US Army Corps of Engineers


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CHARLESTON PENINSULA, SOUTH CAROLINA

A COASTAL FLOOD RISK MANAGEMENT STUDY

DRAFT FEASIBILITY REPORT / ENVIRONMENTAL IMPACT STATEMENT

SEPTEMBER 2021

Charleston Peninsula Coastal Flood Risk Management Study
Draft Integrated Feasibility Report / Environmental Impact Statement

Lead Agency: U.S. Department of the Army, U.S. 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 Health & Environmental Control; South Carolina Department of Natural Resources

Title of Proposed Project: Charleston Peninsula Coastal Flood Risk Management Study

State Involved: South Carolina

Abstract: This draft integrated Feasibility Report and Environmental Impact Statement (FR/EIS) documents the planning process and presents the findings of the study. This FR/EIS supersedes the previously issued 2020 Feasibility Report and Environmental Assessment and meets the environmental review and disclosure requirements of the National Environmental Policy Act. The City of Charleston is the local sponsor for this feasibility study.

The draft 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, and cooperating agencies. 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 draft FR/EIS evaluates effects to a number of resources including aesthetics, cultural, and biological resources. The FR/EIS also documents measures to avoid, offset, or minimize impacts to resources affected by the proposed action where feasible. At the completion of the Charleston Peninsula Coastal Flood 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 funded by Congress, subsequent phases of the project would include Preconstruction Engineering and Design, Construction, and Operations, Maintenance, Repair, Replacement and Rehabilitation.

Comments Due: October 25, 2021

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

Executive Summary

This effort was initiated in October 2018 to evaluate actions that would reduce risk to the Charleston Peninsula from coastal storm surge inundation. While the Charleston Peninsula also experiences flooding from tides and rainfall, the authority and funding for this study does not include the investigation of measures to address these aspects of flood risk management, although they have been included in storm surge inundation analyses. This draft integrated Feasibility Report and Environmental Impact Statement (FR/EIS) documents the planning process and presents the findings of the feasibility study. This FR/EIS supersedes the previously issued 2020 Feasibility Report and Environmental Assessment and meets the environmental review and disclosure requirements of the National Environmental Policy Act (NEPA). The City of Charleston is the local sponsor for this study and the U.S. Army Corps of Engineers (USACE) is the lead agency under NEPA.

Following the public review and comment period for the draft FR/EIS, the Study Team will document issues raised during the review period and evaluate their effect on study recommendations before moving forward with completion of the Final FR/EIS and Record of Decision (ROD). At the completion of the Charleston Peninsula Coastal Flood Risk Management Study, and upon approval by the Chief of Engineers by the United States Army, the recommended plan would be submitted to Congress for authorization and funding. If authorized and funded by Congress, subsequent phases of the project would include Preconstruction Engineering and Design (PED), construction, and operations and maintenance as shown in Figure ES-1.

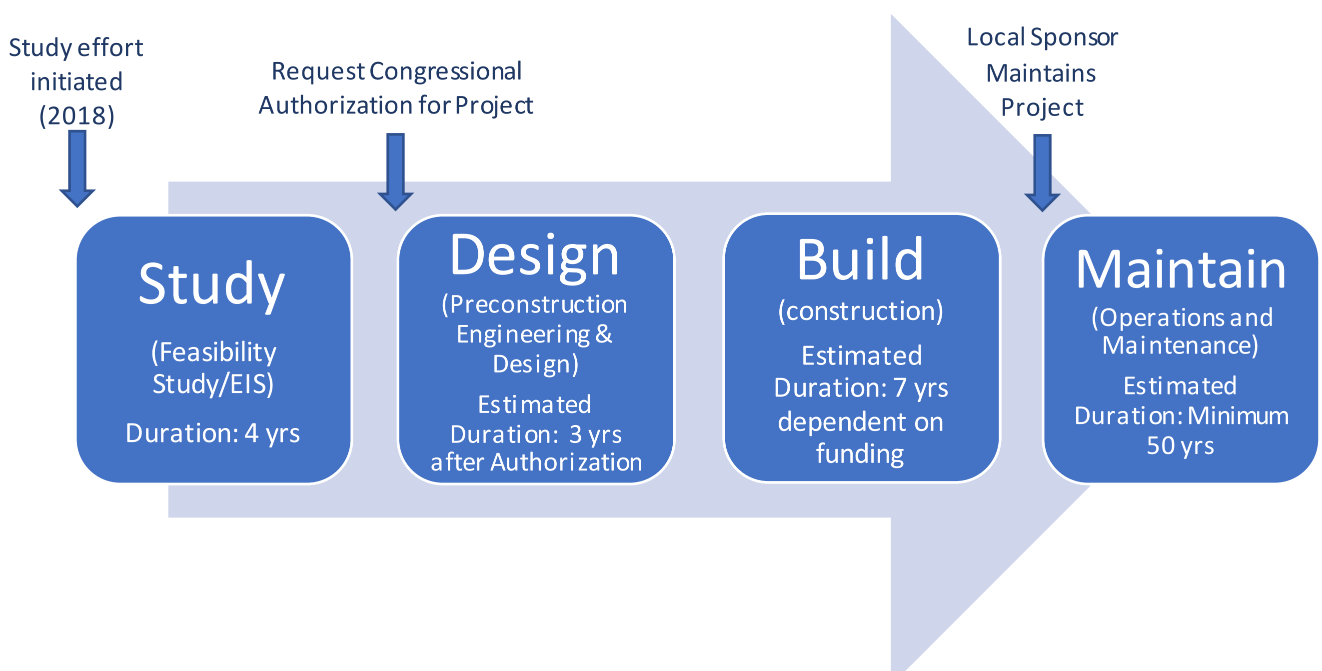

Figure ES-1. Charleston Peninsula Coastal Flood Risk Management project phases.

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). 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 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. 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 can damage or destroy homes and businesses, 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 storm surge inundation is expected to increase 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 non-structural solution set to reduce risk to human health and safety, reduce economic damages from coastal storm surge inundation and increase resilience to coastal storm surge inundation.

ES.2 USACE Planning Process and NEPA Public Involvement

In the Fall of 2018, the Study Team held two planning charrettes, or kickoff meetings, to initiate the planning process. The City of Charleston and key agencies and stakeholders participated in the charettes and collaborated to formulate the initial array of conceptual alternatives. The City of Charleston played a key role in the planning charrettes, and city staff have regularly attended study meetings and provided input into the project planning process. Based largely on input received at the charrettes, the Study Team developed the following study objectives to guide the planning process:

- Reduce risk to human health, safety, and emergency access from coastal storm surge inundation on the Charleston Peninsula through the year 2082.
- Reduce economic damages resulting from and increase resilience to coastal storm surge inundation on the Charleston Peninsula through the year 2082.

At the beginning of the planning process, the Study Team developed an initial array of four action alternatives to meet study objectives (see Chapter 3 of the main report). From that initial array, iterative evaluation and comparison procedures resulted in the identification of a Tentatively Selected Plan (TSP) which included a storm surge wall around the perimeter of the peninsula, a wave attenuating structure (breakwater) in the Charleston Harbor, and nonstructural measures in select areas of the peninsula. In April 2020, a draft integrated Feasibility Report and

Environmental Assessment (FR/EA) was released to the public for review and comment, along with a draft Finding of No Significant Impact. The TSP was then refined with consideration of public, agency, and technical comments and optimized to reduce costs and environmental effects. After review of substantive comments received on the draft FR/EA, further agency analysis, 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.

The Notice of Intent to prepare an EIS for this study was published in the *Federal Register* on March 23, 2021 (86 Federal Register [FR] 15470) beginning the NEPA scoping process. In addition, press release and social media announced the scoping comment period and virtual public scoping meeting, which was held on March 30, 2021. The scoping comment period ended April 22, 2021. USACE received approximately 125 substantive comments during the scoping period.

The 45-day public comment period for the draft FR/EIS begins September 10, 2021. USACE will consider all substantive comments received during the comment period. Due to the ongoing COVID-19 pandemic, USACE will host a virtual public meeting during the public comment period. In addition to accepting comments during the public meeting, comments will be accepted via mail or electronic comment form on the study's website.

Public comments submitted on the draft April 2020 FR/EA will not be further considered as comments on this draft FR/EIS. USACE considered all substantive public comments received on the draft April 2020 FR/EA in USACE's decision to move from an EA to an EIS, as part of the scoping process for the FR/EIS (including with regard to potential alternatives and impacts of the proposed action), and in developing the content of the draft FR/EIS. Any person desiring to provide public comment on this draft FR/EIS should submit their comment on the draft FR/EIS within the 45-day comment period, and not rely on or reference previous input or public comment on the draft April 2020 FR/EA. Only public comments submitted and received within the 45-day comment period on the draft FR/EIS will be considered in the agency's NEPA analysis and development of the final FR/EIS, including the response to public comment appendix

ES.3 How the Plan Has Changed

The wave attenuating structure (breakwater) has been eliminated from the Tentatively Selected Plan (TSP). To buy down uncertainty, the Study Team refined the performance analysis of the breakwater measure to ensure that the feature was producing inundation reduction benefits that exceeded its costs. The refined analysis showed that the breakwater did not produce additional inundation reduction benefits when combined with the storm surge wall. This conclusion reflects the fact that the primary purpose of a breakwater is to reduce impacts from wave attack and erosion, not to reduce inundation. As a result of this analysis, the breakwater measure was screened from the TSP.

Impacts to marsh wetlands and construction costs of the TSP have been reduced. To reduce adverse effects on existing wetland habitat and aquatic resources, the Study Team refined the alignment of the storm surge wall. The extent of wetlands affected was reduced from 111 acres estimated in the April 2020 draft FR/EA to 35 acres estimated in this draft FR/EIS. This process also resulted in an overall reduction in the project cost because constructing the wall on land is significantly less expensive than constructing the wall in wetlands. The alignment of the wall was also moved to tie-in to high ground near the Citadel, which eliminated the need for a miter gate at the Citadel Boat Channel.

Natural and nature based features (NNBF) have been added to the TSP. USACE determined that NNBF could be effective in reducing coastal storm impacts if used in combination with other measures in the plan, and therefore justified. As a result, oyster-reef living shorelines are being proposed in some locations.

Recreation features have been eliminated from the TSP; however similar features may yet be included as cultural or visual mitigation measures. While the April 2020 draft FR/EA included recreation features such as a walkway along the river and river access points as opportunities, such recreation features were determined not to be incidental to the final array of alternatives (i.e., not requiring separable construction costs to realize recreation outputs) and therefore not USACE policy compliant. Existing walkways will be maintained, and new walkways and other features may be incorporated as part of cultural or visual mitigation plans during the design phase or as betterments funded by the non-Federal sponsor.

ES.4 The Tentatively Selected Plan

1. **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 piles on the other side, connected by a concrete cap. 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 ES-2 has been optimized to minimize costs and impacts to the study area. Changes to the alignment may occur during the Preconstruction 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. Specific gate operation procedures would be developed during the PED phase. 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.

2. **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, or the bathtub effect, caused by the storm surge wall.

3. **Nonstructural measures:** In residential areas where construction of the storm surge wall would be impractical due to the topography of the peninsula or other existing constraints, nonstructural measures such as elevations and floodproofing could be applied. Neighborhoods that are largely equal to or higher than the proposed wall elevation, or separated from high-risk areas by high ground, have been identified for nonstructural measures. Those neighborhoods 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. 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 elevation measures would be applied to the Rosemont neighborhood due to the nature of the construction materials and techniques used in these communities.

4. **Natural and Nature Based Features**: In association with the storm surge wall, oyster reef-based living shoreline sills would be constructed in some locations to reduce coastal storm impacts to natural shorelines and other resources seaward of the wall. The living

shoreline sills would reduce erosion of existing wetland marsh, while reducing scour at the proposed storm surge wall. The living shorelines would also provide other environmental benefits. The reef-based living shoreline method/design would be determined during the PED phase.

The TSP would improve the resilience of the Charleston Peninsula by preparing for storm surge inundation events and anticipating and adapting to changing conditions associated with sea level rise and climate change. After implementation of the TSP, the Charleston Peninsula would be able to withstand and recover from coastal storms more quickly. Increased resilience to coastal storm hazards means that fewer economic damages are incurred and there are fewer disruptions to the daily life on the peninsula.

ES.5 Costs and Benefits

The final array of alternative plans was evaluated and compared using coastal and economic modeling to assess the performance and economic benefits of each plan. Table ES-3 summarizes the costs and benefits of the actionable alternative in the final array. Alternative 2 was identified as the plan that reasonably maximizes net National Economic Development (NED) benefits, consistent with protecting the Nation's environment. Therefore, Alternative 2 (Figure ES-1) has been identified as both the NED plan and the TSP.

Table ES-1. Costs and Benefits of Alternative 2 ($1,000).

Cost/Benefit Item	Alternative 2
Investment Costs	–
Project First Cost	$1,099,000
Interest During Construction	$146,000
Total Investment Cost	$1,245,000
Average Annual Cost[1]	–
Average Annual First Cost	$43,900
Annual OMRR&R[2] Cost	$3,000
Average Annual Annualized Costs	$46,900
Benefits[1]	–
Average Annualized Benefits	$479,000
Net Benefits	$432,100
BCR	10.2

[1]Costs are rounded in October 2021 price levels, 2.5% discount rate, and a 50-year period of analysis.
[2]Operation, Maintenance, Repair, Replacement, and Rehabilitation.

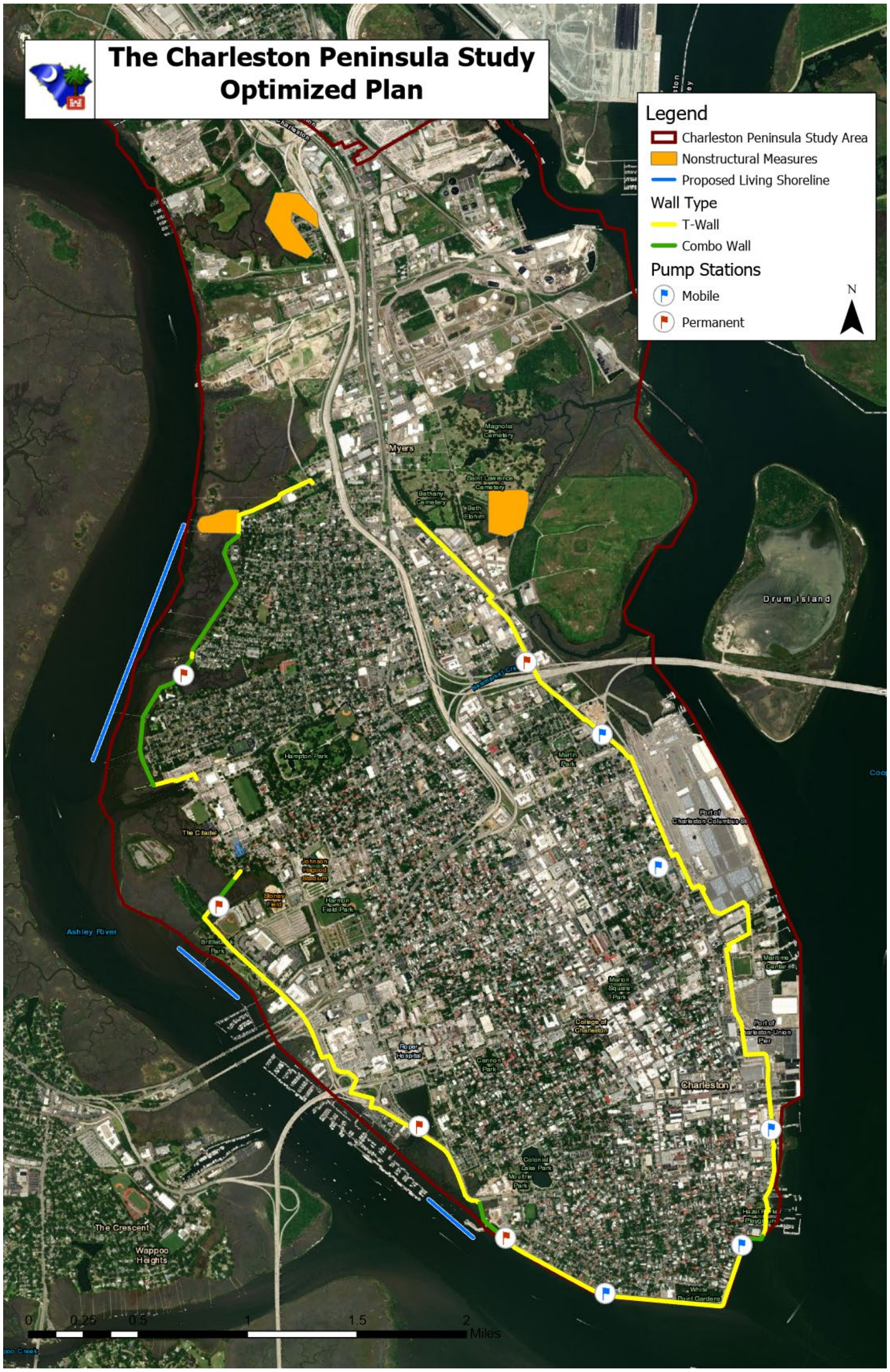

Figure ES-2. The National Economic Development and Tentatively Selected Plan.
Official mapping product of the Management Support Branch, Charleston District, USACE

ES.6 Cost Sharing

Cost accounts from the draft Micro Computer-Aided Cost Estimating System (MCACES) cost estimate for the TSP are displayed in Table ES-4 below. The TSP and the MCACES cost estimate will be refined during the next phase of the study and details will be published in the final FR/EIS.

Table ES-2. Preliminary Cost-Share Responsibilities for the Tentatively Selected Plan ($1,000).[1]

MCACES Account[2]	Item	Federal	Non-Federal	Total
01	Lands and Damages[2]	$0	$135,239	$135,239
02	Relocations[2]	$0	$14,810	$14,810
06	Fish & Wildlife	$27,399	$0	$27,399
11	Levees & Floodwalls	$624,125	$0	$624,125
13	Pumping Plant	$44,565	$0	$44,565
18	Cultural Resource Compliance	$85,846	$0	$85,846
19	Buildings, Grounds & Utilities	$65,725	$0	$65,725
30	Planning, Engineering & Design	$50,504	$0	$50,504
31	Construction Management	$50,504	$0	$50,504
–	**Subtotal**	**$948,669**	**$150,049**	**$1,098,718**
–	Non-Fed Cash Contribution	-$234,502	$234,502	–
–	**Total**	**$714,167**	**$384,551**	**$1,098,718**
–	Percentage	65%	35%	–

[1]Costs are in October 2021 price levels, 2.75% discount rate, and a 50-year period of analysis.
[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."

The estimated first cost of the TSO is $1,098,718,000 (October 2021 price levels). The cost share apportionment is 65% Federal and 35% non-Federal, therefore the Federal portion of the estimated first cost is $714,167,000 and the non-Federal sponsor portion is $384,551,000. 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 non-Federal sponsor will continue to participate in and comply with applicable Federal floodplain management and flood insurance programs.

ES.7 Environmental Impacts and Mitigation

Approximately 555 acres of tidal creeks, mudflats, and saltmarshes remain around the perimeter of the peninsula. All of these 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 in a Coastal Barrier Resources Act Zone.

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, by reducing potential effects on wetland habitat from an earlier conceptualization 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, deeming them less than significant. 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. 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. Some effects would be significant.

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 TSP on historic properties. Consistent with applicable law, USACE is deferring final identification and evaluation of historic properties until after project approval, additional funding becomes available, and prior to construction by executing a Programmatic Agreement (PA). 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. A draft of the PA is included as an appendix to this report and has been provided to the consulting parties for review (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).

There would be effects to aesthetics and visual resources from proposed plan since it would be permanent and visible on land and/or water. Some effects would be significant. As project designs are refined in the PED Phase, effects to the viewshed will continue to be mitigated to the greatest extent practicable 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 safety, 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.

Some of the adverse environmental effects assessed in this draft FR/EIS are considered to be minor, a few are negligible, and some would be significantly adverse. However, important avoidance and minimization measures will be implemented, and compensatory mitigation measures would be taken where appropriate. These will be documented in the Record of Decision (ROD) that will accompany the Final FR/EIS.

ES.8 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 conduct of the 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 implementation of the PA for historic and cultural resources discussed above, and using an MOU for aesthetic resources and a Detailed Visual Resource Assessment Procedure (see Appendix A).

Property Acquisition

In some cases, permanent property acquisition would be needed for project construction, operation, and maintenance. 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 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.

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CHAPTER 1 - Study Information

The City of Charleston is the non-Federal sponsor for the Charleston Peninsula Coastal Flood Risk Management Study. This is a study to assess the feasibility of measures to manage coastal storm surge flood risk for the Charleston Peninsula. The City and the United States Army Corps of Engineers (USACE) signed a Feasibility Cost-Sharing Agreement on October 10, 2018. USACE Coastal Storm Risk Planning Center of Expertise will oversee technical review of the study.

USACE is the lead agency under the National Environmental Policy Act (NEPA). A draft integrated Feasibility Report and Environmental Assessment was published in April 2020 for public review and comment. Based on resource agency and public feedback and agency refinement of the Tentatively Selected Plan (TSP), USACE determined that a full Environmental Impact Statement (EIS) was merited to adequately assess environmental impacts of the proposed project. Pursuant to 33 CFR 230.13, this EIS has been integrated into the Feasibility Report (FR). The integrated FR/EIS meets the environmental review and disclosure requirements of NEPA and documents the planning process to address coastal storm risk for the Charleston Peninsula. 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. Specifically, *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, *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 TSP, and *Chapter 11 – List of Preparers* presents the people who were primarily responsible for preparing the FR/EIS and/or appendices.

The Charleston Peninsula Coastal Flood 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 storm surge inundation, shoreline erosion, and/or wave attack as appropriate to the location's unique set of coastal geography.

1.1 Study Authority

The authority to study all of coastal South Carolina, including the Charleston Peninsula, was provided in the Rivers and Harbors Act of 1962, P.L. 87- 874, Section 110, 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.*"

The Bipartisan Budget Act of 2018 (Public Law 115-123), Division B, Subdivision 1, Title IV, 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.*

1.4 Study Area

In 2018, USACE initiated the Charleston Peninsula Coastal Flood 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 before discharging into the Atlantic Ocean. The Charleston Harbor is a natural tidal estuary sheltered by barrier islands. The Charleston Peninsula is the historic core and urban center of the City of Charleston and is home to approximately 40,000 people. The peninsula portion of the city 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.

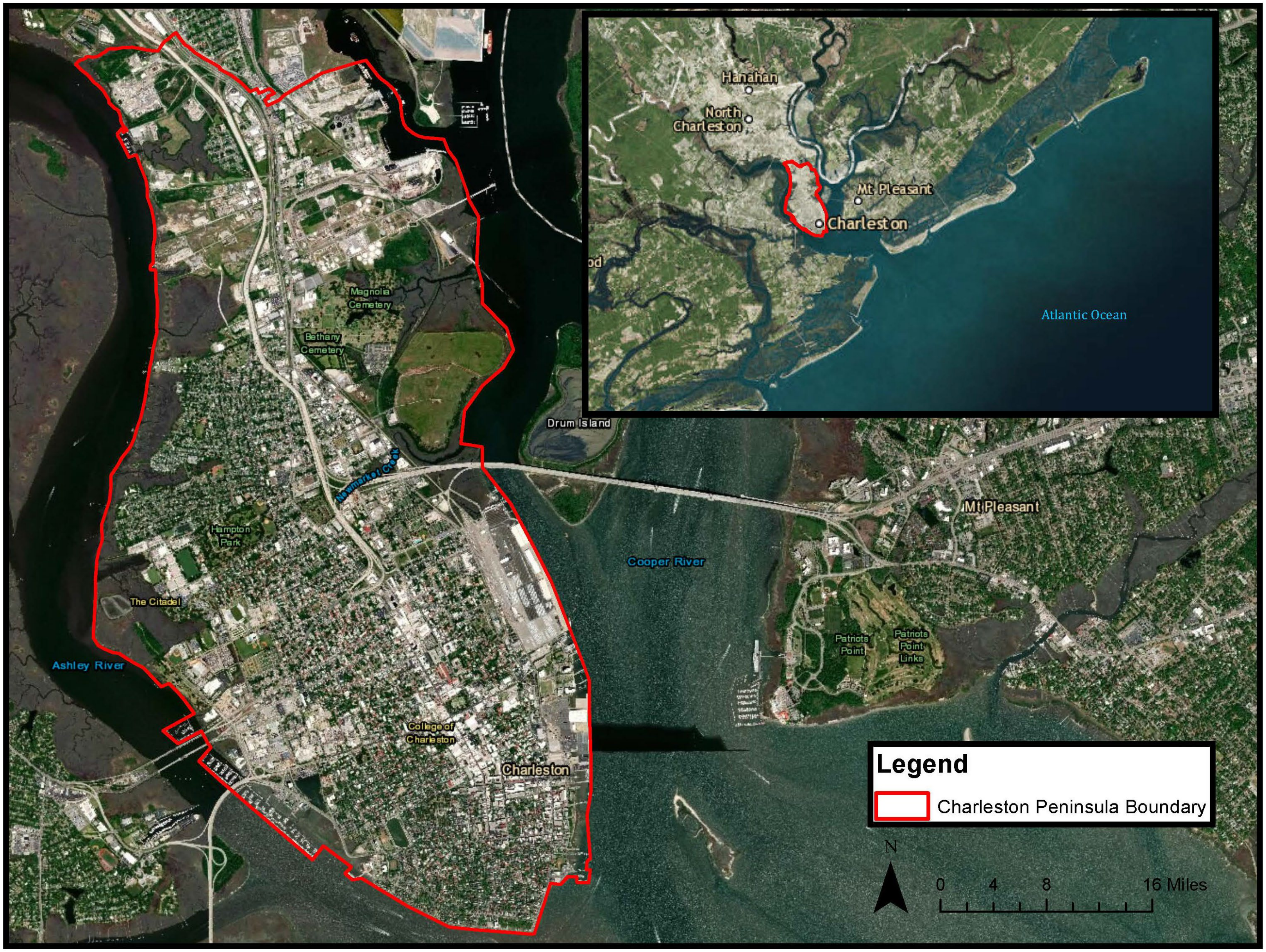

Figure 1-1. The Charleston Peninsula study area is bordered by the Ashley and Cooper Rivers, the Charleston Harbor, and barrier islands. Official mapping product of the Management Support Branch, Charleston District, USACE.

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

1.5 Scope

The intent of the Charleston Peninsula Coastal Flood Risk Management Study is to investigate and recommend potential structural and nonstructural solution sets to reduce the risk of damages from coastal storm surge inundation. The Charleston Peninsula, South Carolina is highly vulnerable to coastal storms which will be further exacerbated by a combination of sea level rise and climate change over the period of analysis. Without a plan to reduce the risk of damages from coastal storm surge inundation, the peninsula's vulnerability to coastal storms is expected to increase over time.

The focus of this study is on flooding due to storm surge inundation. 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, the authority and funding for this study does not include the investigation of measures to address these aspects of flood risk management. However, rainfall-induced flooding is included in inundation analyses, and mitigation for adverse impacts to stormwater runoff will be investigated and recommended as appropriate per ER 1105-2-100, Section 3-3.b.(5).

This draft FR/EIS documents the development and evaluation of alternative plans to address flooding related to coastal storm events on the Charleston Peninsula and culminates in identification of a Tentatively Selected Plan. A final version of the FR/EIS will be published after public and internal USACE reviews.

1.6 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

- 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.
- 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.
- Century V City Plan, 2010
    - The City of Charleston's comprehensive plan that articulates the vision and goals of the city.
    - The plan provides the basis for making decisions related to the following
        - Natural and cultural resources
        - Economic Development
        - Public Safety and services
        - Land use and preservation
        - Transportation options
        - Planning coordination
- 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

- Market Street Drainage Improvement Project, Phase III in construction
    - A new tunnel underneath 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.
    - Phase I completed in 2006
    - Phase II completed in 2014
- 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 2023
- 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.

- 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. Later, the passage of the Rivers and Harbors Act of 1878 authorized the deepening of a channel to a depth of 21 feet MLLW

and the construction of a pair of jetties to stabilize the new channel. In 1898 and 1904, additional dredging was performed to increase channel depths to 26 and 30 feet MLLW, respectively. In 1940, a 35-foot MLLW project was authorized for the Entrance Channel, up Town Creek (past the Union Pier and Columbus Street Terminals) and up the main channel of the Cooper Fiver to the North Charleston Terminal area. In 1986, the channels were authorized to 40 feet MLLW. Finally, in 1996, the major interior channels were authorized to 45 feet MLLW and the Entrance Channel was authorized to 47 feet MLLW.

  - 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
  - Authorized by the Rivers and Harbors Act of 1912 and 1937, the project provides for a channel 30 feet deep MLLW and 300 feet wide from the mouth to the Standard Wharf, a distance of 7.4 miles, suitably widened at bends and at the head of the improvement. The project was completed in 1940. The last operation maintenance dredging occurred in 1954. This project is now inactive.

1.7 Public and Agency Coordination

1.7.1 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 support informed decision-making. This section gives an overview of the public involvement process for this project, including public scoping and tribal coordination. Chapter 5, *Coordination and Public Involvement Process*, provides a more in-depth discussion.

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. On January 31, 2019, a project information meeting was held where the public was informed on the results of the first two planning iterations and input was solicited both in person and via an online form. USACE also solicited public comments on the draft 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 of the draft FR/EA and solicit comments. Approximately 450 comments were received from the public and agencies. Common themes of these comments were, as followed:

- 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 (including environmental justice).

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 would best fulfill NEPA compliance for the study.

1.7.2 Public Scoping

One of the first steps in the NEPA process, particularly for an EIS, is to establish the scope of the project, and one component of accomplishing this step is the public scoping process. The Notice of Intent 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, press release and social media announced the scoping comment period and virtual meeting.

USACE received approximately 125 substantive comments during the scoping period. The scoping comments, generally, fell into several themes, as follows:

- Analysis of wetlands, ecosystem, visual, environmental justice, interior drainage, and climate change
- Potential design features such as natural and nature-based feature, and nonstructural
- Analysis of residual risk, meaning shifting the flooding from project area to somewhere else
- City planning

1.7.3 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 law. For this FR/EIS, the public comment period will be open for 45 days. The purpose of this review is to seek input on the alternatives considered, effects of the alternatives, and associated mitigation. USACE will consider all substantive comments received during the comment period. The complete list of comments received on the draft FR/EIS and responses will be included as an appendix to the Final FR/EIS. USACE will host one public meeting during the public comment period. In addition to accepting comments during the public meeting, comments will be accepted via mail or electronic comment form on the study's website.

Public comments submitted on the draft April 2020 FR/EA will not be further considered as comments on this draft FR/EIS. As mentioned above, USACE considered all substantive public comments received on the draft April 2020 FR/EA in USACE's decision to move from an EA to an EIS, as part of the scoping process for the FR/EIS (including with regard to potential alternatives and impacts of the proposed action), and in developing the content of the draft FR/EIS. Any person desiring to provide public comment on this draft FR/EIS must submit their comment on the draft FR/EIS within the 45-day comment period, and not rely on or reference previous input or public comment on the draft April 2020 FR/EA. Only public comments submitted and received within the 45-day comment period on the draft FR/EIS will be considered in the agency's NEPA analysis and development of the final FR/EIS, including the response to public comment appendix.

1.7.4 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 FR/EIS by providing information and reviewing draft documents. The cooperating agencies are as listed:

- National Marine Fisheries Service
- National Park Service
- US Coast Guard
- US Environmental Protection Agency
- US Fish and Wildlife Service
- South Carolina Department of Archives and History
- South Carolina Department Health & Environmental Control
- South Carolina Department of Natural Resources

1.8 Significance of the Study Area

Charleston, South Carolina is important to the Nation because 1) the history of the community reflects the history of the Nation; 2) strategic military bases in Charleston are critical to national security; and 3) Charleston's port facilities support the Nation's economy.

1.8.1 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 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 dating from the late-eighteenth century to the mid-nineteenth century that document the city's unique and rich history. Refer to the Section 4.10 for an overview of the historical development of Charleston.

1.8.2 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 low cost of living, the area is an ideal place for additional Coast Guard investment. And, as the Port of Charleston is expected to become the deepest harbor on the East Coast by 2021, the maritime importance of the region for the U.S. Coast Guard is set to grow (Forbes, 20 Feb 2020).

1.8.3 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.

1.9 Planning Process and Report Organization

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.

USACE planning process mirrors 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). 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 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. But even coastal storms that arrive at low tide or pass by the Charleston Peninsula can have severe storm surge impacts on the community. The wind- and tide-driven waves of a storm surge 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 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 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 climate change. 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 an intermediate 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 4% annual exceedance probability (25-year) 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 of time. Residents may have flood insurance to cover some damages, but they are still financially impacted by storm events.

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. 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 dodged 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 8th-busiest seaport in the United States in 2017, with nearly 2.2 million cargo containers moving through its terminals. The Port of Charleston is owned and operated by the South Carolina States 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, and this sector has had the highest rate of growth between 2011 and 2012, due in large part to the local initiatives to attract and promote the tech economy. In 2015, Charleston's tech economy was growing 26% faster than the national average – and just as quickly as Silicon Valley.

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, has identified the following opportunities:

- Increase resilience of the Charleston Peninsula to storm surge flooding.
- Create natural areas including open space and stream restoration.

- 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 or visual mitigation plans during the design phase or betterments funded by the non-Federal sponsor, but shall not be included in the primary plan to address storm surge inundation.

2.4 Objectives

An objective is a statement of the intended purposes of the planning process; it is a statement of what an alternative plan should try to achieve over the life of the project. 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 2033, the end of the period of analysis would be 2082.

The PDT has identified the following objectives to help achieve the study goal:

- Reduce risk to human health, safety, and emergency access from coastal storm surge inundation on the Charleston Peninsula through the year 2082.
- Reduce economic damages resulting from and increase resilience to coastal storm surge inundation on the Charleston Peninsula through the year 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 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.
- Minimize adverse effects to threatened and endangered species and Essential Fish Habitat.
- Ensure that environmental justice considerations are not compromised.

- Avoid high-cost modifications and installation of flood gates to Interstate 26 and U.S. Route 17 hurricane evacuation routes.
- Avoid encroaching on navigation channels in the Charleston Harbor and the Ashley and Cooper Rivers (see Figure 2-1).
- Avoid adverse impacts to Coast Guard, port, and marina operations.

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 the Water Resources Development Act (WRDA) of 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. 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.

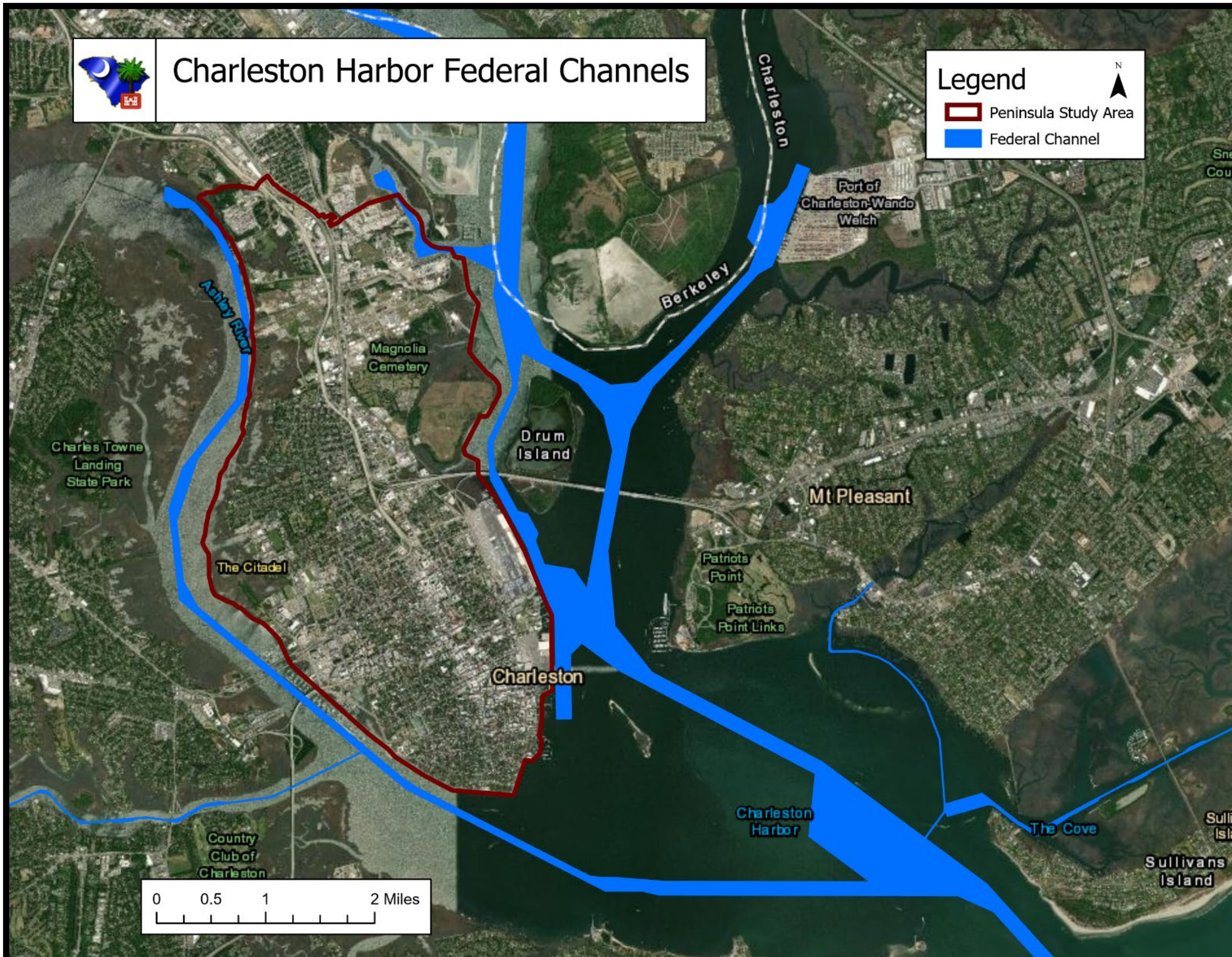
Charleston Harbor Federal Channels
Legend
Peninsula Study Area
Federal Channel
N
Charleston
Berkeley
Port of Charleston-Wando Welch
Ashley River
Magnolia Cemetery
Drum Island
Charles Towne Landing State Park
Mt Pleasant
Patriots Point
Patriots Point Links
The Citadel
Charleston
Charleston Harbor
The Cove
Sullivans Island
Country Club of Charleston
0
0.5
1
2 Miles

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. Twenty-five 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, Tropical Cyclone History). 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. Peak storm tides reached 10 – 12 feet above mean sea level in the Charleston Harbor. Water crashed over the historic seawall and flooded the first floors of homes. However, approximately 30 miles to the north in Bulls Bay, South Carolina, peak storm tides reached about 20 feet above mean sea level. 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. Amazingly, 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 most costly storm in terms of property damage. The storm caused at least $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 moisture 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 9.29 feet MLLW was recorded in Charleston Harbor, which was the third-highest tide to date. Flooding from the harbor along with 9 to10 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 or local interests do not address the problems identified in this study.

