US Army Corps of Engineers

CHARLESTON PENINSULA, SOUTH CAROLINA

A COASTAL FLOOD RISK MANAGEMENT STUDY

DRAFT FEASIBILITY REPORT / ENVIRONMENTAL ASSESSMENT

APRIL 2020

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

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Executive Summary

This draft integrated Feasibility Report and Environmental Assessment (FR/EA) documents the planning process to address coastal storm risk for the Charleston Peninsula. While the Charleston Peninsula also experiences flooding from rainfall, the U.S. Army Corps of Engineers (USACE) has not been authorized to specifically address that issue, although it will be included in the coastal storm risk analysis. USACE and the City of Charleston are sponsoring this study. This integrated report meets the environmental review and disclosure requirements of the National Environmental Policy Act (NEPA). USACE is the lead agency under NEPA.

The Charleston Peninsula is approximately 8 square miles, located on the coast of South Carolina between the Ashley and Cooper Rivers. The two rivers join to form the Charleston Harbor, which is a natural tidal estuary sheltered from the Atlantic Ocean by barrier islands. The Charleston Peninsula is the historic core and urban center of the City of Charleston and is home to approximately 40,000 people.

Charleston is a highly urbanized community on a relatively flat peninsula with nearly all areas 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 the city at risk of flooding from hurricanes, tropical storms, tropical depressions, and nor'easters. Exacerbating the 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 reduce damages from coastal storm surge inundation, the peninsula's vulnerability to coastal storms is expected to increase over time. This report documents the development and evaluation of coastal storm risk management measures and alternative plans to address the resulting flooding problem for Charleston's residents, industries, and businesses.

ES.1 Plan Formulation

Plan formulation is an iterative process by which USACE planners and Project Delivery Teams (PDT) develop and evaluate alternative plans to address a specific water resources problem. To begin the Charleston Peninsula planning process, the 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. In addition to the planning charrettes, City of Charleston technical staff also regularly attended PDT meetings and provided key input into the plan formulation process.

After multiple iterations of the planning process, the following problem statements were identified for the Charleston Peninsula:

- Storm surge inundation on the Charleston Peninsula places people at risk, including the potential for loss of life and declines in public health.
- Access to critical facilities, emergency services, and evacuation routes is limited or cut off entirely during coastal storm surge events on the Charleston Peninsula.
- 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.

Following the definition of flood related problems, the PDT developed the following study objectives, opportunities, and constraints with input from stakeholders. The study objectives are as follows:

- Reduce risk to human health and safety from coastal storm surge inundation on the Charleston Peninsula through the year 2075.
- Reduce economic damages resulting from coastal storm surge inundation on the Charleston Peninsula through the year 2075.

Opportunities include the following:

- Recreation features such as a walkway along the river and river access.
- Natural areas including open space and stream restoration.
- Beneficial use of dredged materials.
- Multi-modal transportation, such as bicycle pathways or small boat traffic via canals.
- Education and research.

Constraints include the following:

- Minimize adverse effects to the historic district and structures.
- Minimize adverse effects to threatened and endangered species and Essential Fish Habitat.
- Avoid high cost modifications to Interstate 26 and U.S. Route 17, which are also hurricane evacuation routes.
- Avoid encroaching on navigation channels in the Charleston Harbor and the Ashley and Cooper Rivers.
- Avoid adverse impacts to Coast Guard, port, and marina, operations.

Various management measures were identified to achieve planning objectives, take advantage of identified opportunities, and avoid planning constraints. Multiple types of management measures were considered, including structural, nonstructural, and natural or nature based features. Management measures were subjected to an initial evaluation assessment based on four evaluation criteria as prescribed by *The Economic and Environmental Principles and Guidelines for Water and Land Related Resources Implementation Studies* (*Principles and Guidelines*). After the initial assessment, management measures were combined into alternative plans using formulation strategies. For this study, the following strategies were used to formulate 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.
- Storage – This strategy focused on measures that would store floodwaters during storm events then release them after the peak event had passed. It was determined that storage by itself would not address the storm surge inundation, however it could address rainfall runoff behind a barrier.
- Conveyance – This strategy focused on measures that would increase the ability of existing flood structures to convey floodwaters or construct new flood structures to convey floodwaters. Since the study area is a peninsula, a "conveyance only" alternative would not address storm surge inundation.
- 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.
- Historic – This strategy focused on restoration of historic creeks and streams as a method of naturally moving floodwaters from the peninsula.
- 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.

The first iterations of the planning process resulted in seven alternative plans plus the No Action Alternative. Natural and nature based features (NNBFs) such as living shorelines were originally included in some of the alternatives, but after further consideration and discussions with local experts, it was decided they would not be effective in addressing storm surge inundation, which is the primary purpose of the study. However, NNBFs could contribute to reducing adverse impacts that may result from some of the measures and are thus proposed in the draft mitigation plan.

The initial array of alternatives are displayed in Tables ES-1 and ES-2 below. Several management measures were repeated across the alternatives, but for the sake of brevity, are not described in the table each time (see Section 3.3 for full descriptions of the initial array of alternatives). Table ES-1 focuses on the defining measure of each alternative rather than comprehensive descriptions and qualitatively assesses how well each alternative meets study objectives without violating constraints. Table ES-2 displays how well each alternative met the four evaluation criteria from the *Principles and Guidelines* and identifies the two action alternatives that were carried forward into the final array in addition to the No Action Alternative.

Table ES-1. Assessment of How Well the Initial Array of Alternatives Meet Study Objectives.

Initial Array of Alternatives		
Alternative	**Defining Measures**	**Assessment**
No Action	• Not applicable	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.
1. Perimeter Protection	• Storm surge wall or levee along perimeter of the peninsula	The strategically placed wall or levee would reduce damages from storm surge inundation, reduce risk to human life and safety, and maintain access to critical facilities, emergency services, and evacuation routes by diverting storm surge water from the peninsula. This alternative meets study objectives.
2. Perimeter Protection + Nonstructural	• Alternative 1 + nonstructural measures	In addition to the storm surge wall or levee, nonstructural measures would be applied to residential structures that would continue to incur damages from storm surge after the wall is constructed. Nonstructural measures include elevation, floodproofing, and buyouts. This alternative meets study objectives.
3. Perimeter Protection + Nonstructural + Wave Attenuator	• Alternative 2 + wave attenuator	In addition to the storm surge wall or levee and nonstructural measures, a wave attenuation structure in the Charleston Harbor would reduce loading on the Battery Wall and reduce the effect of waves overtopping the Battery during coastal storm events. This alternative meets study objectives.
4. Nonstructural Only	• Buyout of all structures in sea level rise footprint • Elevate/floodproof structures in 100 year floodplain	This alternative only includes nonstructural measures and would not address flooding that limits access to critical facilities, emergency services, and evacuation routes. It would not meet the objective of reducing risk to human health and safety. A buyout of all structures in the SLR footprint would also violate the constraint of minimizing adverse effects to the historic district and structures.
5. Historic Creeks	• Storm surge wall along the perimeter of the peninsula. • Restore historic creek beds with pump outfalls at storm surge wall	Restoring historic creek beds would primarily address internal drainage issues. This measure would also be very costly relative to other measures due to associated real estate, and construction of bridges and utility corridors. Screening the historic creeks measure makes this alternative the same as Alternative 1, therefore the entire alternative is eliminated.

Initial Array of Alternatives		
Alternative	**Defining Measures**	**Assessment**
6. Parks & Recreation	• Recessing high ground city owned parks • Elevate walls on Colonial Lake and Long Lake for stormwater detention • Canals along East Battery, Murray Boulevard, and Lockwood Drive	Parks near the shore are at low elevations with high groundwater levels, making them ineffective as excavated 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. Canals block access to private property and would require large footprints and bridges to maintain traffic flow. These measures primarily address internal drainage issues and tidal flooding. This alternative does not meet the objectives of reducing economic damages and risk to human health and safety resulting from storm surge inundation.
7. Storage	• Adding above and/or belowground cisterns • Provide detention areas under parking lots and roads (elevating when needed) • Restore historic creek beds	Because the volume of the ocean is effectively unlimited, cisterns would not reasonably reduce coastal storm surge risk. Assuming an earthen base, the footprint of a raised road would be large and require considerable real estate. Additional cost drivers include modifications to access roads and existing structures. This alternative does not meet the objectives of reducing economic damages and risk to human health and safety resulting from storm surge inundation.

Table ES-2. Screening of Action Alternatives Based on Evaluation Criteria from the Principles and Guidelines.

Alternative	Completeness[1]	Effectiveness[2]	Efficiency[3]	Acceptability[4]	Result
1. Perimeter Protection	High	Medium	Medium	Medium	Screen
2. Perimeter Protection + Nonstructural	High	High	High	Medium	Retain
3. Perimeter Protection + Nonstructural + Wave Attenuator	High	High	High	Medium	Retain
4. Nonstructural Only	High	Low	Low	Low	Screen
5. Historic Creeks	High	Medium	Medium	Medium	Screen
6. Parks & Recreation	High	Low	Low	Medium	Screen
7. Storage	High	Low	Low	Medium	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.

ES.2 Final Array of Conceptual Alternatives

Based on the screening process described above, the final array of alternatives includes Alternative 2, Alternative 3, and the No Action Alternative as described below.

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.

Alternative 2

The management measures included in this alternative are:

- Storm surge wall along the perimeter of the Peninsula (approximately 7.8 miles)
- Nonstructural measures (approximately 100 structures)

The most effective and most efficient type of structure was determined to be a T-wall on land and a combination wall in the marsh. The storm surge wall would be constructed along the perimeter of the peninsula to reduce damages from storm surge inundation. It would be strategically aligned to minimize impacts where possible to existing wetland habitat, cultural resources, and private property. The wall would be strategically located to allow for continued operation of all ports, marinas, and the Coast Guard Station. The wall would tie into high ground as appropriate, including 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. Sections of the new wall would be fitted with walkways and railings to provide additional recreation opportunities in the study area. This alternative would include permanent and temporary pump stations to the extent justified by USACE policy, as well as pedestrian, vehicle, railroad, boat, and storm (tidal flow) gates.

Where placed 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 (also referred to as a 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. To withstand earthquakes, pilings for both wall types would be 50 to 70 feet deep to tie in to 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 easement during construction.

A preliminary analysis showed that net economic benefits for a wall at elevation 12 feet NAVD88 were higher than net benefits for a wall at elevation 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 raising the Ashley River Bridge (U.S. Route 17) which would be very costly, 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 at 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 newly constructed seawall would have to be completely demolished and rebuilt, which would be a significant additional cost. Additional analysis during the course of this study 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 within the study area that would continue to incur damages from storm surge inundation after the wall has been constructed. Nonstructural measures considered include relocations, buyouts, elevations, and floodproofing. Additional analysis during the course of this study will determine the specific application of these measures should the alternative be selected.

Alternative 3

The management measures included in this alternative are:

- Wave attenuation structure offshore of the Battery (approximately 4,000 feet long)
- Storm surge wall along the perimeter of the Peninsula (approximately 7.8 miles)
- Nonstructural measures (approximately 100 structures)

A wave attenuation structure would be constructed in Charleston Harbor to reduce loading on the Battery Wall and reduce the effect of waves overtopping the Battery during storm events. For the purposes of alternative evaluation, comparison, and impact analysis, the wave attenuation structure was analyzed as a breakwater made of granite rock, at an elevation of 16.2 feet NAVD88, with the landward toe placed approximately 230 feet from the shoreline. The structure would be aligned to be parallel with the shoreline, to avoid encroachment into federal channels in the Charleston Harbor and Ashley River. Additional analysis over the course of this study will determine the optimized material type, placement, length, and height of the structure should this alternative be selected.

The storm surge wall along the perimeter of the Peninsula and nonstructural measures in this alternative would adhere to the same constraints and assumptions as described in Alternative 2.

ES.3 Comparison of the Final Array

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 each alternative in the final array. Alternative 3 was identified as the plan that reasonably maximizes net National Economic Development (NED) benefits, consistent with protecting the Nation's environment. Therefore, Alternative 3 (Figure ES-1) has been identified as both the NED plan and the Tentatively Selected Plan (TSP).

Table ES-3. Costs and Benefits of the Final Array ($1,000).

Cost/Benefit Item	Alternative 2	Alternative 3
Investment Costs		
Project First Cost	$1,416,989	$1,753,804
Interest During Construction	$210,818	$260,929
Total Investment Cost	$1,627,807	$2,014,733
Average Annual Cost*		
Average Annual First Cost	$60,295	$74,628
Annual O&M Cost	$5,594	$5,594
Average Annual Annualized Costs	$65,889	$80,222
Benefits*		
Average Annualized Benefits	$153,858	$174,639
Net Benefits	$87,968	$94,418
BCR	2.3	2.2

*First costs and Benefits were annualized using the FY21 discount rate of 2.75% and a 50-year period of analysis.

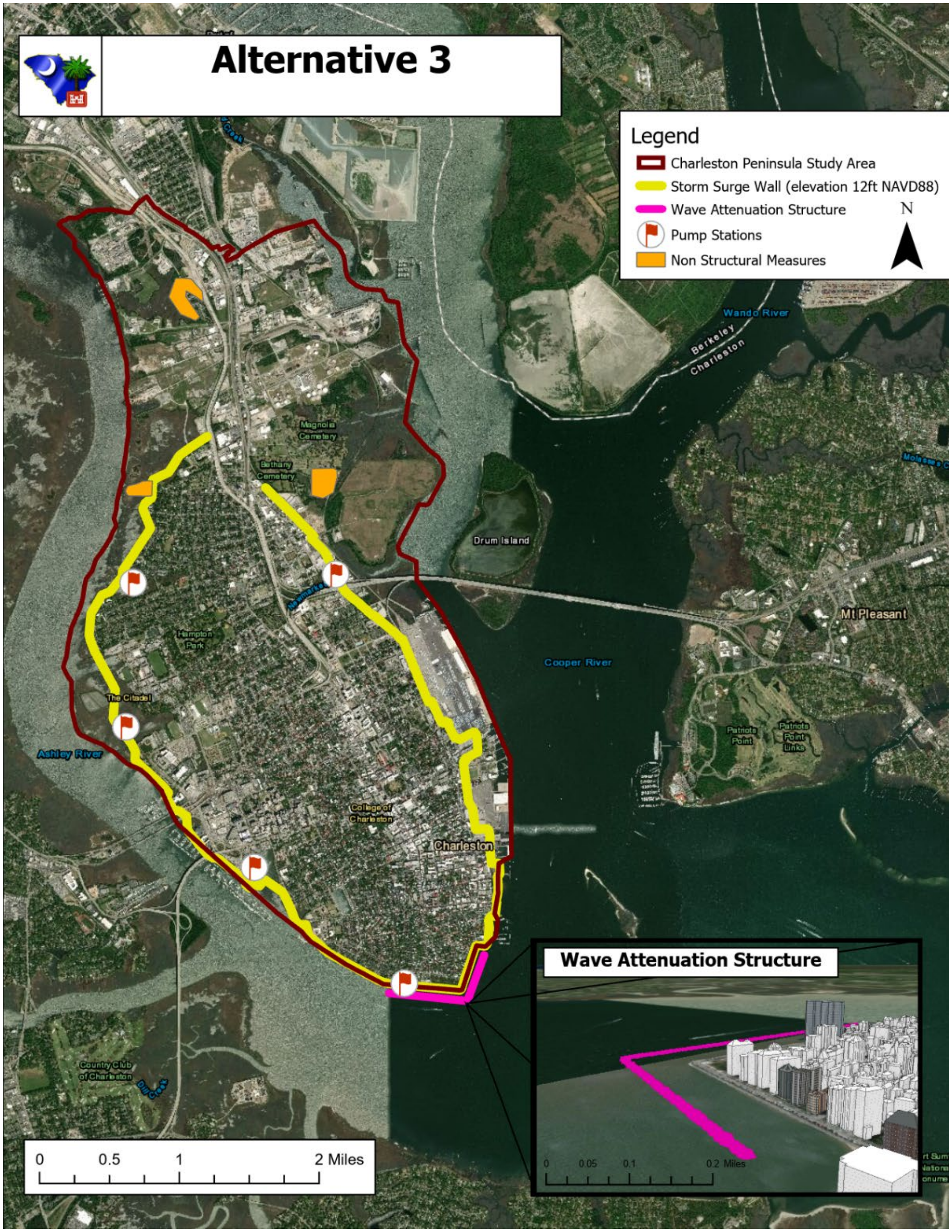

Figure ES-1. The National Economic Development and Tentatively Selected Plan. Official mapping product of the Management Support Branch, Charleston District, USACE

ES.4 Features of 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. 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 continued operation of all ports, marinas, and the Coast Guard Station. The wall would tie into high ground as appropriate, including 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 storm surge wall would also includes multiple pedestrian, vehicle, railroad, boat, and storm (tidal flow) gates. Typically, the gates would remain open, and only be closed when the National Weather Service predicts major flooding for the Charleston Peninsula. Major flooding is currently defined as a storm surge equal to or greater than 8 feet above MLLW or 4.86 feet NAVD88. When major flooding is expected, storm gates would be closed at low tide, in order to keep the rising tide levels from taking storage needed for the associated rainfall. For the vehicular, pedestrian, and railroad gate closings, timing of the closure would be dependent on evacuation needs and anticipated arrival of rising water levels. Gate operation procedures will be refined throughout the study and design 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. **Recreation Features:** Sections of the new wall would be fitted with walkways and railings to provide additional recreation opportunities in the study area. Where possible, the TSP would be modified to adhere to the visual aesthetic of the city, however those additional costs would be the responsibility of the non-Federal sponsor.

3. **Interior Drainage Facilities:** This alternative would include interior drainage facilities, such as permanent and temporary pump stations, to the extent they are justified under USACE policy.

4. **Wave attenuation structure offshore of the Battery:** A wave attenuation structure would be constructed in Charleston Harbor. The purpose of the structure is to reduce loading on the Battery Wall and reduce the effect of waves overtopping during storm events. The structure would be aligned to be parallel with the shoreline and to avoid encroachment into federal channels in the Charleston Harbor and Ashley River.

5. **Nonstructural measures:** In areas where structures would continue to incur damages from storm surge after the wall has been constructed, nonstructural measures such as relocations, buyouts, elevations, and floodproofing could be applied.

ES.5 Environmental Impacts and Mitigation

Because the Charleston Peninsula is highly urbanized, there are not extensive natural resources present. There are a few small tidal creeks, mudflats, and saltmarshes around the perimeter of the peninsula. All of the tidal creeks and saltmarsh on the peninsula are also Essential Fish Habitat (EFH). Threatened and endangered species present in the Charleston Harbor include the West Indian manatee, Atlantic and shortnose sturgeon, and several species of sea turtles. There are no known populations of Federally-listed threatened and endangered terrestrial species on the peninsula, and no designated Critical Habitat. 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 is placed in the marsh. USACE is working with federal and state natural resource agencies to fully assess and minimize these impacts. As project designs are refined and optimized, impacts to saltmarshes will continue to be minimized and, in some cases, avoided by moving the wall onto the land. Living shorelines are being proposed in some locations to reduce scouring from the storm surge wall, stabilize banks, and trap sediments to build up the marsh, promoting overall marsh resilience. The remaining impacts to saltmarshes that cannot be avoided or minimized would be addressed through compensatory mitigation. A Draft Mitigation Plan has been prepared and is included as an appendix to this report. The wave attenuating feature is expected to have minor impacts on natural resources, including listed species.

There would be visual effects from the storm surge wall and wave attenuating structure since they will be permanent and visible on land and/or water. As project designs are refined and optimized, impacts to the viewshed will continue to be minimized through the inclusion of aesthetic and recreational features that preserve the city's cultural and historic nature.

Adverse effects are anticipated for historic and cultural resources including potential acquisition, demolition, modification of historic structures; viewshed and sight line impacts to historic districts; and disturbance of terrestrial and submerged archaeological sites. There is the potential for finding submerged resources in the area off the Battery where the proposed wave attenuating feature is located because that area is part of the Charleston Harbor Naval Battlefield.

As project designs are refined and optimized, impacts to historic and cultural resources will 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. Pursuant to 54 USC 306108, § 800.4(b)(2), and 36 CFR 800.14(b)(1)(ii), 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 Preconstruction, Engineering and Design (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 sent for review by signatories (State Historic Preservation Office, National Park Service, Advisory Council on Historic Preservation) and concurring parties (Historic Charleston Foundation, Preservation Society of Charleston, Catawba Indian Nation).

The study has also identified a number of potential beneficial effects on the environment that would result from reducing storm surge flooding on the peninsula. Reducing the risk of storm surge flooding would have substantial beneficial effects on human safety, and historic and cultural resources, as well as transportation, recreation, and land use.

The majority of the adverse environmental effects assessed in this integrated FR/EA are considered to be minor, a few are negligible, and a few appear at this stage to be significantly adverse, absent mitigation. However, important avoidance and minimization measures will continue to be optimized, and compensatory mitigation measures will be taken to ensure that the adverse impact is less than significant. Therefore, a mitigated Finding of No Significant Impact (FONSI) has been drafted and is included at the end of this report.

ES.6 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 project. The following issues were identified as a result of public scoping, stakeholder engagement, and conduct of the environmental review.

Visual Impacts

The Charleston Peninsula is a scenic tourist destination with a high concentration of historic and cultural resources and the construction of a storm surge wall and wave attenuator would change views of the water from land and conversely of the cityscape from the water. In some places this change would have no adverse effect, and in others it would. A preliminary visual resource analysis is included in Appendix F. The analysis will be refined during the feasibility design phase and used to inform potential measures to minimize adverse effects to visual resources.

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 4. For example, construction will be limited to day time hours to reduce noise and detours will be made available.

This draft FR/EA is available for public review from April 20 – June 20, 2020. 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. All comments received during the public review period will be considered and incorporated into the final FR/EA, as appropriate. A comment and response appendix will be included in the final FR/EA.

ES.7 Estimated Cost and 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/EA.

Table ES-4. First Cost of Tentatively Selected Plan ($1,000).[1]

MCACES Account[2]	Item	Tentatively Selected Plan
01	Lands and Damages	$107,308
02	Relocations	$22,218
06	Fish & Wildlife	$149,201
10	Breakwater & Seawalls	$287,526
11	Levees & Floodwalls	$756,716
13	Pumping Plant	$167,098
14	Recreation Facilities	$85,562
18	Cultural Resource Compliance	$5,902
39	Buildings, Grounds & Utilities	$19,634
	Construction Estimate Totals	**$1,601,165**
30	Planning, Engineering & Design	$76,319
31	Construction Management	$76,319
	Project Total Cost	**$1,753,804**

[1]Costs are in October 2020 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."

Table ES-5 below shows the preliminary cost apportionment for the TSP. The non-Federal sponsor is responsible for all Lands, Easements, Rights of Way, Relocations, and Disposal Site (LERRD) costs. The non-Federal share is 35% of the total project cost.

Table ES-5. Preliminary Cost-Share Responsibilities for the Tentatively Selected Plan ($1,000).[1]

MCACES Account[2]	Item	Federal	Non-Federal	Total
01	Lands and Damages	$0	$107,308	$107,308
02	Relocations	$0	$22,218	$22,218
06	Fish & Wildlife	$149,201	$0	$149,201
10	Breakwater & Seawalls	$287,526	$0	$287,526
11	Levees & Floodwalls	$756,716	$0	$756,716
13	Pumping Plant	$167,098	$0	$167,098
14	Recreation Facilities	$85,562	$0	$85,562
18	Cultural Resource Compliance	$5,902	$0	$5,902
39	Buildings, Grounds & Utilities	$19,634	$0	$19,634
30	Planning, Engineering & Design	$76,319	$0	$76,319
31	Construction Management	$76,319	$0	$76,319
	Subtotal	**$1,624,277**	**$129,526**	**$1,753,804**
	Non-Fed Cash Contribution	-$484,305	$484,305	
	Percentage	65%	35%	
	Total	**$1,139,972**	**$613,831**	**$1,753,804**

[1]Costs are in October 2020 price levels, 2.75% discount rate, and a 50-year period of analysis.

The estimated first cost of the Tentatively Selected Plan is $1,753,804,000 (October 2020 price levels). The cost share apportionment is 65% Federal and 35% non-Federal. The Federal portion of the estimated first cost is $1,139,972,600. The non-Federal sponsor portion of the estimated first cost is $613,831,400. The non-Federal sponsor will agree to provide all lands, easements, rights-of-way, relocations, and suitable borrow and disposal areas. The non-Federal sponsor will 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.

Chapter 1 – Study Information

The City of Charleston and the United States Army Corps of Engineers (USACE) are co-sponsoring this Coastal Storm Risk Management Feasibility Study. The City and USACE signed a Feasibility Cost-Sharing Agreement on October 10, 2018. The 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). This draft integrated Feasibility Report and Environmental Assessment (FR/EA) documents the planning process to address coastal storm risk for the Charleston Peninsula. This integrated report meets the environmental review and disclosure requirements of the NEPA.

The Charleston Peninsula Coastal Flood Risk Management Feasibility Study is one of multiple Coastal Storm Risk Management (CSRM) studies in process throughout the Nation, including 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.

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 22 April 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.

1.2 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 city has undergone dramatic shoreline changes, predominantly 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.

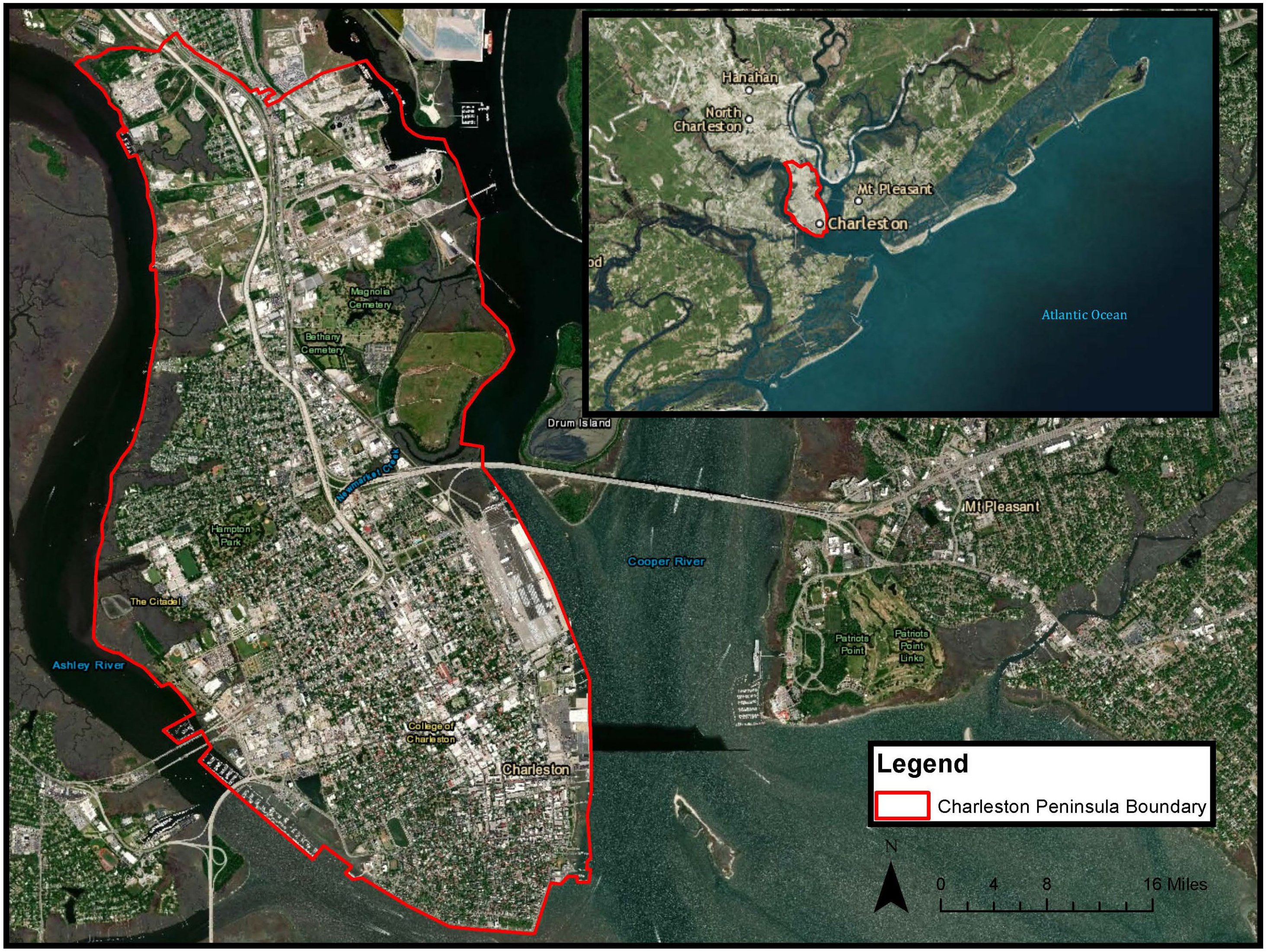

Figure 1-3. Study Area.
Official mapping product of the Management Support Branch, Charleston District, USACE

Figure 1-4. Charleston, South Carolina shoreline in 1849. Source: Wikimedia Commons.

1.3 Purpose and Scope

The purpose of the Charleston Peninsula Coastal Flood Risk Management Study is to investigate and recommend potential structural and nonstructural solution sets to reduce 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 study period. Without a plan to reduce damages from coastal storm surge inundation, the peninsula's vulnerability to coastal storms is expected to increase over time.

The primary focus of this study is 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 rainfall, USACE has not been authorized to specifically address that issue, although it is included in the coastal storm surge inundation analysis. USACE policy ER 1105-2-100, Section 3-3.b.(6) specifies that in urban and urbanizing areas, provision of a basic drainage system to collect and convey local runoff is a non-Federal responsibility. However, 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 report 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.

1.4 Existing Programs, Studies and Projects

Significant data collection and analysis has been completed 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, 2018
    - 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. Soon, the entire drainage system will be greatly improved and connected to the tunnel. 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 III in construction, 2018
    - 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 and II complete
    - Phase IV and V planned completion in 2023
- Calhoun West/Beaufain Drainage Improvement Project, Preliminary Engineering Report is anticipated in early 2019
    - 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 conducting a study for improving drainage in the Calhoun West/Beaufain drainage basin and alleviating 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.

- The Low Battery Seawall Rehabilitation Project
  - 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 would like to now address the Low Battery.
  - The Low Battery wall 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 will be restored and elevated to match the High Battery.
- 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.

1.5 Public and Agency Coordination

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 1-1 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 1-1. 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

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. Public comments were taken into account during subsequent iterations of the planning process.

The PDT 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. The first meeting of the ICT was held in December 2018 and additional meetings will occur throughout the study process.

Table 1-2. Agencies 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 Department of Health and Environmental Control	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

1.6 Significance of the Study Area

Charleston, South Carolina is important to the Nation for a multitude of reasons, including: 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) the Charleston's ports support the Nation's economy.

1.6.1 Historic Charleston

The history of Charleston is one of the longest and most diverse of any community in the United States. This year, the city is celebrating 350 years of existence as a seaport community. The city has 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 attacks by the French, Spanish, Native Americans, and Pirates. Later, key battles of the Revolutionary and Civil War were fought here. Today, the peninsula contains numerous buildings dating from the late eighteenth century – the mid nineteenth century that document the city's unique and rich history. Refer to the Section 4.10 and Appendix A Plan Formulation for an overview of the historical development of Charleston.

1.6.2 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).

1.6.3 Union Pier and Columbus Street Ports

The South Carolina Ports Authority (SCPA) is the 4th largest container seaport on the East Coast with two of the six port terminals located on the Charleston Peninsula. The SCPA generates an annual total economic impact of $63.4 billion in South Carolina and another $12 billion in neighboring states. After completion of the Charleston Harbor Post 45 Deepening Project, the Charleston Harbor will be the deepest harbor on the U.S. East Coast.

1.7 Planning Process and Report Organization

The USACE 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 alternatives plans; and, (6) selection of the recommended plan based upon the comparison of the alternative plans.

This process mirrors the National Environmental Policy Act (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 that could have an impact on the environment. 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. An Environmental Assessment (EA) is prepared in the NEPA process to look at different action alternatives and evaluate the significance of the environmental effects of the alternatives. Where an agency concludes that the environmental impacts of a proposed action can be mitigated to a level where the agency can make a Finding of No Significant Impact (FONSI), the agency may prepare a mitigated FONSI based on those mitigation commitments. Federal agencies have been encouraged to integrate their planning processes with the NEPA process, therefore this document presents an integrated FR/EA.

Chapter 2 – Planning Considerations

This chapter presents the results of the first two steps of the planning process, (1) the specification of water and related land resources problems and opportunities in the study area and (2) inventorying and forecasting resources. The chapter also establishes the planning objectives and constraints, which are the basis for formulation of alternatives, and for the "Need for Action" step of the NEPA process.

2.1 Problems

Charleston is a highly urbanized, relatively flat community with nearly all areas 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 the city 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 would be catastrophic for the community. But even coastal storms that 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 storm surge flooding is the phenomenon of relative sea level rise (RSLR), which is the combination of water level rise and land subsidence. 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.
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.

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 impact on the people, businesses, industry, infrastructure, and critical facilities on the Charleston Peninsula. Refer to Appendix A for a comprehensive list of the major coastal and tropical storm events affecting the Charleston Peninsula since 1950.

2.1.1 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 floor 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.

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 coastal areas of South Carolina and the considerable distance inland over which the storm 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).

2.1.2 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.

2.1.3 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.

2.1.4 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.

2.1.5 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 51 million cubic yards. There were more than 900,000 units of white goods and over 600,000 units of electronic goods. More than 350,000 cars were abandoned.

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 the 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.

2.1.6 Impacts to Critical Facilities 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 2075, 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.

2.1.7 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.

2.2 Opportunities

Opportunities are future desirable conditions that could coincide with the solutions to identified problems in the study area. The project delivery team, with input from stakeholders, has identified the following opportunities:

- Recreation features such as a walkway along the river and river access.
- Natural areas including open space and stream restoration.
- Beneficial use of dredged materials.
- Multi-modal transportation, such as bicycle pathways or small boat traffic via canals.
- Education and research.

The City of Charleston has expressed their desire to maximize recreation opportunities as appropriate with USACE policy. While the federal government will not participate in acquiring lands for recreation purposes, recreation features are appropriate on lands acquired for project purposes.

2.3 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 2026, the end of the period of analysis would be 2075.

The purpose of this study is to investigate and recommend potential structural and nonstructural solution sets to reduce damages from coastal storm surge inundation. The PDT has identified the following objectives to help achieve the study goal:

- Reduce risk to human health and safety from coastal storm surge inundation on the Charleston Peninsula through the year 2075.
- Reduce economic damages resulting from coastal storm surge inundation on the Charleston Peninsula through the year 2075.

2.4 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.
- Avoid high cost modifications to Interstate 26 and U.S. Route 17, which are also 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 two 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 of 1986 requires USACE to address the preservation of cultural and historical values in the formulation and evaluation of alternative plans. The last three constraints are specific to this study. On the Ashley River, any proposed barrier must be strategically placed to avoid impacts to the marina's operation and the federal navigation channel. This constraint in turn requires that a barrier would tie into the existing abutment of the Ashley River Bridge which is 12 feet NAVD88 or that the bridge be modified to raise the elevation or construct a closure gate across the bridge. Either of these options would be a major cost driver and limit the net benefits of a potential barrier structure.

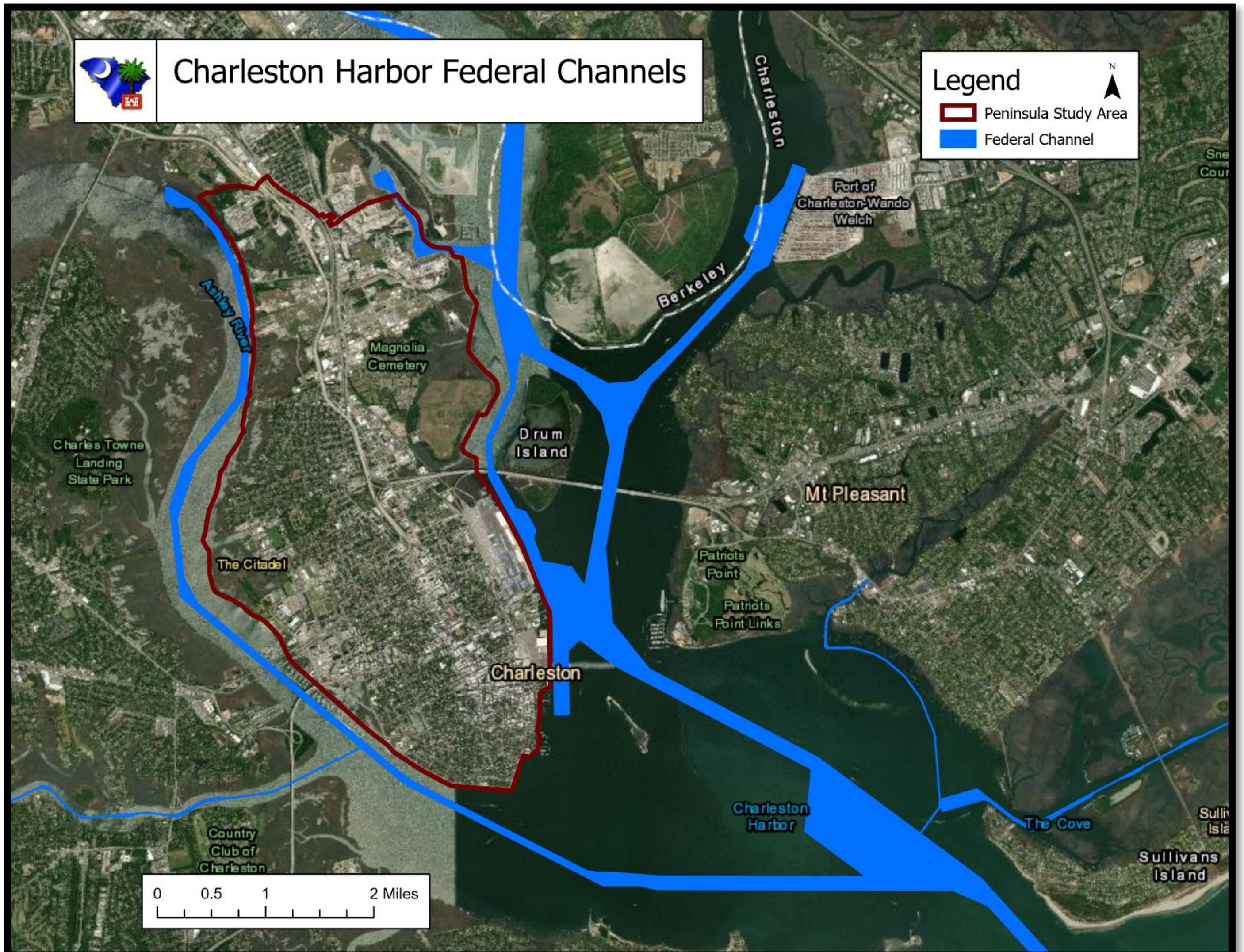

Figure 2-1. Depiction of the federal navigation channels near the study area. Official mapping product of the Management Support Branch, Charleston District, USACE

2.5 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.

2.5.1 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.

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

2.5.2 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 the 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.

2.5.3 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 drain potential 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.

2.5.4 Tidal and Sea Level Rise

The most recent assessments of the Intergovernmental Panel on Climate Change (IPCC) (Fifth Assessment Report) have noted 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.

2.5.5 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 2-2). 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.

