsula Viewshed	Structure	Listed
West Point Rice Mill	Interior Peninsula Viewshed	Structure	Listed
Alverta Long Park Lake/Halsey Blvd. (Site No. 5858)	Construction Effects, Interior Peninsula Viewshed	Historic Area	Eligible
Operations Maintenance Shop/9 Chisolm Street (Site No. 089-6458)	Interior Peninsula Viewshed	Structure	Contributes to Eligible District
Thomas H. Martin Jr. Army Reserve Training Center/9 Chisolm Street (Site No. 089-6457)	Interior Peninsula Viewshed	Structure	Eligible
205 Broad Street	Interior Peninsula Viewshed	Structure	Contributes to Listed District
US Light House Service Sixth District Office Building/196 Tradd Street (Site No. 089-6454)	Interior Peninsula Viewshed	Structure	Eligible
Chisolm’s Rice Mill Storage Building/196 Tradd Street (Site No. 089-6455)	Construction Effects, Interior Peninsula Viewshed	Structure	Eligible
Andrew B. Murray Vocational School/3 Chisolm Street	Interior Peninsula Viewshed	Structure	Listed
Charleston Old and Historic District (Boundary Increase)	Construction Effects, Interior Peninsula Viewshed	District	Listed/NHL

Resource	APE	Site Type	Eligibility
Proposed expansion to Charleston Historic District	Construction Effects, Interior Peninsula Viewshed	District	Eligible
Robert William Roper House/9 E. Battery Street	Construction Effects, Interior Peninsula Viewshed	Structure	Listed/NHL
Miles Brewton House/27 King Street	Interior Peninsula Viewshed	Structure	Listed/NHL
3 Water Street	Interior Peninsula Viewshed	Structure	Contributes to Listed District
38CH1673	Construction Effects, Interior Peninsula Viewshed	Archaeology Site	Unevaluated
3 Meeting Street	Interior Peninsula Viewshed	Structure	Contributes to Listed District
1 Meeting Street	Interior Peninsula Viewshed	Structure	Contributes to Listed District
U.S. Customhouse/200 E. Bay Street	Construction Effects, Interior Peninsula Viewshed	Structure	Listed
Exchange and Provost/ E. Bay and Broad Streets	Interior Peninsula Viewshed	Structure	Listed/NHL
38CH1606	Construction Effects, Interior Peninsula Viewshed	Archaeology Site	Eligible
9 Middle Atlantic Wharf	Construction Effects, Interior Peninsula Viewshed	Structure	Contributes to Listed District
Dutarque-Guida House/105 East Bay Street	Interior Peninsula Viewshed	Structure	Contributes to Listed District
Fleet Landing Building/186 Concord Street	Interior Peninsula Viewshed	Structure	Eligible
4 Vendue Range	Construction Effects, Interior Peninsula Viewshed	Structure	Contributes to Listed District
Charleston's French Quarter District	Interior Peninsula Viewshed	District	Listed
Market Hall and Sheds	Interior Peninsula Viewshed	Structure	Listed/NHL
Charlotte Street Power Plant	Construction Effects, Interior Peninsula Viewshed	Structure	Eligible
Immigration Center (Site No. 2809)	Interior Peninsula Viewshed	Structure	Eligible
38CH1486	Construction Effects, Interior Peninsula Viewshed	Archaeology Site	Unevaluated
38CH1587	Construction Effects, Interior Peninsula Viewshed	Archaeology Site	Eligible

Resource	APE	Site Type	Eligibility
East Bay Elementary/805 Morrison Drive (Site No. 4257)	Construction Effects, Interior Peninsula Viewshed	Structure	Eligible
Charleston Cemeteries Historic District	Construction Effects	District	Listed
USS Yorktown	Exterior Peninsula Viewshed	Structure	Listed/NHL
USS Clamagore	Exterior Peninsula Viewshed	Structure	Listed/NHL
USS Laffey	Exterior Peninsula Viewshed	Structure	Listed/NHL
Castle Pinckney	Exterior Peninsula Viewshed	Structure	Listed
Mount Pleasant Historic District	Exterior Peninsula Viewshed	District	Listed
Moultrieville Historic District	Exterior Peninsula Viewshed	District	Listed
Fort Sumter National Monument	Exterior Peninsula Viewshed	National Monument	Listed
King House/1040 5th Avenue (Site No. 7927)	Exterior Peninsula Viewshed	Structure	Eligible
Site of Old Charles Towne	Exterior Peninsula Viewshed	Multicomponent	Listed

<u>Construction Effects</u>

Construction of the storm surge wall, living shoreline, pump stations, and pedestrian, vehicle, railroad, boat, and storm (tidal flow) gates has the potential to effect historic properties by demolition, ground disturbance, vibration, and/or auditory disturbances that could cause physical destruction and damage to historic properties. Construction of management measures may also introduce new visual elements that could result in a change of character of a historic property's setting or diminish the integrity of a historic property. Visual impacts will be discussed under the Interior and Exterior Peninsula Viewshed Effects sections below. Construction effects were considered within a 200-foot radius from the storm surge wall and other constructed measures. These effects are typically taken into account within 100 feet of construction activities; however, due to a lack of detailed knowledge of the existing subsurface conditions and proposed construction methods, a 200-foot APE was considered during feasibility and may be refined during PED.

Construction of management measures has the potential to affect previously identified and unknown archaeology sites within the construction footprint. The storm surge wall would be constructed on land and in portions of the surrounding marsh. Within the terrestrial portion of the APE there are six previously identified archaeological sites that are eligible for the NRHP or need additional information to determine NRHP eligibility. Due to the urban setting of the Charleston Peninsula, it may not be possible to investigate previously identified archaeology sites prior to construction. Archaeological monitoring would be employed during ground-disturbing activities at these locations and other locales where there is a high probability for encountering intact archaeological deposits. The potential for intact archaeological deposits is lower along the Ashley River side of the peninsula due to later and less dense development of the area; however, there is potential for submerged resources in the marsh where the combo-wall is proposed along the Ashley River (Figure 6-14). A submerged cultural resources survey of the portion of the APE that falls within the marsh would be undertaken prior to construction.

Figure 6-14. “Bird’s Eye View of the City of Charleston, South Carolina, 1872” by C.N. Drie.

Source: Library of Congress, https://www.loc.gov/item/75696567/

The Low and High Battery Seawalls would be directly affected by construction of the storm surge wall. The High Battery Seawall measures approximately 1,450 feet and traverses the extent of East Battery Street. The Low Battery Seawall measures approximately 4,450 feet and extends the length of Murray Boulevard. The seawalls were subject to various stages of construction and the High and Low Battery Seawalls generally date from the beginning of the nineteenth century and the beginning of the twentieth century respectively. Alternative 2 incorporates both seawalls into the storm surge wall’s design; however, proposed construction methodology would raise the existing Low Battery Seawall to 12 feet NAVD88 and completely reconstruct the High Battery Seawall to meet current engineering standards and meet the required elevation of 12 feet NAVD88. The seawalls are historic properties within the COHD; however, they have not been individually documented or provided resources numbers by SC DAH. Further investigation and documentation of the seawalls would be necessary to determine effects of the study and identify any necessary mitigation. Furthermore, the final design specifications of the new storm surge wall are necessary to determine if adverse effects to the High and Low Battery Seawalls can be minimized based on construction materials and methods prior to determining mitigation strategies.

Vibrations from pile driving during construction of the storm surge wall and other management measures has the potential to adversely affect historic structures within the APE. Vibrations can cause structural damage to nearby historic structures that are contributing elements to the COHD, NHLs, or are individually listed or eligible for listing in the NRHP. Murray Boulevard and East Battery Street contain structures that are contributing elements to the COHD and six additional structures that are eligible or listed in the NRHP, including the Robert William Roper House NHL, are also located within the Construction APE (see Table 6-1). Monitoring equipment would be required to ensure vibration does not damage or degrade historic properties to such an extent that their integrity is compromised; however, additional information on construction methods, the existing condition of historic properties, and soil conditions would be necessary to determine a vibration monitoring plan. Effects to historic properties from noise associated with pile driving and the construction equipment, and changes in traffic patterns due to necessary road closures during construction may occur; however, these changes would be temporary, and the original condition of noise and traffic routes would be restored upon completion of the construction. These temporary effects do not pose an adverse effect to historic properties within the APE.

The PA provided in Appendix D outlines the process by which additional historic property surveys would be conducted, effects determined, and avoidance, minimization, and/or mitigation strategies are implemented. The PA also describes archaeological monitoring requirements, the development of vibration monitoring and/or protection plans, and details procedures in the case that adverse effects to historic properties occur inadvertently. In order to minimize construction effects through design of the storm surge wall itself, study plans and specifications would be reviewed at completion intervals of 35, 65, and 95 percent levels of design by the signatories and concurring parties of the PA for review and comment. Although Alternative 2 may adversely affect the High and Low Battery Seawalls and additional historic properties, construction of the new storm surge wall would protect hundreds of historic properties when compared to the No Action/Future Without Alternative (Figure 6-15). As currently designed the seawall is overtopped by water at Murray Boulevard during coastal storms. Incorporating the seawall into a continuous storm surge wall would provide protection to the COHD in addition to those resources that are contributing elements to the COHD.

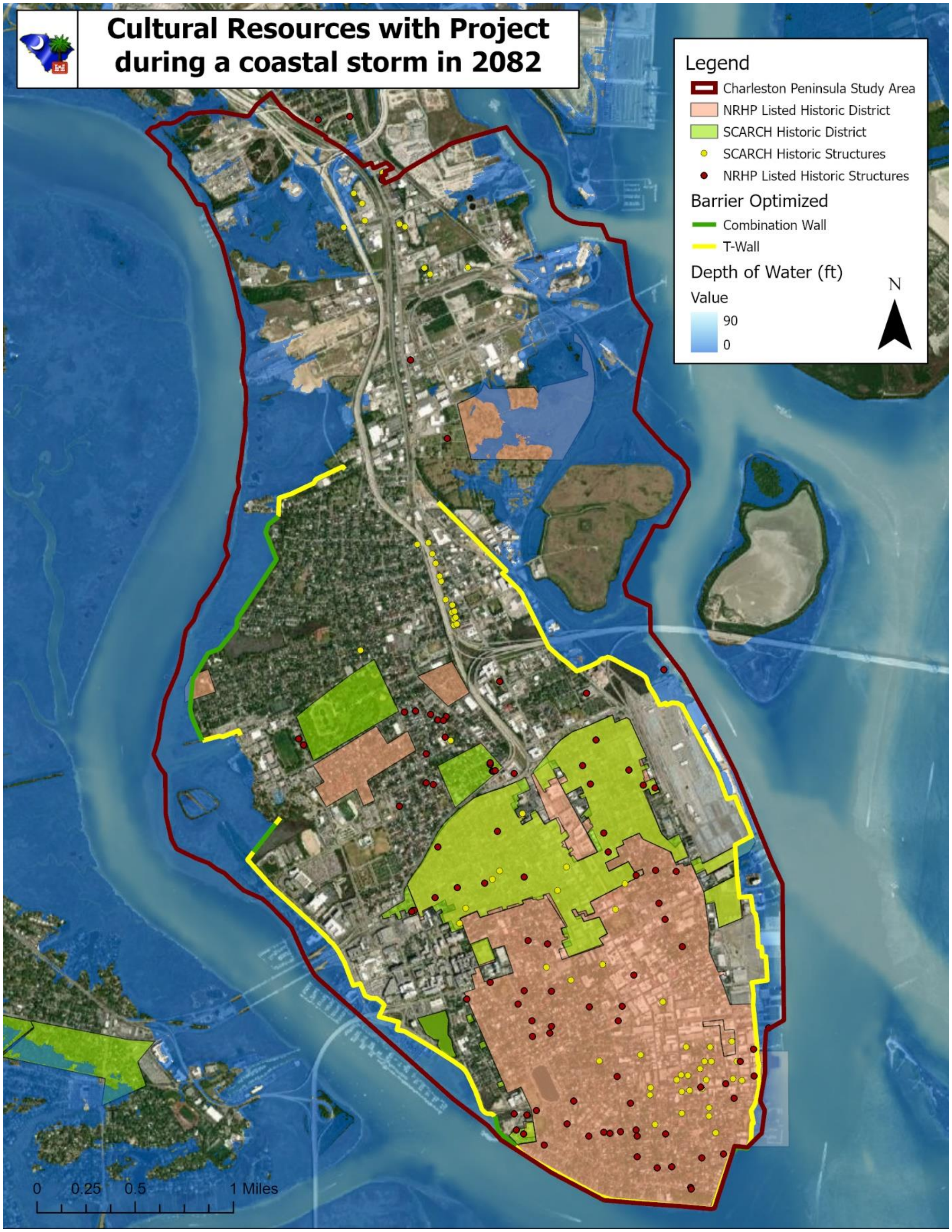

Figure 6-15. Projected conditions in 2082 during a coastal storm with implementation of Alternative 2.

Non-Structural Effects

Under Alternative 2, non-structural measures would be applied to approximately 100 structures located in the upper portion, or Neck area, of the peninsula (see Figure 6-11). Potential non-structural measures include wet and dry floodproofing, elevation, or relocation of structures. Structures within this APE are not part of a previously identified historic district, nor have they been identified as resources individually eligible for the NRHP; however, few historic property surveys have been conducted in this portion of the peninsula. A cultural resources assessment of these areas would be required during PED to determine if any of the structures within the APE are eligible for inclusion in the NRHP. These non-structural measures have the potential to adversely affect historic properties by altering the appearance and characteristics that make the resource eligible for the NRHP. Adverse effects may be avoided by developing floodproofing measures consistent with the Secretary of the Interior's (SOI) Guidelines on Flood Adaptation for Rehabilitating Historic Buildings and meeting the SOI's Standards for Rehabilitation. The PA provided in Appendix D, details survey methodology and outlines the guidelines USACE shall follow to determine effects on historic properties for non-structural measures.

Interior Peninsula Viewshed Effects

A viewshed is the area that is visible from the proposed management measures, including the storm surge wall and associated features. Adverse effects to historic properties from a change to viewshed occur when the features alter, directly or indirectly, any of the characteristics of a historic property that qualify the property for inclusion in the NRHP in a manner that would diminish the integrity of the property's location, design, setting, materials, workmanship, feeling, or association. Due to the proposed location of the storm surge wall on the exterior edge of the peninsula, the highly urbanized environment, street layout, and topography of the Charleston Peninsula itself, the interior peninsula viewshed is limited to those structures immediately facing the proposed storm surge wall or those structures along street corridors up to 1,000 feet from the proposed wall (see Figure 6-13). Historic properties interior to the peninsula outside of the APE cannot view the proposed features in Alternative 2 based on the feasibility-level design of the storm surge wall. The interior peninsula viewshed was determined through GIS analysis, pedestrian survey by the project archaeologist, and in consultation with the agencies and groups that are signatories and concurring parties to the PA; however, the APE may be amended in PED as features are refined and the alignment shifts.

Although the viewshed of the majority of historic properties within the Charleston Peninsula would not be affected by Alternative 2, 33 previously identified historic properties, historic districts and NHLs including the COHD, the Robert William Roper House, the Miles Brewton House, the Exchange and Provost, and the Market Hall and Sheds are located within the interior peninsula viewshed APE. The storm surge wall would be constructed at a height of 12 feet NAVD88 and visual effects to historic properties are dependent on the topography and physical environment of the area surrounding the individual property. Adverse effects to individual properties from construction of the wall and a change in viewshed may be avoided or minimized during PED by wall design, gate or pump station placement, improvements to overall alignment, use of high-quality construction materials, contextualization of design and materials to specific location on the peninsula, use as recreational space, integration of public art or landscape features, and providing for enhanced community experience. In addition, there are portions of the peninsula where the storm surge wall may not dominate the setting or attract the attention of observers because other modern intrusions are found along the perimeter of the COHD. These intrusions include modern buildings (i.e., parking garages, port facilities), paved roads, parking lots, and sidewalks. The storm surge wall may be utilized to create a barrier between modern intrusions and the COHD.

Although impacts to individual historic properties may be minimized or avoided during PED, USACE has determined construction of the storm surge wall would adversely affect the NRHP-listed and NHL-designated COHD by introducing visual elements and altering physical features within the COHD that diminishes the integrity of the setting and feeling. Setting refers to the physical environment of a historic property, such as topographic features, vegetation, manmade features (i.e., fences or paths), and relationships between buildings and other features or open space, including views of the water. Feeling is a historic property's expression of the aesthetic or historic sense of a particular period of time and results from the presence of physical features that, taken together, convey the property's historic character. The COHD is considered historically significant on a National level for its ability to convey the history and architecture of eighteenth and nineteenth century Charleston. The introduction of the visual intrusion created by the storm surge wall would diminish the COHD's ability to convey a cohesive story of the role the city played in the Nation's significant historic events of the eighteenth and nineteenth centuries. This change in the setting and feeling of the COHD would be directly affected by diminishing views of the water regardless of minimization measures undertaken during PED. However, effects to other historic districts, previously identified historic properties, and/or historic properties that may be identified during future survey efforts are unknown at this time. Each historic property would be individually evaluated to determine if a change in the viewshed adversely effects any of the characteristics that qualify the property for inclusion in the NRHP. Depending on final design and placement of the storm surge wall, adverse effects may be avoided; however, historic properties such as Lowndes Grove, where landscape and views of the water are considered an integral part of the site's visual and historic character may be adversely affected by the study. A robust viewshed analysis would be conducted once final study features are sited.

The PA provided in Appendix D outlines the process by which additional historic property surveys would be conducted, effects determined, and avoidance, minimization, and/or mitigation strategies are implemented. Additionally, the PA details how adverse effects from the study to the COHD would be mitigated.

Exterior Peninsula Viewshed Effects

Due to the topography of the Charleston Peninsula and its location between the Ashley and Cooper rivers, the storm surge wall is likely to be observed from historic properties across the rivers on the perimeter of the land surrounding the peninsula. Based on GIS analysis and ground-truthing by the project archaeologist, the storm surge wall would not be visible within 100 to 300 feet inland as the view is obscured by existing structures and vegetation (see Figure 6-12). Historic properties within the exterior peninsula viewshed includes Fort Sumter National Monument, Moultrieville Historic District, Castle Pickney, Mount Pleasant Historic District, Old Charles Towne, USS Yorktown, USS Clamagore, and USS Laffey. Although the storm surge wall may be visible from these historic properties, the distance (~1 to 4 miles) between the features may preclude adverse effects. Additionally, the change is elevation from the existing High and Low Battery Seawalls to the new proposed storm surge wall (approximately 3 feet from the existing height), may not change the viewshed in a way that diminishes the characteristics that qualify these historic properties for inclusion in the NRHP. A robust viewshed analysis would be conducted once the final footprint of the storm surge wall is determined in PED.

Avoidance, Minimization, and Mitigation of Adverse Effects

From the outset, USACE has proceeded with recognition of Section 110(f)'s heightened standard of care with regard to NHLs, and has undertaken the planning and actions necessary to minimize harm to NHLs. In so doing, the agency has balanced undertaking's goals, objectives and costs with the intent of Section 110(f), considering 1) the magnitude of the undertaking's harm to the historical, archaeological and cultural qualities of the NHLs, 2) the public interest in the NHLs and in the undertaking as proposed, and 3) the effect a mitigation action could have on meeting the goals and objectives of the undertaking. In the formulation of alternatives, the minimization of adverse effects to historic districts and structures was one of the key constraints. While adverse effects in the form of introducing visual elements and altering physical features within the Charleston Historic District that diminish the integrity of the setting and feeling is acknowledged, the risk of significant and lasting physical damage to the NHL structures themselves from coastal storm surge inundation events is viewed as the greater harm. Because storage and conveyance are not viable options to reasonably reduce the risk of coastal storm surge flooding as applied to the fully developed Charleston Peninsula, and would themselves introduce some of the same adverse effects, perimeter protection in the form of a storm surge wall is essential, and is in the public interest. Efforts to avoid and minimize harm to NHLs and other historic resources are ongoing, and will continue in PED.

For both Sections 106 and 110(f), adverse effects from the undertaking may be avoided or minimized by storm surge wall design, gate placement, or design of a study feature consistent with the SOI's Guidelines on Flood Adaptation for Rehabilitating Historic Buildings, the SOI's Standards for Rehabilitation, or other appropriate historic resource guidelines or standards. Minimization provided by storm surge wall design or other constructed feature design can include but is not limited to: improvements to overall alignment, high-quality construction materials, contextualization of design and materials to specific location on the peninsula, ability to double as active park/recreational space, integrated public art or landscape features, and enhanced community experience. With the exception of adverse effects to the NRHP-listed and NHL-designated COHD, USACE is deferring final identification and evaluation of historic properties until after study approval, additional funding becomes available, and prior to construction by executing a PA with the South Carolina SHPO, the NPS, the ACHP, the City of Charleston, the Catawba Indian Nation, Historic Charleston Foundation, and the Preservation Society of Charleston. This PA details additional historic property inventories necessary in PED to identify and assess the eligibility of historic properties, how USACE would determine effects of the study on historic properties, the levels of design review necessary to avoid and minimize adverse effects to historic properties, archaeological monitoring requirements, the development of vibration monitoring and/or protection plans, procedures for inadvertent discoveries or adverse effects, and mitigation methods and procedures. The PA covers both Section 106 and 110(f), and has incorporated the input of the signatories with regard to the implementing the requirements for both sections of the NHPA.

Mitigation for adverse visual and cumulative effects from construction of the storm surge wall to the COHD would include an update to the NRHP Nomination Form and the NHL Nomination Form, production of short report, creation of GIS files, and creation of educational materials. The nomination form updates would include updating the period of significance, providing a comprehensive inventory of contributing properties, and a review and potential update to the boundary and areas of significance. The revised Nomination Forms would also include an archaeological context and identify any contributing and/or individually eligible archaeological sites. In addition to the update, a short report that details the COHD narrative description, COHD significance, a comprehensive list of historic properties that contribute to the COHD, and a short summary or table of each individual property that denotes physical address, Universal Transverse Mercator (UTM) coordinates, construction year, and any other information that is relevant to its significance would be prepared. Site forms and GIS locations of all individually eligible or contributing properties would be provided to SC DAH for ArchSite update. Information utilized to update the NHL and NRHP forms and short report would also be utilized to create educational materials, such as brochures and/or online story maps, for distribution through SHPO, NPS, Historic Charleston Foundation, and the Preservation Society of Charleston.

Although Alternative 2 would cause an adverse effect to COHD and has the potential to affect additional historic properties within the APEs, construction of the new storm surge wall would protect hundreds of cultural resources and historic properties when compared to the No Action/Future Without Alternative. USACE recognizes that significant historic districts and properties in and around the peninsula of Charleston are an integral part of the community's life and character; and preservation of this irreplaceable heritage is in the public interest. The knowledge and identification of the Charleston Peninsula's historic resources, together with the goal of preserving the integrity of these resources, would improve the planning and execution of the study. USACE is committed to considering the avoidance and minimization of adverse effects to historic properties in its design of the storm surge wall and other study features during the PED phase of the study. USACE further recognizes its responsibilities under Section 110(f) of the NHPA minimize harm to any affected NHLs. Both beneficial and adverse effects of Alternative 2 have been considered under the NEPA process, Sections 106 and 110(f) of the NHPA, and other relevant federal preservation laws through consultation and development of a PA with the South Carolina SHPO, the NPS, the ACHP, the City of Charleston, the Catawba Indian Nation, Historic Charleston Foundation, and the Preservation Society of Charleston. A record of this correspondence and the PA is provided in Appendix D.

6.12 Recreation

6.12.1 No Action/Future Without Project Alternative

Under the No Action Alternative, climatic changes such as rising sea levels and increasing coastal storms, along with human use patterns such as population growth, are expected to continue over the next 50 years in the Charleston area. T Predicted climate change impacts have the potential to cause changes in the nature and character of the recreational use in the ROI.

The City would use its most current comprehensive plan, Sea Level Rise Strategy (City of Charleston, 2019a), and the City's Parks and Recreation Master Plan (City of Charleston, 2021b) to guide recreational use decisions that support adaptation to shallow coastal flooding. However, recreational facilities and open spaces on the Peninsula are already at risk of storm surge damages because there are no reduction measures in place. Areas and facilities closest to waterways are subject to shoreline erosion and inundation that sometimes causes closures and cancellations of events. Under the No Action Alternative, it is expected that these areas and facilities would be at even greater risk of storm surge impacts in the future.

6.12.2 Alternative 2 (perimeter structure + nonstructural)

<u>Effects on Parks</u>
It is assumed that the City's projects and initiatives described under the No Action Alternative would be implemented under Alternative 2. The conceptual footprint of the storm surge wall on land would directly impact only one public park in the ROI. At Brittlebank Park, parts of the park would need to be excavated in order to place the wall, resulting in a permanent loss of open space at the footprint of the wall. Landscaping, including trees, and any recreational features, such as benches, trails, playgrounds, that are in the footprint would be redesigned and replaced in an alternate yet suitable location in the park. These impacts to recreational use of Brittlebank Park would be permanent; however, access to the park and pier would be maintained with the addition of access gates, reducing the overall impact at the park.

The conceptual footprint of the storm surge wall would also be positioned along roadways that are in close proximity to parks in some places, which could lead to minor effects. Access to some parks from the roadways may be altered by the wall and redirected through access gates. Parks that are in close proximity to the conceptual footprint of the wall include Waterfront Park, Hazel Parker Playground, and White Point Gardens and these parks would remain accessible in the long-term. Aesthetics impacts to these parks and other recreational area are described in Section 6.13 - Visual and Aesthetics. Effects of the wall on walkways and bike paths are discussed in relation to pedestrian transportation in Section 6.17 - Transportation.

No recreational features or uses would be affected by nonstructural measures. The proposed living shoreline sills would not have adverse effects on recreation. However, at specific locations such as along Brittlebank Park, the living shoreline sills would have a beneficial effect on reducing wave action and erosion near the base of the proposed wall and at the marsh edge of the park along the Ashley River, parts of the park that lie seaward of the proposed storm surge wall more resilient to coastal storms.

<u>Construction Related Effects</u>
Some recreational areas could be temporarily affected during construction. During construction of the storm surge wall and related features, some areas may need to be closed or restricted (including at locations of temporary construction staging areas) that may temporarily limit recreational use of open spaces, public parks and marinas. These impacts would be considered short-term and minor. Construction of the nonstructural measures and living shoreline sills would not be expected to adversely affect recreation.

<u>Effects on Boating</u>
No recreational water features or uses on the Cooper River-side would be affected by the storm surge wall. The storm surge wall in the marsh could indirectly affect recreational boating on the Ashley River-side of the Peninsula. Based on the conceptual footprint of the storm surge wall, the alignment of the wall would be on the land-side of the City Marina and two private marinas. The wall would not limit boat access at these locations, but pedestrian access from the land-side to the marinas would be redirected through gates. These marinas may also experience temporary reduced access during construction, but all reasonable measures would be taken through construction staging to limit this.

At Halsey Creek off the Ashley River, it is currently unknown if the tidal creek is used by small-craft recreational boaters in the Wagener Terrace neighborhood. The conceptual footprint of the storm surge wall with sluice gates would limit recreational boating access from the interior of the creek. However, recreational boating access would be available near the mouth of Halsey Creek from the City of Charleston property that aligns it. Therefore, the effect of the wall on recreational use at Halsey Creek would be minor.

The nonstructural measures and pump feature would have no direct or indirect effects on boating. Once the oyster reef-based living shoreline sills are implemented, the low-profile reef structures may limit some light and shallow recreational boats that could access the natural shoreline without the project, such as kayaks, in these areas. Since other areas of shoreline and marina facilities could still be accessed, this effect of the NNBF on boating would be considered insignificant.

6.13 Visuals and Aesthetics

6.13.1 No Action/Future Without Project Alternative

This section describes the effects of the No Action Alternative on visual and aesthetic resources. The Visual Resources Assessment Procedure (VRAP) determines the difference in aesthetic quality between the without-project future and with-project future conditions, utilizing the Management Classification System (MCS) and Visual Impact Assessment (VIA) Procedures. First, the study area was assigned an MCS category which describes the degree and nature of adverse effect acceptable for that category. Next, a VIA was conducted and organized around the five landscape components of water, landform, vegetation, land use, and user activity to determine the nature and magnitude of effects. Once the VIA value was determined, it was then evaluated in the context of technical, institutional, and public considerations to determine the significance of the effects.

Water

The Ashley and Cooper Rivers and the Charleston Harbor are large and generally swift moving. Under the No Action Alternative, places people currently go for views of the water may periodically be closed for repairs due to damages from coastal storm surge. Additionally, some of the views may change over time due to SLR and repeated coastal flooding gradually eroding and inundating the landscape, with the potential for these viewpoints to be rendered inaccessible.

