CHARLESTON HARBOR POST 45

Charleston, South Carolina

Final Integrated Feasibility Report and Environmental Impact Statement

June 2015

Prepared by the U.S. Army Corps of Engineers, Charleston District

U.S. ARMY CORPS OF ENGINEERS
NAVIGATION MISSION

Provide safe, reliable, efficient, and environmentally sustainable waterborne transportation systems for movement of commerce, national security, and recreation.

U.S. ARMY CORPS OF ENGINEERS
ENVIRONMENTAL OPERATING PRINCIPLES

Foster sustainability as a way of life throughout the organization.

Proactively consider environmental consequences of all US Army Corps of Engineers (USACE) activities and act accordingly.

Create mutually supporting economic and environmentally sustainable solutions.

Continue to meet our corporate responsibility and accountability under the law for activities undertaken by the USACE, which may impact human and natural environment.

Consider the environment in employing a risk management and systems approach throughout life cycles of projects and programs.

Leverage scientific, economic, and social knowledge to understand the environmental context and effects of USACE actions in a collaborative manner.

Employ an open, transparent process that respects views of individuals and groups interested in USACE activities.

FOR INFORMATION CONTACT: Mr. Mark Messersmith, U.S. Army Corps of Engineers, Charleston District, 69A Hagood Avenue, Charleston, SC 29403, 843-329-8162, or email: Chas-Post45-Comments@usace.army.mil

CHARLESTON HARBOR POST 45 June 2015

FINAL INTEGRATED FEASIBILITY REPORT AND ENVIRONMENTAL IMPACT STATEMENT

RESPONSIBLE AGENCIES: The lead agency for the navigation study is the U.S. Army Corps of Engineers (USACE), Charleston District. The South Carolina State Ports Authority (SCSPA) is the non-Federal sponsor.

ABSTRACT: Charleston Harbor is located in a natural tidal estuary, formed by the confluence of the Cooper, Ashley, and Wando rivers. The study area encompasses the offshore entrance channel, offshore and landside confined dredged material disposal sites, inner harbor channels, and any extension of the water bodies and shorelines that could be impacted by proposed improvements. Alternative plans combined multiple structural and nonstructural measures to improve the safety and efficiency of the existing navigation system. Navigation concerns include three main types of problems: insufficient Federal channel depths, difficult currents, and restrictive channel widths and turning basins.

The Recommended Plan (RP) is a Locally Preferred Plan (LPP). It proposes the following navigation improvements:

- Deepen the existing entrance channel from a project depth of -47 feet to -54 feet mean lower low water (MLLW) over the existing 800-foot bottom width, while reducing the existing stepped 1,000-foot width to 944 feet from an existing depth of -42 feet to a depth of -49 feet.
- Extend the entrance channel approximately three miles seaward from the existing location to a depth contour including a -54-foot MLLW project depth plus overdepths.
- Deepen the inner harbor from an existing project depth of -45 feet to -52 feet MLLW to the Wando Welch container facility on the Wando River and the new Navy Base Terminal on the Cooper River, and -48 feet MLLW for the reaches above that facility to the North Charleston container facility (over expanded bottom widths from 400 to 1,800 feet).
- Enlarge the existing turning basins to an 1800-foot diameter at the Wando Welch and new SCSPA terminals to accommodate Post Panamax Generation 2 and 3 container ships and widen selected reaches as shown in the Executive Summary: Reference Aid at the end of this section .
- Enlarge the North Charleston Terminal turning basin to a 1650-foot diameter for Post Panamax Generation 2 container ships.
- Place dredged material and raise dikes at the existing upland confined disposal facilities at Clouter Creek, Yellow House Creek, and/or Daniel Island; and for material dredged from the lower harbor, place at the Ocean Dredged Material Disposal Site (ODMDS) and expand. Place rock to create hardbottom habitat near the entrance channel as a least cost beneficial use of dredged material.

The RP is economically justified. It would indirectly impact about 324 acres of wetlands through changes in salinity, which would require mitigation in the form of preservation of up to 665.6 acres of wetlands. Approximately 29 acres of direct impacts to hardbottom areas within the footprint of the entrance channel require mitigation through creation of approximately 30 acres of hardbottom habitat. Construction of the RP would cause temporary increases in turbidity; however, these levels would not exceed permitted variance levels outside the mixing zone. Impacts to fish species may occur due to loss of habitat from potential salinity changes associated with deepening.

CHARLESTON HARBOR POST 45, CHARLESTON, SOUTH CAROLINA

FINAL INTEGRATED FEASIBILITY REPORT AND ENVIRONMENTAL IMPACT STATEMENT

EXECUTIVE SUMMARY

The results of engineering, economic, environmental, and real estate investigations performed for this Feasibility Study (FS) are being used to determine if the Federal government should participate in submitting a report seeking authorization of potential navigation system improvements at Charleston Harbor, South Carolina. The South Carolina State Ports Authority (SCSPA) requested the study under Section 216 of the Flood Control Act of 1970 (Public Law 91-611), which authorizes the review of completed projects in the interest of navigation and related purposes to determine the feasibility of further port deepening.

DESCRIPTION OF REPORT

This Final Integrated Feasibility Report and Environmental Impact Statement (IFR/EIS) documents the FS process and presents the results of investigations and analyses conducted to evaluate modifications to the existing Federal navigation system to improve its ability to efficiently serve the current and future vessel fleet and process the forecasted cargo volumes. It presents: (1) a survey of existing and future conditions; (2) an evaluation of related problems and opportunities; (3) development of potential alternatives; (4) a comparison of costs, benefits, adverse impacts, and feasibility of those alternatives; and (5) identification of a National Economic Development (NED) Plan and Recommended Plan (RP).

PURPOSE AND NEED

The cargo transportation industry continues its shift to increased use of standardized containers used for multimodal (marine, rail, and truck) freight transportation systems. Additionally, the marine vessel fleet is trending to larger, deeper-draft vessels, particularly for containerships. The Federal channels serving Charleston Harbor's major terminals are currently authorized to a depth of -45 feet mean lower low water (MLLW). The existing dimensions of those channels place constraints on deeper-drafting containerships, which result in reduced efficiency and increased costs.

Specific problems warranting Federal consideration include navigation and safety considerations, engineering challenges, and concerns of those who live and work along or around the Federal navigation project. Navigation and safety considerations include three main problems: insufficient Federal channel depths, difficult currents, and restrictive channel widths and turning basins. Larger ships currently experience transportation delays due to insufficient Federal channel depths. To reach port terminals, these larger ships must either light load, experience delays while waiting for favorable tide conditions, or both. These approaches require the vessel operator to forego potential transportation cost savings available from the economies of scale associated with larger ships. Strong and unpredictable ebb tide crosscurrents at the confluence of the Wando and Cooper rivers make turns difficult in the channel reaches immediately north of the Ravenel Bridge. Restrictive channel widths also limit ship passage to one-way traffic in many reaches and larger container ships require expanded turning basins.

ALTERNATIVES AND RECOMMENDED PLAN

Alternative plans combining multiple structural and nonstructural measures to improve the safety and efficiency of the navigation system were considered. The Reference Aid at the end of this summary provides key information and illustrates the general locations of the most important project features.

To determine whether the Federal government should participate in implementing navigation improvements, the expected returns to the national economy (NED benefits) are calculated. NED benefits are generated by addressing inefficiencies in the existing transportation system to lower transportation costs. Net benefits are calculated by subtracting the total cost to construct and maintain the improvements over a 50-year study period from the total transportation cost savings that would be generated by the proposed improvements over that period. The NED Plan is the alternative that reasonably maximizes net NED benefits while remaining consistent with the Federal objective of protecting the nation's environment. Where two cost-effective plans produce similar net benefits, the less costly plan is identified as the NED plan, even though the level of outputs may be less. The NED Plan is normally recommended for implementation. However, if the non-Federal sponsor prefers a more costly plan and is willing to pay the additional costs, a Locally Preferred Plan (LPP) can be recommended if the outputs are similar in kind, and equal to or greater than the outputs of the NED Plan.

In this study, two cost-effective alternatives were developed that generated comparable net benefits. After careful consideration, the USACE identified the less costly alternative as the NED Plan. The RP, presented as the proposed plan is an LPP. It is more costly than the NED plan but generates more net benefits. It would deepen the inner harbor channels leading to the Wando Welch container facility and the new Navy Base Terminal from the existing -45 feet MLLW to -52 feet MLLW, and the channel from the new Navy Base Terminal to the North Charleston container facility from -45 feet MLLW to -48 feet MLLW. The entrance channel would be deepened from -47 feet MLLW to -54 feet MLLW. The NED Plan would deepen all the same segments 2 feet less than the RP, except for the reach between the New Navy Base Terminal to the North Charleston container facility which would be deepened from -45 feet MLLW to -48 feet MLLW. Along with the deepening, widening measures would be applied to accommodate the needs of the future containership fleet that is expected to serve Charleston Harbor. The Reference Aid at the end of this summary compares the existing channel dimensions with the proposed improvements, summarizes the economic benefits and costs associated with the RP and the tentatively identified NED Plan and illustrates the general locations of the proposed improvements.

COSTS AND BENEFITS

The USACE employed the traditional providers of traffic and fleet projections to study the Charleston Harbor project. Based on existing and projected future vessel traffic, vessel fleet mix, trade route allocations, and liner services currently associated with the Port of Charleston, two design vessels were selected. The vessel mix was allocated over time to provide benefit calculations using the HarborSym economic analysis model. The characteristics of the design vessels were used to develop channel dimension and alignment needs. Further refinement of the dimensions and alignment is expected through application of ship simulations prior to developing final designs. The dimensions of the two design vessels are described as follows: (1) a 1,100-foot length, approximately a 141-foot beam, and a 48-foot draft; and (2) a 1,200-foot length, 158-foot beam, and a 50-foot draft. These dimensions correspond with the range of vessels comprising Post Panamax Generation 2 and Generation 3 containership classes.

The projected growth of containerized traffic allocated primarily between the time-modified mix of the two design vessels (without inducing traffic from other ports) has provided average annual net benefits of $80.9 million for the RP and $77.4 million for the NED Plan. While the benefit to cost ratio (BCR) of some shallower alternatives are higher, the RP maximized net benefits and maintained a robust BCR of 3.89. The estimated project costs are $520.9 million and economic investment costs are estimated to be $580.6 million. The entire project is economically justified. Table 1 provides a summary of the Federal and non-Federal costs and Table 2 provides the annualized benefits and costs for the RP. The benefits, almost exclusively attributable to container traffic, are achieved by transportation savings through the use of larger ships to transport the projected cargo volumes.

ENVIRONMENTAL IMPACTS AND MITIGATION

Public and Agency concerns were expressed throughout the study about the effects of the study alternatives on salinity and associated ecological changes to wetlands and fish habitat; water, air and sediment quality; shoreline erosion; cultural resources; and hardbottom habitat; among others. Numerical models and other analytical tools were used to predict and quantify the potential project related effects.

The RP would indirectly impact about 324 acres of wetlands through increases in salinity, which would require mitigation in the form of preservation of about 665.6 acres of wetlands. The USACE has determined that preservation of land within the Francis Marion National Forest best meets the compensatory mitigation requirements. The proposed preservation of ecologically significant parcels would provide important physical, chemical and biological functions for the Cooper River Basin and would contribute to the sustainability of the watershed by ensuring the functions of bottomland hardwood and emergent wetlands on these properties are sustained in perpetuity. The preservation parcels would also enhance lands already within the Francis Marion National Forest by functioning as a buffer to future development.

About 30 acres of hardbottom habitat would be created using dredged material to compensate for direct impacts to about 29 acres of hardbottom habitat currently occurring within the channel and the indirect impacts to hardbottom habitats near the channel. The new hardbottom habitat would consist of two mitigation reefs (1 required, 1 additional) and six (totaling eight) similar new 33-acre reefs that will be constructed as a beneficial use of dredged material. Prior to construction, the locations of these reefs would be refined and coordinated with resource agencies. At the request of the SCDNR Artificial Reef Program, rock material will also be deposited at the 25-acre Charleston Nearshore Reef site as a beneficial use of dredged material. All proposed rock placement is part of the least cost disposal plan because all of the reef placement sites are closer to the dredging site than the alternative Ocean Dredged Material Disposal Site.