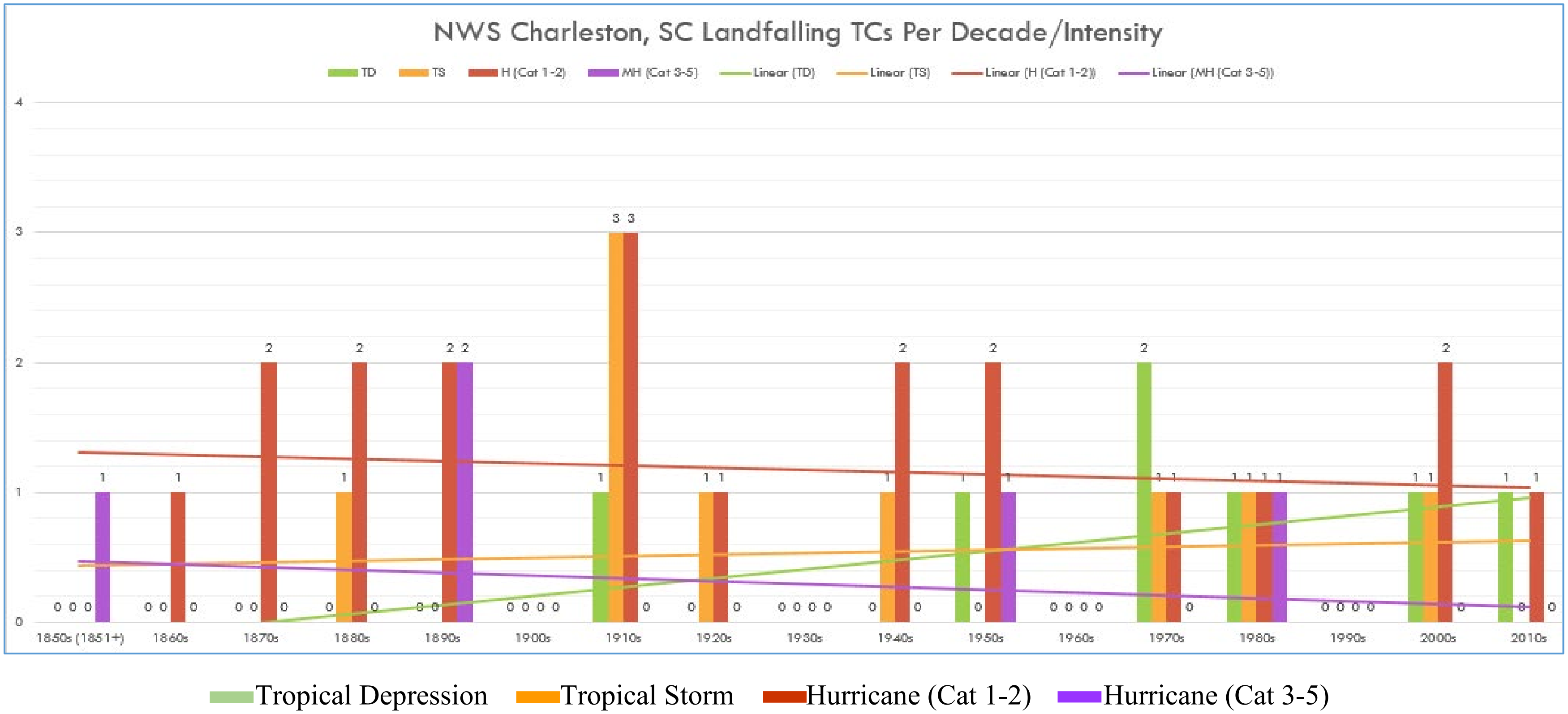

Figure 2-2. Charleston, SC Landfalling Tropical Cyclones by Decade.
Source: National Weather Service.

The study area is highly urbanized so there are not extensive natural resources present. There are some small tidal creeks, mudflats, and saltmarshes around the perimeter of the peninsula. While marsh habitat has adapted to fluctuating water levels and periodic inundation, there is concern regarding storm-induced erosion to existing marsh. Most of the salt marshes around the perimeter of the peninsula do not have the ability to migrate inland with changes in water elevations because they are restricted by roads and other infrastructure. Salt marshes in some areas around the peninsula are predicted to be gone 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.

As development pressures continue to reduce open space and degrade the natural habitat in the Charleston Peninsula, the quantity and quality of natural habitat and open space will continue to decline.

Historic and cultural resources will continue to be at risk from storm surge events. A major draw for tourism is the Charleston Old and Historic District, which encompasses a large portion of the southern peninsula. The historic district contains primarily residential buildings in addition to commercial, ecclesiastical, and government-related buildings. The great concentration of 18th and 19th century buildings give the district a flavor 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.

2.6 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.

2.7 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.

2.7.1 Key uncertainties

At this early stage of the study, there are numerous uncertainties centered primarily around lack of specific data on flooding problems, extent of various floodplains, economic damages, costs of solutions, and environmental impacts. 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 the ports (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

The PDT has assessed these uncertainties and have made specific recommendations for addressing those affecting the study. For those that are implementation concerns, the PDT has made assumptions for the purposes of the study. Those assumptions will be revisited during each planning iteration throughout the study.

Chapter 3 – Conceptual Measures and Alternatives

This chapter describes the identification of management measures and formulation of alternative plans to address the planning objectives identified in Section 2.3. Objectives are repeated here for reference:

- Reduce risk to human health and safety from coastal storm surge inundation on the Charleston Peninsula through the year 2075.
- Reduce economic damages resulting from coastal storm surge inundation on the Charleston Peninsula through the year 2075.

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 to identify and describe problems, opportunities, objectives, and constraints and brainstorm management measures. 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, specific event floodplains, and property values.

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, in addition to a couple additional alternative plans that the PDT formulated. 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 planning objectives. Coastal flood risk management measures consist of three basic types: structural, nonstructural, and natural or nature-based features. As a result, the initial array of alternatives consist of a variety of structural, nonstructural, and natural or nature-based features. 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 in order to reduce the hazard or to influence the course or probability of occurrence of the event. Structural measures are features such as levees, flood walls, and gates that are implemented to protect people and property.

Nonstructural coastal storm risk 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 coastal flood risk management measures work with or restore natural processes with the aim of wave attenuation and storm surge reduction. For this study, raising of marsh surfaces, living shorelines, historic creek restoration, and greenways were considered.

During the first two iterations of the plan formulation process, no new data is produced. Instead the knowledge of the PDT and the knowledge of agencies and stakeholders are used to complete iterations of the planning process and formulate alternatives. Additionally, individual measures are assessed based on effectiveness, constructability, and how well the measure achieves objectives and avoids constraints. However, without further research and analysis, it can be difficult to confidently screen measures at this point. The limitations of specific measures to address storm surge inundation were discussed but most measures were not screened so that they could be considered in combination with other management measures. Early iterations of the planning process also identify data gaps and key uncertainties to focus the remainder of the study. Data gaps and key uncertainties identified during the planning charrettes will be discussed later in this document.

3.1.1 Structural Measures

Charleston Harbor Storm Surge Barrier System

The storm surge barrier system is a series of floodwalls or levees and 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. The primary location of the 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.

Initial 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. For additional rationale to support this screening decision, refer to an excerpt from the Dutch Dialogues Charleston final report call-out box 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.
- The system alignment would be controversial. Deciding who and what to include "inside" the system and who to exclude "outside" the system would be politically difficult. These political considerations must also align with the physical system constraints – geographic, geologic, hydrologic, hydraulic – and economic considerations that come into play.

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 phase, such as a nearshore berm made of dredged material or a manufactured breakwater.

Initial 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

In the early stage of the planning process, different types of storm surge structures were bundled under the category of "storm surge walls." The types of walls considered include seawalls, floodwalls, and bulkheads.

A seawall or floodwall is usually a concrete structure with its weight providing stability against sliding forces and overturning. The wall is considered non-energy absorbing when it is vertical; however, those with a sloping surface or composed of rubble mound may absorb some wave energy. The front face may also be curved or stepped to deflect wave run-up. A bulkhead is a vertical retaining wall that holds soil in place and prevents it from sliding into the sea. A secondary purpose of a bulkhead wall is to protect the land from wave attack. For eroding bluffs and cliffs, bulkheads increase stability by protecting the toe from undercutting. They are often constructed of steel sheet pile that is driven into the ground or anchored, or they can consist of rock-filled timber cribs and gabions.

Based on flood water levels anticipated for this study, it was determined that I-walls and T-walls would be appropriate to use as existing conditions permitted. 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*.

Initial 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 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 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 3-1 shows the vicinity of the project.

Initial assessment: The city is already constructing this measure.

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

Figure 3-1. Vicinity of the Low Battery Wall Reconstruction Project.
Source: City of Charleston.

Ringwall

Ringwalls are constructed with the same engineering requirements as seawalls. The primary difference between a ringwall and a seawall is scale. Whereas a seawall protects a large area (e.g. neighborhood) a ringwall is considered for individual structures or a small grouping of structures. A ringwall could adversely impact the effective floodplain, but generally, the wall is located in close proximity to the building(s) it is protecting, so that floodplain characteristics such as depth and velocity are not impacted.

Initial assessment: A concern regarding ringwalls is that they may entice people to seek shelter in a structure instead of evacuating. This presents a life safety concern in the event a ringwall is overtopped or fails. Additionally, USACE policy does not permit single structure protection.

Status: Screened from consideration.

Deployable Floodwall

Rapid deployment floodwalls are structures such as stop logs or inflatable tubing that are 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.

Initial assessment: The nature of these structures often limits the size or level of protection possible. Storage and maintenance of the equipment is required, as well as personnel trained and available to deploy or construct the systems.

Status: Screened from consideration.

Levees

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

Initial 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

In addition to preventing flooding of evacuation routes, an earthen base would serve as a levee to limit storm surge inundation on the peninsula.

Initial 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 high cost of this measure.

Status: Retained for further consideration.

Canals / Flood Channels

Canals or flood channels 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.

Initial 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: Retained for further consideration.

Colonial Lake Storage

Colonial Lake is completely surrounded by perimeter seawalls. The seawalls function more like retaining walls for the earth on the landside than true "seawalls." At time of low water, the water depth of the lake is approximately six inches immediately alongside the seawall, and the height of the seawall exposed to view is approximately 3 ½ feet. On the west side of the Colonial Lake, a single 42-inch diameter subterranean drainage pipe leads to the Ashley River and provides for flushing action with each tidal cycle. Colonial Lake fluctuates approximately one foot in height during a tidal cycle. The overall wall height is approximate four feet with the exception of a slight rise near the north end of the wall along Ashley Avenue. At this location the wall height rises to approximately 5 feet. The perimeter seawalls could be raised to provide for floodwater storage. Pumps would be required to convey floodwater over the walls.

Initial assessment: Pumping floodwaters into the lake and then back out again would create a significant operation and maintenance burden and with significant associated costs.

Status: Retained for further consideration.

Detention Basins

A detention basin is an excavated area installed on or adjacent to tributaries of rivers, streams, lakes or bays to protect against flooding. To reduce real estate costs, this measure could be achieved by converting existing parks on the Charleston Peninsula into detention basins for short-term storage of storm water.

Initial assessment: 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.

Status: Retained for further consideration.

Underground Cisterns

Underground cisterns and tanks could temporarily store storm water. Industrial pumps would discharge the storm water at a controlled pace after the storm surge has receded. The underground cisterns could serve other purposes between floods, such as parking or educational tours.

Initial assessment: Because the volume of the ocean is effectively unlimited, cisterns would not reasonably reduce coastal storm surge risk.

Status: Retained for further consideration.

3.1.2 Natural or Nature Based Measures

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.

Initial assessment: Marsh naturally adapts to sea level rise through a process called transgression and organic matter in dredged materials can create odor problems. Ultimately, elevating existing marsh wetlands would not reasonably reduce coastal storm surge risk.

Status: Retained for further consideration.

Living Shorelines

Open and exposed shorelines are prone to erosion due to waves. For this conceptual measure, an oyster reef toe would be installed that would allow sediments and vegetation to fill in, or native vegetation could be planted, to reduce erosion and stabilize natural (non-static) shorelines. The oyster reefs and vegetation would provide a buffer against coastal hazards such as wind erosion, wave attack, and tidal inundation during storm events.

Initial assessment: Discussions with local experts suggested that living shorelines would not reasonably reduce coastal storm surge risk. However, they could contribute to reducing adverse impacts that may result from some of the measures, and may be appropriate for mitigation.

Status: Retained for further consideration.

Restore Historical Creeks

This measure 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.

Initial assessment: Restoring historical creeks would primarily address interior drainage issues and would not reasonably reduce coastal storm surge risk.

Status: Retained for further consideration.

3.1.3 Nonstructural Measures

Flood Warning System

A flood warning system is a way of detecting threatening events in advance. This enables the public to be warned en masse so that actions can be taken 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.

Initial assessment: The National Weather Service Forecast Office in Charleston issues flood watches, warnings, and advisories. Local flood warning systems are the responsibility of the local government.

Status: Retained for further consideration.

Elevate Structures

This nonstructural technique lifts an existing structure to an elevation which is at least equal to or greater than the 1% annual exeedance probability flood elevation. 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.

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

Status: Retained for further consideration.

Wet Floodproofing

This nonstructural technique 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 quite applicable to commercial and industrial structures when combined with a flood warning and flood preparedness plan.

Initial assessment: This measure is generally not applicable to large flood depths and high velocity flows.

Status: Retained for further consideration.

Dry Floodproofing

This nonstructural technique consists of waterproofing the 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.

Initial assessment: This measure has limited applicability.

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.

Initial assessment: 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.

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

Status: Retained for further consideration.

Land Use Regulations

Land use regulations within a designated floodplain are effective tools in reducing flood risk and flood damage. 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 to.

Initial assessment: Land use regulations are the responsibility of the local government.

Status: Retained for further consideration.

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. LID employs principles such as preserving and recreating natural landscape features, minimizing effective imperviousness to create functional and appealing site drainage that treat 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.

Initial assessment: Stormwater management is the responsibility of the local government.

Status: Retained for further consideration.

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: Consistent with land use regulations and stormwater management, this measure is considered a local government responsibility.

Status: Retained for further consideration.

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 the 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 things to do with 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 aspects were added to the strategies to address conditions specific to the Charleston Peninsula.

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.
- Storage – This strategy focused on measures that would store floodwaters during storm events then release them after the peak event had passed. It was determined that storage by itself would not address the storm surge inundation, however it could address rainfall runoff behind a barrier.
- Conveyance – This strategy focused on measures that would increase the ability of existing flood structures to convey floodwaters or construct new flood structures to convey floodwaters. Since the study area is a peninsula, a "conveyance only" alternative would not address storm surge inundation.
- 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.

- Historic – This strategy focused on restoration of historic creeks and streams as a method of naturally moving floodwaters from the peninsula.
- 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.

Perimeter Protection Alternative

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 providing 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. The most effective and most efficient type of structure would be a T-wall on land and a combination wall in the marsh. A refined description of this alternative can be found in the Final Array of Alternatives section 3.5.

Perimeter Protection + Wave Attenuating Structure Alternative

This alternative was the result of using the Diversion formulation strategy. The management measures included in this alternative are:

- A wall or levee along the perimeter of the Peninsula
- Living shorelines
- Wave attenuating structure

The wall or levee along the perimeter of the Peninsula would adhere to the same constraints and assumptions as the Storm Surge Barrier Alternative. A wave attenuation structure in the Charleston Harbor may dampen waves, reduce loading on seawalls, and prevent waves from overtopping during storm events. In locations without a newly constructed barrier, living shorelines may reduce erosion and attenuate storm surge moving onshore as well as reduce impacts of sea level rise. Living shorelines, such as an oyster reef toe, would be constructed along tidal wetlands.

Nonstructural Alternative

This alternative was formulated to include 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*

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. Flood warning systems and emergency response plans are also non-federal responsibilities. Measures collectively referred to as low-impact development / green infrastructure are described in Section 3.1.

Perimeter Protection + Wave Attenuating Structure + Nonstructural Alternative

This alternative was formulated using the spatial strategy. The management measures included in this alternative are:

- A wall or levee along a portion of the Peninsula's perimeter
- Living shorelines
- Wave attenuating structure

- Relocations or buyout of structures
- Elevate structures
- Floodproof structures

For this alternative, a wall or levee would be constructed along a portion of the peninsula's perimeter. Where structures are not protected by the wall, a suite of nonstructural measures including relocations or buyouts, structure elevation, or floodproofing measures could apply.

Historical Creeks Alternative

This alternative used the historic formulation strategy which focuses on measure that can protect the shoreline and restore historic stream beds. This alternative was formulated based on the Halsey Map of 1844, which identifies the topography and extent of the historic peninsula prior to the substantial infill and expansion of the shoreline. The Halsey Map was used as a guide to identify the areas of historic stream beds to be restored. The management measures included in this alternative are:

- A wall along the western perimeter and portions of the eastern perimeter of the Peninsula
- Relocations or buyout of structures
- Restoration of historical stream beds with small scale pump outfalls at the perimeter protection (Gadsden Creek, Millpond Creek, Cummings Creek, Vardell's Creek, New Market Creek)

Before they were filled, tidal creeks on the Charleston Peninsula ebbed and flowed with the tides. Now, the locations of the former creeks flood with regularity. Restoring historic creeks would be a nature-based measure that would mimic as closely as possible conditions which would occur in the area absent human changes to the landscape. However, restoring historic creek beds would primarily address internal drainage issues.

Parks & Recreation Alternative

This alternative was formulated using a combination of formulation strategies: storage and spatial. The PDT focused the spatial aspect of the alternative to identify storage opportunities on the peninsula and proposed land use modifications. This alternative was formulated to include both actions that can be implemented by USACE and actions that can be implemented only by the non-Federal sponsor (shown in italics). Per USACE policy, in urban and urbanizing areas provision of a basic drainage system to collect and convey local runoff is a non-federal responsibility. Zoning and emergency response plans are also a non-federal responsibilities.

The management measures included in this alternative are:

- Detention basins at city parks
- Colonial Lake or Marina Lagoon storage improvements
- Canals along East Battery and Lockwood Boulevard

- *Low-impact development / green infrastructure*

Parks near the shore are at low elevations with high groundwater levels, making them ineffective as excavated 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. Canals block access to private property and would require large footprints and bridges to maintain traffic flow.

Storage Alternative

This alternative was formulated using multiple formulation strategies, but with a focus on management measures that store floodwaters. The management measures included in this alternative are:

- Detention basins at city parks and parking lots
- Underground cisterns
- Elevate existing marsh wetland
- Canals / flood channels
- Phased/selective relocations or buyout of structures
- Restore historical stream beds with small scale pump outfalls at the perimeter protection (Gadsden Creek, Millpond Creek, Cummings Creek, Vardell's Creek, New Market Creek)
- *Low-impact development / green infrastructure*

Assuming an earthen base, the footprint of a raised road would be large and require considerable real estate. Additional cost drivers include modifications to access roads and existing structures. Because the volume of the ocean is effectively unlimited, cisterns would not reasonably reduce coastal storm surge risk.

3.4 Screening of Conceptual Alternatives

Following the planning charrettes, the PDT performed additional planning iterations with a focus on screening measures and 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. Each conceptual alternative was found to be constructible. With the exception of the stand-alone, nonstructural alternative, each alternative was found to be compliant with study constraints.

Table 3-1 contains an assessment of how well key measures in each alternative meet the study objectives. In summary, most of the 20 measures identified at the planning charrettes in the Fall of 2018 are most suitable to addressing interior drainage issues and ineffective in addressing storm surge inundation. 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 two action alternatives that were carried forward into the final array.

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

Alternative	Assessment	Meets Study Objectives?
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
1. Perimeter Protection	The strategically placed wall or levee would reduce damages from storm surge inundation, reduce risk to human life and safety, and maintain access to critical facilities, emergency services, and evacuation routes by diverting storm surge water from the peninsula. However, living shorelines were removed from this alternative because they would not reasonably reduce storm surge risk.	Yes
2. Perimeter Protection + Nonstructural	In addition to a storm surge wall or levee, nonstructural measures would be applied to residential structures that would continue to incur damages from storm surge after the wall is constructed.	Yes
3. Perimeter Protection + Nonstructural + Wave Attenuator	In addition to a storm surge wall or levee and nonstructural measures, a wave attenuation structure in the Charleston Harbor would reduce loading on the Battery wall and reduce the effect of waves from overtopping floodwalls during coastal storm events.	Yes
4. Nonstructural Only	This alternative only includes nonstructural measures and would not address storm surge inundation that limits access to critical facilities, emergency services, and evacuation routes. A buyout of all structures in the SLR footprint would also violate the constraint of minimizing adverse effects to the historic district and structures.	No
5. Historic Creeks	Restoring historic creek beds would primarily address internal drainage issues. However, the storm surge wall would reduce damages from storm surge inundation, reduce risk to human life and safety, and maintain access to critical facilities, emergency services, and evacuation routes.	Yes
6. Parks & Recreation	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. Canals block access to private property and would require large footprints and bridges to maintain traffic flow. These measures primarily address internal drainage issues and tidal flooding and are less effective in addressing storm surge inundation. Additionally, these measures are less efficient than other viable options.	No

Alternative	Assessment	Meets Study Objectives?
7. Storage	Because the volume of the ocean is effectively unlimited, cisterns would not reasonably reduce coastal storm surge risk. Assuming an earthen base, the footprint of a raised road would be large and require considerable real estate. Additional cost drivers include modifications to access roads and existing structures. This alternative does not meet the objectives of reducing economic damages and risk to human health and safety resulting from storm surge inundation.	No

Table 3-2. Screening of Alternatives Based on Evaluation Criteria from the Principles and Guidelines.

Alternative	Completeness[1]	Effectiveness[2]	Efficiency[3]	Acceptability[4]	Result
1. Perimeter Protection	High	Medium	Medium	Medium	Screen
2. Perimeter Protection + Nonstructural	High	High	High	Medium	Retain
3. Perimeter Protection + Nonstructural + Wave Attenuator	High	High	High	Medium	Retain
4. Nonstructural Only	High	Low	Low	Low	Screen
5. Historic Creeks	High	Medium	Medium	Medium	Screen
6. Parks & Recreation	High	Low	Low	Medium	Screen
7. Storage	High	Low	Low	Medium	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.

3.5 The Final Array of Conceptual Alternatives

Based on the screening criteria, the final array of alternatives include Alternative 2, Alternative 3, and the No Action Alternative 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 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.

Alternative 2

The management measures included in this alternative are:

- Storm surge wall along the perimeter of the Peninsula (approximately 7.8 miles)
- Nonstructural measures (approximately 100 structures)

The storm surge wall would be constructed along the perimeter of the peninsula to reduce damages from storm surge inundation. 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 ports, marinas, and the Coast Guard Station. The wall would tie into high ground as appropriate, including 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. Sections of the new wall would be fitted with walkways and railings to provide additional recreation opportunities in the study area. 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.

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 3-2). To withstand earthquakes, pilings for both wall types would be 50 to 70 feet deep to tie in to 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 3-2. The Inner Harbor Navigation Canal Surge Barrier in New Orleans is an example of a combo-wall. It is built to approximately 26 feet (NAVD88).

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 9 feet NAVD88 in elevation 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 within the study area that would continue to incur damages from storm surge after the wall has been constructed. Nonstructural measures considered include relocations, buyouts, elevations, and floodproofing. Additional analysis will determine the application of these measures should the alternative be selected.

Alternative 3

The management measures included in this alternative are:

- Wave attenuation structure offshore of the Battery (approximately 4,000 feet long)
- Storm surge wall along the perimeter of the Peninsula (approximately 7.8 miles)

- Nonstructural measures (approximately 100 structures)

A wave attenuation structure would be constructed in Charleston Harbor to reduce loading on the Battery wall and reduce the effect of waves overtopping during storm events. For the purposes of alternative evaluation, comparison, and impact analysis, the wave attenuation structure was analyzed as a breakwater made of granite rock, at an elevation of 16.2 feet NAVD88, with the landward toe placed approximately 230 feet from the shoreline. The structure was aligned to be parallel with the shoreline, to avoid encroachment into federal channels in the Charleston Harbor and Ashley River. Additional analysis will determine the optimized material type, placement, length, and height of the structure should this alternative be selected.

The storm surge wall along the perimeter of the Peninsula and nonstructural measures in this alternative would adhere to the same constraints and assumptions as described in Alternative 2.

Figure 3-3. Alternative 2.
Official mapping product of the Management Support Branch, Charleston District, USACE

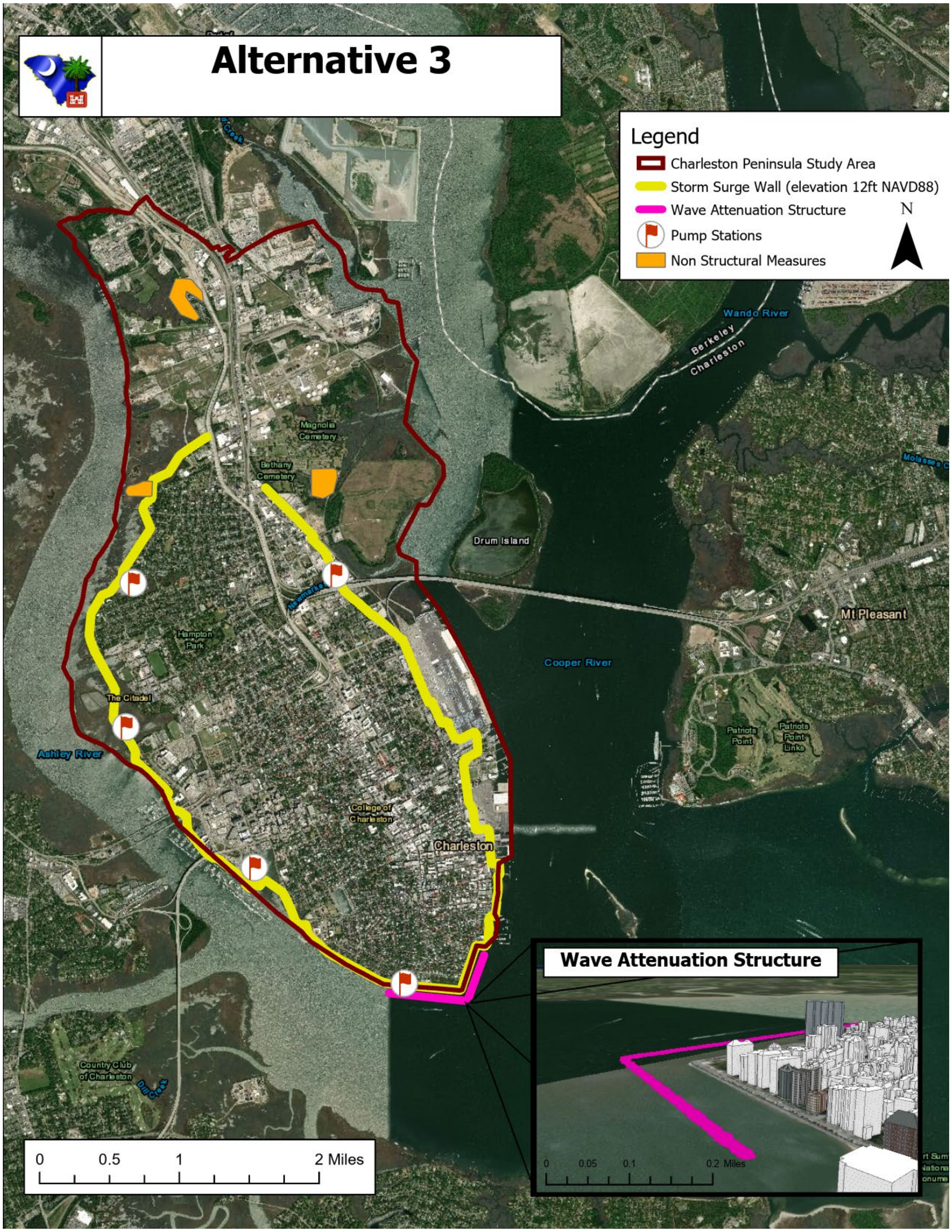

Figure 3-4. Alternative 3.
Official mapping product of the Management Support Branch, Charleston District, USACE

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 a comprehensive plan. 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 Annsonborough 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.

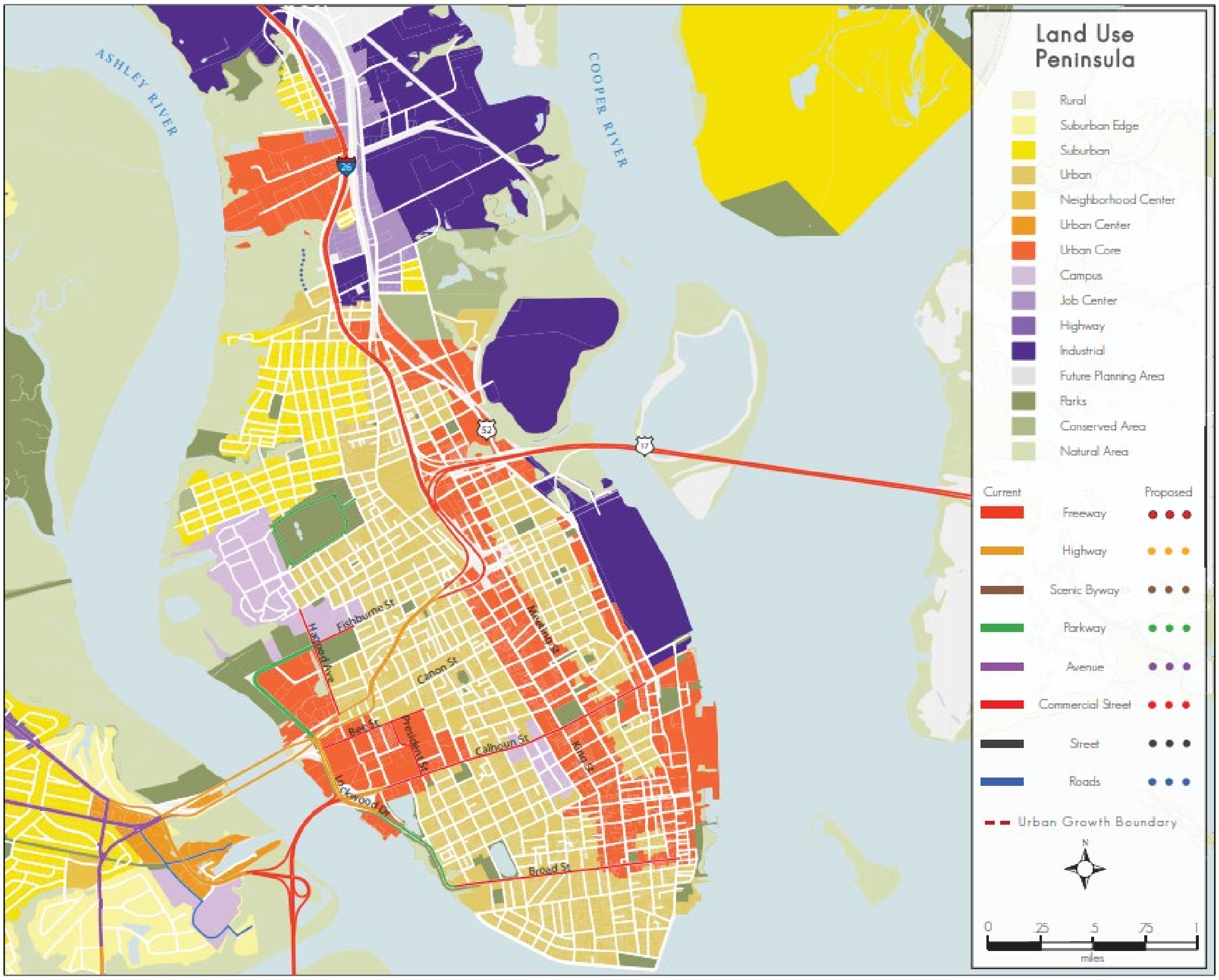

Figure 4-1. Map of land use designations on the Charleston Peninsula. Source: City of Charleston Comprehensive Plan, 2010.

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, including perimeter salt marsh wetlands. The ROI also includes the Charleston Harbor, from the area where the wave attenuator would be sited to current Battery seawall. A more detailed description of the geotechnical conditions can be found in Appendix B, Sub-Appendix 2, Geology and Geotechnical Engineering. For this study, no new geotechnical data were collected. Existing and available geotechnical data from various sources were used. Additional geotechnical information will be collected for the recommended plan during the Preconstruction, Engineering, and Design (PED) phase, including determining if there is any man-made construction fill or construction debris in proposed construction areas.

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 Appendix B, Subappendix 2; 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. There are no geologically significant features in the ROI.

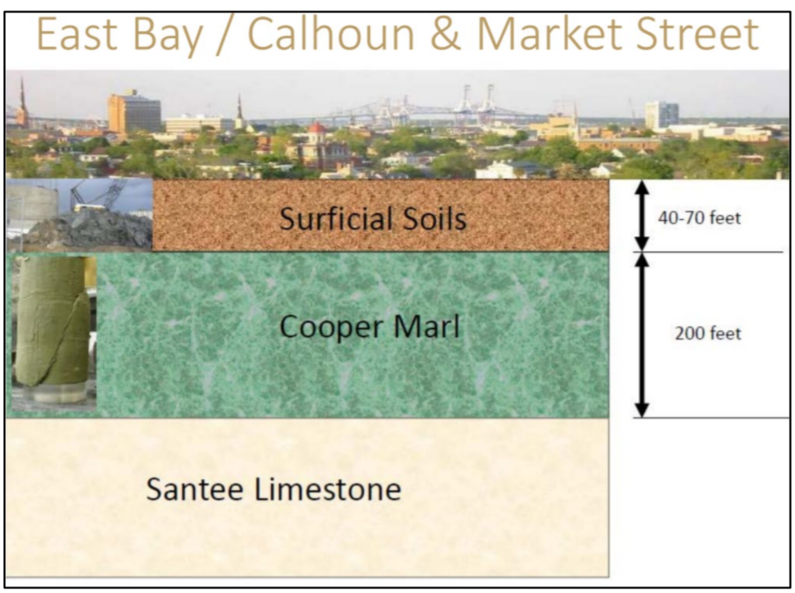

Figure 4-2. Graphical representation of the stratigraphy in the area near East Bay Street, Calhoun Street, and Market Street. Source: City of Charleston.

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 Appendix B, Sub-Appendix 2.

Erosion

Shoreline erosion is caused by winds and wave action. Manmade structures also alter shorelines, such as docks, jetties, and bulkheads. Estuarine shoreline erosion is a growing concern for residential and commercial properties. South Carolina Department of Health and Environmental Control Office for Ocean and Coastal Resource Management (SCDHEC-OCRM) has taken on an effort to assess estuarine, oceanfront, and inlet shoreline positions, calculate shoreline change rates, and identified erosion hotspots. They found that natural and cultural resources are also threatened by estuarine shoreline erosion. Erosion leaves upland bluffs exposed and slumping into adjacent tidal creeks, leading to loss vegetation and marsh shorelines (Jackson, 2017).

Subsidence

The two main causes of subsidence are groundwater withdrawal and shifting tectonic plates. Because so much of the Charleston Peninsula is on filled wetlands that may be contributing to land sinking, subsidence studies for the area are limited.

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 water quality and coastal habitat, which are discussed in subsequent sections of this report. More information on the coastal hydrodynamics and H&H analyses performed for this study can be found in Appendix B, Subappendices 3 and 4. This section also uses information from literature and similar studies/projects, and builds on information from the Floodplains and Water Quality sections, to characterize the potential impacts to coastal hydrodynamics and H&H.

The coastal hydrodynamic, and H&H conditions of water on the Charleston Peninsula and adjacent waterways, including the Charleston Harbor, lower Ashley River, and lower Cooper River are all part of the ROI.

Affected Environment

The study area lies within the Cooper River Watershed (8-Digit Watershed) of the Santee River Basin. The Charleston Peninsula is surrounded by the lower Ashley River to the west and the lower Cooper River to the east, both of which drain (along with the nearby Wando River) into the Charleston Harbor tidal estuary. The waters offshore of the Battery are considered to be the Charleston Harbor. Charleston Harbor extends about four miles to the Atlantic Ocean. The Harbor is sheltered by barrier islands at the entrance.

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 average of 4500 cfs a week. The Federal navigation channel in the Cooper River and Charleston Harbor are regularly dredged to support marine commerce.

Intertidal wetlands in the estuary have been lost over time to development and diking for rice cultivation. It is estimated that 1/3 of the Peninsula's land areas are filled wetlands. All or portions of many tidal creeks on the Charleston Peninsula have been filled. The remaining tidal creeks in the study area are shown in Figure 4-3. They include Belvidere Creek, New Market Creek, Vardell's Creek, Koppers Creek, Diesel Creek, Halsey Creek, Gadsden Creek, and the tributary behind Joe Riley Ballpark that joins with The Citadel Boat Landing channel (see Figure 4-3). There is no known hydrodynamic modeling for any of these creeks or tributaries. Most of these remaining tidal creeks have been substantially altered (e.g., Gadsden Creek and New Market Creek). Due to the shallowness of these creeks, it is likely that the tides control flushing rather than density driven stratification.

Figure 4-3. Current tidal creeks on the Charleston Peninsula.
Official mapping product of the Management Support Branch, Charleston District, USACE

Water Levels

NOAA maintains a tide gage in the Charleston Harbor. It has been measuring water levels continuously since 1921. The Charleston area has a semidiurnal tide cycle, with a tide range of almost 6 feet. In the past 100 years, local sea level has risen 1.07 ft. USACE has calculated still water elevations at five locations in the study area (see Appendix B, Subappendix 4). 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. The height of a wave is dependent upon wind speed and duration, depth of water, and length of fetch, but is a direct function of water depth. As the water depth increase, larger waves are able to form. 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.

Compound flooding is also an issue for the 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.

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, 2008). 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).

Groundwater levels in the surficial aquifer fluctuate with the tides, seasons, and precipitation. Considering local tides in the Charleston Harbor, the groundwater encountered near the perimeter of the Peninsula would be very near the ground surface.

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. 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. Wave attack also damages non-structured shorelines such as beaches and marshes by causing erosion of the sediment that make-up these coastal environments. 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 can also damage or destroy coastal vegetation, which anchor their respective systems in place, and leave the remaining system more vulnerable to additional erosion. As sea level rises, wave attack can be exacerbated in some areas. Structures that are sufficient 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.

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 Charleston Harbor subwatershed that encompasses the Charleston Peninsula and the adjacent waters of the Charleston Harbor, lower Ashley River, and lower Cooper River.

This section describes existing water quality conditions and evaluates potential impacts and mitigation measures. Hydrologic and coastal modeling conducted so far for this study are focused on water levels, and are described in Appendix B and Subappendices 3 and 4, and in section 4.3 above.. No water quality modeling or monitoring has been conducted at this time. Information from literature and similar studies was used to identify potential water quality impacts from the alternatives. This water quality assessment has also been prepared considering the Clean Water Act, S.C. Regulations 61-68 and 61-69, and the Rivers and Harbors Act of 1899.

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. USACE will complete the Section 401 Water Quality Certification Process during the remainder of the feasibility study, and incorporate it into the final report.

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 antidegredation. 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

As described above in the Coastal Hydrodynamics, Hydrology, and Hydraulics section, the study area lies within the Cooper River Watershed (8-Digit Watershed) of the Santee River Basin. The Charleston Peninsula is surrounded by the lower Ashley River to the west and the lower Cooper River to the east, both which drain (along with the nearby Wando River) into the Charleston Harbor tidal estuary. The waters offshore of the Battery are considered to be the Charleston Harbor.