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). About 26 people move to the Tri-County Area each day, making it one of the country's fastest growing regions. 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 130,000. A total of 40,000 reside on the peninsula.

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.

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.

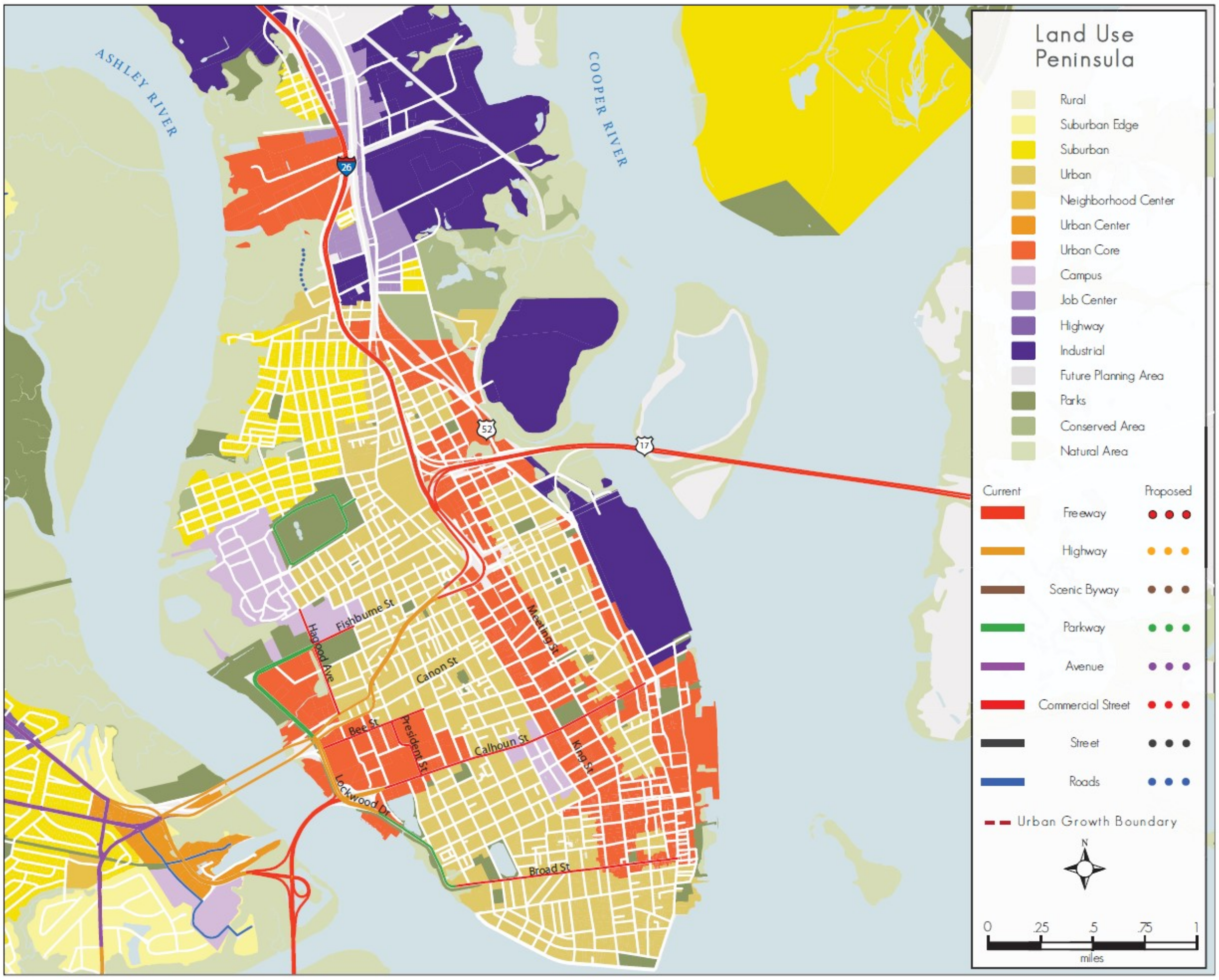

Figure 2-2. Land Use on the Charleston Peninsula. Source: City of Charleston Century V Plan.

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 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 storms 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 1.13 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 the1990s, 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 Battery 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 23.6 in) 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.

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 above mean lower low water (MLLW). Charleston has experienced 8 of the top 15 tides ever recorded in the last four years, although not all were associated with storms. 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 cylcones that do not make landfall still cause storm surge impacts on the peninsula.

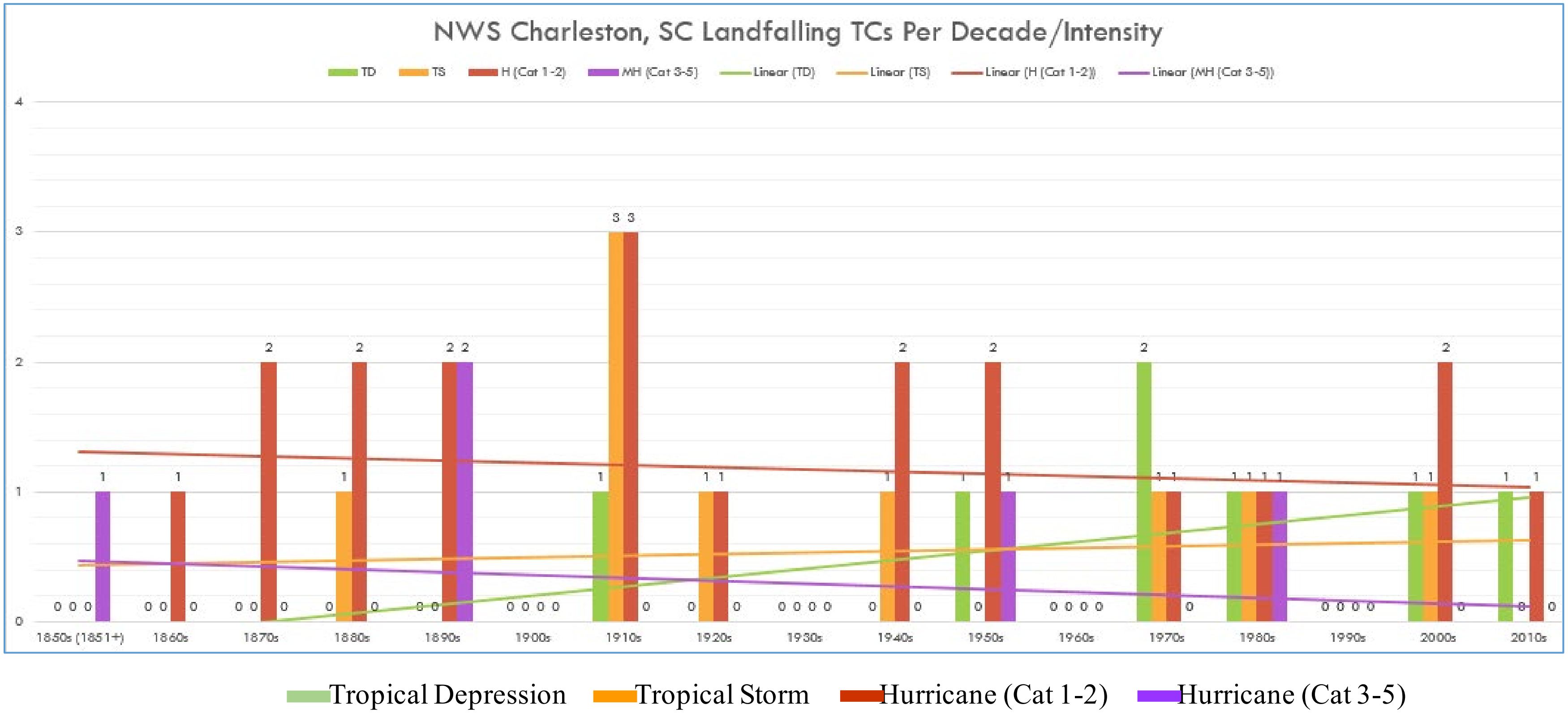

Figure 2-3. Charleston, SC Landfalling Tropical Cyclones by Decade. Source: National Weather Service.

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 withdevelopment 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. The ecosystem services they provide would also be lost in those areas.

Historic and cultural resources will continue to be at risk from storm surge events. A major draw for tourism is the historic architecture associate with the Charleston Old and Historic District (COHD), which encompasses a large portion of the southern peninsula. The CODH 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, approximately 54% of historic structures are at risk from inundation during a 4% annual exceedance probability storm 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 three key coastal storm management measures – structural, nonstructural, and natural and nature based – are being investigated. 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.

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 tentatively selected plan to address the planning objectives for this study.

The time-tested six-step planning process has been enhanced to incorporate risk assessments throughout the process to inform the decisions made during the process. One important aspect of the process is to conduct multiple iterations of the 6-step process at given points during the study and have the team and decision-makers assess the risks identified before proceeding. Another 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 within a limited time and limited resources.

2.9.1 Key Uncertainties

At this stage of the study, there are several uncertainties centered around lack of specific data on interior hydrology and surficial geology, and effects to cultural and visual resources. However, none of the uncertainties identified are beyond the PDT's expectation for risk-informed decision making. The uncertainties documented at this stage in the planning process 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 subsidence on the peninsula
- Future rate of sea level rise
- Timing, duration, or frequency of storm activity

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 through the year 2082.
- Reduce economic damages resulting from and increase resilience to coastal storm surge inundation on the Charleston Peninsula through the year 2082.

As noted in Chapters 1 and 2, the first planning iteration was conducted on October 16, 2018 and included Project Delivery Team (PDT) members, including the City of Charleston. The primary outcome of this iteration was the identification of problems, opportunities, objectives, and constraints. 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 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. Two additional alternative plans that were formulated at a later date are also described 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 flood risk management measures consist of three basic types: structural, nonstructural, and natural or nature-based features, and the initial array of alternatives consists 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.

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 man-made, 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, floodproofing, home elevation, and flood warning systems are examples of nonstructural measures.

Natural or Nature-Based Features (NNBF) refer to those features that define natural coastal landscapes and are either naturally occurring or have been engineered to mimic natural conditions. Examples of NNBF include beaches and dunes; vegetated environments such as maritime forests, salt marshes, freshwater wetlands, and seagrass beds; coral and oyster 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 considered.

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 PDT and the knowledge of agencies and stakeholders are used to brainstorm management measures. 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 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.

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).

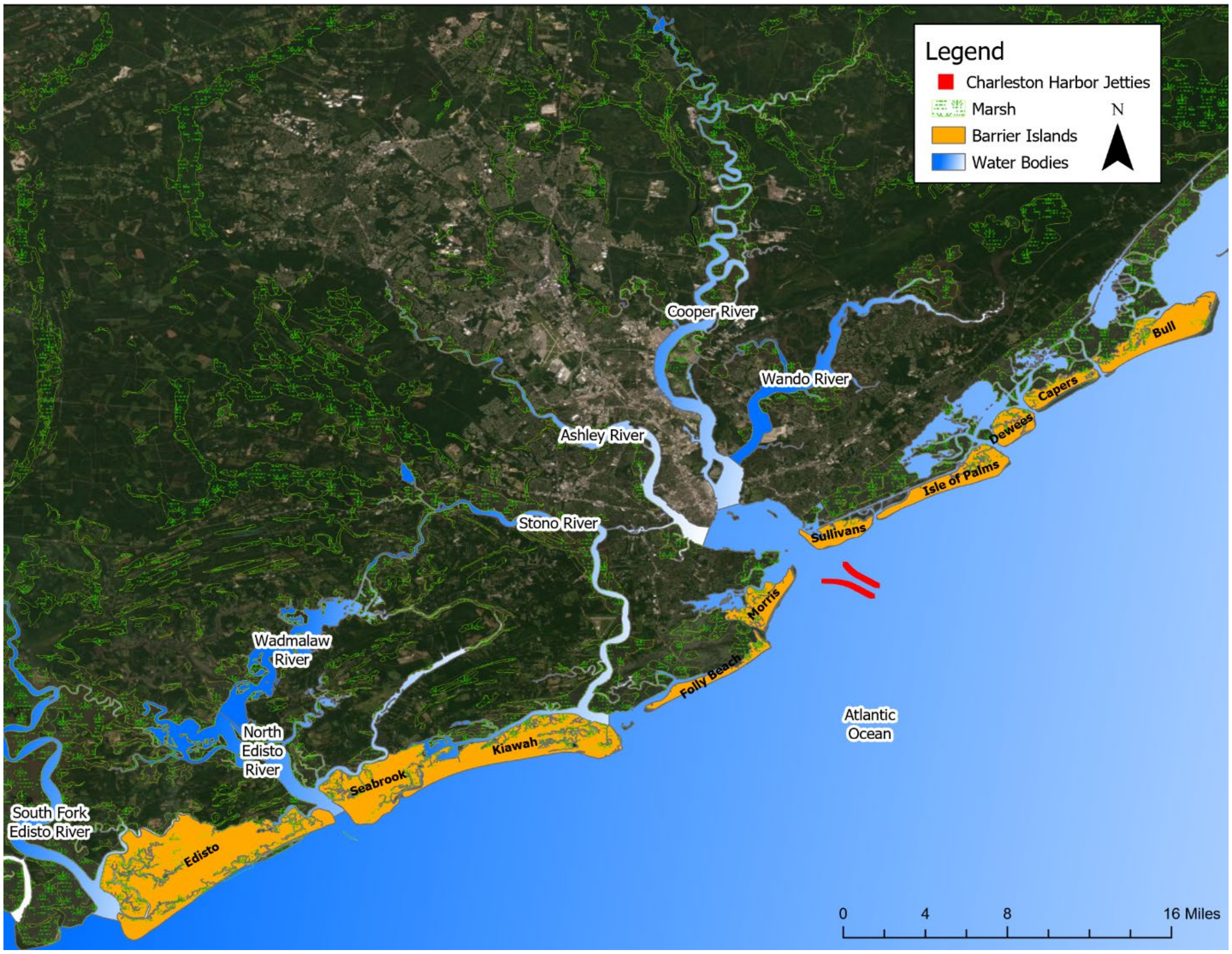

Figure 3-1. Coastal features to be considered for the Charleston Harbor Storm Surge Barrier System.

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, refer to an 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. In the early stage of the planning process, both seawalls and floodwalls were considered under the category of "storm surge walls."

A floodwall is defined as any wall having as its principal function the prevention of flooding of adjacent land. Seawalls are defined as structures separating land and water areas, primarily designed to prevent erosion and other damage due to wave action. They are frequently built at the edge of the water, but can be built inland to withstand periods of high water. Seawalls are generally characterized by a massive cross section and a seaward face shaped to dissipate wave energy. Coastal floodwalls, however, are generally located landward of the normal high-water line so that they are inundated only be hurricane or other surge tide.

Floodwalls such as I-walls and T-walls were determined to be the most appropriate type of wall for the Charleston Peninsula because wave attack and erosion were not identified as significant risk factors for life safety or economic damages. . 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. For RSLR adaptation purposes, it is assumed that T-walls would be used in areas where the design water surface elevation requires a four foot or higher wall. T-Walls would be traditional concrete stem walls with pile supported bases. I-walls would be concrete-capped cantilevered sheet pile walls. T-Walls would be designed in accordance with EM 1110-2-2502, *Retaining and Flood Walls*.

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

Status: Retained for further consideration.

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 9/10 of a mile in length 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 ½ 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 to reach the High Battery. 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 to match the elevation of the High Battery Wall.

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 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. Additionally, USACE policy does not permit single structure protection.

Status: Screened from consideration based on effectiveness, cost efficiency, and USACE policy violations.

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 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 often limits the size or level of protection possible, therefore the measure would not be an effective way to meet study objectives.

Status: Screened from consideration based on effectiveness.

Levees

Levees are man-made, earthen barriers along a water course constructed for the primary purpose of providing flood, storm, and hurricane protection.

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.

Colonial Lake Storage

Colonial Lake is an existing tidally influenced lake in the study area that is completely surrounded by walkways, which function like retaining walls or bulkheads." The current depth of the lake is approximately four to five feet. A single 42-inch diameter subterranean drainage pipe leads to the Ashley River and provides for flushing action with each tidal cycle. The lake's perimeter walls could be raised 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 Colonial Lake would not reasonably reduce storm surge inundation risk. Pumping floodwaters into the lake and then back out again would create a significant operation and maintenance burden and with significant associated costs.

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

Detention Basins

A detention basin is an excavated area installed on or adjacent to rivers, streams, lakes or bays to capture floodwaters and reducing 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.

Status: Screened from consideration based on effectiveness and constructability.

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.

Status: Screened from consideration based on effectiveness.

3.1.3 Natural and Nature-Based Features (NNBF) Considered

Elevate Existing Marsh Wetland

The dense vegetation and shallow waters within wetlands can slow the advance of storm surge somewhat and slightly reduce the surge landward of the wetland or slow its arrival time. Raising marsh wetlands via thin layer placement of dredged materials may reduce the impacts of sea level rise over time, thus preserving natural flood abating functions.

Professional assessment: Marsh naturally adapts to sea level rise through a process called transgression. Organic matter in dredged materials can create odor problems. Existing coastal salt marshes are limited in their extent around much of the peninsula perimeter. Ultimately, elevating existing marsh wetlands would not reasonably reduce coastal storm surge risk.

Status: Screened from consideration based on effectiveness.

Living Shorelines

Open and exposed shorelines are prone to erosion due to waves. For this conceptual measure, an oyster reef-based sill would be installed that would allow sediments and vegetation to fill in, or native vegetation could be planted, to reduce wave action and erosion, and stabilize natural shorelines. The living shoreline sill would dissipate wave energy during storm events by causing waves to break on the reef, rather than the shoreline, and reduce exposure to resources in its lee.

Professional assessment: Discussions with local experts suggested that living shorelines would not reasonably reduce coastal storm surge risk on their own (large storm surges would result in increased overtopping and wave transmission to structures). However, they could be effective in combination with other measures by reducing shoreline erosion seaward of where structural measures are placed.

Status: Retained for further consideration.

Restore Historical Creeks

This measure would restore historical hydrologic patterns on the peninsula, creating riparian and wetland habitat that could attenuate some impacts of flooding. It would include acquiring property where historical creeks once flowed, removing structures, and restoring the creeks. It may be necessary to install an impermeable barrier to block pollutants in the material used to fill the original wetlands. To maintain vehicular and pedestrian circulation, bridges would be required. Utility corridors would also need to be redesigned.

Professional assessment: Extensive relocation of historic structures could be required. Restoring historical creeks would primarily address interior drainage issues and would not reasonably reduce coastal storm surge risk.

Status: Screened from consideration based on effectiveness.

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 crawl spaces. 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: Retained for further consideration.

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.

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.

Status: 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.

Status: 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 basics 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.

Status: Although this measure is not within USACE authority to implement, it is 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, this and other aspects of stormwater management is the responsibility of the local government.

Status: Although this measure is not within USACE authority to implement, it is retained for further consideration by the City of Charleston.

Highwater Emergency Vehicles

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

Initial assessment: This measure would improve access to critical facilities and emergency services. However, consistent with land use regulations and stormwater management, this measure is considered a local government responsibility.

Status: Although this measure is not within USACE authority to implement, it is retained for further consideration by the City of Charleston.

3.2 Formulation of Strategies

This section describes the process for formulating alternative plans from the measures described in Section 3.1. 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 1st planning iteration, the PDT 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 PDT determined that measures related to storage and conveyance (including historical creek restoration) would not reasonably reduce storm surge inundation, the alternatives that were developed using those strategies were 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 sources 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 that may continue to incur damages from storm surge after constructing a barrier.

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 and future without project condition are assumed to be the same for this study. 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, multiple drainage improvement projects, and installation of check valves on existing stormwater outfalls. This will have a positive effect on shallow coastal flooding from rainfall 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 Brittle Bank 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.

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. Existing topography makes extension of a wall or levee into the Neck Area of the peninsula impractical. A refined description of this alternative can be found in the Final Array of Alternatives section 3.5.

2. Perimeter Protection + Nonstructural + NNBF Alternative

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

- A wall along the perimeter of the Peninsula
- Living shorelines
- Relocate or 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. In association with the newly constructed wall, living shorelines would be constructed in some locations to reduce storm impacts to natural shorelines and other resources seaward of the wall. For structures outside of the wall alignment, a suite of nonstructural measures including relocations or buyouts, structure elevation, or floodproofing measures could apply.

3. Perimeter Protection + Wave Attenuating Structure + Nonstructural + NNBF Alternative

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

- A wall along a portion of the Peninsula's perimeter
- Living shorelines
- Wave attenuating structure
- Relocations or buyout of structures
- Elevate structures
- Floodproof structures

The storm surge wall along the perimeter of the Peninsula, nonstructural measures, and living shorelines 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 is incorporated into the recommended plan, other types of wave attenuating structures may be considered during the preconstruction, engineering, and design phase, such as a nearshore berm made of dredged material or a manufactured breakwater.

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 non-Federal sponsor (shown in italics). This alternative would consist of the following measures:

- Relocation or 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 relocation, buyout, elevation, or flood proofing. Per USACE policy, low-impact development / green infrastructure measures are a non-federal responsibility, as are flood warning systems and emergency response plans. Measures collectively referred to as low-impact development / green infrastructure are described in Section 3.1.

3.4 Screening of Conceptual Alternatives

Following the planning charrettes, the PDT 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 the how well measures met a set of criteria.

The screening criteria used in this study 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)*. *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.

Constructability and study constraints were also used as screening criteria. *Constructability* at this stage of planning is the subjective assessment of whether a feature could be constructed or implemented using standard industry techniques and is compliant with USACE policy for implementation. *Study Constraints* is the likelihood that the measure does not violate a constraint.

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 identified the action alternative that was carried forward into the final array.

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 disease and injury associated with storm surge inundation. Protection would benefit a representative cross-section of socio-economic communities on the peninsula.	**Yes**	**Yes**
2. Perimeter Protection + NNBF + 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. This alternative includes the added benefit of reducing impacts to marsh wetlands through construction of NNBF such as living shorelines. Reducing impacts to marsh wetlands seaward of a proposed wall would both maintain existing habitat and reduce erosion and scour at the base of the wall.	**Yes**	**Yes**
3. Perimeter Protection + NNBF + Nonstructural + Wave Attenuator	Like Alternatives 1 and 2, this alternative would reduce damages to structures and reduce risk to human health and safety. A wave attenuation structure in the Charleston Harbor would reduce the effect of waves from overtopping floodwalls during coastal storm events, further limiting inundation on the peninsula. The wave attenuation structure would 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 and/or relocating vulnerable structures on the peninsula. This alternative would not address storm surge inundation that limits access to critical	**Yes**	**No**

	facilities, emergency services, and evacuation routes. Further, a buyout of structures vulnerable to storm surge inundation would violate the constraint of minimizing adverse effects to historic districts and buildings.		

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 + NNBF + Nonstructural	High (3)	High (3)	High (3)	Medium (2)	11	Retain
3. Perimeter Protection + NNBF + Nonstructural + Wave Attenuator	High (3)	Medium (2)	Low (1)	Medium (2)	8	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 alleviates the specified problems and achieves the specified opportunities.
[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 are based on anticipated reactions to project impacts from the public. Each alternative is compatible with existing laws, regulations, and public policies.

Each alternative in the initial array fulfills 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. 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 Alternatives 1 – 3 address both study objectives, Alternative 1, Perimeter Protection, 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 the lowest overall score on the P&G 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. 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. Alternative 4 also received a low score in acceptability due to negative anticipated reactions from the public.

Alternative 3 received the second lowest overall score on the P&G evaluation criteria. The alternative received a medium effectiveness score because while the storm surge wall is effective at reducing storm surge inundation, 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. 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 Feasibility Report and Environmental Assessment 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.

Alternative 1 received the second highest overall score on the P&G evaluation criteria. The alternative received a medium effectiveness score because while the storm surge wall is effective at reducing storm surge inundation, the neighborhoods outside of the wall 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.

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, 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. 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 and future without-project condition are assumed to be the same for this study. Future without-project conditions and assumptions are 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 and shown on Figure 3-3:

- Storm surge wall along the perimeter of the Peninsula (approximately 8.5 miles)
- Nonstructural measures (approximately 100 structures)
- Living shorelines (tentatively 9,300 linear ft)

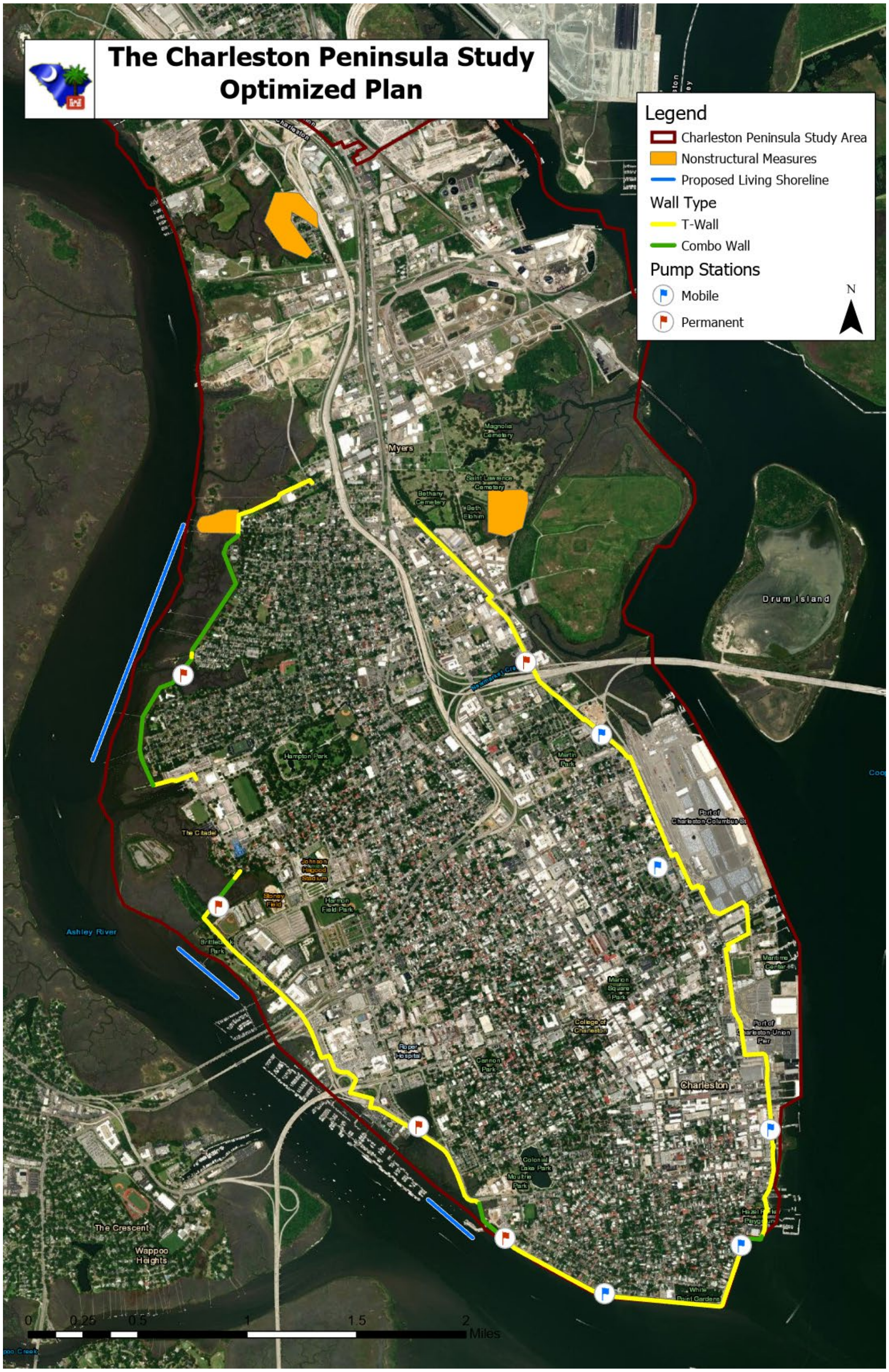

Figure 3-3. Map showing features of Alternative 2

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

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 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. 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 steel piles on the storm surge side and battered steel pipe piles on the other side, connected by a concrete cap (see Figure 3-4). To withstand earthquakes, pilings for both wall types would be 50 to 70 feet deep to tie into marl 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.

Figure 3-4. The Inner Harbor Navigation Canal Surge Barrier in New Orleans is an example of an approximately 26 feet (NAVD88) combo-wall.

A preliminary analysis showed that net economic benefits for a wall built to elevation 12 feet NAVD88 were higher than net benefits for a wall built to 7 or 9 feet NAVD88. For the purposes of alternative evaluation, comparison, and impact analysis, a footprint for a wall with a top elevation of 12 feet NAVD88 was assumed. This elevation was selected because a wall with an elevation higher than 12 feet NAVD88 would require an additional railroad crossing and raising or gating the Ashley River Bridge, which would limit traffic circulation during a coastal storm event. A 15-foot NAVD88 wall could potentially require raising or gating Interstate 26, which is an official hurricane evacuation route. Also, the Low Battery Seawall project currently under construction will be elevation 9 feet NAVD88 once complete and can only support modifications to increase the elevation an additional 3 feet. To add more than 3 feet, the seawall would have to be completely demolished and rebuilt, which would be a significant additional cost. Additional analysis will determine the optimized height and length of the wall should the alternative be selected.

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 impractical to construct the perimeter wall. Nonstructural measures considered include relocations, buyouts, elevations, and floodproofing. The neighborhood of Rosemont in the Neck Area and Bridgeview Village on the northeast edge of the peninsula have been identified as nonstructural areas because they are encompassed by higher ground, making an extension of the wall impractical (see Figure 3-5). Smaller wall systems in these neighborhoods would require acquisition of a significant proportion of the community and/or significant impacts to remaining marsh habitat. Utilities in the Lowndes Point neighborhood have been identified for nonstructural measures because residential homes are already elevated to or above 12 feet NAVD88. Additional analysis will determine the specific application of nonstructural measures should the alternative be selected.

Finally, NNBF in the form large-scale living shorelines would be part of this alternative. Living shoreline sills would be constructed to reduce coastal storm impacts in locations where natural shorelines and other resources are at risk seaward of the perimeter wall (Figure 3.3). The living shorelines would be oyster reef-based for consistency with local practices. Additional analysis will determine final suitable locations of these features should the alternative be selected.

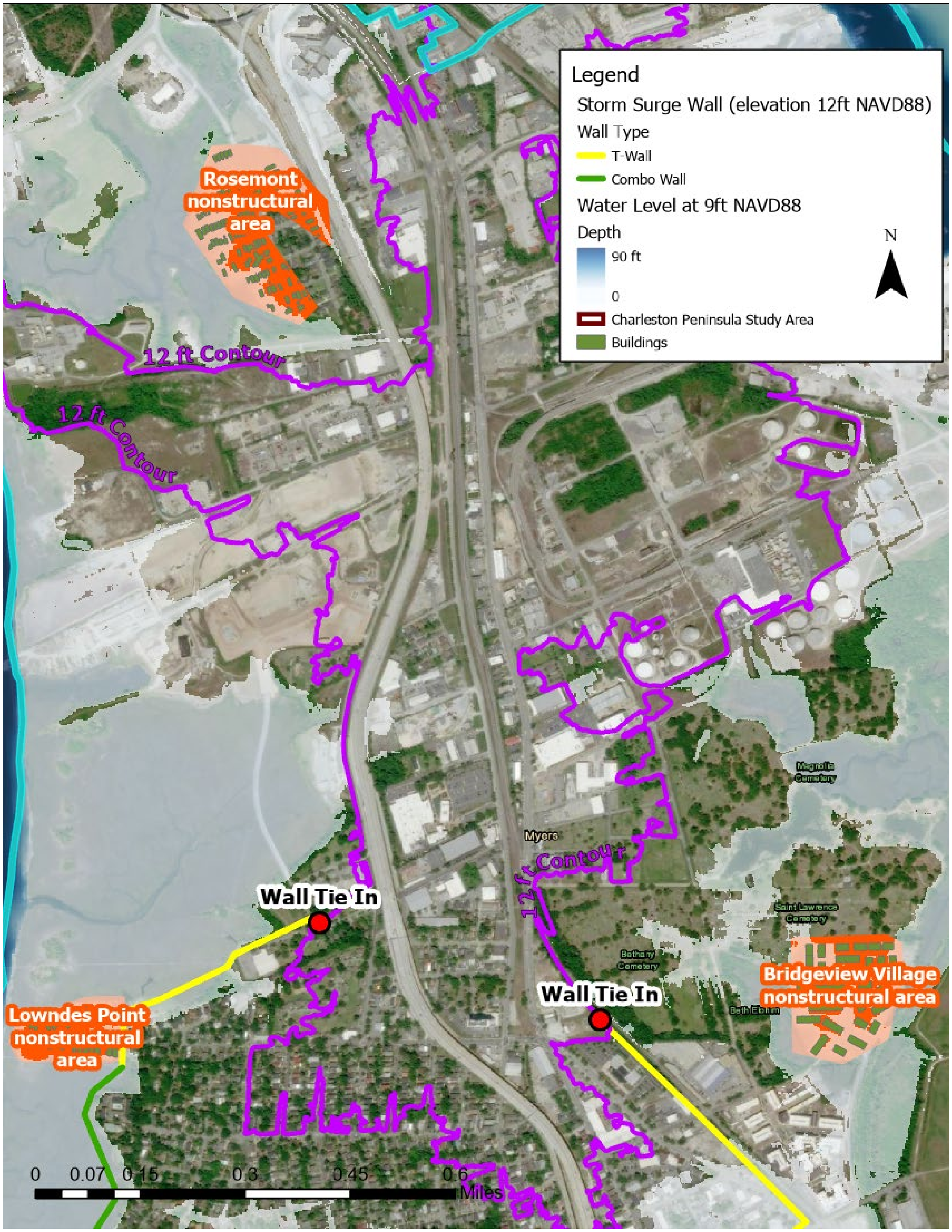

Figure 3-5. Nonstructural areas of Alternative 2 in relation to the 12-foot NAVD88 contour line.

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 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 also has an existing comprehensive plan, Century V Comprehensive Plan. In addition, the City is preparing a new comprehensive plan, Charleston City Plan which is expected to be finalized in September 2021. According to the City of Charleston's Century V Comprehensive Plan (City of Charleston, 2016), the approximately 8 square mile area within the City's jurisdiction on the Charleston Peninsula is zoned as 20% commercial use and 30% heavy industrial. 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 Comprehensive Plan, 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 cross roads. 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.

- Urban: Mixed-use, but primarily residential areas with a wide range of building types and setbacks. Densities range from 8 du/a to 12 du/a. Examples on the Peninsula include Ansonborough and Hampton Park Terrace neighborhoods.

- Urban Core: 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 larger, streets have steady street tree planting, and buildings are set close to wide sidewalks. There would typically only be one or two Urban Core areas in the City. Densities would range from ten dwelling units per acre and up. The Central Business District of Charleston (portions of King, Calhoun, Meeting, East Bay, and Broad Streets), the MUSC/Roper/VA Medical District, and the approved plans for the Magnolia Tract (see below) in the Charleston Neck area are examples of this category on the Charleston Peninsula.

- Campus District: 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 and the College of Charleston.

- Industrial District: The industrial areas would primarily house 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.