TABLE 1 – FEDERAL AND NON-FEDERAL COSTS

FEDERAL/NON-FEDERAL COST APPORTIONMENT – Recommended Plan (Cost at 1 Oct 2014 Price Levels as of 13 Apr 2015 – Benefits Provided 15 Apr 2015) Maximum Widening & Turning Basin Expansion Measures with 800-foot Entrance Channel with Wings			
COST SHARING FOR > 45 FEET			
CONSTRUCTION ITEM/GENERAL NAVIGATION FEATURES (GNF)	**PROJECT COST** Recommended Plan (RP)	**FEDERAL** based on NED cost	**NON-FED GNF Difference** RP minus NED
Dredging --			
Mobilization and & Demobilization (included in segment costs)			
Entrance Channel to Wando (Segment 1)	$390,720,000	$174,930,000	$215,790,000
Drum Island to Daniel Island Reach (Segment 2)	$23,630,000	$10,685,000	$12,945,000
Daniel Island Bend to North Charleston Terminal (Segment 3)	$30,690,000	$15,345,000	$15,345,000
Disposal Area Dike Improvements	$16,780,000	$8,390,000	$8,390,000
Environmental Monitoring-9 Yrs (cultural hist. shoreline erosion)	$5,310,000	$2,655,000	$2,655,000
Environmental Monitoring-9 Yrs (wetlands/hardbottom)	$10,620,000	$5,310,000	$5,310,000
Real Estate, Admin (costs associated with mitigation)	$37,500	$18,750	$18,750
Real Estate Land Payments NFS - 665.6 Acres Wetland Mitigation	$2,995,000	$1,070,000	$1,925,000
Preconstruction, Engineering, Design, & Planning	$5,600,000	$2,800,000	$2,800,000
Construction Management (S&I)	$6,930,000	$3,140,000	$3,790,000
TOTAL GNF	**$493,313,000**	**$224,344,000**	**$268,969,000**
SUBTOTAL – PROJECT FIRST COSTS (rounded)	**$493,300,000**	**$224,300,000**	**$269,000,000**
ADDITIONAL 10% OF (NED) GNF	**$0**	-$44,870,000	$44,870,000
NON-FEDERAL SPONSOR'S PAYMENT OVER 30 YEARS	**$0**	-$44,870,000	**$44,870,000**
NON-FEDERAL LOCAL SERVICE FACILITIES (100% NON-FED)			
Berthing Area Dredging (Wando, New Navy Base, NC Terminals)	$4,970,000	$0	$4,970,000
Port Bulkhead Construction (Wando Terminal)	$22,000,000	$0	$22,000,000
TOTAL NON-FEDERAL LOCAL SERVICE FACILITIES	**$26,970,000**	**$0**	**$26,970,000**
USCG AIDS TO NAVIGATION (100% FEDERAL)	**$620,000**	**$620,000**	$0
PROJECT COSTS 52/48 Plan (rounded)	**521,000,000**	**180,000,000**	**341,000,000**

TABLE 2 – COSTS AND BENEFITS

PROJECT COSTS	$
PROJECT COSTS	$521,000,000
INTEREST DURING CONSTRUCTION	$59,800,000
ECONOMIC INVESTMENT	$580,800,000
Average Annual Equivalent (AAEQ) COSTS	
Economic Investment	$24,200,000
Increased O&M Dredging	$3,740,000
Increased O&M for Navigation Aids	$50,000
TOTAL AAEQ COSTS	$28,000,000
BENEFITS (TRANSPORTATION COST SAVINGS)	
Origin to Destination Deepening	$105,300,000
Channel Widening and Tidal Delay	$3,600,000
TOTAL AAEQ BENEFITS	$108,900,000
AAEQ NET BENEFITS	$80,900,000
BENEFIT TO COST RATIO (at Federal Discount Rate FY14 of 3.375 %)	**3.89**

Construction of the RP would cause temporary and minor adverse impacts to water quality in the areas near dredging activities. The predicted magnitude of project-induced dissolved oxygen reductions are small and would not significantly impact aquatic organisms or require mitigation to comply with state water quality standards. The USACE, Charleston District is committed to monitoring the impacts of the project and ensuring that they are similar to those predicted during the study.

The RP would have no significant effect on any threatened and endangered species. Construction impacts would likely have temporary adverse affects on sea turtles and sturgeon species. However, no long term impacts of the RP would be expected for most threatened and endangered species and it would not likely adversely affect the Atlantic and shortnose sturgeon.

Geophysical, bathymetric and diver investigations of three potential cultural resource targets revealed no culturally significant objects within the project footprint. Dredging in one channel reach in the lower harbor will be monitored by an archaeologist due to one anomaly nearby the channel.

AREAS OF CONTROVERSY AND UNRESOLVED ISSUES

Areas of Controversy: A number of issues were raised by agencies and the public, including salinity-related impacts to wetlands, the associated mitigation and monitoring, impacts to hardbottom habitat, and water quality, and potential impacts to threatened and endangered species.

Issues to be Resolved: The USACE, Charleston District will continue to coordinate the proposed action and the associated impacts identified above as well as any new issues that are identified during the review period with the USACE, South Atlantic Division and Headquarters, as well as the local sponsor, state and Federal agencies, stakeholders, and concerned public. Several Preconstruction Engineering and Design (PED) phase commitments require additional coordination with resource agencies. They include:

- An analysis of potential beneficial use of dredged material projects in addition to the 8 hardbottom habitat reefs currently proposed
- A ship simulation analysis to determine areas where widening measures could be eliminated or reduced, where practicable
- Monitoring efforts, modeling and analyisis before during and after construction to validate the assumptions used in the analysis and verify that no unanticipated changes to wave, current, and sediment transport dynamics, or shoreline erosion resulted from the project
- A detailed evaluation of wetland mitigation using the Uniform Mitigation Assessment Method on the selected parcel proposed for mitigation based on the final project after all widening measures are defined
- An analysis of the benefits of constructing 2-3 new contraction dikes to reduce future maintenance dredging.

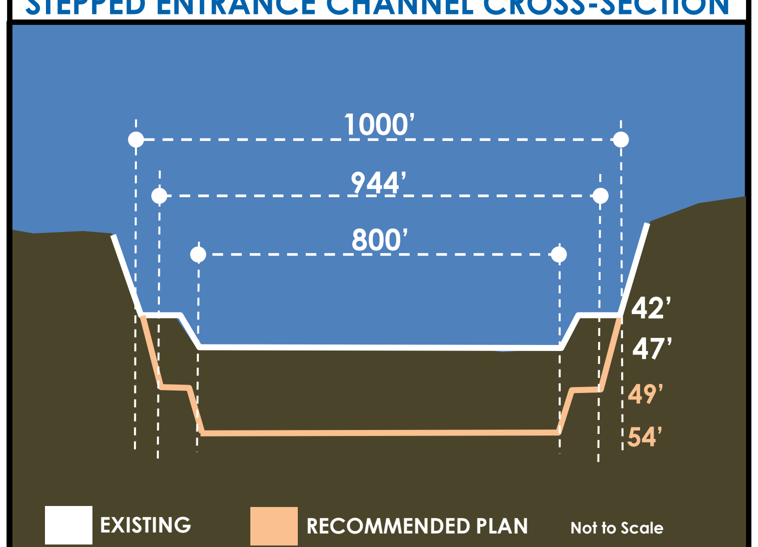
AREAS OF RESIDUAL RISK

The unresolved issues described above present minimal residual risks. The conservative assumptions used to replace data collection efforts during the study make it more likely that costs and impacts will be lower than those presented in the IFR/EIS. Any additional beneficial uses of dredged material would be implemented at the option of the USACE and the cost difference would likely be paid by the the entity requesting the use of the material. Ship simulation is more likely to present opportunities to reduce widening measures than increase them. Decreasing the size of one or more widening measures could significantly reduce both costs and the adverse environmental impacts and associated mitigation requirements. There is general agreement related to the project's overall lack of adverse impacts to waves, currents and erosion in Charleston Harbror. However, it is difficult to accurately predict effects at specific locations with a high degree of confidence. Based on this uncertainty and the presence of several significant natural and historic resource, the USACE agreed to monitor for unanticipated adverse impacts to significant natural and historical resources in Charleston Harbor. Monitoring could detect unanticipated adverse impacts but the likelihood is considered low.

REFERENCE TABLE 1: CHARLESTON HARBOR EXISTING COMPARED TO RECOMMENDED PLAN SEGMENT DIMENSIONS

REACH OR SEGMENT	NOMINAL DEPTH		NOMINAL CHANNEL WIDTH		RECOMMENDED PLAN
	MAINTENANCE	AUTHORIZED	MAINTENANCE	AUTHORIZED	
Entrance Channel	47/42	47/42	42' at 1000'	42' at 1000'	49' at 944' width
Entrance Channel	47/42	47/42	47' at 800'	47' at 800'	54' at 800' width
ENTRANCE CHANNEL TO WANDO WELCH TERMINAL (LOWER HARBOR)					
Mount Pleasant Range	45	45	600-1000	600-1000	52 at 600-1000
Rebellion Reach	45	45	600	600	52 at 600-700
Bennis Reach	45	45	600	600	52 at 700
Horse Reach	45	45	600	600	52 at 700
Hog Island Reach	45	45	600	600	52 at 700
Wando Channel Lower Reach	45	45	400	400	52 at 500
Wando Turning Basin (TB)	45	45	1400	1400	52 with 1800 TB
DRUM ISLAND TO NORTH CHARLESTON TERMINAL (UPPER HARBOR)					
Drum Island Reach	45	45	600	600	52 at 700-800
Myers Bend	45	45	VARIES	VARIES	52 at VARIOUS
Daniel Island Reach	45	45	880	880	52@880 &1800' TB
Daniel Island Bend	45	45	700-880	700-880	48 at 700-880
Clouter Creek Reach	45	45	600	600	48 at 600-650
Navy Yard Reach	45	45	600-675	600-675	48 at 600-675
North Charleston Reach	45	45	500	500	48 at 550
Filbin Creek Reach	45	45	500	500	48 at 550
Port Terminal Reach	45	45	600	600	48 at 600
Ordnance Reach	45	45	1400	1400	48 at 1650
UNION PIER TO WEST OF DRUM ISLAND					
Custom House Reach	45	45	Varies	Varies	45
Upper Town Creek	16	16	250	250	16
Lower Town Creek	45	45	450	450	45
Town Creek Turning Basin	35	35	300	300	35
Tidewater Reach	40	40	650	650	40
OTHER FEDERAL CHANNELS					
Anchorage Basin	35	35	2250	2250	35
Shem Creek Channel	12	12	110	110	12
SHIPYARD RIVER					
Entrance Channel	45	45	300	300	45
Basin A	45	45	700	700	45
Connector Channel	45	45	200	200	45
Basin B	30	30	600	600	30

STEPPED ENTRANCE CHANNEL CROSS-SECTION



ITEM	NED (50/48)	LPP (52/48)	DIFFERENCE (LPP – NED)
Project Cost	$476,000,000	$520,900,000	+$44,900,000
Average Annual Costs	$25,700,000	$28,000,000	+$2,300,000
Average Annual Benefits	$103,100,000	$108,900,000	+$5,800,000
Net Benefits	**$77,400,000**	**$80,900,000**	**+3,500,000**
Benefit Cost Ratio	4.01	3.89	-0.12

CHARLESTON HARBOR POST 45

FINAL FEASIBILITY REPORT/ENVIRONMENTAL IMPACT STATEMENT

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EXECUTIVE SUMMARY

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LIST OF ACRONYMS AND ABBREVIATIONS

AAEQ	average annual equivalent
ACS	American Community Survey
ACP	Panama Canal Authority
AIS	Automatic Identification System
AIWW	Atlantic Intracoastal Waterway
APE	area of potential effect
ASA (CW)	Assistant Secretary to the Army (Civil Works)
ASMFC	Atlantic States Marine Fisheries Commission
BATES	biological assessment of threatened & endangered species
BCDCOG	Berkeley-Charleston-Dorchester Council of Governments
BCR	benefit-cost ratio
BOD	biochemical oxygen demand
CA	Central America
CAA	Clean Air Act
CAR	Caribbean Basin
CBRA	Coastal Barrier Resources Act
CCU	Coastal Carolina University
CDF	confined disposal facilities
CECW	Corps of Engineers Civil Works
CEDA	Central Dredging Association
CEICA	cost effective incremental cost analysis
CEQ	Council of Environmental Quality
CERCLA	Comprehensive Environmental Response, Compensation & Liability Act
CFR	Code of Federal Regulations
cfs	cubic feet per second
CHE	cargo handling equipment
CLT	container loading tool
CMTTP	Cooperative Marine Turtle Tagging Program
CNC	Charleston Naval Complex
CNCMCT	Charleston Naval Complex Marine Container Terminal
CO_2	carbon dioxide
CPUE	catch per unit effort
CSRA	cost & schedule risk analysis
CST	Columbus Street Terminal
CTWA	Coastal Tidelands & Wetlands Act
CWA	Clean Water Act
CY	cubic yards
dB	decibels
dB re 1uPa @1m	decibels relative to 1 micropascal at 1 meter
DCA	Dial Cordy & Associates
DCA/GEC	Dial Cordy & Associates/Gulf Engineering Consultants
DEIS	draft environmental impact statement
DHEC	Department of Health & Environmental Control
DNR	Department of Natural Resources
DO	dissolved oxygen
DON	Department of the Navy
DPS	district population segment
DQM	dredging quality management
E	Endangered
EA	environmental assessment
EC	entrance channel
ECSA	East Coast of South America
ECUS	East Coast of the United States
EDR	Environmental Data Resources
EFDC	Environmental Fluid Dynamics Code
EFH	essential fish habitat
EIS	environmental impact statement
EJ	environmental justice
EM	engineering manual
EO	Executive Order

EOPs	Environmental Operating Principles
EPA	Environmental Protection Agency
EQ	environmental quality
ER	Engineering Regulation
ERDC	Engineering Research & Development Center
ESA	Endangered Species Act
ESO	endangered species observers
FAC	Florida Administration Code
FCC	fully cellular container
FE	far east
FIFR/EIS	Final Integrated Feasibility Report & Environmental Impact Statement
FMC	fishery management council
FR	federal register
FS	feasibility study
ft	foot/feet
FWCC	Fish & Wildlife Conservation Commission
FWOP	future without project
GEC	Gulf Engineering Consultants
GHG	greenhouse gas
GI	global insight
GIS	geographic information system
GNF	general navigation features
GRBO	Gulf of Mexico Regional Biological Opinion
GRP	gross regional product
HAB	hazardous air pollutants
HAPC	habitat areas of particular concern
HC	hydrocarbon
HEA	habitat equivalency analysis
HSI	habitat suitability index
HTRW	Hazardous, Toxic, & Radioactive Waste
Hz	Hertz
ICT	interagency coordination team
IDC	interest during construction
IFR/EIS	Integrated Feasibility Report & Environmental Impact Statement
IMPROVE	Interagency Monitoring of Protected Visual Environments
IPCC	Intergovernmental Panel on Climate Change
ISC/ME	Indian Sub continental & Middle East
ITEM	intertidal emergent marsh
IWR	Institute of Water Resources
kHz	kilohertz
LEDPA	least environmentally damaging practicable alternative
LERRs	Land, Easement, Rights-of-way, and Relocation
lm/ft^2	linear meters per square foot
LOA	length overall
LPP	locally preferred plan
m	meter
MAFMC	Mid-Atlantic Fishery Management Council
MALAA	may affect likely to adversely affect
MANLAA	may affect not likely to adversely affect
MCY	million cubic yards
MED	Mediterranean
mg/L	milligrams per liter
MHHW	mean higher high water
MHW	mean high water
ml	milliliters
MLLW	mean lower low water
MMAMP	Mitigation, Monitoring & Adaptive Management Plan
MMPA	Marine Mammal Protection Act
mm/s	millimeters per second
MPRSA	Marine Protection, Research, & Sanctuaries Act
MSA	Magnuson-Stevens Fishery Conservation & Management Act