<u>Water Quality Standards</u>

Water quality standards provide an indication of current conditions. The provisional classifications for waters in the ROI are shown in Figure 4-4. For the lower Ashley River, there are two classifications found: "Class Saltwater A" (SA), and SA with special site-specific conditions from 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 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. 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.

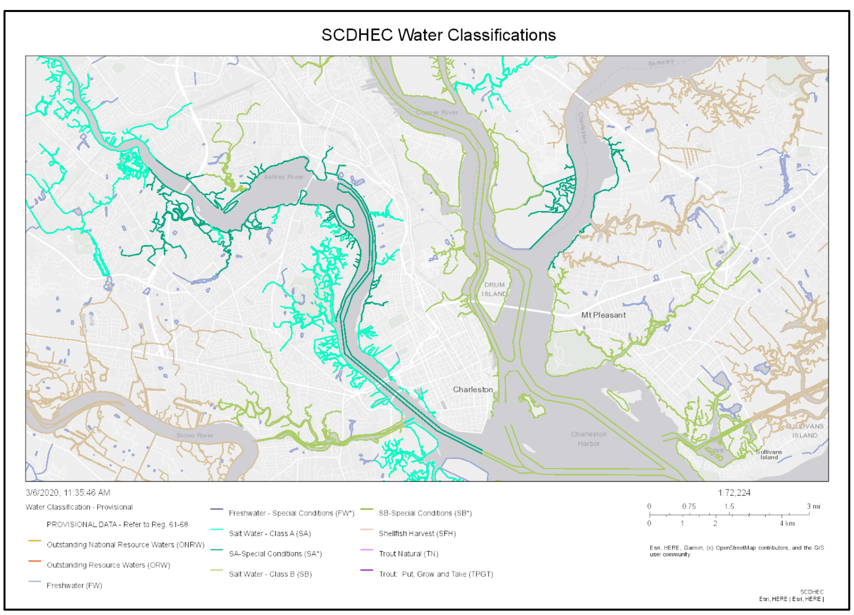

Figure 4-4. Provisional classifications for waters in the ROI. Source: SCDHEC.

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 4-5). 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.

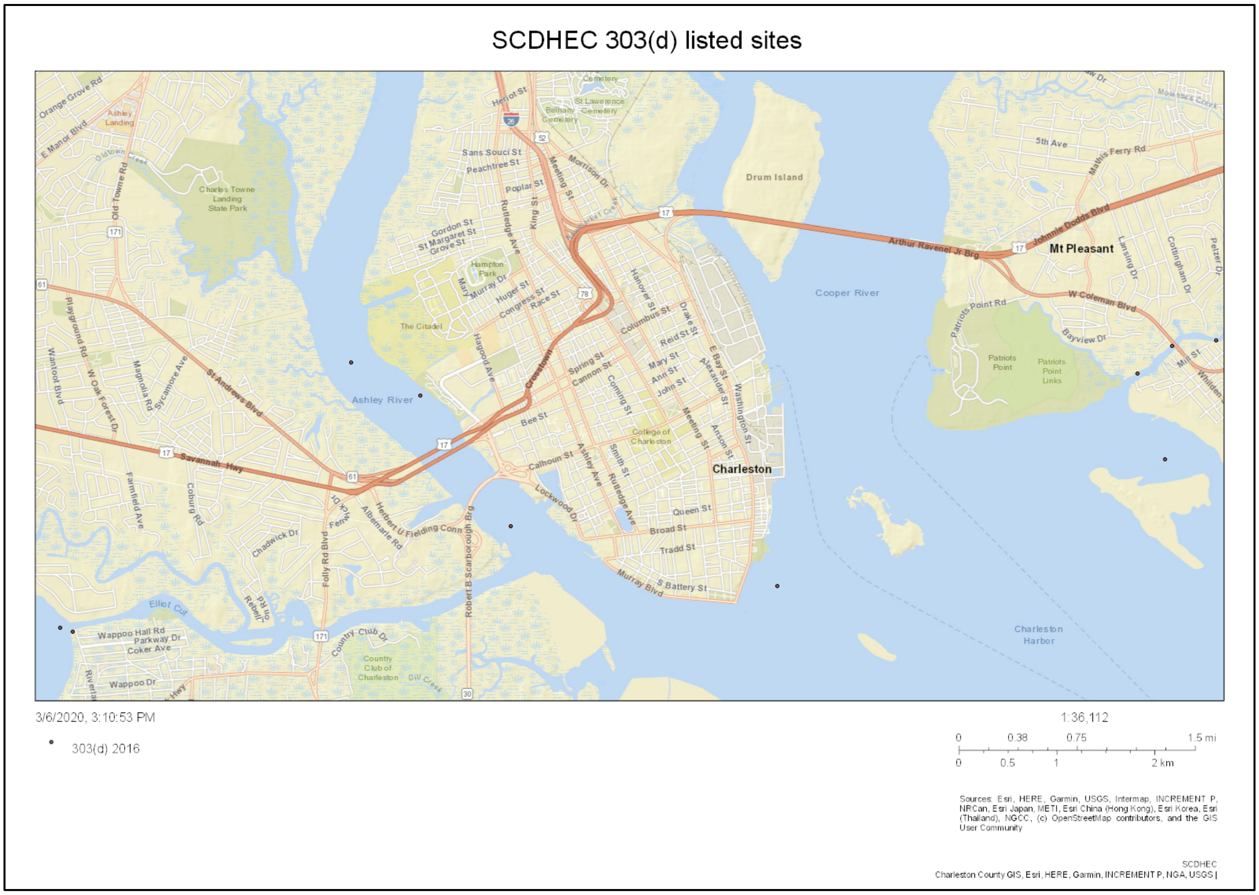

Figure 4-5. Impaired water quality sites in the ROI. The sites closest to the peninsula are impaired due to fecal matter. Source: SCDHEC

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 dissolved oxygen (DO) (https://www.scdhec.gov/sites/default/files/docs/HomeAndEnvironment/Docs/Chas_Hbr_DO_TMDL.pdf). 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.

DO is important to the survival of aquatic organisms, and often serves as a general indicator of the overall health of a tidal creek system. DO concentrations are dependent on a number of factors such as temperature, salinity, wind, turbulence, atmospheric pressure, and pollutants. The diversion of freshwater flow into the Cooper 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. The SCDHEC instantaneous and daily average water quality standards for DO are 4 and 5 mg/L, respectively.

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, and 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 the 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 around the Charleston Harbor sub 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 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, then 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 Cooperation 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 interest shall prepare a Floodplain Management Plan designed to reduce the impacts of future flooding in the project area. It should be based on post-project floodplain conditions. The primary focus of the Plan should be to address potential measures from this study, practices and policies which will reduce the impacts of future residual flooding, help preserve levels of risk reduction provided by the USACE project and preserve and enhance natural floodplain values. In addition, the Plan should address the risk of future flood damages to structures within the post-project floodplain and internal drainage issues related to USACE's coastal 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.

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. The peninsula has either experienced past flooding or has the potential to be flooded, including from tidal, rainfall, storm surge event-driven flooding. 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

Parts of the Charleston Peninsula lie within the 500-year floodplain, but most of it is in the100-year floodplain, of the Charleston Harbor. There are approximately 6,670 structures (out of 12,095) in the FEMA 100 year floodplain on the Charleston Peninsula.

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) regulations 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 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. This study falls under the Atlantic and Gulf Coast Plain Region Regional Supplement to the Corps of Engineers Wetland Delineation Manual: (Version 2.0). 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 includes any breakwater, storm gate, storm surge wall, 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.

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) are also in the ROI. To assess impacts to these areas requires additional modeling which will be conducted in the remainder of the feasibility study (see Appendix B, Subappendix 4). If adverse environmental effects are determined, potential mitigation measures will be proposed and incorporated in the final report and final Mitigation Plan.

Wetland information was derived for this study from 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 land cover mapping from NOAA's Coastal Change Analysis Program (2015) and Google Earth imagery were also used to verify our understanding of wetland distribution. An official delineation for impacted wetlands will be completed in the PED phase in accordance with the Corps of Engineers Wetland Delineation Manual, which USACE uses pursuant to Section 404 of the CWA.

Affected Environment

The Charleston Peninsula is highly urbanized, so relatively few wetlands remain. As discussed in Chapter 1, wetlands have been filled over time in the study area to give way to new development. In addition to human development, wetland distribution is influenced by water elevation, which fluctuates in response to daily tides, rainfall and freshwater drainage, and winds. The majority of the remaining wetlands in the study area can be found around the perimeter of the peninsula and are polyhaline, meaning they have a salinity range between 18 and 30 ppt. These wetlands include estuarine emergent marshes, or salt marshes, characterized by smooth cordgrass (*Spartina alterniflora*) and black needlerush (*Juncus roemerianus*). Higher emergent marshes may contain sea oxeye (*Borrichia frutescens*), salt grass (*Distichlis spicata*), and salt meadow hay (*Spartina patens*). The term salt marsh will be used throughout the remainder of this section to refer to the wetlands assessed. Figure 4-6 shows the general distribution of wetlands within the study area.

Small areas of freshwater emergent or scrub shrub wetlands can be found on the Charleston Peninsula, primarily near Magnolia Cemetery, but are not in close proximity of the structural measures being proposed.

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. 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).

As discussed above, wetlands in the study area have already been altered by development. In addition to filling, shorelines have been hardened. Most notable is the approximately 1.2 miles of shoreline along the Battery where the current seawall exists. Other armored areas of shoreline in the study area can be found near the Charleston Maritime Center, by the Bristol Condominiums, near the Courtyard Marriot and Hilton Garden Inn hotels off of Lockwood Blvd, and along the City Marina and Historic Rice Mill Building. Perimeter salt marshes are also currently vulnerable to erosion from wave action, with the exception of some marsh shorelines behind man-made structures that serve to break waves, such as the City Marina on the Ashley River. The shoreline here is actually accreting seaward.

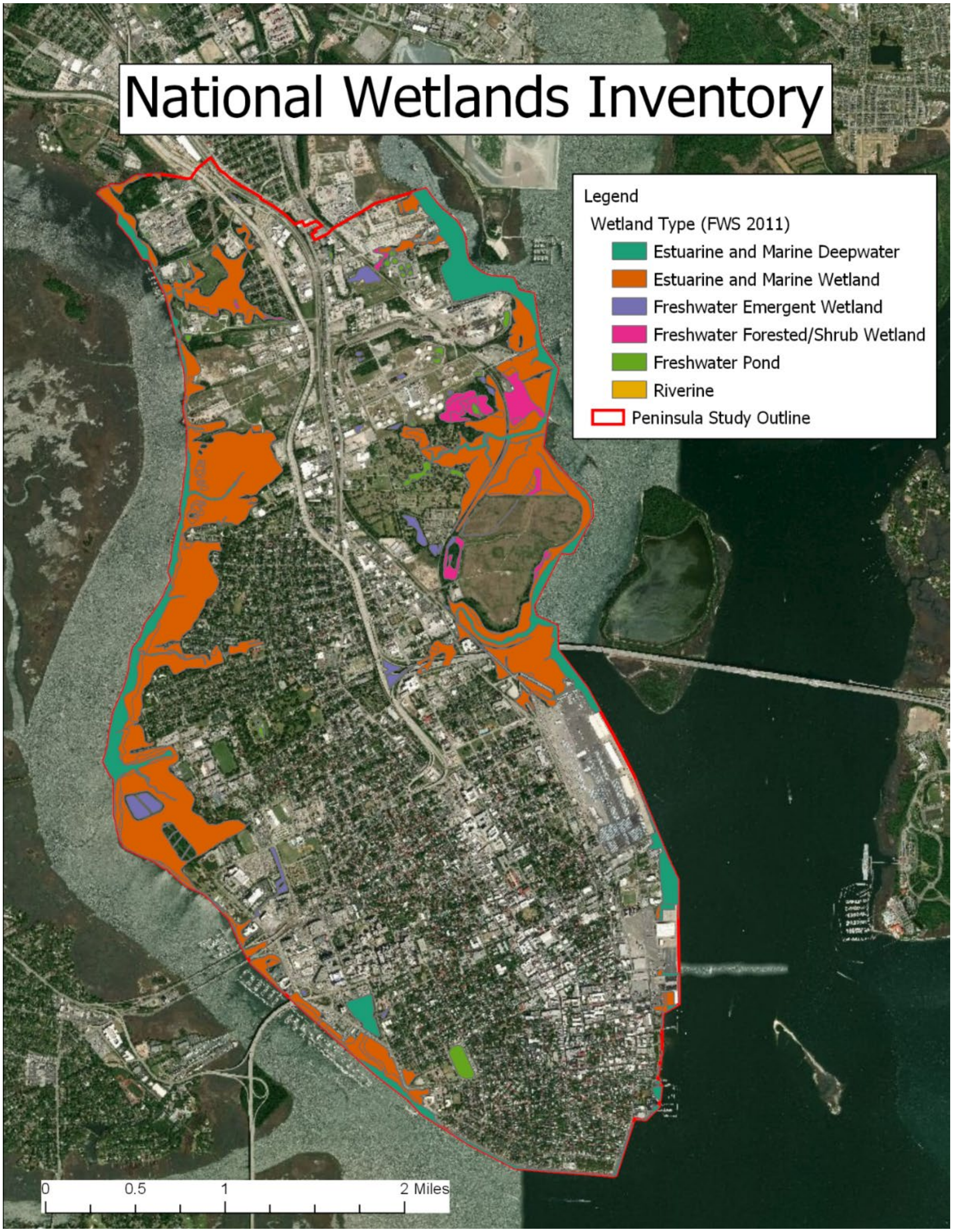

Figure 4-6. Distribution of types of wetlands in the study area.
Data source: USFWS NWI 2011.
Official mapping product of the Management Support Branch, Charleston District, USACE

Some salt marsh wetlands in the study area are already being completely inundated upon extreme high tides, where there isn't sufficient capacity to store the water, and no place for the marshes to migrate inland because of roads and other infrastructure. This is especially true for marshes along Lockwood Blvd (see Figure 4-7), Gadsden Greek, and New Market Creek.

Figure 4-7. The perimeter saltmarsh between Lockwood Blvd and the U.S. Coast Guard at high tide during a storm in December 2019.

4.7 Aquatic Resources

This section focuses primarily on fishery resources and marine mammals, **including species of special status**, and their habitat (terrestrial species, including special status species, are addressed in in the Terrestrial Wildlife and Vegetation section below). 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. "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. 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. 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.

In addition to special status species, aquatic resources are also afforded protections under the Marine Mammal Protection Act (MMPA) of 1972, as amended. 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.

Effects evaluated in this section include direct impacts to fish and fishery resources, and indirect impacts through alterations to their habitat. The ESA 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. The Magnuson-Stevens Fishery Conservation and Management Act of 1994 (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 fish and marine mammal 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

There are important recreational and commercial fisheries in the ROI, particularly supported by salt marshes in their juvenile stages. This includes many invertebrate and fish species. There are also a number of charismatic rays, sharks, marine mammals and sea turtles in the ROI. There are five federally-listed Threatened and Endangered species (species of special concern) in the ROI. These aquatic resources are described here.

Invertebrates

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*), whelk, eastern oysters (*Crassostrea virginica*), ribbed mussels (*Geukensia demissa*), hard clams (*Mercenaria mercenaria*), Eastern mud snails (*Ilyanassa obsolete*) and periwinkles (*Littoraria irrorata*) (Sanger and Parker, 2016). Many of these species are also economically important in South Carolina. More information on their habitat significance can be found below.

Fish

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 also have commercial or recreational value. Threats to many of these species include habitat loss, pollutants, and degraded water quality.

Two federally-protected fish species also occur in the Charleston Harbor and the Cooper River. They are 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 are a subtropical, anadromous species that typically migrates up rivers in the spring in this region to spawn. Historically, over-fishing affected sturgeon populations. Current prominent threats to these species include habitat loss or fragmentation, dredging, migration/passage barriers, pollution, and decreased water quality. Tagging and tracking by the SCDNR of shortnose and Atlantic sturgeon show 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. There is federally-designated Critical Habitat for the Atlantic sturgeon in the in the Cooper River. However, there are no in-water features or construction proposed in or near the Atlantic sturgeon Critical Habitat.

Cartilaginous fishes, such as the Atlantic stingray (*Dasyatis sabina*) and the bonnethead shark (*Sphyrna tiburo*), can also be found in the ROI. Sharks move into estuaries in the spring, and then head offshore in the fall.

Many of the invertebrate and fish species described above are supported by tidal wetlands found along the Lower Ashley and Lower Cooper Rivers. Habitats include emergent tidal marshes dominated by cordgrass (*Spartina alternaflora*) and black rush (*Juncus roemerianus*), as described in Wetlands section of this report. 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 scrub shrub wetlands that support wax myrtle (*Myrica cerifera*), salt marsh elder (*Iva frutescens*) and groundsel tree (*Baccharis halimifolia*) (Sanger and Parker, 2016). All of the tidal creeks and tributaries, along with their adjacent saltmarshes and oyster reefs, in the study area 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. For specific life stages estuarine-dependent and nearshore snapper-grouper species, EFH includes the areas inshore of the 100 foot-deep contour, which includes salt and brackish marshes, tidal creeks, and soft subtidal sediments of the Charleston Harbor.

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 an Essential Fish Habitat Assessment. USACE will formally consult with NOAA under the MSA, and address any conservation recommendations from NOAA in the Final Report.

<u>Marine Mammals</u>

Marine mammals known in the ROI include bottlenose dolphin (*Tursiops truncates*) and West Indian manatees (*Trichechus manatus*). The West Indian Manatee is a federally-listed threatened species, that is afforded additional Federal protection under the MMPA of 1972, as amended (16USC 1461). It is a transient species but is becoming more common in South Carolina waters. Manatees are most abundant in the warm waters of peninsular Florida, but some migrate along the South Carolina coast during the summer into the winter months. Manatees have been sited around Charleston in the Cooper River, Ashley River, and the Atlantic Intracoastal Water Way. In 2018, they were even sited in Shem Creek. Manatees can inhabit shallow (5-20 feet) salt and fresh waters. Because of the high tidal amplitude in South Carolina, manatees feed on abundant salt marsh grasses at high tide and submerged algae beds at low tide.

<u>Sea Turtles</u>

There are four species of sea turtles known to occur in or near waters of the Charleston Harbor, all of which are endangered species: 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, are not likely in the ROI. Loggerhead and green sea turtles are the most common species in South Carolina waters, respectively. Subadult and adult loggerheads move into coastal waters, such as Charleston Harbor, to prey on benthic invertebrates including mollusks and decapod crustaceans. 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 tidal creeks.

Primary threats to sea turtles include vessel strikes, dredging, by-catch and entanglement in fishing gear, and various natural and anthropogenic impacts to their nesting habitat, such as beach erosion, beach armoring, and artificial lighting. In the Charleston area, Critical Habitat for loggerhead sea turtles has been designated for Folly Beach and Morris Island, but these are well outside of the ROI.

Due to hundreds of years of development and marine commerce in the area, rivers and waterways surrounding and adjacent to the Charleston Peninsula have been impacted over time. All waterways in the ROI are currently closed to shellfish harvesting due to reduced water quality. Habitat has been lost due to filling of tidal wetlands and armoring of shorelines – most notably the current Battery seawall. Roads with culverts intersect three of the Peninsula's remaining tidal creeks, already restricting (but not impeding) flow and passage, including New Market Creek, Gadsden Creek, and Halsey Creek. It is not known if there are any biota studies and/or habitat assessments for the tidal creeks or tributaries on the Charleston Peninsula that document the presence or utilization by any specific species, nor the quality of the immediate habitat.

4.8 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 mudflats found around the Charleston Peninsula, as well as the bottom of the Charleston Harbor (this is the ROI). These small invertebrates can usually be seen without a microscope, and fall into two groups: epifauna that live attached to the sediment surface, and infauna that burrow and live in the sediment. 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 are regulated under the Magnuson-Stevens Fishery Conservation and Management Act.

Affected Environment

Intertidal and subtidal mudflats (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. Subtidal waters of the Charleston Harbor are classified as estuarine, subtidal, unconsolidated bottom, and are considered to be submerged deepwater habitat.

The intertidal mudflats and subtidal bottom found in the ROI are considered EFH. Benthic resources in the ROI generally include mollusks, polycheates, oligochates, nematodes, and amphipods. The individual species of benthic assemblages present in a particular area are usually consistent with their known sediment and salinity preferences, but may vary depending on the intensity of water flow. Most benthic macrofauna are relatively sedimentary, and are sensitive to changing environmental conditions. It is not known if there are any benthic macrofauna or sediment studies for the tidal creeks or tributarieson the Peninsula. Residential and/or commercial development surrounds all of them, so none are considered undisturbed.

4.9 Terrestrial Wildlife and Upland Vegetation

This section focuses on upland plants and terrestrial species of invertebrates, amphibians, reptiles, birds, and mammals, **including species of special status**. Special status species are already defined in Section 4.7 Aquatic Resources above as those listed as threatened or endangered and protected by the ESA.

The ROI for terrestrial wildlife and plants includes the Charleston Peninsula study area. The analysis also considers noise and disturbance effects from the alternatives on terrestrial species.

Affected Environment

Over time, development on the Charleston Peninsula has eliminated or fragmented terrestrial wildlife habitat and corridors; very little unaltered habitat remains. According to the USFWS, there are no known populations of federally-protected threatened and endangered wildlife species in the study area (see FWCA Planning Aid Letter in Appendix F). Existing tidal wetlands on the Peninsula could serve as potential foraging habitat for the endangered American wood stork (a large, long-legged wading bird), but there are no known roosting areas or rookeries currently located on the Peninsula.

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 MacGillivray’s seaside sparrows (*Ammodramus maritimus macgillivraii*) and monarch butterflies (*Danaus plexippus*). The MacGillivray’s seaside sparrow inhabits coastal salt and brackish marshes. They also breed at lower elevations of high marsh. The monarch butterfly is a highly-recognizable butterfly, but its population is declining. They feed on a wide range of flowering plants, and 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.

The USFWS also indicated that there are no known federally-protected threatened and endangered plant species in the study area (see FWCA Planning Aid Letter in Appendix F). Although there are three Federally endangered flowering plants known to occur in Charleston County – American chaffseed (*Schwalbea Americana*), Canby's dropwort (*Oxypolis canbyi*) and Pondberry (*Lindera melissifolia*) – suitable habitat for these species is not found in the ROI.

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 avoe 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.

4.10 Cultural Resources

The management of cultural resources is regulated under federal laws such as the National Historic Preservation Act (NHPA) of 1966, the Archaeological and Historic Preservation Act of 1974, the American Indian Religious Freedom Act of 1978, the Archeological Resource Protection Act of 1979, the National Environmental Policy Act (NEPA), and the Native American Graves Protection and Repatriation Act of 1990. Several regulations provide guidance on consulting with Federally-recognized tribes. Under Department of Defense Instruction (DoDI) 4710.02, *Department of Defense Interactions with Federally-Recognized Tribes* (2006) which governs DoD interactions with federally-recognized tribes, and EO 13175, *Consultation and Coordination with Indian Governments* (2000), USACE is charged with regular and meaningful consultation with Native American tribal officials in the development of policies that have tribal implications. The USACE Charleston District consults with 12 federally-recognized tribes who have interests in projects that are conducted in Charleston County. Only one tribe, the Catawba Indian Nation, has a recognized reservation within the state.

Cultural resources considered in this section are those defined by the National Historic Preservation Act (NHPA) as properties listed, or eligible for listing, in the National Register of Historic Places (NRHP) and are referred to as historic properties as well as resources that have unknown NRHP status requiring additional investigation. In order to be considered historically significant for the National Register, a property must meet one of the following criteria as defined in 36 CFR § 60.4:

a. Association with events that have made a substantial contribution to the broad patterns of our history;

b. Association with the lives of persons substantial in our past;

c. Embodiment of the distinctive characteristics of a type, period, or method of construction, or that represent the work of a master, or that possess high artistic values, or that represent a substantial or distinguishable entity whose components may lack individual distinction; or

d. Have yielded, or may be likely to yield, information important in prehistory or history.

Historic properties include buildings, structures, sites, districts, objects, cultural items, Indian sacred sites, archaeological artifact collections, and archaeological resources (36 CFR 800.16(l)(1)).

The analysis of impacts to cultural resources relies on existing information primarily from South Carolina's ArchSite database and the South Carolina Department of Archives and History (SC DAH) and project designs and measures available at the time of writing. The Area of Potential Effects (APE) for cultural resources extends beyond the study area and is defined as the areas where structural measures are implemented and non-structural measures are applied to historic properties as defined in 36 C.F.R. §800.16(l). 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)). Effects may be direct or indirect. Examples of effects include visual intrusions, alterations of setting, noise, vibrations, viewsheds, and physical impacts. Indirect effects may occur where submerged sites may be affected by changes in hydrology.

Affected Environment

The current conditions of the study area are shaped by the past setting and history, the current historic properties, and historic properties that have not yet been identified.

Archaeological and Historical Setting

Modern day South Carolina has been inhabited by humans for over 12,000 years. Evidence of some of the earliest human occupation that pre-dates the Clovis (Paleoindian period) 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.). 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. Little is known about this period, however, it is agreed that populations were 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 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 three main periods: Early, Middle and Late. During the Archaic period populations grew and became less mobile towards the end of the period. Technological innovations such as pottery 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 - 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. During this period there are some written records, but generally significant gaps exists. 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 Seewee, Wando, Etiwan, and Sampa resided in villages in the Charleston Harbor area when the Lords Proprietors settled the area. Archaeologically little is known of this period in the Charleston area.

The Charleston area was part of the Carolina colony, 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. By 1681 the settlement had grown and was moved across the river to the peninsula.

History of the Charleston Peninsula

Early settlement of the peninsula was concentrated along the Cooper River. Settlers constructed a network of fortifications – walls, cannon, moats – that encircled the town and protected its inhabitants from attacks by the French, Spanish, Native Americans and pirates (see Figure 4-8). The early deerskin trade with the nearby Indians helped Charles Town develop into a major port of the Carolinas and by the end of the seventeenth century, approximately 64,000 deerskins were being exported annually to England. Rice and cotton also contributed to the city’s economy and prosperity, and 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.

Figure 4-8. 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)*

To grow the colony quickly, the Lords Proprietors established religious tolerance as one of the original tenants. This promise attracted numerous religious groups to Charles Town with the hope of experiencing religious freedom. Protestant denominations, Huguenots, Jews, Quakers, Afro-Carolinians, and Roman Catholics from a variety of countries migrated to the colony. As a result of these migrations, Charles Town became home to one of the largest Jewish communities in North America. The Jewish Coming Street Cemetery, first established in 1762, attests to their long standing presence in the community. The first Anglican church, St. Philip's Episcopal, was built in 1682, although later destroyed by fire; the Old Bethel United Methodist Church, was established by both free and enslaved residents in 1797; and the congregation of the Emanuel

A.M.E. Church stems from a religious group organized solely by African Americans, free and enslaved, in 1791.

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 (see Figure 4-9). 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 race course 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).

According to U.S. Census data, the 1860 population for Charleston was just over 40,500 persons, making it the 22nd largest city in the United States with a majority of the population enslaved persons. Shortly after the election of Abraham Lincoln in 1860 the state of South Carolina succeeded from the Union and in April 1861 the first shots of the Civil War were fired from 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 (see Figure 4-10). 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.

After the Civil War many structures were never rebuild 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.

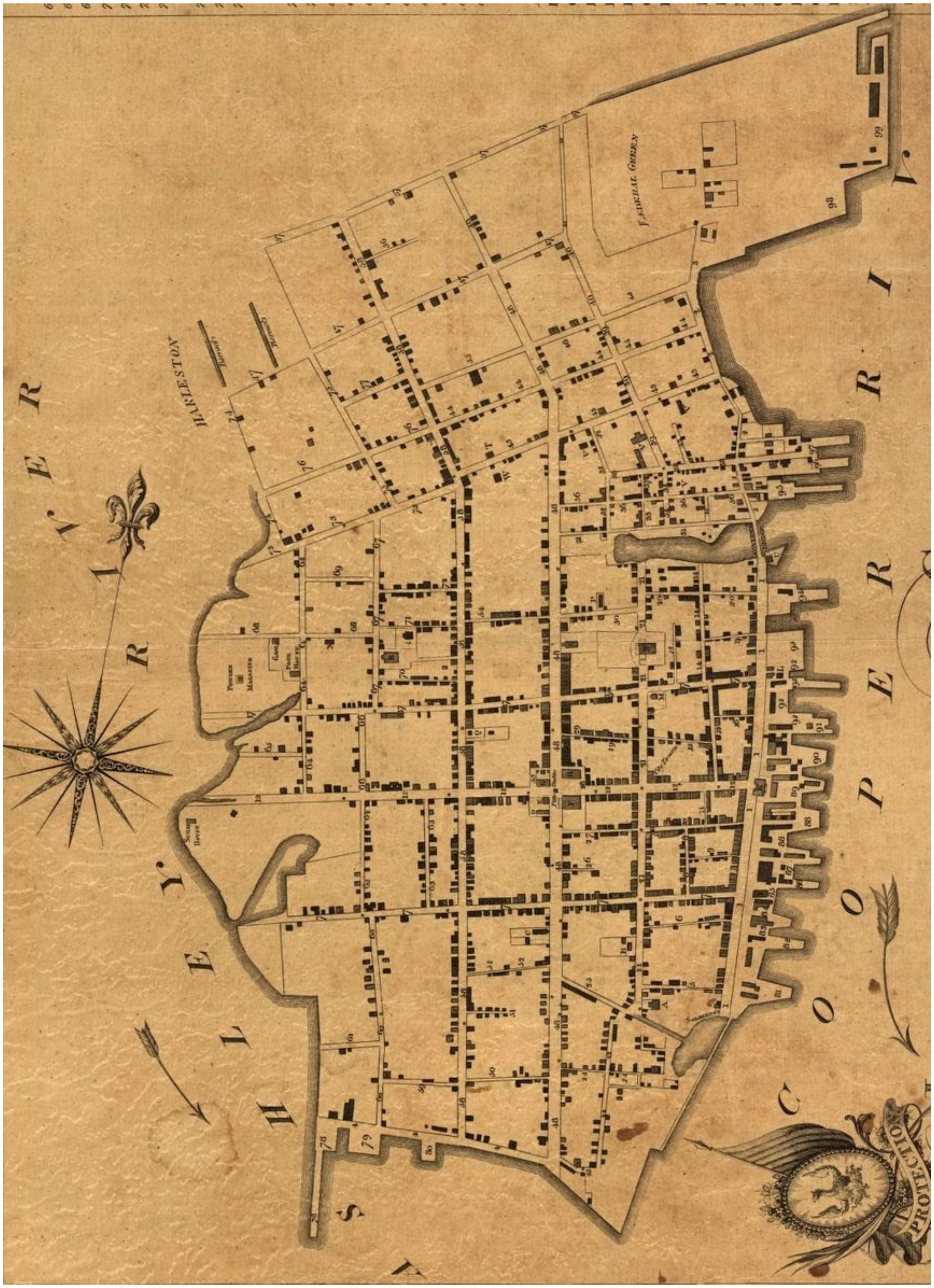

Figure 4-9. Portion of *Ichnography of Charleston, South-Carolina: at the request of Adam Tunno, Esq., for the use of the Phoenix Fire-Company of London, taken from actual survey, 2d August 1788*, E. Petrie, 1790, showing growth of lower peninsula. Source: Library of Congress, https://www.loc.gov/item/80692362/.

Figure 4-10. ***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/.

Inventory of Cultural Resources in Study Area

As of November 7, 2019, there were 197 cultural resources in the study area that have been listed as a district or individually on the NRHP, determined eligible for listing on the NRHP, or require additional investigation to determine NRHP eligibility. This number does not include contributing elements to historic districts. Eighty-one of the resources are archaeological sites; five resources are historic areas or districts that are eligible, but not listed on the NRHP; 35 structures or buildings are individually eligible for the NRHP or require additional investigation; and 76 historic properties are listed on the NRHP. Of these 76 NRHP-listed historic properties, 30 are designated National Historic Landmarks (NHL) and four are historic districts. It should be noted that these numbers do not include the contributing elements that are associated with the NRHP-listed or eligible historic districts. This data was derived primarily from SC ArchSite, an online 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. The database includes recorded resources regardless of NRHP eligibility status, but does not contain all contributing elements. A complete inventory of these properties can be found in Appendix D.

Cultural resources are distributed throughout the peninsula, but the largest concentration of historic properties is found in the lower portion of the peninsula (south of Highway 17) in the Charleston Old and Historic District (COHD) (see Figure 4-11). This historic district, which was also designated a National Historic Landmark (NHL) in 1960, consists of an assemblage of eighteenth and nineteenth century buildings and structures that collectively possess a unique visual appeal of old Charleston. Subsequent nominations in the 1970s and 1980s expanded the boundary and extended the period of significance to 1941. The COHD contains primarily residential buildings, in addition to institutional resources such as churches and government-related buildings. Many buildings are significant both for associations with historic events or persons and for architecture. According to ArchSite, there are 30 structures that have been designed as NHLs; 7 historic structures are individually eligible for listing on the NRHP; and 20 are individually listed on the Register. The SC DAH maintains a list of historic properties that have been determined to be contributing elements to the COHD. As of November 2019 the list contained 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 (John Sylvest, personal communication, November 2019). The COHD covers approximately 2 square miles, but the NHL boundary for the COHD is smaller than what is shown in ArchSite as the NHL boundary does not include the later boundary expansions (Ellen Rankin, personal communication October 2019). Both the National Park Service (NPS) and SC DAH staff agree that a complete list of all contributing elements is lacking.

The COHD includes several historic neighborhoods and the King Street/Meeting Street commercial corridor. Included in the COHD are the Low and High Battery Seawalls, whose construction facilitated the creation of Murray Boulevard and East Battery Street, respectively. The High Battery seawall was constructed during the early nineteenth century and measured approximately 1,400 feet long. Its creation facilitated the development of East Battery Street and White Point Garden. Murray Boulevard neighborhood is a mile-long waterfront drive created in 1909-11 when the Low Battery Seawall was constructed and 47 acres of mud flats were filled, surveyed and platted for residential development.

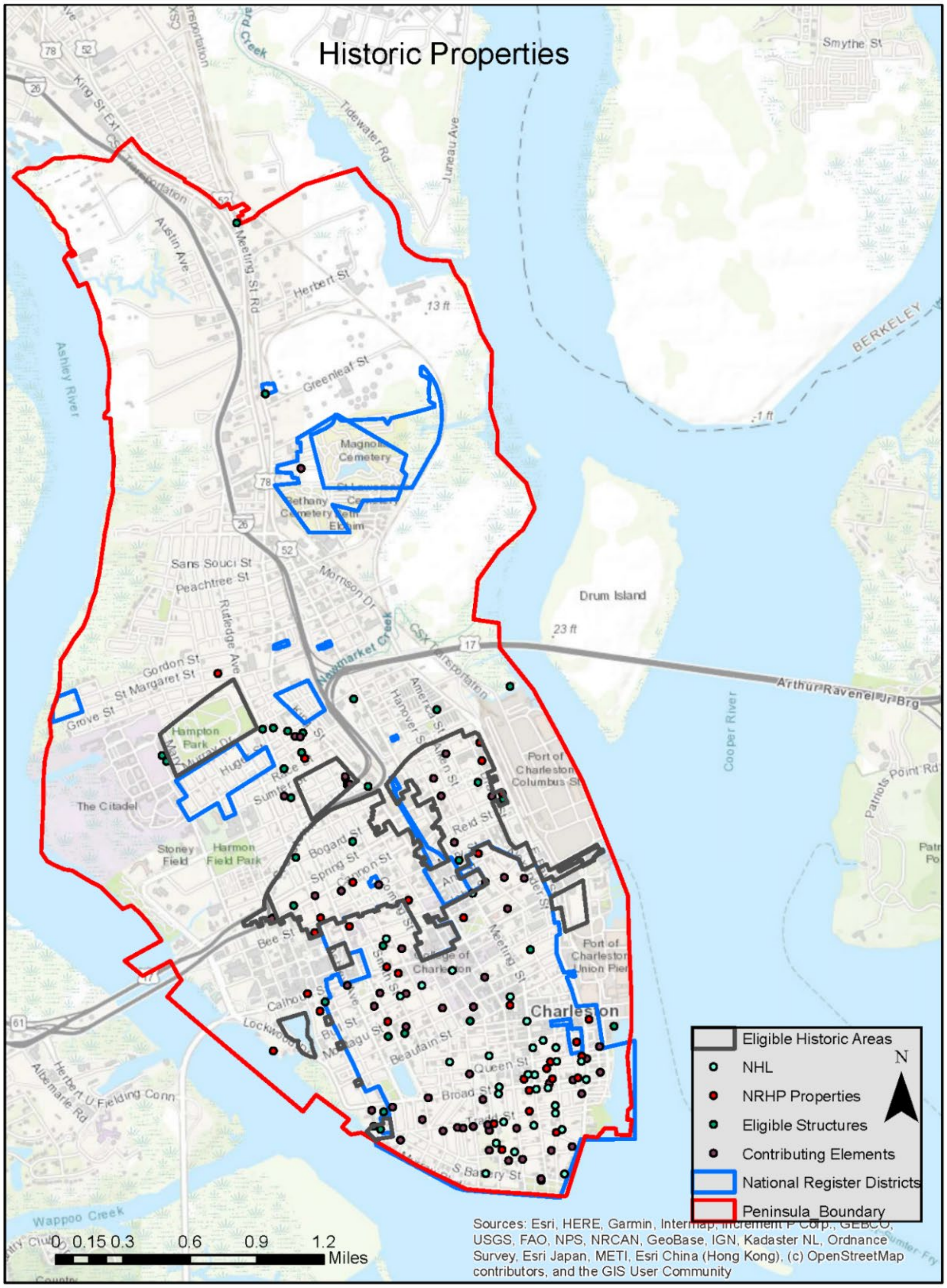

Figure 4-11. Historic properties* located on the peninsula within Study Area
Data source: ArchSite.
***Archaeological sites are not depicted due to sensitivity of information.**

Potential for Unidentified Cultural Resources.

In spite of the high number of recorded archaeological sites on the peninsula (n=103), limited archaeological investigations have been conducted to date (see Figure 4-12). Field investigations for South Carolina Department of Transportation and other infrastructure projects are the most prevalent. The survey areas are located on the east side of the peninsula and were conducted for bridge replacement projects (Cooper River Bridge; Grace Memorial Bridge). The Charleston Museum initiated a historic archaeological research program in the 1970s which has contributed greatly to Charleston's historic archaeological record. These investigations are generally associated with historic house sites.

Figure 4-12. Archaeological survey areas in Study Area.
Source: ArchSite.

Due the peninsula's long history of human occupation, the possibility for encountering unrecorded and unevaluated cultural resources is relatively high. A review of historic maps indicates that the probability of locating buried archaeological deposits is high, in areas on the Cooper River side of the peninsula where early settlement and growth occurred. While much of the study area has been developed, it is possible that intact archaeological deposits, especially prehistoric period deposits, exist below the level of ground disturbance.

The area just south of the Battery in Charleston Harbor has a high potential to contain submerged cultural resources. Remnants of Charleston's maritime heritage and the naval operations of both the Union and Confederate troops are found in submerged archaeological remains in Charleston Harbor. The Charleston Harbor Naval Battlefield encompasses the harbor and extends approximately 5 miles off the coast (see Figure 4-13). From 1861 to 1865 this area was the scene of numerous battles and skirmishes between the Union and Confederate navies.