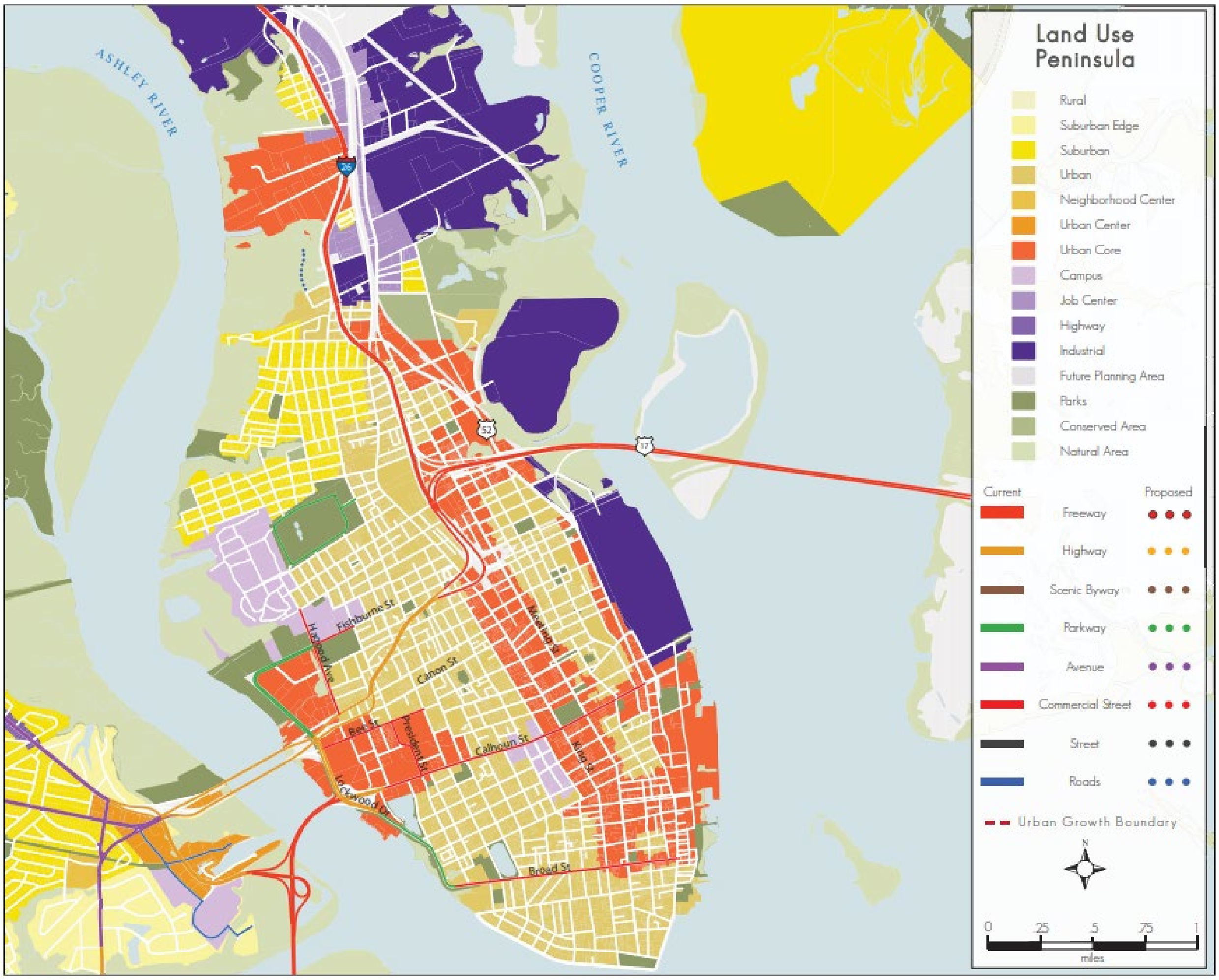

Figure 4-1. Map of land use designations on the Charleston Peninsula

Source: City of Charleston Comprehensive Plan, 2010.

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. 2015 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.

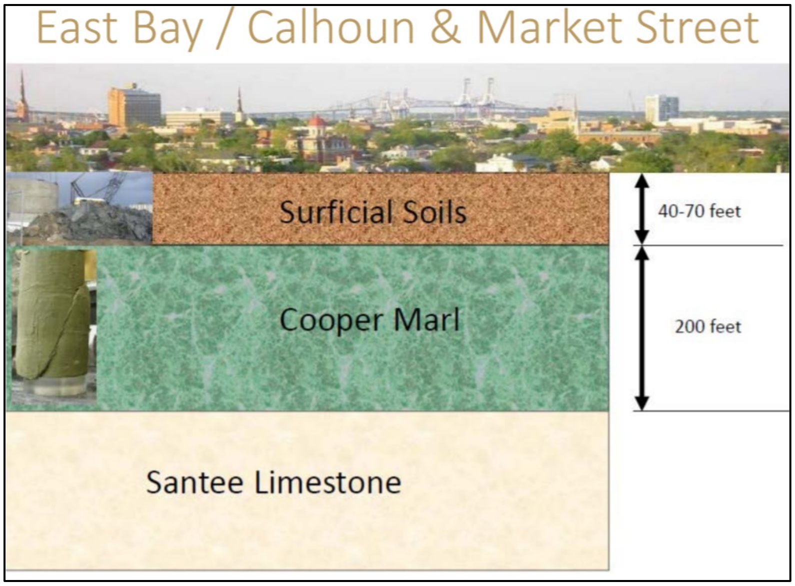

Figure 4-2. Graphical representation of the stratigraphy in the area near East Bay Street, Calhoun Street, and Market Street

Source: City of Charleston.

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.

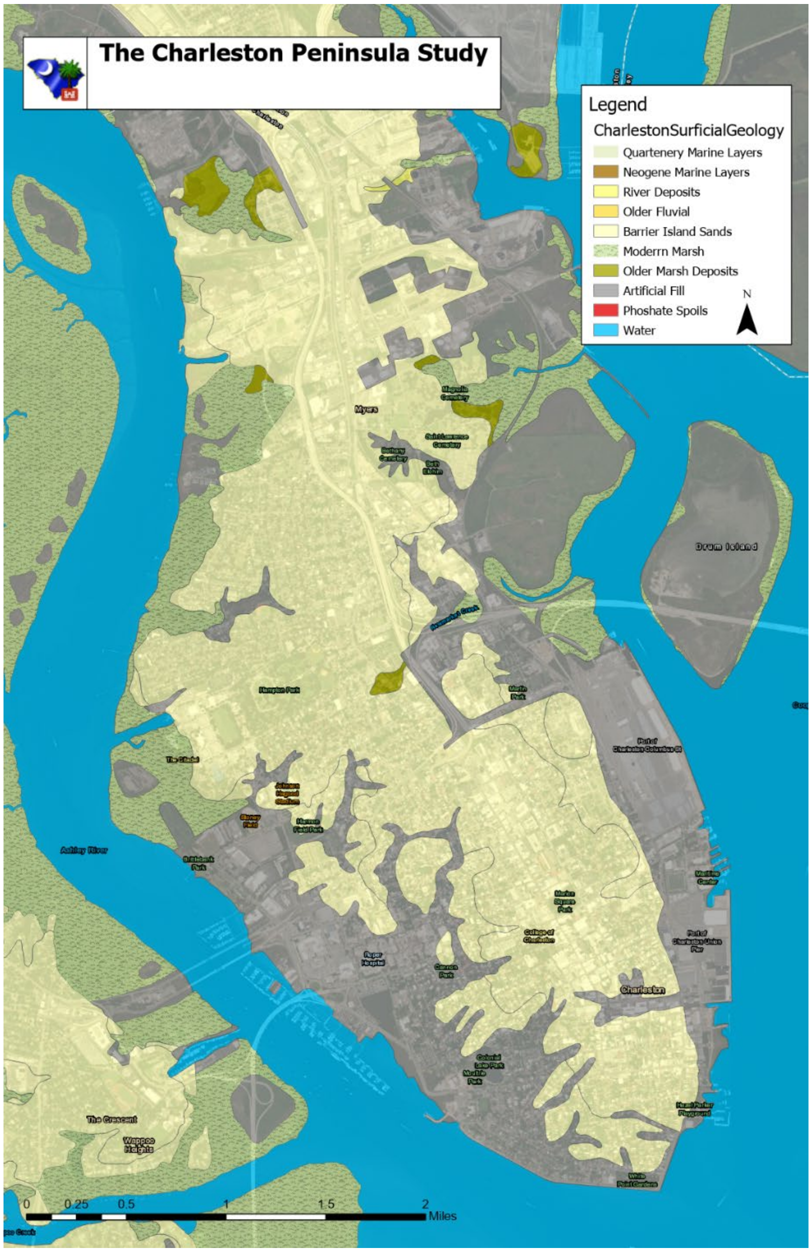

Figure 4-3. Surficial geology of the Charleston Peninsula

Source: Weems et al. 2014

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 on 1886. The Charleston Peninsula is located in a "hot spot" of high seismic activity and is deemed to be within a high seismic hazard zone. This area is known as the Charleston Seismic 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, but most of the area is experiencing low to very low shoreline change (see Figure 4-4).

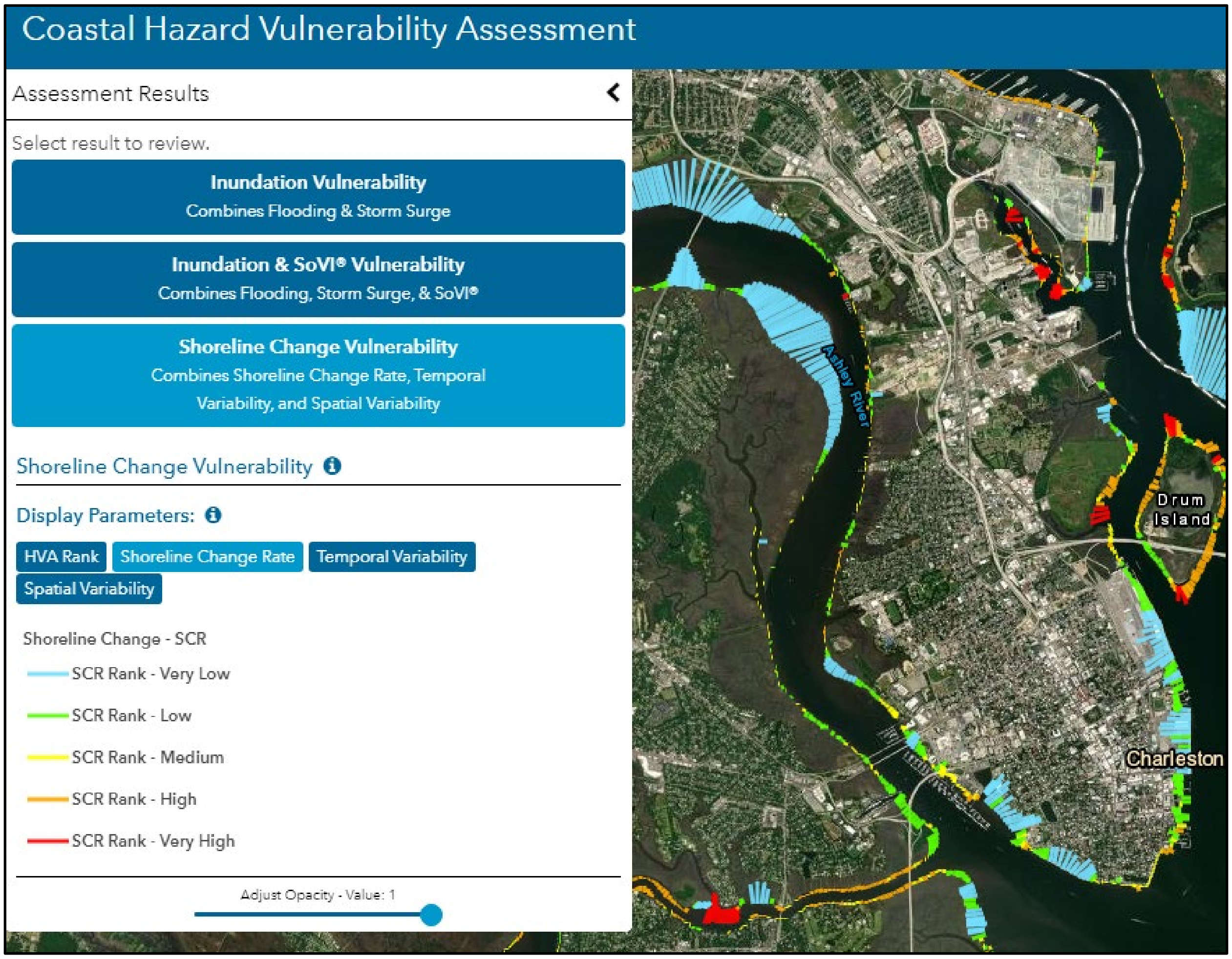

Figure 4-4. Map of shoreline change rates around the Charleston Peninsula from the Coastal Hazard Vulnerability Assessment Tool

Source: SCDHEC-OCRM.

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 the Charleston area 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 ROI is not believed to be caused by crustal deformation or groundwater extraction. The past glaciation did not advance far enough towards Charleston to influence the mantle. Additionally, groundwater extraction in the region isn't great enough to lower the groundwater table. 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 attributing to compaction of the soils beneath it.

Scouring

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. 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 model used for this study include ADCIRC, STWAVE, and related products provided by SCDNR, and HEC RAS 2D 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 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 an a 4500 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 rather than density driven stratification.

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).

USACE has calculated still water elevations at five locations in the study area from over 1000 points to use for evaluation and modeling (see Sub-Appendix B4 - Coastal). Storm surge is driven by storm winds and waves as documented by the still water level. The still water surge elevation is the water elevation due solely from effects of astronomical tides, storm surge, and wave setup on the water surface, but does not include wave heights. 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, depth of water, and length of fetch, but is also a direct function of water depth. As the water depth increase, 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.

Figure 4-5. Current tidal creeks on the Charleston Peninsula

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

Coastal flooding in Charleston is increasing. In 1950, coastal flooding in the Charleston area occurred about 2 days annually for a total of 4 hours. In 2014, coastal 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 the last four years, some associated with storms. The National Weather Service indicates major flooding occurs in Charleston at 8 ft. (MLLW) which equates to 4.86 ft. (NAVD88). At present day, 4.86 ft. NAVD88 is equivalent to approximately a 50% annual exceedance probably (AEP) Still Water Level (without rainfall included). The National Weather Service describes major coastal flooding impacts at this level as widespread flooding on the Charleston Peninsula with numerous roads flooded and impassable, and some impact to structures. 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.

Compound flooding is also an issue for the Charleston Peninsula. Compound flooding occurs when a combination of 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 results in long term flooding from the compounding effect.

Ground Water

Historically, the 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 currently receives its drinking water from Bushy Park and Edisto River. As groundwater levels have continued to decline, Charleston was designated as a capacity-use area to regulate groundwater withdrawals due to 180-ft drawdowns in the Middendorf aquifer. Coastal drought in South Carolina has exacerbated the reduction in water levels (USGS, 2010). Groundwater occurs at water-table depth of 3-15 feet in the Charleston area, with annual fluctuations between 1 to 6 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.

Groundwater from the surficial aquifer is acceptable for general use, but its inconsistent yield, along with saltwater intrusion, has limited the municipal use of this aquifer (Park, 1985). The shallow groundwater levels in the surficial aquifer of the Charleston Peninsula fluctuates 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 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 U.S. SCDHEC administers the state's Section 401 Water Quality Certification Process.

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 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 is 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.

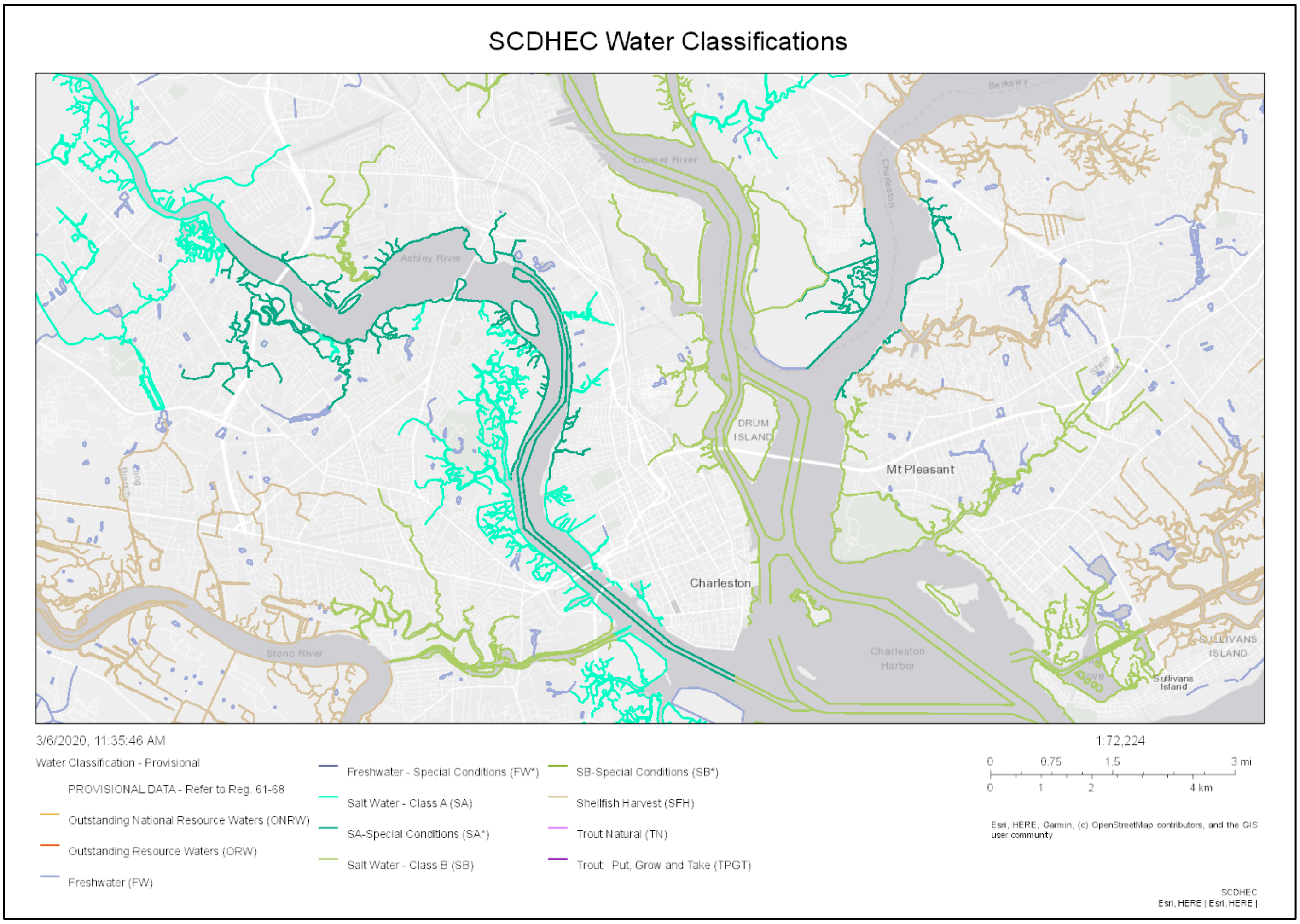

Figure 4-6. Provisional classifications for waters in the ROI

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.

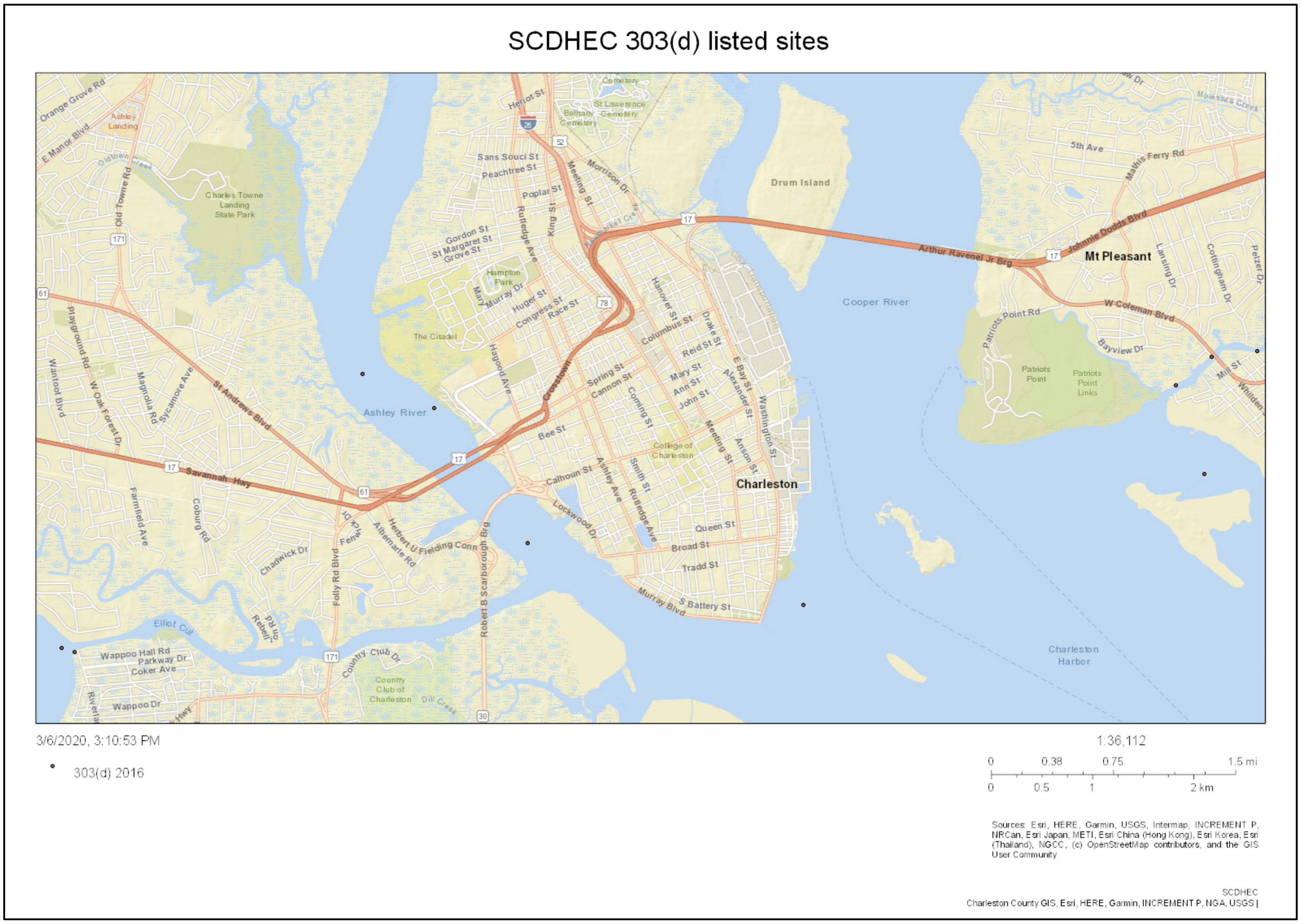

Figure 4-7. Impaired water quality sites in the ROI. The sites closest to the peninsula are impaired due to fecal matter

Source: SCDHEC

Dissolved Oxygen

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 also monitors water quality across the state's estuaries. The Ashley River is an area that has repeatedly shown to have fair to poor water quality and biological condition over time. The most recent data from 2017-2018 shows that in the upper Ashley River, water quality parameters for dissolved oxygen and bacteria were fair; pH, total nitrogen, and chlorophyll a were low; and total phosphorous was high, resulting in a total water quality index score of 3, or fair. This is an open water sampling site, and in general, the water quality in tidal creeks is shown to be more variable and have overall lower water quality compared to open waters of South Carolina (Sanger et al. 2020).

In the Cooper River, the diversion of freshwater flow into the River from Lake Moultrie starting in the 1940s has caused the Cooper River to shift from vertically well-mixed, to a more stratified condition that has influenced DO and salinity.

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).

Salinity

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. Salinity concentrations in the Cooper River and the Ashley River can range from 5 to 18 ppt, and 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, 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 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 flood 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, upstream of the lower Ashley and Cooper Rivers are not part of the ROI.

Affected Environment

Since the Charleston Peninsula is highly urbanized, relatively flat with nearly all areas 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 the100-year floodplain, while some parts lie 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.

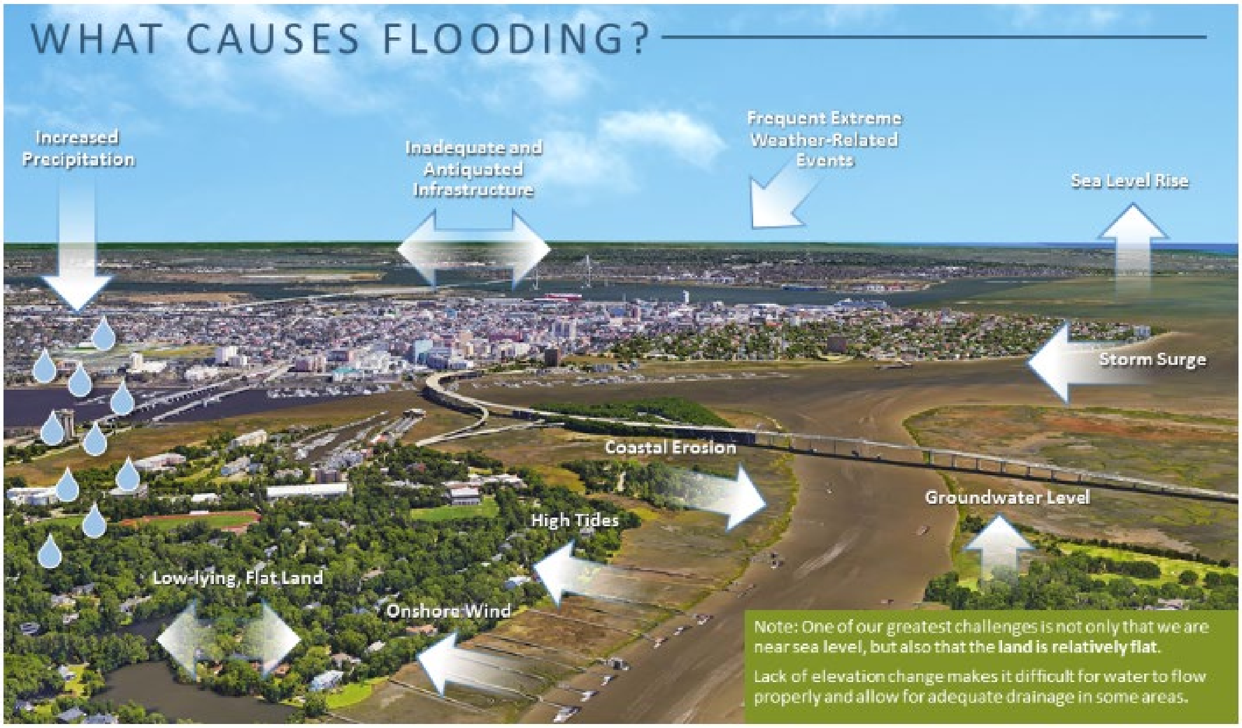

Figure 4-8. Local factors that contribute to flooding in the Charleston, SC area

Source: City of Charleston.

Interior Flooding

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. The following projects are intended to improve interior drainage on the Peninsula during heavy flooding from rainfall.

- Market Street Drainage Improvement Project, Phase III in construction (two previous phases have already been completed). Previous phases included the installation of 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, Phase III and IV in construction (two previous phases have been completed, and two more are planned after this one). This project includes construction of a large pumping station with a total capacity of 900 cfs.
- Calhoun West/Beaufain Drainage Improvement Project in design (Preliminary Engineering Report completed in early 2020). This project will result in a new pump station around King and Huger Streets with an approximate capacity of 156 cfs.

- MUSC Pump Station. Currently active with a total capacity of 114 cfs.

Coastal 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.

The City of Charleston already has two existing structures that help to reduce coastal 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. At the time of this feasibility study, the City of Charleston is implementing a project to modify the Low Battery Wall and 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 regulations that govern 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. A Section 404 evaluation will be completed for this study and included in the Final Report.

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 in 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 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 Channel is classified as a freshwater emergent wetland but it is actively used for placement of dredge material and is not managed for habitat.

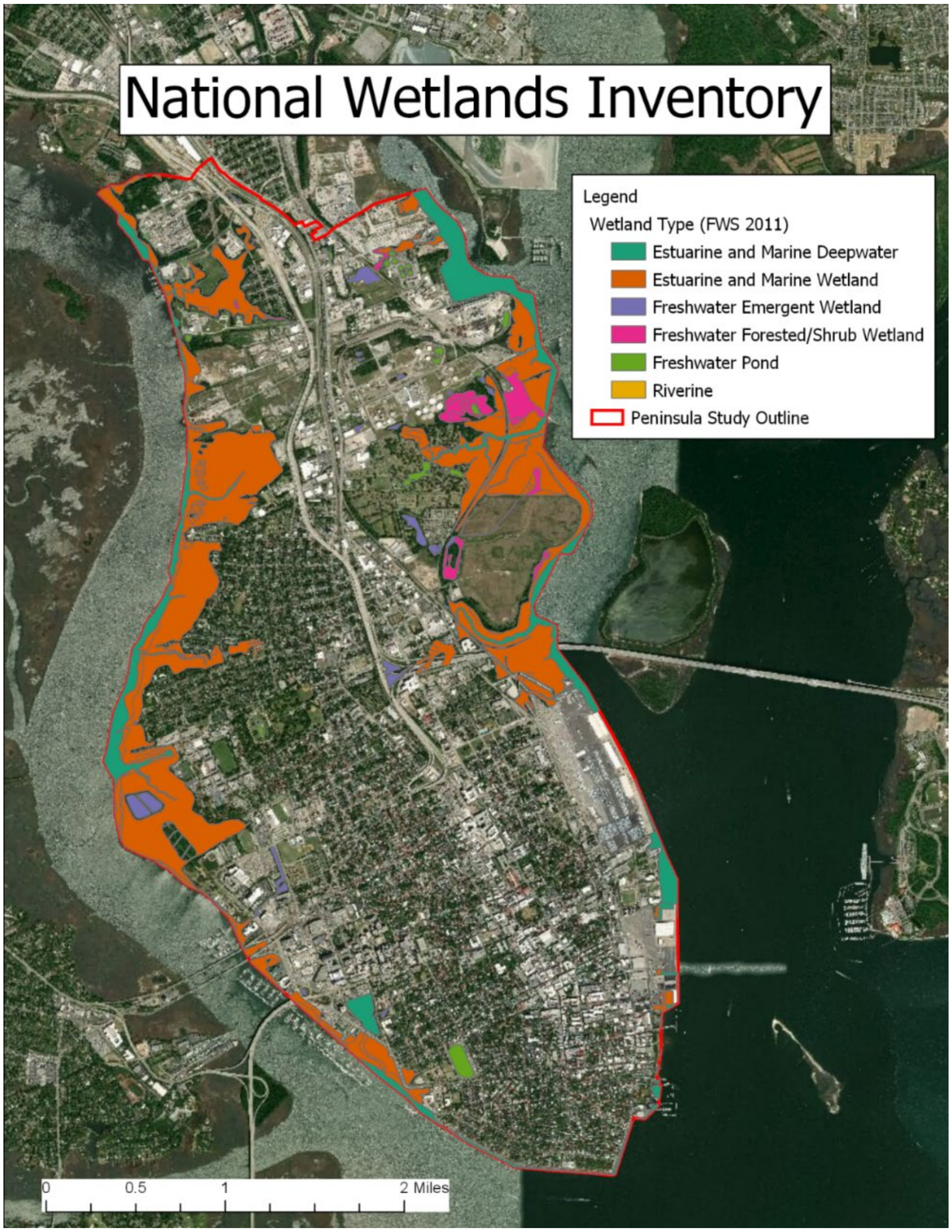

Figure 4-9. Distribution of types of wetlands in the study area

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 small 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 Gadsen Creek by multiple culverts, and in Halsey Creek by one culvert. At Koppers Creek, tidal restrictions include embankments and one road culvert. The Citadel 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 ha watershed is impervious cover.

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. Rip rap 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 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 2020; USFWS IPaC (n.d.)

Fish

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.

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 and 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.

<u>Birds</u>

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 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 Draft 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.

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. 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. In general, densities of fish, crabs, shrimps, and other large species are higher in tidal creek habitats compared to open water habitats, likely due to the importance of shallower creek habitats as refuge and nursery grounds for many of these species. They verify that recreationally and commercially important species of spot, white shrimp, brown shrimp, and Atlantic blue crabs are generally more abundant in tidal creek habitats than open water habitats. In the upper Ashely River, the biological and habitat quality indices are shown to be good by SCDNR (Sanger et al, 2020).

All of the tidal creeks and tributaries, along with their adjacent saltmarshes, 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 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 2020b).

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 will be included in the Essential Fish Habitat Assessment that is being prepared for this study.

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 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. In general, the biological condition of benthic communities and sediment quality tends to be lower in tidal creeks than in open waters across South Carolina's estuaries. In the upper Ashley River, the total sediment quality in 2017-2018 was considered to be good (Sanger et al. 2020).

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 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 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 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 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 on, or eligible for inclusion on, the National Register of Historic Places (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 has 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 area 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 note for 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 2020:54). 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 2016:58). 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 Lord 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 2020:13; Navin 2020:58). 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 2016:59). 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 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 2020:64). 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 (Map) of the Province of Carolina in 3 parts, Edw. Crisp 1711 (Library of Congress)

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

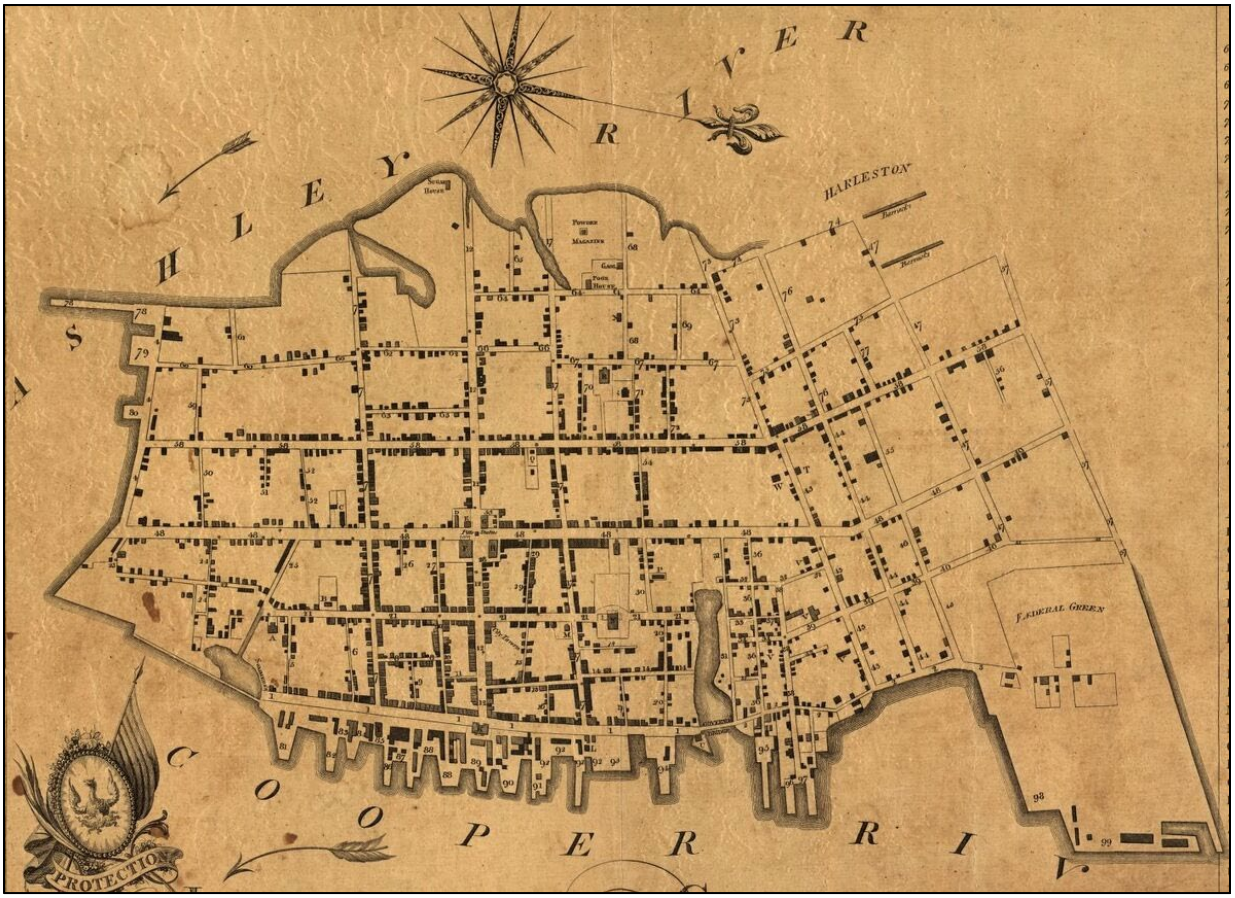

Figure 4-13. Portion of Ichnography of Charleston, South-Carolina: at the request of Adam Tunno, Esq., for the use of the Phoenix Fire-Company of London, taken from actual survey, 2d August 1788, E. Petrie, 1790, showing growth of lower peninsula

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 persons, 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

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 1989:290). 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 1989:290). By the late 1870s, only about one third of the city's 53.5 miles of streets were paved in some form (Fraser 1989:297). 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 natural disasters such as 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 2020:132). 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 then 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 1989:387). This led to an associated influx of naval and support personal 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 2020:162). 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 2020:160).

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.