MSC	Mediterranean Shipping Company
MSI	Maritime Strategies Inc
NAAQs	National Ambient Air Quality Standards
NARW	North Atlantic right whales
NAVFAC	Naval Facility
NBT	Navy Base Terminal
NCT	North Charleston Terminal
NE	no effect
NED	National Economic Development
NEPA	National Environmental Policy Act
NEUR	Northern Europe
NHPA	National Historic Preservation Act
NLAM	not likely to adversely modify
NMFS	National Marine Fisheries Service
nmi	nautical miles
NOA	notice of availability
NOAA	National Oceanic & Atmospheric Administration
NO_x	nitrous oxides
NPDES	National Pollutant Discharge Elimination System
NPS	National Park Service
NRHP	National Register of Historic Places
NTU	nephlometric turbidity units
NWR	National Wildlife Refuge
O_3	ozone
O & M	Operations & Maintenance
OCRM	Bureau of Ocean & Coastal Resource Management
ODMDS	Ocean dredged material disposal site
OGV	Ocean going vessel
OMRR&R	Operations, Maintenance, Repair, Rehabilitation, & Replacement
OPA	otherwise protected area
OSE	other social effects
PBF	physical biological features
PCE	primary constituent elements
PDT	project delivery team
PED	Preconstruction Engineering & Design
PEN	pendulum service
PIERS	Port Import/Export Reporting System
PIT	passive integrated transponder
PM	particulate matter
PMX	Panamax
PPA	project partnership agreement
PPT	parts per thousand
PPX1	Post-Panamax Generation 1
PPX2	Post-Panamax Generation 2
PPX3	Post-Panamax Generation 3
RCRA	Resource Conservation & Recovery Act
RECONS	Regional Economic System
RED	Regional Economic Development
RHA	Rivers & Harbors Act
ROD	record of decision
RP	recommended plan
RPM	reasonable & prudent measures
S & I	Supervision & Inspection
SAC	Charleston District
SAD	South Atlantic Division
SAFMC	South Atlantic Fishery Management Council
SAJ	Jacksonville District
SAM	Mobile District
SAMP	Special Area Management Plan
SARBO	South Atlantic Regional Biological Opinion
SAS	Savannah District
SAW	Wilmington District
SCDAH	South Carolina Department of Archives & History

SCDHEC	South Carolina Department of Health & Environmental Control
SCDHEC-BOW	South Carolina Department of Health & Environmental Control – Bureau of Water
SCDHEC-OCRM	South Carolina Department of Health & Environmental Control – Bureau of Ocean & Coastal Resource Management
SCDNR	South Carolina Department of Natural Resources
SCECAP	South Carolina Estuarine & Coastal Assessment Program
SCIAA	South Carolina Institute of Archaeology & Anthropology
SCPSA	South Carolina Public Service Authority
SCSPA	South Carolina State Ports Authority
SH	shellfish harvesting area
SHPO	State Historic Preservation Office
SLR	sea level rise
SMART	Specific, Measurable, Attainable, Risk Informed, Timely
SME	Society for Mining, Metallurgy, & Exploration
SMMP	Site Management & Monitoring Plan
sp	species
SPA	State Ports Authority
SPM	SubPanamax
STRTM	Sea Turtle Research Techniques Manual
STSSN	Sea Turtle Stranding & Salvage Network
T	Threatened
T & C	terms & conditions
T & E	threatened & endangered species
TEDs	turtle excluder devices
TEUs	twenty-foot equivalent units
TMDL	total maximum daily load
TPCS	total project cost summary
TSP	tentatively selected plan
TSS	total suspended solids
UMAM	uniform mitigation assessment method
UOD	ultimate oxygen demand
UPT	Union Pier Terminal
US	United States
USACE	United States Army Corps of Engineers
USC	United States Code
USCG	United States Coast Guard
USDA	United States Department of Agriculture
USEPA	United States Environmental Protection Agency
USFS	United States Forest Service
USFWS	United States Fish & Wildlife Service
USGS	United States geological survey
USVI	United States Virgin Islands
VOC	volatile organic carbon
WLA	waste load allocation
WQC	water quality certification
WRDA	Water Resources Development Act
WRRDA	Water Resources Reform & Development Act
WWT	Wando Welch Terminal

1.0 STUDY INFORMATION

North Charleston Terminal on the Cooper River

This Final Integrated Feasibility Report and Environmental Impact Statement (IFR/EIS) documents the Feasibility Study (FS) process and presents the results of investigations and analyses conducted to evaluate potential navigation system improvements at Charleston Harbor, South Carolina.

1.1 Introduction

The cargo transportation industry continues its shift to increased use of standardized containers used for multimodal (marine, rail, and truck) freight transportation systems. Additionally, the marine vessel fleet is trending to larger, deeper-draft vessels, particularly for containerships. The federal channels serving Charleston Harbor's major terminals are currently authorized to a depth of 45 feet mean lower low water (MLLW). The existing dimensions of those channels place constraints on deeper-drafting containerships, which result in reduced efficiency and increased costs. The FS has analyzed the beneficial and adverse effects associated with various alternatives that would increase the channel dimensions or apply non-structural measures and balances the economic, environmental, and engineering considerations. This Final IFR/EIS summarizes the results of the FS and will provide the basis for a decision whether to authorize modifications to the existing navigation system or not.

Projections of future waterborne commerce, port-specific traffic, cargo volume, commodity characteristics, vessel size, and trade lane distribution drive the analysis of transportation cost savings across various alternatives. The overall costs and benefits of each alternative are weighed against each other to identify and recommend the best solutions. Dredging, disposal area construction, maintenance, and mitigation for adverse impacts constitute the major project costs. The models used to forecast the future conditions and changes for this FS are consistent with those used on other harbor investigations and have been certified or approved for use by the U.S. Army Corps of Engineers (USACE).

1.2 Study Authority

The USACE initiated the FS at the request of the South Carolina State Ports Authority (SCSPA), the project's non-Federal Sponsor (NFS), under the authorization provided by Section 216 of the Flood Control Act of 1970 (Public Law 91-611). The authorization allows the USACE to review completed projects to adapt to changing conditions:

> *"The Secretary of the Army, acting through the Chief of Engineers, is authorized to review the operation of projects the construction of which has been completed and which were constructed by the Corps of Engineers in the interest of navigation, flood control, water supply, and related purposes, when found advisable due to significantly changed physical or economic conditions, and to report thereon to Congress with recommendations on the advisability of modifying the structures or their operation, and for improving the quality of the environment in the overall public interest."*

A reconnaissance study, completed in 2010, concluded that there was a potential federal interest in pursuing navigation improvements at Charleston Harbor. A Federal Interest exists when the economic benefits exceed the costs to build and maintain a potential project over the period of analysis. That conclusion led to the initiation of the FS and provision of federal funding following execution of the Feasibility Cost Sharing Agreement in 2011. The costs for the FS are shared equally by the USACE and SCSPA. The study phase will end on the date the report is submitted to Congress by the Assistant Secretary of the Army for Civil Works ASA(CW) for authorization. If Congress acts to authorize and fund construction of the project, the construction costs would also be shared. The precise division of costs depends on the specific features of the recommended project.

1.3 Federal Policy and Procedures

The USACE planning process follows the six-step process defined in the Principles and Guidelines for Water and Related Land Resources Implementation Studies. This process, used for all planning studies conducted by the USACE, provides a structured approach to problem solving and provides a rational framework for sound decision making. The six steps include:

Step 1: Identify Problems and Opportunities

Step 2: Inventory and Forecast Conditions

Step 3: Formulate Alternative Plans

Step 4: Evaluate Alternative Plans

Step 5: Compare Alternative Plans

Step 6: Select a Plan

The six-step planning process for this FS was modified through a SMART (Specific, Measurable, Attainable, Risk Informed, Timely) planning modernization initiative that incorporated a planning charette. The charette was a multi-day meeting held at the beginning of the FS process to apply a risk-based approach to streamline the study scope and process by eliminating non-essential activities from the decision-making process. Additionally, the Study was identified as a "We Can't Wait" project. The "We Can't Wait" initiative, backed by Presidential Executive Order 13604, is intended to make the permitting and review process for important infrastructure projects more efficient and effective. These initiatives were followed by Congressional action in the Water Resources Reform and Development Act of 2014 (WRRDA 2014) which codified, generally, Corps' planning parameters limiting the duration, cost, and agency approval process for future feasibility studies (Section 1001(a)), and required that the Corps "expedite the completion of any on-going feasibility study for a project initiated before the date of enactment of this Act" (Section 1003(1)). The Corps has applied these provisions by ensuring that appropriate parameters are maintained for the duration, cost, and agency approval process for the FR/EIS for the Project.

While completing studies faster and at lower costs, the modernized USACE planning process is intended to generate reports that are more concise and easier to understand but still present a thorough analysis of all important considerations. This report integrates the FR and the EIS into a single document to meet the combined requirements of water resource development law and policy, the National Environmental Policy Act (NEPA), and necessary environmental clearances.

1.4 Objectives

The overall federal objective related to water and related land resources project planning is to contribute to National Economic Development (NED), consistent with protecting the Nation's environment, pursuant to national environmental statutes, applicable executive orders, and other federal planning requirements. Water resources project plans are formulated to alleviate problems and take advantage of opportunities in ways that contribute to this objective. Additional information about contributions to NED is provided in Section 3, *Plan Formulation* and in Appendix C, *Economics*.

To determine whether there is a federal interest in implementing navigation improvements at Charleston Harbor, the expected return to the national economy on the total investment to construct and maintain the improvements over a 50-year study period must be calculated. Like most USACE navigation studies, the return to the national economy would be generated by reducing transportation costs by addressing inefficiencies in the existing transportation system. For there to be a federal interest, the contribution to NED must exceed the cost to construct and maintain the project over the period of analysis. The NED benefits associated with each of the alternatives considered are compared with the costs to implement and maintain the improvements, and mitigate for adverse impacts. The results, including recommendations, are summarized in this Final IFR/EIS and the supporting appendices.

1.5 Purpose and Need

The need for modifications to the existing navigation system in Charleston Harbor is generated by physical constraints and the associated inefficiencies that limit the system's ability to safely and efficiently serve the forecasted vessel fleet and process the forecasted cargo volumes. The purpose of this FS is to identify and recommend a comprehensive set of navigation modifications that would reasonably maximize, consistent with protecting the Nation's environment, Charleston Harbor's contribution to net NED benefits by addressing those physical constraints and inefficiencies. Based on the results of the Reconnaissance Report and anticipated vessel fleet and cargo volume changes, modifications to improve the efficiency of the navigation system at Charleston Harbor were identified as having a high potential to provide significant benefits to the national economy. More detailed information about the project objectives and the alternatives developed in accordance with this purpose and need statement are presented in Section 3 of this report.

1.6 Scope

The FS includes (1) a survey of existing and future conditions; (2) an evaluation of related problems and opportunities; (3) development of potential alternatives; (4) evaluation of alternatives; (5) a comparison of costs, benefits, adverse impacts, environmental acceptability, and feasibility of those alternatives; and (6) identification of a Recommended Plan. Information for the analysis came from land and hydrographic surveys, hydrodynamic and water quality modeling, socio-economic projections, sediment sampling, and numerous other data collection efforts. Data from previous studies have been augmented with information from the SCSPA, commercial shippers, federal, state, and local resource agencies, as well as Geographic Information System (GIS) mapping of significant resources and features.

This FS forecasts waterborne cargo volumes, traffic patterns and vessel fleets, and evaluates the need for navigation system improvements over a 50-year period of analysis. It considers a wide range of structural and some non-structural measures within and near the harbor that could address inefficiencies within the system. However, it concentrates on potential changes to water-based transportation system components that are within the scope of the study authority described above. Throughout this Final IFR/EIS, it is important to understand that the total cargo throughput of Charleston Harbor is driven primarily by land-based factors such as population growth, industrial and manufacturing changes, and regional maritime shipping trends and is limited by the capacity of the land-based infrastructure to process it. No project-induced increases in cargo throughput, based on potential water-based improvements to increase efficiency, are anticipated or forecasted.

1.7 Study Area

Charleston Harbor is located in a natural tidal estuary formed around the confluence of the Cooper, Ashley, and Wando Rivers. The City of Charleston is located west of Charleston Harbor, between the Ashley and Cooper Rivers, as well as on Daniel Island between the Cooper and Wando Rivers. James Island and Morris Island are south of the harbor, with Mt. Pleasant and Sullivan's Island to the east and North Charleston to the north. The Entrance Channel accesses the Atlantic Ocean to the southeast between Morris Island and Sullivan's Island. Figure 1-1 shows the locations of the federal channels and major terminals considered in this study. It also illustrates the relative locations of the Inner Harbor, Entrance Channel (Fort Sumter Range), and the dredged material placement sites.

Charleston Harbor includes about 14 square miles of open water. The study area includes the Entrance Channel, dredged material disposal areas, the federal inner harbor channels, and any extension of these water bodies and shorelines that would be impacted by channel enlargement alternatives or any potential associated landside infrastructure changes.