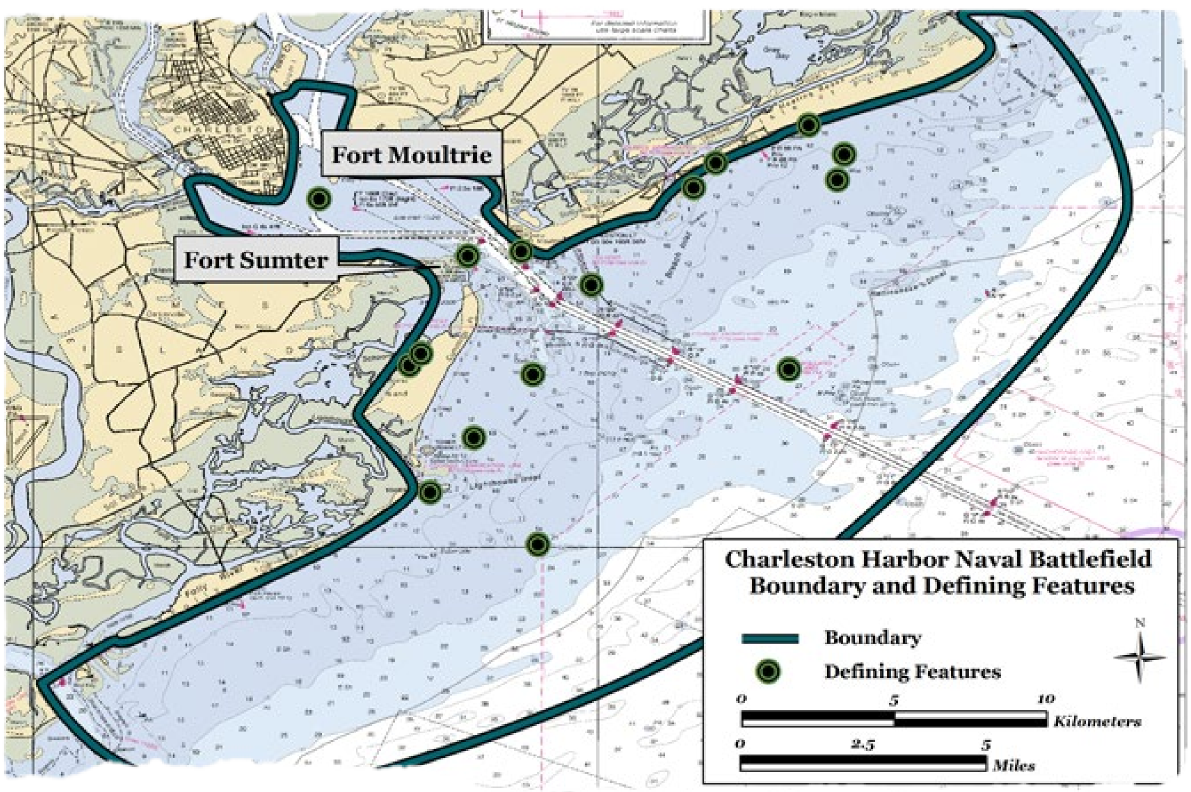

Figure 4-13. Charleston Harbor Naval Battlefield boundary and defining features. Source: University of South Carolina College of Arts and Sciences Maritime Research Division http://artsandsciences.sc.edu/sciaa/mrd/charlestonharbor

As project designs are refined and optimized, impacts to cultural resources will continue to be minimized and avoided in some cases. Because the USACE cannot fully determine how the project may affect historic properties prior to finalization of this feasibility study, a

Programmatic Agreement (PA) will be used to ensure compliance with Section 106 of the National Historic Preservation Act of 1966 (NHPA). Specifically, the scope and diversity of potential effects of the project and constraints of the USACE planning policy make a PA for compliance with Section 106 essential. The PA will allow the USACE to complete the necessary archaeological surveys during the follow on Preconstruction Engineer and Design (PED) phase of the project, and it will also allow any additional architectural inventories and mitigation to be completed after structural and non-structural measures have been clearly defined and sited. The PA will also streamline Section 106 reviews given the potential to affect a high number of historic properties. Therefore, pursuant to 54 U.S.C. 306108, 36 CFR 800.4(b)(2), and 36 CFR 800.14(b)(1)(ii), the Corps is deferring final identification and evaluation of historic properties until after project approval, additional funding becomes available, and prior to construction by executing a PA. A draft of the PA is included as an appendix to this report and has been sent for review by signatories (SHPO, National Park Service and Advisory Council on Historic Preservation) and concurring parties (Historic Charleston Foundation, Preservation Society of Charleston, Catawba Indian Nation).

4.11 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 2020, the City of Charleston will complete 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 4-14. 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 seawall, which is popular with visitors.

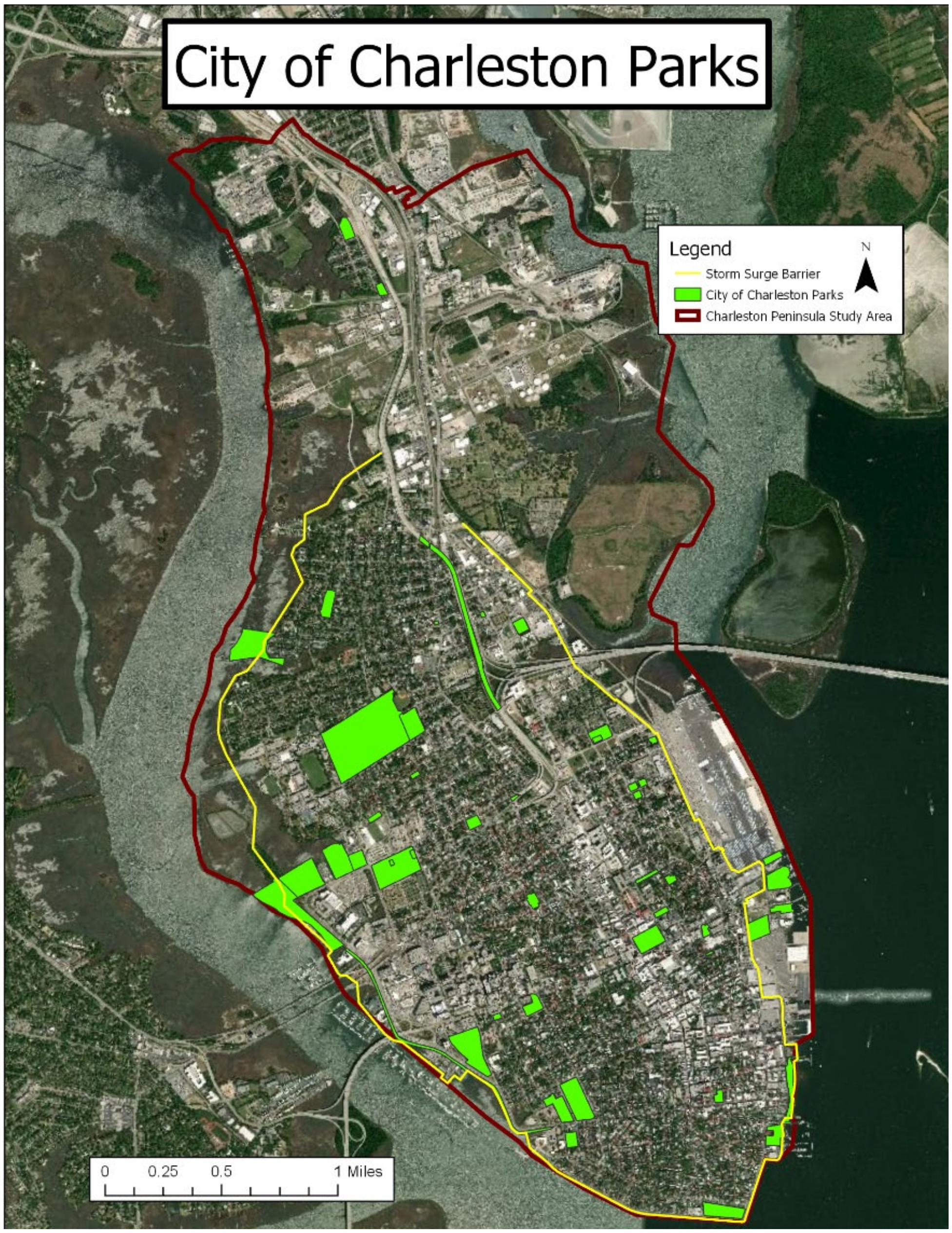

Figure 4-14. Map of parks on the Charleston Peninsula managed by the City of Charleston. Data Source: City of Charleston
Official mapping product of the Management Support Branch, Charleston District, USACE

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.

4.12 Visuals and Aesthetics

Visual resources are the natural and man-made features that comprise the visual qualities of a given area, or "viewshed." These features form the overall impression that an observer receives of an area or its landscape character. Topography, water, vegetation, man-made features, and the degree of panoramic view available are examples of visual characteristics of an area.

Visual resources are mentioned in NEPA and CEQ regulations to implement NEPA under the heading of aesthetics. These regulations identify aesthetics as one of the elements or factors in the human environment that must be considered in determining the effects of a project. As prescribed by NEPA and CEQ, it is the "continuous responsibility" of federal and state governments to "assure all Americans" an environment that is composed of "aesthetically pleasing" surroundings.

The visual resources assessment for this section is further described in Appendix F, Environmental. It was conducted according to USACE guidance, including ER 1105-2-100 (22 Apr 2000), Appendix C Environmental Evaluation & Compliance, section C-5 "Aesthetic Resources", and utilized the procedure recommended there, which is the Visual Resources Assessment Procedure (VRAP) as described in the WES Instructional Report EL-88-1. 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 adverse impact. Such a procedure provides a clear, tractable basis for including aesthetics in plan formulation, design, reformulation, and mitigation planning."

The level of detail used at this time is limited to the Visual Impact Assessment (VIA) "General Procedure". While the General Procedure is being used at this time, use of the Detailed Procedure may be developed and implemented concurrent with continued preparation of the Feasibility Report. The visual quality objectives of the Detailed Procedure would be all those of the general procedure but in a more detailed way, as well as to reduce visual contrast with the landscape as much as possible unless the recommended plan has symbolic value, informative significance, and/or creative design; to borrow at least partly from visual elements of the surrounding landscape; and to identify if mitigation may be necessary to assure compatibility.

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. For the General Procedure contained herein, the visual quality objectives are limited to select places in the ROI for identifying potential visual impacts in a general way. If the analysis is progressed from the General Procedure toward the components of the Detailed Procedure throughout the remainder of the feasibility study, the detailed analysis will be included in the Final Report.

Affected Environment

The ROI is a coastal landscape with large bodies of swiftly moving water, including the Charleston Harbor and the Ashley and Cooper rivers, occasionally with small boat marinas present. In the places observed, these water bodies were often the visually dominant element. On the water were boats of various sizes and purposes, including small boats such as sail boats and motor boats, as well as large ships such as cruise ships and container ships. Scenery across the water bodies in the distance often consisted of a generally urbanized landscape. 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. Land uses in the areas observed were primarily either commercial and institutional buildings, or had commercial and institutional substantially interspersed. Distinct attractive land uses included parks and recreational areas as well as historic steeples visible on the skyline from some locations. Unattractive land uses included industrial buildings and unsightly infrastructure in the skyline such as cell phone towers and directional highway signs. Construction activities are present with cranes on the skyline.

4.13 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 SCDHEC's 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 4-1 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 30 November 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 South Carolina Department of Health and Environmental Control (SC DHEC), maintains a network of air quality monitoring stations located throughout the state. There are two primary monitoring stations in the ROI: one at the Jenkins Avenue Fire Station in North Charleston, and one at the Cape Romain National Wildlife Refuge in Awendaw). The Jenkins Ave station currently monitors nitrogen oxides, sulfur dioxide, and particulate matter, and will become an approved particulate matter monitoring station by EPA in 2020. The Cape Romain station monitors nitrogen oxides, sulfur dioxide, particulate matter, and ozone. There is an additional station on the Charleston Peninsula 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 in 2020.

Currently, Charleston County, as well as 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 4-1.

Table 4-1. South Carolina Ambient Air Quality Standards

Pollutant	**Reference**	**Measuring Interval**	**Standard Level**			
			mg/m³	**µg/m³**	**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.

4.14 Noise

Section 4(b) of the Noise Control Act (NCA) 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 NCA of 1972 to include the intensity, duration, and character of sounds from all sources. Applicable federal guidelines for noise regulation derive from the U.S. Department of Transportation (USDOT) or, more specifically, the Federal Transit Administration and the Federal Highways Administration.

Noise is often considered undesirable because it interferes with communication, damages hearing 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. Wildlife are susceptible to noise, as well as aquatic life since sound can travel underwater.

High-density urban areas can average up to 78 dBA and average density urban areas can average up to 65 dBA during the day and early evening (EPA 1978).

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

Affected Environment

The Charleston Harbor has supported marine commerce since colonial times. Typical noise form the 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.

Existing sources of noise on the Charleston Peninsula are primarily from traffic and industry, such as dock side port operations and rail operations. 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.

The City of Charleston currently has a noise ordinance. It primarily pertains to “loud and unnecessary noises” related to common motor vehicles, vocal noises (e.g., yelling), music, and musical instruments. In 2020, the City is proposing a new ordinance specifically related to noise from building construction operations. It would specify allowable days and times for various construction operations, and noise exemptions. If the new ordinance is ratified by the City, construction of any Federal action alternatives would comply with requirements of the new ordinance.

4.15 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. A Phase 1 site assessment of areas in the ROI will be done as needed during or before the PED phase. If unknown contaminated sites are discovered and a Phase 2 or subsequent action is needed, then a supplemental assessment may be required to address any previously unknown and unaccounted impacts. At this stage in the planning process, the assessment of hazardous materials and waste focuses on 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.

<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 4-2 with their status for non-listing on the NPL.

Table 4-2. CERCLA Sites on the Charleston Peninsula That Are Not Listed on the NPL. (Source: USEPA)

SITE NAME	ADDRESS	NON-NPL STATUS
Ambrose Alley Mercury	6 AMBROSE ALLEY CHARLESTON, SC 29401	Removal Only Site (No Site Assessment Work Needed)
Calhoun Park Area	CALHOUN AT CONCORD STREET CHARLESTON, SC 29401	Remedial Activities Under EPA Enforcement
US Coast Guard Charleston	196 TRADD STREET CHARLESTON, SC 29401-1800	Fed Fac Preliminary Assessment Review Start Needed
USDOI Charleston Harbor Site	CONCORD ST AT END OF CALHOUN ST CHARLESTON, SC 29401	Addressed as Part of Another non-NPL Site
VA (Veterans Administration)	109 BEE STREET CHARLESTON, SC 29401-5703	Fed Fac Preliminary Assessment Review Start Needed

Medical Center Research		
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

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 4-15). 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 4-16) that range from local utilities to small manufacturing operations. There are 21 RCRA sites in the Charleston Neck area of the peninsula (see Figure 4-17). These range from various marine contractors to autobody shops to petrochemical companies.

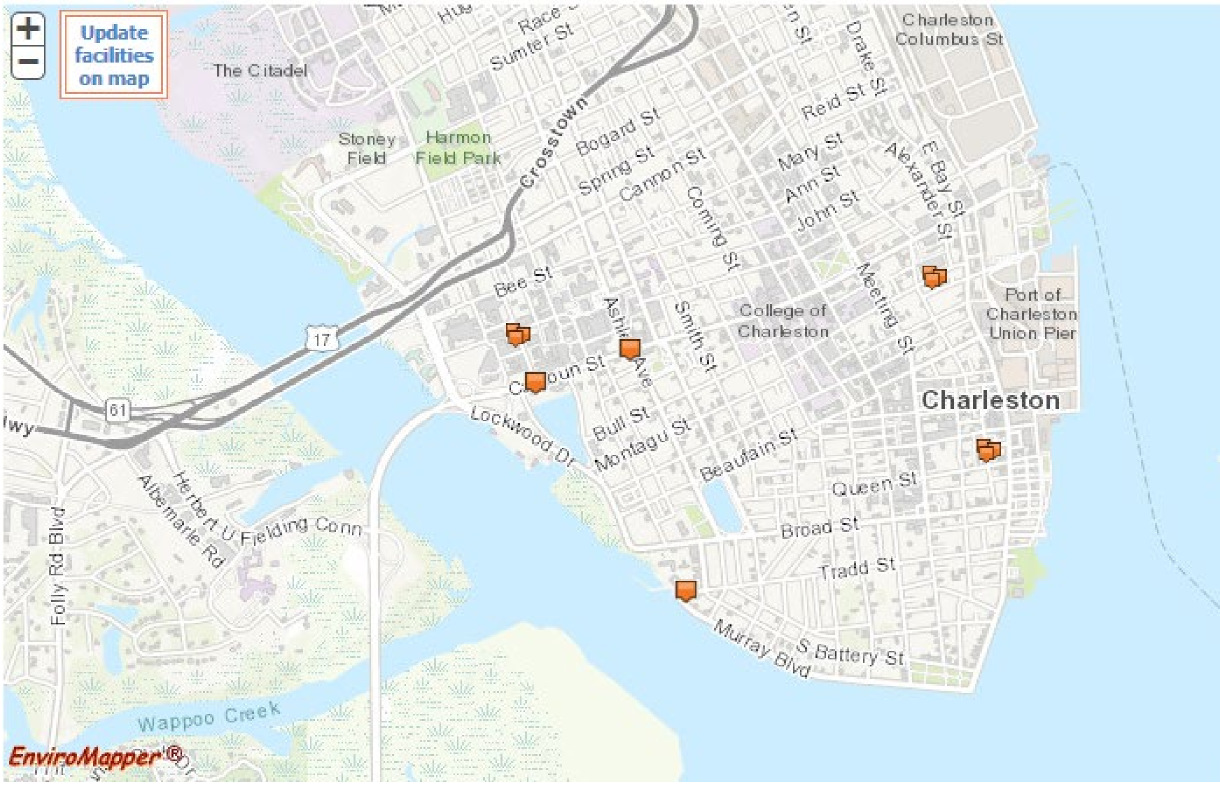

Figure 4-15. RCRA sites on the lower Charleston Peninsula.
Source: USEPA

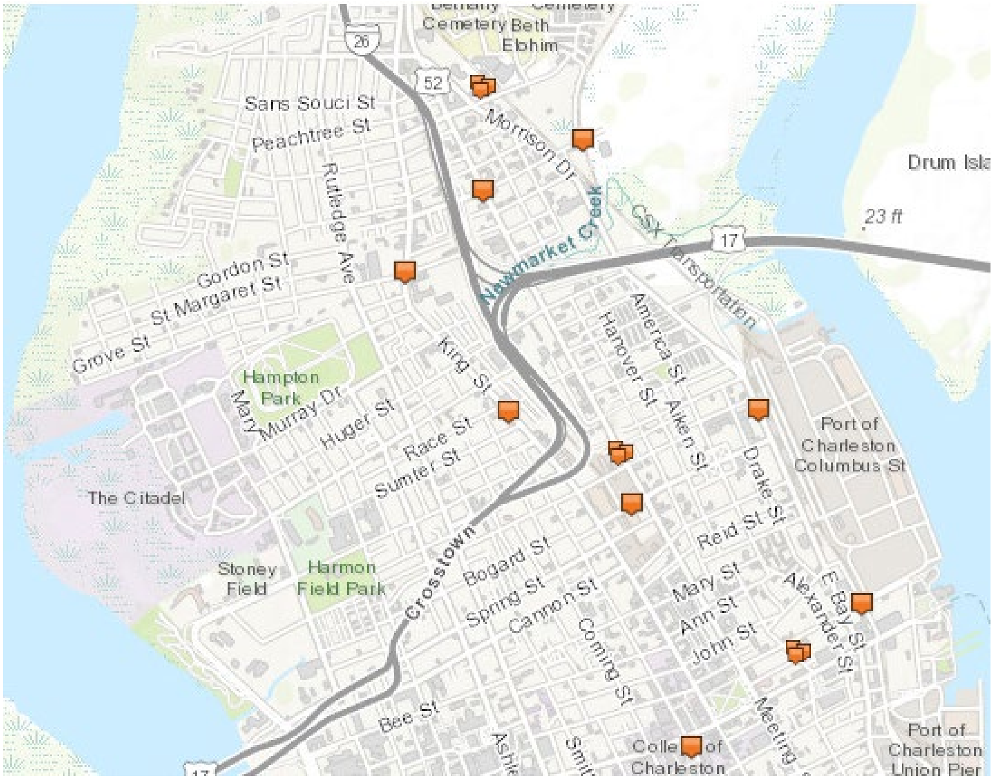

Figure 4-16. RCRA sites on the middle area of the Charleston Peninsula. Source: USEPA

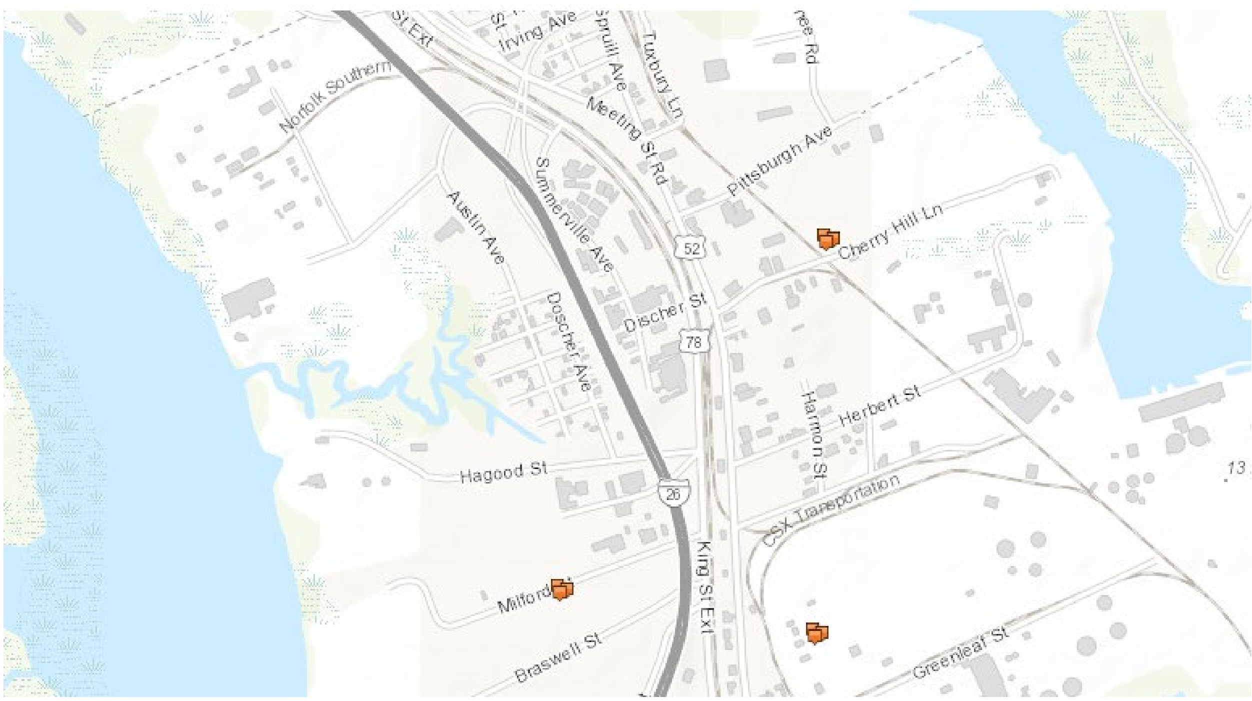

Figure 4-17. RCRA sites in the Charleston Neck area of the Peninsula. Source: USEPA

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 4-18.

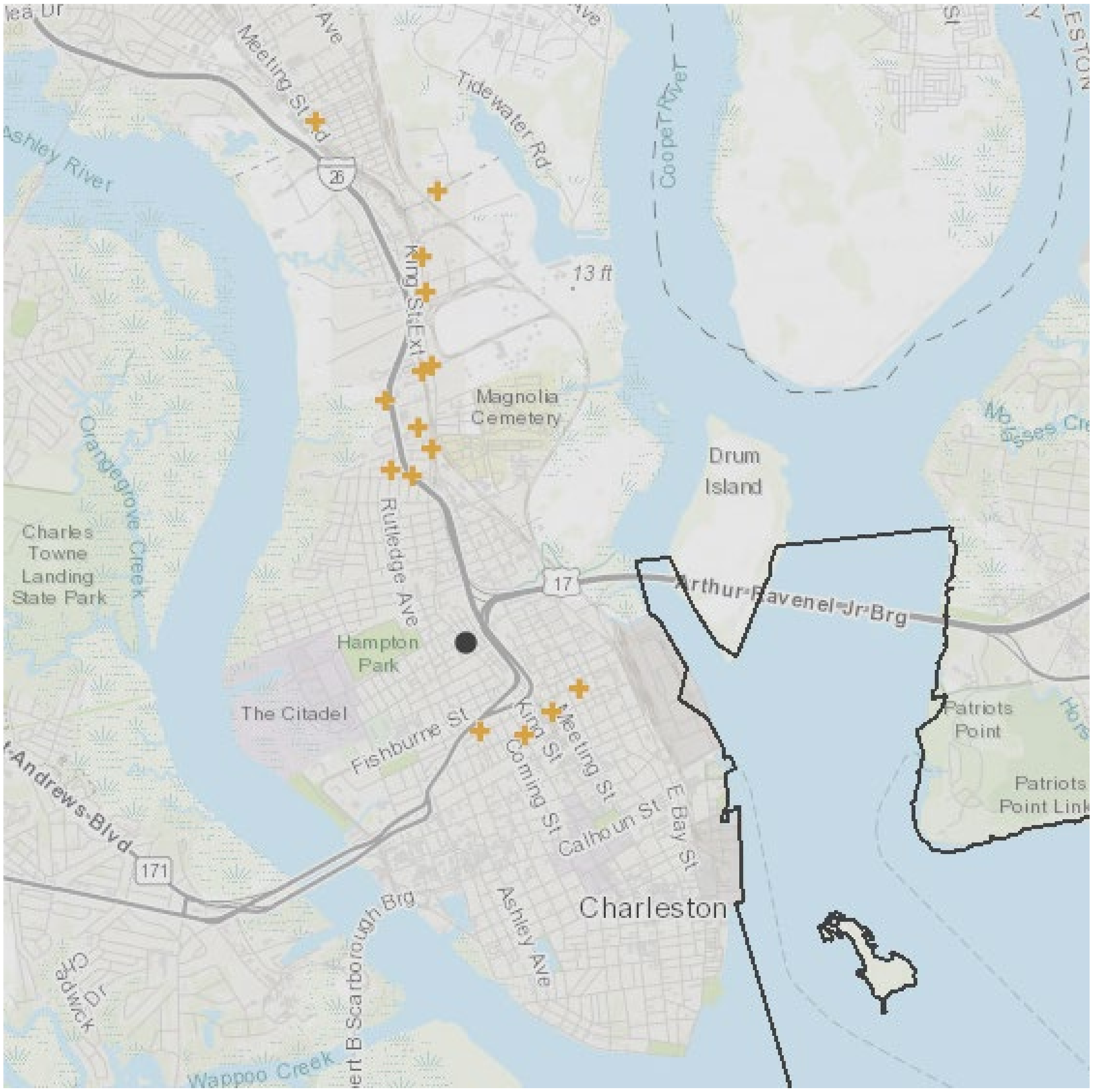

Figure 4-18. Brownfield Cleanup Sites in the study area are shown as gold "+" symbols. Source: USEPA

4.16 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 that may be directly or indirectly affected by the alternatives.

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.

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 Post 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 4-19.

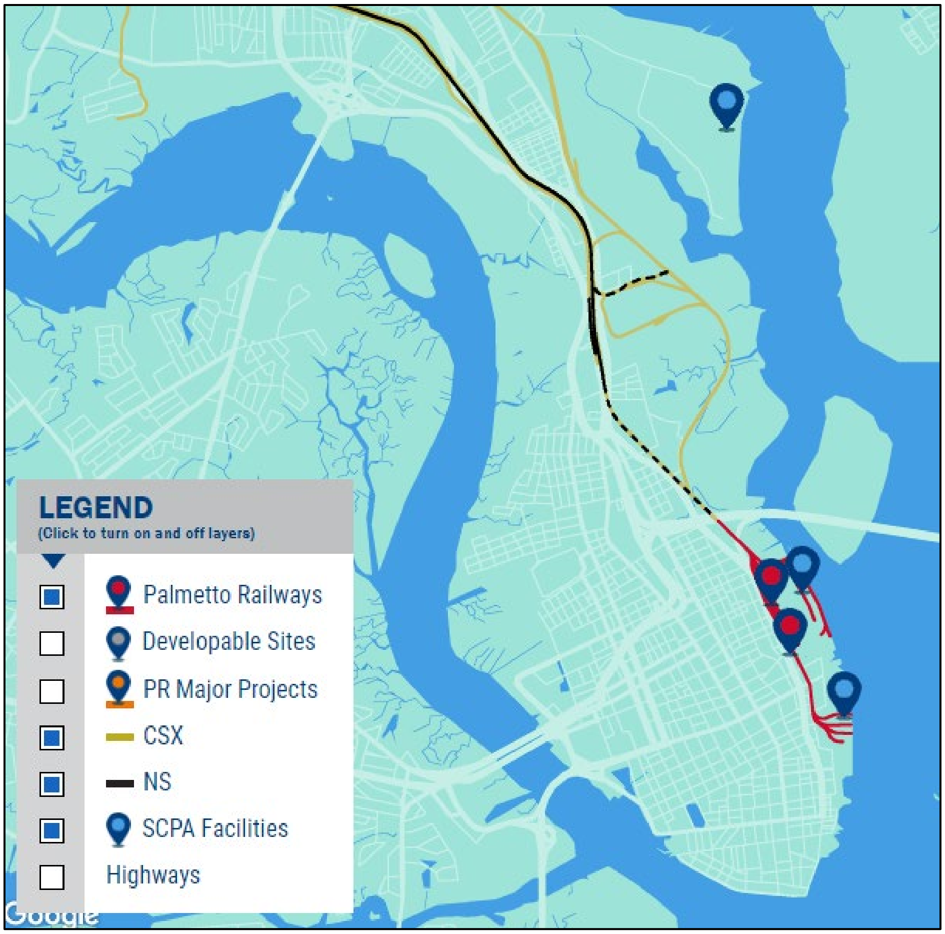

Figure 4-19. Locations of railways operated by Palmetto Railways, CSX, and Norfolk Southern on the Charleston Peninsula.
Source: Palmetto Railways

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 Plan makes recommendations for bicycle and pedestrian physical improvements.

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.

4.17 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 Cooper River, 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. Telecommunications cables may be above ground or buried, but this has not been verified.

Electric and Gas

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

Telecommunications

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

Stormwater

The City of Charleston has numerous stormwater outfalls around the peninsula. 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.

Water and Wastewater

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

4.18 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 responds 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 structures 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

The existing conditions for safety are described here as they relate to coastal flooding, the interior drainage system, and emergency services.

Coastal Flooding

Flooding in the ROI is caused by a number of factors, which often combine to form a complex, multi-faceted challenge. Figure 4-20 demonstrates some of the causes of flooding in the Charleston areas.

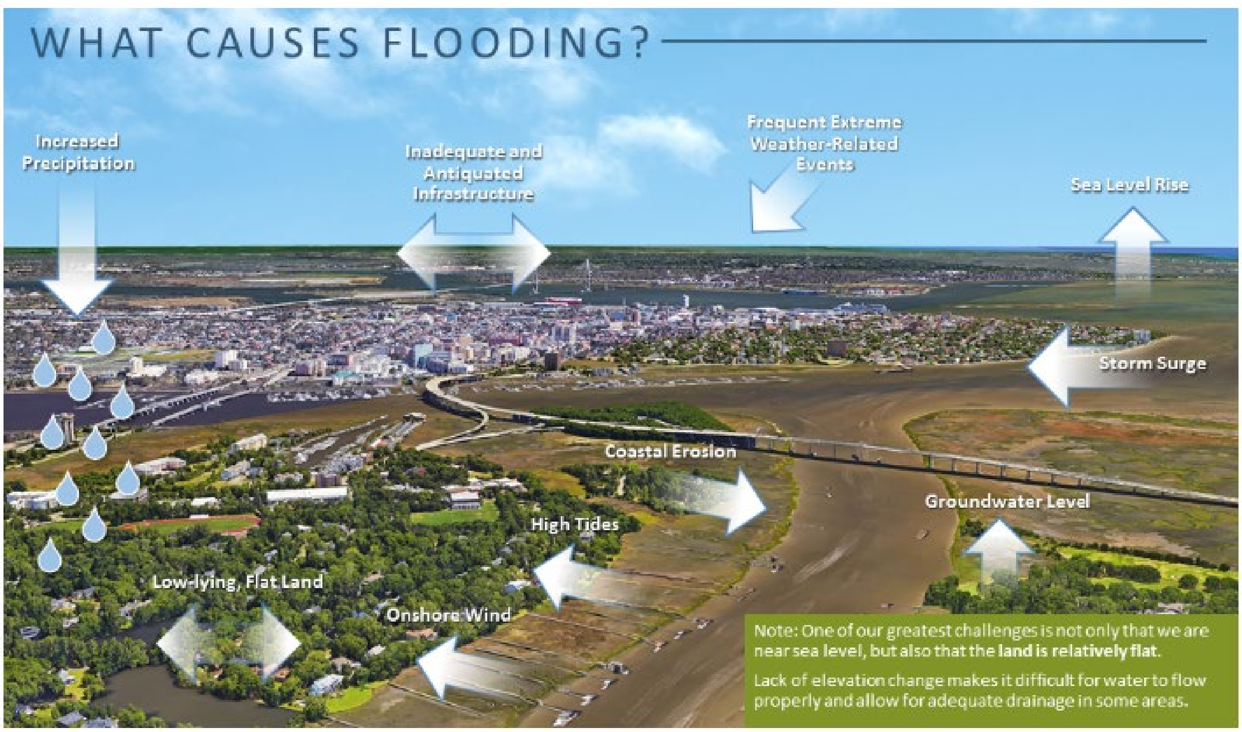

Figure 4-20. Local factors that contribute to flooding in the Charleston, SC area. Source: City of Charleston.

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.

The Charleston area experiences flooding from all three types of tropical cyclones (hurricanes, tropical storms and tropical depressions), and nor'easters. 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 ftNAVD88. 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.

The City of Charleston has a number of initiatives underway to address flooding 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 below).

Interior Drainage System

The City of Charleston currently has a number of projects underway or planned to improve interior drainage from the Peninsula, which are critical for addressing heavy flooding from rainfall.

- 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 is completed in early 2020

Current high tides are influencing the effectiveness of the old drainage system that the City is the city 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.

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

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

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

There are two efforts underway in the Charleston area that relate to emergency response. The Charleston 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. When it is complete, it will identify 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 will highlight 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.

4.19 Environmental Justice, Protection of Children

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.

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 4-21 shows the census tract boundaries on the Charleston Peninsula and surrounding areas.

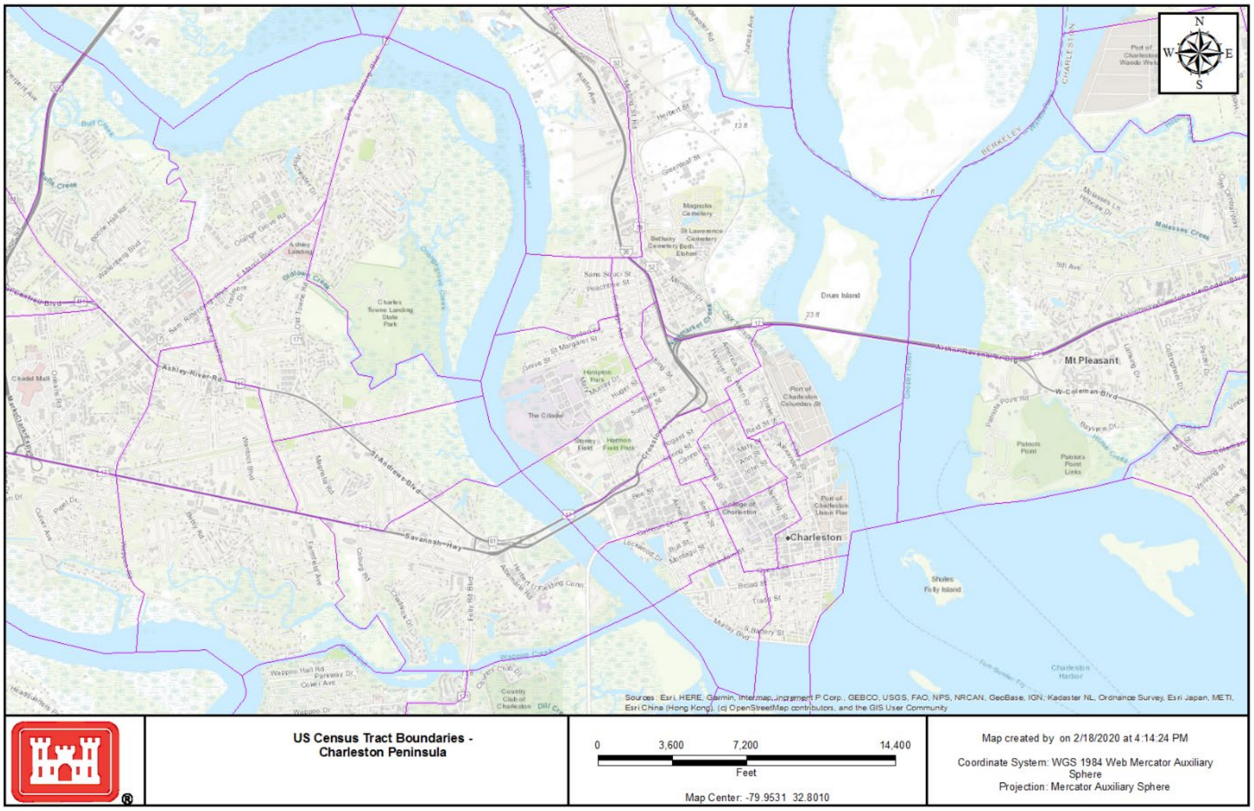

Figure 4-21. Map of US Census Tract boundaries (outlined in purple). There are 16 census tracts on the Charleston Peninsula that overlap with the study area.

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 4-3, 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 4-22. A map showing the distribution of census tracts with percentiles of children under the age of five is shown in Figure 4-23.

The ROI does not contain disproportionate populations of minority, juvenile, elderly, or low-income communities when compared to the surrounding areas.

Table 4-3. 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 $\mu g/m^3$)	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 ($\mu g/m^3$)	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.