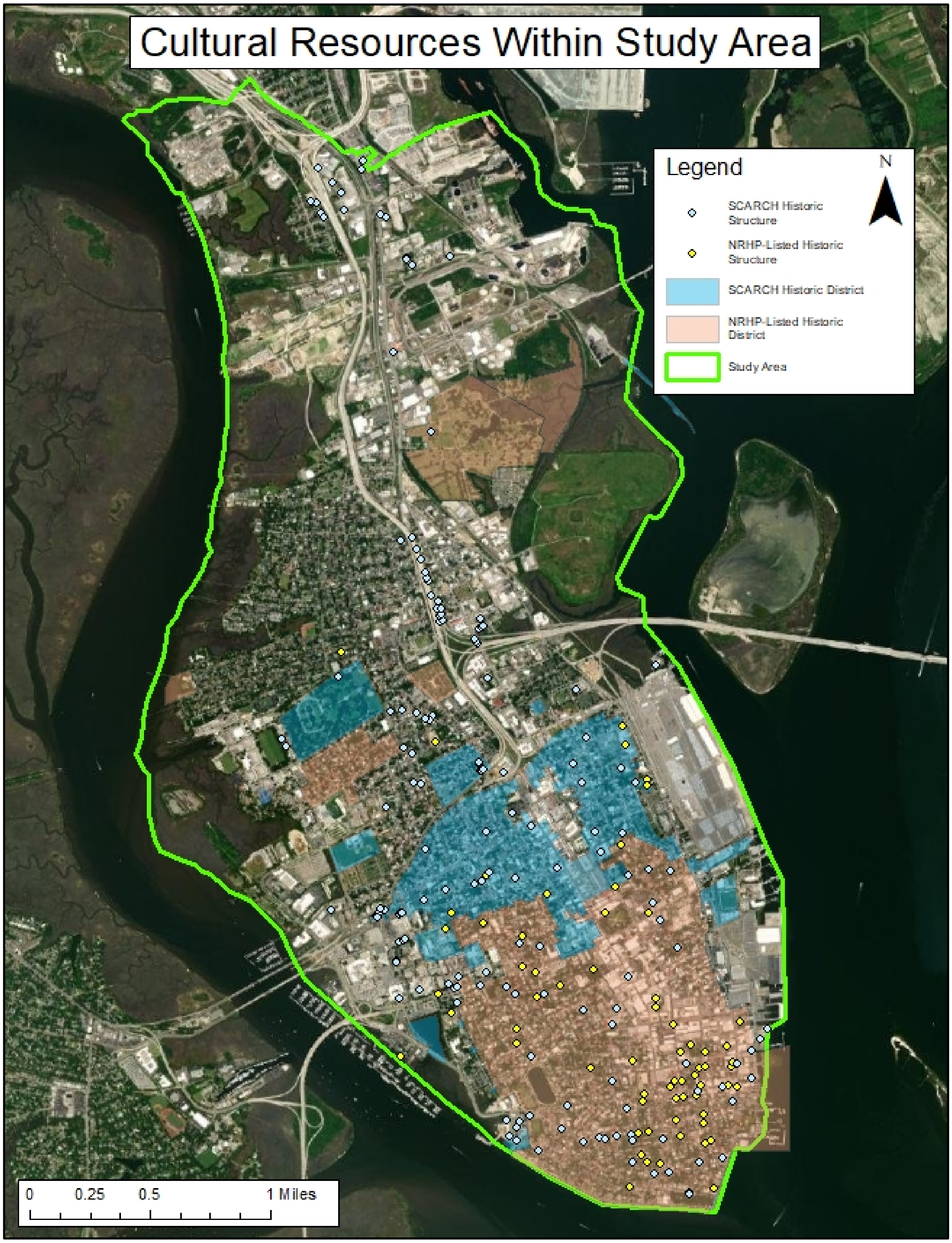

Figure 4-15. Cultural resources located on the peninsula within the Study Area. Archaeological sites are not depicted due to sensitivity of information.

Data source: SC ArchSite

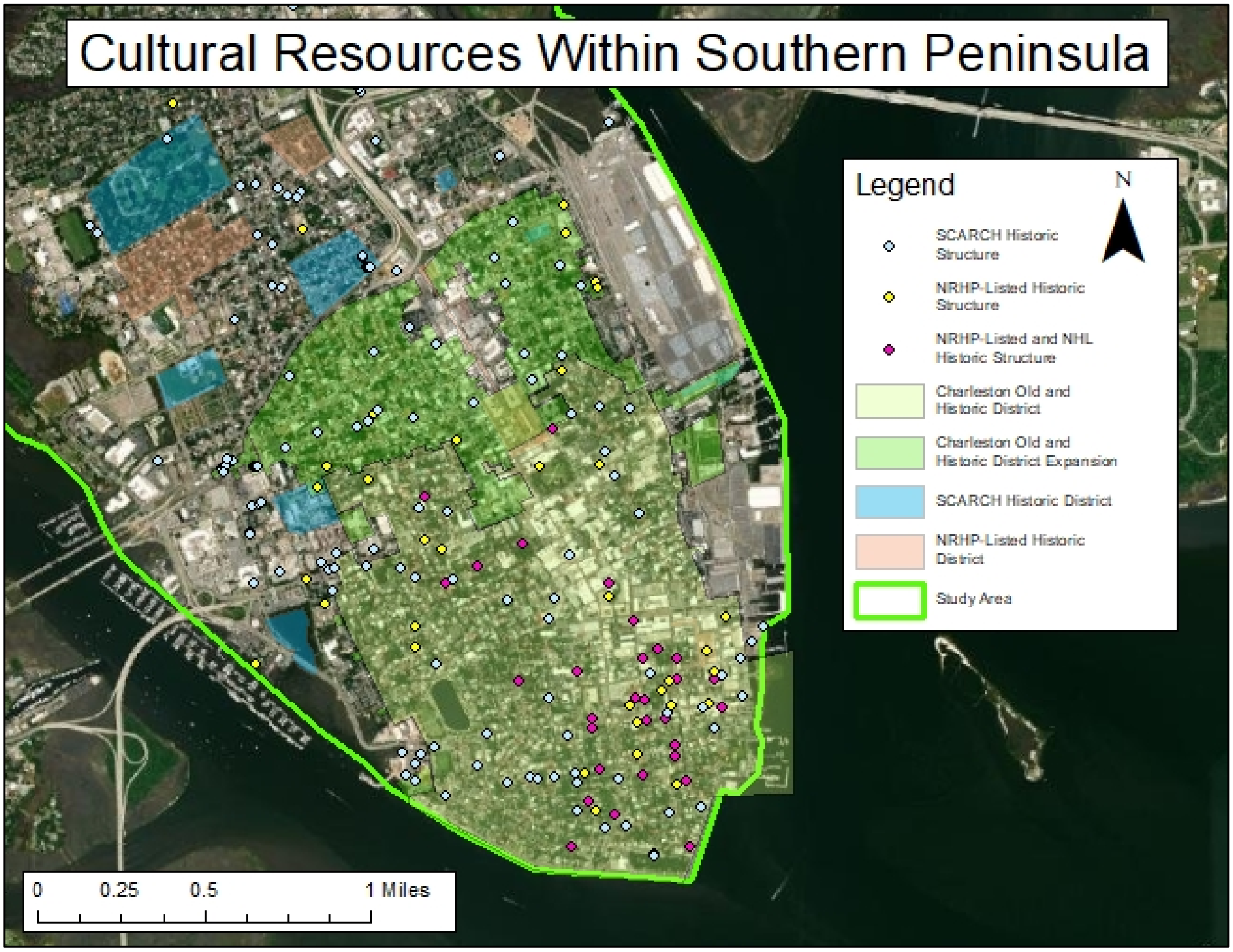

Figure 4-16. Southern portion of Study Area with a focus on the National Historic Landmark districts and structures

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 National Register 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.

One hundred twenty-five 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 has 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.

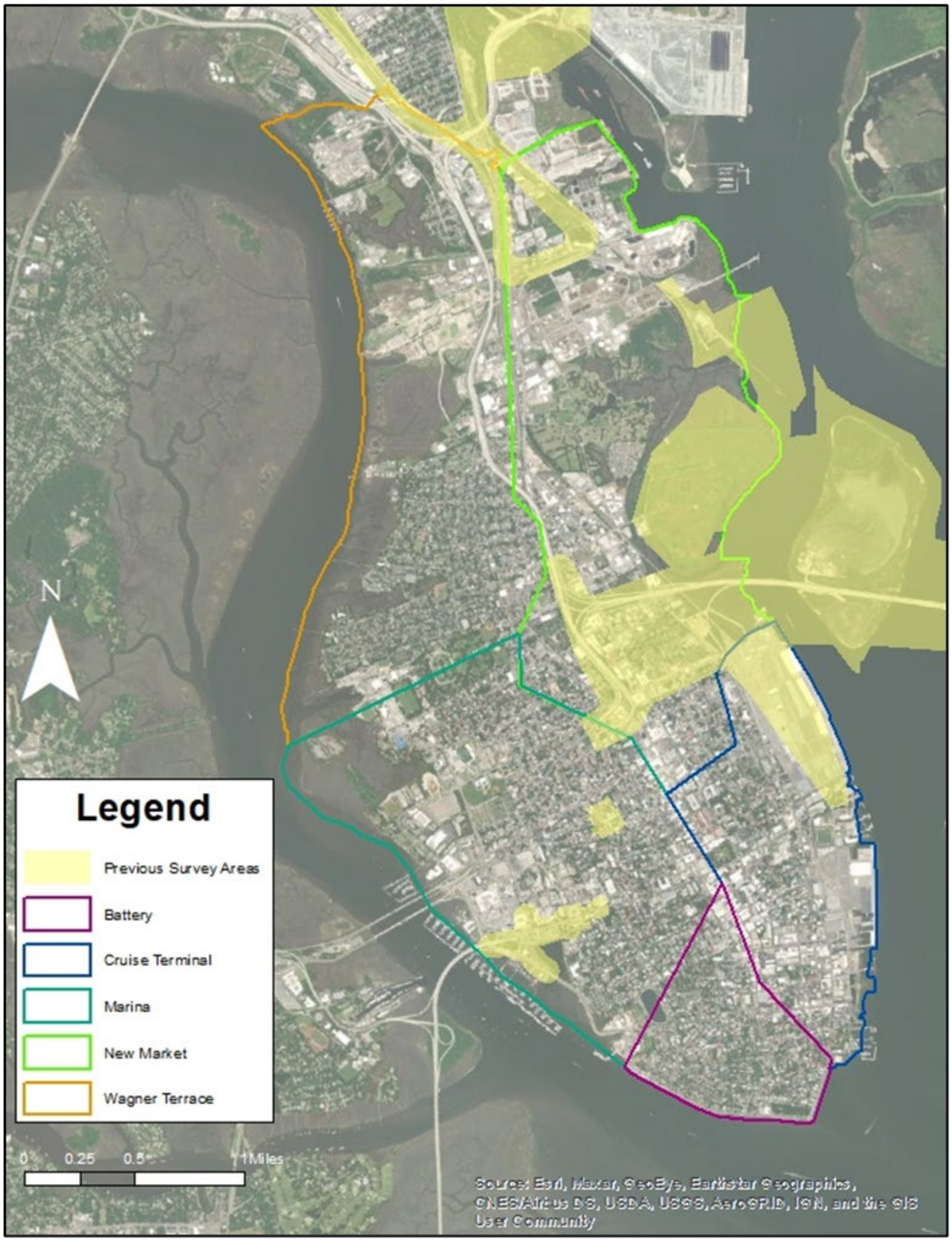

Figure 4-17. Archaeological survey areas in Study Area.

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 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 the 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.

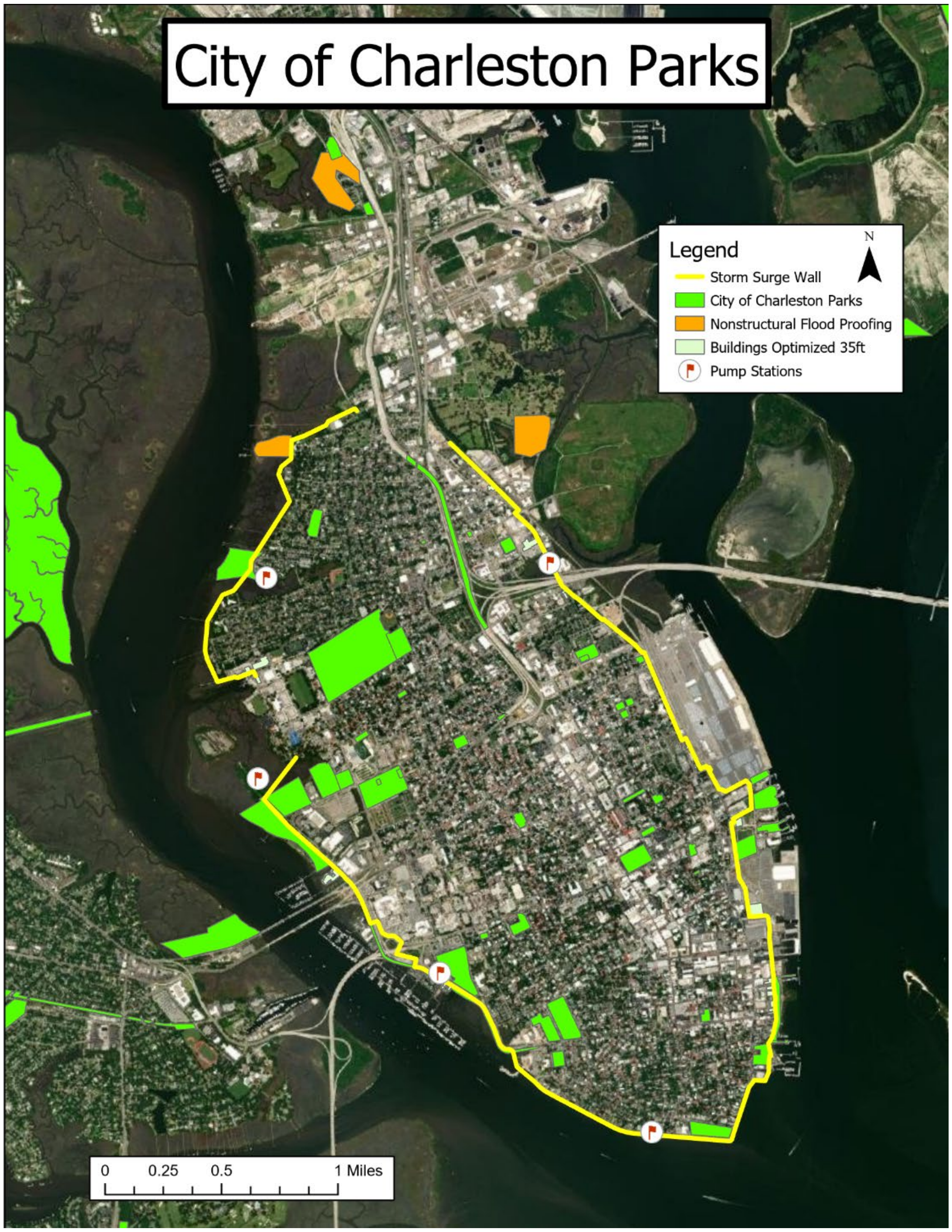

Figure 4-18. Map of parks on the Charleston Peninsula managed by the City of Charleston

Source: City of Charleston; 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 project 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

Water

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.

Landform

The Charleston Peninsula is a coastal landform.

Vegetation

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 project 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.

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). T 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 4-2.

Table 4-2. 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 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 stationery 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 55 dBA to protect the public from all adverse effects on health and welfare in residential areas.

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 (EPA 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 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 Wastes

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 U.S. Environmental Protection Agency (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 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 4-3 with their status for non-listing on the NPL.

Table 4-3. CERCLA Sites on the Charleston Peninsula That Are Not Listed on the NPL

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 ST AT END OF CALHOUN ST	Addressed as Part of Another non-NPL Site

	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 ST. CHARLESTON, SC 29405	Other Cleanup Activity: State-Lead Cleanup

(Source: USEPA)

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.

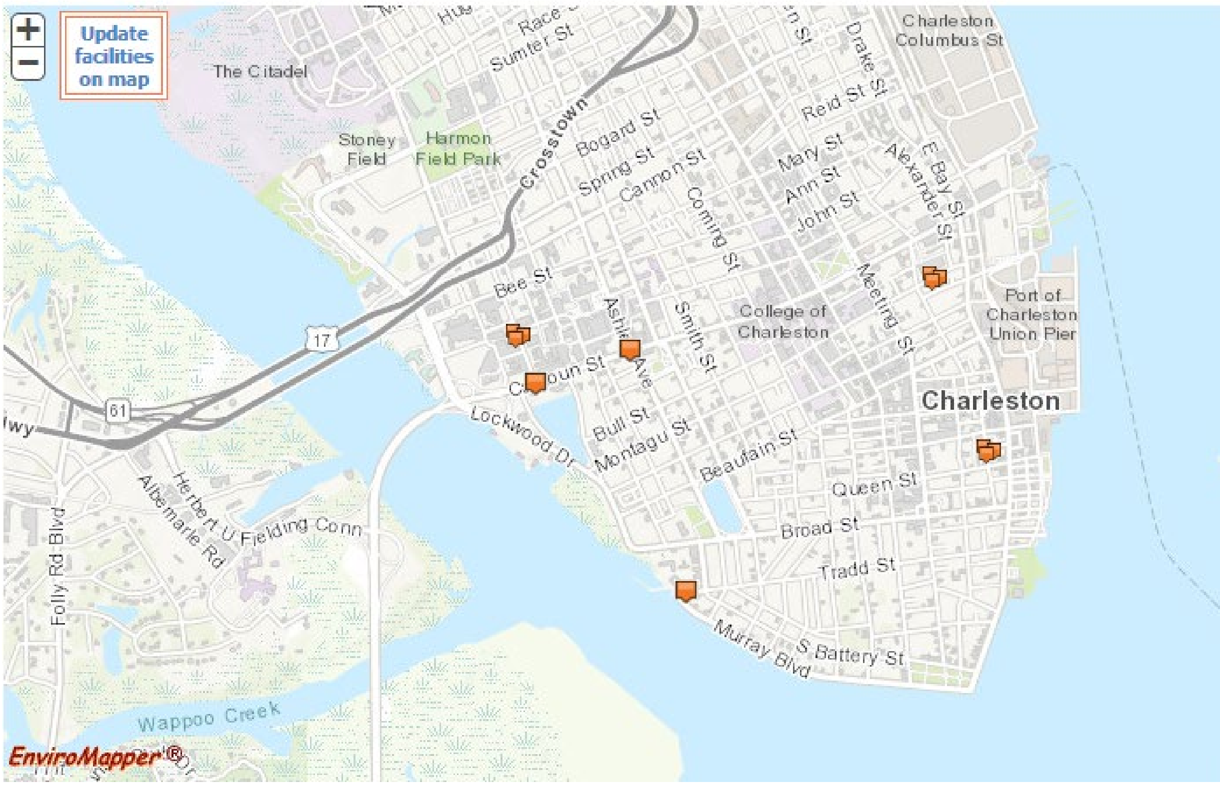

Figure 4-19. RCRA sites on the lower Charleston Peninsula

Source: USEPA

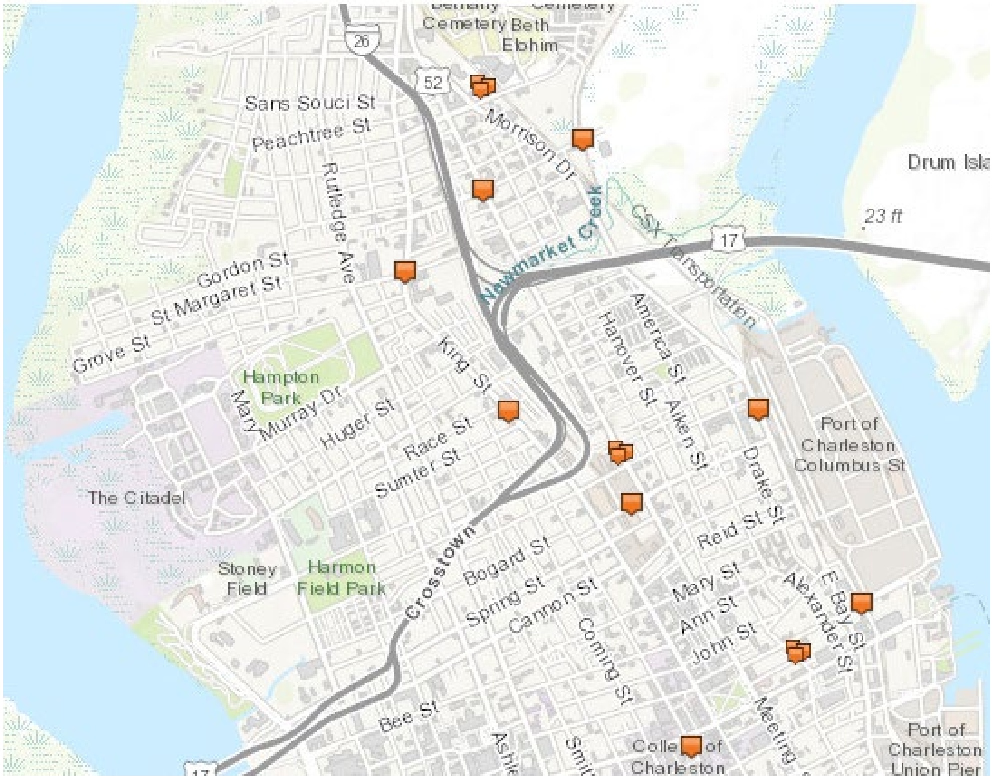

Figure 4-20. RCRA sites on the middle area of the Charleston Peninsula

Source: USEPA

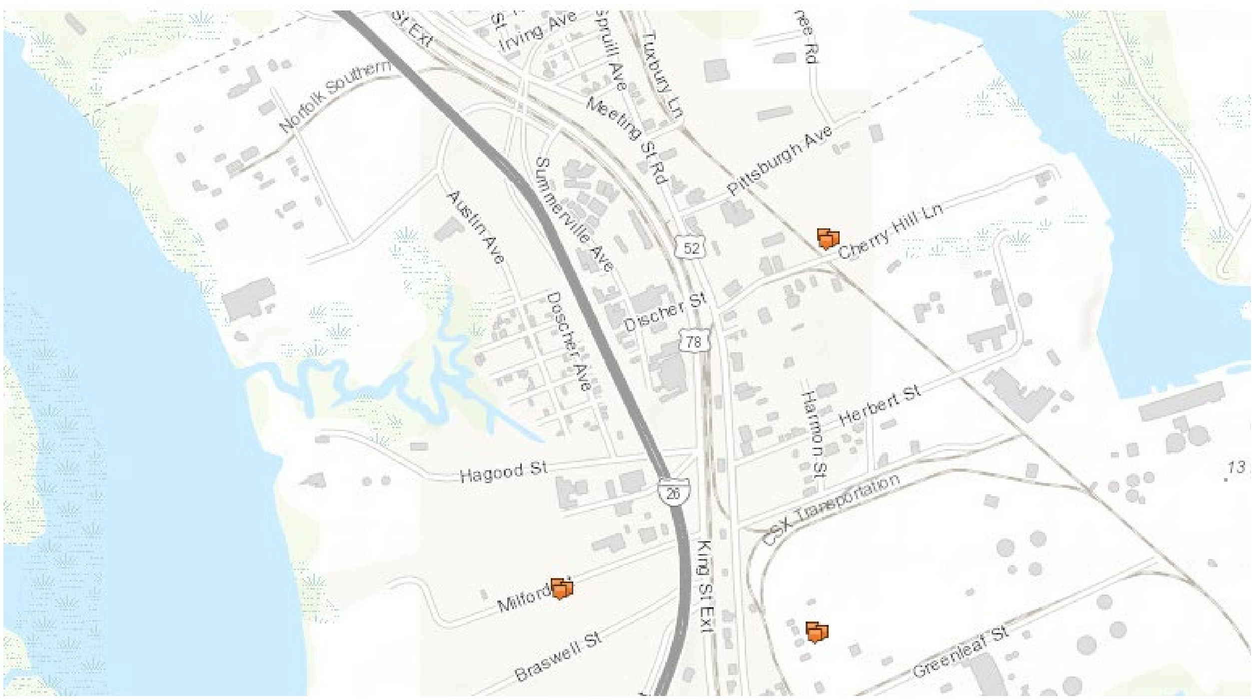

Figure 4-21. RCRA sites in the Charleston Neck area of the Peninsula

Source: USEPA

TRI

Two facilities in the study area have had toxic releases reported to the TRI in the last 10 years. They include Chevron located 1882 Milford St and the Lanxess Corp. located at 2151 King Street Extension. Both are in the Charleston Neck area of the Peninsula.

Solid Waste Facilities

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

Brownfields Sites

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.

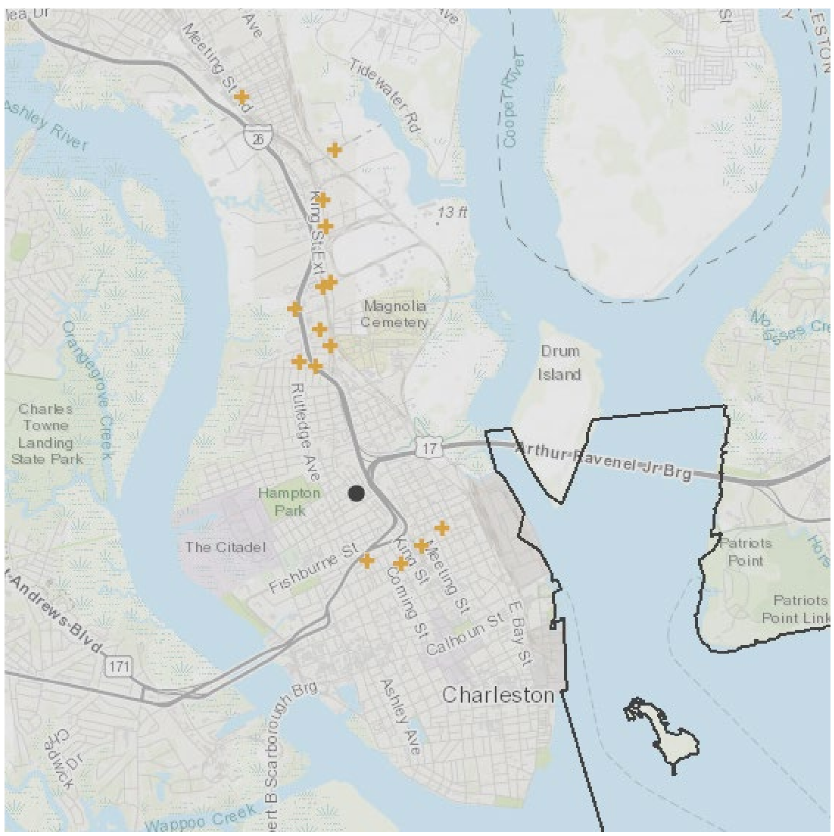

Figure 4-22. Brownfield Cleanup Sites in the study area are shown as gold "+" symbols

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 Columbia 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 begin taking action when the State and County Emergency Operations Centers are partial 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).

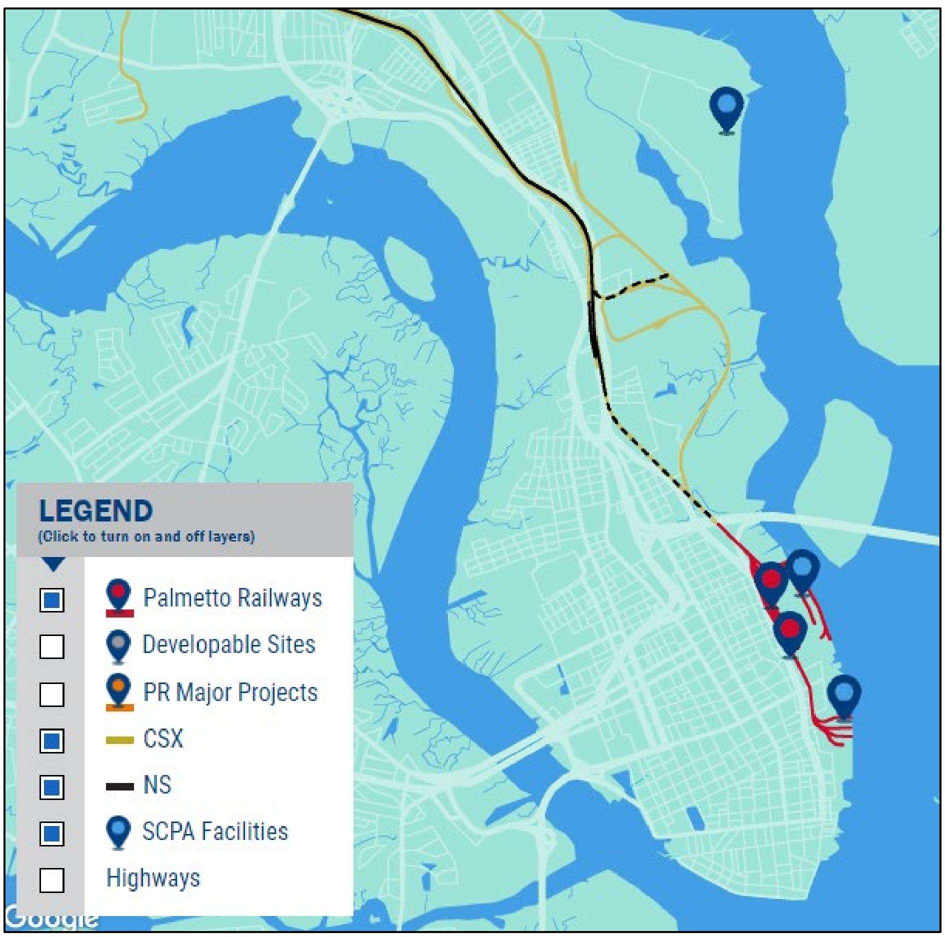

Figure 4-23.Locations of railways operated by Palmetto Railways, CSX, and Norfolk Southern on the Charleston Peninsula

Source: Palmetto Railways

In 2018, the City of Charleston updated their Citywide Transportation Plan 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 are 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.

<u>Electric and Gas</u>
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.

<u>Telecommunications</u>
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.

<u>Stormwater</u>
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:

- Market Street Drainage Improvement Project, Phase III in construction, 2018 (two previous phases have already been completed)
- US 17 Spring/Fishburne (Septima Clark) Drainage Improvement Project, Phase III and IV in construction, 2018 (two previous phases have been completed, and two more are planned after this one)
- Calhoun West/Beaufain Drainage Improvement Project, Preliminary Engineering Report completed in early 2020

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.

<u>Water and Wastewater</u>
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. Intense, heavy rainfall and tidal flooding that has 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 later 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 identifies 6.6 feet (MLLW) as a King Tide, equating to 3.46 feet (NAVD88). Some low-lying areas in the ROI will experience 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 of access is restricted. For example, surface streets including U.S. Route 17 already close during flood events, limiting movement on the peninsula. US Route 17 currently floods more than 10 times per year. In addition to the population of 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 experiences flooding 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 may plan to leave voluntarily or may be 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 flooding include Hurricane Hazel, a Category 4 storm that made landfall near Little River, S.C. in 1954 with 106-miles per hour winds and 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. 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. 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 coastal 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 4.5).

<u>Emergency Services:</u>

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, 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. Moreover, Executive Order 14008, Tackling the Climate Crisis at Home and Abroad, Section 219 directs federal agencies to deliver environmental justice to 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 expand 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.

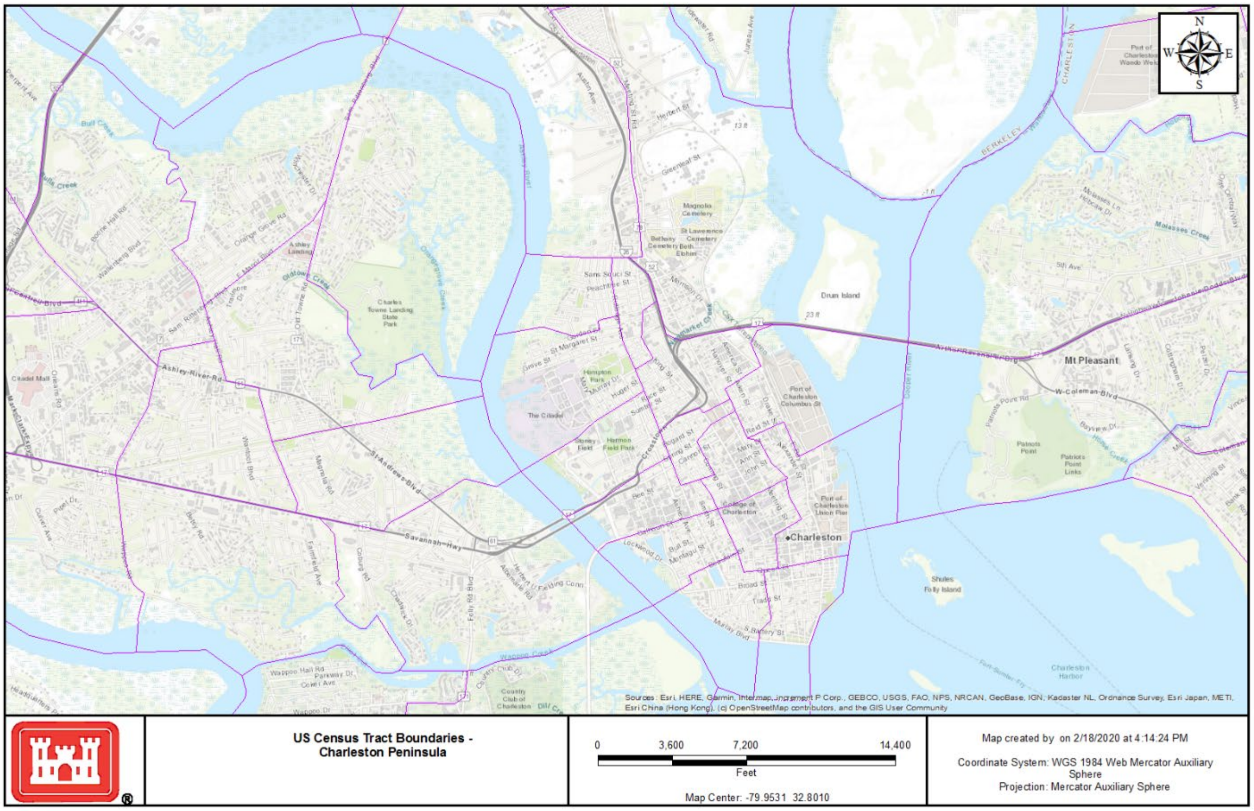

Figure 4-24. Map of US Census Tract boundaries (outlined in purple). There are 16 census tracts on the Charleston Peninsula that overlap with the study area

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 North Charleston Neck area lies to the north.

The USEPA's EJ Screen tool (https://www.epa.gov/ejscreen) was used to identify census communities that are susceptible to key environmental factors in the ROI, based on the 2010 census. The key environmental and demographic variables are presented in Table 4-4, keeping in mind that some of the census tracts represent areas that extend beyond the study area. 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. 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. The distribution of households below the poverty level in the census tracts of the study area is shown in Figure 4-25. A map showing the distribution of census tracts with percentiles of children under the age of five is shown in Figure 4-26.

Table 4-4. Environmental Exposure Indicators and Demographic Susceptibility Indicators for Study Area Census Blocks

Selected Variables	Value	State Avg.	%ile in State	EPA Region Avg.	%ile in EPA Region	USA Avg.	%ile in USA
Environmental Indicators							
Particulate Matter (PM 2.5 in µg/m³)	7.65	8.84	12	8.59	22	8.3	30
Ozone (ppb)	36.3	40.8	14	40	26	43	15
NATA* Diesel PM (µg/m³)	0.675	0.308	99	0.417	80-90th	0.479	80-90th
NATA* Cancer Risk (lifetime risk per million)	41	38	84	36	80-90th	32	80-90th
NATA* Respiratory Hazard Index	0.5	0.53	30	0.52	<50th	0.44	60-70th
Traffic Proximity and Volume (daily traffic count/distance to road)	1300	180	98	350	94	750	86
Lead Paint Indicator (% Pre-1960 Housing)	0.62	0.14	97	0.15	95	0.28	83
Superfund Proximity (site count/km distance)	0.47	0.092	97	0.083	97	0.13	94
RMP Proximity (facility count/km distance)	1.1	0.45	88	0.6	83	0.74	78
Hazardous Waste Proximity (facility count/km distance)	1.7	0.56	91	0.52	92	4	74
Wastewater Discharge Indicator (toxicity-weighted concentration/m distance)	0.18	0.24	95	0.45	95	14	91
Demographic Indicators							
Demographic Index	42%	37%	65	38%	63	36%	65
Minority Population	39%	36%	61	38%	58	39%	58
Low Income Population	45%	37%	66	37%	66	33%	73
Linguistically Isolated Population	1%	2%	65	3%	53	4%	47
Population With Less Than High School Education	9%	13%	42	13%	42	13%	49
Population Under 5 years of age	4%	6%	36	6%	36	6%	34
Population over 64 years of age	12%	16%	34	16%	37	15%	42

* 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.