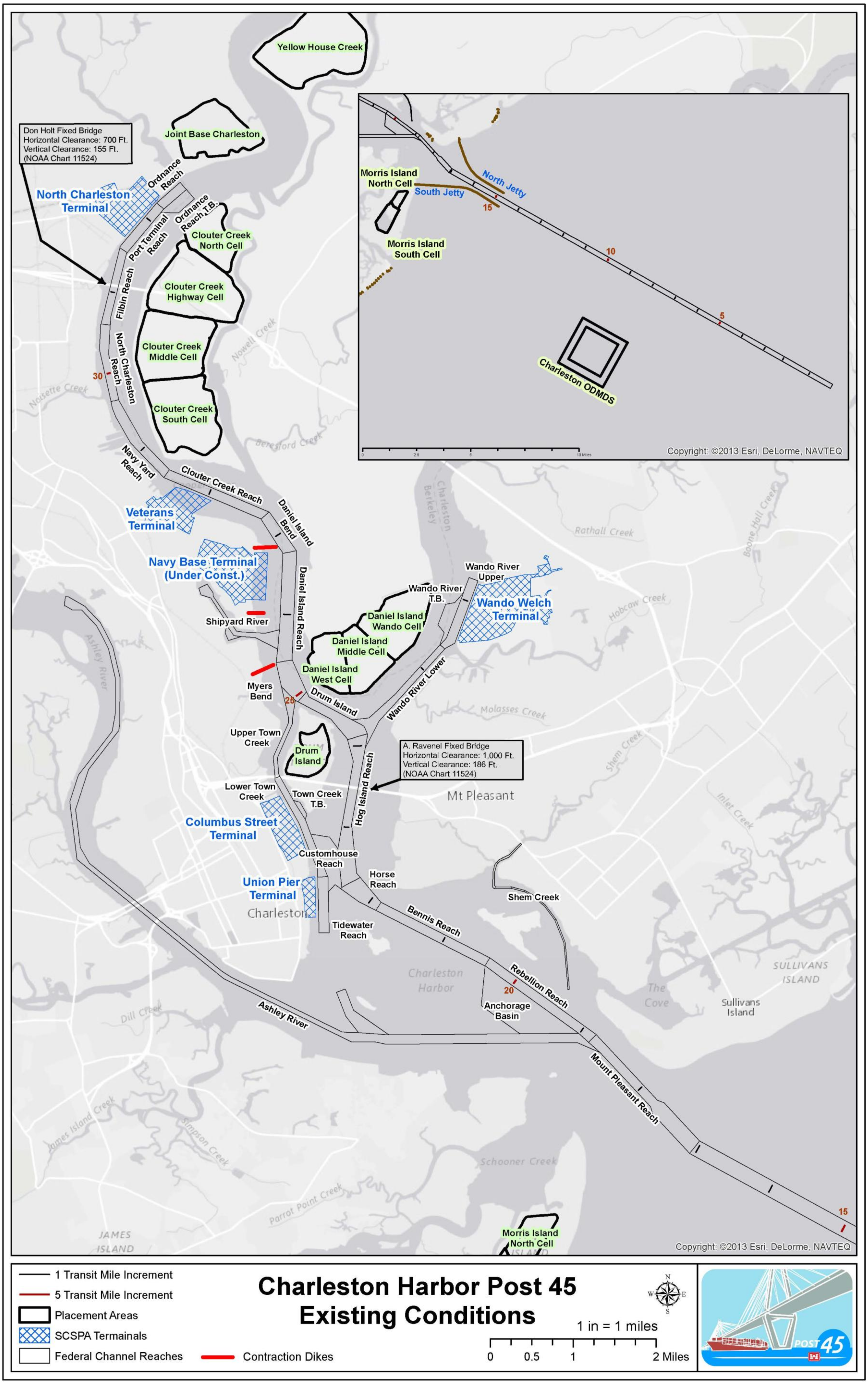


Figure 1-1. Location of the federal channels, material placement sites, bridges, and major terminals

1.8 Existing Project

Historical Perspective. Charleston (originally called Charles Towne) was founded on the west bank of the Ashley River in 1670. In 1680, the colony relocated to Oyster Point (its current location). This relocation gave the community a natural harbor that was more defensible from land and sea assaults. After this move, the city grew in population and economic significance until the early 1800s. Between 1830 and 1850, Charleston Harbor declined in relative importance as New York Harbor expanded and new ports (such as New Orleans) developed. By 1840, Charleston realized that the harbor would need to be at least 17 feet deep to remain competitive. Over time, the harbor has been deepened as needed to adapt to the changing needs of its users. Figure 1-2 provides a simplified timeline of the gradual deepening of Charleston Harbor in response to changing needs.

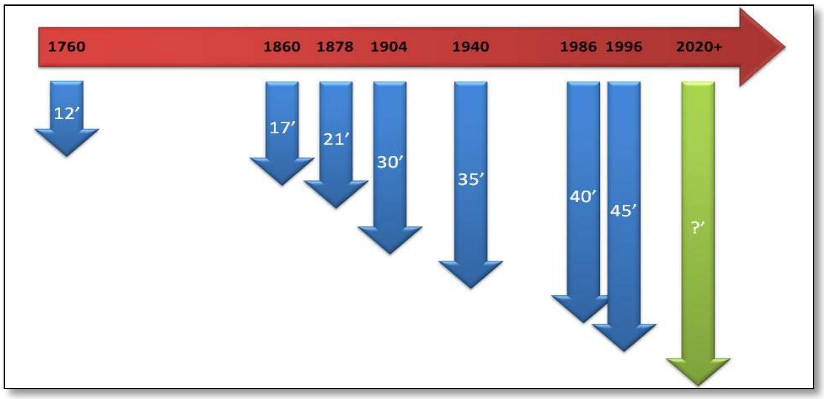


Figure 1-2. Charleston Harbor authorized depth timeline

The Rivers and Harbors Act of 1852 authorized navigation improvements to Charleston Harbor. This work was interrupted by the Civil War and was not completed until after it ended. 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 River 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.

Existing Federal Navigation Project. The Charleston Harbor federal navigation project currently provides limited 2-way traffic and consists of channels, turning basins, an anchorage basin, contraction dikes, jetties, and dredged material disposal areas. The channels have been enlarged through the past 160 years, and the authorized depth supporting the major terminals is 45 feet MLLW (Figure 1-3).

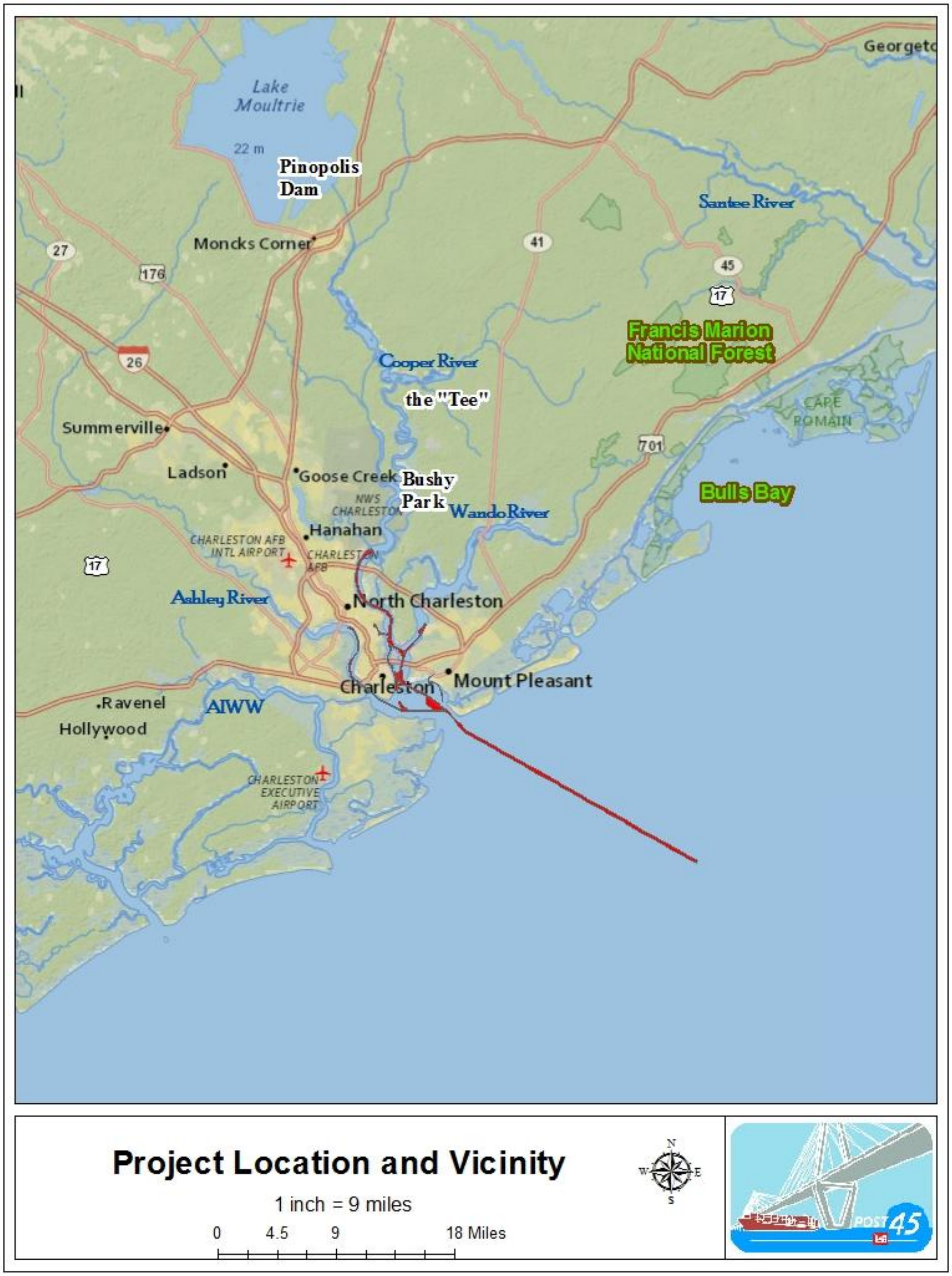


Figure 1-3. Federal navigation system and vicinity

Construction of the existing project was initiated in 1998 and completed in 2004. All of the changes authorized in 1996 have been completed with the exception of the Daniel Island Turning Basin as the terminal it would have serviced was relocated to the former Naval Base. The federal project also includes several side channels that are not considered in this FS because they do not serve the primary container terminals and efficiently meet the current and foreseeable needs.

1.9 Prior Reports and Studies

Over the past 40 years, there has been a succession of feasibility-related reports concerning deepening projects for the Charleston Harbor. Advances in engineering, economics, and other sciences have aided each successive investigation. An abbreviated list of the most important studies and reports relating directly to harbor deepening are summarized below.

1.9.1 Feasibility Studies

Congress authorized deepening of the federal channels in Charleston Harbor from a depth of 40 feet MLLW to 45 feet MLLW based upon ***The Charleston Harbor Deepening/Widening, South Carolina, Report of the Chief of Engineers, 16 July 1996***. This Report was based upon a 1996 Feasibility Study and Environmental Assessment.

1.9.2 Port Inventory

The latest USACE Port Series document, ***Port Series #13***, was published in 1997 and provides a complete inventory (current at that time) of every port terminal covering their berthing statistics, loading/unloading equipment, and landside storage, nationwide. This document also provides basic tidal and climate conditions and dimensions of all the harbor channels. The USACE no longer publishes the Port Series.

1.9.3 Dredging Reports

Charleston Ocean Dredged Material Disposal Site (ODMDS), Site Management And Monitoring Plan, November 2005. This plan was prepared and reviewed by the U.S. Environmental Protection Agency; the USACE; the U.S. Fish and Wildlife Service; the South Carolina Department of Natural Resources; and the SCSPA. This modified site management and monitoring plan replaces the original and incorporates subsequent monitoring results and provisions of the Water Resources Development Act of 1992.

An Environmental Monitoring Study of Hardbottom Reef Areas Near the Charleston Ocean Dredged Material Disposal Site, March 2006. This monitoring report documented the effectiveness of a USACE-constructed “L” shaped berm comprised largely of cooper marl along the southern and western borders of the ODMDS. It was constructed to protect hardbottom reef habitats, and prevent long-term loss of sessile (attached to substrate) biota and associated fin fishes caused by burial by fine-grained sediments dispersed from the ODMDS.

Dredged Material Management Plan, Preliminary Assessment, Charleston Harbor, Charleston, South Carolina, June 2009. The report concluded that there was more than 20 years of capacity to contain the dredged material from Charleston Harbor maintenance dredging.

Final Environmental Assessment, Charleston Harbor Additional Advance Maintenance Dredging, Published September 2009. While the 1996 Feasibility Study and Environmental Assessment (EA) for deepening and widening the channels in Charleston Harbor anticipated dredging depths of 45 feet plus 2 feet of advanced maintenance and 2 feet of allowable overdepth (45+2+2), high shoaling rates necessitated that some reaches be dredged to depths of either 45 feet plus 4 feet of advanced maintenance and 2 feet of allowable overdepth (45+4+2) or 45 feet plus 6 feet of advance maintenance and 2 feet of allowable overdepth (45+6+2). The additional advance maintenance dredging allows the harbor to be maintained on a 12 to 18-month cycle instead of a 6-month cycle.

1.9.4 Waterborne Commerce Statistics

Waterborne Commerce Statistics is published annually by the USACE Waterborne Commerce Statistics Center. It provides the vessel calls by number, draft, and loads for all U.S. ports.

1.9.5 Permits

As port facilities have been added or expanded, they have required federal and state permits. These documents, on file at the Charleston District, provide additional insight to the social, economic, and environmental conditions of Charleston Harbor. Some of the primary recent and reasonably foreseeable permitting actions are discussed in Appendix O (Cumulative Impact Assessment).