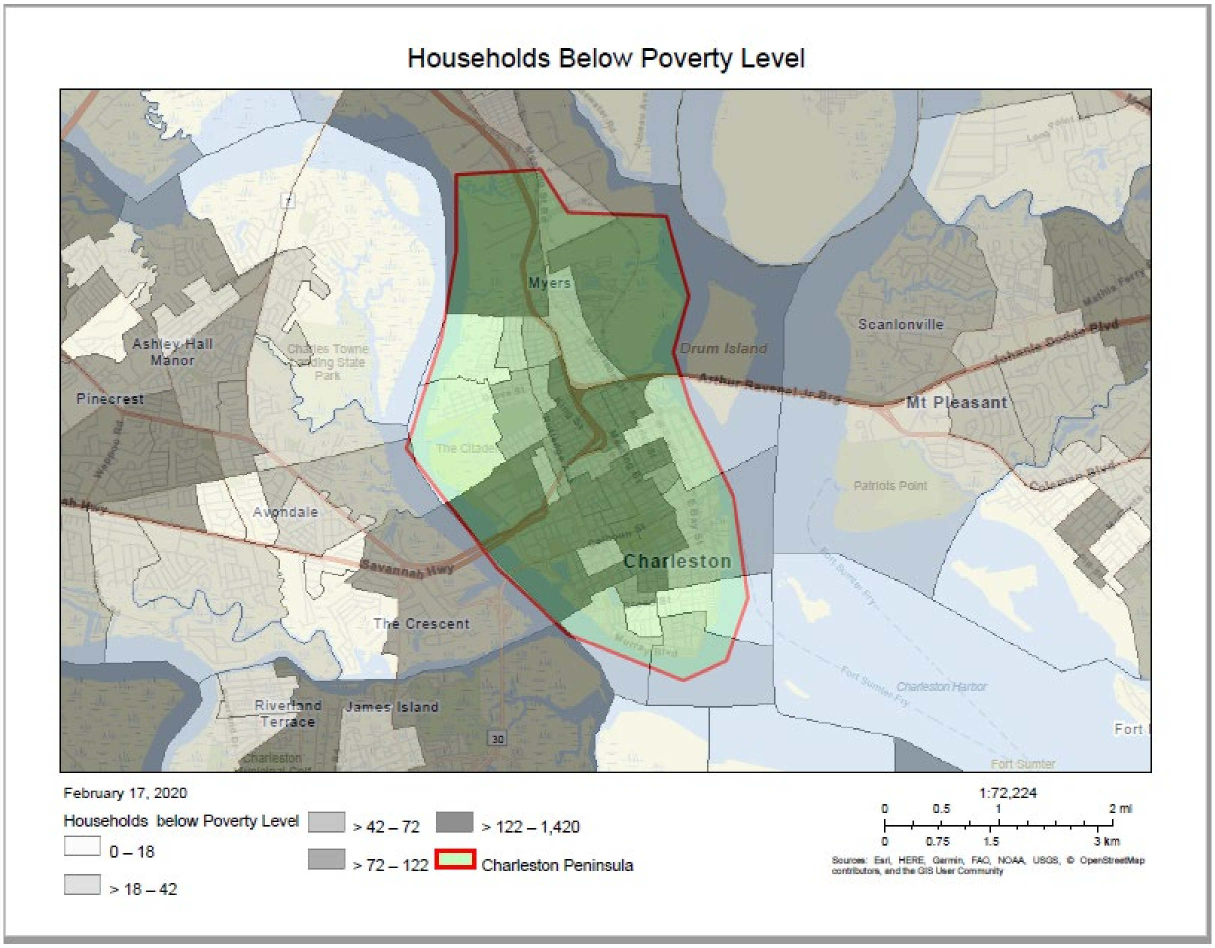

Figure 4-22. Map showing distribution of households below the poverty level (by census tract) in relation to the Charleston Peninsula.
Source: USEPA

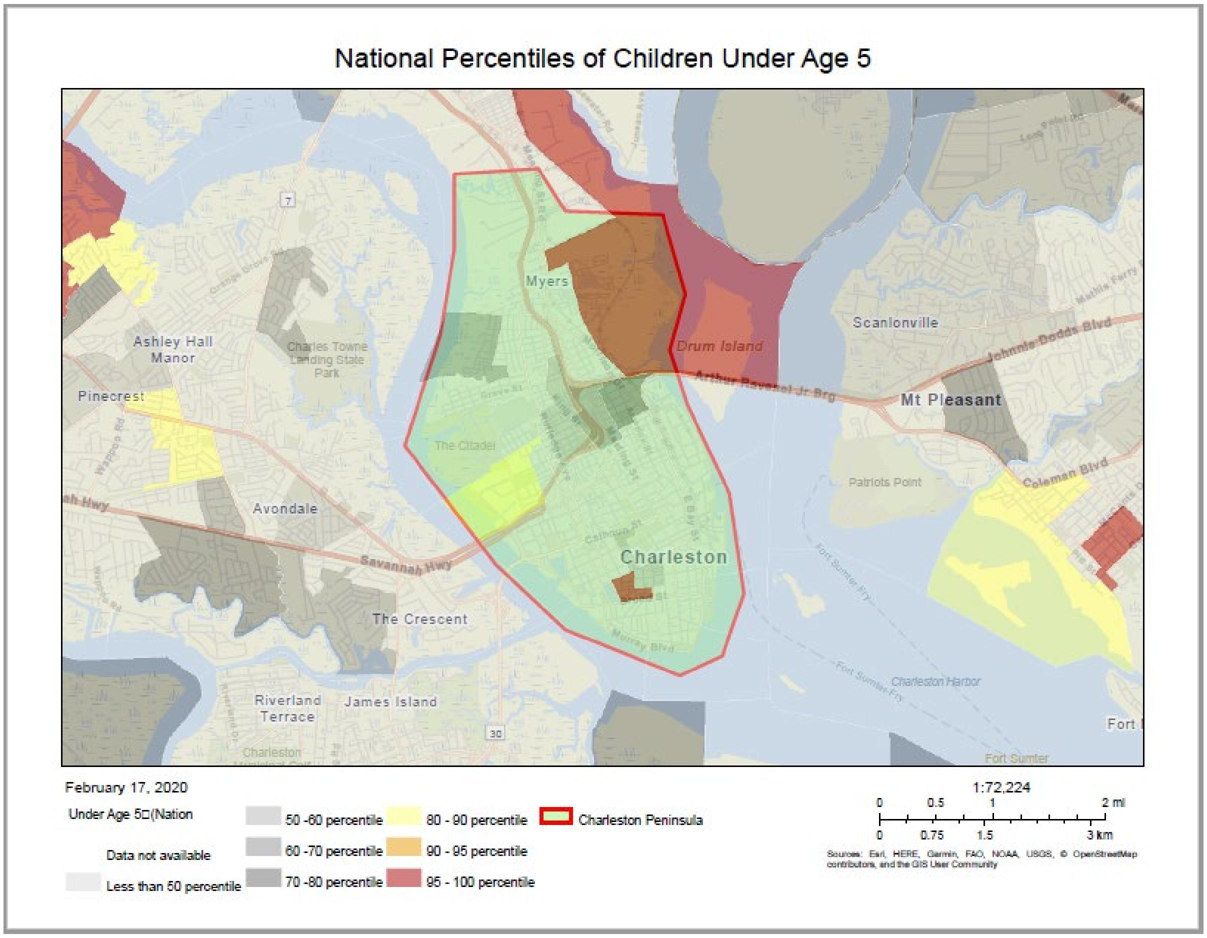

Figure 4-23. Map showing distribution of national percentiles of children under the age of five (by census tract) in relation to the Charleston Peninsula.
Source: USEPA

4.20 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.

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 (NRC, 1987) and the Intergovernmental Panel for Climate Change (IPCC, 2007), and are shown in Figure 4-24 for the Charleston area. For this feasibility study, the proposed alternatives were evaluated by using the intermediate rate, which estimates a 1.13 ft RSLR by the year 2075. Details on the rates used and results of the sea level rise analysis can be found in append B.

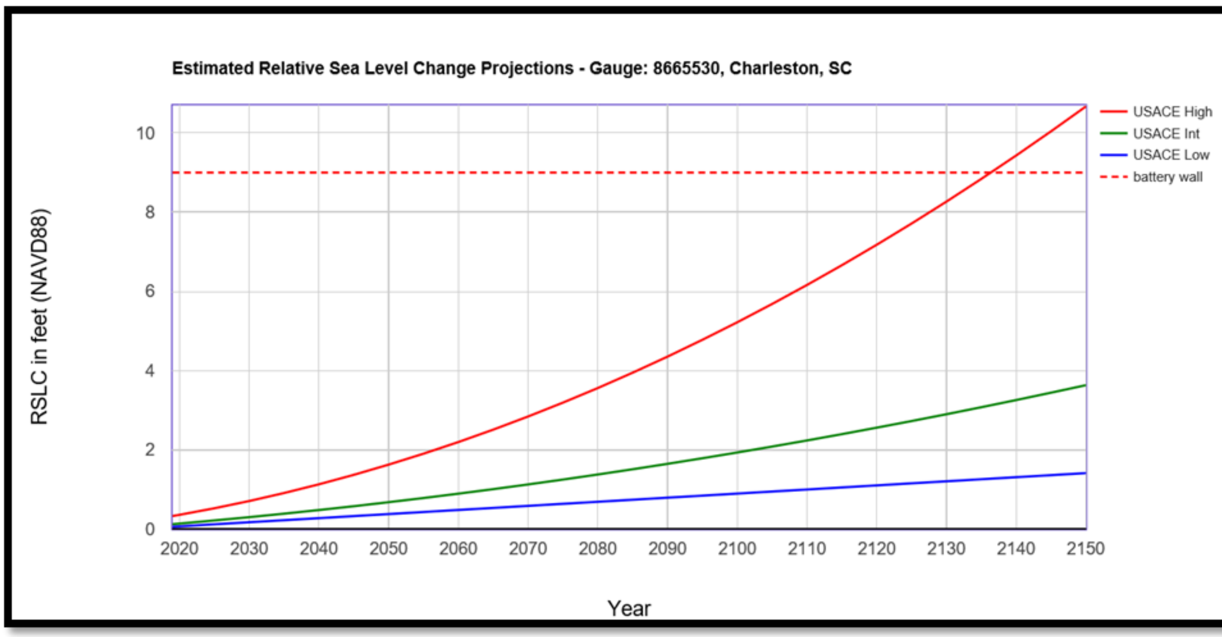

Figure 4-24. Estimated relative sea level change based on projected low, intermediate and high rates. Source: USACE

NOAA has reported a trend in increased frequency of minor tropical cyclones, which is expected to continue in the future (see Section 2.5.5). When major hurricanes do occur, they are expected to be more intense due to increased ocean temperatures.

The ROI for evaluating impacts on climate change includes the entire study area and the surrounding waterways of Charleston Harbor, the Ashley River, and Cooper River.

Affected Environment

The effects of climate change are already being observed in the ROI with the increase 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 4-25).

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 peninsula are already vulnerable to erosion from wave action (among other factors, see the Wetlands section). 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. Possible adaptation for these marshes would be to accrete either up or seaward. Around the City Marina on the Ashley River, the salt marsh is visibly accreting, presumably due to reduced wave action provided by the boat slips seaward of the marsh edge.

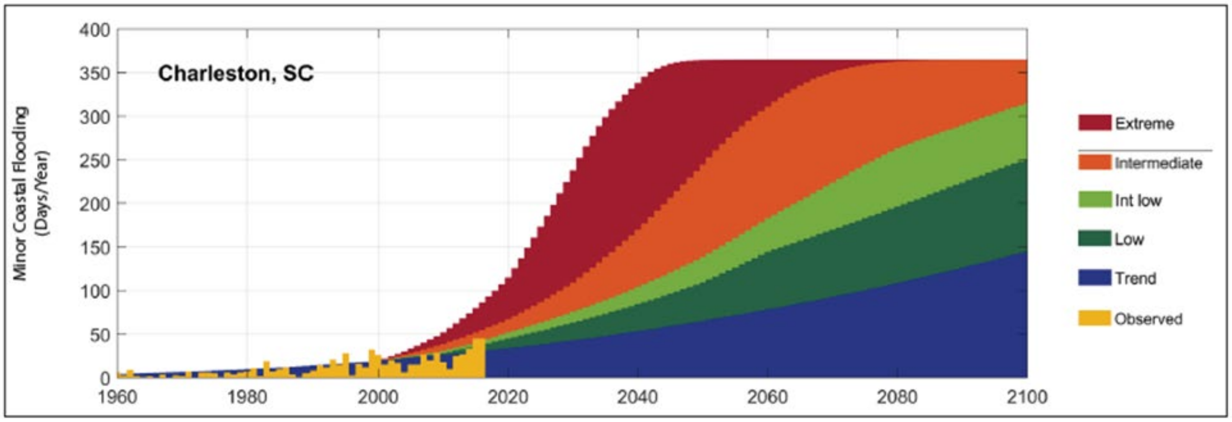

Figure 4-25. Observed and Predicted "minor coastal flooding" in Charleston, SC since 1960 through 2100. Source: City of Charleston.

Chapter 5 – Agency and Stakeholder Views

5.1 Public Participation

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. Comments received during the scoping period can be viewed in Appendix A.

5.2 Public Review of the Draft Report

The public review period for the draft FR/EA is from April 20 – June 20, 2020. Concurrent with the public review period for the draft report USACE will issue a public notice requesting review of the Programmatic Agreement.

5.3 Other Public Involvement

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 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.

5.4 Institutional Involvement

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. The first meeting of the ICT was held in December 2018 and additional meetings will occur throughout the study process.

Table 5-1. 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

5.5 Public Views and Responses

Public views and responses to comments on the draft report will be summarized in the final report.

5.6 Impact on Recommendations

Comments received during the public comment period will be considered and incorporated into the final FR/EA as appropriate. Impacts to the recommended plan will be summarized in the final report.

Chapter 6 – Evaluation and Comparison of the Final Array of Alternatives

The final alternatives have been evaluated based on planning criteria, contributions to planning objectives and the Federal objective, environmental considerations, rough order of magnitude costs, hydraulic effects, and economic benefits. For a detailed description of the hydraulic and economic modeling process, please refer to Appendix B, Engineering, and Appendix C, Economics.

6.1 Hydraulic Effects Analysis

In both alternative plans, the storm surge wall would reduce the damaging effects of storm surge inundation on the Charleston Peninsula. A system of gates in the storm surge wall would remain open during non-storm events 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. Both conceptual alternatives currently include a series of permanent and temporary pumps that would mitigate the bathtub effect of rainfall pooling on the interior of the wall. However, residual interior flooding will be further evaluated during feasibility level design. Interior drainage facilities must be economically justified separately from the line-of-protection project, consistent with Engineer Manual 1110-2-1413 paragraph 3-3.c. The final feasibility report will include incremental justification for any proposed interior drainage facilities that would exceed the USACE minimum facilities standard. Additionally, the potential for surge to deflect off the storm surge wall and induce flooding on surrounding communities will be evaluated during feasibility level design and described in the final FR/EA.

Alternative 3 includes the addition of a wave attenuating structure in the Charleston Harbor, which was modeled as a granite breakwater for evaluation purposes. The breakwater breaks wind-driven waves as they cross the structure, making a small reduction in total water levels at the peninsula. However, small reductions in water levels equate to a reduction in damages to structures over time. Coastal modeling efforts indicate that surge deflecting off the breakwater would not induce flooding on surrounding communities. A wave overtopping analysis of the storm surge wall will be performed during feasibility level design and described in the final FR/EA.

6.2 Life Safety

As part of this study, a life safety risk assessment is being 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 measure. 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*, a quantitative risk assessment will be completed during the feasibility level design phase and described in the final feasibility report. 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).

A Potential Failure Mode Analysis will be performed to discover and assess the way the recommended plan could fail. The intent of the assessment is to verify that construction of the plan poses a tolerable risk to the community within the study area, recommend design changes if risks are considered excessive, and to design concepts that could be incorporated to further reduce risk.

It is currently the study team's determination that the tentatively selected plan would lower the overall life-safety risk for the Charleston Peninsula as compared to the without project condition. However, based on a qualitative risk assessment, the study team determined that the structural measures in Alternative 2 and Alternative 3 could potentially induce two types of impacts that affect life risk: 1) sustaining existing development trends that lead to an increased population subjected to flood risk and 2) transforming the current condition of a relatively slow and steady rise of flood waters to a potentially more severe and immediate flood risk associated with failure of the new storm surge wall system. Even though the consequences of project failure may be higher as compared to the without project condition, the probability of a failure is very low.

During the Preconstruction, Engineering Design (PED) phase, the details of the wall system will be designed with the intent to prevent failure of the structure 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, failure of a gate is assumed to be the most likely failure scenario. The extent of flooding from a gate failure largely depends on the water level elevations. 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.

In addition to potential failures, communicating the risk of overtopping due to storm surge exceeding the wall elevation is critical. For example during Hurricane Hugo, the highest storm surge observation 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. That level of storm surge in Charleston Harbor would overtop the 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. The intention is to reduce damages from more frequent storm surge events, not extreme events. In other words, flood risk remains after construction of either alternative.

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. Alternative 3 includes a wave attenuating structure which would reduce the effect of wave overtopping and wave attack at the Battery. Wave overtopping will be evaluated during feasibility level design once the final elevation of the wall is determined and further analyzed in the PED phase. 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). After finalization of the footprint and elevation of the wall, this study will evaluate interior flood risk, assess 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.

With implementation of Alternative 2 or 3, there is an increased risk 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 will likely be compounded by the construction of a storm surge wall.

In an effort to identify risk to life safety, Alternatives 2 and 3 were modeled for potential life loss as described in Section C.1.7.4.1 of Appendix C. The G2CRM model uses a simplified life loss methodology to provide a rough order of magnitude estimate. The results of the modeling effort show that Alternative 2 would not significantly reduce life loss while Alternative 3 would reduce approximately 79 fatalities when compared to the future-without project condition.

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.

6.3 Economic Analysis

Preliminary, screening-level cost estimates were used for the economic analysis. Table 6-1 summarizes the costs and benefits of each alternative in the final array.

Table 6-1. Costs and Benefits of the Final Array ($1,000).

Cost/Benefit Item	Alternative 2	Alternative 3
Investment Costs		
Project First Cost	$1,416,989	$1,753,804
Interest During Construction	$210,818	$260,929
Total Investment Cost	$1,627,807	$2,014,733
Average Annual Cost[1]		
Average Annual First Cost	$60,295	$74,627
Annual OMRR&R[2] Cost	$5,594	$5,594
Average Annual Annualized Costs	$65,889	$80,221
Benefits[1]		
Average Annualized Benefits	$153,857	$174,639
Net Benefits	$87,968	$94,417
BCR	2.3	2.2

[1]Costs are in October 2020 price levels, 2.75% discount rate, and a 50-year period of analysis.
[2]Operation, Maintenance, Repair, Replacement, and Rehabilitation.

Based on the above comparison, Alternative 3 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.

6.4 The Four Accounts

The four accounts is a set of categories which provide a comprehensive framework to demonstrate both the positive and negative effects of each plan. The intent is to provide decision makers with plan rankings based on advantages and disadvantages of each alternative. In addition, the accounts provide a visual display and assessment as required by NEPA.

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.

Environmental Quality (EQ)

The EQ account assesses the effects on the ecological, cultural, aesthetic, and other attributes of natural and cultural resources. The environmental effects of the various alternatives are classified as direct and 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.

Regional Economic Development (RED)

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. Two measures of the effects of the plan on regional economies are used in the account: regional income and regional employment. Additional information on the RED analysis performed for this study can be found in the Economic Appendix.

Other Social Effects (OSE)

OSE relates to the quality of life, health, and safety in the community. Destruction or disruption of the built environment, esthetic values, community cohesion, and availability of public facilities and services has also been analyzed. These include displacement effects to people and businesses, the general population (including minorities), 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. Additional information on the OSE analysis performed for this study can be found in the Economic Appendix.

Table 6-2. Summary System of Accounts Comparison of Final Array of Alternative Plans.

	No Action	Alternative 2	Alternative 3
1. Plan Description			
	No Action provides no physical project constructed by the Federal Government.	Storm surge wall + nonstructural	Storm surge wall + nonstructural + wave attenuator
2. Impact Assessment			
A. National Economic Development			
1. Project Cost	$0	$1,416,989,000	$1,753,804,000
2. Annual Cost	$0	$65,889,471	$80,221,565
3. Total Annual Benefit	$0	$153,857,901	$174,639,217
4. Annual Net Benefits	$0	$87,968,430	$94,417,652
5. Benefit – Cost Ratio	None	2.3	2.2
B. Environmental Quality			
1. Land Use	No construction activities present; impacts to LU due to continued development and increased flooding	Beneficial impact to LU protected from storm surge damages; change in residential and commercial uses from acquisition for wall would be permanent;	Identified impacts are expected to be the same as Alternative 2; the breakwater would have no effect
2. Geology	No construction activities present; continued shoreline erosion from storms and SLR	Temporary minor impacts during construction; marsh scouring impacts would be minimized and mitigated with living shorelines	Identified impacts are expected to be the same for Alternative 2; the breakwater would result in minor permanent and temporary impacts
3. Hydrology	Beneficial impact to interior hydrology from current City projects	Beneficial impact to compound flooding; permanent and temporary minor impacts to creek flow; scouring effect minimized and mitigated with living shorelines	Identified impacts are expected to be the same for Alternative 2; the breakwater would have a beneficial impact on reduced wave attack and stability of the Battery seawall

	No Action	Alternative 2	Alternative 3
4. Water Quality	No construction activities present; long term water quality conditions impacted by SLR	All impacts localized; temporary and minor impacts during construction; minor impacts to salinity; potential for minor indirect impacts on aquatic resources and habitat	Identified impacts are expected to be the same for Alternative 2; similar temporary and minor impacts during construction of the breakwater
5. Floodplains	No construction activities; continued impact to structures in the floodplain due to increased flooding	Substantial beneficial impact to structures in floodplain; adverse impact if wall or gates fail or waves overtop but similar to no action	Identified impacts are expected to be the same for Alternative 2; breakwater would have no effect
6. Wetlands	No construction activities present; remaining wetlands in the urban environment would be impacted by sea level rise and increased salinity and not be able to migrate inland due to development	Permanent direct impact (loss of wetland) at footprint of wall, and potential for temporary and permanent indirect impacts behind wall; potentially significant adverse wetland impacts would be addressed through compensatory mitigation	Identified impacts are expected to be the same as Alternative 2; the breakwater would have minor adverse effects on waters of the U.S.
7. Aquatic Resources	No construction activities present; effects of climate change, sea level rise, and development will continue.	No effect on T&E species; temporary and minor adverse effects from construction of the combo-wall; temporary and permanent adverse effects from the combo-wall.	Identified impacts are expected to be the same for Alternative 2; temporary and permanent impacts from breakwater would be minor; MANLAA for T&E species
8. Benthic Resources	No construction activities present; effects of climate change and sea level rise will continue	Minor temporary and permanent adverse effects from combo-wall	Identified impacts are expected to be the same as Alternative 2; the breakwater would have minor temporary and permanent impacts
9. Terrestrial Wildlife and Plants	No construction activities present; minor impact to wildlife displaced by storms	No effect on T&E species; minor to negligible impacts on other wildlife and plants	Identified impacts are expected to be the same as Alternative 2; the breakwater would have no effect

	No Action	Alternative 2	Alternative 3
10. Cultural Resources & Historic Properties	No construction activities present; historic structures would continue to be damaged from periodic coastal storm surge events.	Archeological sites, historic structures, and historic districts on the peninsula would have temporary and permanent, potentially significant adverse effects; 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.	Identified impacts are expected to be the same for Alternative 2; the breakwater would have potential adverse impacts to submerged resources and the viewshed of historic properties to and from the water; identification, evaluation, and mitigation of adverse effects would be addressed in a Programmatic Agreement, as well as optimization of avoidance and minimization.
11. Recreation	No construction activities present; SLR, storms and erosion would continue to impact recreation facilities and services	Minor adverse and beneficial impacts to parks; minor impacts during construction; minor impact to recreational boating; beneficial impact if new recreational features added (still being evaluated)	Identified impacts are expected to be the same for Alternative 2; minor permanent and temporary effects on recreational boating
12. Visual Aesthetics	SLR, storms, and erosion would continue to impact structures and vegetation near the shoreline, resulting in reconstruction activities, degraded landscapes, or diminished visual character.	Permanent beneficial and adverse effects depending on location, mostly minor; magnitude still being evaluated	Identified impacts are expected to be the same for alternative 2; magnitude of visual impact from breakwater is still being evaluated
13. Air/Noise	No construction activities present; normal noise levels created by traffic and industry such as port and rail operations.	Temporary and minor to negligible increased noise levels and air quality effects during the period of construction.	Identified impacts are expected to be the same for alternative 2; similar temporary and minor impacts during construction of the breakwater

	No Action	Alternative 2	Alternative 3
14. Transportation	No construction activities present; minor impacts to transportation as SLR and storm flooding continue	Temporary minor impacts to transportation during construction and gate closures; beneficial impact from reduced storm flooding to transportation network	Identified impacts are expected to be the same for alternative 2; the breakwater would have negligible effects to waterborne transportation
15. Utilities	No construction activities present; stormwater management would improve with some beneficial impact on reduced compound flooding with storm surge	Temporary minor adverse impacts during construction; beneficial impact of reduced damages to utilities and disruptions in services from storms	Identified impacts are expected to be the same for alternative 2; the breakwater would have no effect
16. Environmental Justice	No construction activities present; flooding would continue to cause damages to all socioeconomic groups in the future	Beneficial impact through reduced storm surge damages that does not favor any socioeconomic group	Identified impacts are expected to be the same for alternative 2; the breakwater would have no effect
17. Climate Change	No construction activities present; climate change and impacts would continue	Temporary minor to negligible effects on climate change; beneficial impact on increased resilience to climate change	Identified impacts are expected to be the same for alternative 2; the breakwater would have temporary negligible effect
C. Regional Economic Development			
1. 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	Slightly higher value added due to additional construction work; temporary jobs added within the region and jobs added within the State; adds to the gross regional product for the State and the Nation

	No Action	Alternative 2	Alternative 3
2. 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	Construction of the wave attenuator would further decrease the risk of flooding to the established urban area; property values may increase relative to other communities in the region that implement lower performing or no coastal storm risk management measures
3. 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	Economic impacts would emerge from increased spending over time
D. Other Social Effects			
1. 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, boaters, and pedestrians during construction; minor, short-term adverse effects to circulation 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	In addition to the adverse and beneficial effects identified in Alternative 2, construction of the breakwater would have minor, short-term adverse effects during construction, and permanent, beneficial effects due to performance during coastal storm events
2. Community Cohesion (displacement of people & businesses)	Future flooding would displace select businesses and residents	Reduced risk to homes and businesses on the Charleston Peninsula	Reduced risk to homes and businesses on the Charleston Peninsula
3. Residual Risk	Risk remains high throughout the study area	Risk of economic damages is reduced by 37%	Risk of economic damages is reduced by 42%

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Chapter 7 – Environmental Consequences

This chapter provides an assessment of the potential impacts of the study alternatives on the environment, including the No Action Alternative, Alternative 2, and Alternative 3.

The No Action Alternative is what the future conditions would be like if the action alternatives are not implemented, and is often referred to as the Future Without Project condition or alternative. The No Action/Future Without Project Alternative would involve no action by USACE to address coastal storm surge risks on the Charleston Peninsula. Construction of structural measures and implementation of non-structural measures would not take place.

Alternative 2 would consist of construction of a storm surge wall with a conceptual footprint of approximately 7.8 miles long along the perimeter or nearshore of the peninsula, and nonstructural measures in select areas of the peninsula. In addition to the storm surge wall and associated gates, pump stations could be necessary to alleviate interior flooding induced by the wall.

Alternative 3 would include the storm surge wall and the nonstructural measures as described in Alternative 2, plus a wave attenuation structure approximately 4,000 feet long that would be located in the Charleston Harbor offshore of the Battery seawall.

7.1 Land Use

Alternative 1 – No Action/Future Without Project

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, casing nuisance flooding, have already increased in frequency. This trend is expected to continue into the future. It is expected that the City will use its Century V 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 NADV88 elevation, which will 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 will 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 $416 million in the study area.

Alternative 2

Under Action 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 have a beneficial impact 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) will 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 will likely cross a limited number of private properties. Figure 7-1 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 will be identified after the conceptual footprint is revised. Only in these select locations is there the potential to cause significant changes in the nature and character of land use in the ROI, which would be identified in the remainder of the feasibility study.

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 impact. Construction is planned to be phased, which will reduce the impact 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. For properties where homeowners choose to voluntarily relocate out of the flood plain, those properties could no longer be zoned for development, and would be considered open-space or similar classification. Where appropriate, this would be a beneficial impact on the land use by removing a land use type that is vulnerable to flood damages.

Lands that are not protected by the structural measures or planned for non-structural measures, would not receive the long-term, positive impacts from reduced flood damages. The current land uses in those areas may be adversely impacted 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 7-1. 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

Alternative 3

The land use effects of the storm surge wall and the nonstructural measures as described for Alternative 2 would be the same for Alterative 3. The addition of the wave attenuation feature, such as a breakwater, would have a beneficial effect on land use by contributing to the reduction of storm surge flood risk to those lands.

7.2 Geology and Soils

Alternative 1 – No Action/Future Without Project

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. Increased erosion of soil, particularly along unprotected shorelines, would be expected to increase as a result of increased storm surge and water levels.

It is expected that the City of Charleston will use its Century V Comprehensive Plan (City of Charleston, 2016) and Sea Level Strategy (City of Charleston, 2019) to guide development decisions that support adaptation to shallow coastal flooding. The risk of earthquakes will continue to dictate how major infrastructure is designed and constructed into the future.

Under the No Action Alternative, the topography of the ROI would largely go unchanged, with the exception of shoreline erosion around the City of Charleston. As sea levels rise and storm events increase over time, the processes of erosion and siltation would continue to occur.

Alternative 2

Construction of a storm surge barrier and associated gates under Action Alternative 2 would result in the short-term effect of soil and sediment disturbance around the area of construction, which could also runoff from the site into nearby waterways. If sediments are disturbed during construction, they can create environmental problems through turbidity, or if harmful contaminants are present. The 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. There are a few contaminated sites in close proximity of the conceptual footprint of the storm surge wall; therefore, soil/sediment chemical analysis may be needed during the PED phase to identify areas that may need to be avoided (see Hazardous Materials section). Impacts from construction-related soil and sediment disturbance are expected to be temporary and insignificant.

Likewise, physical nonstructural measures included in Alternative 2 such as elevation, relocation, buyout, or floodproofing of structures could result in short-term disturbances to soils during construction, as described above. The same BMPs would be implemented to reduce the impacts, and the areas would be returned to pre-construction conditions upon completion. Nonstructural measures are proposed in areas that remain at risk outside of the storm surge wall, so construction would not occur in the same locations and not result in cumulative or additive impacts.

Implementation of the storm surge wall would involve approximately five feet of embedment into the subsurface. Permanent piles would be driven to bear within the Cooper Formation, based on the seismic activity of the area and US DOT guidance (the assumed top of Cooper Formation at different locations in the ROI is presented in Appendix B, Subappendix 2). This is a common practice, as many structures on the peninsula are founded on piles. Impacts to geology and soils would be permanent but considered to be minor based on other projects.

There is the potential that the combination wall, which would be constructed in the marsh and come into daily contact with tidal and wave action, could result in a scouring effect. Vertical barriers made of steel sheet pile do not absorb wave energy, rather it reflects it seaward. This reflection can create turbulence, capable of suspending sediments, leading to scour at the foot of the wall (Bush et al 2004).. The scouring could impact the tidal mudflat habitat, and reduce water clarity. The impact on the outer edge of the marsh may be even greater. A 2018 thesis study looked at the long term effects of bulkheads on salt marsh loss in North Carolina, including the role of wave energy on marsh loss (Burdick, 2018). Rates of outer edge marsh loss were observed to be higher when adjacent to bulkhead sites than to natural shorelines. The rates were not significantly different under different wave energy regimes (high, medium, low).

To mitigate for potential adverse impacts that may result to marshes seaward of the combo-wall due to reflective wave action and scouring, USACE would to construct reef-based living shorelines. These living shorelines would be implemented along the edge of the marsh in front of portions of the combo-wall to stabilize the shoreline from erosion, trap sediments, and build up the overall resilience of the marsh in those areas. More information about this mitigation measure can be found in the Draft Mitigation Plan in Appendix F,. The specific sites, length, and methods for the reef-based living shorelines would be determined during the PED phase.

Direct impacts from the storm surge wall have the potential to produce a range of impacts to geology and soils, but these are expected to be insignificant. Adverse impacts to marsh geology soils seaward of the wall would be minimized and mitigated with living shorelines.

Alternative 3

The environmental effects of the storm surge wall and the nonstructural measures on geology and soils as described for Alternative 2, would be the same for Alterative 3, and the same mitigation measures proposed.

Implementation of the offshore breakwater under Action Alterative 3 would have minor impacts to the geology and sediments of the Charleston Harbor. Construction of the breakwater has the potential to result in the same sediment disturbances described above for construction of the storm surge wall. The same types of BMPs would be used to minimize the effects. There are no known sediment analyses in proximity of the proposed breakwater location, but since excavation is not planned, the need for sediment chemical analysis is not anticipated. The breakwater would be placed on the surface of the harbor seafloor and not embedded, therefore any permanent effects to the geology and sediments would be minor in nature.

7.3 Coastal Hydrodynamics, Hydrology, and Hydraulics

Alternative 1 – No Action/Future Without Project

Climatic changes such as rising sea levels and increasing coastal storms are expected to continue over the next 50 years in the Charleston area. The effects of climate change on water levels are already observed in the ROI with an increase in shallow coastal flooding. This high-tide flooding has an adverse effect on transportation, safety, and recreation through road closures, outdoor event cancellations, etc. This effect is likely to become more frequent and significant as sea levels rise.

It is expected that the City will use its Sea Level Rise Strategy (City of Charleston, 2019) and Stormwater Management Plan (City of Charleston, 2014) to guide decisions that affect hydrology on the peninsula. The City of Charleston will raise the current Low Battery Wall to a 9ft elevation NAVD88, which would provide additional reduction in storm surge damages in the Battery area. It is assumed 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 help manage stormwater from rainfall flooding (see Section 1.4, Exiting Programs, Studies and Projects for more information). It is assumed that check valves would be installed on existing stormwater outfalls. These would have a positive effect on shallow coastal flooding from rainfall events, and on compound flooding.

If the No Action Alternative is selected, storm surge would continue to cause flooding and erosion in the study area. Wave attack would continue to impact shoreline buffers and the existing Battery wall, which may need to be maintained and rehabilitated more often.

Alternative 2

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

USACE used modeling to evaluate impacts from the storm surge wall on interior hydrology of the Charleston Peninsula. These methods and results are described in detail in Appendix B, Engineering. The modeling assessed overland flow and the resulting water surface elevations at various locations in the study area without the storm surge wall (Future Without Project) and with the storm surge wall, during different rainfall and tidal events. Increases in water surface elevation between the two would be considered a temporary impact (it would only occur when the gates are closed for potentially a few days, which is temporary) and could be mitigated with additional water storage or pumps, but is still being evaluated. The impact could also be reduced through proper sizing and number of gates. Therefore, the effect on the interior hydrology would not be significant. The storm surge wall would also have a beneficial effect on interior hydrology during a storm surge event. The modeling showed that the interior water surface levels would actually be lower than without the wall, because the wall is reducing the surge flooding, regardless of pump capacity. This suggests a positive effect on potential compound flooding during a storm event.

The storm surge wall could have an effect on creek and marsh hydrology and hydraulics. In particular the combo-wall and gates could alter flow patterns in Halsey Creek and the tributary near The Citadel (behind the Joe Riley Ballpark) landward of (behind) the wall. Constraining the openings of these waterways with the storm surge wall and gates would change the velocity in these waterways. This is a similar effect of culverts in creeks or streams, which is widely practiced by the Department of Transportation. Road networks are a primary contributor to changes in the volume and timing of peak flows, leading to increases in drainage density of channels, interception of subsurface water, and decreases in the time of overland runoff until it reaches the channel. The rapid runoff time reduces the amount of time water has to infiltrate soil surfaces and be stored, while the increased transport results in a higher peak discharge and power that can erode channels and banks (Castro, 2003). Hydrodynamic modeling conducted for similar coastal storm risk management measures in the Norfolk, VA area (Moffet & Nichol, 2017) determined that constraining the opening of the 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 the Without Project Condition. This change was considered minor, and not significant. Therefore, it can be reasonably expected that impacts on creek hydrology in this study, if similar to the Moffet & Nichol (2017) study, would be minor. Potential scouring that could result from increases in velocity seaward of the gates would be reduced by increasing the number of gates and installing living shorelines (see below).

Upon gate closure during a major storm event, water velocities behind the combination wall (e.g., in Halsey Creek and the tributary behind Joe Riley Ballpark) would drop to zero, as there will temporarily be no tidal exchange or release of water into the Ashely River. The condition could last for a number of days, at which time all gates would be opened when the storm surge outside of the gates has subsided. 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 are temporary and minor.

The combination wall aligned in marshes would be subject to wave attack, with the potential to cause scouring of the marsh seaward of the wall. To reduce scouring from the wall (and induced changes in water velocity through the gates), reef-based living shorelines would be installed at the marsh edge to reduce wave energy, trap sediments, and improve the resilience of the marsh.

The proposed pumps, if applied, would operate during storm events. While this action has the potential to alter local hydrology by artificially moving water, the impacts on hydrology from operating the pumps would be far less than the natural impacts occurring during a storm. Pump operation impacts would be temporary and minor, and not significant.

None of the measures being considered 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 proposed measures along the exterior of the peninsula will 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. This relatively shallow groundwater table will 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. Effects on groundwater would be negligible.

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

Alternative 3

The environmental effects of the storm surge wall and the nonstructural measures on hydrology as described for Alternative 2 would be the same for Alterative 3. The same mitigation measures would be proposed.

Implementation of the offshore breakwater would have a beneficial effect on coastal hydrodynamics by reducing wave energy and thus wave attack on the Battery seawall. The breakwater would reduce the likelihood of overtopping of the floodwall due to wave action and thus flooding, and reduce long-term maintenance needs and costs. This effect would be considered a substantial beneficial impact.

7.4 Water Quality

Alternative 1 – No Action/Future Without Project

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. It is expected that the City will use its Century V Comprehensive Plan (City of Charleston, 2016) and Stormwater Management Plan (City of Charleston, 2014) to guide decisions that affect water quality. It is assumed that the City's Phase III Market Street Drainage Improvement Project, Phase III and IV of the US 17 Spring/Fishburne Drainage Improvement Project, and various other interior drainage projects would be completed to help manage stormwater and thus water quality, from rainfall flooding (see the Safety section and Section 1.4).

If the No Action Alterative is selected, the water quality in and around the Charleston Peninsula would remain undisturbed by any construction activities or any other modifications to the environment due to the various measures being considered. The natural system would continue to function as it has, while 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 (see the Wetlands section and the Aquatic Resources section).

Alternative 2

Under Action Alternative 2, the City of Charleston's initiatives mentioned in the No Action Alternative above are assumed to occur. Potential adverse effects of Action Alternative 2 on local water quality could range from temporary to permanent, but would be localized. With BMPs and continued optimization of avoidance and minimization, the impacts are expected to be minor. .

Construction of the combination wall and storm gates is expected to increase local TSS and turbidity in shallow open water. To reduce and contain the movement of sediments, BMPs would be used that may include silt curtains, settling basins, cofferdams, and other operational modifications. The BMPs would be detailed in an erosion and sediment control plan for construction. Construction-related impacts on water quality would be temporary and localized, and not significant.

In tidal creeks and marshes where the combo-wall and storm gates are proposed, water quality could be permanently modified by altering flow rates. Sheet flow of stormwater and daily tidal flow across the high marsh would be reduced and channeled directly into tidal creeks and tributaries through the storm gates. This has the potential to alter sediment supply to marsh surfaces and increase channel incising. This effect is similar to that of culverts in creeks or streams, which are widely used by the Department of Transportation. Road networks are a primary contributor to changes in the volume and timing of peak flows, leading to increases in drainage density of channels, interception of subsurface water, and decreases in the time of overland runoff until it reaches the channel. The rapid runoff time reduces the amount of time water has to infiltrate soil surfaces and be stored, while the increased transport results in a higher peak discharge and power that can erode channels and banks (Castro, 2003).