Landform

The Charleston Peninsula has a coastal landform. In No Action Alternative, views across marshes and large waterbodies to low-lying neighborhoods would be similar to the present condition for a while, but in the future without project condition SLR and repeated coastal flooding would gradually erode and inundate the landscape. Coastal storm surge could speed erosion, therefore causing further alteration of the landscape and its views. Additionally, coastal storm surge could contribute to periodic closures or inaccessibility of the viewpoints from which the landform can be seen.

Vegetation

Vegetation cover and diversity varies by location. With the No Action Alternative, vegetation would be exposed to coastal storm surge that could change its presence or condition abruptly. Additionally, over time the vegetation would slowly change, and in some cases possibly disappear, due to SLR and repeated coastal flooding.

Land Use

The peninsula has many land use types, but those observed included urban and suburban intensities of residential and residential/commercial mix with a public park, recreational walkway, or public right-of-way amenity present or very close. Marinas and other coastal land uses were often in view. Mostly local or secondary streets were the means of access, but a heavily trafficked primary street was a key access and land use in one observed location.

With the No Action Alternative, land use may be similar to the existing condition for a while but is dependent upon the frequency and severity of coastal storm surge that could damage buildings and eventually contribute to changes in land use. Public parks, recreational walkways, and public right-of-way amenities may also be similar to the existing condition for a while, but subject to periodic closures from coastal storm surge damage. Streets and sidewalks would be similar to the existing condition, dependent upon the frequency and severity of coastal storm surge that could contribute to periodic closures for repairs. Additionally, in some locations SLR and repeated coastal flooding would contribute to the land itself disappearing, and land use would change in response, including the possible loss of structures and amenities, and the possible need to reconfigure or relocate roads and/or sidewalks.

<u>User Activity</u>
User activity often includes vehicular traffic both on water (motor and sail boats) and on land (cars, trucks, motorcycles), as well as people out individually or in groups, often by foot and sometimes bicycle, engaged in recreational activities as well as daily life tasks such as commuting or doing chores. Under the No Action Alternative, user activity would be similar for a while, assuming the places the activities are occurring have not been damaged by coastal storm surge and are open. However, in some locations SLR and repeated coastal flooding would erode and inundate the landscape and change what activities could be supported.

For more information on the VRAP Procedure, or the site inventories that led to this description of the No Action Alternative, see Appendix A - Visual/Aesthetic Resources Assessment.

6.13.2 Alternative 2 (perimeter structure + nonstructural)

This summary describes the effects of the Alternative 2 on visual and aesthetic resources and is based on Basic VIA Forecast description in Appendix A - Visual/Aesthetic Resources Assessment. This summary is organized by the five landscape components of water, landform, vegetation, land use, and user activity. Management measures included in Alternative 2 that have the potential to affect aesthetic resources include structural, nonstructural, and natural and nature-based features.

It is important to note that the aesthetic assessment for Alternative 2 was conducted in August and September of 2020. Most of the project measures and features of Alternative 2 were not yet well defined in August/September of 2020. Therefore, the aesthetic resources assessment focused on evaluating the storm surge wall as it was conceptualized at that time, in order to generalize affects on aesthetic across the proposed plan as a whole.

<u>Water</u>
The Ashley and Cooper Rivers and the Charleston Harbor are large and generally swift moving. In the future with project condition, the Ashley and Cooper rivers and the Charleston Harbor would remain large and generally swift moving. The places people go for views of the water would be more persistent and reliably accessible due to the protection provided by the wall, but the aesthetic experience of the water may be different. What the differences are would vary by location but may include the following: the waterbody may be similarly visible, visible but more screened, and/or no longer visible. Note that more than one of these may simultaneously be true in the same given location, dependent upon the viewer's vantage point. For example, the view at Lockwood Drive would be entirely gone for vehicular traffic, but still visible by pedestrians from the path on the wall (see Appendix A - Visual/Aesthetic Resources Assessment for more details).

<u>Landform</u>
The Charleston Peninsula has a coastal landform. In the future with project condition, access to views across marshes and large waterbodies would be more persistent and reliable due to the protection provided by the wall, but the aesthetic experience of the coastal landform may be different. What the differences are would vary by location but may include the following: the coastal landform may be similarly visible, the horizontal aspect of the coastal landform may be less perceptible, and/or the wall may block the ability to see the coastal landform.

<u>Vegetation</u>
Vegetation cover and diversity varies by location. In the future with project condition vegetation on the outside of the wall would remain exposed to coastal storm surge that could change its presence or condition, but vegetation inside the wall would have increased presence and improved condition due to the reduction of damage from coastal storm surge as well as SLR and coastal flooding. The aesthetic experience of vegetation may be different in the future with project condition. What the differences are would vary by location but may include the following: the view of vegetation may be similar, the view of vegetation may be partially screened, and/or vegetation or the view of vegetation may be lost.

<u>Land Use</u>
The peninsula has many land use types. In the future with project condition land use would be more persistent and accessible more reliably due to the protection provided by the wall, but the experience of the land use may be different. What the differences are would vary by location but may include the following: land use may be similar, or connections between land uses may be more focused through gates where land use on the inside of the wall is more protected and land use outside the wall is not, and/or the wall may change the character of the landscape to such a degree that the land use around it is affected in ways difficult to predict.

User Activity

User activity varies by location. In the future with project condition the places people engage in activity would be more persistent and accessible more reliably due to the protection provided by the wall, but the activity, or the experience of it, may be different. What the differences are would vary by location but may include the following: user activity and the experience of it may be similar, or user activity would be similar, but the experience of the activity would be different with lost or changed views, or user activity would be similarly available but less utilized due to lost or changed views.

Technical, Institutional and Public Considerations

As noted above, a determination of the significance of an adverse impact involves consideration of technical, institutional (laws and policies that affect visual resources), and public (expressed public perceptions of visual impacts) factors. As a general matter, USACE recognizes that aesthetic resources in and around the Charleston Peninsula are an integral part of the community's life and character and that addressing these resources with care is in the public interest.

For more detail regarding these considerations, or on the VRAP Procedure generally, or the site inventories that led to this description of Alternative 2, see Appendix A - Visual/Aesthetic Resources Assessment.

Summary of Effects on Aesthetics based on comparison of Alternative 2 with the No Action Alternative

Based on evaluation of the proposed storm surge wall using the VRAP method, there is the potential for significant adverse effects to visual resources. The study area was assigned an MCS of "Preservation Class" to reflect the unique and distinctive visual quality of the Charleston Peninsula. The VIA resulted in a VIA Value of - 1.80, which is outside of the acceptable adverse effect level for the Preservation Class. Finally, in light of institutional and public considerations, the determination was made that the effects were significant. Specific effects identified are summarized below.

Aesthetic Effects

Implementation of a storm surge wall under Alternative 2 would result in a permanent landscape feature, leading to the following changes in visual resources. The wall is typically dominant and often only somewhat compatible due to Charleston being a coastal landscape commonly holding panoramic views of water. The wall, being an enclosure by design, often blocks these views and becomes a dominant feature in a now enclosed landscape. The wall is characterized as only somewhat compatible because in many places it disrupts the current harmony with the coastal landform, causing the broad and open experience currently available to be lost. Although Alternative 2 may have a significant adverse effect on aesthetic resources, construction of the proposed storm surge wall would provide significant benefits in the form of protecting the

Peninsula's abundant aesthetic resources from the risk of storm surge inundation and resulting structural damage; the No Action/Future Without Alternative would not offer such protection.

Final evaluation of aesthetic resources will occur during the PED phase, assuming authorization of a project and the availability of funds, and prior to construction. At that time, the aesthetic resources assessment would address the optimized plan as presented elsewhere in the main report.

<u>Mitigation of Aesthetic Effects</u>

"Mitigation" with regard to effects on aesthetic resources refers to avoidance, minimization, rectifying, reducing or eliminating, or compensating for adverse impacts. The VRAP identifies that the visual quality objectives to pursue include the following:

- to identify the visual elements characteristic of the landscape;
- to identify ways to borrow at least partly from visual elements of the surrounding landscape;
- to identify ways that contrast can be reduced unless the recommended plan (in this case the Tentatively Selected Plan, which is Alternative 2) has symbolic value, informative significance, and/or creative design that cause contrast to be a desirable characteristic;
- to identify the aesthetic impacts to the landscape; and
- to identify if mitigation may be necessary to assure compatibility.

There are many ways the adverse aesthetic effects of the project could be mitigated, such as:

- storm surge barrier design such as the ability to walk on top, or near the top, of the wall in order to regain panoramic views;
- gate placement that provides relief to the dominance of the wall, or enhances its compatibility;
- alignment improvements such as locating/relocating the wall close to other existing dominant features or features of a large scale, so that the wall's relative dominance is more subordinate;
- design for the ability to double as civic amenity and/or user-activated space;
- integration of public art or landscape features for enhanced community experience, some of which may also assist with reducing scale contrast;
- contextualization of design and materials to specific locations;
- high-quality construction materials; and
- use of vegetation, such as trees that are large at maturity, to provide features that are potentially co-dominant.

ER 1105-2-100, C-5 provides guidance that the levels of project costs for aesthetics during the PED phase should remain consistent with those projected during the feasibility phase. During the feasibility study, a rough order of magnitude and preliminary cost estimate for aesthetic mitigation was developed by USACE using concept designs produced by the City of Charleston.

The resulting draft aesthetic mitigation cost estimate included in the Alternative 2 cost estimate is approximately $5.6M for aesthetic assessment during PED, and approximately $53.9M for first cost construction.

Federal funding for aesthetic mitigation is subject to reasonable limits and may not provide for the cost-sharing of some aesthetic measures desired by the City. The VRAP method provides one method for USACE to determine what is reasonable.

If the City desires an aesthetic measure beyond what is determined necessary by USACE to mitigate significant impacts, then the City may elect to pursue any aesthetic measure through betterments that are funded 100% through the City. These betterments will need to meet the goals and objectives of any Chief's Report resulting from the Charleston Peninsula Coastal Storm Risk Management Study, and cannot compromise the engineering integrity or environmental compliance of a proposed project. Once the PED phase is entered the VRAP would be continued and would inform mitigation and the refinement of the project.

In recognition of just how important aesthetic considerations are for the proposed project, USACE and the City have jointly developed a Memorandum of Understanding (MOU) to ensure a common framework and process for their continued cooperative partnership in the assessment of aesthetic resource effects and mitigation. The MOU is intended to guide the path forward for continued aesthetic assessment as the study moves from the feasibility into the PED phase. Among other things, the MOU addresses the general process, roles, responsibilities, limitations, and goals which USACE and the City recognize for the assessment of aesthetic resources, including with regard to public involvement and the development of appropriate mitigation measures. The draft MOU is included in Appendix A - Visual/Aesthetic Resources Assessment.

6.14 Air Quality

6.14.1 No Action/Future Without Project Alternative

Under the No Action Alternative, it is expected that the City of Charleston's drainage projects would be constructed in the future, contributing minor temporary impacts to air quality. It is assumed that the Charleston Green Plan (City of Charleston, 2010) would be used to guide decisions about activities that reduce greenhouse gases, which might have a slight effect on improved air quality in the future.

6.14.2 Alternative 2 (Perimeter Structure + Nonstructural)

With Alternative 2, it is expected there would be a temporary and localized reduction in air quality during construction of primarily the storm surge wall and features, and to a lesser degree for the nonstructural measures, due to emissions. Emissions would be generated from heavy construction equipment and supporting machinery operating in the area where construction occurs. Construction activities would cause minor, short-term air quality effects in the form of fugitive dust or airborne particulate matter from earthwork and unpaved roads accessed for the construction. Short-term loadings of internal-combustion engine exhaust gases would be negligible. No heavy equipment would be used for construction of the reef-based living shoreline sill feature, although small, motorized boats may be used to access the intertidal zone for construction of the sills. The contribution to emissions would be minimal.

To help minimize construction emissions, reduced idling practices, cleaner fuels, and emission retrofits for construction equipment would be used whenever feasible. Any restrictions due to volatile organic compounds would be covered in Material Safety Data Sheets included in designs, plans, and specifications and the environmental protection plan for construction. Construction could be phased, reducing the potential for cumulative air impacts from multiple construction sites. Diesel engines used to power the hydraulic pumps if electrical power is lost during a storm event would also produce temporary, minimal emissions. All Federal actions must be consistent with state plans for implementing the provisions of the Clean Air Act Amendments (State Implementation Plans). Alternative 2 would be in conformance with the State Implementation Plan because it would not cause violations of the National Ambient Air Quality Standards. Therefore, minor, short term adverse effects would occur to air quality with Alternative 2.

Since this action and any foreseeable future actions would be required to comply with federal and state air quality standards, compliance with these standards would minimize any adverse cumulative effects of the actions.

6.15 Noise

6.15.1 No Action/Future Without Project Alternative

With the No Action Alternative, it is assumed that the City of Charleston would continue to enforce its current noise ordinance, so levels within the city would be expected to stay about the same as they are now. It is expected that the City of Charleston's drainage projects would be constructed in the future, contributing minor temporary impacts to construction noise and low-level noise from their pump stations. It is unclear whether noise levels from other sources around the greater Charleston area, such as from air and marine transportation, would change in the future, but an analysis of this range of alteration is beyond the scope of this feasibility study.

6.15.2 Alternative 2 (perimeter structure + nonstructural)

This alternative assumes that the City of Charleston's new noise ordinance would be in place in the future. Most of the measures and features in Alternative 2 would not have any permanent effects on noise. The only source of permanent noise that would be generated is from the new pump stations. Since the size of the proposed pump stations are consistent with pump stations already operating in the study area and these would be only occasionally and temporarily used, it is assumed that the pumps would be in compliance with the local noise ordinance and have a marginal effect on people or wildlife in the ROI. Any other noise effects from this alternative would be related to construction activities and would be temporary and insignificant with minimization measures. As described in Section 4.15, the City's noise ordinance limits most construction-related noise to 7:00AM to 7:00PM on weekdays, and from 9:00AM to 7:00PM on Saturdays.

Construction Related Effects

There is the potential for adverse noise effects from construction of the storm surge wall and nonstructural measures proposed in Alternative 2. The noise levels would be expected to be typical of construction sites, which include: backhoe (maximum noise level: 80.0 dBA10); compactor (maximum noise level: 80.0 dBA); dozer (maximum noise level: 85.0 dBA); dump truck (maximum noise level: 84.0 dBA); excavator (maximum noise level: 85.0 dBA); front end loader (maximum noise level: 80.0 dBA); tractor (maximum noise level: 84.0 dBA); impact pile driver (maximum noise level: 110 dBA).

The EPA recommends an average 24-hr exposure limit of 55 dBA outdoors to protect the public f health and welfare in residential areas; however, noise abates at a level of -6 dBA per 50 feet away from the source. Within 400 feet away from a construction site, noise due to construction is expected to be about 10dBA higher than ambient noise. Noise sensitive zones of schools and medical facilities are not found immediately adjacent to proposed construction sites but are in close proximity. Construction would take place within a few hundred feet of residential areas, businesses, and hotels in a number of locations. People on the peninsula would be the most likely to be adversely affected by noise. Hotels and business in West Ashley that are in the ROI are over 400 feet away. Communities in the North Charleston Neck would not be in close proximity to construction of the storm surge wall but would be close to where nonstructural measures are planned in the Rosemont neighborhood. In general, less construction equipment and shorter time would be needed for the nonstructural measures which are more typical of residential construction, and would not be considered a major construction effort. As such, the effect is expected to be considerably less than for constructing the storm surge wall.

Construction related noise from the measures and features in Alternative 2 also have the potential to adversely affect fish and wildlife. Terrestrial wildlife species that are able to flee would likely avoid the construction areas due to the noise and human activity, but this would temporarily displace them. Noise associated with the pile driving would be the primarily effect on aquatic resources if the sound travels through water. However, most of the of the pile driving that would occur for the 1.5 miles of storm surge wall in the marsh would be where water depths range from a few inches to a few feet across the tidal cycle, which limits sound traveling through water and thus noise exposure to aquatic resources. Since construction of the oyster reef-based living shoreline sills would not use any heavy equipment, the sills would have no considerable effect on noise.

The potential for adverse noise effects would be minimized by adhering to the City of Charleston's noise ordinance which would limit the times of day when most construction would occur, and thus exposure. In areas where pile driving would occur in open water rather than in the marsh, pile driving would be limited to low tide, when water depths would only be a few feet. This would further limit underwater noise exposure for aquatic resources from pile driving to once a day when adhered to in combination with the City's noise ordinance. While the ROI experiences diurnal tide cycles, only one low tide is likely to occur each day during the City's allowable construction timeframe. This would primarily apply to construction of the storm surge wall by the current U.S. Coast Guard Station on Tradd Street. Nearshore elevation (topobathy) data would be used to help define a low-tide construction window prior to construction.

6.16 Hazardous Materials and Wastes

6.16.1 No Action/Future Without Project Alternative

Under the No Action Alternative, it is assumed that the Koppers Co. Superfund site would still be remediated as described in Section 4.16 that would allow for mixed use development of the Magnolia Tract to occur. It is expected that the remediation would reduce the risk of any exposure that could result from future inundation disturbance at the site.

It is expected that climatic changes such as rising sea levels and increasing coastal storms, would continue over the next 50 years in the Charleston area, continuing to expose other existing hazardous waste sites to inundation and erosion, especially on unprotected shorelines without a Federal action to address these. Hazardous waste sites and facilities that handle hazardous materials would likely continue to pose some risk to the environment and human health through exposure of deposits from erosion and water contamination from inundation from storms or other flooding sources. Even aboveground storage tanks associated with residences pose a risk if damaged by future storms and flooding.

6.16.2 Alternative 2 (perimeter structure + nonstructural)

Potential Interaction Effects with Existing Sites
Although the Koppers Co. Superfund site would be remediated as described in the No Action/Future without Project Alternative so that it no longer poses a risk in the future, implementation of Alternative 2 would have no effect on the site. The planned locations of the storm surge wall and associated features is not near the Superfund site. Nonstructural measures would also have no effect on the Superfund site. While nonstructural measures are proposed in a residential area near the Koppers Superfund site, nonstructural measures are generally low impact and localized, and are not reasonably expected to interact with any hazardous materials from that site. Regardless, the risk of coming into contact with hazardous materials from the

Superfund site and having an adverse effect from Alternative 2 is assumed to not occur due to the USEPA's remedial actions.

The Calhoun Park Area CERCLA site on Concord Street is also in close proximity to the proposed alignment. However, as described in Section 4.16, this site has undergone remediation and redevelopment and considered currently protective. While it might be possible to encounter areas of remaining contamination in the subsurface, it is not expected. If needed, a Phase I and II site assessment could be performed. If contamination were to be discovered, the measures and features of Alternative 2 would be realigned to avoid the contaminated area, therefore having no effect.

Alternative 2, including the structural and nonstructural measures and gate, pump, and living shoreline features are not expected to have any effect, including cumulative, with releases from the TRI sites in the ROI.

Implementation of the storm surge wall could incidentally reduce risks of exposure to hazardous waste at some RCRA sites and facilities during storm flooding events, resulting in a slight beneficial effect. However, these entities are responsible for implementing emergency management plans for reducing risks from accidental releases/exposure.

Construction Related Effects

There is the potential to come into contact with hazardous materials in some locations during construction of the storm surge wall. This could have an adverse effect on human health or fish and wildlife by disturbing and releasing contamination. As described in Chapter 4, Section 4.15, there are a number of other CERCLA sites (not on the National Priorities List), RCRA sites, and Brownsfield sites in the study area. However, most of them are not in close proximity to where the measures in Alternative 2 would be constructed and there would be no effect. The US Coast Guard station on Tradd Street, which is listed under CERCLA and RCRA, is near the proposed wall alignment. However, the storm surge wall would be constructed in the nearshore environment, through salt marsh wetlands, which are not part of the CERCLA and RCRA site, no effect is expected.

There is the potential for adverse effects from constructing the storm surge wall near the Calhoun Park Area CERCLA site. There is also the potential for unplanned encounters with contaminants during construction of the wall in unknown locations since the wall would be located in a few industrialized areas. To minimize these potential effects, a Phase 1 Site assessment would be conducted in the PED phase, which would help to identify if there are contaminated areas where construction is planned. Normally the cleanup and removal of any hazardous or contaminated material within a project area is the responsibility of the local sponsor. If needed, a report would be prepared by the local sponsor describing the guidance on the management of materials that would be encountered during construction. The plan would provide information regarding anticipated volume and characteristic of contaminated materials identified so that there would be appropriate consideration of the transportation, treatment, and disposal of the contaminated materials, if needed. If appropriate, adverse effects from construction could be avoided by moving the wall location, to the extent practicable.

Construction of the storm surge wall and nonstructural measures would involve the use of heavy equipment. Heavy equipment would not be needed for construction of the NNBFs but small, motorized boats may be used. Typical hazardous or toxic materials, such as fuel or oil, could be present at the construction sites/laydown areas, though in relatively small amounts. To reduce the risk of releases into the environment, best management practices for handling such materials would be required of construction contractors such as proper training, use of spill plans, regular maintenance of equipment, etc. With the use of minimization measures, any adverse effects on or from hazardous materials and wastes as a result of implementing Alternative 2 are expected to be minor and temporary during construction.

6.17 Transportation

6.17.1 No Action/Future Without Project Alternative

Under the No Action Alternative, climatic changes such as rising sea levels and increasing coastal storms, along with human use patterns such as population growth, are expected to continue over the next 50 years in the Charleston area, putting more infrastructure at risk of coastal inundation. King tides, causing nuisance flooding on roads, have already increased in frequency. This trend is expected to continue into the future.

The City would use its most current comprehensive plan, Sea Level Strategy (City of Charleston, 2019a), and Citywide Transportation Plan (City of Charleston, 2018) to guide development and transportation decisions that support adaptation to shallow coastal flooding. However, under the No Action Alternative, it is expected that transportation, particularly via roads, would be at even greater risk of storm surge impacts in the future. Streets may be unpassable when flooded, resulting in altered traffic patterns and delays. Traffic delays and stranding of motorists may occur, hindering access to critical facilities on the Peninsula.

With respect to navigation, deepening of the Federal channels in the Charleston Harbor and Cooper River (and Wando River, which is outside of the ROI) that is currently ongoing would be completed by the end of 2022. Regular maintenance of the Federal channels would occur into the future. No considerable effects to waterborne transportation are anticipated under the No Action Alternative.

6.17.2 Alternative 2 (perimeter structure + nonstructural)

Land Transportation Effects

Under Alternative 2, there would be no permanent adverse effects on land-based transportation as a result of the nonstructural measures or the living shoreline sills feature. Minor effects to land-based transportation would occur near where the storm surge wall is built on land. The conceptual footprint for the storm surge wall currently aligns a number of roadways on the Peninsula, most notably Concord Street, Morrison Drive, and Lockwood Blvd. Permanent but minor alternations of roads may result. In some locations, the storm surge wall would be constructed where sidewalks currently exist, adversely affecting pedestrian transportation. This effect would be offset by constructing a walking path on top of the wall in those locations, functioning in a similar manner as the promenade on the existing Battery seawalls. Due to the elevation change, on and off ramps that are compliant with the American with Disabilities Act would be included. More information on the walking path can be found in Sub-Appendix B1 - Structural. The proposed alignment of the storm surge wall would intersect rail lines at Columbus Street Terminal so easements will need to be obtained.

Long-term, direct beneficial effects to land-based transportation would also occur in some areas of the ROI from Alternative 2. With implementation of a storm surge wall and (and closure of the gates), little to no damage would occur to most major transportation infrastructure from storm surge flooding, although rainfall-induced flooding may still occur. With flooding reduced during a storm surge event, critical and emergency facilities on the Peninsula could continue to be accessed therefore resulting in a beneficial effect. Any roads and railways outside of the storm surge wall would continue to experience shallow coastal flooding and rainfall flooding depending on municipal measures in place, and storm surge depending on their elevation.

<u>Potential Effects of Gates</u>

Gates would be installed at all transportation crossings with the wall (streets, rail, pedestrian) to allow access. More information about the road crossing and gates can be found in Appendix B - Engineering. When the gates are closed during a storm surge event, traffic would be blocked, potentially for a number of days, at those locations. At all of these locations, though, road access is available in alternate directions. This may be inconvenient but is not considered a significant effect. Gates do not intersect with any SCDOT evacuation routes. Closure of gates at rail crossings during a storm surge event would restrict rail access, but this would be temporary effect.

All gates would be closed periodically for maintenance. This would be for short durations and not concurrent, and there would be detours provided. With all storm-related gate closures, timing of the closure would be dependent on evacuation needs and anticipated storm surge levels. It is anticipated that existing emergency operation coordination with State and local agencies including the railroads would continue and include any gate operation procedures. Gate maintenance and operation procedures would be refined during PED and included in the Operations and Maintenance Manual.

USACE would continue to look at ways to reduce effects of the storm surge wall on transportation by examining ways to reduce the number of gates in the wall.

Construction Related Effects

Prolonged temporary effects to land-based transportation would occur during construction of the storm surge wall and associated access gates on land. Road closures in the vicinity of the T-wall construction may be needed, as is the case in most development and infrastructure projects in urban environments. These closures would be temporary but may last a number of months. Similar effects may result during construction of the pump stations but are not expected to last as long. Construction may be phased, which would minimize the potential for a cumulative effect on traffic delays at multiple construction sites. Prior to the construction phases, coordination with USACE, the City, SCDOT, and railways would occur to develop a traffic plan to help minimize impacts to any closures during construction. Construction of the reef-based living shorelines would occur primarily from the water-side and could have a temporary, minor effect of increased boat traffic near the shoreline sites during construction.

Implementation of nonstructural measures under Alternative 2 may result in minor, temporary effects during construction of flood-proofing or home raising measures to transportation in roadways or walkways in the immediate vicinity. It would not result in any permanent effects to transportation or navigation.

Water-borne Transportation Effects

The measures in Alternative 2 would have minor effects on navigation and transportation through the water. Where the wall would be constructed off the shoreline (not on high ground) it would primarily be in the marsh where boats do not typically operate. Where it would be in open water, it is at very shallow depths and not in close proximity to Federal navigation channels.

Effects on marine commerce operations or transportation from the wall at Columbus Street Terminal and Union Pier have been minimized by placing the wall in strategic locations away from critical port operations and access gates have been added as needed. This was done in coordination with the SCPA. The wall would intersect the US Coast Guard Station's dock off of Tradd Street; however, an access gate would be included.

Since the oyster reef-based living shoreline sills would be installed in intertidal zone of the shoreline between the low tide and high tide line, not in the subtidal zone, they are not expected to interfere with primary navigation in the Ashley River or other waterways. As with natural oyster reefs, the sills may inhibit small recreational boats from accessing the shoreline where no dock or marina facilities exist. This effect on water-borne transportation would be minimal.

6.18 Utilities

6.17.1 No Action/Future Without Project Alternative

Under the No Action Alternative, climatic changes such as rising sea levels and increasing coastal storms are expected to continue over the next 50 years in the Charleston area. King tides, causing nuisance flooding, have already increased in frequency. Population growth is expected to continue over the next 50 years in the Charleston area, putting more demand on utilities. It is assumed that the City and the utility companies would continue to make incremental improvements and upgrades to utilities on the peninsula. However, above ground utilities in the study area would still be increasingly susceptible to storm damage and coastal inundation. When power goes down during a storm (also due to wind damage), residences, business and emergency services are disrupted, sometimes for days.

The City would use its most current comprehensive plan, Sea Level Rise Strategy (City of Charleston, 2019a), Stormwater Management Plan, and Master Drainage Plan to guide decisions on stormwater management and other utilities that support adaptation to shallow coastal flooding and sea level rise. It is assumed that the City's Phase III Market Street Drainage Improvement Project and Phase III and IV US 17 Spring/Fishburne Drainage Improvement Projects would be completed. It is expected that the remainder of the drainage projects would be implemented in the future to address rainfall flooding. As the City adds check valves to existing stormwater outfalls into the future, this would have a beneficial impact on the effectiveness of stormwater management on the peninsula.

6.17.2 Alternative 2 (perimeter structure + nonstructural)

It is assumed that the City's projects and initiatives described under the No Action Alternative would be implemented under Alternative 2. Permanent effects on utilities from implementation of Alternative 2 would be beneficial, while temporary construction-related effects would be adverse but minor.

The storm surge wall would have a beneficial effect on the stormwater management system during a storm event by reducing surge flooding and by the hydraulic pumps reducing excess rainfall flooding so the interior drainage system can operate more effectively (see Appendix B - Engineering). Power, gas, and presumably telecommunication utilities that are located inside of the storm surge wall would also have the beneficial effect of reduced damages from surge flooding, potentially reducing disruptions in service.

During construction of the storm surge wall, utilities and recipients of those services could be adversely affected. The storm surge wall has the potential to disrupt stormwater outfalls, electrical lines, gas mains, and water and sewer lines during construction. These effects would be temporary and considered minor, and not cumulative since construction would be phased. Additionally, some utilities may need to be moved for construction of the wall but would be relocated in a suitable location. When relocating utilities, Section 30-150 of the City's Code of

Ordinance would be followed. Therefore, this impact would be considered minor. Once constructed, the storm surge wall and gates would not result in any disruption of utilities.