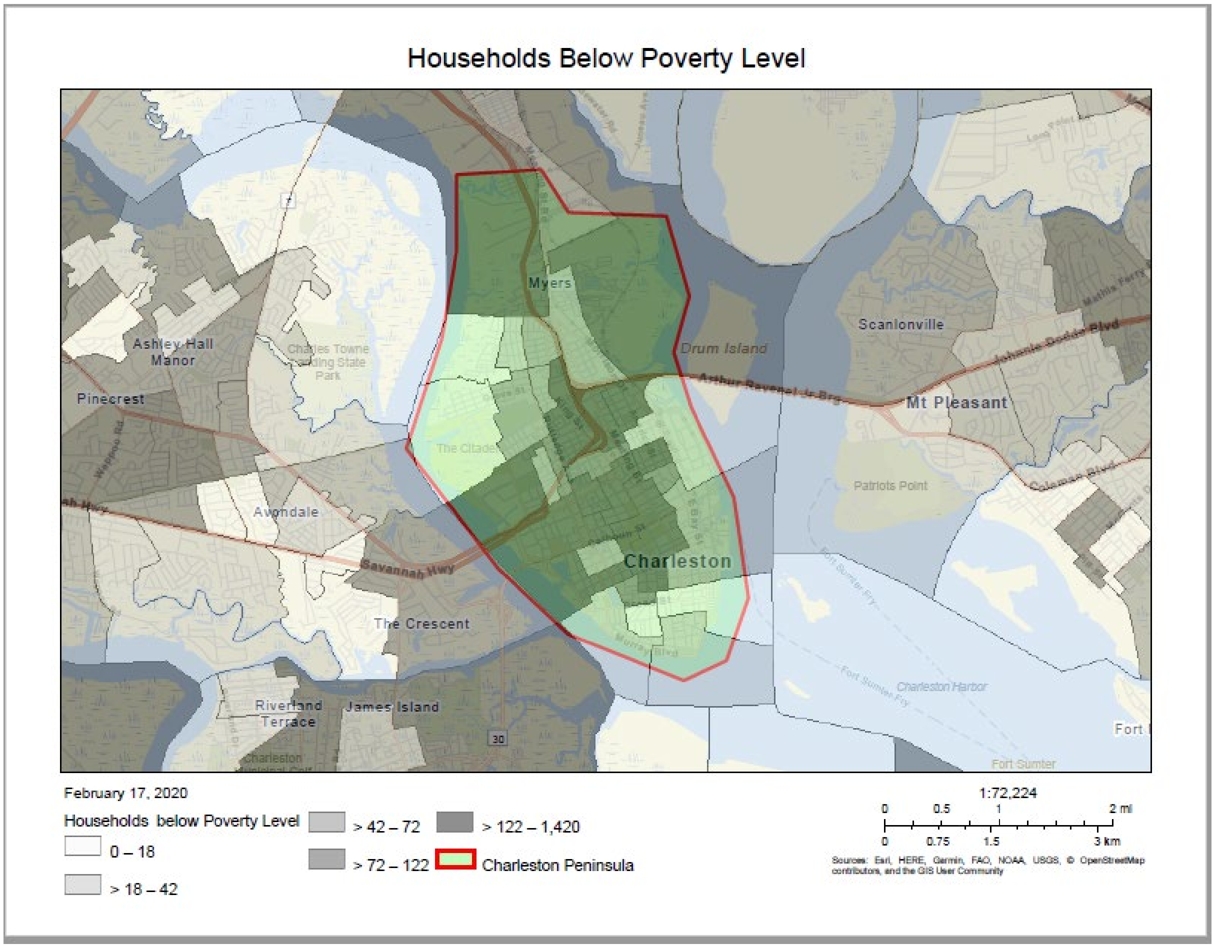

Figure 4-25. Map showing distribution of households below the poverty level (by census tract) in relation to the Charleston Peninsula

Source: USEPA

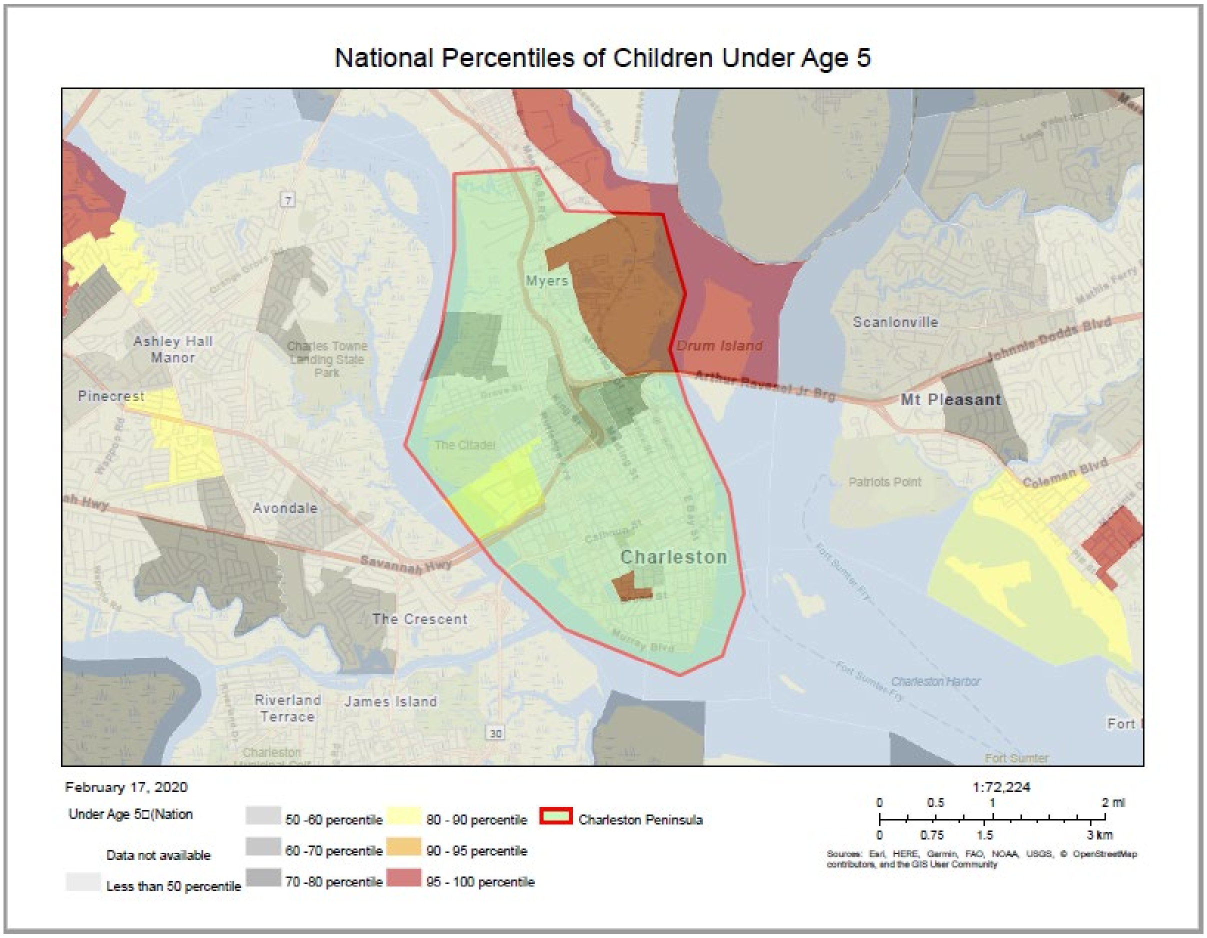

Figure 4-26. Map showing distribution of national percentiles of children under the age of five (by census tract) in relation to the Charleston Peninsula

Source: USEPA

The ROI does not contain disproportionate populations of minority, juvenile, elderly, or low-income communities when compared to the surrounding areas on the Census Track level. However, zooming down to the 2010 Census Block level data within the study area reveals the Rosemont Neighborhood and Bridgeview Village can be described as minority communities.

According to the 2010 Census, the Rosemont Neighborhood falls within Track 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 Track 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 Track 53 on Charleston Peninsula 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; non are available).

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.

The Department of the Army Engineering Regulation 1100-2-8162 (31 Dec 2013) requires that future Relative Sea Level Rise (RSLR) projections must be incorporated into the planning, engineering design, construction and operation of all civil works projects. 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 and 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 4-27). Details on the rates used and results of the sea level rise analysis conducted for this study can be found in Sub-Appendix B4 - Coastal.

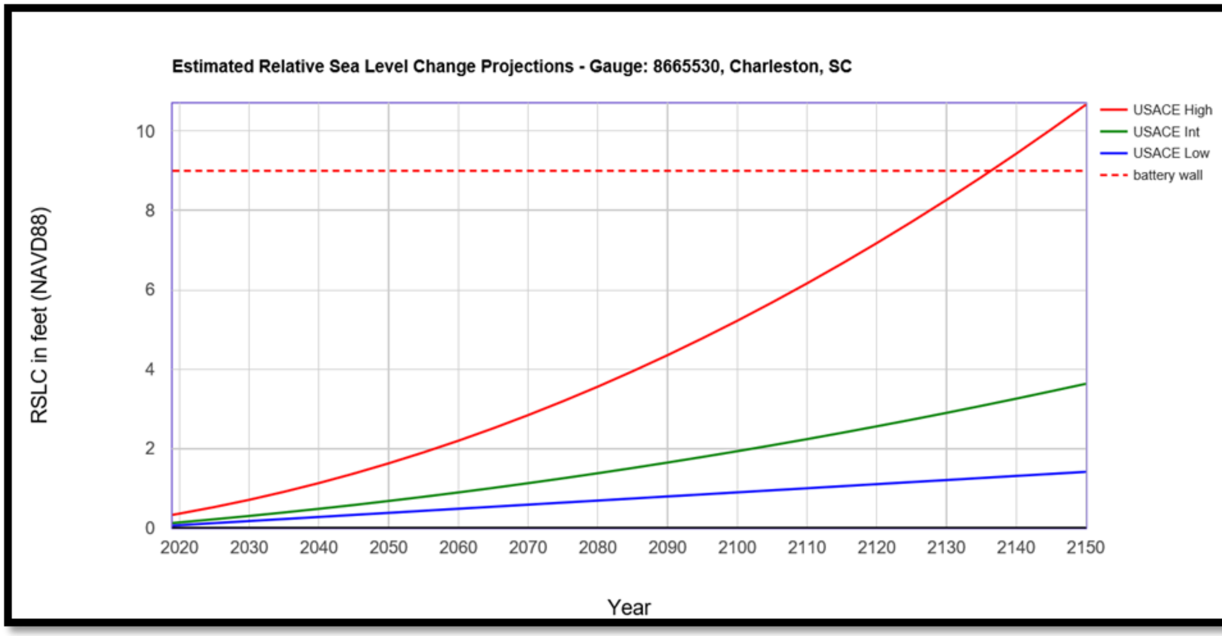

Figure 4-27. Estimated relative sea level change based on projected low, intermediate, and high rates at the Charleston Harbor gage

Source: USACE

For this feasibility study, the future condition for economic evaluation was performed using the intermediate rate of sea level rise for the 50-year project life ending in 2082 as 1.65 feet. The 100 year adaptation range for the project into the future (year 2132) would be 3.19 feet for the intermediate rate of RSLC.

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. 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 4-5 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 4-5. Climate Change Impacts, and Consequences as Identified by the SCDNR Climate Change Technical Working Group

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

(SCDNR, 2021)

Affected Environment

The effects of climate change are already being observed in the ROI with the increase in minor coastal 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. 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.

As relative sea level increases, it no longer takes a strong storm or a hurricane to cause coastal flooding. 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 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 many of the city's storm drainage pipelines.

This trend is expected into the future. According to the City of Charleston (2019), a significant increase is minor coastal flooding is expected in Charleston (and along the entire South Carolina Coast) for decades to come (see Figure 4-28).

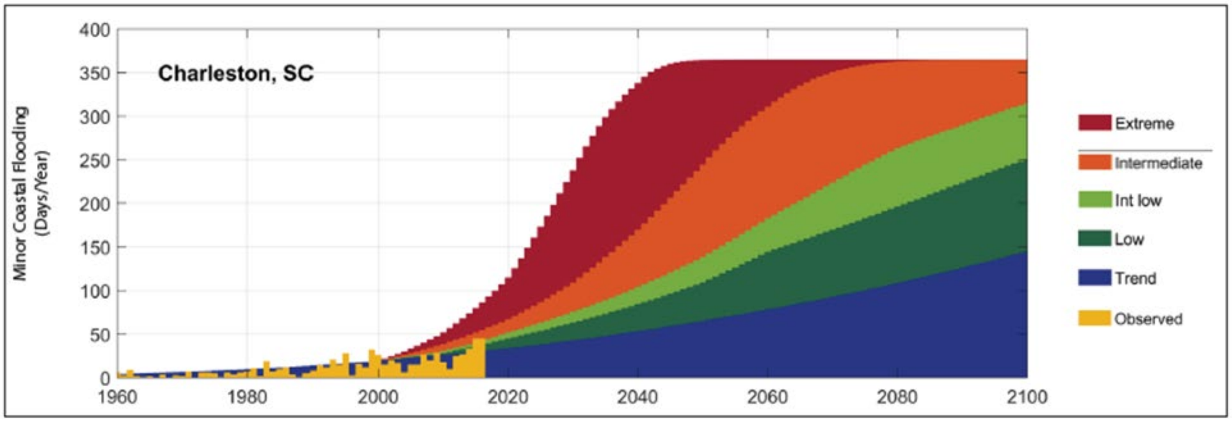

Figure 4-28. Observed and Predicted "minor coastal flooding" in Charleston, SC since 1960 through 2100

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.

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 becomes over inundated on extreme high tides and are unable to retain coastal waters, allowing them to spill over and flood local roadways (see Figure 4-29).

Figure 4-29. The perimeter saltmarsh between Lockwood Blvd and the U.S. Coast Guard at high tide during a storm in December 2019

Source: City of Charleston

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 contributed 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 storm events in the region will be more intense and more frequent compared to the recent past.

CHAPTER 5 - **Coordination and Public Involvement Process**

5.1 NEPA Public Involvement

5.1.1 Public Involvement on the Draft April 2020 FR/EA

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 people 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 followed:

- 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

One of the first steps in the NEPA process, particularly for an EIS, is to establish the scope of the project, and one component of accomplishing this step is the 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, press release and social media announced the scoping comment period and virtual meeting.

USACE received approximately 125 substantive comments during the scoping period. The scoping comments, generally, fell into several themes, as follows:

- Analysis of wetlands, ecosystem, visual, environmental justice, interior drainage, and climate change
- Potential design features such as natural and nature-based feature, and nonstructural
- Analysis of residual risk, meaning shifting the flooding from project area to somewhere else
- City planning

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 EIS, is mandated by Federal laws. For this study's FR/EIS, the public comment period will be open for 45 days. The purpose of this review is to seek input on the alternatives considered, effects of the alternatives, and associated mitigation. USACE will consider all substantive comments received during the comment period. The complete list of comments received on the draft FR/EIS and responses will be included as an appendix to the Final FR/EIS. USACE will host one public meeting during the public comment period. In addition to accepting comments during the public meeting, comments will be accepted via mail or electronic comment form on the study's website.

As mentioned above, USACE considered all substantive public comments received on the draft April 2020 FR/EA in USACE's decision to move from an EA to an EIS, as part of the scoping process for the FR/EIS (including with regard to potential alternatives and impacts of the proposed action), and in developing the content of the draft FR/EIS. Any person desiring to provide public comment on this draft FR/EIS should submit their comment on the draft FR/EIS within the 45-day comment period, and not rely on or reference previous input or public comment on the draft April 2020 FR/EA. Only public comments submitted and received within the 45-day comment period on the draft FR/EIS will be considered in the agency's NEPA analysis and development of the final FR/EIS including the response to public comment appendix.

5.1.4 Response to Public Comments on the Draft FR/EIS

Only comments received on the draft FR/EIS during the public comment period will be considered and incorporated into the final FR/EIS as appropriate. Comments and responses to comments on the draft report will be summarized in the final report.

5.2 Other Public Involvement

The Project Delivery Team (PDT) 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 PDT 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 CEO's 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 PDT 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 PDT has also met with the Dutch Dialogues, CSX Railroad, South Carolina State Port Authority, the South Carolina Department of Transportation, Charleston Medical District, and the Citadel Military College to discuss the project.

On July 23, 2021, members of the PDT met at the Rosemont Community Center 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

5.3 Institutional Involvement

5.3.1 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 PDT 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 occur 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

5.3.2 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 FR/EIS by providing information, and reviewing draft documents. The cooperating agencies are as listed:

- 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

5.4 Agency and Public Coordination of Cultural Resources 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 only the No Action Alternative and Action Alternative 2 (perimeter structure + nonstructural + NNBF).

Since the No Action Alternative is what the future conditions would be like if an action alternative is not implemented, it is often referred to as the Future Without Project condition. 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 or NNBFs, 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 7.1 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 73 gates) and 10 storm surge gates in the form of sluice gates to allow for tidal exchange at creeks that intersect with the proposed wall.

Alternative 2 also includes nonstructural measures in the form of elevating or flood proofing approximately 100 structures in the study area outside of the wall, and approximately 9,300 linear feet of reef-based living shoreline sills as a NNBF.

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 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, 2019) 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 plans to raise the current Low Battery seawall to a 9ft NAVD88 elevation, which would provide additional 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 already at risk of storm surge damages because there are no 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 + NNBF)

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 Dialogs. Most land uses on the Charleston Peninsula would experience a beneficial effect from reduced storm surge damages 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 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. USACE is continuing to examine the feasibility of constructing the wall in certain locations on the peninsula, so the specific properties that may be affected are not known at this time and the wall alignment would be further refined during the design phase. 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. As mentioned above the specific properties are not known at this time.

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.

Non-structural measures would have no effect on the underlying land use, with the exception of locations where relocation of buyouts is determined to be the most feasible non-structural option.

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

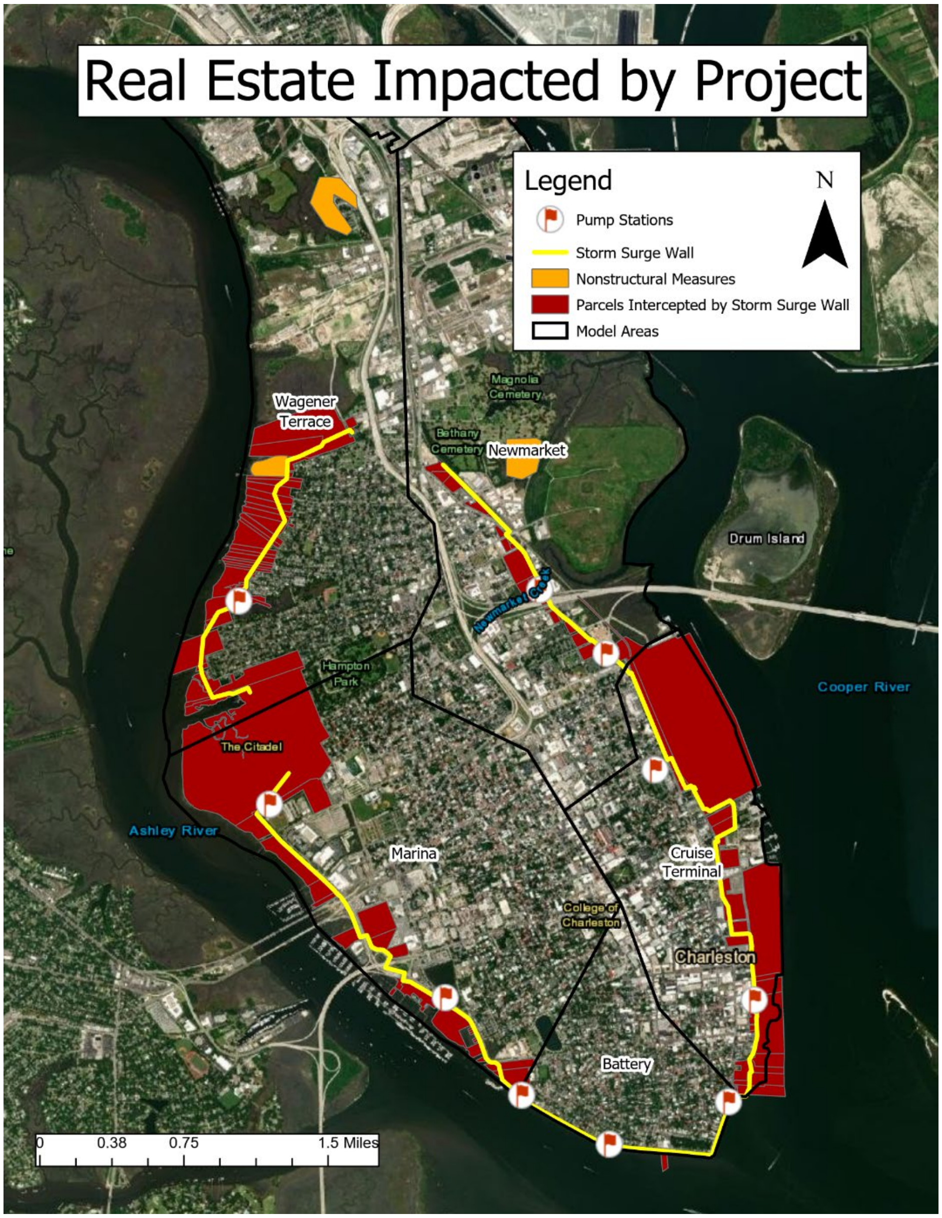

Figure 6-1. Map showing real estate potentially impacted by the current conceptual footprint of the storm surge wall and construction buffer

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 are expected to continue with low erosion occurring in many locations, and with high erosion in some locations around the Charleston Peninsula, unless management measures are put into place to slow the 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, 2019) to guide development decisions that support adaptation to shallow coastal 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.

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 + NNBF)

<u>Construction-Related Effects</u>
Construction of the storm surge wall and associated gates 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 contaminated site of potential concern that is registered with EPA and in close proximity to the planned location of the storm surge wall (Calhoun Park/Concord Street; see Hazardous Waste section). To further evaluate this, a Phase I soil/sediment chemical analysis may be performed during the PED phase. A Phase II analysis may also be conducted. Depending on the results of the analyses, remedial action could be taken or the wall could be relocated.

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.

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. 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 projects. Nonstructural and NNBF measures in this alternative would have no effect on the subsurface geology.

Erosion and Scouring Effects

The living shorelines proposed in Alternative 2 would have a beneficial effect on shoreline erosion in those locations. Living shorelines sills, like those proposed in this study and are commonly practiced in South Carolina, reduce wave energy and trap sediments behind the sill. This may result in sediment accretion and an expansion of marsh vegetation from the shoreline to the sill (SCDNR 2019), having a permanent, long term beneficial effect on shoreline stabilization and reduced erosion compared to the No Action Alternative.

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 may 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 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). It would be reasonable to expect that the proposed storm surge wall in the marsh would induce scouring similar to seawalls that have been studied.

However, the living shorelines that would be implemented as part of this Alternative along the edge of the marsh in front of portions of the wall would minimize the scouring effect. As described above, the living shoreline sills would stabilize the shoreline from erosion, trap sediments, and build up the overall resilience of the marsh, which would help offset the effects of scouring in the marsh. Scouring effects from overtopping of the wall would also be minimal. Based on the overtopping assessment performed as part of the Life Safety Risk Assessment (see

Appendix B - Engineering), reinforcement at the toe of the wall with additional structures or features, such as rip rap, was not determined to be needed.

Living shorelines would have a direct beneficial effect on erosion, while also minimizing impacts on erosion (scouring) from the storm surge so that adverse effects would be minimal. Nonstructural measures in the is alternative would have no effect on erosion.

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 into the future 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 an 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 has 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. Areas 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. They are also expected to occur not only on the Charleston Peninsula, but can reasonably be expected to occur in communities that surround the Peninsula in the ROI, including North Charleston, West Ashley, James Island, and Mount Pleasant.

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, 2019) 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, it is assumed that the City of Charleston would still raise the current Low Battery seawall to a 9ft elevation NAVD88, which would provide some reduction in storm surge impacts in the Battery area compared to current conditions, 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 Phase III Market Street Drainage Improvement Project, Phase III 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). It is also assumed that the City of Charleston would complete installation of check valves on existing stormwater outfalls. 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, structural damages and economic loss caused by flooding, and to shoreline erosion across the study area. Storm surge would also continue to contribute to compound flooding, even with City's improvements to stormwater management.

6.3.2 Alternative 2 (perimeter structure + nonstructural + NNBF)

<u>Effects on Waters Levels Inside the Study Area</u>
With respect to rainfall flooding and management of stormwater 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.

The storm surge wall as proposed in Alternative 2 does have the potential to adversely affect rainfall flooding within the study area. 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. 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 Sub-Appendix B3 – Hydraulics, Hydrology, and Coastal). Changes in interior water levels when the wall was present with its gates closed were different enough in some locations to potentially induce additional flood damages to nearby structures than without the wall.

To mitigate for interior flooding induced by the wall during storm events 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 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 at that location.

The results indicated that at ten different locations around the study area, hydraulic pumps would be needed to mitigate for interior flooding 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 collects, 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. 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)
- Behind Joe Riley Stadium (marsh side) (3 pumps @ 30 cfs)
- By Alberta Long Lake (3 pumps @ 20 cfs)
- Next to the US Coast Guard Station (Tradd Street side) (3 pumps @ 20 cfs)
- By New Market Creek (3 pumps @ 30 cfs)

The other five pump locations would each need 20 cfs of pumping capacity, which is considered small, 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 create. 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.

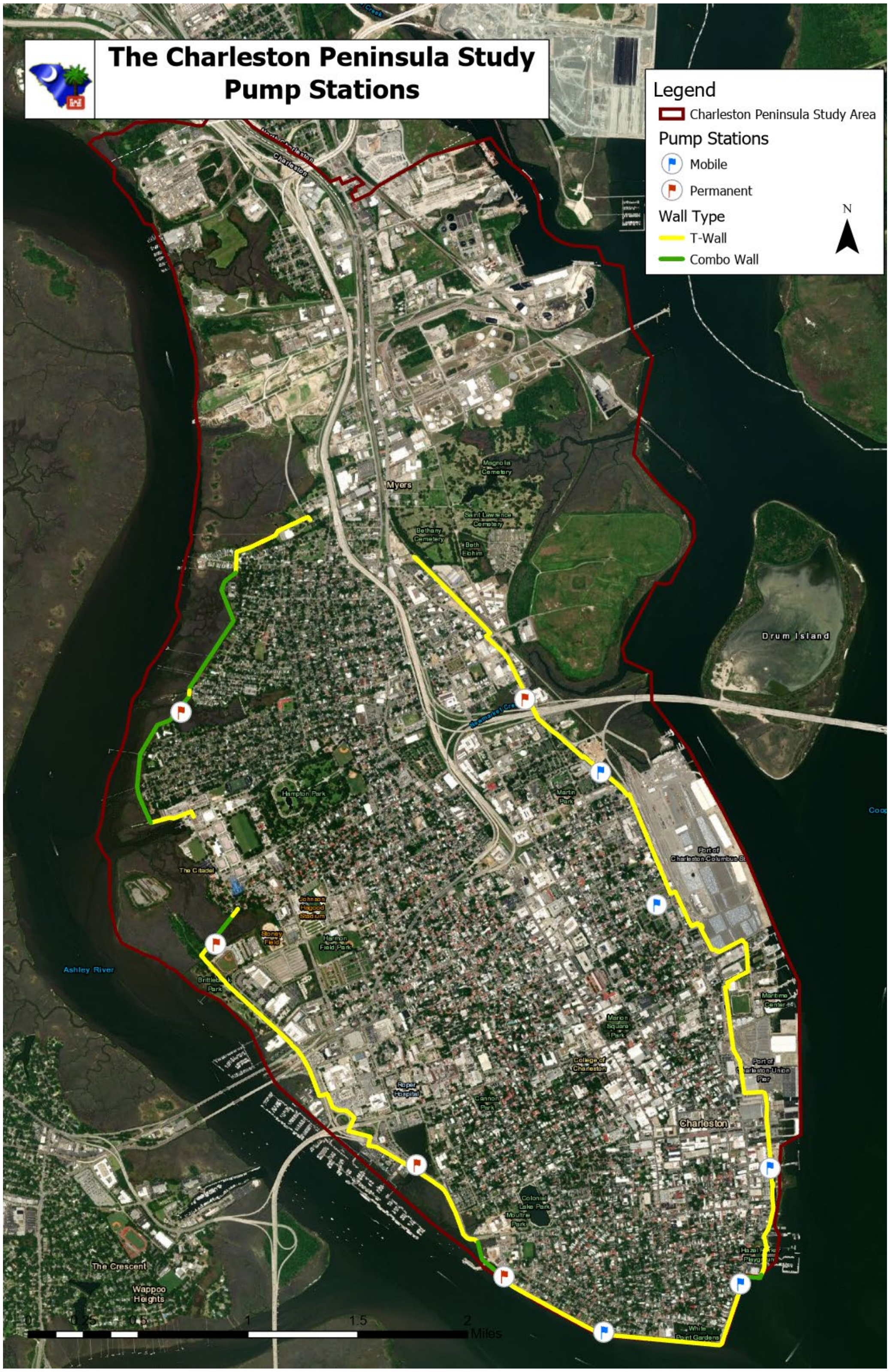

Figure 6-2. Approximate locations of proposed permanent and temporary pump stations

The proposed pumps are sized based on modeling of rainfall for storm events to ensure there is adequate capacity to handle the projected flow. However, the modeling and analysis was based on assumptions about numbers and locations of storm gates and assumptions about when these gates would be opened and closed. These assumptions were made early in the feasibility study due to the extensive time it takes to run the models and analyze outputs. 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 it is a 2-dimensional model that does not account for the subsurface, 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. Additional consideration of the City's subsurface network in the PED phase would help to refine uncertainty in the current model and may suggest that less pumping capacity is needed.

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 a height of 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 that are currently below a ground elevation of 12 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. The Life Safety Risk Assessment conducted for this study also confirms that the wall and nonstructural measures would be effective at reasonably reducing risks to life safety from storm surge flooding up to 12 ft. NAVD88, which would be a significantly beneficial effect of Alternative 2.

<u>Effects on Water Levels Outside of the Study Area</u>
As described in Chapter 4, 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 already being 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, causing them to dissipate within a few wavelengths. Scattering is due to directional/frequency spread of the short-period waves, irregularities in the wall, near-wall bathymetry, adverse wind (wind from the coastal storm blowing against the reflected waves), and complex bathymetry of the far-field (river channels/nearshore).

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.

<u>Effects on Creek Hydrodynamics</u>

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)

Since permanent effects to salt marshes are reasonably expected to occur at the base of the storm surge wall from altered hydrodynamics, the effects to the marsh would be offset through compensatory mitigation of a 25 foot buffer area on both sides of the wall. Compensatory mitigation of salt marsh is described in more detail in Section 6.6 and in the Draft Mitigation in Appendix F - Environmental. As discussed in Section 6.2, Geology and Soils, effects of the wall at the marsh edge from the altered hydrodynamics would be minimized by the proposed living shorelines that are part of this alternative.

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 interesting 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. For this feasibility study, 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. The tidal range is approximately 0.5 ft at low tide to 6 ft at high tide (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 five creeks where gates would be placed at existing tidal restrictions (culverts) at Gadsen Creek, the channel behind Joe Riley Baseball Stadium, Alberta Long Lake, Cummings Creek, and New Market Creek. During the duration of gate closure, there would be a temporarily 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 in this alternative 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 in Alternative 2 involve extraction or withdrawals of groundwater, which would require a permit since the Charleston area is designated a Capacity Use Area. 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 levels are relatively shallow within the Charleston Peninsula and fluctuate 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. Since the groundwater table on the peninsula is relatively shallow, it would likely require some dewatering during construction of the T-wall foundations, and steel and concrete elements would need to consider this in respect to corrosion. Any potential effects of Alternative 2 on groundwater would be negligible.

Nonstructural measures in this alternative would have no effect on hydrology or hydraulics in the ROI.

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. It is also expected that the City's various drainage improvement projects and associated pumping stations, along with various other interior flooding and stormwater management projects, would be completed and minimize further degradation of water quality around the peninsula.

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 is too much 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). Additionally, 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. Generally hypoxic conditions from storms are short term, and water quality conditions return to normal following storms.

6.4.2 Alternative 2 (perimeter structure + nonstructural + NNBF)

Under Alternative 2, the City of Charleston's initiatives mentioned in the No Action Alternative above are assumed to occur and water quality impacts from climate change are still expected to occur. Potential adverse effects of Alternative 2 on local water quality could range from temporary to permanent, but would be localized. With best management practices (BMPs) to protect water quality and implementation of minimization measures, some effects would be minor, but temporary adverse effects on water quality could still occur.

Construction Related Effects

Construction of the storm surge wall 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.

Tidal Restriction Effects

There is the potential for localized water quality to be adversely affected within salt marsh wetlands behind where the storm surge gates 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 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 surge 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. In a study of water control structures in estuaries 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). Since 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 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. To offset those impacts, 90% of loss of essential fish habitat function would be mitigated for through wetland compensation. This is described in Section 6.6 and in the Draft Mitigation Plan in Appendix F - Environmental.

The storm surge gates that are a feature of the perimeter structure in Alternative 2, are themselves also water control structures. In addition to the sluice gates that would be included in the wall where it intersects with Halsey Creek (described above), sluice 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. The locations of the storm surge gates are shown in Figure 6-3 and include:

- culvert at the channel behind Joe Riley Stadium from the Citadel marsh
- culvert at Gadsen Creek under Lockwood Blvd
- culvert at Alberta Long Lake under Lockwood Blvd
- culvert at Cummings Creek under Lockwood Blvd
- culvert at New Market Creek under Morrison Drive

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

While the sluice gates would be open at all times to avoid effects on daily tidal flow and existing water quality at those culvert locations (impacts at Halsey Creek already described above), all of the sluice 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. 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 significance 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).

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. Real-time local water level and other meteorological information from the National Weather Service's Charleston Weather Forecast Office would also be used to inform decisions about gate timing. Gate closure/opening protocols would be developed during the PED phase and would be binding in the Project Partnership Agreement and Operation and Maintenance manual between USACE and the City of Charleston.

While the adverse effects on water quality from closing of the storm surge gates would be temporary and minimized, they still have the potential to be of concern in some locations.

<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. The living shoreline 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.

The primary purpose of the hydraulic pumps that would operate temporarily during a storm surge event as described in Section 6.3, would be to minimize rainfall and stormwater flooding impacts on the interior of the wall. The five proposed temporary pump stations would collect street-level stormwater that "ponds" because of the wall and 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 with 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 marshes. 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 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 could be installed if required. 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 the 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 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 HMGP FMA 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 wide-spread across the study area. It is also assumed that the Low Battery seawall would be at a 9ft elevation NAVD88 in the future, which would provide additional reduction in storm surge damages in the Battery area where the seawall had previously been effective up to 7 ft of storm surge. Many homes and businesses across the rest of the Peninsula (not in the Battery) would remain at risk to storm surge impacts that are not addressed by city initiatives. Under the No Action Alternative, it is expected that these people 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 an intermediate rate of sea level rise, it is estimated that in the year 2075, 50% of police stations, 42% of health care facilities, and 29% of fire stations on the peninsula would be flooded by 9 feet NAVD88 (which is the height of the current Battery seawalls) of water during a 4% ACE 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 (NCA4). Future projected yearly damages from coastal storms (with forecasted sea level rise) without a Federal project are expected to reach as much as $773 million in the study area (see the Appendix C - Economics).

6.5.2 Alternative 2 (perimeter structure + nonstructural + NNBF)

Interior Flooding Effects

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 interior 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 interior flooding, but that would be mitigated by the use of hydraulic pumps, and not considered significant.

Coastal Flooding Effects and Implications for Floodplain Management

With implementation of the structural, nonstructural, and NNBF measures in Alternative 2, 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 202(c) of the Water Resources Development Act 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 right-of-ways, engineering and design, implementation of conservation measures, etc. However, the benefits of flood reduction on life safety 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. NNBFs in this alternative would have no effect.

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 salt water 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 are currently limited to inland migration by 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 current Peninsula salt marshes along the Ashley River (see Figures 6-4 through 6-6). Figure 6-4 shows the baseline wetlands (primarily salt marshes in dark purple) in the ROI as of 2000. Figure 6-5 shows the wetland distribution in 2050 using an intermediate sea level rise rate, and assuming a moderate rate of accretion may occur, which is conservative. The tool shows that salt marshes along Lockwood Blvd would convert to unconsolidated shoreline (mudflats), as well as in areas of Halsey Creek and along the shorelines of the Ashley River near the Wagener Terrace area in just 30 years from now. Figure 6-6 shows the wetland distribution in 2080 using an intermediate sea level rise rate, and assuming a moderate rate of accretion would occur. The tool shows that the current salt marshes along Lockwood Blvd would be completely lost to open water, and greater areas of salt marsh along Halsey Creek and the Wagener Terrace area would be converted to unconsolidated shoreline (mudflats). Note that in 2050 and 2080 there is very little transitional change occurring within these salt marsh wetlands to brackish marsh, but rather they are shown to be completely lost. However, it is assumed under this alternative that the City of Charleston would use their Sea Level Strategy (City of Charleston, 2019) 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.