The tidal creeks that would be impacted by the combo-wall and gates are currently not well-studied, and water quality modeling has not been conducted. Information is available for similar studies in other locations, although the river systems and tidal regimes may not be the same. Hydrodynamic modeling was conducted by Moffatt & Nichol (2017) for similar proposed structural measures (storm surge wall with sluice gates) by USACE Norfolk District to reduce storm surge flooding in Norfolk, VA. They predicted that minor, negligible changes in salinity and in "tidally averaged freshwater age" post-construction of the structures under normal operating conditions (sluice gate open) would result compared to without the structures.

Moffet & Nichol (2017) also conducted modeling to assess potential impacts caused by a gate closure of five days (estimated) during a storm surge event. Results predicted 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 areas, but in the next reach of the waterway, the salinity dropped from low 20s to approximately 10 ppt, staying close within the mesohaline range. The modeled salinity changes that resulted during temporary closure of the storm gates were not considered great enough to induce mortality of benthos. Although salinity levels may fluctuate for several days once the gates reopened after the storm, they would return to pre-closure conditions. This temporary change in salinity was considered to be minor and not significant in that study. All of the tidal creeks of the Charleston Peninsula are mesohaline (between 5 and 18 ppt). Estuarine species typically found in tidal creeks and saltmarshes around Charleston are used to experiencing temporary fluctuations and would likely not be significantly impacted. Based on available information, it could be expected that gate closure impacts on salinity for this study, if similar to the Moffet & Nichol (2017) study, would be localized, temporary, and minor.

The Moffet & Nichol (2017) study for Norfolk, VA did not model for changes in DO. For the current feasibility study for the Charleston Peninsula, changes in DO levels could occur but are not expected to be permanent or significant from the combo-wall.

For the T-wall, which would be on land, soil and sediment control measures to reduce off-site runoff to waterways would be implemented during construction. Construction would be monitored to ensure erosion and stormwater BMPs are adequate in preventing sediment and pollution migration into nearby waters. An erosion and sediment control plan detailing construction BMPs would be prepared. Impacts from construction of the T-wall on water quality would be temporary and minor.

None of the nonstructural measures would occur in waterways of the ROI. Runoff control measures as described above would be implemented if needed. Impacts to water quality from the nonstructural measures would be negligible.

In addition to implementing BMPs during construction, a number of other actions are being considered to minimize the impacts of the measures to water quality. Stormwater naturally flows to these hydrologic features, but to minimize the impacts of increased stormwater runoff, the use of pumps are being evaluated (see Appendix B, Engineering). An estimated five permanent pumps could be installed near creeks and tributaries, and an estimated five temporary pumps could be used, to move water through the wall to reduce rainwater accumulation. USACE is continuing to evaluate the conceptual footprint of the storm surge wall and the possibility of moving it onto land and out of marshes, mudflats and shallow waters where feasible, further reducing the potential for water quality impacts. Furthermore, all actions would be required to adhere to local, state, and federal regulations (described at the beginning of this section) and BMPs, which are designed to limit negative impacts to water quality. Compliance of present and future projects with these regulations, combined with implementation of BMPs for the action alternatives, would minimize any adverse cumulative impacts.

Alternative 3

The environmental effects of the storm surge wall and the nonstructural measures as described for Alternative 2 would be the same for Alterative 3, and the same mitigation measures proposed for potential water quality impacts.

Implementation of the offshore breakwater under Action Alterative 3 would have temporary and minor impacts to water quality of the Charleston Harbor from construction. Construction of the breakwater would result in minor sediment disturbances such as increased TSS and turbidity. Similar BMPs discussed above for construction of the storm surge wall would be used to minimize the effects. Construction of the storm surge wall and breakwater would be phased, to further reduce the minor and localized water quality impacts.

7.5 Floodplains

Alternative 1 – No Action/Future Without Project

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 people in the floodplain at risk of flooding. King tides, casing nuisance flooding, have already increased in frequency. This trend is expected to continue into the future.

It is assumed the City will continue its efforts under the Bluebelt program and FEMA HMGP FMA programs to guide flood mitigation planning decisions that reduce risks to some people and property, but would not be wide-spread across the study area. It is also expected that the City will use its Century V Comprehensive Plan, Charleston Green Plan (City of Charleston, 2010), Sea Level Strategy (City of Charleston, 2019), and its forthcoming Hazard Mitigation Plan described in Section 4.18 to guide decisions that support adaptation and resilience to shallow coastal flooding. New development on the Peninsula must be built to 2 feet above base flood elevation . The City of Charleston will also raise the current Low Battery Wall to a 9ft elevation NAVD88, which will provide additional reduction in storm surge damages in the Battery area.

Many homes and businesses across the rest of the Peninsula (not in the Battery) are already at risk of storm surge damages that are not addressed by city initiatives. Under the No Action Alternative, it is expected that these properties in the floodplain will 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 $416 million in the study area.

Alternative 2

It is assumed that the City projects and initiatives described under the No Action Alternative would be implemented under Alternative 2. It is also expected that the City would comply with Section 202(c) of the Water Resources Development Act. In alignment with Executive Order 11988, the following potential impacts – beneficial and adverse – have been considered.

With implementation of the structural measures under Action Alternative 2, there would be no direct impact on the floodplain, but it would reduce damages for a large number of structures in the floodplain of the ROI from storm surge flooding. This would be a substantial indirect beneficial impact. The cost of these measures reflects the size and complexity of the system, including the storm surge wall, gates, road closures for construction, number of pumps needed, real estate needs including easements and right-of-ways, engineering and design, etc. After a community experiences several flood events, the damages prevented can easily justify the costs for such an action. If properly inspected, maintained, and operated, the storm surge risk reduction system can last and function as designed during its period of analysis.

The nonstructural measures in Alternative 2 are small in scale, such that any adverse environmental and/or floodplain impacts would be considered temporary and negligible. Any property that becomes permanent open space due to acquisition or relocation would be a beneficial impact, especially if it involves a repetitive loss structure where flood damage will never occur and the open space can be used for an acceptable use in a floodplain. Implementation of nonstructural measures would also help reduce flood insurance premiums and keep neighborhoods and communities sustainable and resilient after a flood, which is a beneficial impact to 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.

Alternative 3

The environmental effects of the storm surge wall and the nonstructural measures on the floodplain, as described for Alternative 2 would be the same for Alterative 3. The addition of the wave attenuation feature, such as a breakwater, would have no effect on the floodplain.

7.6 Wetlands

Alternative 1 – No Action/Future Without Project

Climatic changes such as rising sea levels and increasing coastal storms are expected to continue over the next 50 years in the Charleston area. In general, wetlands both inside and outside of the ROI are at risk of increased damage and loss from projected increases in sea level rise. As described above, salt marsh wetlands are already being completely inundated during extreme high tides, which are increasing in frequency due to sea level rise. King tides, causing nuisance flooding, have already increased in frequency. Inundation alone does not necessarily have an adverse impact on wetlands, but when marsh surfaces and vegetation cannot retreat inland or otherwise no longer keep up with increased water depths and salinity regimes, they will die. They will also continue to further erode. This effect is likely to occur in the future for some salt marshes in the ROI.

NOAA's Marsh Migration mapping tool in their Sea Level Rise Viewer (https://coast.noaa.gov/digitalcoast/tools/slr.html) was used to understand how wetlands may change into the future due to rising sea levels. It predicts dramatic changes for the current salt marshes on the Ashley River-side of the Peninsula (see Figures 7-2a – 7-2c). Figure 7-2a shows the baseline wetlands (primarily salt marshes in dark purple) in the ROI as of 2000. Figure 7-2b 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 predicts 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 7-2c shows the wetland distribution in 2080 (close to the 2075 planning horizon for this study; note the tool only displays in increments of decades) using an intermediate sea level rise rate, and assuming a moderate rate of accretion would occur. The tool predicts 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 predicted to be completely lost. If the tool was applied with an assumption that no considerable accretion occurs over time, the impacts to salt marshes in the years 2050 and 2080 are even more dramatic (not shown here). This lack of accretion into the future in unsheltered areas is very possible, considering current erosion rates and considering no actions to increase sediment deposition on marshes. It can also be assumed that the ecosystem services provided by these marshes that would be lost to sea level rise into the future, would also be lost. This would include providing marsh habitat and storm protection.

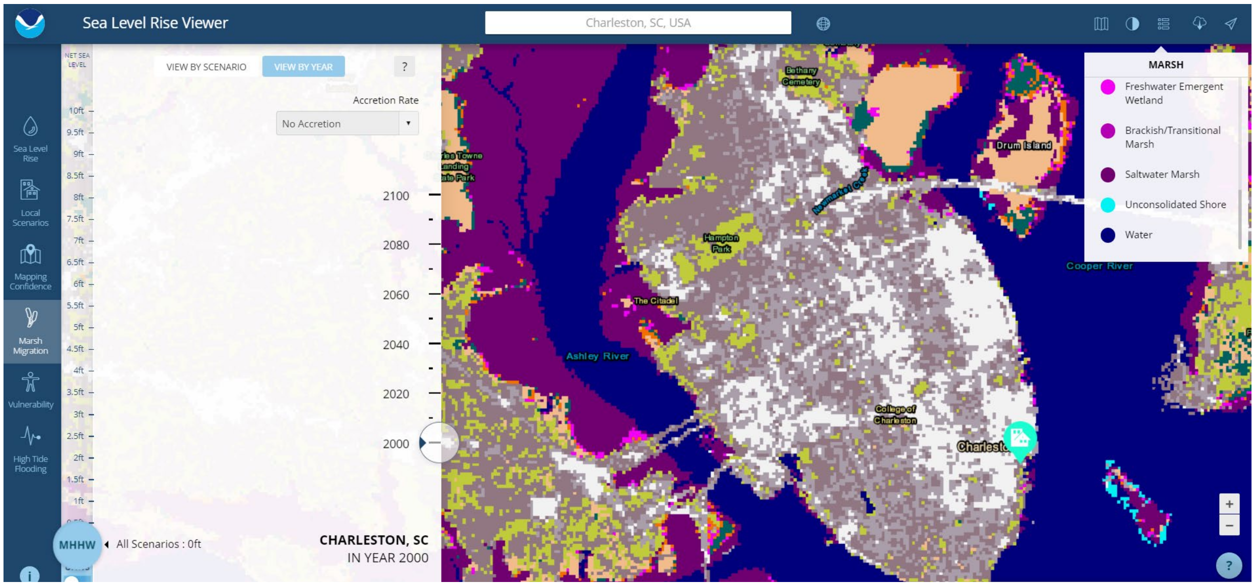

Figure 7-2a. Distribution of coastal wetlands in the year 2000 in the Charleston Peninsula area. Source: NOAA Sea Level Rise Viewer.

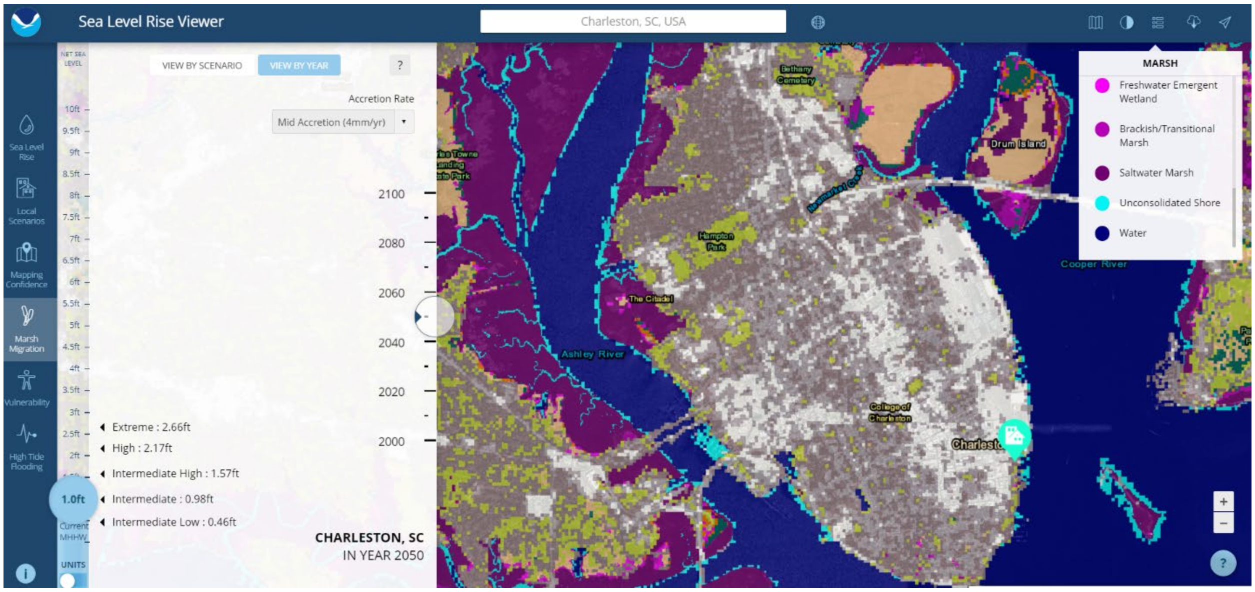

Figure 7-2b. Predicted distribution of coastal wetlands in the Charleston Peninsula area in year 2050, based on a moderate rate of sea level rise (approximately 1 foot) and a moderate rate of sediment accretion of 4 mm/yr. Source: NOAA Sea Level Rise Viewer.

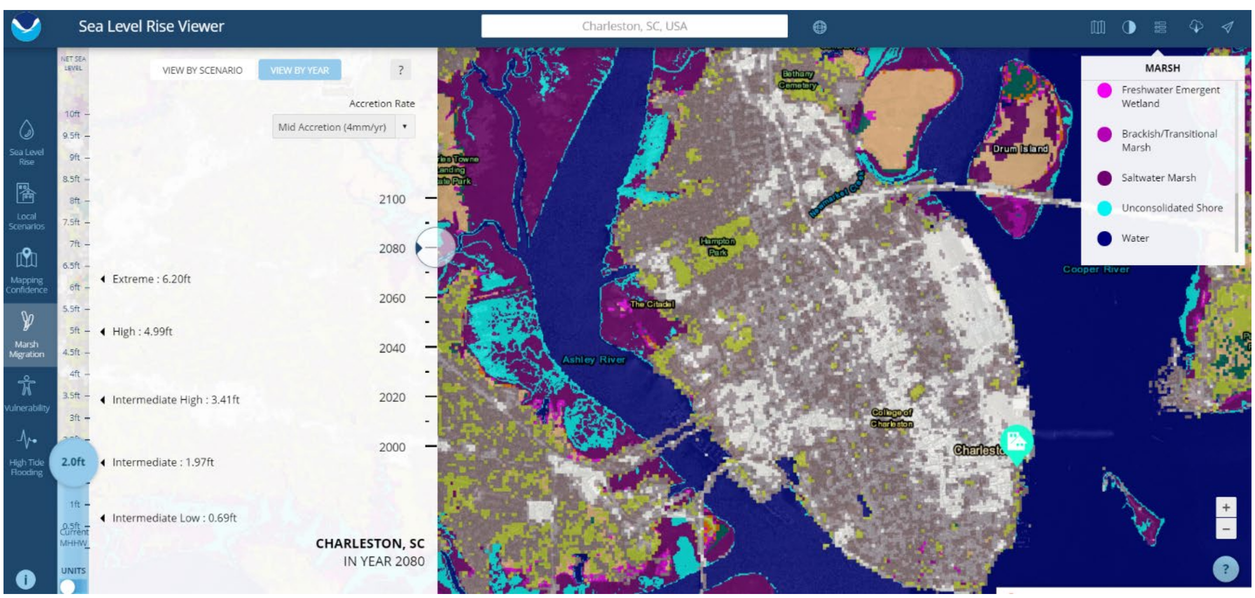

Figure 7-2c. Predicted distribution of coastal wetlands in the Charleston Peninsula area in year 2080, based on a moderate rate of sea level rise (approximately 2 feet) and a moderate rate of sediment accretion of 4 mm/yr. Source: NOAA Sea Level Rise Viewer.

It is expected that the City of Charleston will use their Century V Comprehensive Plan (City of Charleston, 2016), Charleston Green Plan (City of Charleston, 2010), and Sea Level Strategy (City of Charleston, 2019) to guide decisions that support adaptation to shallow coastal flooding and protection of natural resources. One of the City's land use recommendations includes protecting and improving natural resources, and maintaining a lush, green environment in urban and suburban areas of the City. There are no projects currently planned to restore or enhance marshes on the peninsula. However, a project has recently been completed in the ROI by the City of Charleston and The Citadel Foundation that created oyster reef habitat along the shoreline of the Ashley River in West Ashely, across from The Citadel and Brittlebank Park. This was done for mitigation of wetland impacts from other local projects, and is currently in the post-construction monitoring phase. It is expected that these reefs would provide shoreline stabilization and protection from wave energy, as well as habitat, in the ROI.

Alternative 2

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

Implementation of the T-wall would have no direct impacts to salt marsh wetlands in the ROI. Where feasible, USACE is planning to construct the storm surge barrier in the form of a T-wall on land/high ground to avoid impacts to perimeter saltmarsh wetlands. Where this is not feasible, a combination-wall is proposed to be constructed approximately 35 feet off of the shoreline, intersecting with either perimeter salt marshes or mudflats. Storm gates would also be installed along the combo-wall to allow tidal flow to wetlands in tidal creeks and tributaries landward of the wall.

There would be a permanent, direct adverse impacts to saltmarsh wetlands at the site of the combination wall and associated gates (loss of wetland). At this stage in the study while the footprint of the wall is still conceptual, a jurisdictional wetland delineation has not been conducted at these locations. This would be done be in the PED phase. Until the project is further evaluated and designed, the extent of wetland impacts are estimated and preliminary, based on existing information (described above). Consideration of salt marsh loss in the future due to sea level rise, as described in the No Action Alternative/ Future Without Project, would also be considered in estimating the long-term impacts and compensatory mitigation from Alternative 2. Since the storm surge wall will have storm gates that allow for tidal flow and sediment exchange between salt mash seaward of the wall, and landward of the wall, it would not be expected to significantly impact the potential for marsh migration that already exists under current or future without project conditions.

The proposed combo-wall and associated gates also have the potential for indirect adverse impacts to water quality in the salt marsh wetlands behind the barrier, and in tidal creeks when the gates are closed for short periods of time during significant storm surge events and for maintenance. These are discussed in Section 7.4 Water Quality and Section 7.7 Aquatic Resources, and are expected to have minor impacts on the wetland community. However, additional evaluation will be conducted during the remainder of the feasibility phase to assess if the indirect effects are temporary or permanent, and better understand their magnitude.

Up to approximately 111 acres of saltmarsh wetlands could be adversely impacted by implementation of Alternative 2, including 26 acres directly impacted and 85 acres indirectly impacted (see Figure 7-3). This is the maximum extent estimated, and will likely be reduced based on refined information and additional actions to minimize the effects. For example, USACE is continuing to assess ways to avoid impacts to salt marsh wetlands in additional locations by moving the conceptual location of the storm surge wall from the marsh, to land/high ground. Direct and indirect impacts to saltmarsh wetlands that cannot be avoided or minimized, and are more than negligible, will be addressed through compensatory mitigation to ensure that the effects of this alternative are less than significant (see the Draft Mitigation Plan in Appendix F for more information about planned compensatory mitigation).

The proposed combo-wall would also have the potential to impact salt marshes seaward of the proposed wall, including scouring of the marsh (discussed in section 7.2, Geology and Soils). Living shorelines, in appropriate locations, will help to offset these impacts by reducing wave action and stabilizing the shoreline and marsh surface between the living shoreline and combination wall. This is being proposed for mitigation (see the Draft Mitigation Plan in Appendix F for more information on planned living shorelines).

Alternative 3

The environmental effects of the storm surge wall and the nonstructural measures as described for Alternative 2 would be the same for Alterative 3 with respect to wetlands. Implementation of the breakwater under Alternative 3 that would occur in subtidal waters would have a minor adverse impact to these waters primarily due to impacts on benthic resources (see Section 7.8, Benthic Resources). There could also be a minor impact to subtidal waters during construction of the breakwater, but BMPs would be implemented as described in Section 7.4, Water Quality.

Figure 7-3. Map showing the approximate locations of marsh that could potentially be impacted by the conceptual footprint of the 12 foot NADV88 storm surge wall. Official mapping product of the Management Support Branch, Charleston District, USACE

7.7 Aquatic Resources

Alternative 1 – No Action/Future Without Project

Population growth would continue over the next 50 years in the Charleston area. It is expected that the City of Charleston will use its Century V Comprehensive Plan (City of Charleston, 2016), Charleston Green Plan (City of Charleston, 2010), and Sea Level Strategy (City of Charleston, 2019) to guide development and conservation decisions that support adaptation to climate change and sustainable land use. As a result of climate change, global temperatures and sea level are expected to rise in the foreseeable 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 the estuarine and coastal ecosystems in the ROI.

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 and invertebrates. There could be shifts in spawning habitat availability and timing and the effects of this change on fish populations could be detrimental, although relatively uncertain at this time. The shifts in salinity, temperature, and sea level rise all have the potential to result in shifts in prey species availability, which could also cause detrimental effects to fish resources and habitats.

Alternative 2

Under Action Alternative 2, the City of Charleston's initiatives mentioned in the No Action Alternative above are assumed to occur. Some of the structural measures proposed under Action Alternative 2 would have the potential to adversely affect aquatic resources, as described below.

The T-wall would be constructed on land, and would occur mostly in areas that are already developed. The T-wall would not be in direct contact with any tidal creeks or tributaries, but rather align with roadways with existing culverts that cross tidal creeks, such as where Morrison Drive currently crosses New Market Creek. BMPs would be used to control any runoff to nearby waterways during construction, such as those described in the Geology and Soils and Water Quality sections. Construction impacts of the T-wall to aquatic resources would be negligible, and no permanent or long-term effects would result.

Because the combination-wall and storm gates would be offset from the shoreline on the Ashley River-side of the Peninsula by approximately 35 feet, thus positioned in salt marsh, mudflats, and creek channels, they would result in direct and indirect impacts to aquatic resources in this portion of the ROI.

Construction of the combo-wall could have a direct adverse effect on individuals through entrainment and/or siltation of eggs, larvae, and demersal, and/or slow moving fish species.

Disturbance from heavy equipment such as noise and turbidity during construction of the combination wall and installation of gates may indirectly affect the foraging behavior of individual fish, but will be temporary. Sediment suspension during construction can also reduce DO levels. This effect is expected to be temporary and localized in nature. BMPs would be used during construction to reduce the temporary disruptions of noise and turbidity. Construction would be phased, which would minimize the range of impact areas. Considering the abundance of habitat across the Ashley River from the impacted areas, and farther up the Ashley River, construction impacts to aquatic resources would be minor.

The combo-wall would also have adverse effects on habitats utilized by fish, as described in the Wetlands Section. There would be a permanent impact through the loss of saltmarsh habitat and benthic prey resources at the footprint of the wall. The combo-wall could also lead to a reduction in ecological function of the saltmarsh habitat behind the combo-wall, having an indirect effect on aquatic resources. As described in Section 7.6 Wetlands and Section 7.4 Water Quality, the combo-wall would alter sheet flow of water across the marsh, channeling it directly through the storm surge gates. This is a similar effect caused by culverts which are widely used under roads that intersect tidal creeks. This change in hydrology has the potential to alter flow rates, sedimentation, dissolved oxygen levels, and salinity concentrations. Aquatic organisms can experience physiological stress and/or mortality as a result of substantial reductions and/or low levels of DO. The SCDHEC instantaneous and daily average water quality standards for DO are 4 and 5 mg/L, respectively. Salinity directly influences fish, clams, and crustaceans such as the blue crab, as well as influencing DO concentrations. If DO levels are altered by implementation of the combo-wall and storm gates, the effect would be localized and temporary but would be adverse. The magnitude of the adverse effect on ecological function will continue to be assessed as USACE refines the placement and design of the wall (see below).

The storm gates would also have the potential to affect aquatic resources. Under Alternative 2, there are two types of storm gates planned, sluice gates and a miter gate. The functionality of these gates are described in detail in Appendix B, along with a map of their preliminary locations. The gates would remain open, and would be closed when the National Weather Service predicts major flooding for the Charleston Peninsula. Major flooding is currently defined as a storm surge equal to or greater than 8 feet above MLLW or 4.86 feet NAVD88. When major flooding is expected, storm gates will be closed at low tide, in order to keep the rising tide levels from taking storage needed for the associated rainfall. Under non-event conditions, fish and invertebrate passage into tidal creeks and tributaries along the Ashley River-side of the Peninsula would be more limited, but not completely restricted. With the miter gate, some species may be discouraged from passing through it, further limiting their access to habitat on the other side of it.

Impacts to aquatic resources are expected to be greatest during the limited events when the storm gates are closed. Closure of the storm gates could extend for up to be few days. This would be a direct but temporary impediment to movement of fish and invertebrates, including larvae, in and out of the tidal creeks, tributaries, and saltmarshes that the combo-wall intersects. During the storm gate closures, indirect effects could result because tidal fluxes in water would cease for up to a few days, potentially reducing water quality by altering salinity and DO. The changes in water quality alone may not be severe enough to induce mortality, as many estuarine species are able to adapt to short-term environmental changes. The changes could have compound and/or cumulative interactions, causing increased stress levels to fish populations, which may lead to increased susceptibility to disease or even a mortality event (Tietze 2016; Bachman and Rand 2008). The changes could also temporarily affect breeding and/or foraging behaviors.

As described in Appendix B Engineering, the storm surge gates would be closed on the last low tide before impacts from the storm event are predicted to occur. This would allow most mobile species to travel out of the storm gate on the retreating tide, reducing the number of aquatic organisms that may be impacted. It is assumed that most storm events will be accompanied by intense rainfall, and that the creeks and marshes behind the combo-wall and storm gates will fill with rainwater. Stormwater naturally flows to these hydrologic features, but to minimize the impacts of increased stormwater runoff, pumps are being proposed but still evaluated. An estimated five permanent pumps and five mobile pumps could be installed near creeks and major tributaries and other land areas to move water through the wall and alleviate additional rainwater accumulation (see Appendix B). There is a possibility that aquatic resources that remained behind the gate before the storm event could get entrained in the pumps at the creeks during this process.

The gates would also be closed occasionally for maintenance (see Appendix B Engineering), although the gates may not all be closed at the same time, reducing the potential for an unnecessary cumulative impacts from closure.

Implementation of nonstructural measures in Action Alternative 2 would not result any significant, adverse effects to aquatic resources in the ROI. Modification of existing residential structures, including elevation or flood proofing, could result in negligible and temporary disturbances. If a buyout or relocation of homes and/or businesses at risk to coastal flooding occurred, impacts to aquatic resources have the potential to be moderately beneficial and permanent, as these areas would be reverted back to more natural environment and low-impact land use that could allow for habitat restoration or connectivity in the future.

Therefore, Action Alternative 2 would result in temporary to permanent adverse effects to aquatic resources. The extent and magnitude of impacts to managed fishery species and their habitat will be influenced by existing conditions, future conditions, and design-specific factors of this alternative, including the final location of the storm surge wall and the number and types of storm gates and pumps. USACE is continuing to study the feasibility of relocating the conceptual footprint of the combo-wall to high ground (converting it to a T-wall design) in some locations, in order to minimize impacts to aquatic resources and EFH. The exact number and location of storm gates will be determined in the PED phase based on the practical number needed to reduce impacts. The feasibility of eliminating the miter gate in the footprint near the Citadel boat landing will also be assessed, which would appreciably reduce adverse impacts to aquatic resources. USACE does not expect any changes in the footprint of the combo-wall during the remainder of the feasibility phase that would result in an *increase* in the extent or in the types of effects to aquatic resources. Once the impacts are fully assessed, they will be included in the EFH Assessment that USACE is preparing for consultation with NOAA Fisheries under the MSA.

Alternative 3

The environmental effects of the storm surge wall and the nonstructural measures as described for Alternative 2 would be the same for Alterative 3, and the same mitigation measures proposed for aquatic resources. Adverse effects could also result to aquatic resources in the ROI from implementation of the offshore breakwater under this action alterative.

A wave attenuation feature, such as a conceptual breakwater of up to approximately 4,000 feet long, 16 feet from bottom elevation, and covering approximately 15 acres in the Charleston Harbor has the potential to affect special-status species including the Federally-threatened West Indian Manatee, several endangered species of sea turtles, and the two sturgeon species in the ROI. The potential presence of these species in the area of the wave attenuator could result in short-term, minor impacts on these species during construction, including direct collision with construction vessels and indirectly through disturbances such as increased turbidity and noise.

There would be direct adverse impact to up to 15 acres of benthic (macro and micro) prey resources at the site of the breakwater (see more in Section 7.8 Benthic Resources). Considering the amount of surrounding unconsolidated bottom habitat for foraging in the ROI, this would be considered a minor, indirect impact to aquatic resources. The breakwater would be over 200 feet offshore from the Battery wall, so it would not entrap any aquatic resources. No lasting long-term impacts are expected from implementation of the breakwater on EFH or federally-listed or other species.

Typical BMPs would be implemented during construction to reduce the effects of noise and turbidity. The wave attenuation feature would be constructed in a manner such that it would not restrict movement by aquatic resources. USACE is also continuing to examine the feasibility of reducing the footprint of the breakwater, which would further minimize the minor impacts. The footprint of the breakwater would not be enlarged, due to potential interference with the Federal navigation channel.

The USFWS' standard protection guidelines for the West Indian manatee would be implemented as a conservation measure to reduce the likelihood of impacts, which may also benefit other listed species. USACE will prepare a Biological Assessment and consult with USFWS under the

MMPA and Section 7 of the ESA on the potential impacts from the offshore breakwater on the West Indian manatee, and will consult with NOAA Fisheries under Section 7 with respect to sea turtles and sturgeon. A determination of "May Affect But Not Likely To Adversely Affect" is anticipated. USFWS' and NOAA's responses will be addressed in the Final Report.

7.8 Benthic Resources

Alternative 1 – No Action/Future Without Project

As a result of climate change, global temperatures and sea level are expected to rise in the foreseeable 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 the estuarine and coastal ecosystems in the Charleston area.

Under the No Action Alternative, benthic resources in the ROI would remain undisturbed by any construction activities or any other modifications to their environment due to the various measures being considered. The benthic environment would continue to function as it has in this urban environment. Changes in salinity and temperatures from climate change could adversely affect benthic macrofauna in the future. An analysis of this range of alteration is beyond the scope of this feasibility study.

Alternative 2

As described in the Aquatic Resources section above, the T-wall would be constructed on land so effects to benthic resources would be similar to aquatic resources. There would be no direct impacts, and any indirect impacts from construction to benthic resources would be negligible, with no permanent or long-term effects.

Implementation of the combo-wall would result in direct and indirect adverse impacts to benthic resources in the ROI. There would be a permanent, direct impact through the loss of benthic resources along 26 acres of the current conceptual footprint of the wall. Considering the extent of benthic resources found along the intertidal and subtidal bottom of the Ashley River and its tributaries, this effect would be considered minor. Indirect impacts would result in a similar manner as those described above in the Aquatic Resources section. The combo-wall would alter sheet flow of water across the marsh, channeling it directly through the storm surge gates. This is a similar effect caused by culverts, which are widely used under roads that traverse smaller tidal creeks. This change in hydrology has the potential to alter flow rates, sedimentation, DO levels, and salinity concentrations, all of which benthic resources are sensitive to. In particular, changes in water flow behind the combination wall could lead to minor changes in salinity that impact the distribution of benthic communities, although this is expected to be minor (see section 4.1, Water Quality). In an environmental baseline study of benthic habitat conducted by SCDNR for the

USACE's Charleston Harbor Deepening Post 45 Project (Sanger et al., 2013), macrobenthic communities in the Ashley River (near the ROI) 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. Therefore, implementation of the combo-wall resulting in minor changes in salinity would not be expected to result in significant adverse effects on benthic communities. Benthic organisms are also sensitive to oxygen exchange that occurs at the sediment-water interface. It is not expected that DO levels would be permanently altered by implementation of the combo-wall and storm gates.

During the storm gate closures, indirect effects could also result because tidal fluxes in water would cease for up to a few days, potentially altering salinity and increasing the number of harmful nutrients in the water. These changes would be localized in these creeks and marshes and temporary. It is expected that equilibrium would return when the gates are re-opened after a few days (or less). There is not likely to be a long term permanent, adverse change in the benthic community.

Construction of the combo-wall could also indirectly affect benthic resources by suspending sediments that lead to reduced DO levels. This effect is expected to be temporary and localized in nature. BMPs would be used during construction to reduce the extent of turbidity, as described in Section 7.4 Water Quality.

Impacts from the structural measures in Alternative 2 are expected to be adverse but minor. USACE is continuing to study the feasibility of relocating the conceptual footprint of the combo-wall to high ground (converting it to a T-wall design) in some locations, which would further minimize effects to benthic resources. Implementation of nonstructural measures in Action Alternative 2 would not result significant, adverse effects to benthic resources in the ROI.

Alternative 3

The environmental effects of the storm surge wall and the nonstructural measures on benthic resources as described for Alternative 2 would be the same for Alterative 3, and the same mitigation measures proposed. Adverse effects could also result to benthic resources in the ROI from implementation of the offshore breakwater under this action alterative.

A wave attenuation feature, such as a conceptual breakwater of up to approximately 4,000 feet long, 16 feet from bottom elevation, and covering approximately 15 acres in the Charleston Harbor would have a direct, permanent impact through loss of benthic resources in subtidal unconsolidated bottom along the footprint of the offshore breakwater. Excavation of bottom habitat would not occur, but benthic organisms at the surface within the footprint would be essentially smothered. Benthic resources near the footprint of the breakwater may be disturbed during construction, but would be expected to recover post-construction. Considering the size of the breakwater compared to the amount of sediment substrate available in the Charleston Harbor, there would not be a lasting, significant adverse impact to benthic resources from the proposed breakwater. The breakwater also has the potential to provide an unintended positive habitat impact, as it may serve as hard substrate for benthic dwelling invertebrates that attracts fish for foraging.

7.9 Terrestrial Wildlife and Upland Vegetation

Alternative 1 – No Action/Future Without Project

Under the No Action Alternative, population growth would continue over the next 50 years in the Charleston area. It is expected that the City of Charleston will use its Century V Comprehensive Plan (City of Charleston, 2016), Charleston Green Plan (City of Charleston, 2010), and Sea Level Strategy (City of Charleston, 2019) to guide development and conservation decisions that support adaptation to climate change and sustainable land use.

As a result of climate change, global temperatures and sea level are expected to rise in the foreseeable future. Predicted climate change impacts have the potential to affect the nature and character of coastal ecosystems in the ROI. Terrestrial areas would flood more often due to storm surge, temporarily displacing terrestrial wildlife to higher ground; this would be a minor impact to terrestrial wildlife in the Future Without Project condition.

Alternative 2

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

No terrestrial Threatened and Endangered plant or wildlife species would be affected by this alternative. Adverse effects on other wildlife and vegetation from implementation of structural and non-structural measures in this alternative would be negligible to minor, and may even have a slight beneficial effect of reduced storm surge flooding that temporarily displaces urban wildlife. Due to the fact that the Charleston Peninsula is already urbanized, most species of wildlife here are already adapted to altered conditions. The impacts to wildlife from construction of the measures in Alternative 2, including non-structural measures such as floodproofing, are predicted to be minor and temporary, producing largely a disturbance effect similar to that already experienced in the ROI. Removal and/or disturbance of some upland vegetation, primarily trees and shrubs will be required for construction of the storm surge wall, which could be minor and temporary to permanent in duration, with indirect minor effects on wildlife that may utilize the vegetation. To reduce the impacts, trees that need be removed would be replaced in a nearby location after construction is completed (but not within the buffer zone of the wall). During construction, appropriate BMPs 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.

If a buyout or relocation of homes at risk to coastal flooding were implemented as part of the nonstructural measures in Alternative 2, impacts to wildlife have the potential to be moderately beneficial and permanent, as these areas would be reverted back to a more natural state, which could provide wildlife habitat where it was previously fragmented and/or non-existent. Nonphysical measures in this alternative, such as flood warning systems and flood preparedness plans, would have no adverse effect on terrestrial wildlife and vegetation.

Alternative 3

The environmental effects of the storm surge wall and the nonstructural measures on terrestrial wildlife and vegetation as described for Alternative 2, would be the same for Alterative 3. Implementation of the offshore breakwater would have no effect on terrestrial wildlife and vegetation.

7.10 Cultural Resources

Alternative 1 – No Action/Future Without Project

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. These trends are expected to continue into the future, would have the potential to adversely affect cultural resources within the study area.

Section 2.1 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. Many historic properties on the peninsula have been affected to varying degrees during these events due to the area's relatively flat topography, fill of marshes and creeks, and low elevation (<20 feet NAVD88), and flooding effects would be expected to continue in the future. The Future Without Project conditions in 2075 show that approximately 50% of the historic structures located on the Charleston Peninsula are situated in areas that would be at risk of being inundated to some degree during coastal storms at an elevation of 9 feet NAVD88 (see Figure 7-4). 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 (see Figure 7-5).