Implementation of nonstructural measures under Alternative 2 may require local investigations for existing utilities at those locations, such as service lines to individual buildings for gas, water, sewage, and in some cases (where lines are underground) power. Telecommunications should not be affected by the nonstructural measures. Elevation of structures is the measure most likely to require utilities investigations, including elevation of local utilities that service individual buildings. Local actions may include raising of HVAC structures, power substation raising, and possibly relocating and/or altering water service lines. Such impacts would be minor, temporary, and limited to individual buildings and, therefore, would not be significant. Because of their location in the intertidal zone and low-impact construction methods, the reef-based living shoreline sills would have no effect on utilities.

6.19 Safety

6.19.1 No Action/Future Without Project Alternative

Under the No Action Alternative, climatic changes such as rising sea levels and increasing coastal storms are expected to continue over the next 50 years in the Charleston area. King tides, causing nuisance flooding, have already increased in frequency. Population growth is expected to continue over the next 50 years in the Charleston area, putting more people at risk. Under the No Action Alternative, it is expected that the residents and businesses of the City of Charleston would become increasingly susceptible to coastal inundation. Future projected yearly damages from coastal storms (with forecasted sea level rise) are expected to reach as much as $773 million in the study area.

The City would use its most current comprehensive plan and Sea Level Strategy (City of Charleston, 2019a) to guide development decisions that support adaptation to shallow coastal flooding and sea level rise. It is expected that the City’s new hazard risk assessment and their new Hazard Mitigation Plan would be completed and influence how the City prepares and responds to flooding, including the emergency services provided by the Police and Fire Departments.

It is assumed that the City’s future phases of the Market Street Drainage Improvement Project and US 17 Spring/Fishburne Drainage Improvement Project would be completed. It is expected that the remainder of the other drainage projects would be implemented in the future to address rainfall flooding.

Under No Action/Future Without Project Alternative it can be reasonably predicted that cumulative impacts on safety would occur from increased storm surge flooding, tidal flooding, climate change, erosion, and other factors. The City of Charleston is located at a low elevation and surrounded mostly by waterways, which presents additional challenges for drainage when there is a limited drainage gradient and a large tidal regime (approximately 6 feet). This results in notable areas of the City that also support infrastructure critical to life and safety being susceptible to flooding from nuisance flooding, typically associated with high tides, and to severe, but less frequent, flooding from hurricanes and tropical storms. Under the Future Without Project Alternative, erosion, flooding, and loss of wetland buffers in the City of Charleston are anticipated to continue to occur, which would put the public at risk. Widespread areas within the city would be vulnerable to flooding, leading to various potentially dangerous conditions such as flooded roadways, power outages, and stranded residents during a storm surge event due to limited or blocked transportation and evacuation routes It is assumed that the City of Charleston and their residents would follow emergency management plans and evacuation orders if they are issued for a storm surge event.

6.19.2 Alternative 2 (perimeter structure + nonstructural)

It is expected that the City of Charleston's resiliency efforts described in the No Action Alternative would continue into the future, contributing to some reduced stormwater flooding and shallow coastal flooding impacts to improve public safety.

Alternative 2, including the structural and nonstructural measures, would have long-term beneficial effects on health and safety including critical facilities and for life loss, due to the reduction of widespread storm surge flooding during major storm events. For example, storm surge damages would be reduced for the peninsula's six fire stations, two police stations, six colleges, twelve public schools, and three major health facilities. The reduced probability of storm surge inundation also translates to reduced likelihood of drowning, exposure to short-term and long-term hazards, and associated mental health consequences. Life loss modeling conducted for this study indicate that there would be approximately 105 fewer deaths by drowning over a 50-year period of analysis when comparing Alternative 2 to the No Action Alternative (see Section 7.2.1). Even though it is assumed that the City of Charleston and its residents would still follow emergency management plans and mandatory evacuation orders with implementation of Alternative 2, injuries to first responders and individuals who do not evacuate would also be reduced with this Alternative. Longer term storm impacts like mold-borne illness and mental health consequences from lost livelihoods or community dislocations would also be reduced.

The opening and closing of the multiple pedestrian, vehicle, rail gates could pose temporary, minor safety risks to the public during major storm events; however as described in the Transportation section, alternate routes would be available on roads where there would be gate closures.

Minor adverse short-term safety effect on the public (motorists, boaters, and pedestrians) and emergency services in the ROI could occur during construction of the storm surge wall and associated features, and to a lesser degree of the nonstructural measures. Temporary road closures would likely result, but alternate routes would be provided. Construction would be phased so the effects would not be additive. Construction areas would be secured from trespassers. Worker safety protocols would be followed as prescribed by the Occupational Safety and Health Act (OSHA).

No direct effects on public safety or health are expected from the NNBF proposed in Alternative 2.

6.20 Environmental Justice

6.20.1 No Action/Future Without Project Alternative

Under the No Action Alternative, climatic changes such as rising sea levels and increasing coastal storms, along with human use patterns such as population growth, are expected to continue over the next 50 years in the Charleston area, putting more people at risk of coastal inundation.

It is assumed that the City of Charleston would continue to use the Neck Area Plan (City of Charleston, 2003) to guide development decisions in this area. The City of Charleston is expected to complete its project to raise the Low Battery Wall as described in Section 1.4, which provides some reduction in storm surge damages to neighborhoods in the Battery area, but this action would not extend reduction in storm surge damages beyond the Battery area. All of the low income and minority community neighborhoods on the peninsula would remain vulnerable to storm surge flooding. Among these are the Rosemont Neighborhood, Bridgeview Village, and the public housing communities of Cooper River Court, Meeting Street Manor, Gadsden Green, and Robert Mills Manor. Additionally, embedded within the public housing communities of Cooper River Court and Meeting Street Manor is the Sanders-Clyde Elementary School. Under the No Action Alternative, it is expected that these minority communities and Sanders-Clyde Elementary School would be at even greater risk from storm surge impacts in the future.

6.20.2 Alternative 2 (perimeter structure + nonstructural)

Alternative 2 would provide significant storm surge risk reduction benefits for low income and minority (disadvantaged) communities through implementation of the storm surge wall. There are a number of low-income or minority community neighborhoods on the peninsula that would be inside the plan's primary structural measure, the perimeter storm surge wall. Among these are the public housing communities of Cooper River Court, Meeting Street Manor, Gadsden Green, and Robert Mills Manor. In addition, census tracts which are more than 50% minority or low income are encompassed within the storm surge wall. Alternative 2 reduces the storm surge risk up to elevation 12 ft NAVD88 posed to all of the City of Charleston public housing areas shown in Figure 6-16, including those mentioned above. This also includes reduction of risk to Sanders-

Clyde Elementary School, based on the perimeter structure's proposed location. The non-structural solutions in Alternative 2 provide storm risk reduction for the minority communities of Bridgeview Village and the Rosemont Neighborhood (see discussion below). As described in Section 6.19, all City of Charleston residents would be expected to follow official evacuation orders if they are issued for the Peninsula, regardless of implementation of structural and nonstructural measures in Alternative 2.

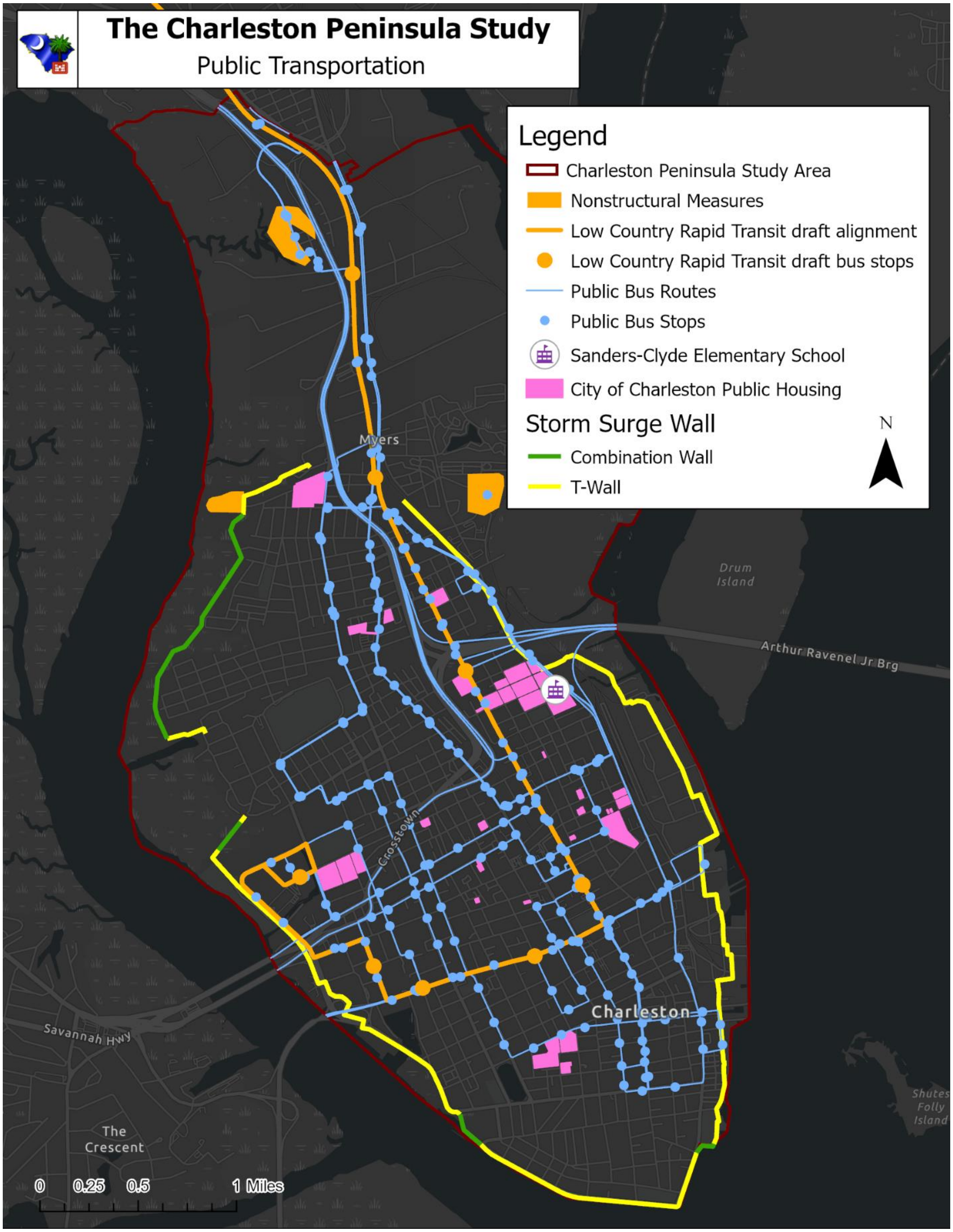

Figure 6-16. Map showing the current public bus stops and draft Low Country Rapid Transit alignment and public bus stops. This map also shows locations of public housing in the study area.

Unlike minority and low-income disadvantaged communities for which risk reduction would be achieved by a wall, Bridgeview Village and the Rosemont Neighborhood would receive nonstructural measures for storm surge risk reduction. Both are within the ROI where construction of a storm surge wall is not practicable due to topography and other constraints. Dry floodproofing and structure elevations would be used to reduce damages from storm surge.

Bridgeview Village is located on the east side of the ROI at the northern end of the study area. Large areas of marsh wetland and an adjacent large, historic cemetery would make construction of a wall for this community impracticable. Further, the ground elevation in this area is already at least 9 ft NAVD88. To avoid impacts to private property, cultural resources, and natural resources for the 3 ft of elevation (NADV88) needed to reduce impacts to structures for storm surges between 9 and 12 ft NAVD88, nonstructural measures are proposed to provide the same risk reduction to structures as the wall would provide elsewhere in the ROI. Because Bridgeview Village consists of cement block apartment style buildings, elevating these structures would not be possible. Therefore, as part of Alternative 2, floodproofing is planned for this community. Floodproofing consists of specifically designed first-floor windows and doors that seal watertight and can withstand the pressure of floodwater necessary to provide risk reduction to a three-foot depth. In the event of surge flooding with a water surface elevation of up to 12 ft NAVD88, these windows and doors would prevent water from entering the structures and reduce the risk of damages inside. In the absence of flooding, these windows and doors function like any other windows and doors, allowing required ingress/egress. North Romney Road, leading into Bridgeview Village from Morrison Drive via Romney Road floods during heavy rain and storm events, which can leave residents stranded and restrict access for emergency vehicles. While this type of flooding and drainage issue is not within USACE's authority to implement as part of this study, USACE would recommend that this access road be realigned/elevated to reduce flooding and ensure access during flood events.

The Rosemont Neighborhood is a community at the far northern end of the ROI along the Ashley River. Unlike Bridgeview, Rosemont consists of detached single-family homes. This community dates to the 1950s. The area is historically minority occupied and continues to be a minority community to be considered for environmental justice issues. This community has been negatively impacted in the past by the construction of Interstate 26 and industrial growth, resulting in cumulative effects. These impacts from existing conditions, along with the proximity of a large marsh wetland have resulted in flooding concerns for the residents. Similar to Bridgeview Village, construction of a wall in this area is constrained due in part by potential marsh wetland impacts, and the proximity of homes in this area being built very close to the shoreline. Construction of the wall on land would require involuntary buyouts of homes along the marsh wetland, further disrupting community cohesion. Topographically, the natural tie-in for a storm surge wall would be located on the eastward side of I-26, which would essentially encapsulate this community inside a wall. Given the lack of subsurface drainage throughout Rosemount, the wall would create a significant bathtub effect that would need to be mitigated by large pump stations at the end of most streets, which would in turn require significant real estate acquisition. To reduce impacts to private property and natural resources, Alternative 2 would include non-structural measures – primarily home elevation – for those structures with first floors not already at or above 12 ft NAVD88. Home elevation would be voluntary and would lift flood prone properties to an elevation above 12ft. NAVD88 to reduce the risk of storm surge flooding damages. Identification of the particular homes to be elevated and homeowners' voluntary commitment to home elevation would occur during the PED phase. Details of eligibility for temporary relocation assistance for tenants would also occur during the PED phase. It is the expectation that these residents would return to their homes in the Rosemont Neighborhood after the home elevations are complete. Other federal programs, such as those offered through Housing and Urban Development (HUD), could be leveraged to provide improvements to homes as needed to successfully elevate some of these homes. As with the Bridgeview area, roads in Rosemont are prone to flooding from heavy rains. USACE would recommend that local city and county entities address this issue in concert with home elevation for a more comprehensive solution to the flooding concerns in this neighborhood.

Finally, the public housing communities of Cooper River Court and Meeting Street Manor, located nearer to the center of the Peninsula, while benefiting from reduced storm surge impacts by the storm surge wall, could be indirectly affected by the wall because it could reduce access to public transportation during construction. To minimize this, adaptive management for City Bus Routes during and following construction of the storm surge wall would occur to reduce impediments of access to public transportation posed by the storm surge wall for these communities, and therefore would not be significant. Figure 6-16 shows the current bus stops for Low Country Rapid Transit throughout the Peninsula.

The living shoreline sill feature proposed in Alternative 2 would provide improved resilience to natural shorelines along the Ashley River from coastal storms and are not intended to provide benefits to any particular community in the study area. No permanent adverse effects from the reef-based living shoreline sills would occur, and any adverse effects during construction would be localized, temporary, and minor.

USACE has evaluated minority and low-income populations and disadvantaged communities around the Peninsula that could potentially be affected by the storm surge wall and associated features. These communities are not expected to experience environmental effects from the storm surge wall that would be disproportionately high and adverse compared to other communities affected by the storm surge wall. Indeed, one of the strengths of the proposed Alternative 2 is that the storm surge wall would provide protection to a cross-section of socio-economic communities on the peninsula, and that protection would be augmented by nonstructural measures, which encompass additional low income and minority communities where a wall is not practicable.

There are no indications that implementation of Alternative 2 would be contrary to the goals of Executive Orders 12898, 13985, 14008 or would it create disproportionately high and adverse environmental effects for minority or low-income populations or disadvantaged communities in the ROI. The perimeter structure is not expected to displace water to EJ communities outside the wall nor does this plan present any material environmental health or safety risks to children as directed under Executive Order 13045.

6.21 Climate Change

6.21.1 No Action/Future Without Project Alternative

Under the No Action Alternative, climate change trends are expected to continue into the future, resulting in increased sea levels, air temperatures, ocean temperatures, ocean acidification, and changes in currents, upwelling, tropical events, precipitation and other weather patterns. Warmer ocean temperatures would provide more energy to hurricanes creating conditions for more intense storms in the future.

The Charleston Harbor tide gauge has been measuring sea level since 1899 and continuously since 1921, which can be used to estimate future sea level rise. In that nearly 100-year time span, local sea level has risen 1.07 feet. The City of Charleston has also experienced a marked increase in the number of days of "minor coastal flooding" over time, which will increase along with rising sea levels. Similarly, the water table below Charleston will continue to rise, limiting the effectiveness of gravity drainage post-storm. Assuming an intermediate rate of sea level rise, it is estimated that water levels in the Charleston Harbor would increase 1.65 feet over the 50-year study period (through 2082). Subsidence also affects relative sea level rise as soil deposited naturally or placed by humans in the intertidal zone compacts over time. There is the possibility for synergistic effects from a combination of climate change factors, including sea level rise and an increase in the frequency and strength of storms, to increase the risk from coastal inundation in the coming years for City of Charleston if the No Action Alterative is implemented, however such an analysis is beyond the scope of this feasibility study.

It is expected that the City of Charleston would use its Flooding and Sea Level Rise Strategy (City of Charleston, 2019a) to guide future decisions that support adaptation and resilience to climate change. It is unclear how actions taken by the City or others would directly influence greenhouse gas emissions and climate change in the future.

6.21.2 Alternative 2 (perimeter structure + nonstructural)

Effects from Alterative 2 on climate change through greenhouse gas emissions produced during construction of the structural and nonstructural measures and use of diesel backup generators for pump stations would result in only slight increases in greenhouse gases and be below thresholds under the present status of attainment of air quality (see Section 6.14, Air Quality). No heavy equipment would be used for construction of the NNBF. Therefore, direct effects on climate change from this action are expected to be negligible.

It is assumed that City of Charleston actions taken from their Flooding and Sea Level Rise Strategy in the No Action Alternative would provide some improvement to the city's resilience against climate change impacts and would also occur under Alternative 2. Yet, implementation of the structural and non-structural measures and related features in Alternative 2 would result in a significant increase in the City of Charleston's resilience towards the impacts of climate change. USACE modeling shows that even if the high rate of sea level rise occurs into the future rather than at the intermediate rate, there is only a 2.2% probability of water elevations exceeding 12 ft NAVD88 by the year 2082 (end of period of analysis) for which Alternative 2 is designed. Structures, as well as natural areas, would be less vulnerable to the impacts of storm surge flooding in the future than with the No Action Alternative. Alternative 2 could also have a secondary beneficial effect of reducing some impacts of sea level rise and increased tidal flooding.

6.22 Cumulative Impacts

Cumulative impacts are defined by the Council on Environmental Quality (40 CFR 1508.7) as "the impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions, regardless of what agency (Federal or non-Federal) or person undertakes such other actions. Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time."

To assess the potential for cumulative impacts, USACE and City of Charleston identified past, present, and reasonably foreseeable future actions (PPRFFA) in, or reasonably near, the study area. Cumulative impacts were considered for the alternative, by examining the potential additive and interactive impacts of the alternative with the other past, present, and reasonably foreseeable future actions. The No Action Alternative is not examined for cumulative effects since there is no incremental impact. Cumulative effects have been briefly considered in the relevant environmental effects subsections, and are addressed in greater detail here. This section first summarizes the principal projects or actions evaluated for cumulative effects with the proposed action, and then addresses the key resource areas examined for cumulative effects.

6.22.1 Past, Present, and Reasonably Foreseeable Future Actions (PPRFFA)

USACE Charleston Harbor Deepening, Post 45 Project: USACE is currently undertaking a large, deep draft navigation project to deepen the Charleston Harbor (locally referred to as the Post 45 Project), including the Entrance Channel and portions of the Cooper and Wando Rivers that drain into the Charleston Harbor. The project does not include any dredging in the Ashley River. The project began in 2018. The project has recently been fully-funded, and is on-track to be completed in 2022. The Post 45 Project will have been completed for several years by the time

Alternative 2 is implemented for the current study. Some environmental conditions have been predicted to change as a result from deepening of the Charleston Harbor, particularly migration of the salt wedge up the Cooper and Ashley Rivers that would adversely impact tidal-influenced freshwater wetlands. Predicted salinity impacts to wetlands from the Post 45 Project have already been addressed through compensatory mitigation. However, the predicted impacts have launched an extensive wetland monitoring effort by USACE. Extensive baseline data have been collected to characterize existing wetlands including vegetation through both remote sensing and in situ sampling, including sediment porewater data, in affected areas for the Post 45 Project including on the Ashley River, which would continue for 5 years post-construction

USDOI/NPS Rehabilitation of the Breakwater at Fort Sumter National Monument: The National Park Service is currently planning to re-construct a breakwater at the historic Fort Sumter National Monument in the Charleston Harbor. The purpose is to protect Fort Sumter from erosion and structural damage due to wave action, intensified by forecasted sea level rise. A final Environmental Assessment and FONSI were published in April of 2019 entitled “Proposed Rehabilitation of the Breakwater at Fort Sumter National Monument.” The Federal action involves extracting existing stone riprap along the exterior foundation wall of Fort Sumer and relocating them approximately 60 feet out into the Charleston Harbor to create a breakwater. A living shoreline would be created between the breakwater and the fort walls.

City of Charleston Market Street Drainage Improvement Project, Phase III: This project's third phase would be the improvement of the surface drainage collection system to the previously installed new tunnel underneath Market Street connecting to the Concord Street pump station (which can pump about 7.2 million gallons of water out of the City in an hour). To date, 3 drop shafts along Market Street are connected to the tunnel and are already having a positive impact on localized flooding in The Market area (personal communication, City of Charleston). When complete, the entire drainage system would be greatly improved and connected to the tunnel. The sidewalks and streetscape of Market Street would also be improved. Information obtained from the archival research conducted for this and other City drainage projects would add to the archaeological database and assist in the identification of areas that have the highest potential to contain archaeological deposits.

City of Charleston US 17 Spring/Fishburne (Septima Clark) Drainage Improvement Project, Phase III and IV: This phase of the project began construction in 2016. It is a project that includes more than 8,000 linear feet of deep underground tunnels that are currently being connected to an outfall and pump station between the Ashley River bridges. This project would serve more than 500 acres of the western peninsula and would keep Highway 17 open during most rain events when complete. Phase IV is currently in construction to install the wetwell and outfall structures while a future Phase V is planned for completion in 2023. Mitigation for impacts to natural resources from the recent construction has been completed (see Ashley River Oyster Enhancement Project below).

City of Charleston Calhoun West/Beaufain Drainage Improvement Project: This is a planned project with a Preliminary Engineering Report completed in early 2020. The Calhoun West/Beaufain basin contains the Medical University of South Carolina (MUSC), the College of Charleston, Roper Hospital, and many businesses and residences that are impacted by frequent flooding. Flooding of streets poses many problems including restricting access to hospitals, diverting traffic around accumulated water, and damage to vehicles parked along flooded streets. The City of Charleston is currently planning this project for improving drainage in the Calhoun West/Beaufain drainage basin and alleviating many of the existing drainage problems. Ultimately, the project would increase the capacity of the stormwater collection and conveyance system as well as provide means to convey stormwater directly into the Ashley River during storms and tidal events via this pumping system.

Calhoun Street East Drainage Improvement Project, 1999: This was the first modern, major capital drainage improvement project completed by the City of Charleston. The project consisted of an 8-ft diameter tunnel under Calhoun Street from Marion Square to Concord Street, a 5.5-ft diameter tunnel under Meeting Street from Mary Street to Marion Square, large and small drop shafts along Meeting and Calhoun Streets, and a stormwater pump station on Concord Street with 3 pumps each capable of pumping water in excess of 30,000 gallons per minute.

Ashley River Oyster Enhancement Project: This project was completed in 2019. City of Charleston and The Citadel Foundation constructed approximately 1.3 acres of oyster reefs in this habitat enhancement project along the Ashley River as mitigation for construction projects on the Peninsula. The reefs serve as mitigation for habitat impacts from dredging of the channel off the Ashley River leading to The Citadel boat landing and pier construction there, while serving as habitat mitigation for impacts from the City's next phases of the US 17/Spring Fishburne (Septima Clark Parkway) drainage project. The reefs were constructed on the West Ashley side of the Ashley River, roughly across from The Citadel and Brittlebank Park on the Peninsula (see Figure 6-17). The South Carolina Department of Natural Resources is currently monitoring the success of the reefs.

Figure 6-17. Locations of where oyster reefs were constructed for the Ashley River Oyster Enhancement Project.

Source: City of Charleston.

6.22.2 Key Resources Areas

Wetlands

No collectively significant effects are expected from the proposed alternative and PPRFFA. Of the PPRFFA noted above, the only one with an appreciable impact on wetlands is USACE's Charleston Harbor Deepening, Post 45 Project. While the Post 45 project was expected to have a significant impact on wetlands prior to mitigation, those impacts are not expected to be cumulative with the alternative here. The projected wetland impacts of the Post 45 Project were indirect effects to tidal freshwater wetlands located outside of the ROI for this study as a result of potential migration of the salt wedge up the Cooper and Ashley Rivers. Alternative 2 would have direct impacts and anticipated indirect impacts on tidal salt marsh (versus tidal freshwater) wetlands as a result of the storm surge barrier and gates. While these are situated on the Ashley

River, they are limited to the footprint of and isolated areas behind the proposed storm surge wall and gates. In addition, it is noted that the wetland impacts for both the Post 45 Project and for the current study would each be mitigated to a negligible level of impact. It is also noted that future, unidentified actions impacting wetlands in the ROI for this study would be subject to regulatory permitting and mitigation requirements, thereby limiting any potential contribution to cumulative effects posed by these actions. Finally, the extensive wetland monitoring effort undertaken for the Post 45 project might be leveraged if it is deemed necessary to assess wetland impacts further up the Ashley River in the wetlands ROI for this study.

Aquatic Resources

The principal permanent adverse impact on aquatic resources (other than wetlands) of the PPRFFA is also due to the Post 45 Project. The primary impact of Post 45 to aquatic resources was to hardbottom habitat, for which extensive mitigation was proposed. None of the measures in the alternative would affect hard bottom habitat.

A beneficial cumulative effect is expected to result from the combination of the reef-based living shorelines proposed as part of this study and the oyster reef construction recently completed as part of the Ashley River Oyster Enhancement Project. Both would contribute to improvement of shoreline erosion and marsh resilience in this area of the Ashley River.

This study is anticipated to have minor effects on aquatic threatened and endangered species (May Affect but Not Likely to Adversely Affect). No collectively significant adverse effects on aquatic resources are anticipated from the proposed action together with the PPRFFA.

Water Quality

No collectively significant effects on water quality are expected from the proposed alternative and PPRFFA. Again, the principal PPRFFA impacting long term water quality is the Post 45 project. As noted above, the principal water quality effect anticipated for the Post 45 project was to salinity as a result of the migration of the salt wedge up the Cooper and Ashley Rivers. Any resulting water quality impacts to tidal freshwater wetlands were fully mitigated. Any water quality impacts from the alternative for the current study would be localized and not contribute to any salinity migration up the Ashley River. The Post 45 project was also determined to make a slight contribution to cumulative effects on dissolved oxygen, though that contribution was well within SCDHEC's anti-degradation rule. The alternative for the current study may contribute to an adverse effect on dissolved oxygen, but it would be temporary and localized. In terms of temporary effects to water quality resulting from construction, construction of this study would not commence until after the completion of all of the identified PPRFFA.

Historic and Cultural Resources

The cumulative effects of the proposed alternative and the PPRFFA include both beneficial and adverse effects. USACE has determined there would be adverse visual and cumulative effects to the COHD as a result of Alternative 2. These effects would be mitigated as detailed in Section 6.11. Additional adverse direct, indirect, and cumulative effects to other historic properties may be identified during PED. As noted previously, construction on any project resulting from this study would not commence until after the completion of all the identified PPRFFAs, such that cumulative effects can be identified during PED as outlined in the PA presented in Appendix D. Potential adverse effects as a result of Alternative 2 for this study may take the form of disturbance of previously undiscovered archeological sites, visual intrusions on the historical setting and viewshed, vibration damage to historic structures as a result of construction and pile driving, as well as physical impacts to any NRHP-eligible structures that may be identified for nonstructural measures.