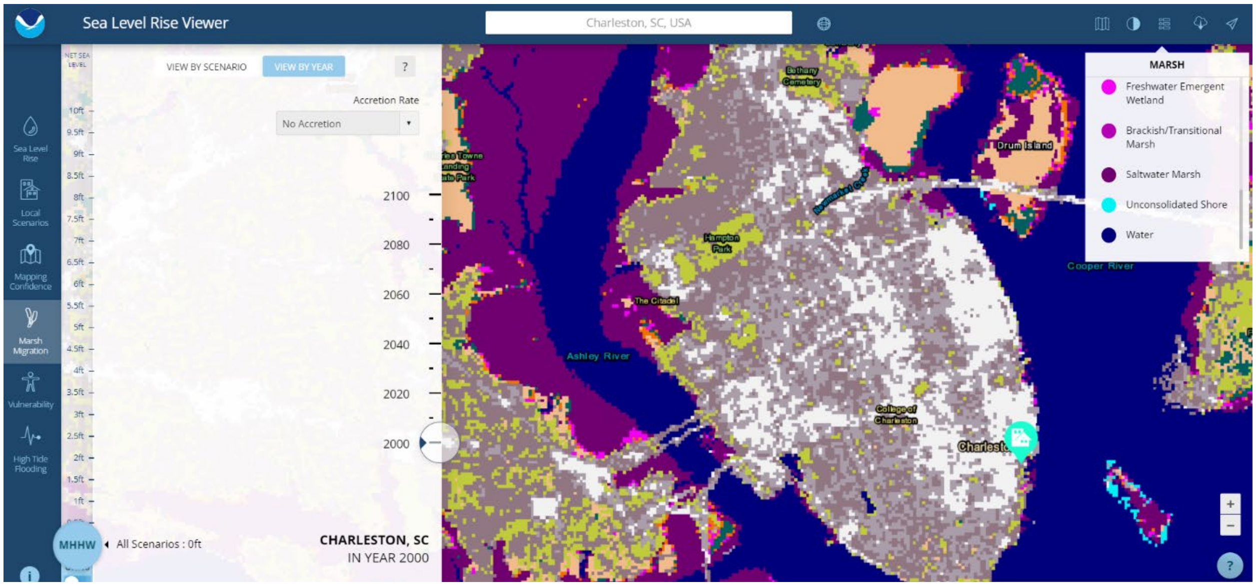

Figure 6-4. Distribution of coastal wetlands in the year 2000 in the Charleston Peninsula area

Source: NOAA Sea Level Rise Viewer.

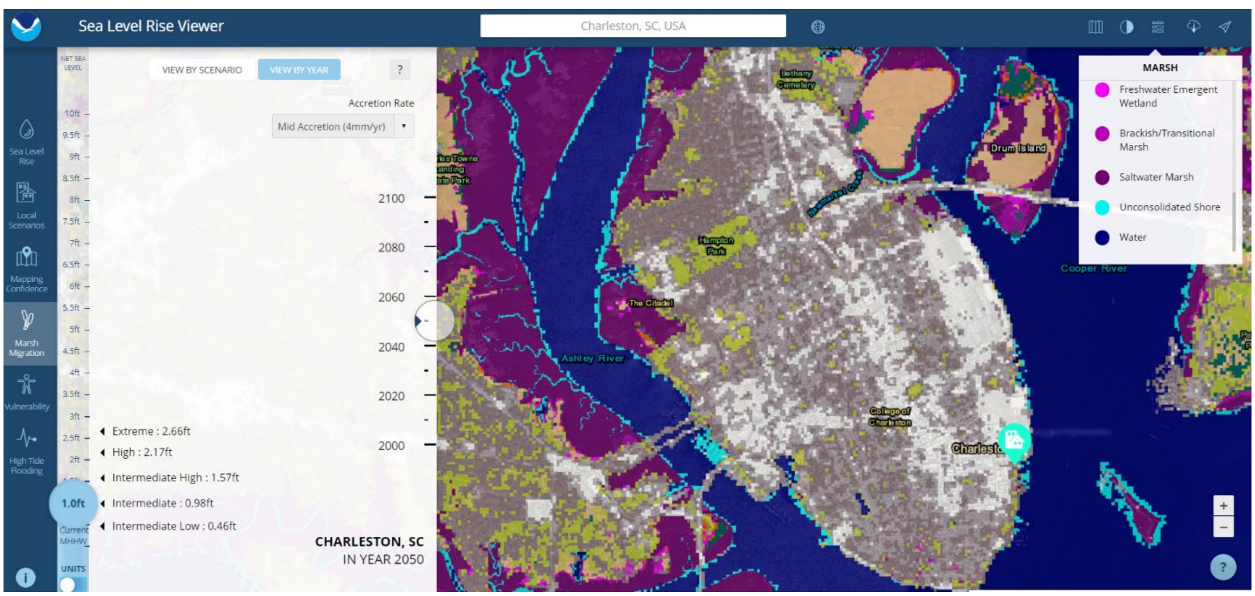

Figure 6-5. Predicted distribution of coastal wetlands in the Charleston Peninsula area in year 2050, based on a moderate rate of sea level rise (approximately 1 foot) and a moderate rate of sediment accretion of 4 mm/yr

Source: NOAA Sea Level Rise Viewer.

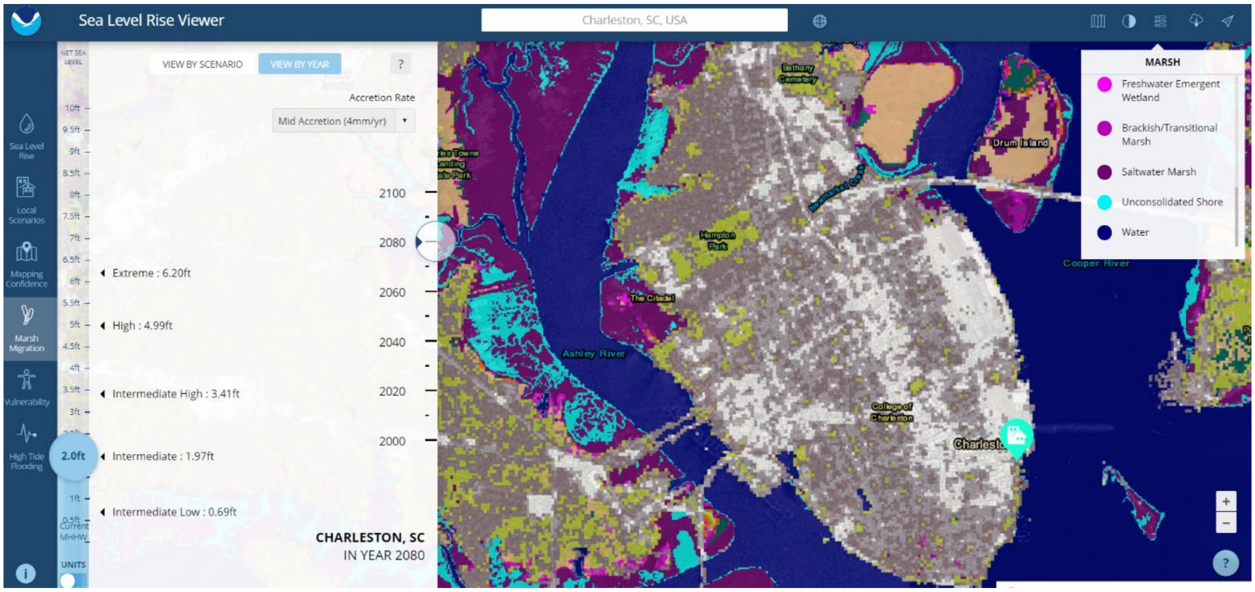

Figure 6-6. Predicted distribution of coastal wetlands in the Charleston Peninsula area in year 2080, based on a moderate rate of sea level rise (approximately 2 feet) and a moderate rate of sediment accretion of 4 mm/yr

Source: NOAA Sea Level Rise Viewer.

6.6.2 Alternative 2 (perimeter structure + nonstructural + NNBF)

Construction Related Effects

Adverse effects on wetlands may occur during construction of the storm surge wall where it takes place in salt marsh wetlands. Construction of the wall in the marsh would mostly occur from the water-side. The use of heavy equipment could disturb sediments and destroy marsh vegetation.

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 impacts 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.

Construction of nonstrutrucal measures to structures on the upland would have no direct effect on marsh wetlands, and construction techniques used for creating reef-based living shoreline are generally considered low-impact and with only minor disturbance to marshes which have shown to quickly recover in other living shoreline projects.

<u>Wetland Loss Effects</u>

Alternative 2 has the potential to induce a significant adverse effect on wetlands in the ROI. Approximately 1.5 miles of the 8.5 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. As described in Section 6.3, there is also the potential for permanent effects to the marsh around the base of the wall due to altered hydrodynamics and scouring induced by the wall. A 16 ft buffer on either side of the wall is estimated for permanent adverse marsh effects at the base. Additionally, some small areas of fringing marsh in between the storm surge wall and upland would be restricted from tidal flow due to the wall. 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 loss of the salt marsh in those locations. Figure 6-7 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, 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, even though it is currently altered and would be considered impaired by Sanger et al. 2015, 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 being 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 due to the partial restriction, 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 would result in approximately 35 acres of permanent loss of salt marsh function, out of the 555 acres of salt marsh wetlands currently existing on the Charleston Peninsula. Note that the nonstructural measures and living shoreline sills in this alternative would not contribute to any wetland losses.

Steps have already been taken to avoid direct 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, considerable portion of the storm surge was moved from the marsh to the land, avoiding 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 in the amount of wetlands potentially impacted from the previous conceptualization of the TSP in the draft FR/EA of April 2020. To minimize effects where the wall is planned in the marsh, it is planned 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 direct losses of 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, per regulations 33 CFR Parts 325 and 332 (see the Draft Mitigation Plan in Appendix F - Environmental for more information). Therefore, after avoidance and minimization, remaining adverse effects on wetlands form 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. They would provide co-benefits of creating oyster habitat and saltmarsh habitat for fish and invertebrates (Peterson et al. 2005) If planting of marsh grass is involved with the living shoreline design (this would be determined in PED phase) then that would result 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 marsh is expected to expand.

Figure 6-7. 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 + NNBF)

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 in this alternative on listed species has been performed and informal consultation with USFWS and NMFS is underway. ESA consultation documentation prepared to date 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 employed, and are described below as they relate to each group of species.

<u>Fish (shortnose sturgeon, Atlantic sturgeon and Atlantic sturgeon critical habitat)</u>
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 this alternative 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 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. If required, small manufactured treatment devices or sediment settling basins could be installed, depending the pump and location. 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, 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 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 temporary, and discharged water is assumed to immediately mix with the turbulent waters of the storm surge event, so that hot spots would not result.

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, though another tidal restriction at a railroad crossing, 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 pumps would be compliant with state water quality standards, it is not expected that Atlantic sturgeon critical habitat would significantly affected by the hydraulic pump during its limited operation.

<u>Marine Mammals (West Indian manatee, bottlenose dolphin)</u>
Alternative 2 is not expected to have an adverse effect on the West Indian manatee or bottlenose dolphins from the Charleston Estuarine System stock.

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 for the species. For the manatee, adverse 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 topobathy 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.

Pumps that would be temporarily used as part of Alternative 2 are not expected to have adverse effects on manatees or dolphins. Direct interference with the pumps would not occur since the pumps would be located either on land or in shallow areas near, but not in, marshes behind the storm surge wall where marine mammals would not reasonably be present. Rain and storm water that are discharged from temporary pumping operations during occasional storm surge events would be expected to meet state water quality standards (see the "Fish" section above for more information about operations of the pumps).

There is also the potential for the alternative 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 Operations and Maintenance 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 ridely sea turtles because their presence in the ROI is rare. For loggerhead and green sea turtles, any effects would be considered minimal. 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 found in Halsey Creek, there is a rare possibility that a loggerhead or green sea turtle 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 any sea turtles would migrate from Halsey Creek into the deeper Ashley River. Sea turtles 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 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.

<u>Birds (American wood stork, eastern blackrail, and other migratory birds)</u>
Adverse effects on 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 would be expected to occur.

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.

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, 2019) 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 + NNBF)

Under Alternative 2, the City of Charleston's initiatives mentioned in the No Action Alternative above are assumed to occur.

Construction Related Effects

Construction of the storm surge wall 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 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 (Washington State 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 on concrete, not steel.

Construction activities related to installing reef-based living shorelines as proposed in Alternative 2 are generally considered low impact to the environment and would not be expected to have an adverse effect on aquatic resources.

To minimize the potential for adverse effects of 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 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 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.

Hydraulic Pump Effects
Temporary use of the hydraulic pumps in Alternative 2 are not expected to significantly affect aquatic resources. Discharges from pumping stations would be compliant with state water quality standards. If required, small manufactured treatment devices or sediment settling basins could be installed, depending on the pump and location. 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, 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 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 temporary, and discharged water is assumed to immediately mix with the turbulent waters of the storm surge event, so that hot spots would not result.

Habitat Effects
All of the salt marsh-tidal creek systems (including the water column and tidal flats) in the study area are 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, permanent loss of available salt marsh habitat of approximately 27 acres of salt marsh, distributed in a few locations along the Ashley River (refer back to Figure 6-7.

The storm surge wall also has the potential to adversely affect aquatic resources through 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, species richness, 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). 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 lost, or significantly degraded.

Alternative 2 has the greatest potential to adversely affect aquatic resources from water quality changes when the 10 sluice gates would temporarily 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 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 based on other studies, from supersaturated to hypoxic conditions. Even though the effect on water quality would be temporary, hypoxia has the potential to result in an adverse effects to aquatic resources including mortality. The extent of significance of gate closures on aquatic resources would vary depending on the existing conditions and quality of habitat and aquatic resources in the locations where the gates are planned. For example, some of the "creeks" where storm surge gates would be installed to reduce storm surge influx, have been highly altered, impaired, and some channelized by development, providing reduced existing habitat functions.

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, a considerable portion of the storm surge wall 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 sluice 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 five other culverted creek/channel locations 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, losses of salt marsh and habitat functions from the storm surge wall that cannot be avoided or minimized would be offset through compensatory mitigation, which is required for wetlands per regulations 33 CFR Parts 325 and 332 and the South Carolina Coastal Tidelands and Wetland Act (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 living shoreline sills in Alternative 2 would have a beneficial effect on aquatic resources. 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. Adverse effects to aquatic resources that could result during temporary closure of the storm gates will be minimized to the extent practicable, but some are unavoidable.

6.9 Benthic Resources

6.9.1 No Action/Future Without Project Alternative

Under the No Action Alternative, benthic resources in the ROI 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 + NNBF)

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 in the marsh and on land, and construction of nonstructural measures. Living shorelines 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 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 6-8). 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 a estuarine tidal flat. The potentially affected area of the tidal flat is roughly half an acre area.

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. 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 wetland mitigation. Potential loss of the sandy tidal flat at "Battery Beach" would also be offset through compensatory wetland mitigation, as described in 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; Alternative 2 also includes permanent beneficial effects.

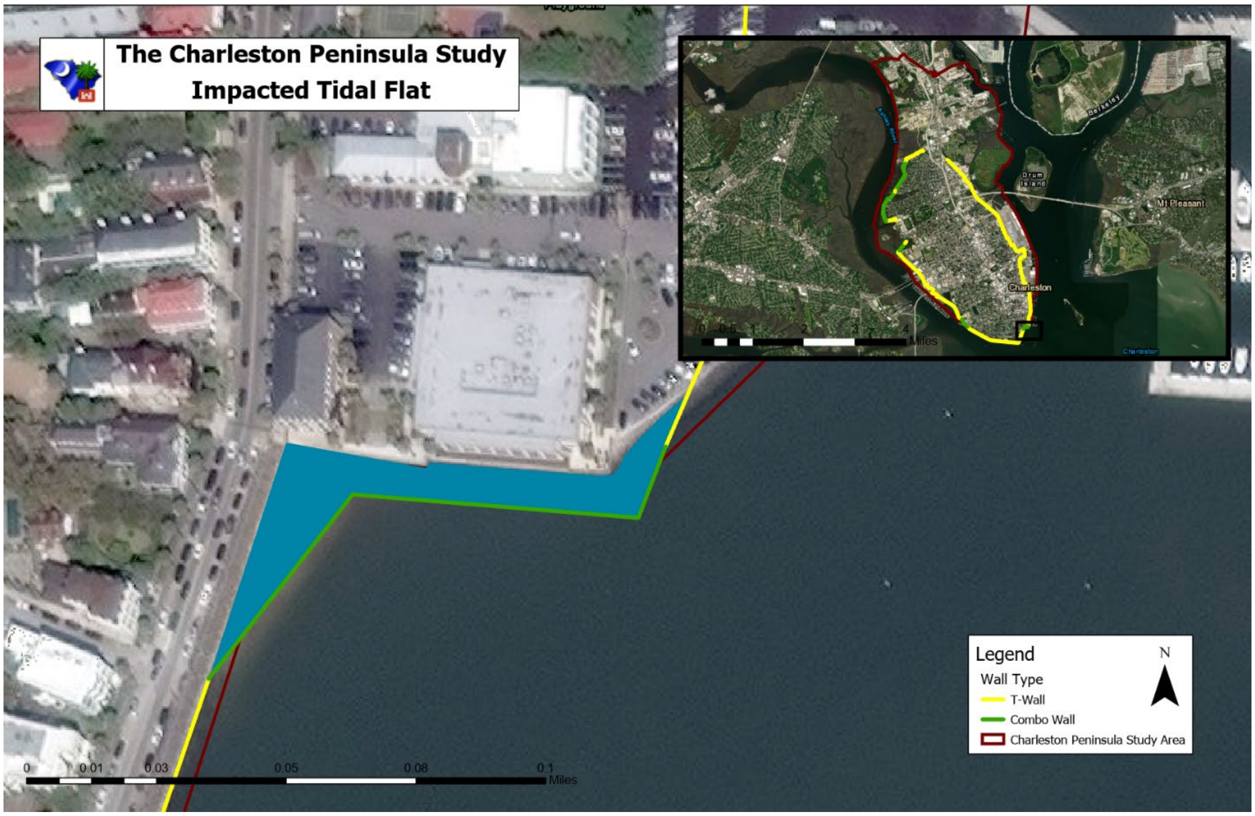

Figure 6-8. Map of "Battery Beach" tidal flat potentially affected by the storm surge wall.

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 storm 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 + NNBF)

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.

The creation of living shoreline sills with Alternative 2 would have a beneficial effect for wading and other birds that utilize oyster reef and salt marsh for foraging by creating new habitat.

Construction Related Effects

Construction of the storm surge wall and nonstructural measures 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. 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 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 be removed would be replaced in a nearby location after construction is completed (but not within the buffer zone of the wall).

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 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 2075 show that approximately 50 percent of the historic structures located on the Charleston Peninsula are situated in areas that would be at risk of flooding in a 25-year flood event (Figure 6-9). 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 6-10).

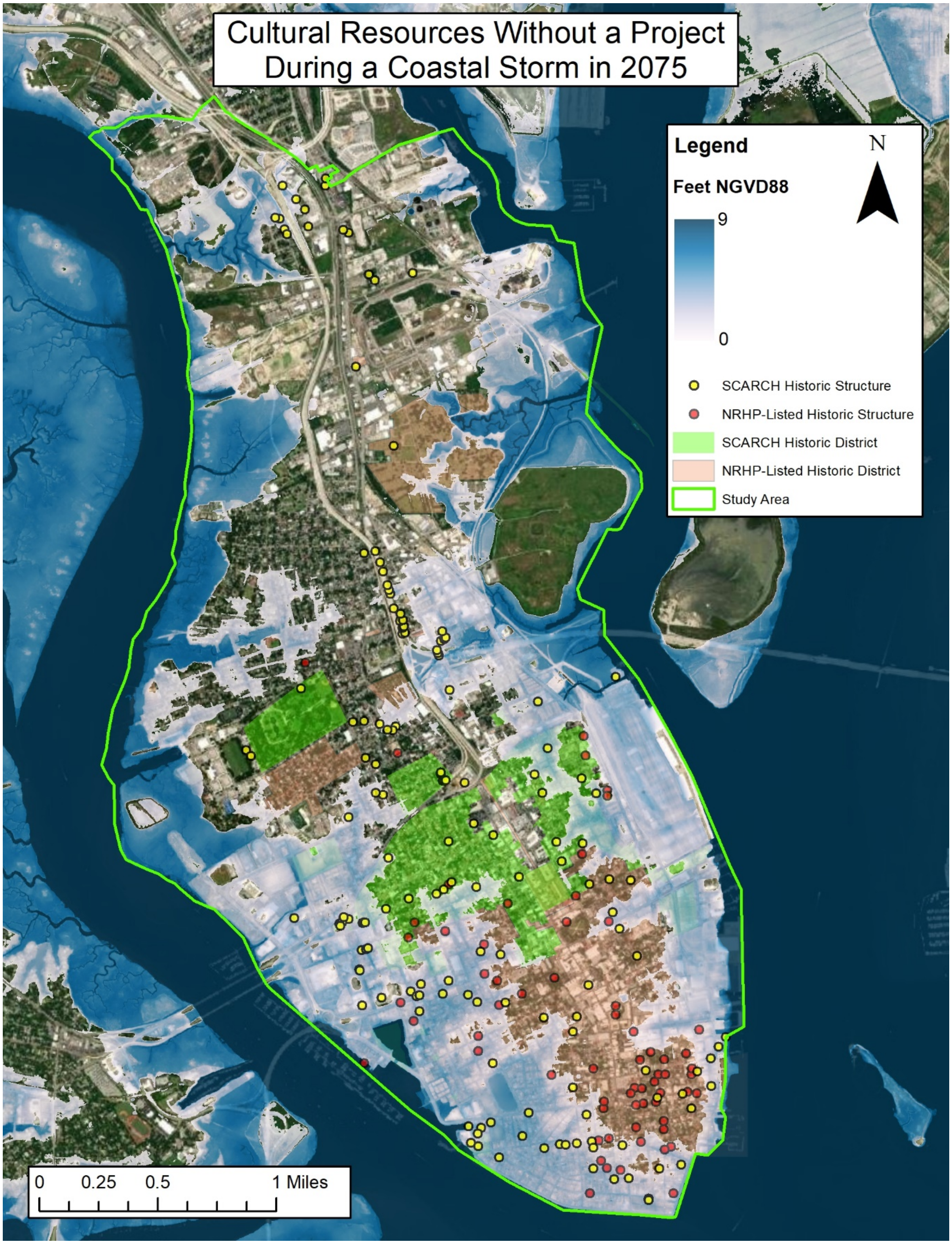

Figure 6-9. Projected conditions for a 25-year flood event in 2075 without implementation of Study

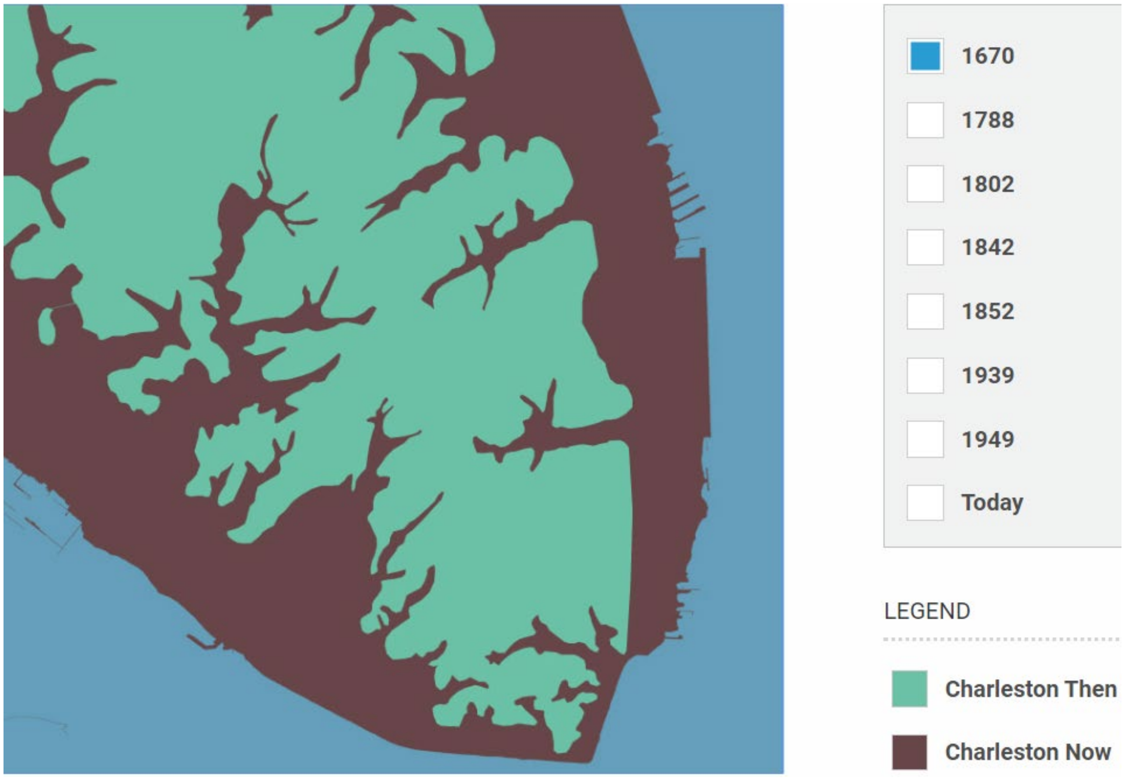

Figure 6-10. Outline of the peninsula in 1670

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 the meet the criteria for evaluation for 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* (2019) (https://www.charleston-sc.gov/DocumentCenter/View/18518/BAR-Elevation-Design) provides design considerations to ensure historic structures retain their character and historic significance. In addition properties within historic districts, the BAR has jurisdiction over any external changes to the 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. 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 + NNBF)

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 8.5-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, and non-structural measures which include raising buildings and floodproofing. The installation of approximately 9,300 linear feet of reef-based living shoreline sills as a NNBF would not require ground disturbance or create a change in the viewshed; therefore, the Corps has determined the NNBF has no potential to effect historic properties or cultural resources and is not included in the area of potential effects (APE) in the discussion below.

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 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 6-11 through 6-14 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 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.

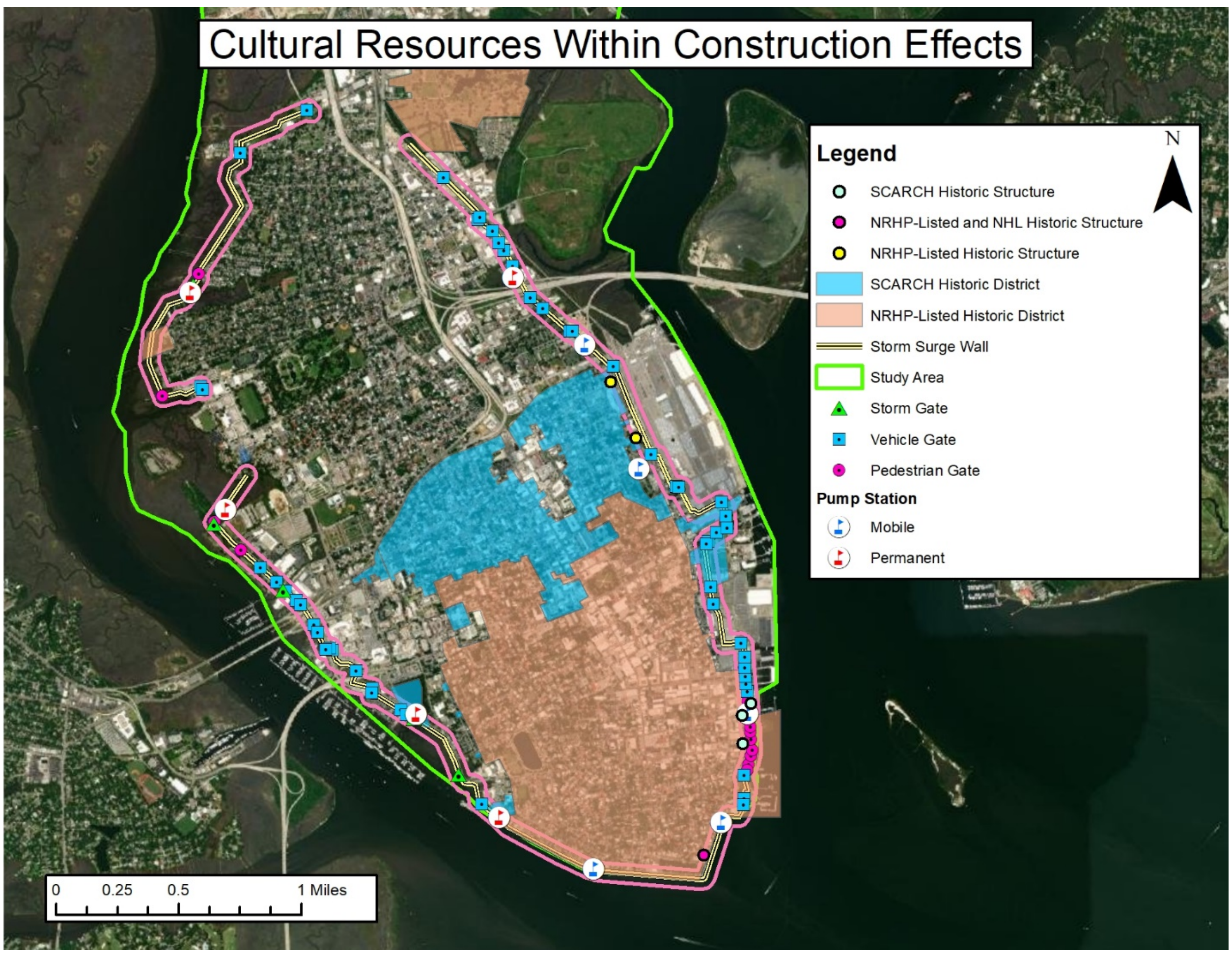

Figure 6-11. Cultural resources within the Construction Areas of Potential Effects. Note archaeological sites have not been included due to sensitivity

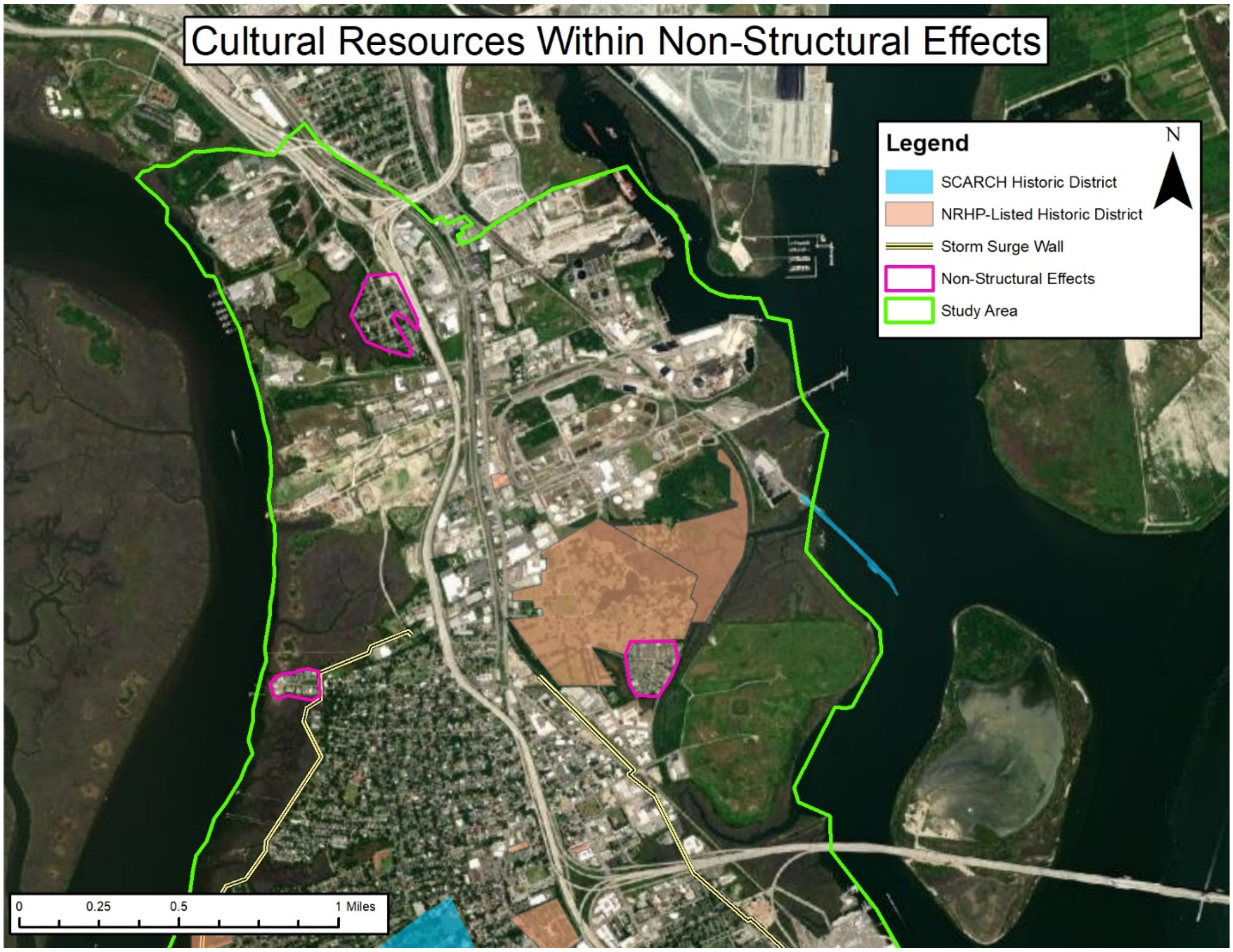

Figure 6-12. Non-Structural Areas of Potential Effects

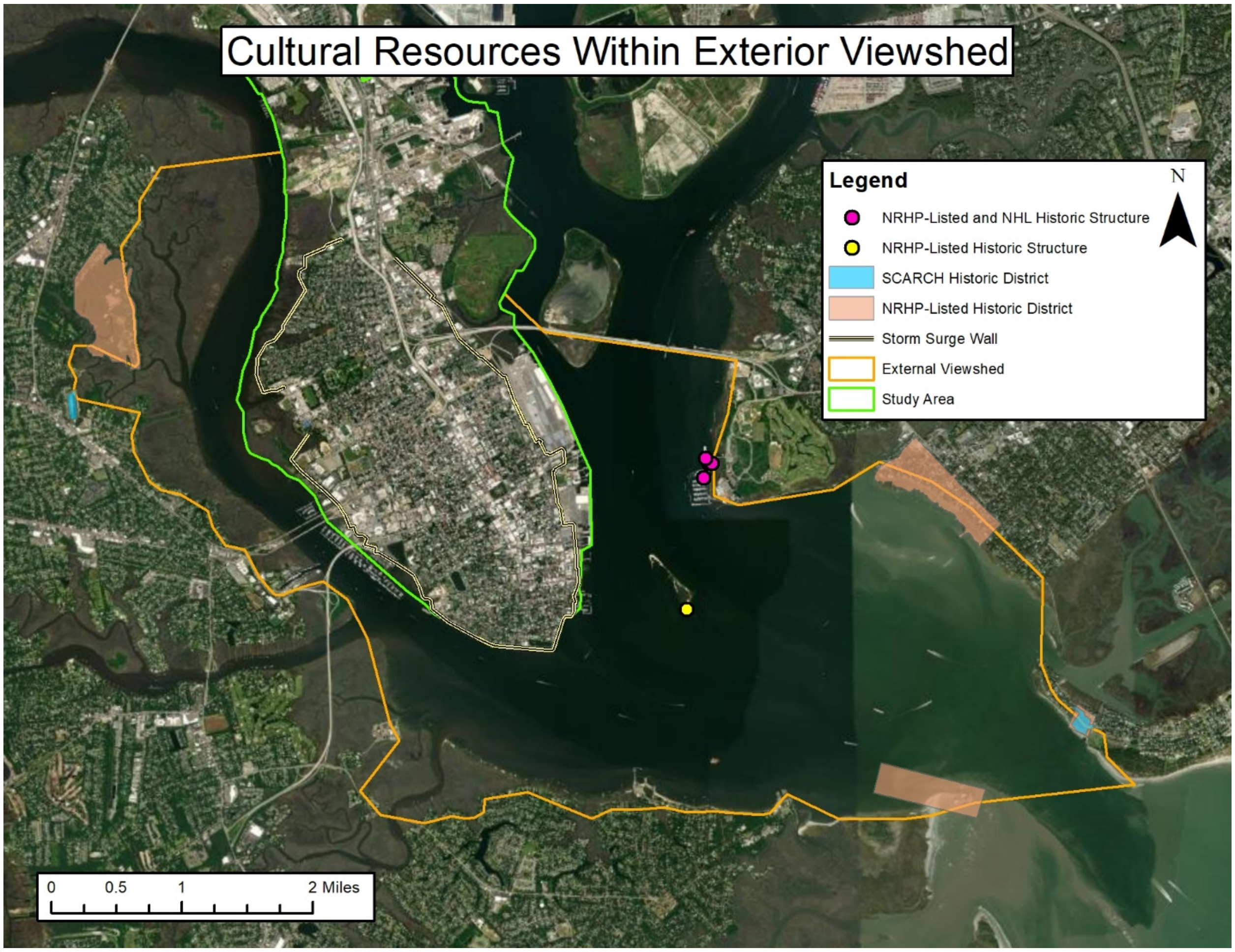

Figure 6-13. Exterior viewshed Areas of Potential Effects

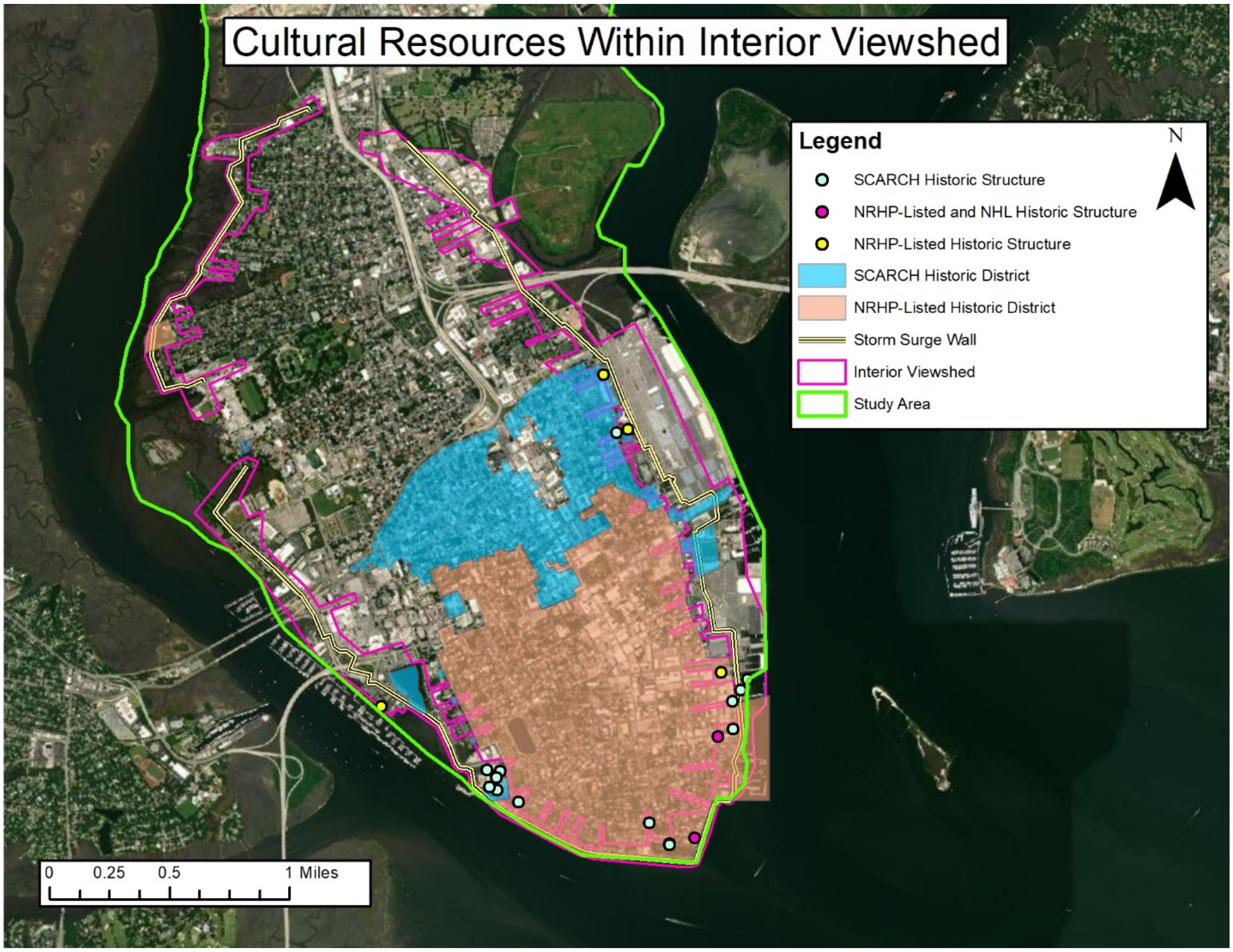

Figure 6-14. Cultural resources within the Interior viewshed Areas of Potential Effects. Note archaeological sites have not been included due to sensitivity

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 the 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
Unnamed/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. 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
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

Resource	APE	Site Type	Eligibility
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	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
Presqui'ile/2 Amherst Street	Construction Effects, Interior Peninsula Viewshed	Structure	Listed
Josiah Smith Tennent House	Construction Effects, Interior Peninsula Viewshed	Structure	Listed
Columbus Street Elementary/63 Columbus Street (Site No. 4256)	Interior Peninsula Viewshed	Structure	Eligible
Faber House; Hametic Hotel/635 East Bay Street (Site No. 0276)	Construction Effects, Interior Peninsula Viewshed	Structure	Eligible
Cigar Factory	Construction Effects, Interior Peninsula Viewshed	Structure	Listed
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

Construction Effects

Construction of the storm surge wall, 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. These effects are typically taken into account within a 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 effect 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 four 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 6-15). A submerged cultural resources survey of the portion of the APE that falls within the marsh would be undertaken prior to construction.