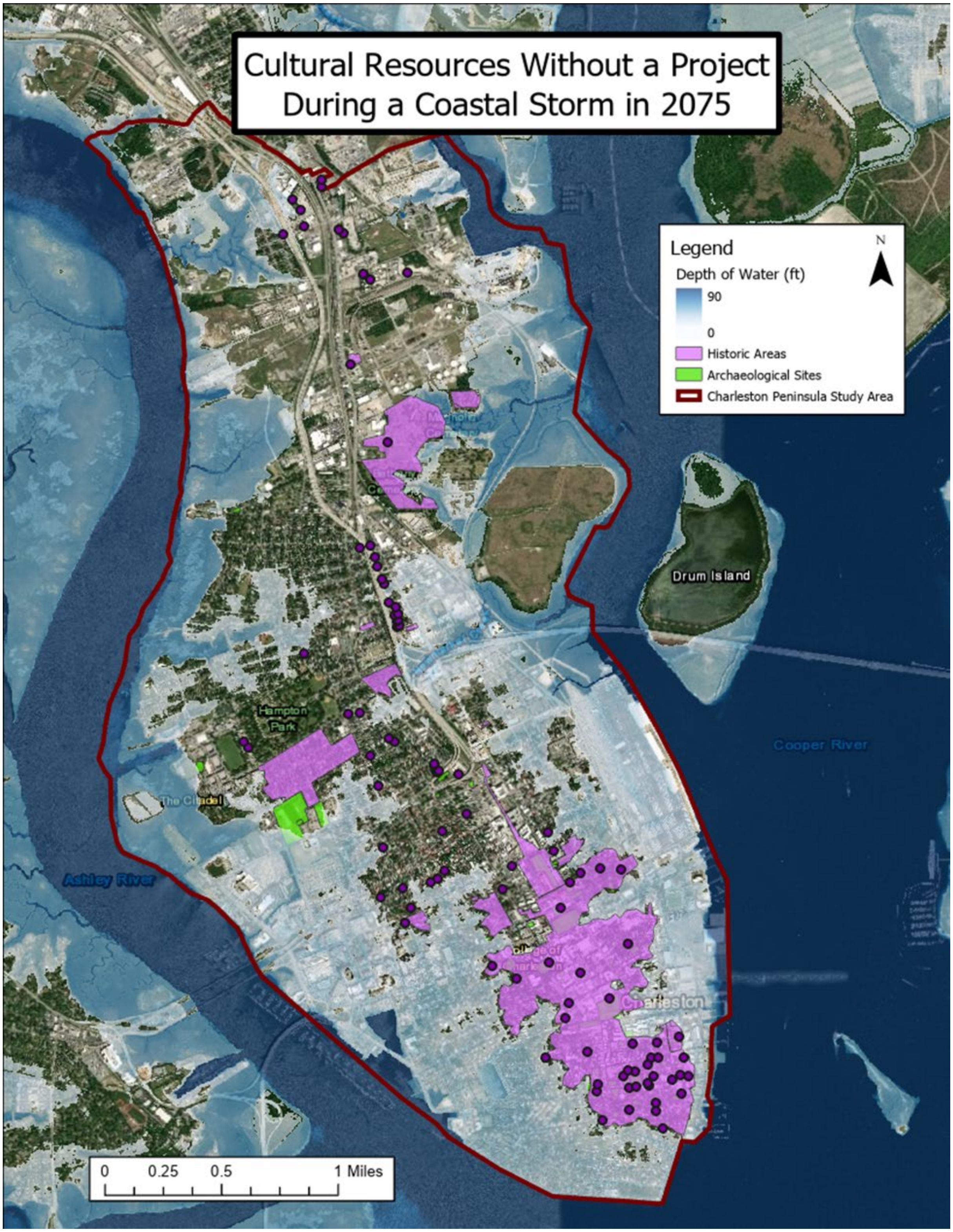

Figure 7-4. Projected conditions in 2075 without implementation of Project
Official mapping product of the Management Support Branch, Charleston District, USACE

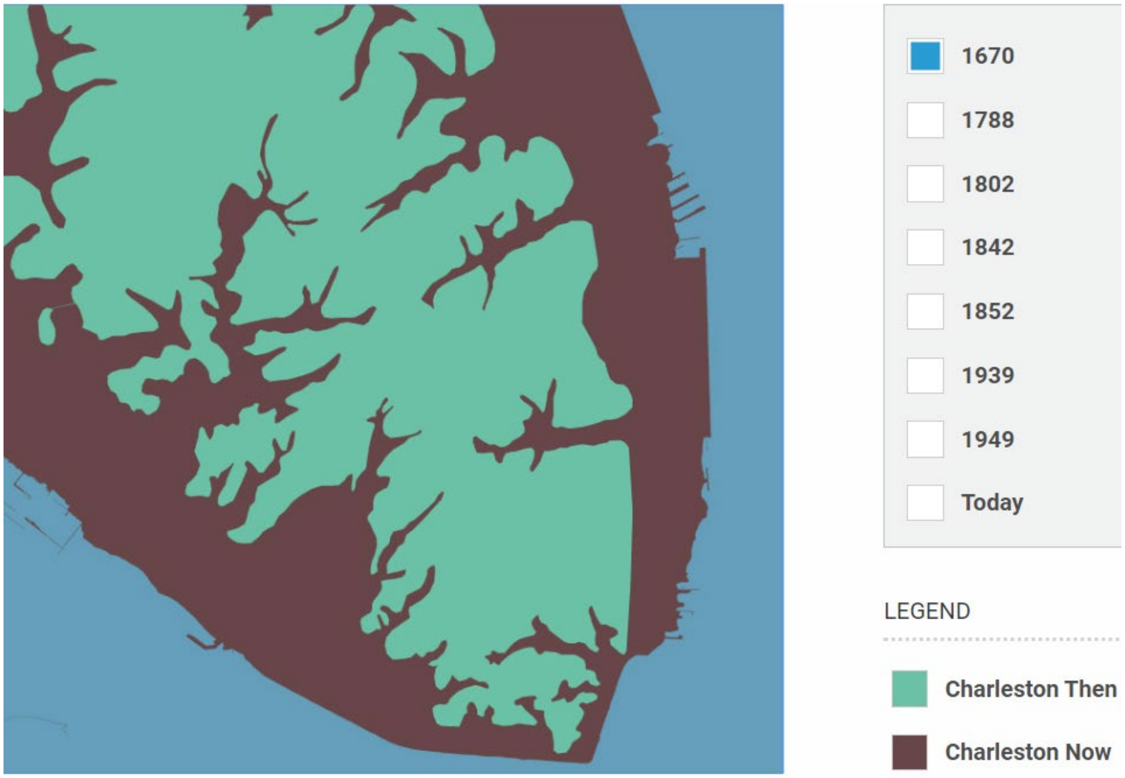

Figure 7-5: Outline of the peninsula in 1670
Source: Historic Charleston Foundation
https://www.historiccharleston.org/research/maps/

It would be expected that historic properties, especially historic architectural resources, will continue to be added to the cultural resources inventory as they become 50 years of age or older and their historic value increases, warranting evaluation for the NRHP. The South Carolina State Historic Preservation Office oversees the Statewide Survey of Historic Properties Program, which systematically identifies historic properties within a specific geographical area. These surveys would be expected to continue and would add to Charleston's historic resources inventory. The results of these surveys would expand existing boundaries of, and create new historic districts as well as identify resources that are individually eligible for the NRHP, particularly resources constructed in the mid-late twentieth century. As a result the number of historic properties that would be exposed to storm surge and flood waters would increase through time.

The City of Charleston formalized a process in 2019 for elevating historic structures in historic districts to protect historic properties from flood waters and damage. This process would be expected to continue without implementation of the Project. 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) provide design considerations to ensure historic structures retain their character and historic significance. In addition to the historic districts, the BAR has jurisdiction over all structures included on the Landmark Overlay Properties list (https://www.charleston-sc.gov/DocumentCenter/View/1261/Landmark-Overlay-properties---list--details?bidId=). Owners of historic buildings and structures are not required to elevate the structures; the cost of elevating a historic structure is the responsibility of the owner. Historic properties that remain at their original elevation would potentially be subject to repeated damages and deterioration. In addition to damage to the foundations of historic structures, flood waters would have the potential to cause damage to interior systems such as electrical wiring, ductwork, heating and air systems and interior finishes. Repeated flooding would also adversely impact historic landscaping and plants. Historic archaeological sites and deposits associated with historic structures could potentially be impacted through measures taken to protect personal property.

Alternative 2

Under Alternative 2, the T-wall would be constructed in highly developed residential and urbanized areas on the lower peninsula along the Battery and the Cooper River side of the peninsula. Urban archaeology near the Cooper River has produced significant finds for large construction projects and the potential to locate intact archaeological deposits during construction of the storm surge wall is high. One previously recorded archaeological site, the Granville Bastion (38CH1673), is located near the High Battery Seawall and within the permanent easement of the current storm surge wall alignment and will require mitigation if it cannot be avoided. The Penderois site (38CH0700), a 17-18th century historic archaeological site located along the Ashley River, is within the proposed storm surge wall alignment. This site has an unknown NRHP status and will require additional investigation if the alignment cannot avoid the site. 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. There is potential for submerged resources in areas near the marsh where the Combo-wall would be constructed along the Ashley River (see Figure 7-6).

The Low and High Battery Seawalls would be directly affected by construction of the storm surge wall. The seawalls are historic properties within the COHD. The current storm surge wall alignment would incorporate the Low and High Battery Seawalls into the storm surge wall's design. Rehabilitation of the Low Battery Seawall (Murray Boulevard) is underway by the City of Charleston and is not part of Alternative 2. For Alternative 2 the rehabilitated wall would be retained and the seawall would be raised to reach the required seawall elevation. The High Battery Seawall (East Battery Street) would be completely rebuilt to meet current engineering standards and constructed to the required elevation. Although the original High Battery Seawall would be adversely affected, incorporating it into the storm surge wall would protect the historic properties that are within the COHD. As currently designed the seawall allows water to come around the west end of the wall at Murray Boulevard and flood during coastal storms Water could flow around the current end at E. Battery Street during a flood event of about 8 ft NAVD88, and it would also come over the wall at 9 ft NAVD88. Incorporating the seawall into a continuous storm surge wall would provide protection to the COHD and all of its contributing elements.

Figure 7-6. 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/

Vibrations from pile driving during construction would have the potential to directly affect historic structures near the wall's footprint. Vibrations could cause structural damage to nearby historic structures that are historic properties that are contributing elements to the COHD, NHLs, or are individually listed or eligible for listing on the National Register. In addition to vibrations from pile driving, heavy equipment could also cause damaging vibrations. Murray Boulevard and East Battery Street contain structures that are contributing elements to the COHD. One structure on E. Battery Street, the Robert William Roper House, is also a NHL. The degree of damage sustained would depend on the type of structure, the structure's current condition, and the magnitude of energy transmitted to the surrounding ground. Monitoring equipment may be required to ensure the level of vibration does not damage or degrade the historic properties to such an extent that the integrity is compromised.

In addition to vibrations, historic properties may be subject to other direct effects during the construction phase that would be temporary and would not be expected to have an adverse effect on the NRHP status of historic properties. Heavy machinery and equipment will be required to construct the storm surge wall. These types of vehicles are not normally part of the setting of the COHD or historic properties and will create a visual intrusion altering viewsheds within the COHD, to and from historic properties, and to and from historic properties and the water. These visual intrusions would be temporary and removed once construction of the storm surge wall is complete and would not affect the NRHP-status of the historic properties. Noise associated with pile driving and the construction equipment would also be a temporary intrusion. Traffic pattern changes and road closures would occur during construction, but these changes would be temporary and the original routes would be restored upon completion of the storm surge wall.

The storm surge wall itself would be an intrusion on the visual setting and viewsheds of the COHD, the contributing elements and individually listed and eligible NRHP properties, especially along Murray Boulevard, East Battery Street, the lower portion of East Bay Street, and the eastern ends of South Adgers Wharf north to Vendue Range. The storm surge wall in these areas would run within or along the boundary of the COHD. The introduction of a new feature in the COHD would have the potential to affect the COHD's ability to convey significance through its integrity, particularly setting and feeling. Setting refers to the physical environment of a historic property, such as topographic features; vegetation; simple manmade features (i.e., fences or paths) and relationships between buildings and other features or open space. Feeling is a historic property's expression of the aesthetic or historic sense of a particular period of time. Contributing elements, NHLs and individually listed or eligible properties would be similarly affected. The COHD and its contributing elements are considered historically significant on a National level for the history and architecture of eighteenth and nineteenth century Charleston. The introduction of the visual intrusion created by the storm surge wall would have the potential to 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. The storm surge wall would be visible when looking from inside the COHD towards the Cooper and Ashley Rivers (i.e., outer edges of the peninsula) and when looking from the water to the COHD. While the storm surge wall would be visible, it would 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. In some areas of the COHD near Hazel Parker Playground and Waterfront Park, the storm surge wall would create a separation or barrier between the edge of the peninsula and the COHD boundary where it extends off-shore into the Cooper River. Even though the COHD boundary extends from the peninsula into the water, there are no contributing elements that are located off the peninsula that would be separated or isolated from other historic properties by the storm surge wall. While the storm surge wall would be within the viewsheds of some of the NRHP listed resources and NHLs, the wall would protect the portions of the COHD and the historic properties that are below the storm surge wall elevation that are prone to flooding. The COHD presently contains over 750 contributing elements. A viewshed analysis would be required to determine how and to what degree characteristics of the COHD, its contributing element, NHLs, and individually listed and eligible resources are diminished by the storm surge wall.

The storm surge wall would also create potential viewshed impacts to Lowndes Grove, located on the Ashley River side. Lowndes Grove, a historic house, was constructed circa 1786 and is listed on the NRHP because of its architectural value. The property associated with the house extends west to the Ashley River and includes large oak trees and marsh, and the land is considered an integral part of the site's visual and historic character. The combo-wall would be constructed in the marsh near the historic site.

Nonstructural measures would be applied to approximately 100 structures that are located in the upper portion, or Neck area, of the peninsula (see Figure 7-7). The structures are not part of a historic district, nor have they been identified as historic properties that are individually eligible for the National Register of Historic Places. Few historic resources surveys have been conducted in this portion of the peninsula. A historic structures assessment would be required if nonstructural measures are applied to structures that were not previously evaluated for the National Register of Historic Places that are 50 years old and older. These measures have the potential to adversely affect historic structures that are eligible for the NRHP by altering the appearance and characteristics that make the resource eligible for the National Register.

The adverse impacts to historic properties that are potentially significant will be addressed by the programmatic agreement process and appropriate mitigation for Alternative 2. Although there have been few archaeological surveys, the potential to encounter intact historic archaeological deposits is high, especially along the Cooper River side of the peninsula. The viewshed of the COHD would be altered by the storm surge wall and a viewshed analysis would be required to determine if the integrity of the district is diminished and adversely affected (see Section 4.12, Visuals and Aesthetics). There would also be a beneficial effect resulting from the reduction in the risk of adverse, physical damage to structures and setting resulting from storm surge flooding.

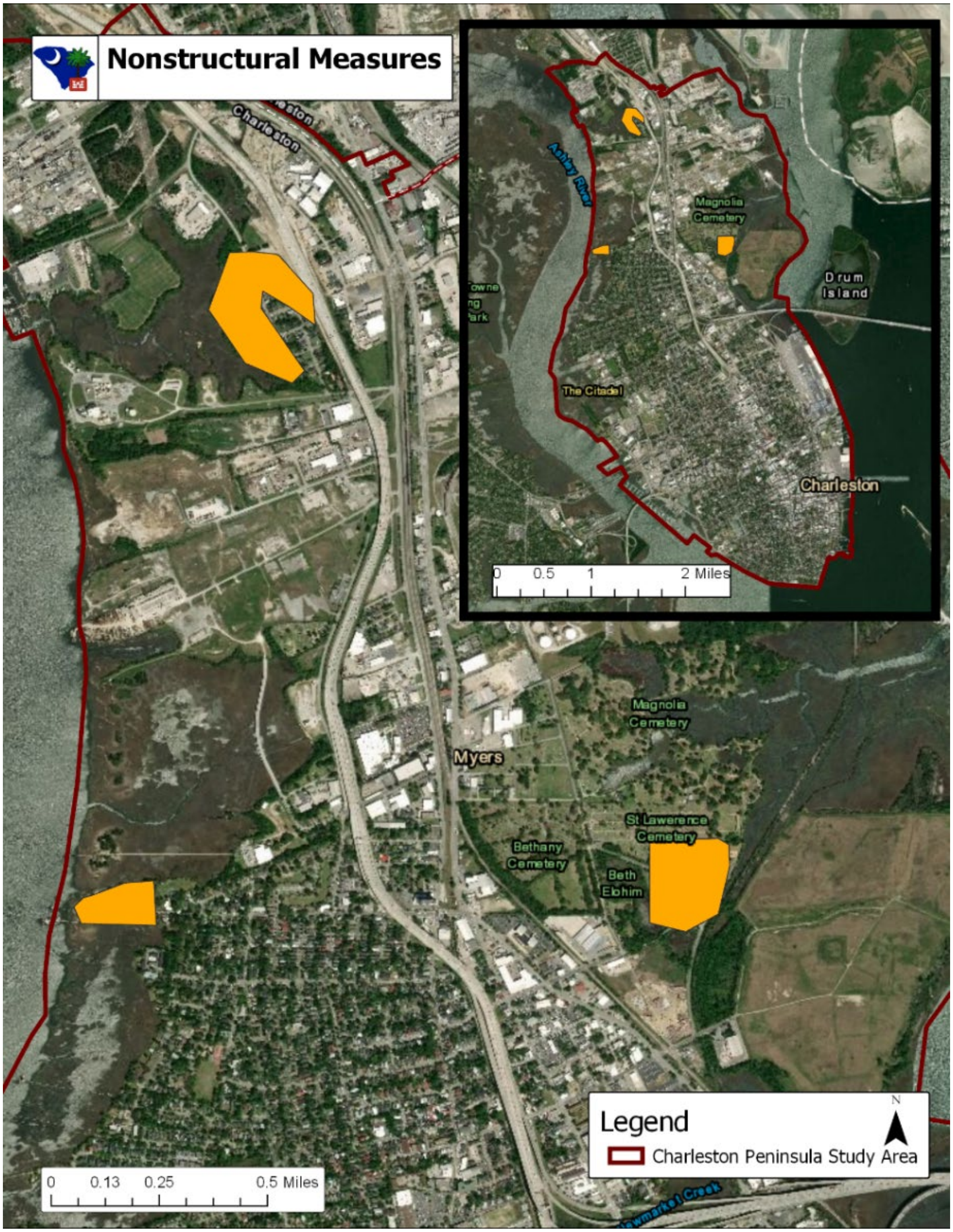

Figure 7-7. Approximate areas where nonstructural measures may be implemented. Official mapping product of the Management Support Branch, Charleston District, USACE

Alternative 3

The environmental effects of the storm surge wall and the nonstructural measures as described for Alternative 2 would be the same for Alternative 3, with respect to cultural resources.

Construction of the wave attenuation structure would have the potential to adversely impact submerged resources. Few remote sensing surveys have been conducted in Charleston Harbor and there are no recorded submerged historic properties in the location of the proposed wave attenuation structure. A survey conducted by the South Carolina Institute of Archaeology and Anthropology Maritime Research Division has identified six remote sensing anomalies that lie 180-200 feet south of the Low Battery Seawall. None of these have been inspected by divers, so their NRHP status is unknown at this time. Remote sensing surveys to locate the anomalies and diver investigation would be required if the wave attenuation structure is sited near the recorded anomalies. Locations that have not been previously surveyed would require investigation as this area has high potential to contain submerged resources.

The wave attenuation structure would have the potential to cause adverse impacts to the viewshed of the COHD if it obstructs the views of historic properties to and from the water. A viewshed analysis would need to be conducted to determine how much, if any of the viewshed would be affected, and if it would cause a cumulative impact with a change in viewshed of raising the Battery seawall. The design of the structure will not be finalized until the PED phase.

Adverse impacts to historic properties that are potentially significant for Alternative 3 would be addressed by the programmatic agreement process and appropriate mitigation. Impacts caused by construction of the storm surge wall would be the same as described in Alternative 2. Impacts caused by implementation of non-structural measures would also be the same as described in Alternative 2. In addition to the impacts described in Alternative 2, construction of a wave attenuation structure that is part of Alternative 3 in the area south of the Battery could impact shipwreck sites and other submerged archaeological resources in Charleston Harbor although none are recorded in the area. There would also be a beneficial effect resulting from the reduction in the risk of adverse, physical damage to structures and setting resulting from storm surge flooding.

7.11 Recreation

Alternative 1 – No Action/Future Without Project

Under Alternative 2, 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.

It is expected that the City will use its Century V Comprehensive Plan (City of Charleston, 2016), Sea Level Rise Strategy (City of Charleston, 2019), and the forthcoming Parks and Recreation Master Plan 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 places will be at even greater risk of storm surge impacts in the future.

Alternative 2

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 T-wall 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. Access gates would be added through the wall so that access to the park and pier can be maintained. These impacts to recreational use of Brittlebank Park would be permanent but minor. The T-wall would also have a beneficial impact on Brittlebank Park by reducing storm surge flooding across the park, as well as shallow coastal flooding, allowing it to stay accessible longer for residents and visitors.

In the conceptual footprint, the T-wall would also be positioned along roadways that are in close proximity to parks in some places, which could lead to minor indirect 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 T-wall include Waterfront Park, Hazel Parker Playground, and White Point Gardens, but access at these may not be limited. Some recreational areas could also be temporarily impacted 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 public parks and marinas. These impacts would be considered minor.

The combo-wall and storm gates would indirectly impact recreational boating on the Ashley River-side of the Peninsula. Based on the conceptual footprint of the storm surge wall, the combo-wall would intersect with the City Marina and with two private marinas. The wall would not limit boat access, 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 the channel leading to the Citadel Boat Landing, boating access would be limited, but not restricted, through the proposed miter gate. These impacts would be permanent, but considered minor. 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 combo-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 impact of the combo-wall on recreational use at Halsey Creek would be minor.

No recreational water features on the Cooper River-side would be affected by the storm surge wall. Additionally, no recreational features or uses would be affected by nonstructural measures.

City of Charleston and USACE are still considering a number of design features that would help to reduce the impacts of the structural measures, and allowing the storm surge wall to serve as a recreation feature and make it more aesthetically pleasing while staying consistent with the nature and character of Charleston. Examples may include adding a walking path on the wall in some locations. Additive recreational features are being evaluated and will be incorporated in the Final Report.

Alternative 3

. The environmental effects of the storm surge wall and the nonstructural measures on recreation as described for Alternative 2 would be the same for Alterative 3. Implementation of the offshore breakwater under this Action Alterative would not result in adverse effects to recreation other than posing as obstruction to recreational water-borne vessels that are outside of the Federal navigation channel. The breakwater could impede but should not restrict these vessels. Additional vessels would be present in the Charleston Harbor during construction of the breakwater, but this would have a minor effect on water-borne recreational in the ROI.

7.12 Visuals and Aesthetics

Alternative 1 – No Action/Future Without Project

Under the No Action Alternative, it is assumed that the City of Charleston will raise the current Low Battery Wall to a 9ft elevation NAVD88, which will provide additional reduction in storm surge damages in the Battery area, but also alter the view.

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 and infrastructure at risk of coastal inundation. This trend is expected to continue into the future. These trends are likely to result in changes to the visual resources in the ROI in the without-project condition. As relative sea level rises and storm surge affects the ROI more frequently and with increasing intensity, the landscapes at the rivers' and harbor's edges 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 damages, and if they didn't then the visual quality of the landscape would progressively degrade. This would likely adversely affect the user's experience of the site they were visiting more than it would affect their experience of views across a water body.

Similarly, park trees and other urban plantings will experience storm surge damages and, dependent on the severity, may need to be replaced. Additionally, the type and distribution of vegetation in open spaces such as marshes and forested wetlands, including those in view from the peninsula, may change over time due to relative sea level rise and storm surge damages, with these places gradually being lost and/or their visual character changed.

The No Action Alternative/Future Without Project conditions could also lead to tourism facilities, including commercial and institutional buildings as well as historic areas or buildings, being closed more often and for longer periods due to storm surge flooding and/or recovery efforts. This may adversely affect visitors' experience of the landscape as they move across it to get to the water's edge, but once at the water's edge it may not affect their experience of views across water bodies. The storm surge damages wouldn't be limited to touristic and commercial/institutional areas either, since residential neighborhoods would be equally subject, and the visual impact of the damages would be adverse there as well, unless or until restoration and repair were undertaken. Because the Charleston Old and Historic District, which is a major draw for tourism, contains primarily residential buildings in addition to the commercial, ecclesiastical and government-related buildings that are there, restoration and repair not undertaken by individual property owners could degrade the visual quality of the historic peninsula. Finally, if damaged, unattractive land uses including industrial buildings and unsightly infrastructure in the skyline such as cell phone towers and directional highway signs would likely be restored to similar low visual quality/condition, but could have opportunities for improvement.

Under the No Action Alternative/Future Without Project condition, places such as Brittlebank Park could erode away under repeated storm surge damages, and the park events that currently happen there would have to scale down over time or, perhaps, relocate – whether they would stay in the Charleston metropolitan area or relocate outside the region is unknown. Historic tours along the water's edge of The High Battery, if it was declared unsafe due to gradually crumbling away, would have to relocate to The Low Battery or elsewhere. General river and harbor viewing would move inland as the water's edge did, new piers for fishing and docks/marinas for boating would eventually have to be built. Construction activities there and throughout the receding city would be ongoing to continually make the remaining city anew.

Alternative 2

Under Alternative 2, it is assumed that the City's project to raise the Low Battery Wall to a 9ft elevation NAVD88 as described in the No Action Alternative, would occur. Implementation of a storm surge wall under Alternative 2 would result in a permanent landscape feature, leading to potential changes in visual resources. As relative sea level rises and storm surge affects the Charleston area more frequently and with increasing intensity, inundation of the landscapes at the rivers' and harbor's edges would experience less storm surge damages. However, the storm surge wall would be visible to varying degrees depending on location and view, and on the height of the wall above existing ground elevation at that location (see Figure 7-8), and may in some cases have an adverse impact to visual resources, while in others it may not.

Those parts of the urbanized landscape closest to the water's edge would need to rebuild or restore less often than with the No Action Alternative due to being at reduced risk from storm surge damages up to the level of reduced damages it is designed for. This includes but is not limited to park trees and other urban plantings. This means the visual quality of the landscape would be maintained more consistently for a longer period of time with-project than without-project, having a beneficial effect. However, the presence of the storm surge wall could adversely affect the visitors' experience of some places they would visit more than others, depending on location. Generally, though, the storm surge wall is not anticipated to affect their experience of views across water bodies.

With Action Alternative 2, the type and distribution of vegetation in open spaces such as marshes and forested wetlands may change based on the placement of the storm surge wall, either due to its presence or due to its absence, changing the visual character of some places.

The future conditions with Alternative 2 would lead to tourism facilities, including commercial and institutional buildings as well as historic areas or buildings, being at reduced risk of damages by the storm surge wall, and would likely shorten the time needed for recovery from storms, resulting in a beneficial effect. Relative to the without-project condition, this would improve visitors' experience of the landscape as they move across it to get to the water's edge, but may also adversely affect their experience of views across water bodies, depending on their location relative to the location of the storm surge wall and its height at that elevation. The residential neighborhoods would also be at reduced risk of damages up to the designed level, and the visual impact of the damages similarly shortened/reduced, with them and visitors enjoying the benefit. Yet, their experience of views may also be adversely impacted depending on their location relative to the location and elevation of the storm surge wall. Unattractive land uses including industrial buildings and unsightly infrastructure in the skyline such as cell phone towers and directional highway signs would likely remain unchanged.

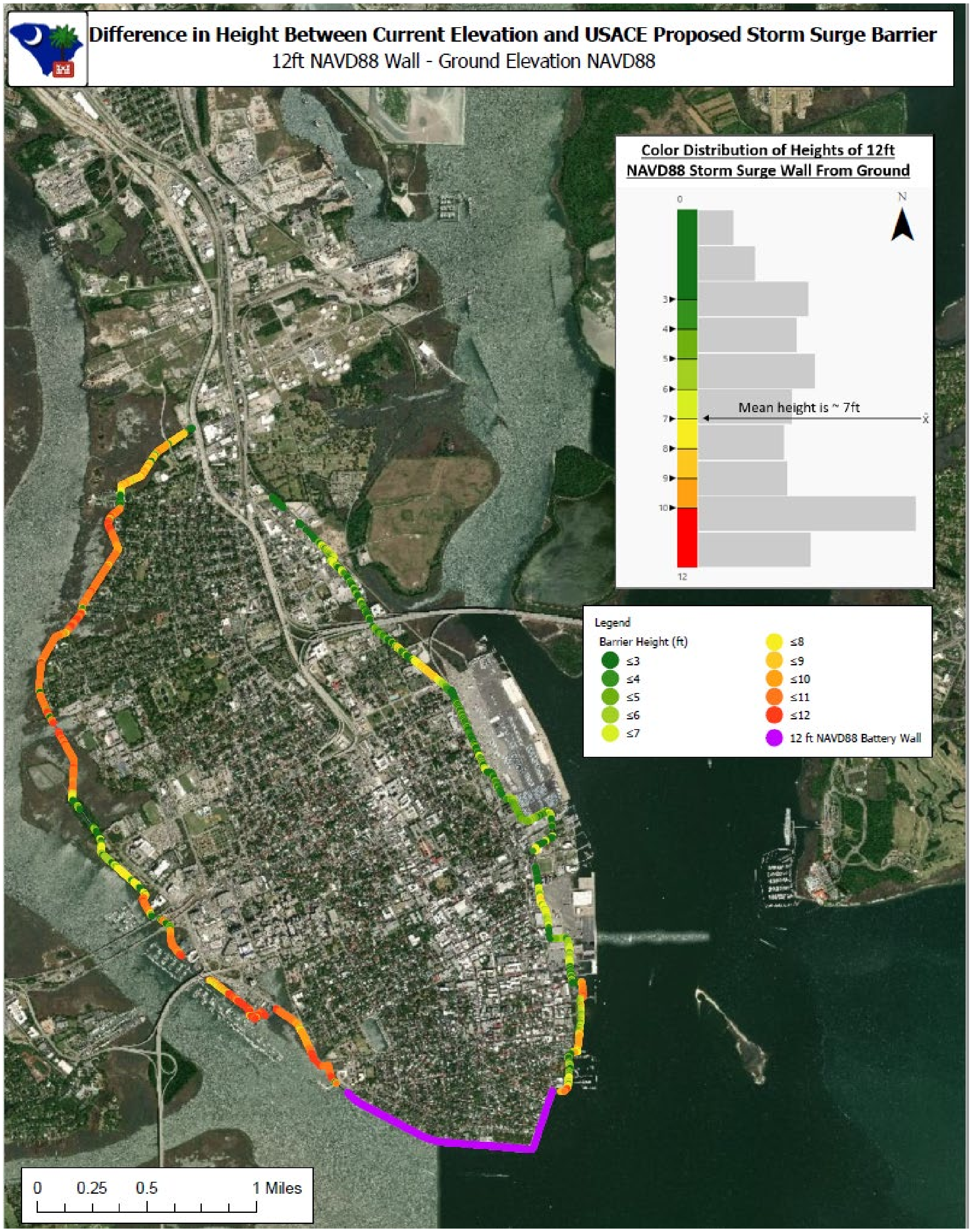

Figure 7-8. Map showing the difference in relative height of the conceptual storm surge wall compared to the ground elevations. Green shades suggest higher ground elevations, so a lower wall can be expected to reach 12 ft NAVD88, and red shades suggest lower ground elevations so a higher wall can be expected to reach 12 ft NAVD88.
Official mapping product of the Management Support Branch, Charleston District, USACE

Depending on the location of the wall, places such as Brittlebank Park would experience less storm surge impacts that result in park closures, and the park events that currently happen there could remain. Historic tours along the water's edge of The Battery could continue, with their experience changing very little. General river and harbor viewing could continue in generally the same locations, but their experience in some cases could change, dependent upon location and wall elevation at that location. Existing piers for fishing and docks/marinas for boating would largely remain where they are. Construction activities throughout the city could continue according to current city plans due to reduced impacts from storm surge.

Therefore, implementation of the structural measures in Alternative 2 have the potential to result in permanent effects on visual resources in the ROI that may be beneficial or adverse, depending on location. Some effects are expected to be minor. To determine the magnitude of some of the impacts, a VIA that uses the Detailed Procedure may be needed. If adverse impacts are determined, then the analysis would consider proposed mitigation features to reduce the visual impacts. Since the plan for nonstructural measures is still very conceptual at this time, the effects of non-structural measures on visual resources have not been assessed. This will be included in the Final Report.

Alternative 3

The environmental effects of the storm surge wall as described for Alternative 2 would be the same for Alterative 3 with respect to visual resources. The effects of nonstructural measures are yet to be evaluated, as stated in Alternative 2. The addition of the wave attenuation feature, such as a breakwater that could appear higher relative to the wall at The Battery, would have a visual impact for which the magnitude still needs to be evaluated. USACE is continuing to evaluate the size/footprint of the breakwater in order to minimize potential impacts.

7.13 Air Quality

Alternative 1 – No Action

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

Alternative 2

Under Alternative 2, it is expected there would be a temporary and localized reduction in air quality during construction of 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 would 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). Action 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, no significant impacts would occur to air quality under 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.

Alternative 3

The environmental effects of the storm surge wall and the nonstructural measures as described for Alternative 2 would be the same for Alterative 3 for air quality. Construction of the offshore breakwater for action Alternative 3 would also result in minor, short-term effects on air quality from construction equipment emissions. The same actions would apply to minimize emissions as in Alternative 2, and the emissions would not exceed air quality standards. Construction would be phased which would also minimize impacts. Therefore, no significant impacts would occur to air quality under Alternative 3.

7.14 Noise

Alternative 1 – No Action/Future Without Project

Under the No Action Alternative, it is assumed that the City of Charleston would continue to enforce its current noise ordinance, so levels would stay about the same as they are now. As redevelopment continues to occur on the Peninsula, there is the potential for construction-related noise to be reduced in duration if the new Building Construction Operation Noise ordinance is ratified, as described in Section 4.14. Noises related to uses of the Charleston Harbor would not drastically change over time. It is expected that the City of Charleston's drainage projects would be constructed in the future, contributing minor temporary impacts to construction noise.

Alternative 2

During construction of the storm surge wall and associated gates under Alternative 2, there will be noise associated with these operations. The noise levels would 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).

Noise abates at a level of -6 dBA per 50 feet away from the source. Within 400 feet away from the 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 will take place within a few hundred feet of residential areas, businesses, and hotels in a number of locations. Several parks intersect with the proposed construction sites, but it is assumed that public access to the parks or closest to the construction would be restricted during construction for safety reasons. Hotels and business in West Ashley that are in the ROI would have a direct site line to construction of the combo-wall, but are over 400 feet away. Since the conceptual footprint of the storm surge barrier does not extend to the City limits in the Neck area, communities in the North Charleston Neck area would be considered too far away to be impacted by construction noise.

Terrestrial wildlife who are able to flee would likely avoid the construction areas due to the noise, which would be temporary. Construction of the combo-wall will occur in the marsh and mudflats, not in open water so limited sound would travel through water. Fish are likely to exhibit avoidance behavior away from the construction areas. Regardless, BMPs would be implemented to the extent practicable to reduce noise impacts on aquatic and benthic resources, especially during pile driving.

Nonstructural measures in Alternative 2 may involve some construction through home-raising and flood proofing. These would include construction equipment whose noise levels are similar, but lower, than those described above. In general, less equipment and shorter time would be needed. Nonphysical measures in this alternative, such as flood warning systems and flood preparedness plans, would have no effect on noise.

Best practices can be used to reduce the impacts of construction-related noise. Construction would be phased, so noise impacts in multiple locations would not occur, reducing the potential for any cumulative effect. Construction activities would be limited to normal business hours and not occur at night, early mornings, or on Sundays. If the new Building Construction Operation Ordinance is ratified, these practices and others would be necessary.

Therefore, construction noise impacts from Alternative 2 would be temporary and minor.

Alternative 3

The environmental effects of the storm surge wall and the nonstructural measures as described for Alternative 2 would be the same for Alterative 3 with respect to noise. Implementation of the offshore breakwater under Alterative 3 could also result in noise impacts during construction.

Although the offshore breakwater will be visible from land, the impacts of construction noise on receptors in the area of the Battery should be limited due to the distance. The Battery Wall also serves as an obstruction that would reduce noise levels. Construction of the breakwater could create an underwater noise disturbance for sea turtles, sturgeon, and manatees. No drilling or dredging would be involved so noise would primarily come from construction boats with heavy equipment. Best practices and conservation measures, such as those in the standard manatee guidelines, would be used to minimize these impacts. Noise impacts from construction of the breakwater would be temporary and minor.

7.15 Hazardous Materials and Wastes

Alternative 1 – No Action/Future Without Project

Under the No Action Alternative, it is assumed that the Koppers Co. Superfund site would still be remediated as described in Section 4.15 to 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, along with human use patterns such as population growth, will continue over the next 50 years in the Charleston area. Increased erosion of soil, particularly along unprotected shorelines, would be expected to increase as a result of increased storm surge and water levels. Hazardous materials and waste may have an increased risk to the environment through exposure of deposits from erosion and water contamination from inundation from storms.

Alternative 2

Although the Koppers Co. Superfund site will 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 Superfund site is not in an area of the Peninsula where the current conceptual footprint of the storm surge wall is planned. Nonstructural measures are proposed in a residential area near the Koppers Superfund site. Nonstructural measures are generally low impact and localized, and are not expected to interact with any hazardous materials from that site, although risks from the Superfund site are assumed to be removed anyway due to the USEPA's remedial actions.

There are a number of other CERCLA, RCRA, and Brownsfield sites in the study area, and most would not be directly impacted by the alternative because of their location. There is the possibility that the structural measures in Alternative 2 could adversely affect hazardous materials or waste at a few of these sites during construction, putting exposure to human health at risk, including the Calhoun Park Areas CERCLA site on Concord Street. The impacts would be minimized by avoiding construction in areas of known hazardous waste sites to the extent practicable. Some areas where the conceptual storm surge wall is planned are industrialized and there is the potential for unplanned encounters with contaminants during construction of the wall. Therefore, a Phase 1 Site assessment would be conducted in the PED phase, which would help 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 contaminated, or otherwise, that would be encountered during construction should be considered during the PED phase. The plan would provide information regarding anticipated volume and characteristic of contaminated materials identified so that there is appropriate consideration of the transportation, treatment, and disposal of the contaminated materials.

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

Therefore, adverse impacts involving hazardous materials and wastes from implementation of Alternative 2 are expected to be minor and temporary during construction. Additionally, 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.

Alternative 3

The environmental effects of the storm surge wall and the nonstructural measures on hazardous materials and waste as described for Alternative 2 would be the same for Alterative 3, and the same minimization measures proposed. Implementation of the offshore breakwater under Alternative 3 would have a negligible impact on hazardous materials and wastes. The breakwater would be placed on the surface of the harbor seafloor and not embedded, and while there would be some sediment disturbance during construction, it is not likely to result in considerable exposure of subsurface materials to humans or aquatic life. Additionally, there are no known contaminated sites in close proximity of the proposed breakwater location, so the need for sediment chemical analysis is not anticipated.

7.16 Transportation

Alternative 1 – No Action/Future Without Project

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, casing nuisance flooding on roads, have already increased in frequency. This trend is expected to continue into the future.

It is expected that the City of Charleston will use its Century V Comprehensive Plan (City of Charleston, 2016), 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, will 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 out of the ROI) will be completed two years from now. No significant impacts to waterborne transportation are anticipated under the No Action Alternative.

Alternative 2

Under Alternative 2, minor impacts to land-based transportation would occur near the T-wall. The conceptual footprint for the storm surge barrier currently aligns a number of roadways on the Peninsula, most notably Concord Street and Morrison Drive. Road and pedestrian traffic may need to be altered but this is not expected to adversely affect transportation. Gates would be installed at all transportation crossings with the T-wall (streets, rail, pedestrian) to allow access. More information about the road crossing and gates can be found in Appendix B. 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 impact. 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, but this would be for short durations and not concurrent, and there would be detours provided.

Prolonged temporary impacts to land-based transportation would occur during construction of the T-wall and associated access gates. 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 would be phased, so there would be no cumulative impact from traffic delays at multiple construction sites.

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.

Because the combo-wall is constructed off the shoreline, there would be limited impacts to land-based transportation, Land based staging areas for the combo-wall may need to be identified (to be done in PED phase). If the comb-wall intersects intersects with any roads or bridges, access gates would be included. Impacts to waterborne transportation would be minor. The combo-wall would not impact any marine commerce on the Cooper River-side, as the storm surge wall will be on land in this area.

Long-term, direct beneficial effects to 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 transportation infrastructure from storm surge flooding, although rainfall-induced flooding may still occur. With flooding reduced during a storm surge event, critical facilities on the Peninsula would continue to be accessed. These would be important beneficial impacts.

Alternative 3

The environmental effects of the storm surge wall and the nonstructural measures on transportation as described for Alternative 2, would be the same for Alterative 3. Implementation of the offshore breakwater under Alternative 3 would not result in any significant effects. The breakwater would not be located in a Federal navigation channel. Additional vessels would be present in the Charleston Harbor during construction of the breakwater, but this would have a negligible effect on waterborne transportation in the ROI. Implementation of the breakwater would have some beneficial effect on road transportation in the Battery area during a storm surge event by reducing the potential of waves overtopping of the wall.

7.17 Utilities

Alternative 1 – No Action/Future Without Project

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 will 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.

It is expected that the City of Charleston will use its Century V Comprehensive Plan (City of Charleston, 2016), 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.

Alternative 2

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 impacts would be adverse, minor and not significant.

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). 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 would be adversely affected. Based on the current conceptual footprint of the storm surge wall, the wall has the potential to disrupt stormwater outfalls in 32 locations, electrical lines in 33 locations (although not all may be in service), gas mains at 12 locations, and sewage lines in 18 locations and water lines in 22 (although some are abandoned) 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.