There may be cumulative impacts to previously undiscovered archeological sites from ground disturbing activities connected with the City's various drainage projects among the PPRFFA (Market Street Phase III, US 17 Spring/Fishburne Phases III and IV, Calhoun West/Beaufain, and Calhoun East) and the Low Battery Seawall Rehabilitation Project. The drainage projects include ground disturbing activities during construction (i.e., clearing, grading, and excavation) that could potentially affect prehistoric and historic archaeological deposits. However, due to the urban nature of the Charleston Peninsula, effects to previously unidentified archaeological sites cannot be recognized until they are observed during monitoring. These projects often include appropriate mitigation provisions (for example, the Low Battery Seawall Rehabilitation Project includes a Memorandum of Agreement to ensure appropriate mitigation) which add information to the archaeological record of and would assist in the future identification of areas that have the highest potential to contain archaeological deposits. Information gathered from the PPRFFAs would be used to help minimize effects for the alternative. The stipulations of the PA for this project would ensure that the appropriate avoidance and minimization measures are updated to avoid adverse cumulative effects, and if necessary, practicable mitigation would be pursued to compensate for the project's contribution to cumulative effects.

Additional adverse visual or vibratory effects caused by the addition of new visual elements or caused by construction by the PPRFFAs has the potential to combine with Alternative 2 to create cumulative effects. The PA outlines how to avoid and minimize these effects through design of project features and monitoring plans. None of the PPRFFAs are expected to introduce adverse visual effects, apart from the City's Low Battery Seawall; however, mitigation of these cumulative adverse effects is provided in the PA. The City's Low Battery Seawall Rehabilitation Project includes monitoring during construction to determine whether and to what extent vibrations are damaging to historic properties. Information obtained during vibration monitoring from the City's project would be used to help develop allowable vibration amplitudes along with construction monitoring requirements that would be needed for implementation of Alternative 2, thereby reducing the overall potential cumulative impact. USACE does not expect cumulative effects beyond those addressed above; however, should additional effects be identified once design and placement of features is finalized in PED, the PA outlines how to identify, avoid, minimize, and/or mitigate for these impacts.

While Alternative 2 would contribute to adverse cumulative effects (as outlined above), it would substantially contribute to a beneficial cumulative effect in terms of protecting historic and cultural resources. In combination with the City's various drainage projects among the PPRFFA (Market Street Phase III, US 17 Spring/Fishburne Phases III and IV, Calhoun West/Beaufain, and Calhoun East) and the City's Low Battery Seawall Rehabilitation Project, the study's proposed action would contribute to a reduction of the risk of compound flooding and resultant physical damage to historic structures. This risk reduction would benefit the safety of those living and working in the COHD by protecting vital emergency response and evacuation routes. Anticipated sea level rise and increased storm surge flood events, coupled with interior stormwater flooding, pose a very real risk to the physical integrity of historic structures on the Charleston Peninsula.

Visual and Aesthetics

Cumulative effects include both beneficial and adverse impacts from the proposed alternative and PPRFFA. USACE has determined there would be cumulative effects to visual and aesthetic resources as a result of Alternative 2 and PPRFFA.

Adverse visual and aesthetic impacts as a result of Alternative 2 were summarized in Section 6.13.2, as well as how they would be mitigated. Construction impacts may occur with construction of the storm surge wall and associated features. The impacts to aesthetic resources are anticipated to be the same as impacts to other environmental and cultural resources, which are described earlier in this section. The PPRFFA of harbor deepening, breakwaters at Fort Sumter, the City's various drainage projects, and the oyster reefs will have no adverse visual impact to the Peninsula. Aesthetic impacts from the City's Low Battery Seawall Rehabilitation Project are inherently combined into any aesthetic assessment of Alternative 2 since they share the same footprint and are of the same nature. Therefore, no collectively significant additional adverse impacts are expected from the proposed alternative when combined with the PPRFFA. Additional cumulative effects may be identified during PED, including additional adverse impacts caused by the addition of new visual elements or caused by construction. As noted previously, construction on any project resulting from this study would not commence until after PED, such that cumulative effects can be identified during PED as outlined in the MOU presented in Appendix A. The MOU identifies how to avoid and minimize adverse impacts through design of project features during PED.

Alternative 2 and PPRFFA would substantially contribute to a beneficial cumulative effect in terms of protecting visual and aesthetic resources. In combination with the City's various drainage projects and the City's Low Battery Seawall Rehabilitation Project, the study's proposed action would contribute to a reduction of the risk of compound flooding and resultant physical damage to visual and aesthetic resources. This risk reduction would benefit the safety of those living and working in the project area by protecting vital emergency response and evacuation routes. Anticipated sea level rise and increased storm surge flood events, coupled with interior stormwater flooding, pose risk to the physical integrity of visual and aesthetic resources on the Charleston Peninsula that Alternative 2 and PPRFFA address.

Environmental Justice

Interstate 26 Projects and Superfund Sites near Rosemont: The initial construction of the Interstate 26 projects bifurcated Charleston's Rosemont neighborhood in the late 1960s to the detriment of the community's cohesion and its aesthetics. Although locals assert the recent expansion of Interstate 26 from four to six lanes marginally exacerbated the impact Interstate 26 has on the neighborhood, the Department of Transportation's sound barrier was constructed to mitigate the highway's disruption and was completed in the Spring of 2021. The Rosemont neighborhood is also surrounded by an industrial area which has led to its being within close proximity to several Superfund Sites, one of which is on the EPA's National Priorities List (NPL) for past and future environmental remediation. As described in Section 4.16, the NPL site has been remediated so that it is now rezoned for mixed use redevelopment, and the other sites have also had remedial action taken. While individually disruptive or adverse to the living conditions on Charleston Peninsula and to the Rosemont Neighborhood, these changes to the local environment would not be compounded by any measure included in Alternative 2 and in fact, Alternative 2 would mitigate coastal storm surge risk for the Rosemont Neighborhood in addition to the other majority minority or low-income neighborhoods on Charleston Peninsula (see Sections 4.20 and 6.20)

CHAPTER 7 - Evaluation and Comparison of the Final Array of Alternatives

This chapter provides an assessment of the No Action Alternative and Alternative 2 based on contributions to study objectives and the Federal objective, including economic benefits. Life safety risk and impacts to surrounding communities are also assessed. For a detailed description of hydraulic and economic modeling processes, please refer to Appendix B – Engineering, and Appendix C – Economics, respectively.

7.1 Contribution to Study Objectives

7.1.1 Objective: Reduce Risk to Human Health, Safety, and Emergency Access

Alternative 2 would lower the overall risk to human health and safety on the Charleston Peninsula as compared to the No Action Alternative / Future Without Project Condition. Alternative 2 would reduce risk of death, injury, or illness by decreasing the probability of storm surge inundation behind the storm surge wall and limiting the consequences of storm surge inundation in neighborhoods treated with nonstructural measures. Alternative 2 would reduce the likelihood of drowning, exposure to short-term and long-term hazards, and associated mental health consequences. Life loss modeling efforts indicate that there would be approximately 105 fewer deaths by drowning over a 50-year period of analysis when comparing Alternative 2 to the No Action Alternative (see Table 7-2). Longer term impacts like mold-borne illness and mental health consequences from lost livelihoods or community dislocations would also be reduced.

Alternative 2 would also reduce impacts to critical facilities, emergency services, and evacuation routes by decreasing the probability of storm surge inundation behind the storm surge wall. The reduced probability of storm surge inundation translates to fewer interruptions to hospital and public safety operations and fewer road closures that impede emergency responders and limit movement on the peninsula.

7.1.2 Objective: Reduce Economic Damages and Increase Resilience

Alternative 2 would reduce economic damages on the Charleston Peninsula as compared to the No Action Alternative / Future Without Project Condition. Alternative 2 would reduce damages to commercial and residential structures and their contents by decreasing the probability of storm surge inundation and adapting structures to reduce the consequences of storm surge inundation. Modelling analyses described in both the Engineering and Economics Appendices demonstrated a reduction in economic damages between the Future Without Project Condition and Alternative 2. As shown in Table 7-1, present value damages for the entire study area were reduced by approximately $14,723,000,000 or 58% with implementation of Alternative 2.

Table 7-1. Damage Comparison between Future Without Project Conditions and Alternative 2 ($1,000s).

–	Present Value Damages	Average Annual Damages
Future Without Project Conditions	$25,134,000	$842,000
Alternative 2	$10,411,000	$349,000
Damages Reduced	$14,723,000	$493,000

As described throughout this report, the Charleston Peninsula is vulnerable to the coastal hazard of storm surge inundation now and that vulnerability is expected to be increase over time. Alternative 2 will significantly reduce that vulnerability, while the No Action / Future Without Project Condition will provide no comprehensive approach to offset that increase. EP 1100-1-5, USACE Guide to Resilience Practices (1 December 2020), recognizes resilience as "the ability to anticipate, prepare for, and adapt to changing conditions and withstand, respond to, and recover rapidly from disruptions." Alternative 2 would improve the resilience of the Charleston Peninsula by preparing for anticipated storm surge inundation events and adapting to anticipated changing conditions associated with projected sea level rise and climate change. After implementation of Alternative 2, the Charleston Peninsula would be able to withstand (absorb) and recover from coastal storms more quickly. Increased resilience to coastal storm flood hazards means that fewer economic damages are incurred and there are fewer disruptions to the daily life on the peninsula. And, when coupled with ongoing local efforts to address flood risk from other sources, Alternative 2 would contribute to system resilience for the Charleston Peninsula.

7.2 Federal Objective and Comprehensive Benefits

In consideration of the many competing demands for limited Federal resources, it is intended that Federal investments in water resources as a whole should strive to maximize public benefits, with appropriate consideration of costs. The *Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies* (Water Resources Council, 1983) defines the overall Federal objective of project planning as contributing to national economic development (NED) consistent with protecting the Nation's environment. In addition to the NED account, other accounts to evaluate the public benefits and detriments of alternative plans include environmental quality (EQ), regional economic development (RED) and other social effects (OSE). Both monetary and nonmonetary effects are considered in the Federal investment decision.

The Assistant Secretary of the Army for Civil Works issued a policy guidance memorandum dated January 5, 2021 (Policy Directive - Comprehensive Documentation of Benefits in Decision Documents). The memorandum expanded on existing policies and guidance to ensure the USACE decision making framework considers, in a comprehensive manner, the total benefits of project alternatives, including the equal consideration of environmental, economic, and social categories. Because a Tentatively Selected Plan was identified for this study prior to the publication of the policy directive memorandum, comprehensive benefits of the plan are analyzed qualitatively or with modeling applications. The following sections describe each benefit category and an associated benefit metric in accordance with the policy directive memo. The NED plan is also identified.

7.2.1 Other Social Effects (OSE)

The OSE benefit category relates to the quality of life, health, and safety in the community. Destruction or disruption of the built environment, aesthetic values, community cohesion, and availability of public facilities and services may be analyzed under this benefit category. Assessments of beneficial and adverse effects are based on comparisons of the No Action Alternative to Alternative 2. The social effects of the alternatives have both direct effects and indirect effects. Direct effects result immediately from constructing the project. Indirect effects result from the effects of the project on existing patterns, including ecosystem patterns, in the study area.

For the Charleston Peninsula study, the OSE evaluation focuses on life safety. In an effort to identify impacts to life safety, the No Action Alternative / Future Without Project Condition and Alternative 2 were modeled for potential life loss in the Generation II Coastal Risk Model (G2CRM) developed by the Institute for Water Resources to support planning-level studies of hurricane risk reduction systems. G2CRM models life loss using a simplified methodology. The model makes assumptions based on evacuation plans and calculates deaths by drowning on a per-storm, per-structure basis. Each storm has a relative probability and an equivalent specific peak water level. Water levels from a suite of storms were applied to each structure in the study area. For the residents of those structures, there are three possible lethality functions depending on their age and whether the structure is one, two or more stories. The lethality functions are safe, compromised, and chance dependent on the height of the storm surge over the structure's foundation (see Figure 7-1). Safe would have the lowest expected life loss, although safe does not imply there is no life loss, and chance would have the highest expected life loss.

Figure 7-1. Lethality function based on age, structure type, and storm surge height.

The following table presents mean life loss estimates for the No Action Alternative / Future Without Project Condition and Alternative 2 over a 50-year period of analysis. The incremental life loss suggests that Alternative 2 would effectively reduce life safety risk associated with storm surge inundation.

Table 7-2. Life Loss Estimates.

–	FWOP Life Loss	Alternative 2 Life Loss	Incremental Life Loss
Under 65	28.5	6.7	(21.8)
Over 65	149.4	62.4	(87)
Total	177.9	70.1	(107.8)

There is considerable uncertainty associated with modeling life loss; therefore, the results of the modeling should be viewed as more qualitative as opposed to a quantitative assessment of life loss even though the results are stated in numerical values. Also, the results should be viewed in terms of order of magnitude compared to the baseline. It is important to note that a breach or structural failure scenario was not assumed when modeling life loss estimates for the No Action / Future Without Project Condition and Alternative 2. Additional information on life loss modeling performed for this study can be found in the Appendix C - Economics. Section 7.4, below, provides a Life Safety Risk Assessment.

7.2.2 National Economic Development (NED)

The NED account includes the estimates of project costs and benefits used to calculate net economic benefits. This analysis establishes the economic feasibility of each plan and is used to identify Federal interest. The NED analysis dates back to the Flood Control Act of 1936 in which Congress determined that the Federal Government should participate in flood management and determine the costs and benefits of those activities. The analysis has been documented and refined over the years in various publications, including the *Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies (P&G).*

Class 3 cost estimates were used for the economic analysis as documented in Appendix B – Sub-Appendix 5, Cost Engineering. A full display of the modeling analysis for the NED account is located in Appendix C – Economics Table 7-3 summarizes the costs and benefits of Alternative 2.

Alternative 2 was identified as the plan that reasonably maximizes net National Economic Development (NED) benefits, consistent with protecting the Nation's environment and is therefore the NED Plan.

Table 7-3. Costs and Benefits of Alternative 2 ($1,000).

Cost/Benefit Item	Alternative 2
Investment Costs	–
Project First Cost	$1,133,000
Interest During Construction	$130,000
Total Investment Cost	$1,269,000
Average Annual Cost[1]	–
Average Annual First Cost	$42,500
Annual OMRR&R[2] Cost	$3,000
Average Annual Costs	$45,500
Benefits[1]	–
Average Annualized Benefits	$493,000
Net Benefits	$447,500
BCR	10.8

[1]Costs are rounded in 2022 price levels, 2.25% discount rate, and a 50-year period of analysis.
[2]Operation, Maintenance, Repair, Replacement, and Rehabilitation.

7.2.3 Regional Economic Development (RED)

The RED benefit category measures changes in the distribution of regional economic activity that result from alternative plans. Changes in economic activity and employment that occur locally or regionally when a project is implemented are excluded from the NED account to the extent that they are offset through transfers of this economic activity and employment to other regions of the Nation. The effects on the regional economy, including income effects, income transfers, and employment effects not addressed in the NED account are evaluated in the RED account. Two measures of the effects of the plan on regional economies are used in the account: regional income and regional employment.

The input-output macroeconomic model RECONS was used to address the impacts of the construction spending associated with Alternative 2. This analysis employs input-output economic analysis, which measures the interdependence among industries and workers in an economy. This analysis uses a matrix representation of a region's economy to predict the effect the implementation of a project would have on various industries. The greater the interdependence among industry sectors, the larger the multiplier effect of the economy. Changes to government spending drive the input-output model to project new levels of sales (outputs), value added (Gross Regional Product or GRP), employment, and income for each industry.

Direct effects represent the impacts the new federal expenditures have on industries which directly support the new project. Labor and construction materials can be considered direct components to the project. Indirect effects represent changes to secondary industries that support the direct industries. Induced effects are changes in consumer spending patterns caused by the change in employment and income within the industries affected by the direct and induced effects. The additional income workers receive via a project and spent on clothing, groceries, dining out, and other items in the regional area are secondary or induced effects.

For Charleston County, SC, the construction stimulus of $1.132 billion would generate 10,696 full-time equivalent jobs, $817 million in labor income, and $1.505 billion in output. For the state of South Carolina, as a whole, the construction stimulus would generate 12,932 full-time equivalent jobs, $896,641 million in labor income, and $1.798 billion in output. For the Country, as a whole, the construction stimulus would generate 18,499 full-time equivalent jobs, $1.358 billion in labor income, and $3.076 billion in output (see Table 7-4).

Table 7-4. RECONS – Overall Summary.

Area	**Local Capture ($000)**	**Output ($000)**	**Jobs***	**Labor Income ($000)**	**Value Added ($000)**
Local					
Direct Impact		$868,937	7,057.6	$591,701	$587,835
Secondary Impact		$636,631	3,639.1	$225,363	$368,704
Total Impact	$868,937	$1,505,568	10,696.7	$817,064	$956,539
State					
Direct Impact		$962,847	8,124.4	$625,697	$645,760
Secondary Impact		$835,145	4,807.9	$270,944	$459,714
Total Impact	$962,847	$1,797,992	12,932.3	$896,641	$1,105,474
US					
Direct Impact		$1,080,294	9,589.7	$722,287	$730,855
Secondary Impact		$1,955,438	8,909.7	$635,633	$1,087,996
Total Impact	$1,080,294	$3,075,732	18,499.4	$1,357,920	$1,818,850

*Jobs are presented in full-time equivalence.

7.2.4 Environmental Quality (EQ)

The EQ account assesses the effects on the ecological, cultural, aesthetic, and other attributes of natural and cultural resources. The environmental effects that may be considered can be categorized as direct or indirect. Direct effects result immediately from constructing and operating the project. Indirect effects are effects caused by the action that occur later in time or farther removed in distance but are still reasonably foreseeable. Indirect effects may include growth inducing effects and other effects related to induced changes in the pattern of land use, population density or growth rate, and related effects on air, water, and other natural systems, including ecosystems.

The beneficial and adverse environmental effects of Alternative 2 have been identified in Chapter 6 of this report. In accordance with the comprehensive benefits policy directive memorandum, the EQ evaluation focuses on the oyster reef-based sill (living shoreline) intended to minimize adverse effects of the storm surge wall on marsh erosion or scouring. Reefs dissipate incident wave energy by causing waves to break on the reef, rather than the shoreline, and reduce exposure to resources in its lee. The rugosity and friction created by reefs reduce wave height and energy that lead to wave run-up. By considerably reducing the wave energy that comes from coastal storms, boat wake, etc., living shoreline sills minimize the reflection of wave energy on hardened structures that create turbulence capable of suspending sediments and vegetation seaward of the structure. The sills also reduce erosion at the shoreline edge, and overall improve the stability and resilience of the marsh.

One of the important co-benefits of living shorelines is the creation of habitat. By using oysters to form the sills (as opposed to rock), the oysters themselves create reef habitat that can be self-sustaining over time. Intertidal oyster reefs in South Carolina are associated with over 83 species of finfish and invertebrates that are commercially and recreationally important to the economy. Oyster reefs also improve water quality and clarity (SCDNR 2019).

Living shorelines also promote marsh growth, which further enhances coastal protection through NNBFs (Bridges et al., 2021). With reduced wave energy created by the sill, sediments can accumulate between the sill and the shoreline, and raise the intertidal surface elevation. This leads to horizontal and vertical accretion resulting in seaward expansion of salt marsh vegetation (SCDNR 2019). This effect can also help offset marsh scouring at the base of structures. The natural ability of oyster reefs to vertically increase over time make them especially valuable for helping marshes keep pace with rising sea levels.

Hardened structures intended to reduce wave attack and shoreline erosion such as bulkheads and revetments provide none of these co-benefits. Rip rap is the universal countermeasure for scouring and is often more expensive than using natural or nature-based features for erosion control. While oyster-reef sills are susceptible to damage and overtopping by event-based hazards, such as storm surge during extreme storm events, they often perform better during storms than bulkheads (SCDNR 2019).

7.2.5 Benefit Category Summary

The benefit categories described in this section serve as evaluation criteria to demonstrate both the positive and negative effects of alternative plans. The intent is to describe advantages and disadvantages of each alternative so that decision makers may adequately compare plans. In addition, the benefit categories provide a visual display and assessment of plans as required by NEPA. A summary of benefit category effects is displayed in Table 7-5.

Table 7-5. Summary of Benefit Category Effects for the Final Array of Alternative Plans.

–	**No Action**	**Alternative 2**
–	No Action provides no physical project constructed by the Federal Government	Storm surge wall + nonstructural
Other Social Effects		
Life, Health, Safety	The vulnerability of residents and businesses to storm surge inundation will increase over time due to sea level rise and climate change	Minor, short-term adverse effects to motorists, and pedestrians during construction; minor, short-term adverse effects to transportation when traffic and pedestrian gates are closed; permanent, beneficial effects due to the performance of the storm surge wall and nonstructural measures during coastal storm events
Community Cohesion (displacement of people & businesses)	Future flooding would displace select businesses and residents	Reduced risk of damages to homes and businesses on the Charleston Peninsula and reduced need for potentially cost-prohibitive repairs that displace residents and business owners
National Economic Development		
Project Cost	$0	$1,133,000,000
Annual Cost	$0	$42,500,000
Total Annual Benefit	$0	$493,000,000
Annual Net Benefits	$0	$447,500,000
Benefit – Cost Ratio	None	10.8
Residual Risk	Risk remains high throughout the study area	Risk of economic damages is reduced by 58%
Regional Economic Development		

–	No Action	Alternative 2
General Economic Gains	Future flooding would destroy infrastructure which impacts the region's ability to produce goods and services; little to no RED benefits	Economic impacts would emerge from increased spending over time
Construction Impacts for Charleston County, South Carolina	No construction of major water resources infrastructure to stimulate income and employment	Construction stimulus would generate 10,696.7 full-time equivalent jobs and $817.064 million in labor income
Construction Impacts for State of South Carolina (including Charleston County)	No construction of major water resources infrastructure to stimulate income and employment	Construction stimulus would generate 12,932.3 full-time equivalent jobs and $896.641 million in labor income
Environmental Quality		
Land Use	No construction activities present; land uses would continue to be affected by future development, storm surge, and shallow coastal flooding	Beneficial effect on land uses from reduced storm surge flooding; permanent modifications in land use would be minor
Geology	No construction activities present; continued shoreline erosion from storms and sea level rise	Minor temporary construction impacts and permanent impacts; living shoreline provides beneficial effect on shoreline erosion and scouring
Hydrology	No construction activities; beneficial improvements to interior flooding from current City stormwater management projects; continue to experience storm surge and compound flooding	Beneficial effect on storm surge flooding and compound flooding; permanent adverse effects (particularly on flow and interior flooding) considered minor with minimization measures; negligible effect on flooding and shorelines outside of study area
Water Quality	No construction activities present; future development continues to degrade water quality; long term water quality conditions impacted by SLR	All impacts localized; minor temporary construction impacts; other temporary and permanent adverse effects on water quality would be either mitigated (with wetlands) or minimized to extent practicable.

–	No Action	Alternative 2
Floodplains	No construction activities; continued impact to structures in the floodplain due to storm surge and shallow coastal flooding	Substantial beneficial effect to people and structures in floodplain; adverse effect in the event of failure but similar to no action
Wetlands	No construction activities present; existing salt marshes would be impacted by sea level rise and not able to migrate inland due to development; future urban development contributes to wetland loss or degradation	Permanent direct and indirect adverse effects remaining after avoidance and minimization would be mitigated where justified to a level of negligible adverse effect; minor temporary construction effects; living shorelines provides beneficial effect on wetlands
Special Status Species	No construction activities; urban development continues to contribute to habitat and water quality degradation for protected species	No effect for some protected species; minor to negligible permanent and temporary effects for other protected species, including from construction
Aquatic Resources	No construction activities present; effects of climate change, sea level rise, and development will continue to affect aquatic species.	Permanent indirect adverse effects remaining after avoidance and minimization would be mitigated where justified to a level of negligible adverse effects; minor temporary construction effects; living shorelines provides beneficial effect on aquatic resources
Benthic Resources	No construction activities present; effects of climate change and sea level rise will continue to affect benthic communities	Permanent direct and indirect adverse effects remaining after avoidance and minimization would be mitigated where justified to a level of negligible adverse effects; minor temporary construction effects
Terrestrial Wildlife and Plants	No construction activities present; effects of climate change, sea level rise, and development will continue to affect wildlife; minor effect on wildlife displaced by storms	Minor to negligible permanent effects on wildlife and plants; minor temporary construction effects

–	**No Action**	**Alternative 2**
Cultural Resources & Historic Properties	No construction activities present; historic structures would continue to be damaged from periodic coastal storm surge events.	Potentially significant adverse effects to archeological sites, historic structures, and historic districts within the APE. A Programmatic Agreement prioritizing avoidance and minimization, and for the identification, evaluation, and mitigation of adverse effects has been developed address the lack of detailed design in feasibility. Beneficial effects include substantial reduction of damages to historic properties from periodic coastal storm surge events.
Recreation	No construction activities present; sea level rise, storm surge and coastal erosion would continue to impact recreational areas, facilities, and services	Minor permanent effects with minimization; minor temporary construction effects
Visual Aesthetics	Visual/aesthetic resources would continue to be damaged by periodic coastal storm surge events.	Potentially significant adverse aesthetic effects on water, landform, vegetation, land use and user activity; reasonable mitigation and minimization to be identified during PED. Beneficial effects include substantial reduction of damages to aesthetic resources from periodic costal storm surge events.
Air	No construction activities present; air quality and contributions from existing industrial sources to GHG emissions assumed to stay same into future	Negligible temporary construction effects
Noise	No construction activities present; assume normal noise levels created by traffic, industry, and City pumps continue into future.	Minor permanent noise effects (pumps); temporary construction noise considered minor with minimization measures
Transportation	No construction activities present; minor impacts to transportation as sea level rise and storm flooding continue into the future	Minor temporary construction effects; permanent changes in transportation would be minor; beneficial effect of reduced storm surge flooding to transportation network

–	No Action	Alternative 2
Utilities	No construction activities present; beneficial improvements to stormwater management with completion of current City projects	Minor permanent effects and temporary construction effects; beneficial effect of reduced damages to utilities and disruptions in services from storm surge flooding
Environmental Justice	No construction activities present; flooding of structures would continue to cause damages to all socioeconomic groups in the future	Beneficial effects through reduced risk of storm surge damages; alternative does not disproportionately favor or adversely burden any socioeconomic or disadvantaged group
Climate Change	No construction activities present; assumes sea levels will continue to rise and coastal storms will increase into the future with local effects on almost all environmental resources to varying degrees	Negligible contributions to climate change; beneficial effects on increasing resilience to climate change and associated SLR
Construction Activities	Although property would be repaired to pre-flood conditions subsequent to each flood event, it would be temporary and minor compared to overall economic losses	Value added: temporary jobs added within the region and jobs added within the State; adds to the gross regional product for the State and the Nation
Future Residential Development	Current development trends will continue until nuisance flooding and storm surge inundation are no longer tenable	Storm surge wall construction would decrease the risk of flooding to the established urban area; property values may increase relative to other communities in the region that have not implemented coastal storm risk reduction measures

7.3 Impacts to Surrounding Communities

Since release of the draft FR/EA in April of 2020, the potential for the proposed storm surge wall to deflect water and impact surrounding communities was analyzed using the Advanced Circulation Model (ADCIRC, a state-of-the-art modeling software developed and frequently used by research institutions, industry and other government entities to simulate and closely analyze complex storm systems). The analysis examined the potential for induced flooding in James Island, West Ashley, North Charleston, Daniel Island, and Mount Pleasant. A full description of the analysis can be found in Engineering Appendix B, Coastal Sub-Appendix B-4, Chapter 6 – Wave Refraction on Surrounding Areas.

The study of impacts to adjacent communities modeled 11 severe, synthetic storms, both with and without the proposed storm surge wall. "*Severe*" storms for purposes of the modeling were those *with a storm surge equal to or in excess of the perimeter storm surge wall height*. "*Synthetic*" storms, as opposed to historic storm events, are used to facilitate modeling of a broad range of storm characteristics. Generated by the Federal Emergency Management Agency, the synthetic storms were selected based on their probable alignment to Charleston's climate and hurricane history and included events producing storm surges of nine to more than 17 feet NAVD88. The storms varied in characteristics such as wind speed, storm path, size and overall intensity. The analysis also integrated a projected intermediate sea level rise of 1.65 feet, charting and comparing water surface elevations with and without a federal project across significant storm surge flooding events both today and into 2082, the study's 50-year period of analysis.

The modeling results indicated that the storm surge wall would induce a marginal difference in water surface elevations in the surrounding communities (see Figure 7-2). Water surface elevations ranged from an increase or decrease of less than one inch depending on location. This marginal difference in water surface elevation is in addition to what would have statistically occurred in these areas. For example, on James Island, a storm resulted in water elevations of 11.9 feet NAVD88 with no storm surge wall and 11.97 feet NAVD88 with a storm surge wall. Structural damages as a result of the marginal differences in water surface elevations in surrounding communities would be highly unlikely, therefore this analysis suggests that the construction of a wall on the Charleston Peninsula would have a negligible adverse effect of increased flooding damages to surrounding communities during a storm surge event.