Figure 6-15. 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 rehabilitate and raise the existing Low Battery Seawall to 12 feet NGVD88 and completely reconstruct the High Battery Seawall to meet current engineering standards and meet the required elevation of 12 feet NGVD88. The seawalls are historic properties within the COHD; however, they have not been individually documented or provided resources numbers by SCDAH. 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 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 National Register. Murray Boulevard and East Battery Street contain structures that are contributing elements to the COHD and 10 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 6-16). 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.

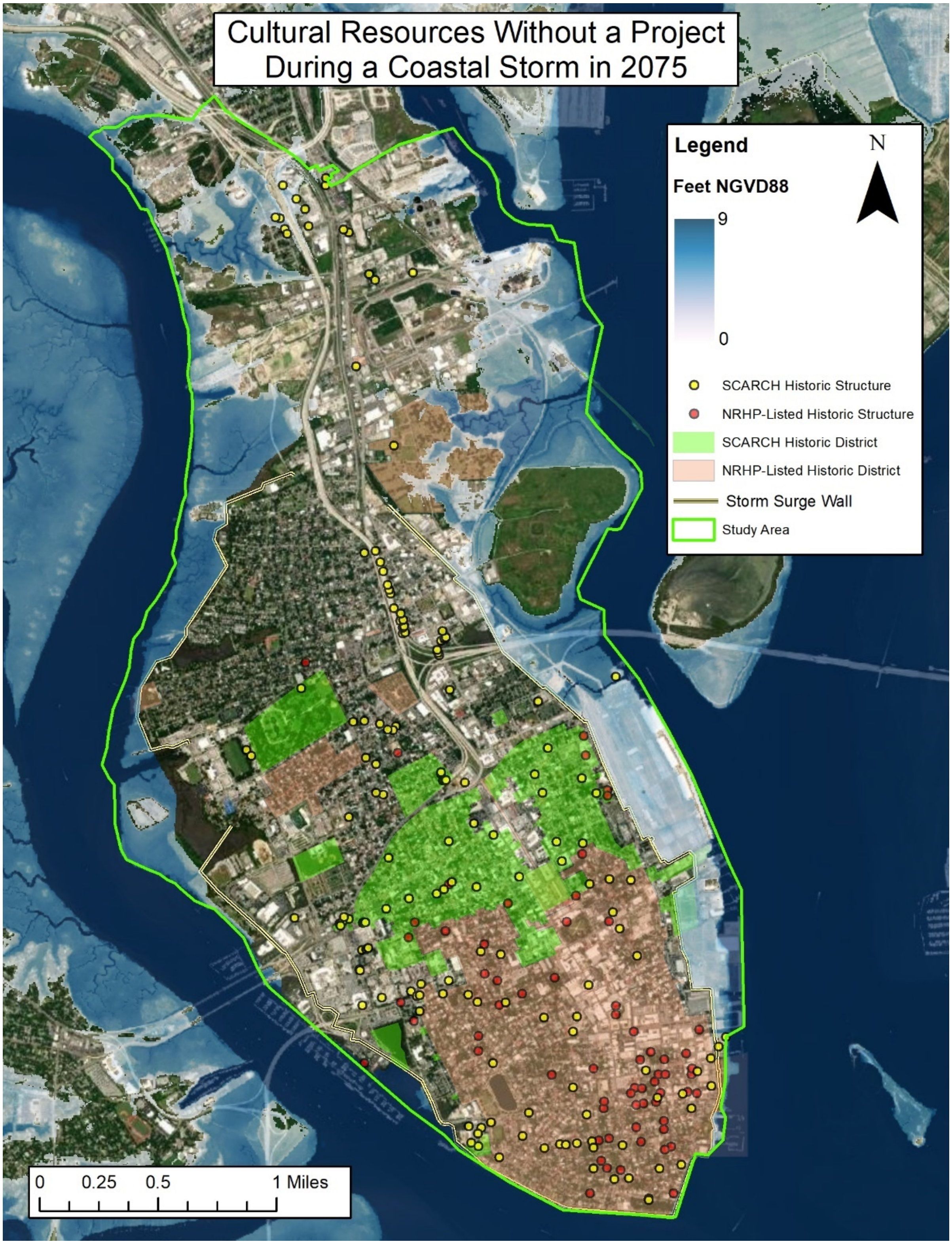

Figure 6-16. Projected conditions in 2075 during a coastal storm with implementation of the Study

<u>Non-Structural Effects</u>

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 6-12). 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 6-14). 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, 35 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 NGVD88 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 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 6-13). 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

As stated previously, 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 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.

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 SCDAH 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 No Action Alternative, climatic changes such as rising sea levels and increasing coastal storms, along with human use patterns such population growth, are expected to continue over the next 50 years in the Charleston area. This trend is expected to continue into the future. 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, 2019), and the City's Parks and Recreation Master Plan (City of Charleston, 2021) 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 + NNBF)

Effects on Parks

It is assumed that the City 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 wall would also have a beneficial effect on Brittlebank Park by reducing storm surge flooding across the park, as well as shallow coastal flooding.

In the conceptual footprint, the storm surgewall would also be positioned along roadways that are in close proximity to parks in some places, which could lead to minor impacts. 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.

Construction Related Effects

Some recreational areas could be temporarily affected during construction. During construction of the storm surge wall, 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.

Effects on Boating

No recreational water features 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 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.

6.13 Visuals and Aesthetics

6.13.1 No Action/Future Without Project Alternative

This summary 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.

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 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.

User Activity

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 + NNBF)

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 effect 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 aesthetic impacts across the project as a whole. Because assessment would be continued during PED, the following discussion is part of an ongoing effort and should not be considered final.

<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.

Land Use

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 Aesthetic Impacts 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 an 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 project impacts are summarized below.

Project Impacts

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 impact 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.

Mitigation of Aesthetic Impacts

"*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 aesthetic impacts of the project could be mitigated. A few ideas follow:

- 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 Flood 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.

A draft Memorandum of Understanding (MOU) between USACE and the City of Charleston has been developed to ensure a common understanding between the parties for their continued cooperative partnership in the assessment of aesthetic resource impacts 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 + NNBF)

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 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.

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. 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 termadverse 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 + NNBF)

This alternative assumes that the City of Charleston's new noise ordinance would be in place and would guide future conditions related to noise generated by actions of others. The only source of permanent noise effects that may result from Alternative 2 would be from the new pump stations that would operate during a storm surge event. 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 used, it is assumed that the pumps in this alternative 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.

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 to protect the public from all adverse effects on 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, as this 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 for 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 noise exposure to aquatic resources.

Adverse noise effects would be minimized by adhering to the City of Charleston's noise ordinance which would limit the times and days when construction would occur. 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 likely be a few feet. This would primarily apply to construction of the storm surge wall by the current U.S. Coast Guard Station on Tradd Street. Nearshore 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. Other hazardous waste sites and facilities that handle hazardous materials would likely continue to exist into the future, continuing to pose some risk to the environment and human health. It is also expected that climatic changes such as rising sea levels and increasing coastal storms, would continue over the next 50 years in the Charleston area, potentially increasing erosion, especially on unprotected shorelines and exposing existing hazardous waste sites to inundation without a Federal action to address these. Hazardous materials and waste may pose an increased risk to the environment through exposure of deposits from erosion and water contamination from inundation from storms.

6.16.2 Alternative 2 (perimeter structure + nonstructural + NNBF)

Alternative 2 would not use or generate any hazardous material or waste.

<u>Potential Interaction Effects with Existing Sites</u>
Although the Koppers Co. Superfund site would be remediated 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 for living shoreline sills 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.

Alternative 2 is not expected to have any effect, including cumulative, with releases from the TRI sites in the ROI.

Implementation of the storm surge wall would reduce risks of exposure at some sites and facilities during storm flooding events, resulting in a slight beneficial effect.

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 There are only two sites in close proximity, the Calhoun Park Area CERCLA site on Concord Street and the US Coast Guard station on Tradd Street, which is listed under CERCLA and RCRA. However, by the US Coast Guard location, and 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, therefore having no effect.

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. Therefore, any adverse effects on hazardous materials and wastes from 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 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, 2019), 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 strandings 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 material effects to waterborne transportation are anticipated under the No Action Alternative.

6.17.2 Alternative 2 (perimeter structure + nonstructural + NNBF)

Land Transportation Effects

Under Alternative 2, 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 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 be outside of any railway easements to avoid the rail lines.

Long-term, direct beneficial effects to land based transportation would also occur in 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 transportation infrastructure from storm surge flooding, although rainfall-induced flooding may still occur. Any roads, railways, and Columbia Street Terminal in the current wall alignment on the outside of the storm surge wall would continue to experience shallow coastal flooding and rainfall flooding, and storm surge. With flooding reduced during a storm surge event, critical facilities on the Peninsula would continue to be accessed and therefore resulting in a beneficial effect.

Potential Effects of Gates

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 completely restrict rail access, but this would be temporary.

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 arrival of rising water 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 throughout the study and design, phases and included in the Operations and Maintenance Plan.

USACE is continuing to look at ways to reduce the impacts of the storm surge wall on transportation by examining the feasibility of moving the current conceptual footprint to areas that would reduce the number of gates needed.

Construction Related Effects

Prolonged temporary impacts 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. 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.

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-born 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 any Federal navigation channels. The wall in the marsh does not intersect with any roads or bridges. It does interest with the US Coast Guard Station's dock off of Tradd Street; however an access gate would be included.

Effects on marine commerce operations or transportation from the wall at Columbus Street Terminal and Union Pier have been minimized by placing the wall on land rather than waterside, and in strategic locations away from critical port operations.

6.18 Utilities

6.18.1 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, 2019), 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. It is assumed that check valves would be installed on existing stormwater outfalls. These would have a beneficial impact on the effectiveness of stormwater management on the peninsula into the future.

6.18.2 Alternative 2 (perimeter structure + nonstructural + NNBF)

It is assumed that the City projects and initiatives described under the No Action Alternative would be implemented under Alternative 2. Permanent impacts to utilities from implementation of Alternative 2 would be beneficial, while temporary construction-related impacts would be adverse and minor.

The storm surge wall and associated pumps would have a beneficial effect on the stormwater management system during a storm event by reducing surge 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 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.

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, 2019) to guide development decisions that support adaptation to shallow coastal flooding. It is expected that the City's new hazard risk assessment and their new Hazard Mitigation Plan (described in Section 4.5) 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 Phase III Market Street Drainage Improvement Project and Phase III and IV US 17 Spring/Fishburne Drainage Improvement Project would be completed. It is expected that the remainder of the drainage projects would be implemented in the future to address rainfall flooding. It is assumed that check valves would continue to be installed on existing stormwater outfalls. These would have a positive effect by reducing damages as a result of shallow coastal flooding from rainfall events.

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 noticeable 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, 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.

6.19.2 Alternative 2 (perimeter structure + nonstructural + NNBF)

It is expected that the City of Charleston's resiliency efforts described in the No Action Alternative would continue into the future, contributing to reduced stormwater flooding.

Implementation of the storm surge wall in Alternative 2 would reduce damages in large areas of the City from storm surge flooding during major storm surge events, and the nonstructural measures would reduce damages to selected structures in the study area that are not inside of the wall or not already at base-flood elevation. These would be permanent, direct beneficial effects. However, risks of shallow coastal flooding and rainfall flooding, and wave overtopping would still remain as described in the No Action Alternative. 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 impacts to the public (motorists, boaters, and pedestrians) and emergency services in the ROI would occur during construction of the Alternative 2 measures. Temporary road closures would likely result, but alternate routes would be provided. Construction would be phased so the impacts would not be additive. Construction areas would be secured from trespassers, in addition to worker safety as prescribed by the Occupational Safety and Health Act (OSHA).

Alternative 2 has the potential to produce minor short-term, adverse safety impacts on the public and emergency services during construction, and long-term beneficial effects on safety, due to the prevention of widespread storm surge flooding during major storm events. Rainfall flooding could still occur but would expect to be improved by the City's drainage projects assumed in the No Action Alternative.

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. It is also assumed that the City would complete its existing project to raise the current Low Battery Wall to a 9ft elevation NAVD88 as described in Section 1.4, which would provide additional 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. Three particular areas, the Rosemont Neighborhood, Bridgeview Village, and the public housing communities of Cooper River Court and Meeting Street Manor, all referenced in section 4.20, are minority communities and are already vulnerable to flood damages. 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 three 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 + NNBF)

Alternative 2 would provide significant risk reduction benefits from storm surge through the storm surge wall or non-structural measures for the three minority communities identified. Alternative 2 reduces the storm surge risk posed to the public housing communities of Cooper River Court and Meeting Street Manor, in addition to the risk posed to Sanders-Clyde Elementary School, based on the perimeter structure's proposed location. Additionally, Alternative 2 includes plans for non-structural solutions for the minority communities of Bridgeview Village and the Rosemont Neighborhood.

The non-structural solutions for Bridgeview Village and the Rosemont Neighborhood, both within the ROI where construction of a storm surge wall is not practicable, are dry flood proofing and residential elevations respectively. Similar to communities that are protected by a storm surge wall, any local evacuation order must be followed to ensure life/safety considerations.

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 make construction of a wall for this community impracticable. Further, the ground elevation in this area is already at least 9 ft NAVD88. The study team developed a more appropriate non-structural solution to provide risk reduction from the same coastal storm hazard risk as the wall would provide elsewhere in the ROI. Because Bridgeview Village consists of cement block apartment style buildings, elevating these structures is not possible. Therefore, as part of Alternative 2, floodproofing is recommended 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 door, 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 not a problem within USACE's authority to correct, this access road is recommended to 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. These impacts, along with the proximity of a large marsh wetland have resulted in flooding concerns for the residents. Again, construction of a wall in this area is impracticable due in part to the large marsh wetland impacts construction in the water would create, and the homes in this community are built very close to the marsh wetland. Construction of the wall on land would require involuntary buyouts of homes along the marsh wetland, further disrupting community cohesion. Instead, Alternative 2 recommends non-structural measures – primarily home elevation – for those structures not already at or above 12 ft NAVD88. Home elevation would be voluntary and would lift flood prone properties out of the path of flood waters to reduce the risk of flood damages. Identification if the particular homes to be elevated woudl occur during PED understanding that temporary relocation assistance would be necessary. 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. Like in the Bridgeview area, roads in Rosemont are prone to flooding from heavy rains. USACE recommends that local city and county entities address this issue in concert with the home elevation for a more complete 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 could be adversely affected by construction of the wall through reduced access to public transportation. Adaptive management for City Bus Routes during and following construction of the perimeter wall would mitigate many impediments of access to public transportation posed by the perimeter wall for these communities, and therefore would not be significant. Figure 6-17 shows the current bus stops and draft Low County Rapid Transit alignment and bus stops throughout the Peninsula.

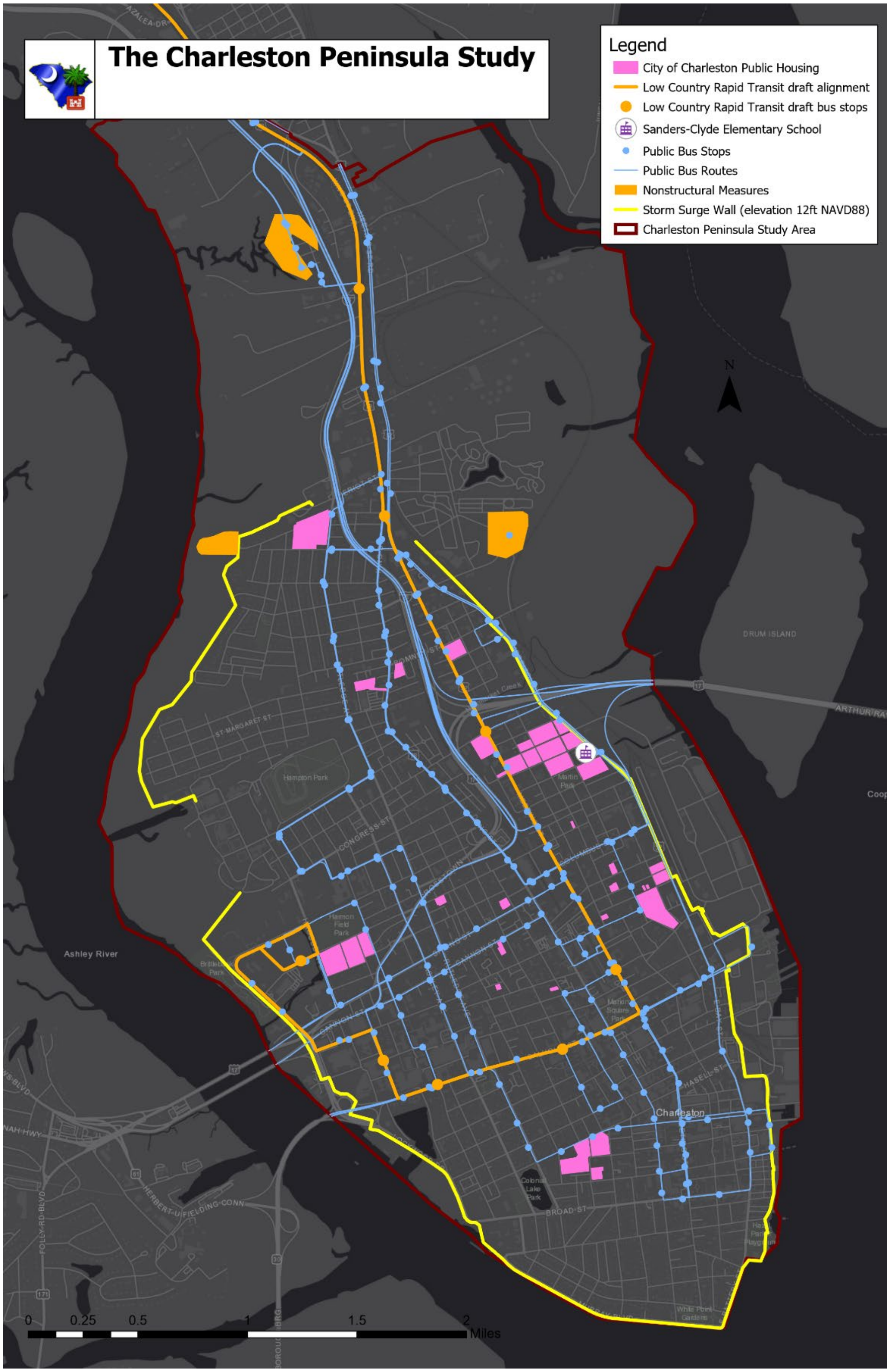

Figure 6-17. Map showing the current public bus stops and draft Low County Rapid Transit alignment and bus stops

USACE has evaluated other minority and low-income populations and disadvantaged communities around the Peninsula that could potentially be affected by the storm surge wall. 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 for additional low income and minority communities where a wall is not merited.

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. Sea level has already risen over one foot in the last 100 years in the Charleston area, and minor coastal flooding is increasing because of it. Examples of localized climate change effects that could be expected if no action is taken include portions of Lockwood Dr, a primary road to the Medical District, that are currently at elevation 5 feet NAVD88, and a small portion that are at elevation 4 feet NAVD88, and Hagood Ave and Fishburne St (which have hydrologic connections to Gadsen Creek) that are currently at elevation 4 feet NAVD88, would experience coastal flooding more frequently with sea level rise. Based on a high rate of sea level change, high tide would flood these areas twice a day around the year 2085, as well as for an intermediate rate of sea level change in the year 2150. The Battery seawall is overtopped at every high tide with a high rate of sea level rise around the year 2035. Based on the NWS threshold for “King tides” at 3.46 feet NAVD88, this would occur every tide by year 2145 based on an intermediate rate of sea level change. 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 Sea Level Strategy (City of Charleston, 2019) 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 + NNBF)

Effects from Alterative 2 on climate change through greenhouse gas emissions produced during construction of the structural and nonstructural measures 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). Therefore, direct effects on climate change from this action are expected to be negligible.

It is assumed that City of Charleston actions taken from the Climate Action Plan 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, non-structural and NNBF measures in Alternative 2 would result in a significant increase in the City of Charleston's resilience towards the impacts of climate change. Structures would be less vulnerable to the impacts of storm surge flooding in the future. Alternative 2 would also have a secondary beneficial effect of reducing some impacts of sea level rise.

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 would be several years complete by the time an alternative is implemented for the current study (the estimated start date for planning purposes of this feasibility study is 2025). 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 Ashely Rivers that would adversely impact tidally-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 pumping systems.
- **City of Charleston Low Battery Seawall Rehabilitation Project:** This project is in construction. After more than 100 years of exposure to aggressive environmental conditions, several powerful hurricanes, and numerous extreme high tides, the entire Battery seawall 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 seawall extends approximately 9/10 of a mile in length in the general east-west direction along the north 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 ½ feet from the top of the Low Battery sidewalk to the High Battery walkway. The Low Battery wall is being restored and elevated to match the High Battery.
- **Calhoun Street East Drainage Improvement Project, 1999**: This was 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 approximate 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 The Citadel boat landing and peir 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 Ashely River, roughly across from The Citadel and Brittlebank Park on the Peninsula (see Figure 6-18). The South Carolina Department of Natural Resources is currently monitoring the success of the reefs.

Figure 6-18. Locations of where oyster reefs were constructed for the Ashley River Oyster Enhancement Project

Source: City of Charleston.

6.22.2 Key Resources Areas

<u>Wetlands</u>

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 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 the condition of estuarine shorelines 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, the earliest start date of any project resulting from this study is anticipated no sooner than 2032. As a result, construction on such a project 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, 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 actions 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, poses a very real risk to the physical integrity of historic structures on the Charleston Peninsula.

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, planning criteria including economic benefits, and hydraulic effects. For a detailed description of the hydraulic and economic modeling process, please refer to Appendix B – Engineering, and Appendix C – Economics, respectively. Environmental considerations are assessed in the following chapter of this report.

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. The reduced probability of storm surge inundation translates to reduced 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). Injuries to first responders and individuals who do not evacuate would also be reduced. 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 $13,585,000 or 62% 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	$21,935,000	$773,400
Alternative 2	$8,350,000	$294,400
Damages Reduced	$13,585,000	$479,000

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 exacerbated in the No Action / Future Without Project Condition. 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 will 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 NED and environmental quality (EQ), other accounts to evaluate the public benefits and detriments of alternative plans include regional economic development (RED) and other social effects (OSE). 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. The following sections describe each benefit category, including identification of the NED plan.

7.2.1 Other Social Effects (OSE) – Life Safety

OSE 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. These include displacement effects to people and businesses, the general population (beneficial and adverse effects to minority, low income, and disadvantaged communities are anticipated to be representative of those experienced by the general population), and public health and safety. Assessments of beneficial and adverse effects are based on comparisons of the with-project alternative to the without-project alternatives conditions expected to prevail in the future in the absence of the project. 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 criteria 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 (developed by the Institute for Water Resources to support planning-level studies of hurricane risk reduction systems). The model 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 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	26.6	5.3	(21.3)
Over 65	144.3	64.6	(84.9)
Total	170.9	69.9	(104.6)

There is considerable uncertainty associated with modeling life loss; therefore, the results of the modeling should be viewed as more qualitative as oppose 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 failure scenario was not assumed when modeling life loss estimates for the Future Without Project Condition and Alternative 2. Although the TSP could potentially transform the relatively slow and steady rise of a storm surge to a potentially more severe and immediate flood risk associated with a failure of the new storm surge wall, the life safety risk assessment described in the following section determined that a failure in the storm surge wall was well below tolerable risk levels. Additional information on the OSE analysis performed for this study can be found in the Appendix C - Economics.

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. 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 residual risk would be 1) the inability to install all gate closures in advance of inundation and 2) an overtopping event (specifically an overtopping event *without* a failure of the wall). Life loss is estimated to be low risk in these scenarios because there would likely be ample warning time to evacuate the site and their evacuation rates are typically high. 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. The intention underlying Alternative 2 is to reduce damages from more frequent storm surge events, not extreme events. Hurricane Hugo provides an example. While the proposed wall height would have stopped the storm surge inundation actually experienced on the Charleston Peninsula from Hurricane Hugo, it would not have stopped the highest storm surge observation from that storm which was 20.2 feet (6.2 m) at Seewee Bay near McClellanville. At high tide today, that would be an elevation of almost 17 and a half feet NAVD88 in the Charleston Harbor. That level of storm surge would overtop the proposed storm surge wall and inundate the peninsula. It is critical that people understand that the storm surge wall would not completely eliminate storm surge inundation or flood risk so that they take appropriate action to further protect their person and property.

Communicating risks associated with inability to install all gate closures is also critical. With implementation of Alternative 2, there is concern that residents, workers, and visitors may not comply with evacuation orders during coastal storm events. 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 construction of a storm surge wall.

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 evaluated during feasibility level design and further analyzed in the PED phase. During the PED phase, the details of the wall system would be designed with the intent to prevent structural failure from wave overtopping, although there is a limit to the amount of overtopping that any design can withstand. 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 that, if in excess of 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 interior flood risk, an assessment of measures to address the residual risk, or induced flooding, and include 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 interior flood risk. This evaluation will continue to be refined through the Preconstruction, Engineering and Design (PED) phase.

As previously discussed, surge overtopping and failure to properly close gates are assumed to be the most likely failure scenario. 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 in a gate failure situation.

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. 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.

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.

7.2.2 National Economic Development (NED)

The NED account includes the estimates of project benefits and costs used to calculate net economic benefits. A full display of the analysis for the NED account is located in the Economic Appendix. 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 benefits and costs 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)*. It is in the P&G that the following additional accounts of environmental quality, regional economic development, and other social effects are identified.

Preliminary, screening-level cost estimates were used for the economic analysis. Table 7-3 summarizes the costs and benefits of Alternative 2.

Table 7-3. Costs and Benefits of Alternative 2 ($1,000).

Cost/Benefit Item	Alternative 2
Investment Costs	–
Project First Cost	$1,099,000
Interest During Construction	$146,000
Total Investment Cost	$1,245,000
Average Annual Cost[1]	
Average Annual First Cost	$43,900
Annual OMRR&R[2] Cost	$3,000
Average Annual Annualized Costs	$46,900
Benefits[1]	–
Average Annualized Benefits	$479,000
Net Benefits	$432,100
BCR	10.2

[1]Costs are rounded in October 2021 price levels, 2.5% discount rate, and a 50-year period of analysis.
[2]Operation, Maintenance, Repair, Replacement, and Rehabilitation.

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.

7.2.3 Regional Economic Development (RED) – Regional Construction Impacts

The RED analysis 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 $1.098 billion would generate 10,381.4 full-time equivalent jobs, $792.973 million in labor income, and $1.461 billion in output. For the state of South Carolina, as a whole, the construction stimulus would generate 12,551 full-time equivalent jobs, $870.204 million in labor income, and $1.744 billion in output. For the Country, as a whole, the construction stimulus would generate 17,954 full-time equivalent jobs, $1.317 billion in labor income, and $2.985 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	–	$843,318,181	6,849.5	$574,255,454	$570,503,380
Secondary Impact	–	$617,860,707	3,531.8	$218,718,450	$357,833,454
Total Impact	$843,318,181	$1,461,178,888	10,381.4	$792,973,904	$928,336,835
State	–	–	–	–	–
Direct Impact	–	$934,459,369	7,884.8	$607,248,992	$626,721,098
Secondary Impact	–	$810,521,673	4,666.1	$262,955,705	$446,159,772
Total Impact	$934,459,369	$1,744,981,042	12,551.0	$870,204,697	$1,072,880,820
US	–	–	–	–	–
Direct Impact	–	$1,048,443,417	9,307.0	$700,991,951	$709,306,630
Secondary Impact	–	$1,936,605,647	8,647.0	$616,891,961	$1,055,917,977
Total Impact	$1,048,443,417	$2,985,049,063	17,954.0	$1,317,883,912	$1,765,224,608

The local impact area captures about 77% of the direct spending on the project. About 9% of the spending leaks out into other parts of the state of South Carolina. The rest of the nation captures about 10%. The secondary impacts, also referred to as the combined indirect and induced multiplier effects, account for approximately 42% of the total output, about 34% of employment, nearly 28% of labor income, and about 39% of value added for the local impact area of Charleston County, SC. Additional information on the RED analysis performed for this study can be found in the Appendix C - Economics.

7.2.4 Environmental Quality (EQ) – Natural and Nature Based Features

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 may 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.

For the Charleston Peninsula Study, the EQ evaluation criteria focuses on the oyster-reef based sill (living shoreline) associated with the storm surge wall. In South Carolina, oyster-reef sills are effective at stabilizing estuarine shorelines and providing ecological benefits (SCDNR 2019). Construction of oyster-based sills provides immediate increases in habitat. The reef structure itself is considered Essential Fish Habitat. Over 80 species of finfish and invertebrates are associated with intertidal oyster reefs in South Carolina (SCDNR 2019).

Primary and secondary risk management functions of oyster-reef based sills include reducing wave attack and erosion impacts respectively (USACE, in press). In this case, the oyster-based sills would protect existing resources seaward of the storm surge wall. Proposed locations would expand on small-scale living shorelines in the study area that have already shown to be successful in slowing erosion, providing greater resilience to larger areas.

Additionally, the quiescent area of water that is created by the sill often allows sediment to accumulate between the structure and the shoreline. With time, this process can eventually raise the elevation of the bottom and promote expansion of salt marshes (SCDNR 2019, USACE in press). This effect provided by the living shoreline sills will help offset potential marsh scouring of the proposed wall.

Hardened structures intended to reduce wave attack and shoreline erosion such as bulkheads and revetments provide none of these co-benefits. Oyster-reef sills are susceptible to damage and overtopping by event-based hazards, such as storm surge during extreme storm events, but 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 + NNBF + 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	$1,099,000,000
Annual Cost	$0	$46,900,000
Total Annual Benefit	$0	$479,000,000
Annual Net Benefits	$0	$432,100,000
Benefit – Cost Ratio	None	10.2
Residual Risk	Risk remains high throughout the study area	Risk of economic damages is reduced by 90%
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
Charleston County, South Carolina	No construction of major water resources infrastructure to stimulate income and employment	Construction stimulus would generate 10,381.4 full-time equivalent jobs and $792.973 million in labor income
State of South Carolina (including Charleston County)	No construction of major water resources infrastructure to stimulate income and employment	Construction stimulus would generate 12,551 full-time equivalent jobs and $870.204 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; NNBF provides beneficial effect on shoreline erosion
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.
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 if wall or gates fail or waves overtop but similar to no action

–	No Action	Alternative 2
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; NNBF 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; NNBF 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. Due to a lack of detailed design of Alternative 2 during the feasibility phase of the study, identification, evaluation, and mitigation of adverse effects would be addressed in a Programmatic Agreement as well as optimization of avoidance and minimization. Beneficial effects include 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 Mitigation and minimization to be identified to the extent practicable during PED. Beneficial effects include reduction of damages to aesthetic resources from periodic costal storm surge events.
Air	No construction activities; 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 would continue to cause damages to all socioeconomic groups in the future	Beneficial effects through reduced 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 Hydraulic Effects

With implementation of Alternative 2, vulnerable structures in the Rosemont, Bridgeview, and Lowdnes Point communities would be adapted to avoid damages while allowing storm surge to move inland. Along the perimeter of the peninsula, the storm surge wall would limit storm surge from moving inland. In the absence of a coastal storm event, the system of gates in the storm surge wall would remain open to allow for tidal exchange in wetland habitat. When the National Weather Service predicts a coastal storm event will impact the peninsula, the gates would be closed at low tide to allow for maximum storage of rainfall runoff in the wetland habitat.

7.3.1 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 planning horizon.

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.