1.9.6 Water Quality Studies

3-D Modeling Report for the Charleston Harbor System- January 2008, Prepared for the Berkeley Charleston Dorchester Council of Governments by Jordan, Jones, & Goulding. The Cooper and Ashley Rivers were identified as impaired for dissolved oxygen under Section 303(d) of the Clean Water Act (CWA). As a result, multiple model studies were completed to determine a Total Maximum Daily Load (TMDL) for dissolved oxygen (DO) in the rivers that comprise part of the Charleston Harbor. The Berkeley-Charleston-Dorchester Council of Governments (BCDCOG) contracted for a 3-D model application of the Environmental Fluid Dynamics Code (EFDC) to simulate in-stream hydrodynamics and water quality for the purposes of establishing a DO TMDL. The South Carolina Department of Health & Environmental Control (SCDHEC) uses the model to regulate and determine TMDL compliance within the system.

Charleston Harbor Special Area Management Plan (SAMP) – February 2000, Prepared by the South Carolina Department of Health and Environmental Control, Bureau of Ocean and Coastal Resource Management (SCDHEC-OCRM). This SAMP was a response to rapid urbanization of the watershed and consequential eutrophication of the estuary. The objectives of the SAMP were to:

1. Maintain and enhance the quality of the environment in the Charleston Harbor estuarine system.
2. Maintain the range of uses of waters and natural resources of the system.

3. Anticipate and address potential problems before adverse impacts occur.

The SAMP listed recommendations to preserve the harbor by addressing public outreach, biological resources, water quality and growth management.

Ashley River SAMP-1992, Prepared by SCDHEC-OCRM. This SAMP was implemented to develop public policy for the conservation of the natural and historic character of the Ashley River corridor.

Cooper River SAMP-2004, Prepared by SCDHEC-OCRM. This SAMP encompasses approximately 53 miles of the Cooper River from Pinopolis Dam to Old US Highway 52 in Berkeley County. The SAMPs goals were:

1. Determine whether active management of water flows can slow the rate of vegetative succession
2. Preserve the integrity of the existing rice fields
3. Assess the effects of impoundments on waterbird habitat
4. Verify how useful impoundments are to providing species refuges
5. Explore strategies to control invasive aquatic plants
6. Assess the volume and diversity of wetland fauna
7. Determine the impacts of re-impounding on DO and the filtration capacity of open marshes
8. Evaluate the changes in nutrient export from open marshes
9. Investigate measurement measures to improve water quality, fishery productivity, and aquatic diversity.

The Cooper River SAMP resulted in the development of both Cultural Resources and Natural Resources Management Plans.

Watershed Water Quality Assessment for the Catawba-Santee River Basin-December 2005, Prepared by the South Carolina Department of Health and Environmental Control, Bureau of Water (SCDHEC-BOW). This is a living document regularly updated by SCDHEC-BOW. The Assessment summarizes water programs and water quality for all 11 digit watersheds within the basin. The document contains 5-year summary information, geographical presentations of all permitted watershed activities, and other water related information.

State of South Carolina Integrated Report for 2012 Part I: Section 303(d) List of Impaired Waters-May 24, 2012, SCDHEC-BOW. Bi-annually submitted to Environmental Protection Agency (EPA) and Congress, the 303(d) list identifies all waters in South Carolina that do not currently meet water quality standards after the application of point and nonpoint source pollutant controls. Determination of attainment was made using water quality data collected from 2006-2010. At this time, the 2014 303 (d) report is being prepared.

State of South Carolina Integrated Report for 2012 Part II: Section 305 (b) Assessment and Reporting-May 24, 2012, SCDHEC-BOW. Bi-annually submitted to EPA and Congress, the 305(b) is a general assessment of water quality conditions and water pollution control programs in South

Carolina. These determinations are based on SCDHEC ambient water quality monitoring, point source permit monitoring, and the evaluation of nonpoint source data. At this time, the 2014 305 (b) report is being prepared.

The Condition of South Carolina's Estuarine and Coastal Habitats During 2009-2010 Technical Report No. 107- 2013, Prepared by R.F. VanDolah, D.M. Sanger, G.H.M. Riekerk, S.E. Crowe. M.V.Levisen, D.C.Bergquist, D.E.Chestnut, W. McDermott, M.H. Fulton, E. Wirth. The South Carolina Estuarine and Coastal Assessment Program-(SEACAP) program evaluates the state's estuarine habitats using a combination of water quality, sediment quality, and biotic condition parameters. This is a collaborative effort between the South Carolina Department of Natural Resources, the South Carolina Department of Health and Environmental Control, and the National Oceanic and Atmospheric Administration.

1.10 Report Organization

This integrated report serves as the USACE decision support document for the recommended navigation improvements and as the EIS to meet NEPA requirements for the proposed action. It is also formatted to facilitate review and processing by the ASA(CW) to provide a report with recommendations to Congress. The remainder of the report is organized as follows. Sections intended to meet NEPA requirements are qualified with an asterisk:

Section 2: Existing and Future Without Project Conditions *

Section 3: Plan Formulation*

Section 4: Recommended Plan

Section 5: Impacts of the Proposed Project*

Section 6: Environmental Compliance*

Section 7: Public and Agency Participation*

Section 8: List of Preparers*

Section 9: Recommendations

Section 10: References

Section 11: Index*

Appendices

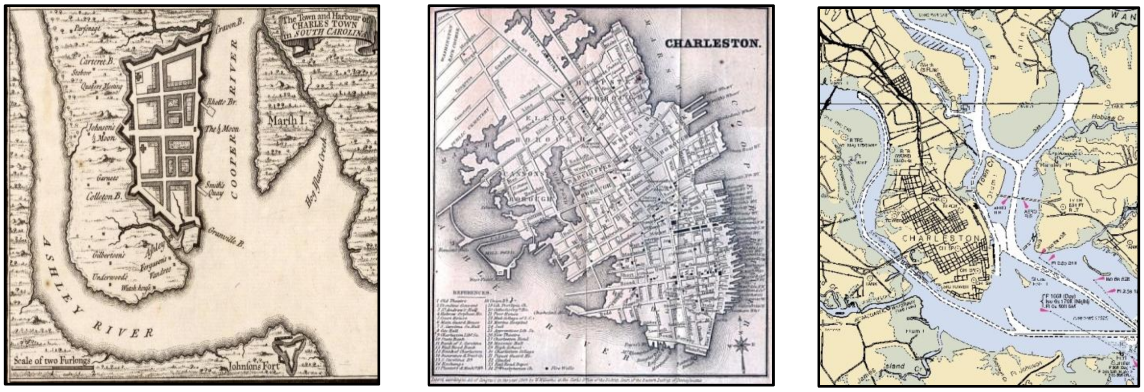
2.0 EXISTING AND FUTURE WITHOUT PROJECT CONDITIONS/NEPA AFFECTED ENVIRONMENT

This chapter describes the existing economic conditions, navigation features, and the physical, and natural environment of Charleston Harbor, all of which are described and analyzed consistent with the National Environmental Policy Act (NEPA) regulations. This section summarizes the existing conditions (baseline) as well as a forecast of the Future Without Project (FWOP) conditions, to provide a sound basis for plan formulation in Section 3 and impact analysis in Section 5. The FWOP condition is synonymous with the No Action Alternative for the NEPA analysis. It describes the anticipated conditions at the end of the study's 50 year period of analysis (2071). The existing conditions are used as the baseline to forecast the changes that would be expected to without USACE action to address inefficiencies in the federal navigation system. The topics in this section are structured to mirror the topics presented in Section 5: Impacts of the Proposed Project, where the "future with project" conditions and impacts are considered. Some of the existing and FWOP conditions are based on outputs of detailed hydrodynamic and environmental modeling that are described in greater detail in the Appendices.

Note: A Reference Aid at the end of this Section provides the reader with the following existing condition information: names of channel reaches, depths, widths, sailing drafts, a map of the harbor and navigation channel, shoaling areas, channel cross-section, standard navigation terminology, and port infrastructure.

2.1 General Setting

Charleston, with a population of about 128,000, is the second largest city in South Carolina. It is part of a rapidly growing metropolitan area known as the Tri-County area (Berkeley County, Charleston County, and Dorchester County) located along the U.S. southeast coast, one of the country's fastest growing regions. The broader Tri-County area has a population of about 700,000. The major components of the local economy include: tourism, educational institutions, medical facilities, and logistics (including navigation). Figure 2-1 shows the progressive growth of Charleston and the historical importance of the harbor to the location of the City.



Herman Moll. 1733 *W. Williams. 1843* *NOAA. 2002*

Figure 2-1. Growth of Charleston and the historical importance of the harbor

Figure 1-3 in Section 1 of this report illustrates the locations of the project, nearby cities, highways, and several major land features near the harbor, including the three major rivers (Ashley River, Cooper River and Wando River) that flow through the harbor. Most of the harbor-related activities are concentrated along the lower portions of the Cooper and Wando Rivers. The upland areas around the harbor are developed as residential, commercial, and industrial areas.

The natural coastline is characterized by sea islands, hummock islands, and barrier islands that are interlaced by estuaries, extensive salt marshes, intertidal areas, and oyster reefs. Freshwater marshes are also present, but many of them are remnants of constructed impoundments, including several 18th century rice fields. A detailed description of the Charleston Harbor estuary can be found in the Charleston Harbor Special Area Management Plan (SAMP), prepared by SCDHEC-Office of Ocean and Coastal Resource Management (OCRM) (SCDHEC-OCRM 2000).

Water-related natural resources and recreational opportunities are abundant within the Study area. In addition to the Atlantic Ocean, rivers and creeks are ubiquitous and two major reservoirs (Lake Moultrie and Lake Marion) are located within 45 miles of Charleston. Francis Marion National Forest, northeast of Charleston, spans nearly 259,000 acres and encompasses vast tracts of recreational lands, aquatic habitats and other natural resources, including protected species.

The Cooper River originates at the confluence of its East and West Branches about 32 miles north of Charleston. Its east and west branches each extend about 20 miles from their confluence known as the "Tee". The East Branch originates as a system of numerous, small channels. The West Branch originates at the Pinopolis Dam, which impounds Lake Moultrie (a freshwater reservoir). Flows from the lake are controlled by the Jefferies Hydroelectric Station which has a maximum capacity of 28,000 cubic feet per second (cfs). It is operated in a semi-peaking mode in accordance with a U.S. Army Corps of Engineers (USACE) agreement with the South Carolina Public Service Authority (SCPSA) that originated from the USACE Cooper River Rediversion Project. Discharges are typically restricted to average weekly flows of 4,500 cfs, although higher discharges may be used to limit salinity concentrations. Some flow through the system is also used to operate the Pinopolis lock, to facilitate navigation and upstream fish passage.

The Ashley River originates about 30 miles northwest of Charleston and flows into the harbor from the west. Some portions of the Ashley River are bordered by large historic plantations, but most are bordered by more dense residential or commercial developments.

The Wando River flows into the harbor from the east. Most of the lower reaches are bordered by extensive marshes while woodland borders most of the upper reaches. Residences, subdivisions, a shipyard and the Wando Welch Terminal border the river's lower reaches.

2.2 Economic Conditions

2.2.1 Relative Trade Volume and Trends

Existing Condition



The Port of Charleston is one of the nation's major ports, ranking 23rd in foreign trade total tonnage and 7th in terms of foreign trade total value (Table 2-1).

Table 2-1. Port of Charleston ranking by foreign trade volume and value (CY 2013) [1]

Total Trade		US Exports		US Imports	
Rank	**Total**	**Rank**	**Export**	**Rank**	**Import**
23	15,389,000 Tons	24	6,492,000 Tons	25	8,897,000 Tons
7	$65,140,000	8	$24,438,000	6	$40,702,000

[1] Although total import tonnage is typically greater than export tonnage, some commodities, such as chemicals and related products and food and farm products have greater export tonnage than import tonnage.

Source: US Census Bureau FT920 US Merchandise Trade: Selected Highlights found at www.aapa-ports.org accessed 05July14

In 2013, the Port of Charleston, handled about 1.6 million twenty-foot equivalent units (TEUs). Its breakbulk cargo totaled 723,420 tons. Historically, the top commodities moved through the port have been agricultural products, consumer goods, machinery, metals, vehicles, chemicals and clay products. Maritime trade including containership cargo at the Port of Charleston has generally been increasing over time. Like most ports, the economic downturn from 2007-2009 substantially reduced tonnage and the number of TEUs handled at the Port of Charleston. However, tonnage, TEUs, and vessel sizes have been steadily increasing since 2009.

In terms of TEU throughput in 2013, the Port of Charleston was the 10th largest container port in the United States and the 4th largest on the east coast (Table 2-2).

Table 2-2. U.S. container port ranking 2013 (TEUs)[1]

Rank	Port Location	TEUs
1	Los Angeles, CA	7,868,583
2	Long Beach, CA	6,730,573
3	Port of New York and New Jersey, NY & NJ	5,467,347
4	Savannah, GA	3,033,727
5	Oakland, CA	2,346,528
6	Norfolk, VA	2,223,532
7	Houston, TX	1,950,071
8	Tacoma, WA	1,891,568
9	Seattle, WA	1,592,753
10	Charleston, SC[2]	1,560,000
11	Port Everglades, FL	927,572
12	Jacksonville, FL[3]	926,809
13	Miami, FL	901,454

[1] Total Twenty-foot Equivalent Units (TEUs) (loaded, empty, domestic, and foreign)
[2] Charleston data for FY13 beginning in July
[3] Jacksonville data for FY13 beginning in October
Sources: Individual port web pages

Figure 2-2 shows the historical tonnage shipped through Charleston Harbor from 1990 through 2012 and Figure 2-3 illustrates the number of imported and exported containers processed through the port. With the notable exception of the economic downturn from 2007 through 2009, tonnage moved through the port has increased nearly every year from 1990 to 2013.