7.4 Life Safety Risk Assessment

Although life-safety risk would be significantly reduced with Alternative 2, some amount or risk would remain after construction of the project. Residual risk must be analyzed pursuant to Engineering and Construction Bulletin 2019-15, *Interim Approach for Risk-Informed Designs for Dam and Levee Projects*, and Planning Bulletin 2019-04, *Incorporating Life Safety into Flood and Costal Storm Risk Management Studies*. To analyze remaining risk, a semi-quantitative life-safety risk assessment was performed to ensure that decision-makers and the public are informed regarding the benefits as well as the risks associated with any flood risk management plan. The assessment applies four tolerable risk guidelines (TRGs) to arrive at a conclusion regarding tolerable risk. These TRGs may be summarized as follows: TRG 1 – Understanding the Risk (whether society is willing to live with the risk to secure the benefits); TRG 2 – Building Risk Awareness (ensuring continued recognition and communication of risk); TRG 3 – Fulfilling Daily Responsibilities (proper monitoring and management of structures or system); and TRG 4 – Actions to Reduce Risk (consideration of cost effective, socially acceptable, or environmentally acceptable ways to further reduce risks).

To assess residual risk and inform tolerable risk determinations, a Potential Failure Mode Analysis (PFMA) was performed. A PFMA is the process of identifying and fully describing potential failure modes based on the study team's understanding of the project's vulnerabilities. The purpose of the PFMA was to discover and assess ways that Alternative 2 could fail and verify that construction of the plan poses a tolerable risk to the community within the study area. If risks are considered excessive, changes in design are recommended and additional design concepts to further reduce risk are identified. The Charleston Peninsula PFMA determined that the primary drivers of incremental risk would be 1) the inability to install all gate closures in advance of inundation and 2) an overtopping event with breach. It is very unlikely the gates throughout the study area would fail to be set. Pedestrian gates could be set well in advance of an impending hurricane and vehicular gates would likely be able to close quickly. There is a remote likelihood there would be sufficient erosion to impact the wall during an overtopping event because of the depth of the wall's foundation, landside armoring, and the relatively short duration of a hurricane loading event. Still, the annual probability of failure is estimated to be straddling the tolerable risk guidelines. All other potential failure modes assessed during the PFMA were judged to be well below tolerable risk thresholds.

Communicating the risk of overtopping due to storm surge exceeding the wall elevation is critical. In 2082, the 12-foot NAVD88 storm surge wall would prevent overtopping by a 1% annual exceedance probability (AEP) (100-year return interval) coastal storm, assuming an intermediate sea level rise scenario. Under that same scenario, a less frequent storm would likely overtop the wall. Assuming a high rate of sea level rise in 2082, the wall would likely be overtopped by the 1% AEP coastal storm. The risk of overtopping is considered tolerable because the risk is as low as reasonably practicable due to the topographic, infrastructure, and viewshed constraints described in Section 3.5.1 as well as significant increases in cost and construction durations associated with constructing a wall higher than 12 ft NAVD88.

In the past the Charleston Peninsula area has had high evacuation rates and the community follows a formal evacuation plan. Over time, those evacuation rates have decreased, and it is uncertain if the population at risk will become overly confident in the ability of the floodwall to prevent inundation of the area and potentially have evacuation rates reduce further. This may be compounded by storms that rapidly change course and don't follow the predicted forecast. As observed during the evacuation order for Hurricane Dorian in 2019, many people elected to stay and wait until predictions were closer to Charleston. This has been a trend since the long evacuation times via Interstate 26 with Hurricane Floyd in 1999, despite the state now prescribing road reversal of the east bound lane and FEMA/USACE identifying other recommended evacuation paths out of the city. There has always been the inherent risk that people will not leave when told to evacuate, but this may be compounded by the implementation of Alternative 2. This risk is something that can be addressed and mitigated in the City's Emergency Response Plan.

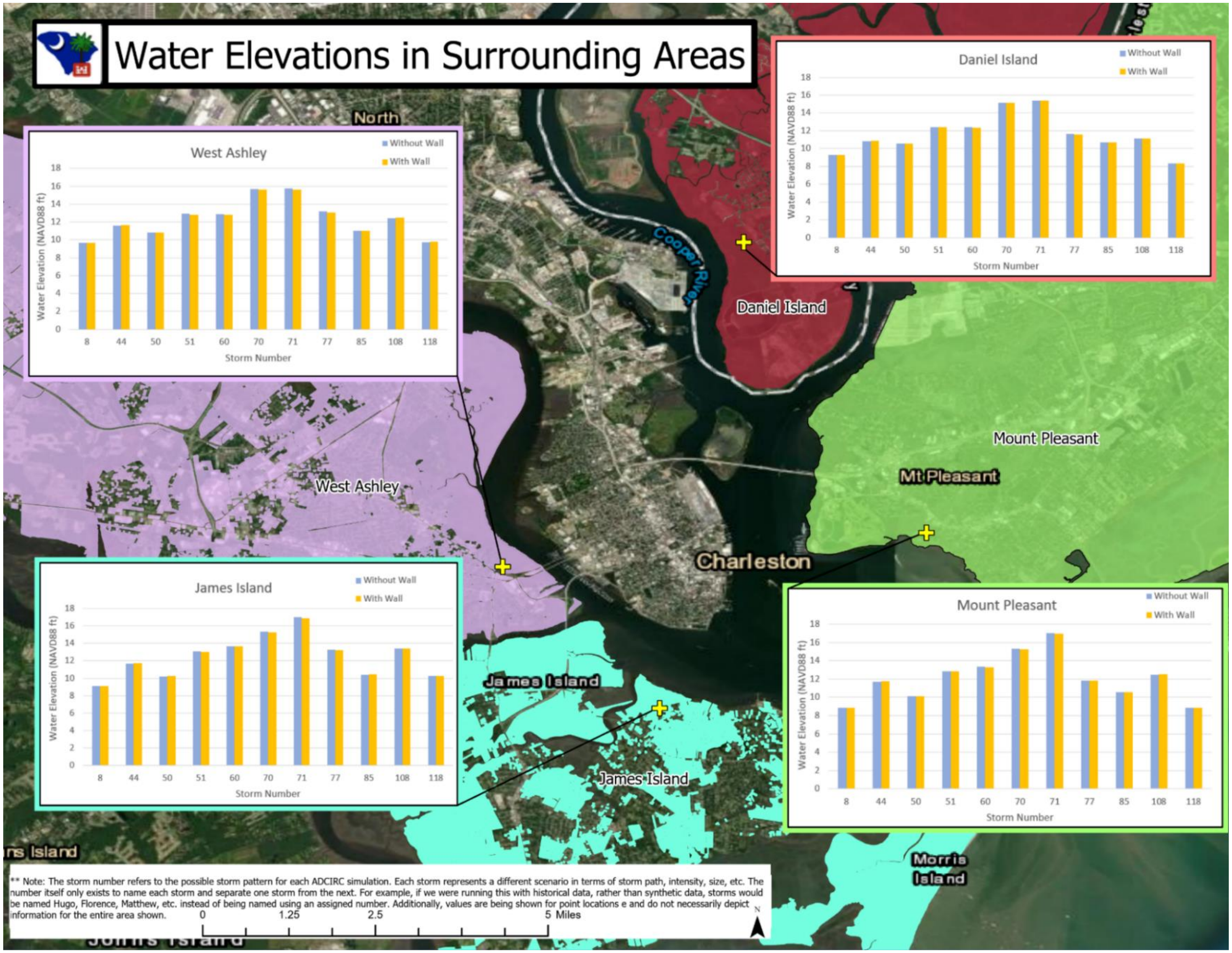

Figure 7-2. ADCIRC modeling results show marginal difference in water surface elevation between with project and without project conditions**.**

For those storm surge elevations that approach the elevation of the wall, there is the risk of wave overtopping due wind-driven waves. While residential and commercial structures are not typically affected by wave attack on the Charleston Peninsula, waves can have high velocities and force that impact people, vehicles, and incidental structures near the shoreline. It may also cause erosion and scour in the areas adjacent to the wave trajectory. Wave overtopping will be further analyzed in the PED phase. The details of the wall system would be designed with the intent to prevent structural failure from wave overtopping. The pilings for the storm surge wall would be 50 to 70 feet deep and tie-in to marl bedrock in order to withstand earthquakes. Because of the significant foundation depths of the storm surge wall, structural failures are unlikely.

Additionally, there is likely to be rainfall associated with any coastal storm surge event which, if in excess of the City's existing pump capacity, would flood streets and low-lying areas, making transit within the city a life safety hazard (much like the city has experienced in the past). This study includes an evaluation of the wall's effect on interior flood risk, an assessment of measures to address the residual risk or induced flooding and includes those measures in the final recommended plan to the extent justified by USACE policy. At this point in the study, the evaluation indicates that five permanent and five temporary pumps are justified to address the wall's expected adverse effect on interior rainfall-induced flood risk. This evaluation will continue to be refined through the Preconstruction, Engineering and Design (PED) phase.

As previously discussed, surge overtopping with breach and failure to properly close gates are assumed to be the most likely failure scenarios. The extent of flooding from such a failure largely depends on the water level elevations and the location of the failure. Due to the topography of the city, failure of a gate may only affect one side or one portion of the peninsula and not the entire interior area. For example, a high ridge in the center of the city would help keep floodwaters on one side of the peninsula. An analysis of the interior topography could identify locations where temporary emergency barriers could be placed to limit the extent of interior flooding if a gate malfunctions or is not closed.

There will be an Operations and Maintenance Manual developed for the City of Charleston to keep gates, pumps, and other features of the project operational. The City already operates and maintains pump stations, has been coordinating with other cities with federal storm surge projects, and is aware of the capacities that would be required to operate Alternative 2. Annual inspections by USACE include a floodwall inspection checklist, which includes 125 specific items dealing with the operation and maintenance of floodwalls, interior drainage, pump stations, channels, operation and trial erections of closure structures, and inspection/video inspection of pipes/conduits that pass through the project alignment to ensure the system is working as designed. The O&M Manual would include an outreach plan to communicate residual risk associated with the project. It is critical that residents understand that Alternative 2 would not eliminate storm surge inundation or flood risk so that they take appropriate action to further protect their person and property.

Separate from overtopping and potential failure modes, the opening and closing of the many pedestrian and vehicular access gates could pose temporary, minor safety risks to the public during major storm events; however as described in the transportation section of this report (Section 4.16), alternate routes would be available on roads where there would be gate closures.

CHAPTER 8 - Recommended Plan

Based on the evaluations described in Chapters 6 and 7, Alternative 2 has been identified as both the NED and Recommended Plan (RP). The RP has been refined throughout the study; designs and cost estimates are semi-detailed and appropriate for budget authorization purposes. The RP will be further refined for construction purposes during the Pre-construction Engineering and Design phase.

8.1 Features of the RP

- **Storm surge wall along the perimeter of the Peninsula**: The storm surge wall would be constructed along the perimeter of the peninsula to reduce damages from storm surge inundation. On land, the storm surge wall would be a T-wall with traditional concrete stem walls and pile supported bases. In the marsh, the storm surge wall would be a combination wall (combo-wall), which consists of continuous vertical piles on the storm surge side and battered pipe piles on the other side, connected by a concrete cap. The length of the proposed wall is approximately 8.7 miles (7.2 miles of T-wall and 1.5 miles of combo-wall). It would be strategically aligned to minimize impacts to existing wetland habitat, cultural and aesthetic resources, and private property while allowing continued operation of all ports, marinas, and the Coast Guard Station. The wall would tie into high ground as appropriate, including the shoreline at the Citadel and the existing Battery Wall. Due to its age and uncertainty about the integrity of the structure, the High Battery would be reconstructed to meet USACE construction standards and raised to provide a consistent level of performance. The proposed elevation of the storm surge wall is 12 feet North American Vertical Datum of 1988 (NAVD88).

  The alignment of the wall displayed in Figure 8-1 has been optimized to minimize costs and impacts to the study area. Changes to the alignment may occur during the Pre-construction Engineering and Design (PED) phase as appropriate. Drivers of the potential changes include, but are not limited to, new developments in technology or construction methodologies, results of additional engineering analyses, unforeseen cultural and historic resources, the presence of buried utilities not discovered during feasibility, and real estate acquisition challenges. Also, during the PED phase, changes will occur for the purpose of aesthetic and cultural mitigation that could not be identified during the feasibility study because they inherently relate to detailed designs.

  The storm surge wall would include multiple pedestrian, vehicle, railroad, and storm (tidal flow) gates. Typically, the gates would remain open, and gate closure procedures would be initiated based on storm surge predictions from the National Weather Service. When major flooding is expected, storm gates would be closed at low tide, to keep the rising tide levels from taking storage needed for associated rainfall. For the vehicular, pedestrian, and railroad gate closings, timing of the closure would be dependent on evacuation needs and the anticipated arrival of rising water levels that close transportation arteries. Gate operation procedures would be refined during the PED phase with input from the City of Charleston, emergency management experts, and weather experts. Specific responsibilities of the non-Federal sponsor regarding execution of work will be described in the Project Partnership Agreement, a legally binding document between the Federal Government and the City of Charleston, as well as the operations, maintenance, repair, replacement, and rehabilitation (OMRR&R) manual.

  - **Interior Drainage Facilities:** Preliminary interior hydrology analyses indicate that five temporary and five permanent, small to medium hydraulic pump stations are justified per ER 1105-2-100, Section 3-3.b.(5). The pump facilities would mitigate interior flooding aggravated by the storm surge wall.

  - **Natural and Nature Based Features**: In association with the storm surge wall, oyster reef-based living shoreline sills would be constructed as a minimization measure to reduce impacts to natural shorelines and other resources seaward of the wall. The living shoreline sills would reduce marsh scour at the proposed storm surge wall and reduce erosion of the shoreline edge. The living shorelines would also provide other environmental benefits. The reef-based living shoreline materials/design would be determined during the PED phase.

- **Nonstructural measures:** In residential areas where construction of the storm surge wall would be impracticable due to the topography of the peninsula and other constraints (see discussion in Section 3.5.1), nonstructural measures such as elevations and floodproofing could be applied. Neighborhoods that have been identified for nonstructural measures include Lowndes Point on the north-western edge of the peninsula, Bridgeview Village on the north-east edge of the peninsula, and the Rosemont community in the Neck Area of the peninsula. Approximately 100 structures have been identified for nonstructural treatment and the minimum proposed design elevation is 12 ft NAVD88. Wet floodproofing measures, such as elevation of utilities, would be applied in the Lowndes Point area because first floors of residential structures are already elevated above 12 feet NAVD88. Dry floodproofing measures would be applied to Bridgeview Village and floodproofing or elevation measures would be applied to the Rosemont neighborhood due to the nature of the construction materials and techniques used in these communities. The minimum proposed design elevation of nonstructural measures is 12 ft NAVD88. Higher design elevations will be considered during the PED phase because the nonstructural measures do not face the same topographic and infrastructure constraints as the storm surge wall.

Figure 8-1. Structural and nonstructural measures of the Recommended Plan and other mitigation/minimization features (hydraulic pumps and living shorelines).

8.2 Performance of the Recommended Plan

A wall with top elevation 12ft NAVD88 would prevent stillwater overtopping for a 0.7% annual exceedance probability (AEP) surge event in 2032 and a 1% AEP event in 2082, assuming an intermediate rate of sea level rise. Engineer Regulation 1105-2-101 requires that project performance is also described with a high degree of assurance. At the upper 90% confidence limit, the 12ft NAVD88 wall would prevent stillwater overtopping for a 2.8% AEP event in 2032 and a 3.6% AEP event in 2082, assuming an intermediate rate of sea level rise. A design elevation of 12ft NAVD88 for nonstructural measures would have the same level of performance as the storm surge wall. Figure 8-2 displays stillwater elevations assuming an intermediate rate of sea level rise for both the average AEP and the 90% confidence AEP in 2032, when the project is first estimated to be complete. Figure 8-3 displays the same information for the year 2082, which is the end of the period of analysis for this study.

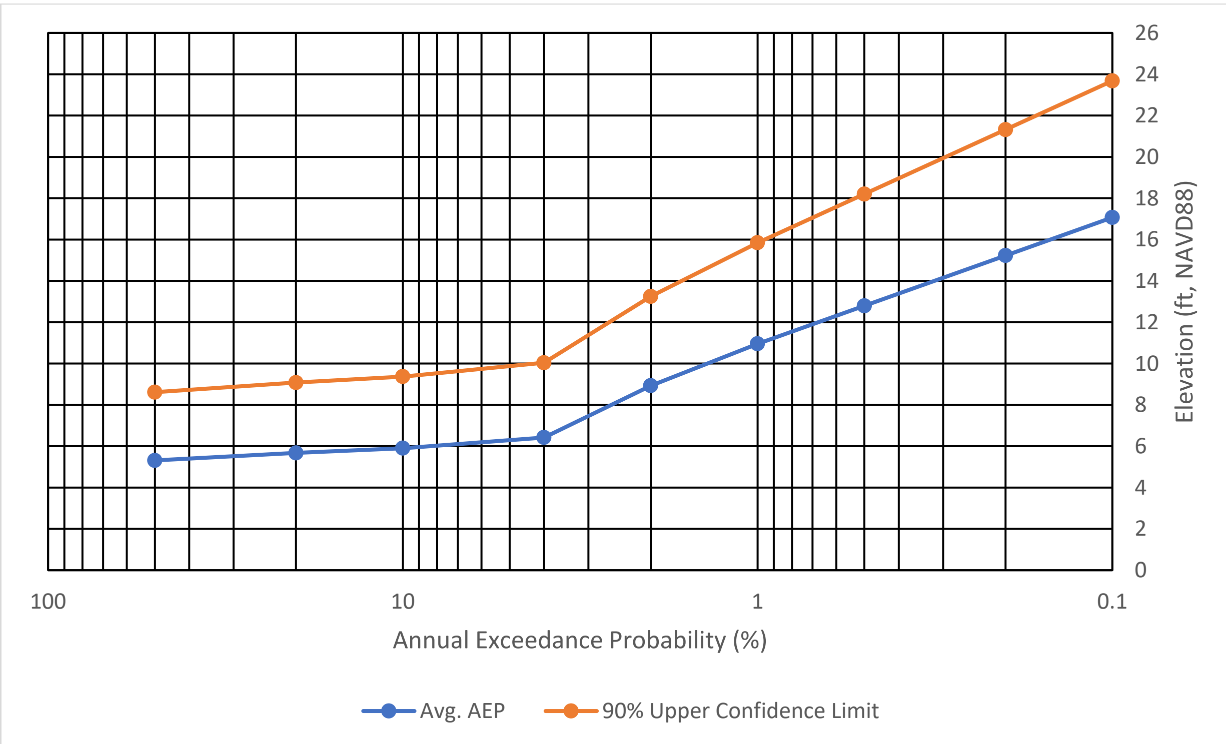

Figure 8-2. Stillwater elevations for average (most likely) annual exceedance probabilities and upper 90% confidence limits in the year 2032 assuming an intermediate rate of sea level rise.

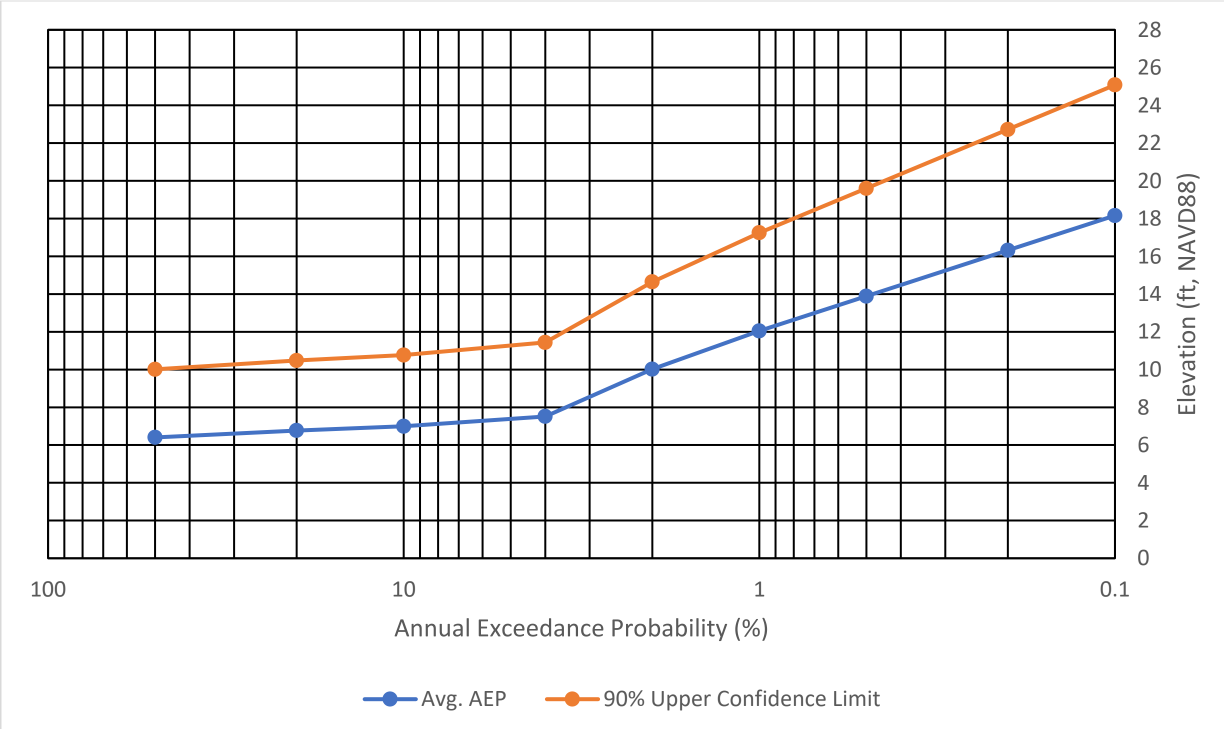

Figure 8-3. Stillwater elevations for average (most likely) annual exceedance probabilities and upper 90% confidence limit in the year 2082 assuming an intermediate rate of sea level rise.

According to National Oceanographic and Atmospheric Administration (NOAA) and using the USACE Sea-LevelChange Curve Calculator (Version 2017.55) for Charleston Gauge 8665530 (Table 8-1), sea levels in 2082 are projected to rise 0.93 feet for the low rate, 1.65 feet for the intermediate rate, and 3.93 feet for the high rate of sea level rise. In 2132, the end of the 100-year adaptation horizon, sea levels are projected to rise 1.45 feet, 3.19 feet, and 8.71 feet for the low, intermediate, and high, respectively, compared to the sea levels from National Tidal Datum Epoch 1992. Figure 8-4 displays sea level trends in relation to Lockwood Drive and the existing Battery Wall.

Higher average sea levels correlate to higher storm surge elevations. Figures 8-5 and 8-6 compare stillwater elevations of the with and without-project conditions. In the year 2082, assuming a high rate of sea level rise, a 9 ft NAVD88 storm surge inundation would be a 20% AEP (or 5-year return interval) event. Without a project to address storm surge inundation, critical facilities, emergency access roads, historic structures, and archaeological sites would be damaged by surge elevations of 9 ft NAVD88. With implementation of Alternative 2, the wall would block surge from inundating the peninsula and recurring damages from high frequency storms would be reduced.

Table 8-1. Estimated sea level change from 1990 to 2150 according to NOAA and using the USACE Sea-Level Change Curve Calculator.

Gauge Status: Active and compliant tide gauge
Epoch: 1983 to 2001
8665530, Charleston, SC
NOAA's 2006 Published Rate: 0.01033 feet/yr
All values are expressed in feet relative to LMSL

Year	USACE Low	USACE Int	USACE High
1992	0.00	0.00	0.00
2002	0.10	0.11	0.14
2012	0.21	0.24	0.36
2022	0.31	0.39	0.64
2032	0.41	0.56	1.01
2042	0.52	0.74	1.44
2052	0.62	0.94	1.96
2062	0.72	1.16	2.54
2072	0.83	1.40	3.20
2082	0.93	1.65	3.93
2092	1.03	1.92	4.74
2102	1.14	2.21	5.62
2112	1.24	2.52	6.58
2122	1.34	2.85	7.61
2132	1.45	3.19	8.71
2142	1.55	3.55	9.89
2150	1.63	3.85	10.89

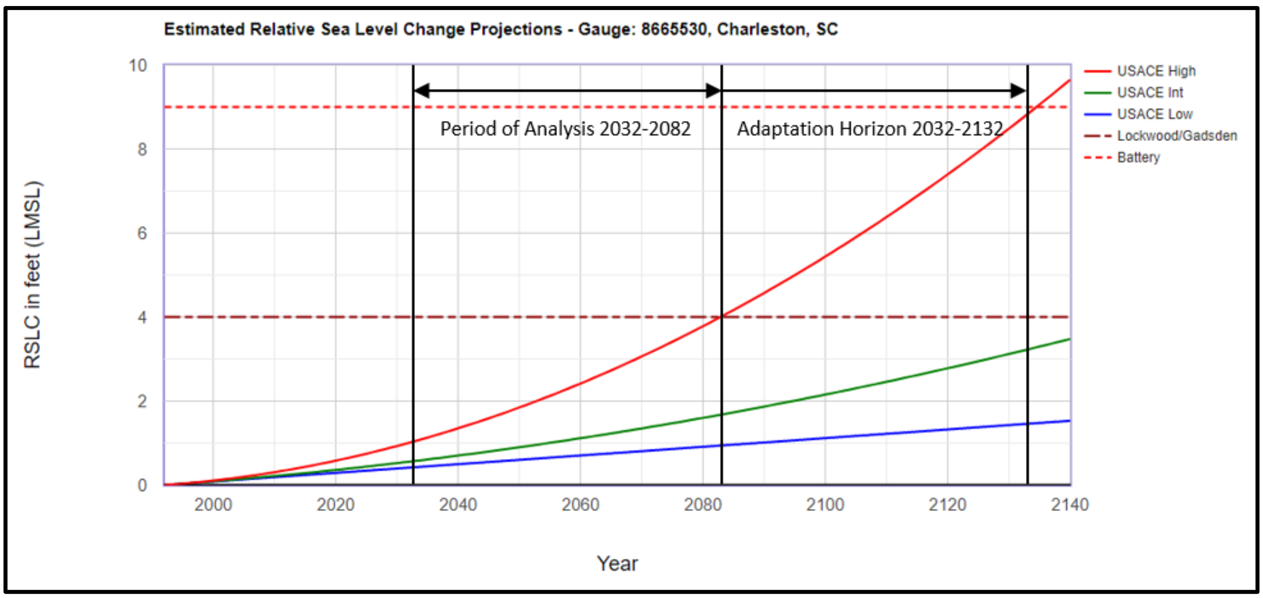

Figure 8-4. Low, Intermediate, and High Sea Level Projection for Charleston Gauge 8665530.

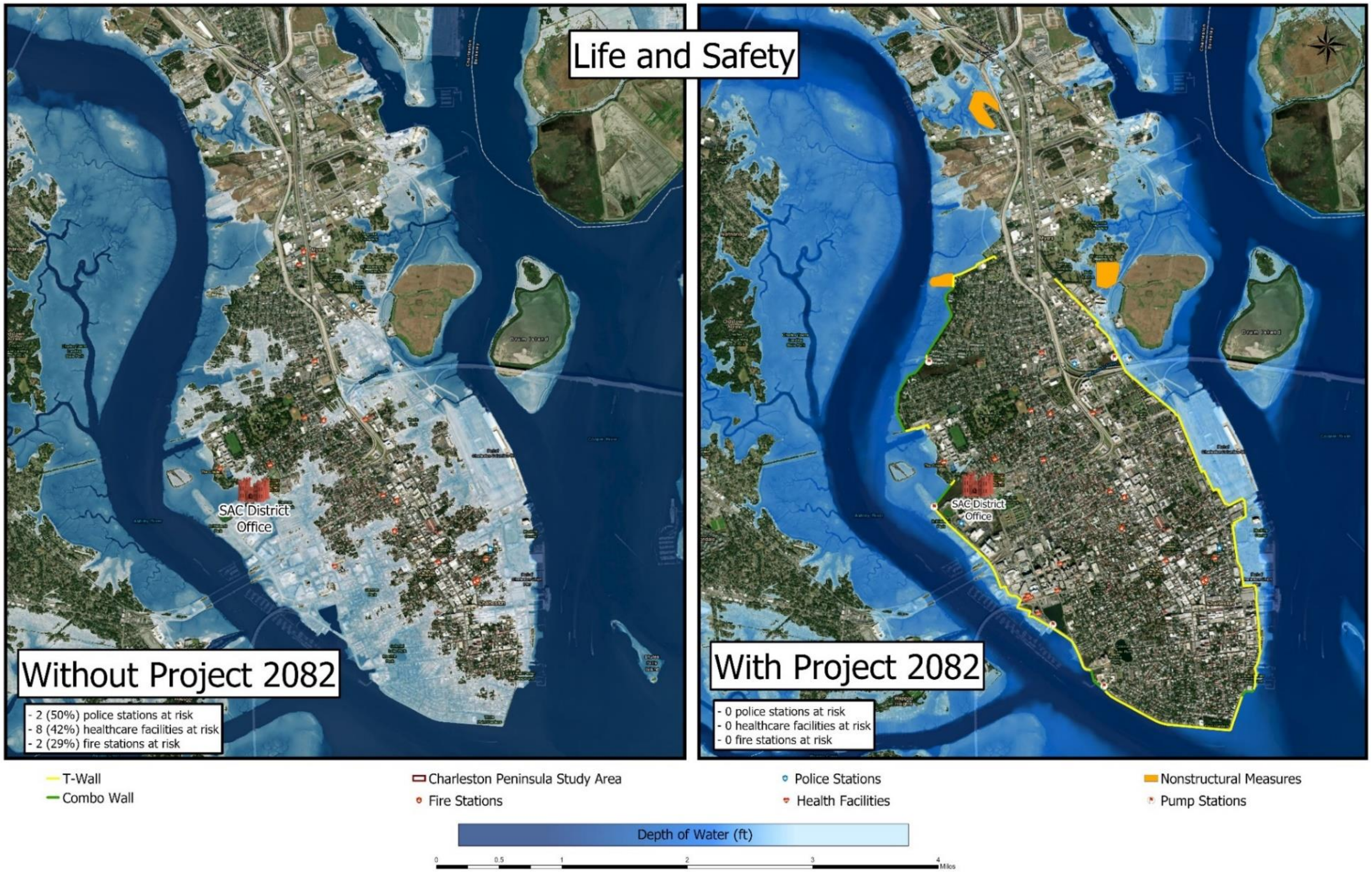

Figure 8-5. Comparison of a 20% AEP coastal storm event in 2082, assuming a high rate of SLR. With implementation of Alternative 2, damages to critical facilities and interruptions in emergency services would be limited and life safety risk would be reduced. Official mapping product of the Management Support Branch, Charleston District, USACE.