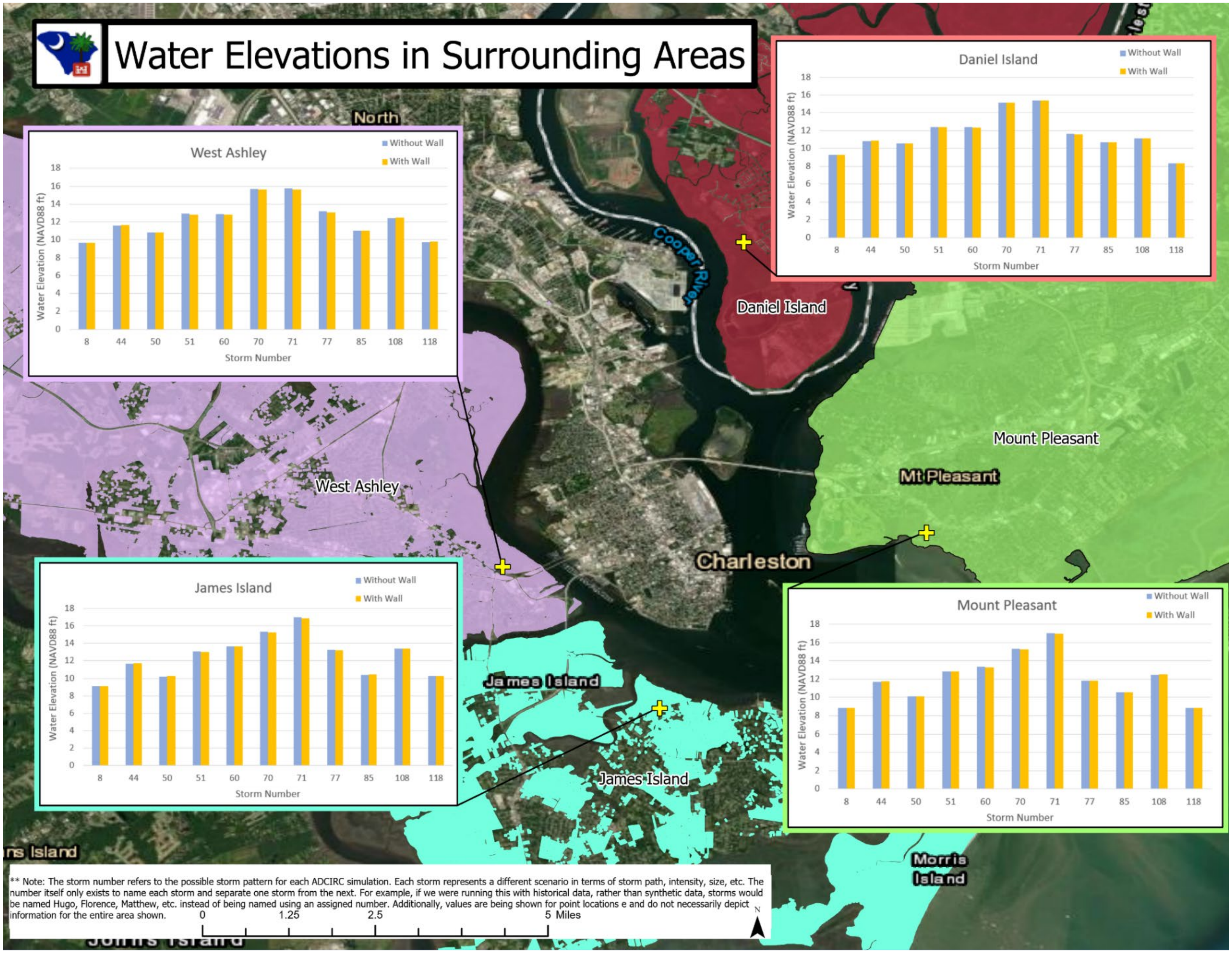
Water Elevations in Surrounding Areas
West Ashley
Without Wall
With Wall
Water Elevation (NAVD88 ft)
Storm Number
8 44 50 51 60 70 71 77 85 108 118
Daniel Island
Without Wall
With Wall
Water Elevation (NAVD88 ft)
Storm Number
James Island
Without Wall
With Wall
Water Elevation (NAVD88 ft)
Storm Number
Mount Pleasant
Without Wall
With Wall
Water Elevation (NAVD88 ft)
Storm Number
North
Cooper River
Daniel Island
Mount Pleasant
Mt Pleasant
West Ashley
Charleston
James Island
James Island
Morris Island
** Note: The storm number refers to the possible storm pattern for each ADCIRC simulation. Each storm represents a different scenario in terms of storm path, intensity, size, etc. The number itself only exists to name each storm and separate one storm from the next. For example, if we were running this with historical data, rather than synthetic data, storms would be named Hugo, Florence, Matthew, etc. instead of being named using an assigned number. Additionally, values are being shown for point locations e and do not necessarily depict information for the entire area shown.
0 1.25 2.5 5 Miles
N

Figure 7-2. ADCIRC modeling results show marginal difference in water surface elevation between with project and without project conditions**.**

CHAPTER 8 - Tentatively Selected Plan

Based on the evaluations described in Chapter 6 and 7, Alternative 2 has been identified as both the NED and Tentatively Selected Plan (TSP). At this stage in the study, the TSP is still considered conceptual and will be further refined throughout the remaining duration of the feasibility study and during the Pre-construction Engineering and Design phase. The description of the plan in the Final FR/EIS will include additional detail developed during the feasibility level design process.

8.1 Features of the TSP

- **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 steel piles on the storm surge side and battered steel pipe piles on the other side, connected by a concrete cap. 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. Specific gate operation procedures would be developed during the PED phase. 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.

- **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, or the bathtub effect, caused by the storm surge wall.

- **Nonstructural measures:** In residential areas where construction of the storm surge wall would be impractical due to the topography of the peninsula or other existing constraints, nonstructural measures such as elevations and floodproofing could be applied. Neighborhoods that are largely equal to or higher than the proposed wall elevation, or separated from high-risk areas by high ground, have been identified for nonstructural measures. Those neighborhoods 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. 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 elevation measures would be applied to the Rosemont neighborhood due to the nature of the construction materials and techniques used in these communities.

- **Natural and Nature Based Features**: In association with the storm surge wall, oyster reef-based living shoreline sills would be constructed in some locations to reduce coastal storm impacts to natural shorelines and other resources seaward of the wall. The living shoreline sills would reduce erosion of existing wetland marsh, while reducing scour at the proposed storm surge wall. The living shorelines would also provide other environmental benefits. The reef-based living shoreline method/design would be determined during the PED phase.

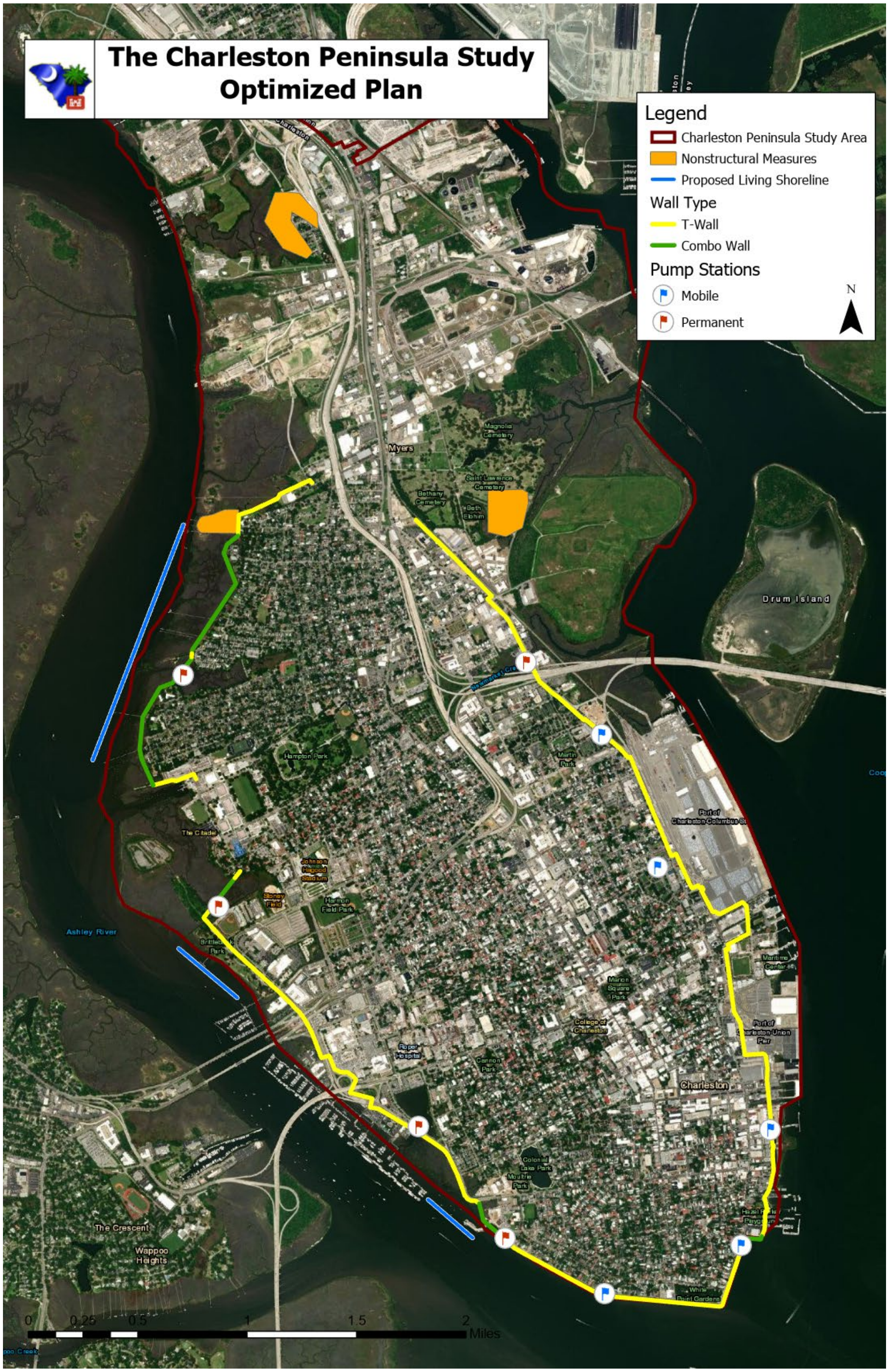

Figure *8-1*. The Tentatively Selected Plan.

8.2 Performance of the Tentatively Selected Plan

Figures 8-2 and 8-3 compare with and without-project conditions, using stillwater elevations. In the year 2082, without a project to address storm surge inundation, assuming an intermediate rate of sea level rise, a 4% Annual Exceedance Probability (AEP) (25-year recurrence interval) storm event would flood critical facilities and emergency access roads to elevation 9 feet NAVD88. Under the same scenario, a significant portion of historic structures and archaeological sites would be flooded to elevation 9 feet NAVD88 as displayed in Figure 8-2. With implementation of the TSP, critical facilities and historic resources would stay dry during the 4% AEP storm event. In the year 2082 assuming an intermediate sea level rise scenario, the 12ft NAVD88 storm surge wall would provide approximately a 2% AEP (50-year) level of performance.

Using an intermediate rate of sea level rise, there is potential for frequent, deep flooding, especially toward the end of the 50-year period of analysis. In anticipation of changing conditions, the TSP would improve the peninsula's ability to withstand and recover rapidly from storm surge events. The TSP is a critical component of improving the peninsula's resilience to storm surge inundation. The proposed storm surge wall would be built so that its elevation may be raised to further adapt to changing conditions if necessary.

8.3 Residual Risk

Residual risk is the risk of inundation in the study area after implementation of the recommended plan. It includes risks associated with the intended performance (non-breach) and risks associated with potential failure modes. The Charleston Peninsula Potential Failure Mode Analysis determined that the primary drivers of residual risk would be 1) the inability to install all gate closures in advance of inundation and 2) an overtopping event (specifically an overtopping event *without* a failure of the wall). From an economic perspective, the project performance of the TSP would be effective enough to reduce about 90% of the flood damages modeled in the Charleston Peninsula with only about 10% of potential flood damages remaining for the 50-year period of analysis.

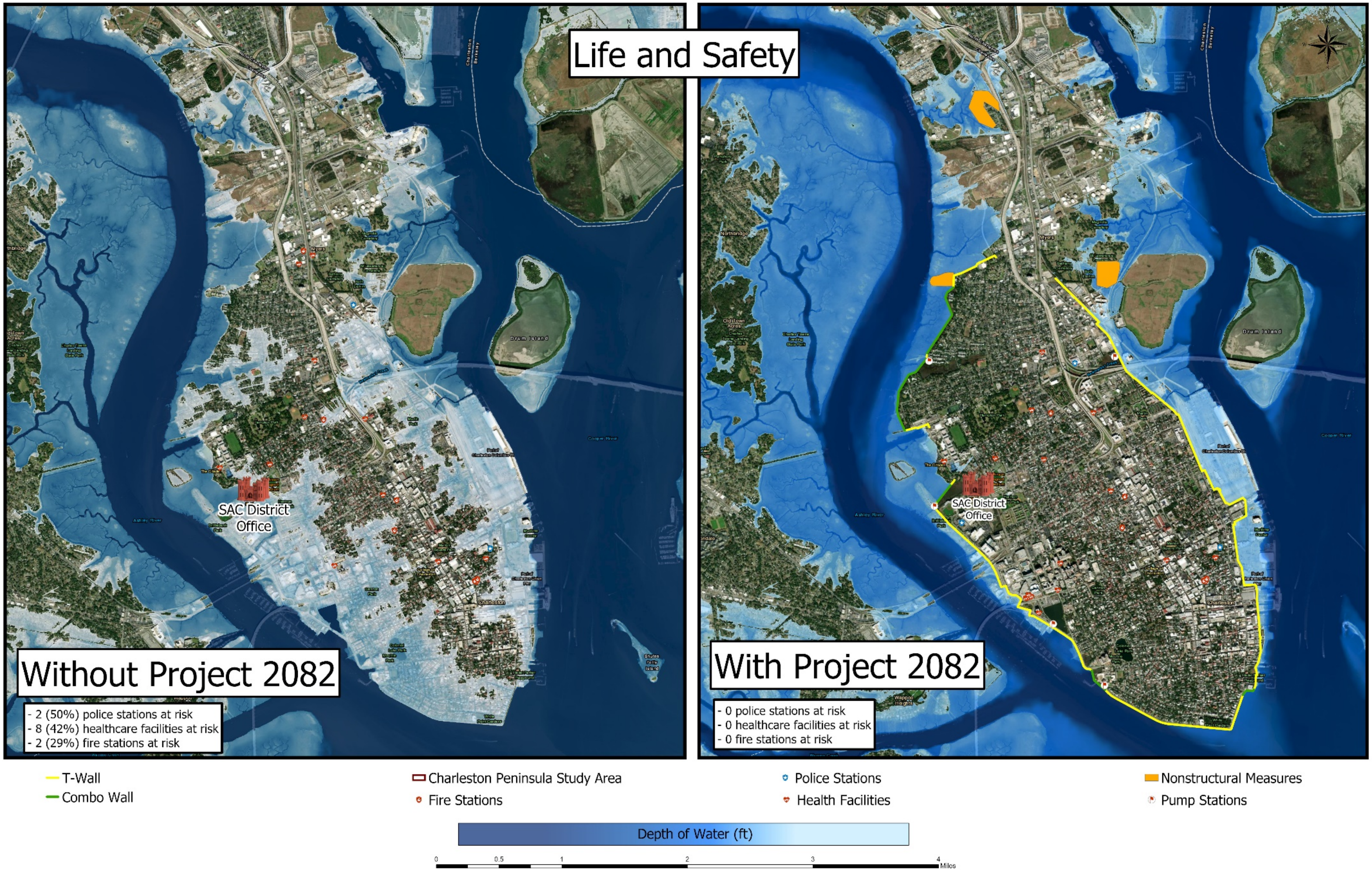
Life and Safety
Without Project 2082
- 2 (50%) police stations at risk
- 8 (42%) healthcare facilities at risk
- 2 (29%) fire stations at risk
SAC District Office
With Project 2082
- 0 police stations at risk
- 0 healthcare facilities at risk
- 0 fire stations at risk
T-Wall
Combo Wall
Charleston Peninsula Study Area
Fire Stations
Police Stations
Health Facilities
Nonstructural Measures
Pump Stations
Depth of Water (ft)
0
0.5
1
2
3
4
Miles

Figure 8-2. Inundation of critical facilities during 4% AEP storm event under the future without project scenario and the future with project scenario. All probabilities and water levels are based on stillwater elevations.

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

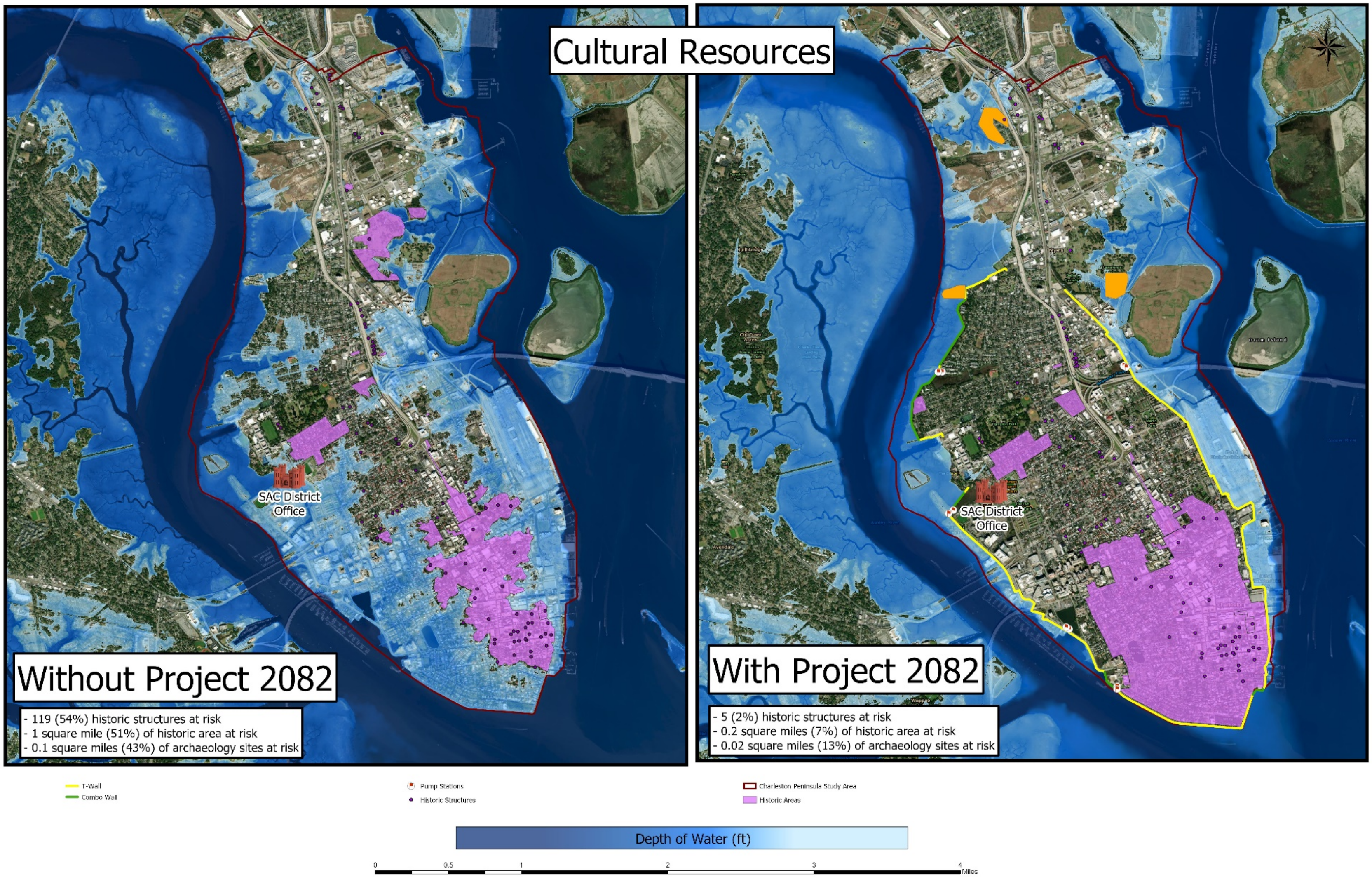

Figure 8-3. Inundation of historic properties during 4% AEP storm event under the future without project scenario and the future with project scenario. All probabilities and water levels are based on stillwater elevations.

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

8.4 Plan Economics and Cost Sharing

The project first cost, estimated on the basis of October 2022 price levels, is $1,098,718,000. Table 8-1 displays the economic costs and benefits of the Tentatively Selected Plan.

Table 8-1. Economic Costs and Benefits of the Tentatively Selected Plan ($1,000).

Cost/Benefit Item	Tentatively Selected Plan
Investment Costs	–
Project First Cost	$1,099,000
Interest During Construction	$ 146,000
Total Investment Cost	$1,245,000
Average Annual Cost[1]	–
Average Annual First Cost	$43,900
Annual OMRR&R[2] Cost	$ 3,000
Average Annual Annualized Costs	$46,900
Benefits[1]	–
Average Annualized Benefits	$479,000
Net Benefits	$432,100
BCR	10.2

[1]Costs are rounded in October 2021 price levels, 2.5% discount rate, and a 50-year period of analysis.
[2]Operation, Maintenance, Repair, Replacement, and Rehabilitation.

The estimated total project first cost for the TSP is $1,098,718,000. The Federal portion of the estimated first cost is $714,167,000 based on WRDA 1986 cost share formulas. The non-Federal portion of the estimated first cost is $384,551,000. Table 8-2 displays the cost share apportionment for the TSP.

Table 8-2. Preliminary Cost-Share Apportionment for Tentatively Selected Plan ($1,000). [1]

MCACES Account[2]	Item	Federal	Non-Federal	Total
01	Lands and Damages[2]	$0	$135,239	$135,239
02	Relocations[2]	$0	$14,810	$14,810
06	Fish & Wildlife	$27,399	$0	$27,399
11	Levees & Floodwalls	$624,125	$0	$624,125
13	Pumping Plant	$44,565	$0	$44,565
18	Cultural Resource Compliance	$85,846	$0	$85,846
19	Buildings, Grounds & Utilities	$65,725	$0	$65,725
30	Planning, Engineering & Design	$50,504	$0	$50,504

31	Construction Management	$50,504	$0	$50,504
–	**Subtotal**	**$948,669**	**$150,049**	**$1,098,718**
–	Non-Fed Cash Contribution	-$234,502	$234,502	–
–	**Total**	**$714,167**	**$384,551**	**$1,098,718**
–	Percentage	65%	35%	–

[1]Costs are in October 2021 price levels, 2.5% discount rate, and a 50-year period of analysis.
[2]Land and Damages and Relocation costs are the responsibility of the non-Federal sponsor and deducted from the cash contribution to meet the required 35% non-Federal cost share apportionment.

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 done. The TSP 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 7-1. During the optimization of the wall alignment after the release of the draft FR/EA in April 2020, efforts to avoid adverse effects 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. These are described in the Draft Mitigation Plan in Appendix F.

Significant adverse effects are expected to wetlands. However, as a result of compensatory mitigation, these effects will be reduced and mitigated to a negligible level.

Potentially significant adverse effects from the TSP are likely for visual and historic/cultural resources. Consideration of ways to reduce the adverse effects to these resources are continuing through the feasibility study and 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. 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 draft PA agreed to by the parties is included in Appendix D for review. In addition, the Corps anticipates entering into an MOU for the assessment of aesthetic (visual) resources with the City of Charleston to document their understanding of the path forward, including into any 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 TSP are described in Chapter 6 and some of them may not be fully avoided, as identified in CEQ regulations (40 C.F.R. § 1502.16).

To facilitate the construction of all of the proposed measures of the TSP, 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
- 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.
- Permanent loss of land, upland vegetation, or other environmental resources at the location of storm surge wall on land
- Temporary construction noise
- Temporary construction equipment, material stockpiles, and activity may interfere with the ability to enjoy activities at or views of aesthetic resources.
- Temporary and localized disruptions to traffic during construction
- Permanent reduction of wetlands and aquatic habitat where the storm surge wall would be constructed on land
- Permanent adverse effects to historic properties listed or eligible for listing in the National Register of Historic Places
- Permanent adverse impacts to significant aesthetic resources, unless mitigated during PED

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 TSP, "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 including 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 and life safety.

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 TSP would result in a minor irreversible use of fossil fuels to execute the construction of the TSP. While wetland resources would be fully lost in some locations, 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.

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 miles of storm surge wall, projects approximately 39 acres of parcels that may require real estate acquisition, relocation, permanent and temporary easements for construction of the structural and nonstructural measures of the TSP. 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 110 parcel ownerships to include 11 parcels to be acquired in fee, 205 temporary and perpetual easements, and 453 rights of entry for the construction of the TSP. A Gross Appraisal was 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 NFS will be required to purchase these lands using the appropriate standard estate.

Where possible, the PDT utilized publicly owned land to minimize take of private property. Areas within the Federal navigation servitude will not require the acquisition of real estate interests. 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, where navigational servitude is not sufficient.

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.

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 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 draft 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, including the incorporation of additional natural and nature-based solutions where appropriate. 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 TSP 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 PDT 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 TSP as appropriate to support sustainable solutions for coastal storm risk reduction.
- 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 Project Delivery Team (PDT) 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 PDT has maintained the project schedule and budget set forth by the Water Resources and Reform Development Act of 2014.
- The PDT pursued opportunities to minimize and avoid potential environmental impacts where possible. The PDT 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 PDT 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

This draft FR/EIS has been released for public and agency review for 45 days. Due to the coronavirus pandemic, alternatives to a public workshop are being considered. Visit the project website (https://www.sac.usace.army.mil/Missions/Civil-Works/Supplemental-Funding/Charleston-Peninsula-Study/) for more information and to submit comments electronically. The draft FR/EIS has also been submitted for Agency Technical Review. After completion of the public review period, comments will be considered and incorporated into the final FR/EIS as appropriate. Comments received during the public comment period, as well as responses to them, will be presented in an appendix to the report. The final FR/EIS will be provided to any public agency that provides comments on the draft FR/EIS

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, the project will enter the PED phase. The PDT has identified design tasks to complete during the feasibility phase as well as design tasks to complete during PED assuming successful approvals, authorization, and appropriation.

8.11.1 PED Tasks

Should the TSP be approved, recommended to Congress for implementation, authorized and appropriated by Congress, the following tasks will be completed during the PED phase.

1. Detailed surveys – there is insufficient detail in the topographic data to accurately place the wall and know impacts to things such as curbs along roadways.
2. Geospatial bathymetric and topographic data – coastal modeling was based on the FEMA model done in the second decade of the 21st century. Changes in bathymetry as well as topography should be evaluated to determine if there are changes to the hydrodynamic model and impacts of the proposed project.
3. Subsurface exploration – subsurface information will need to be gathered along the alignment. Along with determining stratigraphy, it will be important to know if there is any man-made fill or construction debris that may affect construction and pile installation.
4. Field surveys for the identification and evaluation of cultural resources.
5. Avoid, minimize, or mitigate adverse effects to cultural resources.
6. Implementation of Programmatic Agreement under NHPA for historic/cultural resources.
7. Process for aesthetic resources assessment as outlined in Corps/City MOU.
8. Wetland delineations and living shorelines site suitability surveys.
9. Finalize Draft Mitigation Plan.
10. Hazardous Waste Assessment – a Phase I site assessment will be conducted in select locations to determine the potential for hazardous waste within the proposed alignment of the storm surge wall.
11. Storm surge wall design - the proposed design will have a public review period to allow for comment on the latest renderings, alignment, and materials.

12. Seepage analysis for T-wall and combo-wall sections – seepage analysis will need to be completed to determine the proper depth of seepage cutoff walls and the uplift pressures on the T-wall footing.
13. Pile Design – the design of the piles will be required. The design will include selection of pile type (steel H-pile, concrete piles, micro piles, etc.) considering costs, drivability, vibration generation, constructability, and longevity (related to corrosion). In addition to typical pile design, pile driving generated vibrations will need to be evaluated. Both magnitude and distance travel will need to be determined. Maximum allowable vibration amplitudes along with construction monitoring requirements will be needed.
14. Lateral earth pressure – it is anticipated that in some locations, the wall will also act as a retaining wall. Appropriate lateral earth pressures will need to be determined to be used in the design of the retaining wall.
15. I-wall evaluation – there could be a cost savings potential if I-walls can replace T-walls and this should be evaluated along the project alignment where the exposed stem height is 4 feet or less.
16. Final interior hydrology analysis – for this Feasibility study the interior hydrology is based on the overland flow only. The subsurface drainage system is not considered. In PED phase the interior hydrology should be more accurate in determining impacts to ensure the pumps are adequately sized and strategically placed.
17. Boussinesq wave model for wave run-up – rough estimates of wave overtopping will be done in the Feasibility study, however, more accurate Boussinesq wave modeling should be done to determine the wave run-up along the final barrier wall.
18. Transportation Study - a transportation study will be done to assess the modifications to road widths and accessibility within the city to minimize real estate costs, reduce gates by rerouting access to side streets and potential impacts to structures.
19. Finalize gate closure procedure.
20. Safety Assurance Review/Type II Independent External Peer Review.
21. Operation and Maintenance Manual – an Operation and Maintenance Manual (O&M Manual) will be required once the project is constructed. Geotechnical input to the O&M Manual will be required during PED but mainly during and after construction.

CHAPTER 9 - Environmental Compliance and Commitments

This section addresses the primary Federal environmental laws, implementing regulations, and executive orders potentially applicable to the TSP. 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 United States Code [U.S.C.] § 4321 et seq.) provides a commitment that Federal agencies will consider, document, and publicly disclose the environmental effects of their actions. NEPA documents must provide detailed information regarding the purpose and need statement, the proposed action and alternatives, including the No Action Alternative, the environmental impacts of the alternatives, appropriate mitigation measures, and any adverse environmental impacts that cannot be avoided if the proposal is implemented. Agencies are required to demonstrate that decision makers have considered these factors prior to undertaking actions, which is outlined in a decision document like a Record of Decision for an environmental impact statement (EIS) such as this one.

This EIS (which has been integrated with USACE's Feasibility Report for the study) is the primary vehicle to achieve NEPA compliance for the proposed study. Before preparing this document, USACE published a Notice of Intent to prepare an EIS in the Federal Register on March 23, 2021 and held a public scoping meeting virtually, due to concerns of on the ongoing COVID-19 pandemic. The 45-day public review period on the draft EIS provides disclosure of the environmental effects of the alternatives to the public. After review and consideration of agency and public comment on the draft FR/EIS, USACE will proceed to preparation of a final FR/EIS. Following the 30-day public review of the final EIS, USACE decision makers would sign a Record of Decision, outlining the rationale for their 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) and informal consultation is ongoing.

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 determination in a letter dated August 12, 2021. Relevant documentation is included in Appendix F - Environmental. Consultation with NMFS is expected to be completed prior to signing of the Record of Decision.

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 Coordination Act Report (CAR) was jointly prepared by USACE, USFWS, and NMFS and included as 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 measure has been proposed as coordinated with USFWS through ongoing communications.

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 its compliance with the Endangered Species Act. For bottlenose dolphins, 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 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 this draft FR/EIS. An EFH Assessment is currently being prepared and will be submitted to NMFS. This consultation with NMFS is ongoing and 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 APE 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 Federal Water Pollution Control Act of 1972 (33 U.S.C. § 1251 et seq.) is more commonly referred to as the Clean Water Act (CWA). This act 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.

A pre-certification meeting with the South Carolina Department of Health and Environmental Control, Bureau of Water was held May 21, 2021. A Section 401 water quality certification has not been requested by USACE yet but would be obtained for project-specific structural measures, as required, prior to construction.

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. The 404 (b)(1) evaluation will be included in the final FR/EIS.

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 TSP are described in Section 7.12

9.8 Rivers and Harbors Appropriation Act of 1899

Section 10 of the Rivers and Harbors Appropriation Act of 1899 (33 U.S.C. § 403 et seq.), commonly known as the Rivers and Harbors Act, 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. Section 9 of the Rivers and Harbors Act (33 U.S.C. § 491) grants the authority to approve the construction or modification of bridges over any of the navigable waters of the U.S. to the U.S. Coast Guard.

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 wall and installation of NNBF .as part of the federal action 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 contamination is found 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.

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 significant 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 TSP. The anticipated effects and environmental compliance associated with the TSP and the No Action Alternative are summarized in Chapters 6 and 9.

As it is currently conceptualized, the 12ft NAVD88 storm surge wall would provide approximately a 50-year storm surge dynamic still water elevation level of performance in the year 2075 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 tentatively selected plan 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 TSP (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.

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 approximately 40 acres of salt marsh wetland that would be significantly adversely affected by the Federal action, of which 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

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 Perimeter Wall would not cause disproportionately high and adverse effects on any environmental justice populations in accordance with the provisions of Executive Order 12898.

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 Perimeter Wall would not introduce risk that disproportionately affect children. Depending upon the final placement/footprint of the perimeter wall, determined during PED, safety, security, and noise and air pollution reduction benefits could be realized at Sanders-Clyde Elementary School.

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.

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 in provided in Appendix D.

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.

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 Perimeter Wall improves the resilience of Charleston Peninsula to the impacts from climate change and storm surge. The living shorelines proposed in the federal action 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.

CHAPTER 10 - Recommendation

I propose that the features designed to reduce coastal storm risk identified as the Recommended Plan in the Charleston Peninsula Coastal Flood 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 Project Partnership Agreement (PPA) will be prepared, coordinated, and executed subsequent to the approval of this document. The PPA reflects the recommendations of the Feasibility Study and serves as the agreement for the next phase of the project. As the non-Federal project partner, the City of Charleston must comply with all applicable Federal laws and policies and other requirements, including, but not limited to:

A. In a cost sharing coordination with the Federal Government, who shall provide 65% of the initial project cost, provide 35% of the costs of project construction:

> 1. provide all lands, easements, rights of way and relocations (LERR), including suitable borrow areas, uncontaminated with hazardous and toxic wastes, and perform or ensure performance of any relocations determined by the Federal Government to be necessary for the initial construction, operation, and maintenance of this project.
>
> 2. perform, or cause to be performed, any investigations for hazardous substances as are determined necessary to identify the existence and extent of any hazardous substances regulated under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), Public Law (PL) 96-510, as amended, 42 U.S.C. 9601-9675, that may exist in, on, or under lands, easements, or rights-of-way that the Federal Government determines to be required for the construction, operation, and maintenance of the Project. However, for lands that the Federal Government determines to be subject to the navigational servitude, only the Federal Government shall perform such investigations unless the Federal Government provides the non-Federal project partner with prior specific written direction, in which case the non-Federal project partner shall perform such investigations in accordance with such written direction.
>
> 3. coordinate all necessary cleanup and response costs of any CERCLA-regulated materials located in, on, or under lands, easements, or rights-of-way that the Federal Government determines to be necessary for the construction, operation, or maintenance of the project.
>
> 4. cost-share of the cost of mitigation and data recovery activities associated with historic preservation, that are in excess of 1 percent of the total amount authorized to be appropriated for the project.

B. For fifty years, operate, maintain, repair, replace, and rehabilitate the completed project, or functional portion of the project, at no cost to the Government, in a manner compatible with the project's authorized purposes and in accordance with applicable Federal and State laws and any specific directions prescribed by the Government in the Operations, Maintenance, Replacement, Repair and Rehabilitation (OMRR&R) manual and any subsequent amendments thereto.

C. Provide the Federal Government a right to enter, at reasonable times and in a reasonable manner, upon property that the non-Federal project partner, now or hereafter, owns or controls for access to the project for the purpose of inspection, and, if necessary after failure to perform by the non- Federal project partner, for the purpose of completing, operating, maintaining, repairing, replacing, or rehabilitating the project. No completion, operation, maintenance, repair, replacement, or rehabilitation by the Federal Government shall operate to relieve the nonFederal project partner of responsibility to meet the non-Federal project partner's obligations, or to preclude the Federal Government from pursuing any other remedy at law or equity to ensure faithful performance.

D. Hold and save the United States free from all damages arising from the construction, operation, maintenance, repair, replacement, and rehabilitation of the project and any projectrelated betterments, except for damages due to the fault or negligence of the United States or its contractors.

E. Keep, and maintain books, records, documents, and other evidence pertaining to costs and expenses incurred pursuant to the Project in accordance with the standards for financial management systems set forth in the Uniform Administrative Requirements for Grants and Cooperative Agreements to State and Local Governments at 32 Code of Federal regulations (CFR) Section 33.20.

F. As between the Federal Government and the non-Federal project partner, the non-Federal project partner shall be considered the operator of the project for the purpose of CERCLA liability. To the maximum extent practicable, operate, maintain, repair, replace and rehabilitate the project in a manner that will not cause liability to arise under CERCLA.

G. Comply with the applicable provisions of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1790, Public Law 91-646, as amended by Title IV of the Surface Transportation and Unifom1 Relocation Assistance Act of 1987 (Public Law 100-17),and the Unifom1 Regulations contained in 49 CFR Part 24, in acquiring lands, easements, and rights-of-way, required for the construction, operation, and maintenance of the project, including those necessary for relocations, borrow materials, and dredged or excavated material disposal, and inform all affected persons of applicable benefits, policies, and procedures in connection with said Act.

H. Comply with all applicable Federal and State laws and regulations, including, but not limited to, Section 601 of the Civil Rights Act of 1964, Public Law 88-352 (42 U.S.C. 2000d), and Department of Defense directive 5500.11 issued pursuant thereto, as well as Army regulation 600- 7, entitled "Nondiscrimination on the Basis of Handicap in Programs and Activities Assisted or Conducted by the Department of the Army."

I. Participate in and comply with applicable Federal flood plain management and flood insurance programs and comply with the requirements in Section 402 of the Water Resources Development Act of 1986, as amended.

J. Not less than once each year inform affected interests of the extent of storm risk management afforded by the project.

K. Publicize flood plain information in the area concerned and provide this information to zoning and other regulatory agencies for their use in preventing unwise future development in the flood plain and in adopting such regulations as may be necessary to prevent unwise future development and to ensure compatibility with the degree of storm risk management provided by the project.

L. Prevent obstructions of or encroachments on the project (including prescribing and enforcing regulations to prevent such obstructions or encroachments) which might hinder its operation and maintenance, or interfere with its proper function, such as any new development on project lands or the addition of facilities which would degrade the benefits of the project.

M. Provide and maintain necessary access roads, parking areas, and other public use facilities, open and available to all on equal terms.

N. Comply with Section 221 of Public Law 91-611, Flood Control Act of 1970, as amended, and Section 103 of the Water Resources Development Act of 1986, Public Law 99-662, as amended, which provides that the Secretary of the Army shall not commence the construction of any water resources project or separable element thereof, until the non- Federal project partner has entered into a written agreement to furnish its required cooperation for the project or separable element.

O. Quarterly and after storm events, perform surveillance of the project to determine project maintenance or repair needs and provide the results of such surveillance to the Federal Government.

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.

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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 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. Environmental Studies	>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
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/ Mechanical Engineer	13	BS – Mechanical Engineering	Mechanical utilities including central energy plans and distributed utilities such as steam/condensate, hot water/chilled water, compressed	USACE - SAC	Engineering Sub-Appendix

Name	Title	Years of Experience	Degree	Experience/Expertise	Agency	EIS Areas Authored
				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

CHAPTER 12 - References

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