The figures show that both measures of cargo commodities (total tonnage and container numbers) peaked around 2005 and 2006 then declined until 2009. However, since then, both measures have recovered significantly.

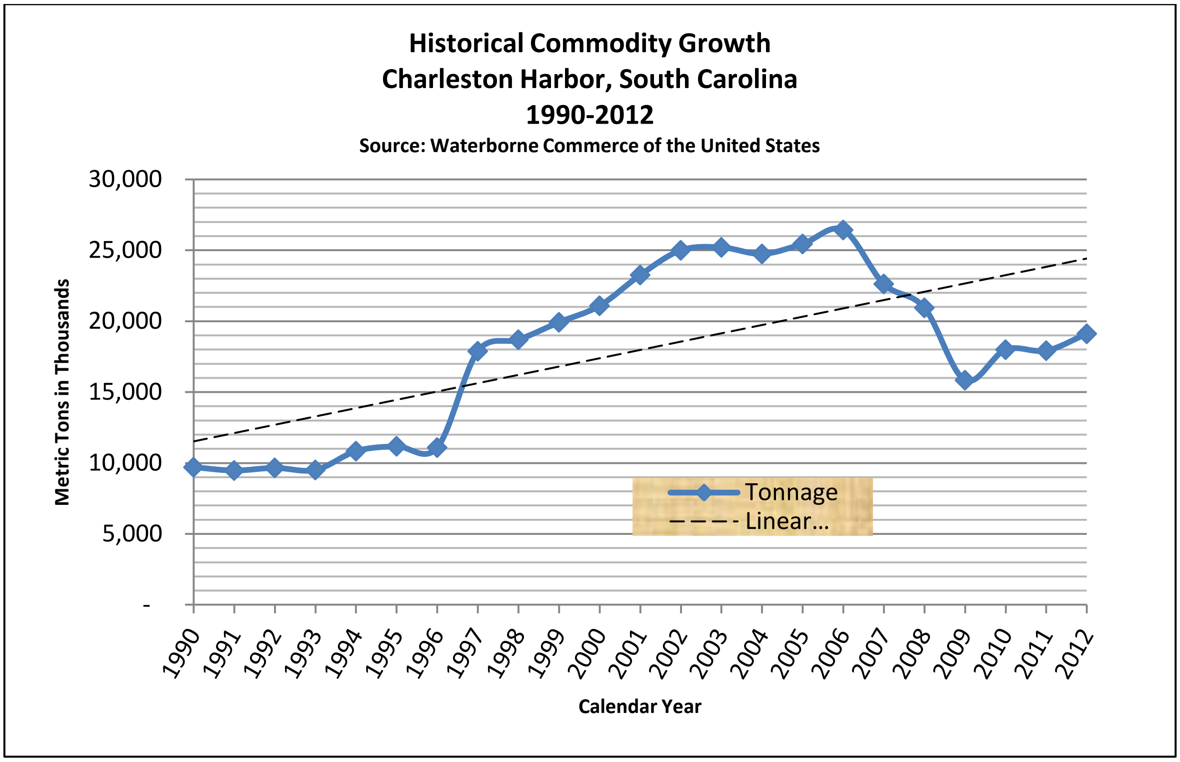


Figure 2-2. Charleston Harbor historical commerce-all commerce (Metric Tons)

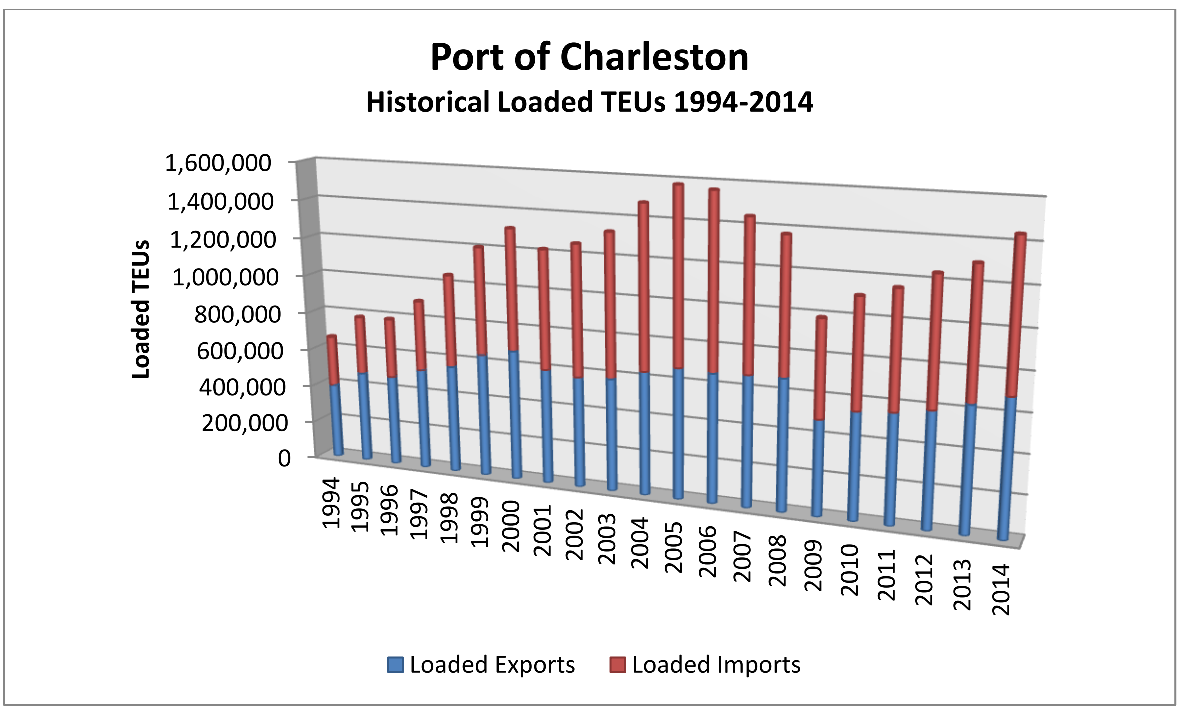


Figure 2-3. Port of Charleston container throughput 1994-2014

Figure 2-4 provides the breakdown of the total commodities and groups of commodities shipped through Charleston Harbor from 2004 through 2012.

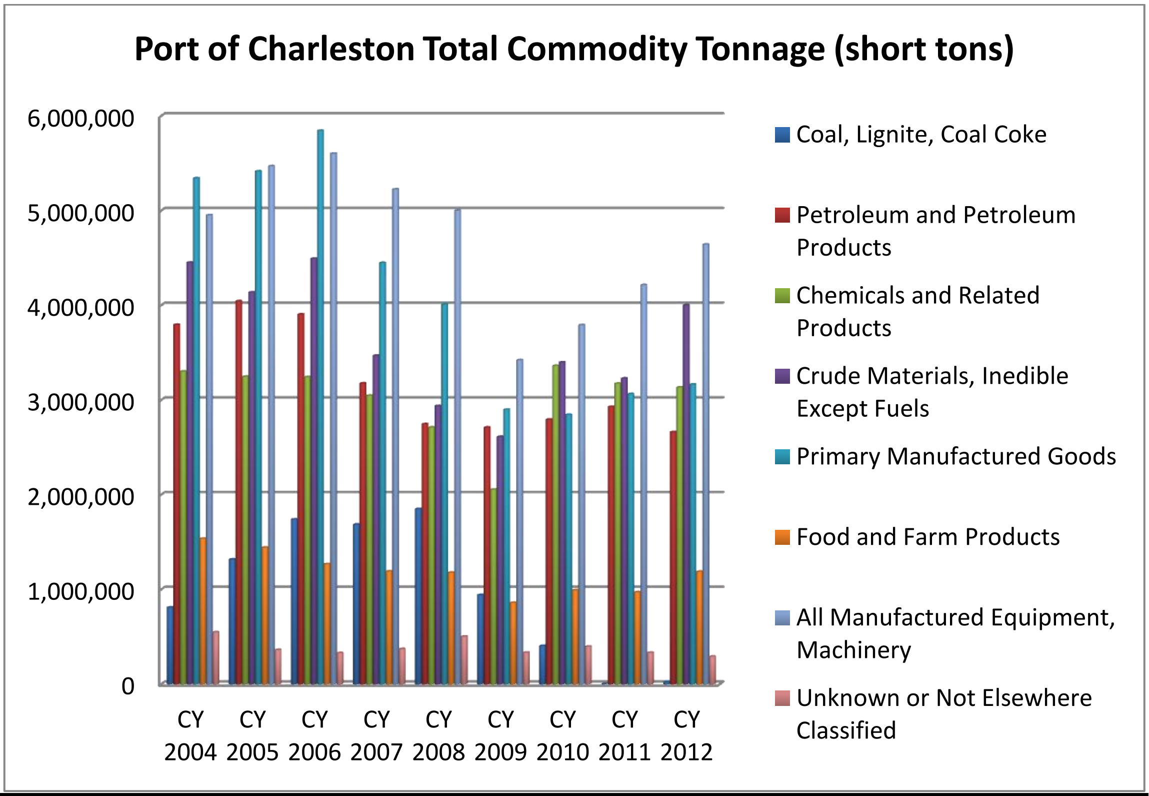


Figure 2-4. Port of Charleston commodity throughput 2004-2012

A comparison of commodity tonnages from 2004 to 2012[1] (Figure 2-4) indicates that:

- coal, lignite and coal coke category tonnage has substantially declined due to reductions in coal imports;
- petroleum and petroleum products category tonnage has generally decreased and does not show the post-2009 rebound exhibited by other commodity categories; and
- Commodity categories (chemicals and related products, crude materials, primary manufactured goods, food and farm products, manufactured equipment, and machinery) tonnage have all increased since 2009.

It is notable that the commodities within the coal and petroleum groups that show long-term declines in total tonnage are generally transported using bulk carriers rather than in containers. This is an important consideration in subsequent analysis because the increasing size and associated draft needs of container vessels has been the primary reason many harbors have and are considering improvement projects. Considering the ongoing shift of greater amounts and proportions of cargo

[1] The most current year that comparable tonnage data is available

being transported using container vessels, the ongoing expansion of the Panama Canal and the rapid increase in the size of containerships utilized world-wide and on the east coast, the analysis and forecasts for this study concentrate on the use and needs of containerships.

Future Without-Project Condition

The future with-project and the without-project conditions use the same future cargo forecast. The cargo forecasts do not depend on changes to the existing navigation system due to the combination of several factors. The primary factors include (not in any specific order): 1) While less efficiently, the existing navigation system is capable of handling the forecasted cargo volumes without modification; 2) for most cargo, even with major constraints and inefficiencies, transportation over water is far less costly than over land; 3) historically, most viable ports make the improvements needed to meet the needs of the shipping industry (this avoids major shifts in cargo volumes between ports); and 4) landside infrastructure changes and other factors such as development of industries, distribution centers, and population shifts tend to have a greater influence on cargo volumes than changes in marine navigation systems. Additional information on forecasting is provided in Appendix C (Economics).

Projected annual commodity tonnage growth rates were developed through a world trade forecasting model provided by Global Insight for the period from 2012 to 2037. Growth rates were then kept constant until 2039 when the port reached its capacity. The commodity forecast is based on a four–year (2008-2011) average of commodities moved through the port and estimated growth rates based on historical trends in commodity shipments. The forecasted commodity tonnage growth rates were applied to the average base to forecast annual commodity tonnage through 2039. From 2039 to 2071, the forecast tonnage and TEUs remain constant. The number of projected port loaded TEUs was then calculated from the projected tonnages for each service based on historical TEU weights calculated from historical port data and Port Import-Export Reporting System (PIERS) data.

For this analysis, services were grouped by the world region that they serve. For example, there are a number of services that call on various ports in the Far East (FE), transit the Panama Canal, proceed to ports along the East Coast of the U.S. (ECUS), and then return to the FE. Services that represent trade within this world area were grouped and entitled “FE (Panama) ECUS”. Other services generally involve trans-oceanic string of ports structured as a continuous loop. The FE ECUS Northern Europe (NEUR) pendulum service (PEN) is a combined world region service and represents both the FE region and the NEUR services. Those services called on various ports in the FE, transit the Panama Canal, proceed to ports along the ECUS, proceed to NEUR and then return to the FE.

Table 2-3 lists the world region applied to the Charleston Harbor Post 45 study and the respective country or blocks of countries that fall within the region. Additional details related to the cargo and commodity forecasts can be found in the Economics Appendix (Appendix C).

Table 2-3. Charleston trade partner and world region groupings

World Region	GI Trade Locations
Africa	South Africa; Kenya; Canada [1] Other East Africa; Other Southern Africa; Western Africa
CAR CA	Caribbean Basin; Other Central America; Mexico
ECSA	Argentina; Brazil; Colombia; Venezuela; Other East Coast of S. America
NEUR	Italy; Slovenia; Spain; Turkey; Portugal; Bulgaria; Romania; Ukraine; Austria The Baltic; Belarus; Belgium; Czech Republic; Denmark; Finland; France Germany; Hungary; Ireland; Moldavia; Netherlands; Norway; United Kingdom; Poland; Russia; Slovakia; Sweden; Switzerland; Other Europe
FE	Australia; Hong Kong; Indonesia; Japan; Malaysia; New Zealand; Philippines South Korea; Taiwan; Thailand; Vietnam; Singapore; China; CIS Southeast
ISC/ME	India; Pakistan; Saudi Arabia; United Arab Emirates; Other Indian Continent; Other Persian Gulf
MED	Algeria; Croatia; Egypt; Greece; Israel; Libya; Morocco; Tunisia; Other Mediterranean
WCSA	Bolivia; Chile; Ecuador; Peru

[1] Canada was included in Africa world trade region because Charleston Harbor container services originating from Africa call to Canadian ports first

Baseline Forecast

The South Atlantic Region is one of the fastest growing parts of the Country. Five South Atlantic states (North Carolina, South Carolina, Georgia, Alabama, and Tennessee) and North Florida have been designated as the Piedmont Atlantic Mega-region, as shown in Figure 2-5.