Implementation of nonstructureal 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. Therefore, they are not significant.

Alternative 3

The environmental effects of the storm surge wall and the nonstructural measures as described for Alternative 2 would be the same for Alterative 3 with respect to utilities. The addition of the wave attenuation feature, such as a breakwater, would have no effect on utilities.

7.18 Safety

Alternative 1 – No Action/Future Without Project

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 will 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 $416 million in the study area.

It is expected that the City of Charleston will use its Century V Comprehensive Plan (City of Charleston, 2016) 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) will 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 on 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 will 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.

Alternative 2

It is expected that the City of Charleston's resiliency efforts described in the No Action Alternative would continue into the future, and contribute 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. Similar risks would still remain as in the Future Without Project condition with shallow coastal flooding and rainfall flooding, and wave overtopping (still being evaluated) that would be a similar result of flooding without implementation of the wall, as expected in the No Action Alternative. The opening and closing of the many access 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.

During construction of the measures in Alternative 2, there would be the potential to produce minor adverse short-term safety impacts to the public (motorists, boaters, and pedestrians) and emergency services in the ROI from the implementation of these 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 will have to be secured, 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.

Alternative 3

The environmental effects of the storm surge wall and the nonstructural measures on safety as described for Alternative 2, would be the same for Alterative 3. Similar construction impacts to safety could result from the breakwater, for boaters and workers. The same actions would apply to minimize construction impacts as for Alternative 2, with the addition of specific safety requirements and precautions from the US Coast Guard for this in-water construction. Therefore, impacts on safety from implementing Alternative 3 would be minor and short term from construction, and beneficial and long term to safety due to the reduction in storm surge flooding from major storm events.

7.19 Environmental Justice, Protection of Children

Alternative 1 – No Action/Future Without Project

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 people at risk of coastal inundation.

It is assumed that the City of Charleston will 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 will complete its existing project to raise the current Low Battery Wall to a 9ft elevation NAVD88 as described in Section 1.4, which will provide additional reduction in storm surge damages to communities in the Battery area. Communities across the rest of the Peninsula are already vulnerable to flood damages where there are is no storm surge barrier. Under the No Action Alternative, it is expected that these communities, some of which include minorities and low income households, will 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 $416 million in the study area.

Alternative 2

Alternative 2 would provide significant risk reduction benefits from storm surge through structural or non-structural measures for all residential structures that are vulnerable to damages in the ROI, now and into the future. These residential structures can be considered a general proxy for households that would be positively impacted by this alternative for the purposes of this assessment. Alternatives 2 is not designed to create a benefit for any specific socioeconomic group or individual.

There are no indications that implementation of Alternative 2 would be contrary to the goals of Executive Order 12898, or would create disproportionately high and adverse environmental effects for minority or low-income populations in the ROI. Similarly, this action alternative does not present any material environmental health or safety risks to children.

Alternative 3

The environmental effects of the storm surge wall and the nonstructural measures as described for Alternative 2 would be the same for Alterative 3 with respect to environmental justice. The addition of the wave attenuation feature, such as a breakwater, under Alternative 3 would have no effect on the environmental health of any particular socioeconomic group, including children.

7.20 Climate Change

Alternative 1 – No Action/Future Without Project

Under the No Action Alternative, 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. Sea levels have already risen in the Charleston area, and minor coastal flooding is increasing. It is expected that the City of Charleston will use its Sea Level Strategy (City of Charleston, 2019) to guide future decisions that support adaptation to shallow coastal flooding, and that any City actions taken outside the scope of this study would improve the city's resilience against climate change impacts. However, the high tide events are predicted to continue to increase with sea level rise. Storm induced flooding will be significantly amplified by sea level rise if no action is taken. Salt marshes in some areas around the peninsula are predicted to be gone 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. This is described in more detail in Section 7.6 Wetlands.

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 study.

Alternative 2

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 7.13, Air Quality). Effectson climate change are expected to be negligible..

It is assumed that any City of Charleston actions taken outside the scope of this study would provide the same improvement to the city's resilience against climate change impacts as in the No Action Alternative. Implementation of the structural, non-structural and mitigation measures for wetlands (specifically living shorelines) in Alternative 2 would result in a significant increase in the City of Charleston's resilience towards the impacts of climate change. The measures in Alternative 2 have the potential to reduce damaging impacts of sea level rise on structures where water would encroach in the Future Without Project. The city would be less vulnerable to the impacts of storm surge flooding and other coastal flooding in the future, resulting in a potential beneficial effect.

Alternative 3

The environmental effects of the storm surge wall and the nonstructural measures as described for Alternative 2 would be the same for Alterative 3 with respect to climate change. Construction of the offshore breakwater for Alternative 3 would also result in temporary, minor and negligible impacts from emissions, but since it would be phased from construction of the other measures, the impact would be minimized. The breakwater would result in a positive reduction in wave height that would also improve the City's resilience to flooding. Implementation of the breakwater measure is not predicted to substantially cumulatively or synergistically interact with climate change.

7.21 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, the 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 two action alternatives, by examining the potential additive and interactive impacts of these alternatives 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.

7.21.1 Past, Present, and Reasonably Foreseeable Future Actions (PPRFFA)

- **USACE Charleston Harbor Deepening, Post 45 Project:** The USACE is currently undertaking a large, deep draft navigation project to deepen the Charleston Harbor (locally referred to as the Post 45 Project), including the Entrance Channel and portions of the Cooper and Wando Rivers that drain into the Charleston Harbor. The project does not include any dredging in the Ashley River. The project began in 2018. The project has recently been fully-funded, and is on-track to be completed in 2022. The Post 45 Project will 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 will 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 will 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 will be greatly improved and connected to the tunnel. The sidewalks and streetscape of Market Street will also be improved. Information obtained from the archival research conducted for this and other City drainage projects will 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 will serve more than 500 acres of the western peninsula and will 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 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.
- **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 7-9). The South Carolina Department of Natural Resources is currently monitoring the success of the reefs.

Figure 7-9. Locations of where oyster reefs were constructed for the Ashley River Oyster Enhancement Project. Source: City of Charleston.

7.21.2 Key Resources Areas

Wetlands

No collectively significant effects are expected from the proposed actions and PPRFFA. Of the PPRFFA noted above, the only one with an appreciable impact on wetlands is the USACE 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 action alternatives 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. The action alternatives (both Alternatives 2 and 3) will 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 will 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 will 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. The only structure associated with the action alternatives for this study that would be situated in deeper water would be the wave attenuation structure associated with Alternative 3. However, the footprint for the wave attenuation structure does not coincide with and would not impact any known hardbottom 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 will contribute to improvement of the condition of estuarine shorelines in this area of the Ashley River.

This study is anticipated to have an insignificant effect 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 action alternatives 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 action alternatives 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 action alternatives for the current study would likewise not contribute to any appreciable adverse impact on dissolved oxygen. In terms of temporary impacts to water quality resulting from construction, the earliest start date of any project resulting from this study is anticipated no sooner than 2025. 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 action alternatives and PPRFFA include both beneficial and adverse effects; however, the adverse effects after mitigation for the contribution of the proposed action alternatives under this study are not expected to be cumulatively significant. Potential temporary adverse effects as a result of the action alternatives for this study are anticipated in the form of noise, vibration, and visual intrusions as a result of the construction process. However, as noted previously, construction on any project resulting from this study would not commence until after the completion of all of the identified PPRFFAs. Potential permanent adverse effects as a result of the action alternatives for this study may take the form of disturbance of previously undiscovered archeological sites, visual intrusions on the historical setting and viewshed, vibration damage as a result of construction and pile driving to historic structures, as well as physical impacts to any eligible structures that may be identified for nonstructural measures such as relocation or buyout.

Some degree of cumulative impact to previously undiscovered archeological sites is to be recognized 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 sites. However, these projects often include appropriate mitigation provisions (for example, the Low Battery Seawall Rehabilitation Project includes a Memorandum of Agreement to ensure appropriate mitigation). In addition, information obtained from the archival research conducted for the City's projects will add to the archaeological database, and assist in the identification of areas that have the highest potential to contain archaeological deposits. This information would be used to help minimize effects for the study action alternatives. The Programmatic Agreement for this study should ensure that appropriate, practicable mitigation is pursued to compensate for the proposed action's contribution to cumulative effects, after avoidance and minimization.

PPRFFAs such as the Low Battery Seawall Rehabilitation Project will combine with the proposed action under the study to adversely impact viewshed and setting by interrupting views from the COHD to Charleston Harbor, as well as to and from individually eligible historic properties and contributing elements. Both will be subject to Agreements to ensure appropriate mitigation to compensate for their respective contributions to this cumulative impact. The Fort Sumter Breakwater Rehabilitation would have no cumulative effects on cultural resources or viewshed. The Fort Sumter breakwater that will be rehabilitated will not impact the historic viewshed looking from and to the Fort and Charleston. While sightlines from Charleston to Fort

Sumter and from the Fort to the City are considered to be one of the foundational cultural values for the National Monument, the Post 45 Project is not excpected to add any cumulative contribution. The study acknowledges the contribution to adverse impact on viewshed and setting of the storm surge wall and gates, and is prepared to address appropriate mitigation with consulting parties under the NHPA in order to ensure that this impact remains below a significant cumulative level.

Vibration damage to historic structures as a result of construction, pile driving, or similar activities would be addressed for the Study's action alternatives by the consultation process under the Programmatic Agreement. The City's Low Battery Seawall Rehabilitation Project is expected to include 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 the study action alternatives, thereby reducing the overall potential cumulative impact. The consultation process under the Programmatic Agreement will likewise address the study's contribution to cumulative effects as a result of any nonstructural measures such as relocations or buyouts that may be identified as this study moves forward.

At the same time that the action alternatives under the study will contribute to adverse cumulative effects (as outlined above), they will 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 will contribute to a reduction of the risk of compound flooding and resultant physical damage to historic structures. This risk reduction would at the same time benefit the safety of those living and working in and among 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.

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Chapter 8 – Tentatively Selected Plan

Based on the evaluations described in Chapter 6 and 7, Alternative 3 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. Assumptions used for evaluation, comparison, and environmental impact analysis can be found in Section 3.5. The description of the plan in the Final FR/EA 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. 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 ports, marinas, and the Coast Guard Station. The wall would tie into high ground as appropriate, including 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.

  The storm surge wall also includes multiple pedestrian, vehicle, railroad, boat, and storm (tidal flow) gates. Typically, the gates would remain open, and would be closed when the National Weather Service predicts major flooding for the Charleston Peninsula. Major flooding is currently defined as a storm surge equal to or greater than 8 feet above MLLW or 4.86 feet NAVD88. When major flooding is expected, storm gates would be closed at low tide, in order to keep the rising tide levels from taking storage needed for the associated rainfall. For the vehicular, pedestrian, and railroad gate closings, timing of the closure would be dependent on evacuation needs and anticipated arrival of rising water levels. Gate operation procedures will be refined throughout the study and design 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.

- **Recreation Features:** Sections of the new wall would be fitted with walkways and railings to provide additional recreation opportunities in the study area. Where possible, the TSP will be modified to adhere to the visual aesthetic of the city, however those additional costs will be the responsibility of the non-Federal sponsor.

- **Interior Drainage Facilities:** This alternative would include interior drainage facilities, such as permanent and temporary pump stations, to the extent they are justified per USACE policy.

- **Wave attenuation structure offshore of the Battery:** A wave attenuation structure would be constructed in Charleston Harbor. The purpose of the structure is to reduce loading on the Battery Wall and reduce the effect of waves overtopping during storm events. The structure would be aligned to be parallel with the shoreline, to avoid encroachment into federal channels in the Charleston Harbor and Ashley River.

- **Nonstructural measures:** In areas where structures would continue to incur damages from storm surge after the wall has been constructed, nonstructural measures such as relocations, buyouts, elevations, and floodproofing could be applied.

8.2 Performance of the Tentatively Selected Plan

Performance of the TSP is assessed using stillwater elevations, which are different than FEMA base flood elevations. Stillwater elevations include storm surge, astronomical tides, and wave setup, but not wave run-up. Note that each probability and water level referenced in this section reflects stillwater elevations. As it is currently conceptualized, the 12ft NAVD88 storm surge wall would provide an approximate 1.35% annual exceedance probability (AEP) (or 74-year) level of performance when first constructed. Assuming an intermediate sea level rise scenario, the 12ft NAVD88 storm surge wall would provide a 2% AEP (or 50-year) level of performance in the year 2075. The level of performance will be refined during feasibility level design and reported in the final FR/EA.

Figures 7-1 and 7-2 compare with and without-project conditions, using stillwater elevations as described above. Without a project to address storm surge inundation, assuming an intermediate rate of sea level rise, in the year 2075, 50% of police stations, 42% of health care facilities, and 29% of fire stations would be flooded to elevation 9 feet NAVD88 during a 4% AEP (25-year) storm event. Similarly, 54% of historic structures and 43% of archaeological sites would be flooded to elevation 9 feet NAVD88 as displayed in Figure 7-2. Under the with-project scenario, critical facilities and historic resources stay dry during the 4% AEP storm event.

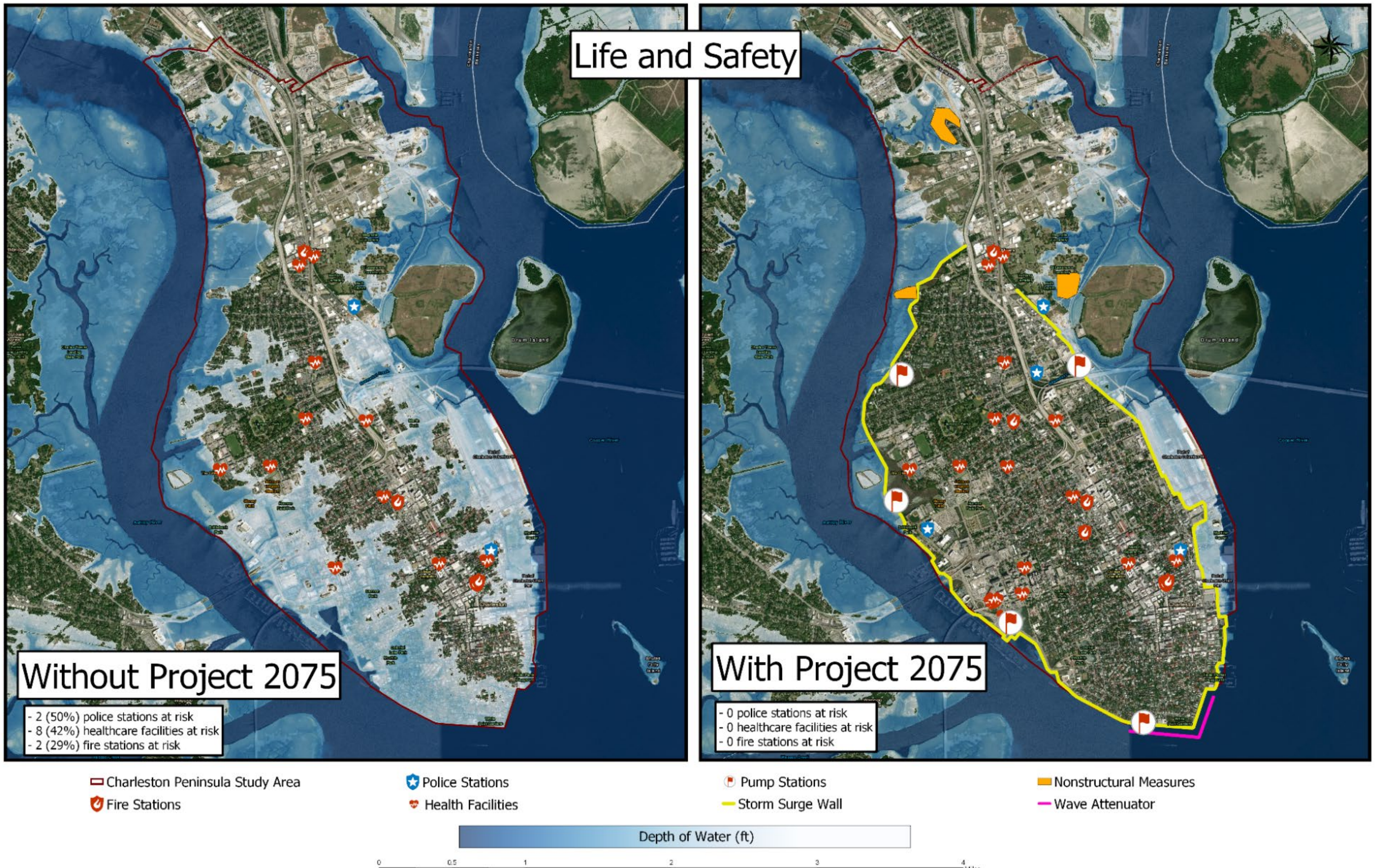

Figure 8-1. Inundation of critical facilities during 4% AEP storm event under the future without project scenario and the future with project scenario. All probabilities and water levels are based on stillwater elevations.
Official mapping product of the Management Support Branch, Charleston District, USACE

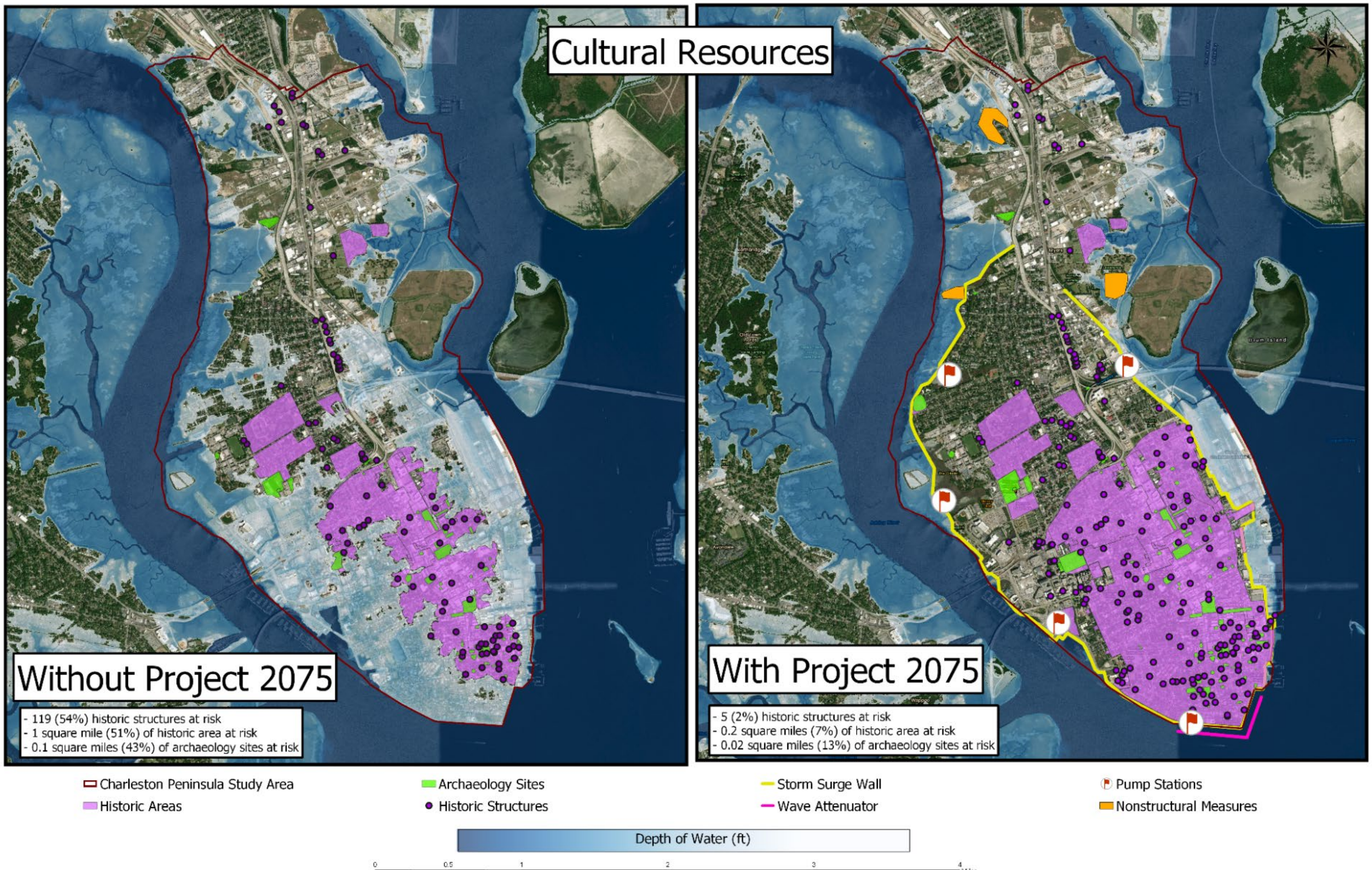

Figure 8-2. Inundation of critical resources during 4% AEP storm event under the future without project scenario and the future with project scenario. All probabilities and water levels are based on stillwater elevations.
Official mapping product of the Management Support Branch, Charleston District, USACE

8.3 Residual Risk

Residual risk is the risk of inundation in the study area after implementation of the recommended plan. The project performance of the TSP would be effective enough to reduce about 42% of the flood damages modeled in the Charleston Peninsula with only about 58% of potential flood damages remaining.

8.4 Plan Economics and Cost Sharing

The project first cost, estimated on the basis of October 2020 price levels amounts to $1,753,804,000. Table 7-2 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	$1,753,804
Interest During Construction	$260,929
Total Investment Cost	$2,014,733
Average Annual Cost[1]	
Average Annual First Cost	$74,627
Annual OMRR&R[2] Cost	$5,594
Average Annual Annualized Costs	$80,221
Benefits[1]	
Average Annualized Benefits	$174,639
Net Benefits	$94,417
BCR	2.2

[1]Costs are in October 2020 price levels, 2.75% 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 $1,753,804,000. The Federal portion of the estimated first cost is $1,139,972,600 based on WRDA 1986 cost share formulas. The non-Federal portion of the estimated first cost is $613,831,400. Table 7-3 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	$107,308	$107,308
02	Relocations[2]	$0	$22,218	$22,218
06	Fish & Wildlife	$149,201	$0	$149,201
10	Breakwater & Seawalls	$287,526	$0	$287,526
11	Levees & Floodwalls	$756,716	$0	$756,716
13	Pumping Plant	$167,098	$0	$167,098
14	Recreation Facilities	$85,562	$0	$85,562
18	Cultural Resource Compliance	$5,902	$0	$5,902
39	Buildings, Grounds & Utilities	$19,634	$0	$19,634
30	Planning, Engineering & Design	$76,319	$0	$76,319
31	Construction Management	$76,319	$0	$76,319
	Subtotal	**$1,624,277**	**$129,526**	**$1,753,804**
	Non-Fed Cash Contribution	-$484,305	$484,305	
	Total	**$1,139,972**	**$613,831**	**$1,753,804**
	Percentage	65%	35%	

[1]Costs are in October 2020 price levels, 2.75% 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/EA, the effects of the alternatives to the human environment have been considered and an evaluation of their anticipated significance has been done. A summary of the expected environmental effects of the three alternatives evaluated in this study can be found in Table 6-1. The TSP is expected to have temporary and permanent environmental effects, some that are beneficial and some that are adverse, but thoseeffects that remain after optimization of avoidance and minimization will be reduced by mitigation to a level of less than significant. Absent mitigation, potentially significant adverse impacts from the TSP are likely for wetlands and cultural resources. Consideration of ways to reduce the adverse effects to the environment are continuing through the feasibility study and through consultation with agencies. An initial assessment of actions that USACE and the City of Charleston can take to mitigate for significant adverse impacts to natural resources are described in the Draft Mitigation Plan (see Appendix F). Based on this assessment, a mitigated FONSI has been drafted and is included as an appendix to this draft report for review. As part of the mitigation process, USACE will execute a programmatic agreement for historic properties. This agreement document will be 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 will include Historic Charleston Foundation, Preservation Society of Charleston, the Catawba Indian Nation and the Naval History and Heritage Command. A copy of the agreement is included in Appendix D for review.

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. The Draft Real Estate Plan (REP) (Appendix E) projects the number of parcels that may require real estate acquisition, relocation, permanent and temporary easements for construction of the structural and nonstructural measures of the TSP. Real Estate Baseline and Rough Order of Magnitude costs has been prepared estimating 18 parcels to be acquired in fee, 118 easements, and 100 rights of entry for the construction of the TSP. In addition to the baseline cost estimate, the Final REP will also include 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 activities, and other issues as required.

Where possible, the PDT utilized publically owned land to minimize take of private property. If a property must be acquired for the project, the non-Federal sponsor will need to acquire all property rights and interest up to and including fee acquisitions. Most of the structural measures for the storm surge wall would require both perpetual maintenance easements and temporary construction easements. Some properties would be acquired in fee title due to the amount of land remaining after the taking (an uneconomic remnant), recreation features and access needs, and habitat mitigation sites, where navigational servitude is not sufficient.

8.7 Operations, Maintenance, Repair, Replacement, and Rehabilitation (OMRR&R)

The local 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 local sponsor will be notified, and their OMRR&R responsibilities will begin. USACE will provide an OMRR&R manual for the City of Charleston, the local 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 local 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 local sponsor should be prepared to carry out maintenance activities on all flood control structures every year. 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. Local 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. On occasion, the local sponsor may have to add stone to control an erosion problem. Pump stations also need to be completely overhauled periodically. Routine maintenance is expected in any project and can be planned for in advanced.

8.8 Executive Order (EO) 11988

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.

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. Alternative flood risk reduction measures were considered as discussed in Section 3.1, however the PDT determined that no other management measure would be effective in reducing risk from storm surge inundation.

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 the tentatively selected plan.

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 environmental impacts 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 any remaining potentially significant impacts.
- The PDT has coordinated with natural resource agencies to better understand environmental context and effects of the proposed project.
- Hosted a public information workshop to explain the planning process, 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.

8.10 Next Steps

This draft FR/EA has been released for public and agency review for 60 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/EA has also been submitted for Independent External Peer Review and Agency Technical Review. After completion of the public review period, comments will be considered and incorporated into the final FR/EA 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/EA will be provided to any public agency that provides comments on the draft FR/EA

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 next phase is Pre-Construction, Engineering, and Design (PED). 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.

8.10.1 Feasibility Level Design Tasks

The following is a list of tasks to be completed before the final version of this report is released and the selected plan is approved by the Chief of Engineers and recommended to Congress.

1. Optimize the elevation and alignment of the storm surge wall and wave attenuating structure.
2. Perform a wave overtopping analysis of the Battery wall.
3. Conduct a structure by structure analysis to refine nonstructural treatments and model benefits.
4. Define recreation features and model benefits.
5. Analyze potential for induced flooding on surrounding communities and design mitigation measures if needed.
6. Assess and incorporate public comments, independent external peer review comments and agency technical review comments.
7. Finalize the compensatory mitigation plan.

8.10.2 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. 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.
2. Field surveys for the identification and evaluation of cultural resources.
3. Avoid, minimize, or mitigate adverse effects to cultural resources.
4. 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.
5. 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.

6. 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.
7. 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.
8. 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.
9. 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 insure the pumps are adequately sized and strategically placed.
10. 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.
11. 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.
12. 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.
13. Gate closure procedure will be finalized during PED phase.

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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 Assessment, proceed with implementation in accordance with the cost sharing provisions set forth in this report.

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.

Rachel Honderd
Lieutenant Colonel, U.S. Army
Commanding

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FINDING OF NO SIGNIFICANT IMPACT

CHARLESTON PENINSULA COASTAL FLOOD RISK MANAGEMENT STUDY CHARLESTON, SOUTH CAROLINA

The U.S. Army Corps of Engineers, Charleston District (Corps) has conducted an environmental analysis in accordance with the National Environmental Policy Act of 1969, as amended. The Final Integrated Feasibility Report and Environmental Assessment (IFR/EA) dated **DATE OF FINAL REPORT**, for the Charleston Peninsula Coastal Flood Risk Management Study addresses coastal storm risk reduction opportunities and feasibility in the Charleston Peninsula, Charleston, South Carolina. The final recommendation is contained in the report of the Chief of Engineers, dated **DATE OF SIGNED CHIEF'S REPORT**.

The Final IFR/EA, incorporated herein by reference, evaluated various alternatives that would reduce risks to health, safety, and economic damages from coastal storm inundation in the study area. The recommended plan is the National Economic Development (NED) Plan and includes:

- **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. The wall would be approximately 7.8 miles in length with a top elevation of 12 feet NAVD88. It would be strategically aligned to minimize impacts to existing wetland habitat, cultural resources, and private property. The wall would be located on the landward side of all ports, marinas, and the Coast Guard Station to allow for continued operation. The wall would tie into high ground as appropriate, including 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 12 feet NAVD88.

  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. To withstand earthquakes, pilings for both wall types would be 50 to 70 feet deep to tie in to 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.

  The storm surge wall also includes multiple pedestrian, vehicle, railroad, boat, and storm (tidal flow) gates. Typically, the gates would remain open and only be closed when the National Weather Service predicts major flooding for the Charleston Peninsula. Major flooding is currently defined as a storm surge equal to or greater than 8 feet above MLLW or 4.86 feet NAVD88. When major flooding is expected, storm gates would be closed at low tide, in order to keep the rising tide levels from taking storage needed for the associated rainfall. For the vehicular, pedestrian, and railroad gate closings, timing of the closure would be dependent on evacuation needs and anticipated arrival of rising water levels.

Recreation features: Sections of the new wall would be fitted with walkways and railings to provide additional recreation opportunities in the study area. Where possible, the wall would be modified to adhere to the visual aesthetic of the city, however those additional costs will be the responsibility of the non-Federal sponsor.

Interior drainage facilities: This plan will include interior drainage facilities, such as permanent and temporary pump stations, to the extent they are justified per USACE policy.

Wave attenuation structure offshore of the Battery: A wave attenuation structure would be constructed in Charleston Harbor to reduce loading on the Battery Wall and reduce the effect of waves overtopping during storm events. The structure would be approximately 4,000 feet long with the top crest at elevation of 16.2 feet NAVD88. The landward toe of the structure would be 230 feet from the shoreline and aligned to avoid encroachment into federal channels in the Charleston Harbor and Ashley River.

Nonstructural measures: In areas where structures would continue to incur damages from storm surge after the wall has been constructed, nonstructural measures such as relocations, buyouts, elevations, and floodproofing could be applied to approximately 100 residential structures.

- **Mitigation:** Implementation of any required environmental compensatory mitigation and associated monitoring and mitigation area adaptive management plan, when applicable and appropriate. Monitoring will continue until any required mitigation has been determined to be successful based on the identified criteria within the Mitigation Plan included in Appendix F. Monitoring is expected to last no more than 10 years.

In addition to a “no action” plan, two alternatives were evaluated. The alternatives included a storm surge wall with storm gates plus nonstructural measures for residential structures outside of the storm surge wall, and a similar alternative with the same storm surge wall and nonstructural measures, with the addition of a wave attenuator. These alternatives, including the no action alternative were evaluated and compared, and alternative 3 with the storm surge wall, nonstructural measures, and wave attenuator was selected. These are discussed in Chapter 3 – Conceptual Measures and Alternatives, of the IFR/EA.

SUMMARY OF POTENTIAL EFFECTS:

For all alternatives, the potential effects were evaluated, as appropriate. A summary assessment of the potential effects of the recommended plan are listed in Table 1:

Table 1: Summary of Potential Effects of the Recommended Plan

	Insignificant effects	Insignificant effects as a result of mitigation*	Resource unaffected by action
Air quality	☒	☐	☐
Wetlands	☐	☒	☐
Aquatic resources	☒	☐	☐
Benthic resources	☒	☐	☐
Terrestrial wildlife and upland vegetation	☒	☐	☐
Threatened/Endangered species/critical habitat	☒	☐	☐
Historic properties	☐	☒	☐
Other cultural resources	☒	☐	☐
Visuals and aesthetics	☒	☐	☐
Utilities	☒	☐	☐
Hazardous and toxic waste	☒	☐	☐
Coastal hydraulics	☒	☐	☐
Land use	☒	☐	☐
Transportation	☒	☐	☐
Noise levels	☒	☐	☐
Recreation	☒	☐	☐
Environmental justice	☒	☐	☐
Geology and soils	☒	☐	☐
Water quality	☒	☐	☐
Climate change	☒	☐	☐

All practicable and appropriate means to avoid or minimize adverse environmental effects were analyzed and incorporated into the recommended plan. Best management practices (BMPs) as detailed in the IFR/EA will be implemented, if appropriate, to minimize impacts. These include best practices used in construction that reduce noise, traffic, water quality, and other impacts. Impacts have also been avoided and minimized through size, placement, and design considerations of the structural measures, for example siting the storm surge wall in public right of ways where feasible. Reef-based living shoreline are planned to reduce scouring and other effects that may result from the storm surge wall. These and other mitigation measures are described in the Mitigation Plan in Appendix F of the IFR/EA. Appropriate steps are being taken to reduce impacts to cultural and historic resources as outlined in the Programmatic Agreement in Appendix D of the IFR/EA.

COMPENSATORY MITIGATION:

COMPENSATORY MITIGATION REQUIRED:

The recommended plan will result in unavoidable adverse impacts to an estimated maximum of 111 acres of estuarine emergent wetlands *(*direct impacts are estimated at 26 acres, and indirect at 85 acres - *acreage to be updated for Final FONSI)* and to historic resources. To mitigate for these unavoidable adverse impacts, the U.S. Army Corps of Engineers will is providing compensatory wetland mitigation for wetland functions lost as a result of the storm surge wall to ensure no net loss. This requirement will be satisfied by either purchasing wetland mitigation credits from a wetland mitigation bank or by conducting permittee-responsible mitigation involving estuarine emergent wetland restoration (*selected wetland mitigation alternative will be updated in Final FONSI*). Compensatory wetland mitigation is described in the Mitigation Plan in Appendix F of the IFR/EA.

Because the USACE cannot fully determine how the project may affect historic properties prior to finalization of this feasibility study, a Programmatic Agreement (PA) has been signed to ensure compliance with Section 106 of the National Historic Preservation Act of 1966 (NHPA). Specifically, the scope and diversity of potential effects of the recommended plan and constraints of the USACE planning policy made a PA for compliance with Section 106 essential. The PA allows the USACE to complete the necessary archaeological surveys during the follow on Preconstruction Engineer and Design (PED) phase of the project, and it also allows any additional architectural inventories and mitigation to be completed after structural and non-structural measures have been clearly defined and sited. The PA streamlines Section 106 reviews given the potential to affect a high number of historic properties. Therefore, pursuant to 54 U.S.C. 306108, 36 CFR 800.4(b)(2), and 36 CFR 800.14(b)(1)(ii), the Corps defers final identification and evaluation of historic properties until after project approval, additional funding becomes available, and prior to construction by executing a PA. The PA is included in Appendix D of this IFR/EA and has been (*prior to signature*) reviewed by signatories (South Carolina SHPO, National Park Service, Advisory Council on Historic Preservation, City of Charleston) and concurring parties (Historic Charleston Foundation, Preservation Society of Charleston, and Catawba Indian Nation).

PUBLIC REVIEW:

Public review of the draft IFR/EA and FONSI was completed on **DATE COMMENT PERIOD ENDS**. All comments submitted during the public review period were responded to in the Final IFR/EA and FONSI. A 30-day state and agency review of the Final IFR/EA was completed on **DATE REVIEW PERIOD ENDS**. Comments from state and federal agency review did not result in any changes to the final IFR/EA *(to be update for Final FONSI)*.

OTHER ENVIRONMENTAL AND CULTURAL COMPLIANCE REQUIREMENTS:

ENDANGERED SPECIES ACT

INFORMAL CONSULATION:

Pursuant to section 7 of the Endangered Species Act of 1973, as amended, the U.S. Army Corps of Engineers determined that the recommended plan may affect but is not likely to adversely affect the following federally listed species or their designated critical habitat: shortnose sturgeon (*Acipenser brevirostrum*), Atlantic sturgeon (*Acipenser oxyrhynchus*), Kemp's ridley sea turtle (*Lepidochelys kempii*), leatherback sea turtle (*Dermochelys coriacea*), loggerhead sea turtle (*Coretta caretta*) and green sea turtle (*Chelonia mydas*). The National Marine Fisheries Service (NMFS) concurred with the Corps' determination on **DATE OF CONCURRENCE LETTER**

Pursuant to section 7 of the Endangered Species Act of 1973, as amended, the U.S. Army Corps of Engineers determined that the recommended plan may affect but is not likely to adversely affect the following federally listed species or their designated critical habitat: West Indian manatee (*Trichechus manatus)*. The U.S. Fish and Wildlife Service (FWS) concurred with the Corps' determination on **DATE OF CONCURRENCE LETTER**

NATIONAL HISTORIC PRESERVATION ACT

HISTORIC PROPERTIES ADVERSELY AFFECTED:

Pursuant to section 106 of the National Historic Preservation Act of 1966, as amended, the U.S. Army Corps of Engineers determined that historic properties may be adversely affected by the recommended plan. The Corps, South Carolina SHPO, National Park Service, City of Charleston and the Advisory Council on Historic Preservation entered into a Programmatic Agreement, dated **DATE OF AGREEMENT.** All terms and conditions resulting from the agreement shall be implemented in order to minimize adverse impacts to historic properties. The PA is found in Appendix D of the IFR/EA.

CLEAN WATER ACT SECTION 404(B)(1) COMPLIANCE

Pursuant to the Clean Water Act of 1972, as amended, the discharge of dredged or fill material associated with the recommended plan has been found to be compliant with section 404(b)(1) Guidelines (40 CFR 230). The Clean Water Act Section 404(b)(1) Guidelines evaluation is found in Appendix F of the IFR/EA.

CLEAN WATER ACT SECTION 401 COMPLIANCE

401 WQC OBTAINED:
A water quality certification pursuant to section 401 of the Clean Water Act was obtained from the South Carolina Department of Health and Environmental Control. All conditions of the water quality certification shall be implemented in order to minimize adverse impacts to water quality.

COASTAL ZONE MANAGEMENT ACT

CZMA CONSISTENCY ISSUED:
A determination of consistency with the South Carolina Coastal Zone Management program pursuant to the Coastal Zone Management Act of 1972 was obtained from the South Carolina Department of Health and Environmental Control, Office of Coastal Resource Management. All conditions of the consistency determination shall be implemented in order to minimize adverse impacts to the coastal zone.

OTHER SIGNIFICANT ENVIRONMENTAL COMPLIANCE:

All applicable environmental laws have been considered and coordination with appropriate agencies and officials has been completed. Pursuant to the Magnuson-Stevens Fishery Conservation and Management Act of 1994, the USACE determined that Essential Fish Habitat is adversely affected by the recommended plan as a result of the impacts to estuarine emergent wetlands. The impacted estuarine emergent wetlands will be mitigated with compensatory mitigation as described above. The National Marine Fisheries Service's habitat conservation recommendations are in Appendix F of the IFR/EA.

FINDING

Technical, environmental, and economic criteria used in the formulation of alternative plans were those specified in the Water Resources Council's 1983 Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies. All applicable laws, executive orders, regulations, and local government plans were considered in evaluation of alternatives. Based on this report, the reviews by other Federal, State and local agencies, Tribes, input of the public, and the review by my staff, it is my determination that the recommended plan would not cause significant adverse effects on the quality of the human environment; therefore, preparation of an Environmental Impact Statement is not required.

Date	Rachel A. Honderd, PMP Lt Cornel, Corps of Engineers District Commander

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