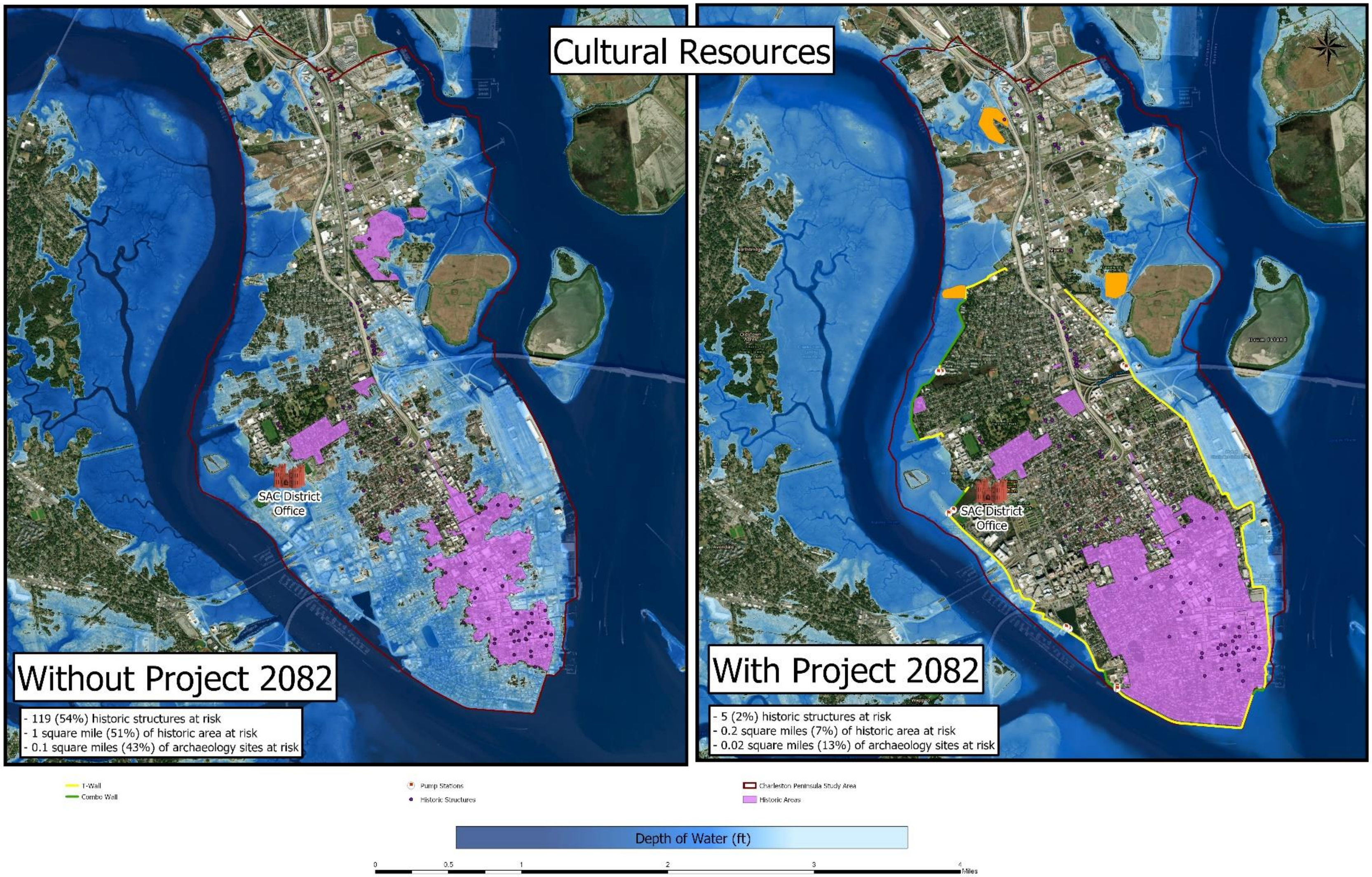

Figure 8-6. Comparison of a 20% AEP coastal storm event in 2082, assuming a high rate of SLR. With implementation of Alternative 2, damages to historic structures and cultural resources would be limited. Official mapping product of the Management Support Branch, Charleston District, USACE.

While Figures 8-5 and 8-6 depict frequent, deep flooding under a high rate of sea level rise, there is potential for frequent, relatively deep flooding under all three sea level rise scenarios. Table 8-2 shows projected stillwater elevations for the 20% AEP under the low, intermediate, high sea level rise scenarios at three points in time. Assuming a high rate of sea level rise in 2132, the proposed storm surge wall would be overtopped and structures elevated to 12ft NAVD88 would be inundated during the 20% AEP event. In 2132, assuming the low and intermediate rates of sea level rise, the wall would be overtopped and elevated structures would be inundated during less frequent events (0.5% and 1% AEP respectively).

Table 8-2. Comparison of inundation depths at the 5-year return interval for three SLR scenarios.

Projected Stillwater Elevations for 20% AEP Storm Event			
SLR Scenario	**Year 2032**	**Year 2082**	**Year 2132**
Low	5.5	6.1	6.6
Intermediate	5.7	6.8	8.3
High	6.1	9.1*	13.8

*Depicted in Figures 8-5 and 8-6.

The proposed storm surge wall would be built so that its top elevation may be raised to adapt to changing conditions as necessary. Gates may be strengthened by adding panels at the top along with bracing on the landward side or replaced to achieve higher design elevations. With sea level rise, pumping efficiency will be reduced as pumps will have to pump against higher head and for longer durations. With increased loadings and operation, there should also expect to be increased operations and maintenance activities. Living shorelines are expected to naturally adapt to sea level rise over time with respect to sediment capture, vertical growth of the oyster reef structure, and marsh elevation to keep pace with the intertidal zone as it shifts, and natural succession of plants and animals which make for a healthy ecosystem. However, consideration would be given during the PED phase to design elements that may enhance resiliency such as planting of marsh grass behind the sill which can increase sediment capture and stimulate accretion, among other benefits. Consideration for intentional adaptation and maintenance will also be given during the PED phase and included in the Mitigation Plan, such as the need for additional substrate to enhance oyster settlement if needed. Any damaged sections of the living shoreline sills would be repaired in accordance with the OMRR&R manual.

Depending on actual rates of sea level rise, the City of Charleston may consider the benefits of adapting the proposed plan when associated risks are no longer tolerable. Should the high rate of SLR be realized, the performance of the RP would be adversely affected in the year 2132 (a century later), with the wall overtopping on nearly an annual basis (Table 8-3). However, the RP would still perform effectively under the low and intermediate SLR scenario. Overall, the RP would improve the peninsula’s ability to withstand and recover rapidly from storm surge events. The RP is a critical component of improving the peninsula’s resilience to storm surge inundation.

Table 8-3. Comparison of AEP events associated with 12ft NAVD88 water levels under each SLR scenario.

Mean AEP at 12 ft NAVD88			
SLR Scenario	**2032**	**2082**	**2132**
Low	0.7%	0.8%	1%
Intermediate	0.7%	1%	1.8%
High	0.8%	2.2%	100%

8.3 Residual Risk

Implementation of the RP would not eliminate risk. Regarding economic risk, assuming the wall does not fail, the project would reduce economic damages by about 58%. About 42% of economic damages would remain for the 50-year period of analysis. Regarding life safety risk, although considered as low as reasonably practicable, non-breach residual risk significantly exceeds Tolerable Risk Guideline 1, meaning non-Federal actions regarding Tolerable Risk Guidelines 2 and 3 are paramount. Refer to Engineering Appendix section 5.14.1, Life Safety Risk Assessment.

8.4 Plan Economics and Cost Sharing

The project first cost, estimated based on 2022 price levels, is $1,086,655,000. Table 8-4 displays the Micro-Computer Aided Cost Estimating System (MCACES) costs and Table 8-5 displays the economic costs and benefits of the Recommended Plan.

Table 8-4. First Costs of the Recommended Plan ($1,000).

MCACES Account	Description	Total First Cost[1]
02	Relocations	$15,230
06	Fish & Wildlife Facilities	$27,633
11	Levees & Floodwalls	$645,311
13	Pumping Plant	$48,112
18	Cultural Resource Preservation	$87,821
19	Buildings, Grounds & Utilities	$55,130
	Construction Estimate Totals	$879,237
01	Lands and Damages	$130,209
30	Planning, Engineering & Design	$61,504
31	Construction Management	$61,504
	Total First Cost	**$1,132,096**

Table 8-5. Economic Costs and Benefits of the Recommended Plan ($1,000).

Cost/Benefit Item	Recommended Plan
Investment Costs	–
Project First Cost	$1,133,000
Interest During Construction	$ 130,000
Total Investment Cost	$1,269,000
Average Annual Cost[1]	–
Average Annual First Cost	$42,500
Annual OMRR&R[2] Cost	$ 3,000
Average Annual Costs	$45,500
Benefits[1]	–
Average Annualized Benefits	$493,000
Net Benefits	$447,500
BCR	10.8

[1]Costs are rounded in 2022 price levels, FY22 discount rate (2.25%), and a 50-year period of analysis.
[2]Operation, Maintenance, Repair, Replacement, and Rehabilitation.

The estimated total project first cost for the RP is $1,132,096,000. The Federal portion of the estimated first cost is $735,862,000 based on WRDA 1986 cost share formulas. The non-Federal portion of the estimated first cost is $396,234,000. Table 8-6 displays the cost share apportionment for the RP.

Table 8-6. Preliminary Cost-Share Apportionment for Recommended Plan ($1,000). [1]

	Federal (65%)	Non-Federal (35%)	Total
Initial Project Cost	$735,862	$396,234	$1,132,096
LERRD Credit	-	$145,439	-
Cash Contribution	-	$250,795	-

[1]Costs are in 2022 price levels.
[2]Land and Damages and Relocation costs are thfe responsibility of the non-Federal sponsor and deducted from the cash contribution to meet the required 35% non-Federal cost share apportionment.

8.4.1 Nonstructural Incremental Justification

Engineer Regulation 1105-2-100, Appendix E, page E-9, Section I, E-3. c. (2) requires that *"[a] separable element is any part of a project which has separately assigned benefits and costs, and which can be implemented as a separate action (at a later date or as a separate project)… Separable elements usually must be incrementally justified."*

Even though the nonstructural measures are included in Alternative 2 and not a standalone alternative, the nonstructural measures could technically be implemented as a separate action (separate project) from the perimeter wall. Therefore, the nonstructural measure can be considered an increment of the plan and must be incrementally justified. Table 8-7 displays the nonstructural measure incremental justification (BCR ≥ 1.0).

Table 8-7. Nonstructural Incremental Analysis.

Present Value Damages Reduced	Average Annual Damages Reduced	Nonstructural Measure First Cost	Nonstructural Measure Annual Cost	Net Benefits	BCR
$38,300,000	$1,290,000	$34,300,000	$1,150,000	$140,000	1.1

8.5 Environmental Effects and Mitigation

For this draft integrated FR/EIS, the effects of the alternatives to the human environment have been considered and an evaluation of their anticipated significance has been completed. The RP is expected to have temporary and permanent effects on the environment, some that are beneficial and some that are adverse. A summary of the expected environmental effects of the two alternatives evaluated in this study can be found in Table 7-5. Early on, the resource categories of wetlands and historic/cultural were identified as presenting the potential for significant effect, prior to mitigation. Subsequently, aesthetics was identified as a third resource area with the potential for significant impact, pre-mitigation. Regarding the effect of Alternative 2 on wetlands, since the release of the draft FR/EA in April 2020, efforts have been made to optimize the wall alignment, including to avoid adverse effects on wetlands. This has resulted in a significant reduction in effects (particularly on salt marsh, but also on aquatic resources). Numerous minimization measures have also been proposed to lessen the adverse effects, including NNBFs that also promote coastal storm resilience. Mitigation for wetlands and associated aquatic resources is described in the Draft Mitigation Plan in Appendix F - Environmental.

Potentially significant adverse effects from the RP are likely for visual and historic/cultural resources. Ways to prioritize and reduce the adverse effects to these resources have been incorporated into the planning process, considered and estimated through the feasibility study and will continue into the PED phase. As part of the mitigation process, USACE is executing a Programmatic Agreement (PA) for historic properties. This agreement document is being executed by USACE, the South Carolina State Historic Preservation Officer, the National Park Service, the City of Charleston and the Advisory Council on Historic Preservation. Signatories had the opportunity to provide input on the content and terms of the PA. Concurring parties include Historic Charleston Foundation, Preservation Society of Charleston, the Catawba Indian Nation and the Naval History and Heritage Command. A copy of the PA agreed to by the parties is included in Appendix D. In addition, the Corps and City have drafted an MOU for the assessment of aesthetic (visual) resources to guide their common understanding of the path forward, including into the PED phase of the project.

8.5.1 Unavoidable Adverse Effects

Unavoidable adverse effects are those effects that cannot be avoided should the alternative be implemented. The effects of the RP are described in Chapter 6 and some of them may not be fully avoided, as identified in the Council on Environmental Quality regulations (40 C.F.R. § 1502.16).

To facilitate the construction of all of the proposed measures of the RP, some adverse environmental effects could occur within the project area. The following list summarizes expected adverse environmental effects that are more fully described in Chapter 6:

- Temporary, minor, and localized degradation of water quality from increases in turbidity during in-water work, which could indirectly affect aquatic resources; effects would be minimized
- Temporary localized degradation of water quality in marsh areas where the storm gates would temporarily close during a storm surge event would have indirect effects of reduced water quality on aquatic resources, depending on the nature of any given storm; effects would be mitigated and minimized as appropriate
- Permanent loss of land, upland vegetation such as trees, or other environmental resources at the location of storm surge wall on land; effects would be minimized and mitigated as appropriate
- Temporary construction noise; effects would be minimized
- Temporary construction zones and equipment, material stockpiles, and activity may temporarily interfere with recreation and aesthetics
- Temporary and localized disruptions to traffic and utilities during construction; effects would be minimized
- Permanent reduction of wetlands and aquatic habitat where the storm surge wall would be constructed in marsh to the land; effects would be mitigated
- Permanent adverse effects to historic properties listed or eligible for listing in the National Register of Historic Places; effects would be mitigated
- Permanent adverse impacts to important aesthetic resources; effects would be mitigated

8.5.2 Relationship between Short-Term Uses and Long-Term Productivity

NEPA requires that an EIS consider the relationship between short-term uses of the environment and the impacts that such uses may have on the maintenance and enhancement of long-term productivity of the affected environment (40 CFR § 1501.16). This section compares the short- and long-term environmental effects of the proposed project. For the RP, “short-term” refers to the temporary phase of construction of the proposed project, while “long-term” refers to the 50-

year period of analysis of the proposed project and beyond. Chapter 6 of this document evaluates the direct, indirect, and cumulative effects that could result from the alternatives. Short-term impacts caused by the phased construction of the project would occur during and immediately after construction and would generally result in adverse effects. Many of the adverse effects would be lessened through mitigation and minimization, including through compensation, NNBFs, and BMPs. Moreover, many of the analyzed resource categories of the human environment would experience significant long-term benefits from construction of the proposed project. Therefore, the long-term effect that would occur over the life of the project would result in net overall beneficial effects on the human environment through the reduction of storm surge flooding that currently threatens property, life safety, historic/cultural resources, and other values.

8.5.3 Irreversible and Irretrievable Commitment of Resources

NEPA requires that environmental analysis include identification of any irreversible and irretrievable commitments of resources. Irreversible effects primarily result from use or destruction of a specific resource (e.g., energy and minerals) that cannot be replaced within a reasonable period. Irretrievable resource commitments involve the loss in value of an affected resource that cannot be restored because of the action (e.g., extinction of a species or the disturbance of a cultural site).

The proposed Federal action is designed to have minimal irreversible and irretrievable commitment of resources. The RP would result in a minor irreversible use of fossil fuels to execute the construction of the RP. While wetland resources would be fully lost in some locations where avoidance and minimization is not practicable, this would not be considered irreversible or irretrievable because the lost wetland functions would be offset through compensatory mitigation. All construction effects are assumed to be short-term and minor on aquatic and water quality, which would recover in a relatively short period. Loss of cultural resources (e.g., historic structures) resulting from changes to the viewshed, and loss of previously unidentified archaeology sites within the construction footprint would be an irreversible and irretrievable commitment; however, effects to those cultural resources that are listed in or eligible for listing in the National Register of Historic Places will require mitigation as outlined in the Programmatic Agreement. Loss of aesthetic resources, if not mitigated during PED, would be irreversible and irretrievable. A draft Memorandum of Understanding outlines how impacts to aesthetic resources would continue to be assessed and mitigation pursued during PED.

It is worth noting that in the case of both historic/cultural resources and aesthetic resources, the No Action Alternative / Future Without Project condition contemplates a significant loss of these resources without the comprehensive protection from storm surge damage which Alternative 2 would provide.

8.6 Real Estate Requirements

The non-Federal sponsor is responsible for the acquisition of all lands, easements, rights of way, relocations, and disposal areas (LERRD) that are required for the construction, operation, and maintenance of the proposed project. Based on available information, the Real Estate Plan (REP) (Appendix E) considering 8.7 miles of storm surge wall, projects approximately 58 acres of parcels that may require real estate acquisition, relocation, permanent and temporary easements for construction of the structural and nonstructural measures of the RP. The standard estates have been reviewed for sufficiency and were found to be acceptable for the project. The Real Estate Baseline Cost Estimate has been prepared estimating 134 parcel ownerships to include 11 parcels to be acquired in fee, 237 temporary and perpetual easements for construction of the storm surge wall, and 453 rights of entry/applications for the elevation or floodproofing of homes. A Gross Appraisal and Administrative Update were completed to support the overall Real Estate Base Cost Estimate and project approval authorization and funding. The Final REP (Appendix E) includes other relevant information on the non-Federal sponsor's ownership of land, proposed standard and nonstandard estates, existing federal projects, potential relocations under the Uniform Relocation Assistance and Real Property Acquisition Policies Act (P.L. 91-646, as amended), facility/utility relocations, a schedule for real estate acquisition activities, and other issues as required. Should it be determined that additional lands are required during the design phase, the City of Charleston would be required to purchase these lands using the appropriate standard estate.

Wherever possible, the study team utilized public owned land to minimize the acquisition or taking of private property. If a property must be acquired for the project, the non-Federal sponsor will need to acquire all property rights and interest up to and including fee acquisitions. Most of the structural measures for the storm surge wall would require both perpetual maintenance easements and temporary construction easements. Some properties would be acquired in fee title due to the amount of land remaining after the taking (an uneconomic remnant), recreation features and access needs, and habitat mitigation sites, and where navigational servitude is not sufficient. (See Real Estate Appendix E).

8.7 Operations, Maintenance, Repair, Replacement, and Rehabilitation (OMRR&R)

The non-federal sponsor is responsible for 100 percent of all operation, maintenance, repair, replacement, and rehabilitation (OMRR&R) activities and costs. Once a functional portion of the project has been constructed, the non-federal sponsor will be notified, and their OMRR&R responsibilities will begin. USACE will provide an OMRR&R manual for the City of Charleston, the non-federal sponsor for this project. The intent of the manual is to provide the city with clear and comprehensive guidance on the operation and maintenance of floodwalls, gates, other flood control structures, and habitat mitigation sites. It will describe how to plan and prepare for high water and storm events and lay out steps to take during emergencies that will help reduce the threat of flooding. The manual will also explain the types of assistance that USACE can provide to a community before, during, and after a flood.

While the precise provisions of the O&M Manual will be developed in the PED phase, storm gates and pump stations must be operated consistent with the project purpose. Operation of storm gates will be in response to an authoritative forecast of coastal storm surge flooding on the Charleston Peninsula. Tidal and precipitation flooding unrelated to coastal storm events will not be a basis for operation of the storm gates. Further modeling and analysis of storm surge gate and pump operations will be conducted as part of PED.

Monitoring and inspections must occur to ensure that the project functions as designed and that the local sponsor conforms to all OMRR&R recommendations and requirements that will assist in functionality of the project. USACE, in coordination with the City of Charleston, will inspect and rate the project each year. The non-federal sponsor must maintain the floodwall to at least the minimally acceptable standard to remain eligible for federal rehabilitation assistance through the USACE Rehabilitation and Inspection Program (PL 84-99). USACE also shares the results with FEMA, to help inform decisions about levee accreditation for flood insurance purposes. The inspection ratings are available in the National Levee Database.

The non-federal sponsor should be prepared to carry out maintenance activities on all flood control structures every year to reduce risks of failure and unintended consequences. Regular maintenance is critical, because many types of problems will escalate exponentially when left unchecked. There are many ongoing requirements of which one should be aware. For example, debris and unwanted growth need to be removed from levees, riprap, and the areas adjacent to floodwalls, and from channels and waterways. The non-federal sponsor will need to periodically install closure structures as required by the inspection and levee safety program. Grass adjacent to floodwalls has to be cut low and maintained and no trees shall be planted on or within 15 feet of a levee structure. Metal gates and other components need to be painted and greased periodically. Concrete damage needs to be identified and repaired early or it will get worse. Standard maintenance for cathodic protection systems will be needed as well. Beyond these examples of ongoing maintenance, there are also more significant repairs that will be necessary from time to time. Pump stations also need to be completely overhauled periodically. Routine maintenance is expected in any project and can be planned for in advance.

8.8 Views of the Non-Federal Sponsor

The City of Charleston supports the proposal as outlined in the U.S. Army Corps of Engineers Coastal Flood Risk Management Study for the Charleston Peninsula as a solution for storm surge protection of our most critical assets on the peninsula, including: vulnerable and historic neighborhoods; regional and state-wide economic drivers, like the multi-institutional Charleston Medical District and the South Carolina Ports Authority; major state highways; institutions of higher learning; and rich national historic and cultural landmarks. The proposal allows for the city to continue to adapt and plan into the next 50 years and beyond. We view the study proposed action as a foundational element for the City's overall plan to address flooding. The design of the proposed action will be further developed during the PED phase, pursuant to a negotiated Design Agreement, including the incorporation of additional natural and nature-based solutions where appropriate and revisions and improvements to the alignment. The City of Charleston values the opportunity to continue to engage with USACE to complete the feasibility study and continue to refine the proposed action into the PED phase. The City of Charleston encourages the public to review the draft report and provide comments. Please see Appendix H for further details.

8.9 Environmental Operating Principles

The RP supports each of the seven USACE Environmental Operating Principles. The re-energized Environmental Operating Principles are:

1. Foster sustainability as a way of life throughout the organization.
2. Proactively consider environmental consequences of all Corps activities and act accordingly.
3. Create mutually supporting economic and environmentally sustainable solutions.
4. Continue to meet our corporate responsibility and accountability under the law for activities undertaken by the Corps, which may impact human and natural environments.
5. Consider the environment in employing a risk management and systems approach throughout the life cycles of the projects and programs.
6. Leverage scientific, economic and social knowledge to understand the environmental context and effects of Corps actions in a collaborative manner.
7. Employ an open, transparent process that respects views of individuals and groups interested in Corps activities.

The Environmental Operating Principles are met in the following ways:

- Efforts to minimize and avoid adverse effects on the environment have been made throughout the study process while maximizing future safety and economic benefits to the community.
- A draft mitigation plan has been prepared to address non-negligible adverse effects which remain after avoidance and minimization.
- The study team has coordinated with environmental resource agencies to better understand environmental context and effects of the proposed action.
- NNBFs have been considered and incorporated into the RP as environmental minimization measures but they are also sustainable solutions for qualitative coastal storm risk reduction benefits.

- USACE has hosted several public meetings and engagement opportunities to explain the planning and NEPA processes, communicate flood risk reduction measures under consideration, and seek feedback from the community.

8.10 USACE Campaign Plan

The mission of the U.S. Army Corps of Engineers is to provide vital public engineering services in peace and war to strengthen the Nation's security, energize the economy and reduce risks from disasters. In order to meet this mission, the agency has developed the USACE Campaign Plan (FY18-22) as a component of the corporate strategic management process to establish priorities, focus on transformation initiatives, measure and guide progress and adapt to the needs of the future. The goals and supporting objectives of the Campaign Plan are:

Goal 1 – Support National Security

Objective 1a – Support Combatant Command and U.S. Government agency security objectives to advance our Nation's interests around the globe

Objective 1b – Enable a ready, resilient, and capable installation support management community

Objective 1c – Support the Nation and the Army in achieving our energy security, sustainability, and environmental goals

Objective 1d – Support the Engineer Regiment's efforts to provide professional EN leaders and units ready for complex missions in any environment

Goal 2 – Deliver Integrated Water Resource Solutions

Objective 2a – Deliver Quality Water Resource Solutions and Services

Objective 2b – Deliver the Civil Works Program and innovative solutions

Objective 2c – Develop the Civil Works Program to meet the future needs of the Nation

Objective 2d – Manage the life-cycle of water resources infrastructure systems to consistently deliver reliable and sustainable performance

Goal 3 – Reduce Disaster Risk

Objective 3a – Enhance interagency disaster response and risk reduction capabilities

Objective 3b – Enhance interagency disaster recovery capabilities

Objective 3c – Enhance interagency disaster mitigation capabilities

Objective 3d – Deliver and advance Army Geospatial Engineering

Goal 4 – Prepare for Tomorrow

Objective 4a – Maintain and advance DoD and Army critical enabling technologies

Objective 4b – Build a secure cyber foundation and modernize IM/IT using sound investment strategies

Objective 4c – Streamline USACE business, acquisition, and governance processes and optimize financial management

Objective 4d – Build ready and resilient people and teams through innovative talent management and leader development strategies and programs

The Charleston Peninsula Coastal Flood Risk Management Study has been responsive to these goals and objectives by:

Deliver Quality Water Resource Solutions and Services:

- The study team has been working closely with the City of Charleston and key stakeholders to understand the nature of the flood problem and the benefits and impacts of potential solutions.
- The study team has maintained the project schedule and budget set forth by the Water Resources and Reform Development Act of 2014.
- The study team pursued opportunities to minimize and avoid potential environmental impacts where possible. The study team has prepared a draft plan to mitigate impacts prior to environmental damage.

Deliver the Civil Works Program and innovative solutions:

- The Charleston District has utilized alternative resourcing by using technical experts from other districts as necessary.
- The study team analyzed a regional storm surge barrier system as a larger scale solution, but in concurrence with the Dutch Dialogues report, found the system to be inefficient and too complex to implement.

8.11 Next Steps

The Feasibility Phase is the first phase in the USACE Civil Works Project Development Process. The completion of the Feasibility Phase is marked by approval by the Chief of Engineers and signature of the Chief's Report, which is then submitted to Congress for consideration. If the project is authorized and funded by Congress, or the Secretary of the Army determines that the project is justified and funding is available, the project will enter the PED phase upon execution of a Design Agreement between USACE and the City. During the PED phase, USACE and the City would complete the detailed engineering & technical studies and design needed to prepare for construction of the project consistent with the decision document

8.11.1 PED Tasks

Should the proposed project proceed to the PED phase, the following tasks offer a good representation of those anticipated to be completed during PED.