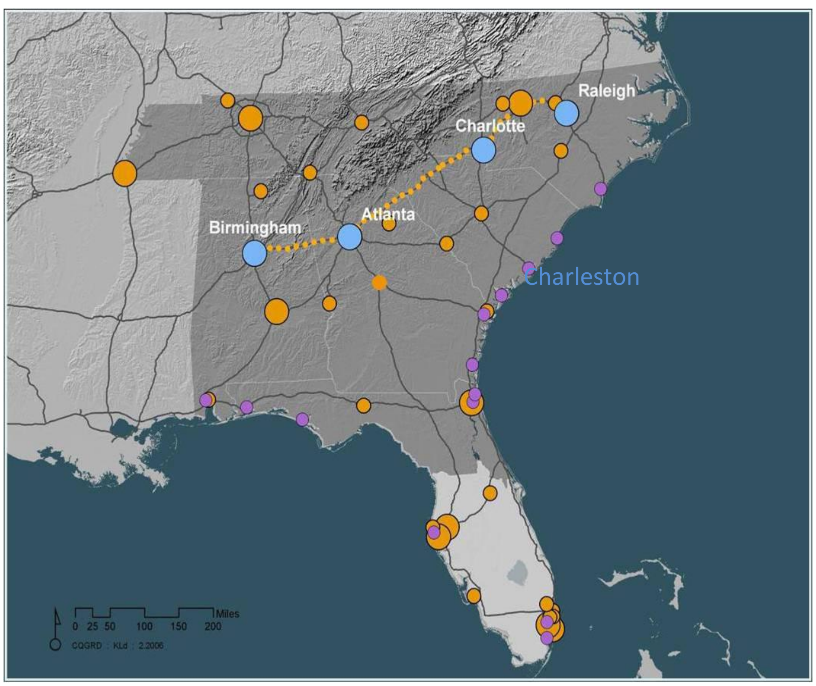


Figure 2-5. Piedmont Atlantic Mega region

The population of this Mega-region in 2000 was 34 million people (over 12 percent of the total U.S. population), and it is expected to grow to over 57 million by 2050 (approximately 13.5 percent of the total U.S. population) (GT 2006). Much of this growth is occurring in a crescent-shaped area of economic activity from Raleigh-Durham, NC, to Birmingham, AL, and includes Charlotte, NC, and Atlanta, GA. This region is growing faster than the surrounding areas and much faster than the U.S. as a whole. The Port of Charleston is ideally suited to serve this growing part of the nation.

To minimize the impact of potential anomalies in trade volumes on long-term forecast, empirical data from 2008 to 2011 were used to develop a baseline, allowing the forecast to capture both economic prosperity and downturn which occurred over that timeframe.

The following tables illustrate historical 2008, 2009, 2010, and 2011 containerized tonnage moved through the Port of Charleston. Table 2-4 provides the historical containerized imports moved through the Port of Charleston from 2008 to 2011; Table 2-5 provides the same information for exports; and Table 2-6 presents the baseline imports and exports.

Table 2-4. Historical containerized imports (Metric Tons)

World Region Service	2008	2009	2010	2011	4-yr avg
Africa	108,580	102,565	89,371	81,105	95,405
Caribbean CAM	109,330	12,442	0	0	30,443
ECSA	275,781	233,675	305,118	297,634	278,052
FE (Panama)	332,503	315,377	819,187	893,730	590,199
FE (Suez)	303,367	285,473	468,889	572,123	407,463
FE ECUS NEUR PEN	738,358	526,562	224,324	238,680	431,981
ISC/ME	761,668	554,493	587,125	528,723	608,002
MED	272,430	122,822	84,014	74,042	138,327
NEUR	2,003,341	1,314,938	1,501,731	1,684,545	1,626,139
WCSA	115,550	108,595	192,518	167,077	145,935
Total	**4,907,367**	**3,470,357**	**4,081,768**	**4,372,591**	**4,351,946**

As shown, containerized imports declined from 4.9 million tons in 2008 to 4.4 million tons in 2011. In 2009, the market experienced a drastic decrease but the import tonnage has rebounded since. Trade with NEUR has dominated Charleston's market, followed by the Indian Subcontinent & Middle East (ISC/ME) and the Far East, East Coast U.S. deployment that calls Northern Europe before returning to Far East (FE ECUS NEUR PEN). The top import commodities include furniture; auto parts; sheets, towels, blankets; fabrics including raw cotton; auto and truck tires and tubes; and general cargo. Average imports from all the world regions were estimated to total 4.4 million tons. This import trade volume represents the baseline from which forecasted import commerce was developed.

As shown in Table 2-5, containerized exports declined from 4.7 million tons in 2008 to 4.5 million tons in 2011. Since 2009, exports have exceeded imports in terms of tonnage. The top export cargo includes paper and paperboard, wood pulp; auto parts; logs and lumber; and fabrics and raw cotton. As with imports, containerized trade with NEUR dominated Charleston's market with 27 percent of trade volume, followed by ISC/ME at 15 percent, and FE ECUS NEUR PEN at 12 percent. Average exports to all the world regions were estimated to total 4.7 million tons. This export trade volume represents the baseline from which forecasted commerce was estimated. Table 2-6 summarizes the baseline for both imports and exports by world region and service route that were used to develop the future cargo forecasts.

Table 2-5. Historical containerized exports (Metric Tons)

World Region Service	2008	2009	2010	2011	4-yr avg
Africa	277,257	183,558	248,259	261,564	242,659
Caribbean/CAM	160,115	20,602	0	0	45,179
ECSA	445,333	294,431	467,906	400,577	402,062
FE (Panama)	242,748	283,366	695,034	982,164	550,828
FE (Suez)	229,757	229,874	422,436	464,806	336,718
FE ECUS NEUR PEN	951,843	622,415	335,306	296,270	551,458
ISC/ME	837,555	728,481	651,443	633,075	712,638
MED	391,642	233,938	162,506	133,846	230,483
NEUR	1,182,010	1,031,980	1,401,464	1,363,480	1,244,733
WCSA	368,006	284,900	421,401	389,288	365,899
Total	**4,720,266**	**3,630,653**	**4,386,364**	**4,537,792**	**4,682,658**

Table 2-6. Charleston baseline commodity (Metric Tons)

World Region Service	Imports	Exports	Total
Africa	95,405	242,659	338,065
Caribbean CAM	30,443	45,179	75,622
ECSA	278,052	402,062	680,113
FE (Panama)	590,199	550,828	1,141,028
FE (Suez)	407,463	336,718	744,181
FE ECUS NEUR PEN	431,981	551,458	983,439
ISC/ME	608,002	712,638	1,320,640
MED	138,327	230,483	368,810
NEUR	1,626,139	1,244,733	2,870,872
WCSA	145,935	365,899	511,833
Total	**4,351,946**	**4,682,658**	**9,034,604**

Commodity and TEU Forecasts

In 2011, containerized trade forecasts were obtained from Global Insight (GI), which operates as a research firm to provide economic and financial coverage of countries, regions, and industries. When making global trade forecasts, GI employs sophisticated macroeconomic models which contain all commodities that have physical volume. The commodities are then grouped into 88 categories derived from the International Standard Industrial Classification. GI tracks 66 major countries then groups the remaining world trade partners into 12 regions according to their geographic location.

Accordingly, they forecast 88 commodities among 78 countries or regions and include 528,528 potential trade flows.

The GI trade forecast for Charleston includes 78 countries (e.g. Brazil) or regions (e.g. Other Southern Africa). First, the data by trade locations were grouped by the world region where they are geographically located. The world regions which trade with Charleston Harbor were used for this grouping: Africa, CAR CA, ECSA, NEUR, FE, ISC/ME, MED, and WCSA.

Table 2-7 displays GI's imports forecast by world region for selected years within the forecast period. The world region aggregate was developed by combining the tonnages from each country or region. The GI forecast indicates that FE Region[2], NEUR and the ISC/ME will dominate Charleston imports, growing to 5.3 million tons, 4.4 million tons, and 3.1 million tons, respectively, by 2037.

Table 2-7. GI's Charleston Harbor containerized trade forecast-imports

Charleston World Region	2015	2020	2025	2030	2035	2036	2037
Africa	116,083	133,669	156,266	178,575	202,693	208,555	213,754
CAR CA	106,490	122,297	141,732	161,220	184,195	189,346	194,732
ECSA	494,168	617,955	790,617	980,346	1,155,306	1,193,930	1,235,557
FE	1,990,131	2,616,143	3,486,518	4,349,174	5,017,398	5,144,618	5,288,493
ISC/ME	1,001,303	1,394,585	1,932,128	2,518,341	2,939,586	3,018,403	3,116,986
MED	38,646	46,022	55,484	65,372	76,961	79,643	82,372
NEUR	2,495,575	2,844,482	3,278,432	3,708,359	4,208,321	4,321,882	4,438,932
WSCA	126,368	137,474	151,070	165,615	182,247	185,911	189,638
Total Imports	**6,368,764**	**7,912,626**	**9,992,247**	**12,127,003**	**13,966,707**	**14,342,288**	**14,760,464**

Source: IHS Global Insight

The import forecast yearly rate of change for each region between each year is shown in Table 2-8. The rate of change was calculated from the annual commodity forecast developed by GI. The data illustrate that economic conditions are cyclical and that the fastest growth will take place in the FE, the ISC/ME.

Table 2-8. Charleston Harbor import forecast-percent rate of change

[2] The Far East Region is served by three service routes: FE (Panama), FE (Suez) & FE ECUS NEUR PEN.

Charleston World Region	2012*	2013*	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
AFRICA	3%	6%	4%	4%	3%	4%	2%	2%	2%	4%	3%	3%	3%	3%	3%	3%	3%	3%	2%	3%
CAR CA	4%	7%	4%	4%	3%	4%	2%	2%	2%	4%	3%	3%	3%	3%	3%	3%	3%	3%	2%	3%
ECSA	4%	8%	5%	5%	4%	6%	4%	4%	4%	5%	5%	5%	5%	5%	5%	5%	5%	5%	3%	3%
FE	4%	9%	6%	6%	5%	7%	5%	5%	6%	7%	6%	6%	5%	6%	5%	5%	5%	5%	3%	3%
ISC/ME	8%	13%	9%	8%	7%	9%	6%	6%	6%	7%	7%	7%	7%	7%	7%	6%	6%	6%	2%	3%
MED	3%	6%	4%	4%	3%	5%	3%	3%	3%	4%	4%	4%	4%	4%	4%	3%	3%	3%	3%	3%
NEUR	5%	6%	3%	3%	2%	4%	2%	2%	2%	4%	3%	3%	3%	3%	3%	2%	3%	2%	2%	2%
WSCA	4%	4%	1%	1%	1%	3%	1%	1%	1%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%

Source: IHS Global Insight

*Actual aggregate growth rates for2011, 2012 and 2013 exceeded the forecasted rates by 19%, 24% and 23%, respectively

The FE, NEUR and ISC/ME regions are forecast to receive 73% of exports shipped from Charleston. Exports to NEUR are forecast to total 2.2 million tons in 2015 and grow to 4.6 million tons by 2037. Similarly exports to the FE are forecast to total 1.4 million tons in 2015 and grow to 4.7 million tons in 2037 (Table 2-9)

Table 2-9. GI's Charleston Harbor containerized trade forecast-exports

Charleston World Region	2015	2020	2025	2030	2035	2036	2037
Africa	312,837	389,637	471,498	553,197	643,229	664,252	682,397
CAR CA	193,952	245,755	296,945	350,240	412,509	426,296	440,880
ECSA	752,506	943,352	1,148,964	1,373,285	1,637,265	1,696,845	1,761,211
FE	1,410,624	2,018,677	2,881,146	3,915,564	4,489,984	4,607,573	4,737,197
ISC/ME	1,069,895	1,436,594	1,833,078	2,257,590	2,666,059	2,753,131	2,842,377
MED	143,683	182,023	222,333	264,847	313,072	323,869	335,083
NEUR	2,161,214	2,708,980	3,251,720	3,788,073	4,371,494	4,501,611	4,642,103
WCSA	279,924	347,914	410,823	471,334	541,146	557,090	573,854
Total Exports	**6,324,636**	**8,272,932**	**10,516,509**	**12,974,130**	**15,074,759**	**15,530,666**	**16,015,103**

Source: IHS Global Insight

The export forecast rate of change are shown in Table 2-10. As illustrated the rate of change varies by trade region and year. The amount of uncertainty or risk of exports appears to be less pronounced than that of the forecasted imports. Also the rate of change in exports is slightly higher than that of imports.