- Conduct detailed surveys or assessments, such as: topographic, geospatial bathymetric, geotechnical (subsurface), wetland delineation, living shoreline site suitability, Phase I Environmental Site Assessment (HTRW), and other applicable surveys.
- Continue to refine storm surge wall alignment based upon surveys and identified opportunities.
- Detailed design of nonstructural measures, such as: structure by structure surveys to refine nonstructural treatment recommendations, optimizing design elevation of nonstructural measures, etc.
- Implement the Programmatic Agreement under the NHPA for historic/cultural resources, to include: surveys of historic/cultural/archeological resources, evaluation of identified resources, determination of effects from project features, identification of appropriate mitigation with a priority on avoidance and minimization; and conduct related consultation.
- Conduct aesthetic resources assessment using the VRAP as outlined in the Corps/City MOU, including: the identification of aesthetic resources and conditions, the assessment of the nature and extent of effects on aesthetic resources, design considerations such as compatibility, and the determination of appropriate mitigation.
- Finalize the Mitigation Plan and continue to investigate opportunities to incorporate NNBF/green features or mitigation.
- Engineering and technical studies regarding the storm surge wall, such as: seepage analysis, design of supporting piles, determination of lateral earth pressures, and refining of interior (including City's subsurface drainage system) and coastal hydrology analysis.
- Conduct a transportation study to inform PED-related decisions.
- Perform Safety Assurance Review/Type II Independent External Peer Review.
- Detail the Operation, Maintenance, Repair, Replacement, and Rehabilitation Manual procedures for finalization during the construction phase.

This is not intended to be an exhaustive list. USACE will remain open to opportunities to incorporate additional climate change resilience, consistent with the framework of PED. Regarding NEPA during PED, USACE will follow Appendix A to 33 CFR Part 230 - Processing Corps NEPA Documents, 3. Projects in Preconstruction Engineering and Design.

8.11.2 Preliminary Acquisition Strategy and Phasing

For cost estimating purposes, the assumed acquisition strategy for PED is based on full funding available to award one unrestricted large business architect-engineering contract to execute some of the PED tasks. The contract will last between 3-4 years in duration and will engineer/design the entire Charleston Peninsula Coastal Storm Risk Management project. The detailed plans/specs will be separated into 4 segments (Marina, Port/New Market, Battery and Wagener Terrace) for phasing of construction contracts.

For cost estimating purposes, the assumed acquisition strategy for construction is based on full funding available to award multiple firm fixed price construction contracts via unrestricted best value solicitations. Due to the construction duration for the Marina and Port/New Market segments it is assumed these contracts will be awarded concurrently after the design is completed and last approximately 6-7 years. The next two construction contracts for the Battery and Wagener Terrace segments will be awarded between 2-3 years after award of the Marina and Port/New Market segments due to their anticipated construction duration. Construction contracts for pump houses/pumps and natural-based features will be included in their respective construction phases.

In addition, non-structural contracts will be a stand-alone PED and construction contracts that will begin concurrently with the initiation of PED and first construction efforts.

CHAPTER 9 - Environmental Compliance and Commitments

This section addresses the primary Federal environmental laws, implementing regulations, and executive orders potentially applicable to the RP. The applicable environmental statutes are summarized below along with a brief description of the law, regulations, and executive orders. The status of compliance and environmental commitments identified for each to date are also included.

9.1 National Environmental Policy Act

The National Environmental Policy Act (NEPA) of 1969 (42 U.S.C. § 4321 et seq.) establishes the broad national framework for protecting our environment. It requires Federal agencies to consider, document, and publicly disclose the environmental effects of their actions prior to undertaking any major federal action that significantly affects the environment. NEPA documents must provide detailed information regarding: the purpose and need; the proposed action and alternatives, including the No Action Alternative; the environmental impacts of the alternatives; appropriate mitigation measures; any adverse environmental impacts that cannot be avoided if the proposal is implemented; and, any irreversible and irretrievable commitments of resources which would be involved in the proposed action should it be implemented. Where the impact will be significant, Federal agencies are required to document their consideration of these factors in an Environmental Impact Statement (EIS) and conclude the NEPA process with a decision document known as a Record of Decision (ROD).

This EIS (which has been integrated with USACE's Feasibility Report, or FR, for the study) is the primary vehicle to achieve NEPA compliance for this study. Before preparing this final FR/EIS, USACE initiated the NEPA process by preparing and releasing in April 2020 a draft Feasibility Report and Environmental Assessment. After further agency analysis and after consideration of public comments on the draft FR/EA, USACE concluded that an EIS would best meet the intent of NEPA. Accordingly, a Notice of Intent to Prepare a Draft Integrated Feasibility Report and Environmental Impact Statement was published in the Federal Register on March 23, 2021, and the public scoping meeting was held virtually due to concerns stemming from the ongoing COVID-19 pandemic. The Notice of Availability was published in the *Federal Register* on September 10, 2021 (86 FR 50713), beginning the 45-day public comment period on the draft FR/EIS. After review and consideration of agency and public comment on the draft FR/EIS, USACE has prepared this final FR/EIS, including Appendix I – Response to Public Comments. Following the 30-day public review of the final FR/EIS, the USACE decision-maker will sign a Record of Decision, outlining the rationale for the decision.

9.2 Endangered Species Act

The Endangered Species Act (ESA) of 1973 (16 U.S.C. §§ 1531–1544), amended in 1988, establishes a national program for the conservation of threatened and endangered species of fish, wildlife, and plants and the habitat upon which they depend. Section 7(a)(2) of the ESA requires that Federal agencies consult with the National Marine Fisheries Service (NMFS) and U.S. Fish and Wildlife Service (USFWS), as appropriate, to ensure that their actions are not likely to jeopardize the continued existence of endangered or threatened species or to adversely modify or destroy their designated critical habitats.

USACE has been coordinating with both NMFS and USFWS throughout the development of this draft EIS. Effects to threatened and endangered species and critical habitat have been evaluated with respect to Section 7(a)(2).

For threatened and endangered species and critical habitat under the jurisdiction of USFWS, either a *no effect* or a *may affect but not likely to adversely affect* determination has been made by USACE. USFWS concurred with this determination in a letter dated August 12, 2021. Subsequently, USACE requested concurrence on the oyster reef-based living shoreline and the wall realignment along the SCPA properties in an email dated January 11, 2022, with either a *no effect* or a *may affect but not likely to adversely affect* determination. USFWS concurred with this determination stating that their August 12, 2021, concurrence letter serves to provide Section 7 concurrence for the oyster reef-based living shoreline and the wall realignment along the SCPA properties in an email dated January 12, 2022. Relevant documentation is included in Appendix F - Environmental.

For threatened and endangered species and critical habitat under the jurisdiction of NMFS, a *may affect but not likely to adversely affect* determination has been made by USACE, and an informal consultation was requested on September 24, 2021. Informal consultation is ongoing and expected to be completed prior to signing of the Record of Decision. Relevant documentation is included in Appendix F - Environmental.

9.3 Fish and Wildlife Conservation

9.3.1 Fish and Wildlife Coordination Act of 1934

The Fish and Wildlife Coordination Act of 1934, as amended (16 U.S.C. §§ 661–667e), provides authority for USFWS and NMFS involvement in evaluating impacts to fish and wildlife from proposed water resource development projects. It requires that fish and wildlife resources receive equal consideration to other development project features. It requires Federal agencies that construct, license, or permit water resource development projects to consult with the USFWS, NMFS, and state resource agencies regarding the impacts on fish and wildlife resources and measures to mitigate these impacts when waters of any stream or other body of water are "proposed . . . to be impounded, diverted . . . or . . . otherwise controlled or modified . . ." Section 2(b) requires the USFWS to produce a Coordination Act Report (CAR) that describes fish and wildlife resources in a project area, potential impacts of a proposed project, and recommendations for a project.

The study is in compliance with the Fish and Wildlife Coordination Act. A CAR was jointly prepared by USACE, USFWS, and NMFS and is included for reference to this integrated FR/EIS in Appendix F - Environmental. The CAR identifies species considerations for potential effects of the proposed federal action based on published information and provides recommendations to balance effects resulting from the federal action with natural resource conservation. Information from the CAR has been considered in development of the FR/EIS.

9.3.2 Migratory Bird Treaty Act and Executive Order 13186, Responsibilities of Federal Agencies to Protect Migratory Birds

The Migratory Bird Treaty Act (16 U.S.C. §§ 703–712), as amended, protects over 800 bird species and their habitat, and implements various treaties and conventions between the United States and other countries, including Canada, Japan, Mexico, and Russia, for the protection of migratory birds. Under the act, taking, killing, or possessing migratory birds, or their eggs or nests, is unlawful. The act classifies most species of birds as migratory, except for upland and non-native birds such as pheasant, chukar, gray partridge, house sparrow, European starling, and rock dove. Executive Order 13186, dated January 10, 2001, directs Federal agencies to evaluate the effects of their actions on migratory birds, with emphasis on species of concern, and inform USFWS of potential negative effects to migratory birds.

USACE does not anticipate that migratory birds would be adversely affected by the proposed federal action, but since they are present in the area, appropriate minimization measures have been proposed and coordinated with USFWS.

9.3.3 Marine Mammal Protection Act

The Marine Mammal Protection Act (MMPA) of 1972 (16 U.S.C. §§ 1361–1407) prohibits the take of marine mammals, including harassment, hunting, capturing, collecting, or killing, except through permits and authorizations under the MMPA.

USACE has evaluated effects on marine mammals in this FR/EIS and proposed protective measures to minimize effects on marine mammals. The need for incidental take statements for manatees or dolphins under the MMPA is not anticipated. For manatees, USACE has demonstrated compliance with the MMPA through consultation with USFWS during compliance with the Endangered Species Act. For bottlenose dolphins, which are not protected under the Endangered Species Act, MMPA consultation with NMFS would be initiated at a later time if needed, but prior to construction.

9.3.4 Magnuson-Stevens Fishery Conservation and Management Act

The Magnuson-Stevens Fishery Conservation and Management Act (16 U.S.C. § 1801 et seq.) requires Federal agencies to consult with NMFS on activities that may adversely affect Essential Fish Habitat (EFH). The objective of an EFH assessment is to determine whether the proposed action(s) “may adversely affect” designated EFH for relevant commercial, federally managed fisheries species within the proposed action area. EFH includes those waters and substrate necessary for fish spawning, breeding, feeding, or growth to maturity.

USACE has been coordinating with NMFS throughout the development of the FR/EIS. An EFH Assessment has been prepared, and consultation with NMFS was requested by USACE on September 24, 2021. A copy of the EFH Assessment can be found in Appendix F - Environmental. Consultation is expected to be completed prior to signing of the ROD.

9.4 Cultural Resources

9.4.1 National Historic Preservation Act (NHPA)

Section 106 of the National Historic Preservation Act (54 U.S.C. § 306108) and its implementing regulations, 36 Code of Federal Regulations (C.F.R.) Part 800, provides a regulatory framework for the identification, documentation, and evaluation of historic and cultural resources that may be affected by Federal undertakings. Under the act, Federal agencies must take into account the effects of their undertakings on historic properties, including resources that are listed or are eligible for listing in the National Register of Historic Places, and afford the Advisory Council on Historic Preservation a reasonable opportunity to comment on such undertaking. Additionally, a Federal agency shall consult with any tribe that attaches religious and cultural significance to such properties. Section 110(f) of the NHPA (54 U.S.C. § 306107) requires USACE to minimize harm to all National Historic Landmarks (NHL) within the Area of Potential Effects to the maximum extent possible.

As detailed in Chapter 5, USACE has consulted with all appropriate federal, state, and tribal agencies with an interest in cultural resources affected by the undertaking. Copies of this correspondence is provided in Appendix D. Pursuant to 36 C.F.R. § 800.4(b)(2), USACE has taken into account the effect of the undertaking on historic properties and has taken the appropriate planning and actions with regard to NHLs by execution of a Programmatic Agreement with the South Carolina SHPO, the ACHP, the City of Charleston, the NPS, the Catawba Indian Nation, Historic Charleston Foundation, and the Preservation Society of Charleston, in compliance with this Act.

The Archaeological Resources Protection Act (ARPA) of 1979 (16 U.S.C. §§ 470aa–470mm; Public Law 96-95, as amended) protects archaeological resources and sites on federally-owned and Indian lands and fosters increased cooperation and exchange of information between governmental authorities, the professional archaeological community, and private individuals.

The act established civil and criminal penalties for the destruction or alteration of cultural resources. This Act is not applicable as the undertaking will not affect archaeological resources on federally or tribally owned lands.

9.4.2 Antiquities Act

The Antiquities Act of 1906 (54 U.S.C. §§ 320301–320303; Public Law 59-209) gives the President of the United States authority to create national monuments to protect important natural, cultural, or scientific features and resources. The act requires a permit be issued from the secretary of the department with land management responsibilities prior to any excavation of archaeological material. It further requires all material excavated as a result of an Antiquities Permit be properly housed in a museum or facility. This act is considered to be the beginning of a long tradition of cultural resources management and protection by the Federal government. This Act is not applicable as the undertaking will not affect archaeological resources on federally owned land.

9.4.3 Native American Graves Protection and Repatriation Act

The Native American Graves Protection and Repatriation Act (25 U.S.C. §§ 3001–3013; Public Law 101-601) describes the rights of Native American lineal descendants, Indian tribes, and Native Hawaiian organizations with respect to the treatment, repatriation, and disposition of Native American human remains, funerary objects, sacred objects, and objects of cultural patrimony, with which they can show a relationship of lineal descent or cultural affiliation. This Act applies to federally owned lands, including Reservation lands. The undertaking does not occur on federally or tribally owned lands.

9.4.4 American Indian Religious Freedom Act

The American Indian Religious Freedom Act of 1978 (42 U.S.C. § 1996) establishes protection and preservation of Native Americans' rights of freedom of belief, expression, and exercise of traditional religions. These rights include, but are not limited to, access to sacred sites, freedom to worship through traditional ceremonial rites, and the possession and use of objects traditionally considered sacred by their respective cultures. The act requires policies of all governmental agencies to accommodate access to, and use of, Native American religious sites to the extent that the use is practicable and is consistent with an agency's essential missions. USACE does not anticipate the undertaking will infringe upon the rights afforded under the American Indian Religious Freedom Act to area Native American tribes. USACE has consulted with the appropriate federally recognized Tribes in accordance with the Act, including the Absentee-Shawnee Tribe of Indians of Oklahoma, the Alabama-Quassarte Tribal Town, the Catawba Indian Nation, the Chickasaw Nation, the Delaware Tribe of Indians, the Eastern Band of the Cherokee Indians, the Eastern Shawnee Tribe of Oklahoma, the Kialegee Tribal Town, the Muscogee (Creek) Nation, the Shawnee Tribe, the Thlopthlocco Tribal Town, and the Poarch

Band of Creek Indians. USACE will continue to consult and work with area tribes to protect and provide access to sacred sites should they be identified.

9.5 Clean Water Act of 1972

The Clean Water Act of 1972 (33 U.S.C. § 1251 et seq.) is the primary legislative vehicle for Federal pollution control programs and the basic structure for regulating discharges of pollutants into waters of the U.S. The CWA was established to "restore and maintain the chemical, physical, and biological integrity of the nation's waters." The CWA sets goals to eliminate discharges of pollutants into navigable waters, protect fish and wildlife, and prohibit the discharge of toxic pollutants in quantities that could adversely affect the environment. The sections of the CWA that may apply to the Preferred Alternative are Section 401, regarding state water quality certifications that existing water quality standards would not be violated if a Federal permit that causes discharges into navigable waters were issued; Section 402, regarding discharges of pollutants from point sources under the National Pollutant Discharge Elimination System (NPDES); and Section 404, regarding fill material discharged into the waters of the U.S., including wetlands.

On January 18, 2022, USACE requested from SCDHEC a letter of confirmation acknowledging USACE's coordination on this project with SCDHEC, SCDHEC 's potential preliminary findings, if available, and acknowledgement of USACE's plans to obtain a Water Quality Certification at a later date, prior to implementation of the project. USACE received the letter of confirmation from SCDHEC, dated January 26, 2022 (Appendix F).

Section 404 of the CWA and implementing USACE regulations at 33 C.F.R. 336(c)(4) and 33 C.F.R. 320.4(b) require USACE to avoid, minimize, and mitigate impacts to wetlands. The steps that USACE has and will continue to take actions to avoid, minimize and compensate for adverse effects of the Federal action are described in the Draft Mitigation Plan found in Appendix F - Environmental. A wetland delineation survey will be conducted in the PED phase to verify the exact number of acres affected and refine the wetland mitigation requirement. The 404 (b)(1) evaluation concluded that the proposed disposal site(s) for the discharge of fill material would comply with the requirements of the Clean Water Act Section 404(b)(1) guidelines, with the inclusion of appropriate and practical conditions to minimize adverse effects on the aquatic ecosystem. The complete 404(b)(1) Evaluation can be found in Appendix F - Environmental.

9.6 Clean Air Act of 1972

The Clean Air Act, as amended (42 U.S.C. § 7401, et seq.), requires EPA and the states to carry out programs intended to ensure attainment of National Ambient Air Quality Standards. EPA is authorized to establish air quality standards for six "criteria" air pollutants: carbon monoxide, lead, nitrogen dioxide, ozone, particulate matter ($PM_{2.5}$, PM_{10}), and sulfur dioxide. EPA uses these six criteria pollutants as indicators of air quality. EPA has established National Ambient Air Quality Standards for each criteria pollutant, which defines the maximum allowable concentration. If the standard for a pollutant is exceeded, adverse effects on human health may occur. When an area exceeds these standards, it is designated as a nonattainment area.

Potential effects on air quality have been evaluated as part of the FR/EIS and the federal action is expected to be compliant with the Clean Air Act. The study area is in an attainment area for all air quality criteria and the federal action would not cause the area to go out of attainment.

9.7 Federal Water Project Recreation Act

In the planning of any Federal navigation, flood control, reclamation, or water resources project, the Federal Water Project Recreation Act, as amended (16 U.S.C. § 460l-12 et seq.) requires that full consideration be given to the opportunities that the project affords for outdoor recreation and fish and wildlife enhancement. The act requires planning with respect to development of recreation potential. Projects must be constructed, maintained, and operated in such a manner if recreational opportunities are consistent with the purpose of the project. Effects to recreation analyzed for the RP are described in Section 7.12

9.8 Rivers and Harbors Act of 1899

Section 10 of the Rivers and Harbors Act of 1899 (33 U.S.C. § 403 et seq.) prohibits the construction of any wharf, pier, dolphin, boom, weir, breakwater, bulkhead, jetty, or other structures in any navigable water without Congressional consent or approval by USACE. Section 10 regulates structures in or over any navigable water of the U.S., the excavating from or depositing of material in such waters, or the accomplishment of any other work affecting the course, location, condition, or capacity of such waters.

The Cooper River, Ashley River, and Charleston Harbor are navigable waters under the Rivers and Harbors Act within the region of influence of the proposed federal action. The construction of the storm surge wall and installation of living shorelines sills in the intertidal zone would not obstruct the maintenance of navigation or interfere with navigation safety. This study is compliant with the Rivers and Harbors Act of 1899.

9.9 Comprehensive Environmental Response, Compensation, and Liability Act

The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), as amended (42 U.S.C. § 9601 et seq.), which was later amended by the Superfund Amendments and Reauthorization Act of 1986, sets forth regulations for cleanup of hazardous substances after improper disposal; identifies federal response authority; and outlines responsibilities and liabilities of potentially responsible parties, who are past/present owners or operators of the site, a person who arranged disposal of hazardous substances at a site, or a person who transported hazardous substances to a site they selected for disposal. CERCLA also specifies where Superfund money can be used for site cleanup.

No hazardous waste will be generated from implementation of the federal action. There are a few National Priority Listed sites in the study area. A Phase I assessment will be conducted during the PED phase. If areas of contamination are identified, the federal action would avoid disturbing those areas to the extent feasible. If unexpected contamination is encountered during the operations, maintenance, or construction activities associated with the federal action, USACE will comply with CERCLA.

9.10 Coastal Zone Management Act

The Coastal Zone Management Act of 1972 requires each Federal agency activity performed within or outside the coastal zone that affects land or water use, or natural resources of the coastal zone to be carried out in a manner which is consistent to the maximum extent practicable, i.e., fully consistent, with the enforceable policies of approved state management programs.

The South Carolina Coastal Management Program was authorized in 1977 under SC's Coastal Tidelands and Wetlands Act (CTWA), and South Carolina DHEC's Office of Ocean and Coastal Resource Management is responsible for the implementation of the state's program. The goals of the South Carolina Coastal Management Program are attained by enforcement of the policies of the State as codified within the South Carolina Code of Regulations (SC Code of Regulations Chapter 30).

According to 15 CFR 930.37, a Federal agency may use its NEPA documents as a vehicle for its consistency determination with Coastal Zone Management Act. Therefore, USACE has prepared a determination of consistency with the enforceable policies of the SC Coastal Management Program with this FR/EIS. It can be found in Appendix F - Environmental.

In accordance with the CZMA, USACE has determined that the Federal action would be carried out in a manner that is fully consistent with the enforceable policies of the SC Coastal Management Program to the maximum extent practicable with respect to the following policy groups: Areas of Special Resource Significance; Stormwater Management; Erosion Control; Wildlife and Fisheries Management; Dredging; and Recreation and Tourism. The remainder of the state's policy groups were not applicable.

On January 11, 2022, the Office of Ocean and Coastal Resource Management concurred, with conditions, that the Federal action would be consistent with the enforceable policies of the SC Coastal Management Program. Their response can be found Appendix F – Environmental. The Office of Ocean and Coastal Resource Management 's conditions are listed below with USACE' understanding of the condition:

1. "As this project is a Federal Agency Development Project (15 CFR 930.31(b)), this concurrence is only for the planning and study phase under the FR/EIS. When the project moves to the PED and construction phases of the development project, a consistency determination is required for each of these major phases to ensure a continued consistency with the enforceable policies of the SC Coastal Zone Management Program."
    - From the final FR/EIS to the start of PED, no further design refinements will occur; therefore the CZMA concurrence dated January 11, 2022 would still be applicable. As the project develops a more detailed design in PED, a consistency determination would be obtained prior to construction.

2. "This concurrence is only applicable should the project continue as a direct federal agency activity to be carried out by the US Army Corps of Engineers. If at any time, the project will be conducted by the identified non-federal sponsor, or another non-federal agency entity, all review and work will require a SCDHEC OCRM Critical Area Permit."
    - In the event that in-kind work is proposed by the non-federal sponsor, USACE will coordinate with OCRM to achieve a common understanding of the need to secure a SCDHEC OCRM Critical Area Permit for the proposed work.

3. "Coastal resource effects to the salt marsh, species habitats, and cultural resources must be adequately mitigated for. SCDHEC OCRM must be included in the review of those mitigative measures during the future phases of the development project."
    - USACE will continue to coordinate with SCDHEC OCRM along with the other resource agencies to finalize the mitigation plan in the PED phase.

9.11 Compensatory Mitigation for Losses of Aquatic Resources (40 CFR Part 230 and 33 CFR Parts 325 and 332)

Section 2036(a) of WRDA 2007 (33 USC 2283) required, among other things, that mitigation plans comply with the applicable mitigation standards and policies of the regulatory programs administered by the Secretary of the Army. On April 10, 2008, USACE and USEPA published regulations entitled, "Compensatory Mitigation for Losses of Aquatic Resources" ("Mitigation Rule"). The primary goal of these regulations was to improve the quality and success of compensatory mitigation plans that are designed and implemented to offset impacts to aquatic resources. The Mitigation Rule emphasizes the strategic selection of mitigation sites on a watershed basis and established equivalent standards for all types of compensatory mitigation (mitigation banks, in-lieu fee programs, and permittee-responsible mitigation plans). According to the regulation, compensatory mitigation means the restoration (re-establishment or rehabilitation), establishment (creation), enhancement, and/or in certain circumstances preservation of wetlands for the purposes of offsetting unavoidable adverse impacts which remain after all appropriate and practicable avoidance and minimization has been achieved. The three mechanisms for providing compensatory mitigation listed in order of preference as stated in the Mitigation Rule are the following: mitigation banks, in-lieu fee programs, and permittee-responsible mitigation. Compensatory mitigation is necessary to offset these unavoidable impacts to aquatic resource functions and services and to meet the programmatic goal of "no overall net loss" of aquatic resource functions and services.

Implementation Guidance for Section 2036(a) issued 31 August 2009 concluded that civil works guidance on mitigation planning was consistent with the standards and polices of the Corps Regulatory Program for wetlands mitigation. However, the Mitigation Rule underlies the mitigation framework laid out for compensatory mitigation of the adverse effects to salt marsh wetlands that are expected from the Federal action. This framework is described in detail in the Draft Mitigation Plan in Appendix F - Environmental.

9.12 Executive Order 11988, Floodplain Management

Executive Order 11988, dated May 24, 1977, states that each Federal agency shall take action to reduce the risk of flood loss, minimize the impacts of floods on human safety, and restore and preserve the natural values of floodplains while carrying out its responsibilities for (1) acquiring, managing, and disposing of Federal lands; (2) providing Federal investments in construction and improvements; and (3) conducting activities affecting land use, including water resources planning and regulating activities. To comply with this order, each Federal agency has a responsibility to evaluate the potential effects of any actions it may take in the floodplain, to ensure its planning programs consider flood hazards and floodplain management, and to implement the policies and requirements of the order.

The objective of the study is to reduce flood risk within the study area. The objective of EO 11988 is to avoid to the extent possible, long- and short-term adverse impacts associated with the occupancy and modification of the base flood plain and avoid direct and indirect support of development in the base flood plain wherever there is a practicable alternative. The study is responsive to the objective of EO 11988 because the proposed features focus on reducing the threat of flooding to the existing urban area. Project features would reduce the hazard and risk associated with floods thereby minimizing the effects of floods on life safety, health, and welfare, and would preserve the remaining natural and beneficial values of the floodplain, as analyzed in Chapter 6 Environmental Consequences.

Portions of the storm surge wall would be constructed in FEMA Flood Zone VE, which is the base coastal flood plain with velocity hazard (wave action). Other portions of the storm surge wall would be constructed in FEMA Flood Zone AE, which is the base flood plain. Multiple flood risk reduction measures were considered including nonstructural, structural and NNBF measures as discussed in Section 3.1. These measures were screened, combined, and evaluated, and ultimately determining Alternative 2 is the RP. The anticipated effects and environmental compliance associated with the RP and the No Action Alternative are summarized in Chapters 6 and 9.

As it is currently conceptualized, the RP would provide approximately a 1% AEP level of performance in the year 2082 assuming an intermediate sea level rise scenario. A system of gates would allow for tidal exchange when the gates are open. When a coastal storm event is anticipated, gates would be closed at low tide, leaving storage space in marsh areas for interior drainage, preserving the natural floodplain function.

The Charleston Peninsula is already experiencing a construction boom and an influx of new residents despite the existing flood risk. After substantial plan formulation efforts, no practicable alternative was found to address coastal storm flood risk to existing development. Therefore, the RP may support some new development. It should be noted that the current development trend is expected to continue with or without any action by USACE.

During this study, public outreach has been conducted with the public and multiple stakeholders. The 45-day public review period on the draft FR/EIS and a public meeting provides the public the opportunity to comment on the study. Because most of the Charleston Peninsula is located in the 100-year floodplain and any actions to address the risk of storm surge flooding would require location within that floodplain or adjacent floodways, there is no practicable alternative to locating an action in the floodplain. Further, based on the screening and evaluation process, the RP (Alternative 2) is the most responsive and only practicable alternative that will substantially meet all of the study objectives, as well as the EO 11988 objectives of reducing the hazard and risk associated with floods, and minimizing the impact of floods on human safety, health and welfare, as described in Chapters 3, 4, 6, and 7. This final FR/EIS and the proposed action are in compliance with this Executive Order.

9.13 Executive Order 11990, Protection of Wetlands

Executive Order 11990, dated May 24, 1977, requires Federal agencies to take action to avoid adversely impacting wetlands wherever possible, to minimize wetland destruction and preserve the values of wetlands, and to prescribe procedures to implement the policies and procedures of this executive order. In addition, Federal agencies shall incorporate floodplain management goals and wetlands protection considerations into its planning, regulatory, and decision-making processes.

USACE has evaluated potential direct and indirect effects on wetlands from the federal action and taken considerable steps to avoid adverse effects. After avoidance and minimization, USACE has identified that salt marsh wetland would be significantly adversely affected by the Federal action and approximately 35 acres of wetland habitat function lost would be offset through compensatory mitigation. The steps that USACE has and will take to avoid, minimize and mitigate for adverse effects of the Federal action on wetlands are described in the Draft Mitigation Plan found in Appendix F – Environmental. This final FR/EIS and the proposed action are in compliance with this Executive Order.

9.14 Executive Order 12898, Environmental Justice

Executive Order 12898, dated February 11, 1994, requires Federal agencies to consider whether agency actions may have disproportionately high and adverse human health or environmental effects on minority populations, low-income populations, and Indian tribes. For the purpose of Executive Order 12898, minority populations include people of the following origins: African American, American Indian and Alaska Native, Native Hawaiian or Other Pacific Islander, and Hispanic (of any race). Low-income populations are populations that are at or below the poverty line, as established by the U.S. Department of Health and Human Services.

Based on the discussion, analysis, and mitigation described in Chapters 4 and 7, the storm surge wall would not cause disproportionately high and adverse effects on any environmental justice populations in accordance with the provisions of Executive Order 12898. This final FR/EIS and the proposed action are in compliance with this Executive Order.

9.15 Executive Order 13045, Protection of Children from Environmental Health Risks and Safety Risks

Executive Order 13045, dated April 23, 1997, requires each federal agency to identify and assess environmental health and safety risks that may disproportionately affect children and ensures that policies, programs, activities, and standards address disproportionate risk to children that results from environmental health or safety risks.

Based on the discussion, analysis, and mitigation described in Chapters 4 and 7, the storm surge wall would not introduce risk that disproportionately affect children. Depending upon the final placement/footprint of the storm surge wall, determined during PED, safety, security, and noise and air pollution reduction benefits could be realized at Sanders-Clyde Elementary School. This final FR/EIS and the proposed action are in compliance with this Executive Order.

9.16 Executive Order 13007, Indian Sacred Sites

Executive Order 13007, dated May 24, 1996, directs Federal agencies to accommodate access to and ceremonial use of Indian sacred sites by Indian religious practitioners. To the extent practicable, permitted by law, and not clearly inconsistent with essential agency functions, the co-lead agencies are to avoid adversely affecting the physical integrity of such sacred sites and to maintain the confidentiality of sacred sites when appropriate. The order encourages government-to-government consultation with tribes concerning sacred sites. Some sacred sites may qualify as historic properties under the National Historic Preservation Act. This E.O. is directed towards executive branch agencies with statutory or administrative responsibility for the management of federal lands. The undertaking would not affect federally owned or administered lands and is in compliance with this E.O.

9.17 Executive Order 11593, Protection and Enhancement of the Cultural Environment

Executive Order 11593, dated May 13, 1971, directs Federal agencies to provide leadership in preserving, restoring, and maintaining the historic and cultural environment of the Nation. USACE are addressing compliance with Executive Order 11593 by complying with the National Historic Preservation Act. This final FR/EIS and the proposed action are in compliance with this Executive Order.

9.18 Executive Order 13175, Consultation and Coordination with Indian Tribal Governments

The United States has a unique legal relationship with Indian tribal governments as set forth in the Constitution of the United States, treaties, statutes, executive orders, and court decisions. This order directs federal agencies to formulate and establish "regular and meaningful consultation and collaboration with tribal officials in the development of federal policies that have tribal implications, to strengthen the United States government-to-government relationships with Indian tribes, and to reduce the imposition of unfunded mandates upon Indian tribes." This consultation is meant to work toward a mutual consensus and is intended to begin at the earliest planning stages, before decisions are made and actions are taken. Consistent with this executive order, USACE consulted with the appropriate federally recognized Tribes that have an interest in the study area including the Absentee-Shawnee Tribe of Indians of Oklahoma, the Alabama-Quassarte Tribal Town, the Catawba Indian Nation, the Chickasaw Nation, the Delaware Tribe of Indians, the Eastern Band of the Cherokee Indians, the Eastern Shawnee Tribe of Oklahoma, the Kialegee Tribal Town, the Muscogee (Creek) Nation, the Shawnee Tribe, the Thlopthlocco Tribal Town, and the Poarch Band of Creek Indians. Copies of this consultation are provided in Appendix D. This final FR/EIS and the proposed action are in compliance with this Executive Order.

9.19 Executive Order 13985, Advancing Racial Equity and Support for Underserved Communities Through the Federal Government

Executive Order 13985, dated January 20, 2021 acknowledges the increasing inequities attributable to the converging economic, health, and climate crises, and directs federal agencies to pursue a comprehensive approach to advancing equity for all. USACE's approach to EO 12898 and EO 14008 to ensure that minority, low income, and disadvantaged communities receive equitable treatment and are not subject to disproportionately high and adverse effects will likewise serve the overall goal of this Executive Order. This final FR/EIS and the proposed action are in compliance with this Executive Order.

9.20 Executive Order 14008, Tackling the Climate Crises at Home and Abroad, Section 219, and 223

Executive Order 14008, dated January 27, 2021, directs Federal agencies to take a Government-wide coordinated approach, coupled with substantive engagement by community stakeholders, to combat the climate crisis by reducing climate pollution in every sector of the economy; to increase resilience to the impacts of climate change; to protect public health; to conserve our lands, waters, and biodiversity; to deliver environmental justice to disadvantaged communities; and to spur well-paying union jobs and economic growth.

Section 219 of the EO requires Federal agencies, among other things, to "[develop] programs, policies, and activities to address the disproportionately high and adverse human health, environmental, climate-related and other cumulative impacts on disadvantaged communities. Pursuant to the order, and its corresponding Interim Implementation Guidance for the Justice40 Initiative, released by the Office of Management and Budget July 20, 2021, this draft FR/EIS will include in its analysis of communities that meet environmental justice criteria as defined by EO 12898 those groups collectively identified as "disadvantaged communities."

Consistent with the objectives on this order, the storm surge wall would improve the resilience of Charleston Peninsula to the impacts from climate change and storm surge. The living shorelines proposed for erosion minimization also improve the resilience of natural systems to the effects of climate change and coastal storms. In so doing, the storm surge wall would provide protection to a cross-section of socio-economic communities on the peninsula without disproportionately burdening minority, low income, or disadvantaged communities, and that protection would be augmented by nonstructural measures for additional low income and minority communities where a wall is not merited. This final FR/EIS and the proposed action are in compliance with this Executive Order.

CHAPTER 10 - Recommendation

I propose that the features designed to reduce coastal storm risk identified as the Recommended Plan in the Charleston Peninsula Coastal Storm Risk Management Integrated Feasibility Report and Environmental Impact Statement, proceed with implementation in accordance with the cost sharing provisions set forth in this report.

The City of Charleston has indicated support for the recommendations presented in this document. A Design Agreement for Preconstruction Engineering and Design (PED) would be prepared, coordinated, and executed subsequent to the approval of this document. Following PED and contingent upon Congressional authorization, a Project Partnership Agreement (PPA) would be prepared, coordinated, and executed subsequent to the approval of this document. Federal implementation of the project for coastal storm risk management includes, but is not limited to, the following required items of local cooperation to be undertaken by the non-Federal sponsor in accordance with applicable Federal laws, regulations, and policies:

a. Provide 35 percent of construction costs, as further specified below:

1. Provide, during design, 35 percent of design costs in accordance with the terms of a design agreement entered into prior to commencement of design work for the project;

2. Provide all real property interests, including placement area improvements, and perform all relocations determined by the Federal government to be required for the project;

3. Provide, during construction, any additional contribution necessary to make its total contribution equal to at least 35 percent of construction costs;

b. Prevent obstructions or encroachments on the project (including prescribing and enforcing regulations to prevent such obstructions or encroachments) that might reduce the level of coastal storm risk reduction the project affords, hinder operation and maintenance of the project, or interfere with the project's proper function;

c. Inform affected interests, at least yearly, of the extent of risk reduction afforded by the project; participate in and comply with applicable Federal floodplain management and flood insurance programs; prepare a floodplain management plan for the project to be implemented not later than one year after completion of construction of the project; and publicize floodplain information in the area concerned and provide this information to zoning and other regulatory agencies for their use in adopting regulations, or taking other actions, to prevent unwise future development and to ensure compatibility with the project;

d. Operate, maintain, repair, rehabilitate, and replace the project or functional portion thereof at no cost to the Federal government, in a manner compatible with the project's authorized purposes and in accordance with applicable Federal laws and regulations and any specific directions prescribed by the Federal government;

e. Give the Federal government a right to enter, at reasonable times and in a reasonable manner, upon property that the non-Federal sponsor owns or controls for access to the project to inspect the project, and, if necessary, to undertake work necessary to the proper functioning of the project for its authorized purpose;

f. Hold and save the Federal government free from all damages arising from design, construction, operation, maintenance, repair, rehabilitation, and replacement of the project, except for damages due to the fault or negligence of the Federal government or its contractors;

g. Perform, or ensure performance of, any investigations for hazardous, toxic, and radioactive wastes (HTRW) that are determined necessary to identify the existence and extent of any HTRW regulated under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), 42 U.S.C. 9601-9675, and any other applicable law, that may exist in, on, or under real property interests that the Federal government determines to be necessary for construction, operation and maintenance of the project;

h. Agree, as between the Federal government and the non-Federal sponsor, to be solely responsible for the performance and costs of cleanup and response of any HTRW regulated under applicable law that are located in, on, or under real property interests required for construction, operation, and maintenance of the project, including the costs of any studies and investigations necessary to determine an appropriate response to the contamination, without reimbursement or credit by the Federal government;

i. Agree, as between the Federal government and the non-Federal sponsor, that the non-Federal sponsor shall be considered the owner and operator of the project for the purpose of CERCLA liability or other applicable law, and to the maximum extent practicable shall carry out its responsibilities in a manner that will not cause HTRW liability to arise under applicable law; and

j. Comply with the applicable provisions of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, Public Law 91-646, as amended, (42 U.S.C. 4630 and 4655) and the Uniform Regulations contained in 49 C.F.R Part 24, in acquiring real property interests necessary for construction, operation, and maintenance of the project including those necessary for relocations, and placement area improvements; and inform all affected persons of applicable benefits, policies, and procedures in connection with said act.

The recommendations contained herein reflect the information available at this time, and current Department of the Army, and U.S. Army Corps of Engineers policies governing formulation of individual studies and projects. The recommendations do not reflect the program and budget priorities inherent to the formulation of a national Civil Works construction program, nor the perspective of higher review levels within the Executive Branch of the U.S. Government. Consequently, the recommendations may be modified before they are transmitted to Congress as proposals for implementation funding. However, prior to transmittal to Congress, the sponsor, the State, interested federal agencies, and other interested parties will be advised of any modifications, and be afforded the opportunity to comment further.

Andrew C. Johannes
Lieutenant Colonel, U.S. Army
Commander and District Engineer

CHAPTER 11 - Preparers

Table 11-1. List of Preparers.

Name	Title	Years of Experience	Degree	Experience/Expertise	Agency	EIS Areas Authored
Bethney Ward	Environmental Lead / Biologist	20+	M.S. Environmental Studies, B.S. Biology	NEPA, environmental compliance, landscape characterization and watershed planning, NNBF planning	USACE	Geology and Soils, H&H, Water Quality, Floodplains, Wetlands, Aquatic Resources, Benthic Resources, Terrestrial Resources, Air Quality, Noise, Hazardous Materials and Waste, Climate Change, Cumulative Impacts, Mitigation Plan
Carter Rucker	Coastal Engineer	1	M.S. & B.S. Civil Engineering (concentration in coastal)	Coastal modeling, coastal engineering, civil engineering	USACE	Coastal Sub-Appendix
Corrie Stetzel	Water Resources Planner	7	B.S. Community & Regional Development	Federal project planning and environmental compliance	USACE SPK	Plan Formulation
Diane Perkins	Sr. Water Resources Planner	>20	Master of Landscape Architecture, Master of Urban Planning, B.A.	>10 years federal water resources planning and project management, and >10 years in a variety of urban planning and landscape architecture endeavors in various levels of government and the private sector.	USACE SAC	Aesthetic Resources

Name	Title	Years of Experience	Degree	Experience/Expertise	Agency	EIS Areas Authored
			Environmental Studies			
Dorothy M. Steinbeiser	Senior Realty Specialist	18	AS – Real Estate Finance	Civil Works/Cost Share Projects, Real Estate Plans	USACE SAS	Real Estate Appendix
Hannah Hadley	Environmental Coordinator	16	B.A. Anthropology	NEPA and environmental compliance	USACE	Land Use, Recreation, Transportation, Utilities, Safety Sections and Environmental Compliance Chapter
Jimmie Elliott	Hydraulic Engineer	6	B.S. in Civil Engineering	Hydraulic modeling - Dam/Levee Breach modeling, Hurricane Flood Inundation Modeling, watershed developmental modeling for river forecasting models. (Primarily Modeling, Mapping, and Consequence or MMC related programs using the HEC-RAS software with little experience using HEC-HMS)	USACE	Interior Hydrology Sub-Appendix
Kaylan Koszela	Special Projects Manager, City of Charleston	1	BA	Federal policy & regulations	City of Charleston	Non-federal sponsor
Kurt A. Heckendorf, P.E.	Civil Engineer (Geotechnical)	19	B.S. and M.S. in Civil Engineering	Geotechnical engineering (levees and dams), flood risk management project design, engineer technical lead	USACE	Geologic and Geotechnical Sub-Appendix
Lance Mahar, P.E.	Engineering Technical Lead/	13	BS – Mechanical Engineering	Mechanical utilities including central energy plans and distributed utilities such as steam/condensate, hot	USACE - SAC	Engineering Sub-Appendix

Name	Title	Years of Experience	Degree	Experience/Expertise	Agency	EIS Areas Authored
	Mechanical Engineer			water/chilled water, compressed air, water, wastewater, purified water		
Mark Wilbert	City of Charleston Chief Resilience Officer	8	BA	Emergency Management, Resilience	City of Charleston	Non-Federal Sponsor
Meredith A. Moreno	Lead Archaeologist	15	B.A. and M.A. in Archaeology	Cultural Resources, National Historic Preservation Act compliance	USACE SAJ	Cultural Resources
Robert V. Sheehan	Appraiser	16	BA – Transportation & Logistics Mgt	MAI Designated, Certified General Appraiser	USACE SAS	Gross Appraisal
Stephen Phillips	Economist	3	B.A. in Economics and Master of Health Administration	Regional Economist. Experience on FRM & CSRM Economic Analyses (NED & RED) and OSE and EJ Analyses.	USACE	Stephen Phillips
Vongmony Var	Economist	20+	BS and Master's in Business Administration	Regional Economist and Consequence Specialist. Completed Economic Analysis for numerous Planning Feasibility Studies. Consequence Specialist for Dam and Levee Safety. Certified as a Dam and Levee Safety, Flood Risk Management, and Coastal Storm Risk Management Agency Technical Reviewer	USACE	Vongmony Var

CHAPTER 12 - References

American Lung Association. 2017. State of the Air Report – Report Card for Cities and Counties. https://www.lung.org/research/sota/city-rankings; accessed March 2021

Arendt, MD, JA Schwenter, AL Segars, JI Byrd, PP Maier, JD Whitaker, DW Owens, G Blanvillain, JM Quattro, MA Roberts. 2012. Catch rates and demographics of loggerhead sea turtles (*Caretta Caretta*) captured from the Charleston, South Carolina, shipping channel during the period of mandatory use of turtle excluder devices (TEDs). *Fishery Bulletin* 110:98-109.

Arora, M., Casas-Mullet, R., Costelloe, J.F., Peterson, T.J., McCluskey, A.H., and Stewardson, M.J. 2017. Chapter 6 – Impacts of Hydrological Alterations on Water Quality. In: Water for the Environment, Policy and Science to Implementation and Management. Pages 101-126.

Bartelme, Tony. 2020. "Rising Waters: Forget About Climate Change. The Real Story is Climate Speed." Post and Courier. May 20, 2020. Available at: https://www.postandcourier.com/rising-waters/forget-about-climate-change-the-real-story-is-climate-speed/article_b0785be0-8e2f-11ea-bc3f-3bd7afe8bdf2.html.

Boutin, B. P. & Targett, T., E. 2013. Fish and blue crab assemblages in the shore zone of tidal creeks in the Delaware coastal bays. *Northeastern Naturalist 20: 69-90.*

Bridges, T.S., J.K. King, J.D. Simm, M.W. Beck, G. Collins, Q. Lodder, and R.K. Mohan, eds. 2021. International Guidelines on Natural and Nature-Based Features for Flood Risk Management. Vicksburg, MS: U.S. Army Engineer Research and Development Center.

Burdick, S.A. 2018. Thesis: Effects of Bulkheads on Salt Marsh Loss: A Multi-Decadal Assessment Using Remote Sensing. Submitted in partial fulfilment of requirements for Master of Environmental Management degree, Nicholas School of the Environment, Duke University. April 27, 2018, 31p.

Bush, D.M., Pilkey, O.H. and Neal, W.J. 2001. Human Impact on Coastal Topography. Encyclopedia of Ocean Sciences, Vol. 1, Elsevier Ltd., pp 480-489.

Butler, Christina. 2020. *Lowcountry at High Tide: A History of Flooding, Drainage, and Reclamation in Charleston, South Carolina*. University of South Carolina, Columbia, South Carolina.

Castro, J. 2003. Geomorphologic Impacts of Culvert Replacement and Removal: Avoiding Channel Incision. USFWS Technical Note, Portland, OR.

City of Charleston. 2021a. Charleston City Plan, Charleston, South Carolina. October 2021.

______. 2021b. One Charleston Parks and Recreation Master Plan, Charleston, South Carolina. July 2021.

______. 2019a. Flooding and Sea Level Rise Strategy, Charleston, South Carolina. February 2019.

______. 2019b. Board of Architectural Review. "Design Guidelines for Elevating Historic Buildings". Adopted July 24, 2019. https://www.charleston-sc.gov/DocumentCenter/View/18518/BAR-Elevation-Design

______. 2018. Charleston, South Carolina Citywide Transportation Plan. July 2018. https://www.charleston-sc.gov/DocumentCenter/View/23517/City-Transportation-Plan-Final-07-2018_low-res

______. 2016. Century V, City of Charleston 2010 Comprehensive Plan Update; with revisions December 2016.

______. 2014. City of Charleston Stormwater Management Plan. NPDES Certificate No. SCR031301, File No. 46423416. November 2014.

______. 2010. Charleston Green Plan: A Roadmap to Sustainability.

______. 2003. Charleston Neck Plan. December 6, 2003.

Cowardin, LM, Carter, V, Golet, F.C.and LaRoe, E.T. 1979. Classification of wetlands and deepwater habitats of the United States. US Fish and Wildlife Service FWS/OBS 79/31. 103pp.

Dai, Z.; Amatya, D., Sun, G., Trettin, C.C.; Li, C., Li, H. 2011. Climate variability and its impact on forest hydrology on South Carolina coastal plain of USA. *Atmosphere*. 2: 330-357

Diaz, Olivia. 2021. "Charleston Flooded by 8.5 Foot Tide, 10th Highest Swell to Hit the City's Harbor." Post and Courier. November 7, 2021. Available at: Charleston flooded by 8.5 foot tide, 10th highest swell to hit the city's harbor | SC Climate and Environment News | postandcourier.com

Fraser, Walter J. 1989. *Charleston! Charleston! The History of a Southern City*. University of South Carolina Press, Columbia, South Carolina.

Goodyear, Albert C. 2005. Summary of the Allendale Paleoindian Expedition 2003-2004 Field Seasons. *Legacy*, Vol.9 March 2005.

Harris, M. Scott, Paul T. Gayes, Jack L. Kindinger, James G. Flocks, David E. Krantiz, and Patricia Donovan. 2005. Quaternary Geomorphology and Modern Coastal Development in Response to an Inherent Geologic Framework: An Example from Charleston, South Carolina. *Journal of Coastal Research* 21(1):49-64.

Jackson, Chester W. 2017. "Mapping Coastal Erosion Hazards Along Sheltered Coastlines in South Carolina, 1849 – 2015." Summary Report submitted to South Carolina Office of Ocean and Coastal Resource Management and US Army Corps of Engineers Charleston District. Georgia Southern University, Applied Coastal Research Lab, 2017.

JMT. 2015. "Charleston Seawall Repairs: The Low Battery Seawall Rehabilitation Project." Report prepared by JMT Engineering for the City of Charleston, October 30, 2015.

Middel, H. & Verones, F. 2017. Making marine noise pollution impacts heard: The case of cetaceans in the North Sea within life cycle Impact assessment. *Sustainability* 2017: 1-17.

Moffat & Nichol. 2017. "Hydrodynamic modeling and initial water quality evaluations supporting the federal feasibility study and NEPA documentation – Broad Creek." Presented to City of Norfolk, August 30, 2017.

National Academy of Engineering (NAE). 2010. "Technology for a Quieter America." Washington, DC: National Academies Press.

Navin, John J. 2020. *The Grim Years: Settling South Carolina, 1670–1720*. University of South Carolina Press, Columbia, South Carolina.

National Oceanic and Atmospheric Administration (NOAA). 2020a. "Tropical Cyclone History for Southeast South Carolina and Northern Portions of Southeast Georgia." NOAA National Weather Service, February 13, 2020.

______. 2020b. South Carolina Threatened and Endangered Species and Critical Habitats under NOAA Fisheries Jurisdiction. NOAA Fisheries Southeast Regional Office. https://www.fisheries.noaa.gov/southeast/consultations/south-carolina. Updated February 5, 2020.

______. 2020c. Habitat Areas of Particular Concern within Essential Fish Habitat in the South Atlantic (https://www.fisheries.noaa.gov/southeast/habitat-conservation/habitat-areas-particular-concern-within-essential-fish-habitat); Essential Fish Habitat Mapper Tool (https://www.fisheries.noaa.gov/resource/map/essential-fish-habitat-mapper). National Marine Fisheries Service, Habitat Conservation Division. Updated 2020.

______. 2018. “Patterns and Projections of High Tide Flooding Along the U.S. Coastline Using a Common Impact Threshold.” February 2018.

______. 2018. “Technical Guidance for Assessing Effects of Anthropogenic Sound on Marine Mammal Hearing (Version 2.0).” National Marine Fisheries Service, Office of Protected Resources. NOAA Technical Memorandum NMFS-OPR-59, April 2018.

______. 2017. “State of the Climate: National Climate Report for May 2017”, National Centers for Environmental Information, June 2017.

______. 2016. Common Bottlenose Dolphin (*Tursiops truncates truncates*) Charleston Estuarine System Stock Report. National Marine Fisheries Service, May 2016.

______. n.d. Storm Surge Overview. NOAA National Hurricane Center, https://www.nhc.noaa.gov/surge/, accessed September 2021.

______. n.d. Shortnose sturgeon (https://www.fisheries.noaa.gov/species/shortnose-sturgeon); Atlantic sturgeon (https://www.fisheries.noaa.gov/species/atlantic-sturgeon). NOAA Fisheries.

Palmetto Railways. 2021. Personal communication with Patrick McCrory on July 14, 2021.

Park, D. 1985. The groundwater resources of Charleston, Berkeley, and Dorchester Counties, South Carolina, State of South Carolina. Water Resources Commission Report No. 139, 79p.

Peterson, C.H., Grabowski, J.H., and Powers, S.P. 2003. Estimated enhancement of fish production resulting from restoring oyster reef habitat: Quantitative valuation. Marine Ecology Progress Series 264:249-264.

Ritter, A. F., Wasson, K., Lonhart, S. I., Preisler, R. K., Woolfolk, A., Griffith, K. A., Connors, S. & Helman, K. W. 2008. Ecological signatures of anthropogenically altered tidal exchange in estuarine ecosystems. *Estuaries and Coasts* 31: 554-571.

Sanger, Denise and Catherine Parker. 2016. Guide to Salt Marshes and Tidal Creeks in the Southeastern United States. South Carolina Department of Natural Resources, Columbia, SC, 100p.

Sanger, D., Blair, A., DiDonato, G., Washburn, T. Jones, S., Riekerk, G., Wirth, E., Stewart, J., White, D., Vandiver L, & Holland A. F. 2015. Impacts of coastal development on the ecology of tidal creek ecosystems of the US Southeast including consequences to humans. *Estuaries and Coasts* 8:549-566.

Sanger, D.M., S.P. Johnson, A.W. Tweel, D.E. Chestnut, B. Rabon, M.H. Fulton, and E. Wirth. 2020. “The Condition of South Carolina’s Estuarine and Coastal Habitats During 2017-2018: Technical Report.” Charleston, SC: South Carolina Marine Resources Division. Technical Report No. 111. 52 p.

Seney, E. E. & Musick J. A. 2007. Historical diet analysis of loggerhead seat turtles (*Caretta caretta*) in Virginia. *Copeia* 2007:478-489.

South Carolina Department of Archives and History. 2021. SC Archsite. Electronic database, http://www.scarchsite.org/default.aspx, accessed July 6, 2021.

South Carolina Department of Health and Environmental Control (SCDHEC). 2019. Groundwater Capacity Use Areas – Lowcountry. South Carolina Department of Health and Environmental Control, Bureau of Water. https://scdhec.gov/bow/groundwater-use-reporting/groundwater-management-planning/groundwater-capacity-use-areas-lowcountry; accessed March 2021.

______. 2014. “R.61-68, WATER CLASSIFICATIONS & STANDARDS”, Bureau of Water, June 27, 2014.

______. 2013. “Total Maximum Daily Load Revision (for) Charleston Harbor, Cooper, Ashley, and Wando Rivers” Bureau of Water Technical Document Number: 0506-13; March 2013.

South Carolina Department of Natural Resources (SCDNR). 2021. “Climate Change Impacts to Natural Resources in South Carolina.” South Carolina Department of Natural Resources Climate Change Technical Working Group. January 15, 2021

______. 2019. Summary of Living Shoreline Research to Inform Regulatory Decision- Making in South Carolina. Charleston, SC: South Carolina Marine Resources Division. Technical Report No. 110. 49 p.

South Carolina Water Resources Commission. 1990. “Hurricane Hugo.” State of South Carolina Water Resources Commission, South Carolina State Climatology Office, Climate Report No. G-37, August 1990.

Sweet WV. and Park J. 2014. From the extreme to the mean: Acceleration and tipping points of coastal inundation from sea level rise. *Earth’s Future* 2: 579–600.

Tsouvalas, A. 2020. Underwater noise emission due to offshore pile installation: A review. *Energies* 13(12):1-41.

Turner, R.E., and S. Brody. 1983. “Habitat suitability index models: Northern Gulf of Mexico brown shrimp and white shrimp.” US Fish and Wildlife Service, FWS/OBS-82/l0.54. 24 pp.

Tyack, P. L. 2008. Implications for marine mammals of large-scale changes in the marine acoustic environment. *Journal of Mammalogy* 89: 549-558.

US Army Corps of Engineers (USACE). In press. “South Atlantic Coastal Study (SACS) Measures and Costs Library Report.” South Atlantic Division, Atlanta, GA. 179p.

USACE. (1996.) “Final Report: An Analysis of the US Army Corps of Engineers Shore Protection Program.” IWR Report 96-PS-1.

US Congressional Research Service, “Disaster Debris Removal After Hurricane Katrina: Status and Associated Issues” (RL33477; April 2, 2008), by Linda Luther.

United States, Congress, “Fourth National Climate Assessment.” *Fourth National Climate Assessment*, U.S. Government Publishing Office, 2018.

US Environmental Protection Agency (USEPA). 2020a. Sites in Reuse: Calhoun Park Area Site. EPA Region 4 Reuse Fact Sheet, June 2020.

______. 2020b. EJSCREEN: Environmental Justice Screening and Mapping Tool, Version 2.0, https://www.epa.gov/ejscreen. Accessed February 2020.

______. 1978. “Protective Noise Levels,” Office of Noise Abatement and Control, Washington, D.C. U.S. Environmental Protection Agency Report 550/9-79-100, November 1978.

US Fish and Wildlife Service (USFWS). (n.d.) Information for Planning and Consultation (IPaC) Tool, US Fish and Wildlife Service. https://ecos.fws.gov/ipac/ Accessed June 17, 2021.

______. 2019. Species status assessment report for the eastern black rail (*Laterallus jamaicensis jamaicensis*), Version 1.3. August 2019. Atlanta, GA.

______. 2015. *Loggerhead sea turtle* (*Caretta caretta*). North Florida Ecological Services Office. https://www.fws.gov/northflorida/SeaTurtles/Turtle%20Factsheets/loggerhead-sea-turtle.htm

______. 2008. *West Indian Manatee* (*Trichechus manatus*). US Fish and Wildlife Service Southeast Region.

______. 1990. Habitat Management Guidelines for the Wood Stork in the Southeast Region. Unpublished reference document.

US Geologic Survey (USGS). 2010. “Groundwater Availability in the Atlantic Coastal Plain Aquifers of North and South Carolina.” Groundwater Resources Program, Professional Paper 1773.

Washington State Department of Transportation (DOT). 2012. Underwater Vibratory Sound Levels from a Battered Pile Installation at Seattle Colman Dock. Office of Air Quality and Noise, Seattle, WA, March 2012.

Walton Jr., T.L. and Sensabaugh W. 1979. Seawall Design on the Open Coast. Florida Sea Grant College, Report No. 29, June.

Weems, R.E., Lewis, W.C., Lemon, E.M., Chirico, P.G., and Crider, E.A. 2014. Surficial geologic map of the Charleston region, Berkeley, Charleston, Colleton, Dorchester, and Georgetown Counties, South Carolina, U.S. Geological Survey, Open-File Report OF-2013-1030, 1:100,000.

Zeirden, Martha A. and Elizabeth J. Reitz. 2016. *Charleston: An Archaeology of Life in a Coastal Community*. University Press of Florida, Gainesville, Florida.