Table 2-10. Charleston Harbor export forecast-rate of change

Charleston World Region	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
AFRICA	9%	7%	6%	5%	4%	4%	5%	5%	5%	4%	4%	4%	4%	4%	4%	3%	3%	3%	3%	3%
CAR	5%	5%	5%	5%	5%	5%	5%	5%	5%	4%	4%	4%	4%	3%	3%	3%	3%	3%	3%	3%
ECSA	8%	6%	5%	5%	5%	5%	5%	5%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	3%	4%
FE	9%	9%	8%	8%	7%	7%	7%	7%	7%	7%	7%	7%	7%	7%	7%	7%	7%	7%	2%	3%
ISC/ME	13	12	9%	8%	7%	6%	6%	6%	6%	5%	5%	5%	5%	5%	5%	5%	5%	5%	3%	3%
MED	4%	5%	6%	5%	5%	5%	5%	5%	5%	4%	4%	4%	4%	4%	4%	4%	4%	4%	3%	3%
NEUR	3%	5%	5%	5%	5%	5%	5%	5%	4%	4%	4%	4%	4%	3%	3%	3%	3%	3%	3%	3%
WSCA	2%	4%	4%	4%	5%	4%	5%	4%	4%	4%	4%	3%	3%	3%	3%	3%	3%	3%	3%	3%

Numerous container services call on Charleston Harbor which are operated by many carriers and have trade routes which originate in various parts of the world. Therefore services were grouped by the world region that they serve. For example, there are a number of services that call on various ports in the FE, transit the Panama Canal, proceed to ports along the east coast of the East Coast of the U.S. (ECUS), and then return to the FE. Services that represent trade within this world area were grouped and entitled "FE (Panama) ECUS". Other services generally involve trans-oceanic string of ports structured as a continuous loop. The FE ECUS NEUR PEN is a combined world region service and represents both the FE region and the NEUR services. Those services called on various ports in the FE, transit the Panama Canal, proceed to ports along the ECUS, proceed to NEUR, and then return to the FE. The "PEN" indicates a pendulum service.

The FE and NEUR services were initially analyzed separately but some parts or portions of these regions were later combined to create a pendulum because these services represent a fraction of the projected containerized movement for another service. Traffic for the FE Region was split as follows: FE (Panama) 37 percent, FE (Suez) 22 percent, and FE ECUS NEUR PEN 41 percent. Similarly containerized movement for the NEUR region was split into NEUR 68 percent and FE ECUS NEUR PEN by 32 percent. The FE ECUS NEUR PEN from FE region and FE ECUS NEUR PEN from the NEUR region were combined to create one pendulum. Services that represent trade within this world area were grouped and entitled FE ECUS NEUR PEN.

The FE (Panama) ECUS service calls on FE ports, crosses the Pacific Ocean, and transits the Panama Canal before calling on ECUS ports. After completing the vessel's ECUS rotation, the ship returns to the FE via the Panama Canal. Similarly, the FE (Suez) ECUS service calls on various ports in the FE and Africa before transiting the Suez Canal and stopping at the Mediterranean. After its Mediterranean port of call, the vessel crosses the Atlantic and calls on numerous ECUS ports before returning to the FE by calling on many of the same ports visited during the first leg of its voyage.

Table 2-11 summarizes the total TEU import and export forecasts. Port capacity (4.2 million TEU) is forecasted to be reached in 2039; therefore, the long-term forecast was constrained to the 2037 levels of about 4 million TEUs from that point forward. As shown in Table 2-12, ISC/ME, NEUR and the FE trade is forecasted to continue to dominate imports over the entire forecast period.

Table 2-11. Total TEU forecast by trade route for imports and exports

TOTAL TEUS - IMPORTS				
	2022	2027	2032	2037
Africa	34,193	39,644	45,017	51,185
CAR CA	8,388	9,618	10,914	12,522
ECSA	79,325	100,885	121,363	143,340
FE (Panama)	175,760	228,868	273,597	313,637
FE (Suez)	111,639	145,372	173,783	199,215
FE ECUS NEUR PEN	102,765	126,291	147,494	168,677
ISC/ME	194,313	266,262	326,969	379,806
MED	36,553	43,601	51,182	60,465
NEUR	309,228	352,267	397,821	453,341
WCSA	40,961	44,858	49,191	54,253
Total	**1,093,126**	**1,357,666**	**1,597,329**	**1,836,442**

TOTAL TEUS - EXPORTS				
	2022	2027	2032	2037
Africa	44,176	52,828	61,525	71,499
CAR CA	10,287	12,277	14,448	17,041
ECSA	76,621	92,524	110,240	131,888
FE (Panama)	216,152	308,380	383,430	439,771
FE (Suez)	113,269	161,599	200,928	230,452
FE ECUS NEUR PEN	145,472	189,971	228,538	263,342
ISC/ME	213,525	269,702	325,151	382,091
MED	43,855	53,072	62,739	74,336
NEUR	286,616	339,794	392,336	454,792
WCSA	66,998	77,994	89,246	102,934
Total	**1,216,971**	**1,558,142**	**1,868,581**	**2,168,146**

2.2.2 Existing Fleet - Vessel Classes

In this analysis, containerships are classified as sub-Panamax, Panamax, Post-Panamax Generation I (PPX1), Post-Panamax Generation II (PPX2), and Post-Panamax Generation III (PPX3) based on a combination of vessel characteristics. Table 2-12, below, provides some current vessel attributes that were used in the analysis to characterize each class of vessel.

Table 2-12. Generalized containership class & subclass attributes

Vessel Class	Vessel Subclass	LOA	LBP	Beam	Maximum SLLD	Capacity (DWT)	Applied Draft	TEU Rating	% of Class
Sub Panamax	SPM - Ag - CL 7	571	534	87	31	20,643	31.00 to 31.99	1,447	0.4
Sub Panamax	SPM - Ag - CL 8	576	540	84	32	22,184	32.00 to 32.99	1,529	11.2
Sub Panamax	SPM - Ag - CL 9	585	549	90	33	24,283	33.00 to 33.99	1,618	0.4
Sub Panamax	SPM - Ag - CL 10	596	559	92	35	24,812	34.00 to 34.99	1,778	6
Sub Panamax	SPM - Ag - CL 11	603	566	92	36	25,370	35.00 to 35.99	1,895	4.4
Sub Panamax	SPM - Ag - CL 12	657	621	98	36	31,139	36.00 to 36.99	2,268	22.4
Sub Panamax	SPM - Ag - CL 13	676	636	99	38	33,887	37.00 to 37.99	2,470	55.2
Panamax	PMX - Ag - CL 1	777	729	105	38	42,183	38.00 to 38.99	3,084	6.8
Panamax	PMX - Ag - CL 2	766	723	104	39	43,311	39.00 to 39.99	3,188	12.9
Panamax	PMX - Ag - CL 3	794	753	106	40	44,991	40.00 to 40.99	3,389	3
Panamax	PMX - Ag - CL 4	846	801	106	41	50,070	41.00 to 41.99	3,841	35.8
Panamax	PMX - Ag - CL 5	907	859	106	43	56,792	42.00 to 42.99	4,125	12.3
Panamax	PMX - Ag - CL 6	887	839	104	43	54,885	43.00 to 43.99	3,993	0.9
Panamax	PMX - Ag - CL 7	959	921	106	44	64,956	44.00 to 44.99	5,100	28.3

Vessel Class	Vessel Subclass	LOA	LBP	Beam	Maximum SLLD	Capacity (DWT)	Applied Draft	TEU Rating	% of Class
PPX 1	PPXGn I - CL 5.50	1045	905	132	48	80,651	46.00 to 46.99	7,600	100
PPX 2	PPXGn II - CL 10.50	1205	1060	143	49	106,737	47.00 to 48.99	12,000	100
PPX 3	PPXGn III - CL 11.10	1201	1148	158	50	138,080	49.00 to 49.99	12,000+	100

One characteristic that commonly defines a vessel class size is the vessel's beam (width). Currently, the largest beam that can be accommodated by the Panama Canal is 106 feet. This width has historically defined the beam of Panamax vessels. However, Panamax vessel lengths, drafts, and TEU capacities have increased over time such that some of the newer Panamax containerships have a rated capacity of 5,100 TEUs, which is double the capacity of some older Panamax containerships.

The existing Charleston Harbor navigation system, completed in 2004, was designed to serve Panamax and similar size container vessels limited to a draft of about 42 feet. When the most recent harbor improvements were authorized in 1996, Sub Panamax and Panamax vessels made up about 80 percent of the containership capacity in the world fleet and new-build vessels, and all of the fleet calling Charleston. Since then, larger Post-Panamax, including PPX3 class vessels have accounted for increasing percentages of new-build vessels and the world fleet. Figure 2-6 illustrates the trends in average gross tonnage transported on both the average and deepest drafting vessels serving Charleston Harbor from 2006 to 2013.

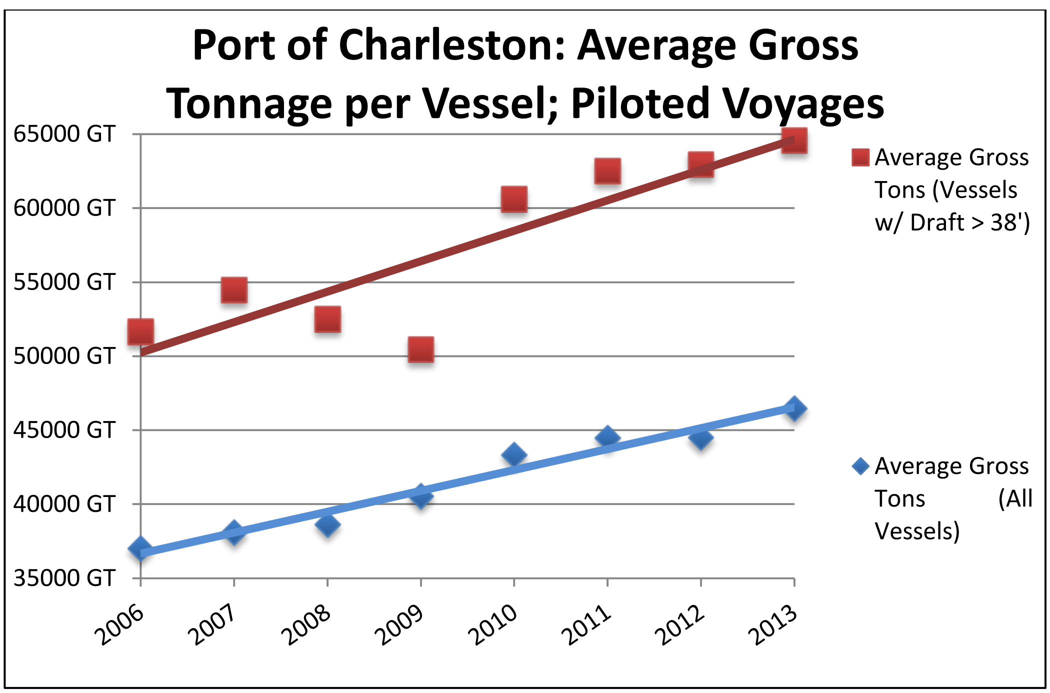


Figure 2-6. Piloted vessels annual average gross tonnage from 2006 to 2013

The increasing average tonnage reflects the historical and ongoing increase in the size of vessels serving Charleston Harbor. Since 2006, the average per-vessel tonnage has increased by about 25 percent for all vessels and by about 27 percent for the deepest drafting vessels. This large shift in vessel size was not anticipated in the 1996 study.

The containership fleet currently calling on the Port of Charleston consists mostly of Panamax, Post-Panamax Generation 1, and Post-Panamax Generation 2 vessels. All of the Asian services currently calling on the port via the Panama Canal deploy Panamax vessels. Post-Panamax vessels currently calling on the Port are deployed on services to the Middle East, India, Europe, and Asia via the Suez Canal. The liner services presented in Table 2-13 are regularly scheduled weekly services, which call at each foreign and U.S. port in the service loop at a specified day of the week. The longer the liner service loop (greater distance and/or more ports) the greater the number of vessels deployed on the service to maintain a weekly schedule at each port. Currently, all Generation III and all other container vessels drafting more than 41 feet have been limited to the Wando Welch Terminal. Additional details can be found in Appendix C.

The size of containerships on routes not constrained by the Panama Canal has been increasing. Provided there is sufficient cargo to maintain an efficient level of vessel utilization, larger vessels are more economically efficient and typically replace smaller vessels as cargo volumes increase. It is important to note that cargo volumes on a liner service may increase due to growth in trade, or consolidation of multiple carriers on a service. These two conditions combined with the availability of Post-Panamax Generation 1 and Post-Panamax Generation 2 vessels, which have been replaced with even larger vessels on Asia to Asia and Asia to Europe services, has led to an increase in vessel size at Charleston and other U.S. east coast ports. Table 2-13 shows vessel and capacity increase between Q1 2012 and Q3 2014 for selected routes for the Port of Charleston.

Table 2-13. Port of Charleston liner services (July 2014)

Weekly Services	Main Carrier	Foreign Countries Served	Vessel Size (TEUs)
Americas/ECNA-WCSA	Hamburg Sud/CSAV	Columbia, Panama, Chile, Ecuador, Peru	3,100-4,250
AMEX	Maersk/MSC	Bahamas, South Africa	1,800-3,200
AWE3	CKYH-Green Alliance	China, South Korea, Mexico	4,000-4,700
AWE5	CKYH-Green Alliance	China, South Korea	4,000-4,300
AX2	G6 Alliance	England, Belgium, Germany, France, Mexico	4,600-4,900
CEC	G6 Alliance	China, Singapore, Saudi Arabia, Viet Nam	8,100-9,600
ECNA - WCSA	MSC	Bahamas, Jamaica, Panama, Columbia, Peru, Chile	4,300-5,100
Golden Gate	MSC	China, Singapore, Israel, Bahamas, India	8,000-9,200
Indamex	CMA CGM/APL/Hapag	Pakistan, India, Egypt, Saudi Arabia	4,100-5,100
Indus Express	MSC	India, Spain, Bahamas	2,700-5,000
MECL1	Maersk	Spain, United Arab Emirates, Pakistan, India, Oman	6,200-6,400
NUE	Evergreen	South Korea, China, Japan, Panama	4,200-5,100
AANZ/OC1	Hamburg Sud/Maersk	Columbia, Panama, New Zealand, Australia	3,100-4,100
PA2	G6 Alliance	Taiwan, South Korea, Japan, Panama, Netherlands, Germany, England, France	4,300-4,900
PEX 3	CMA CGM	China, South Korea, Panama, Russia	4,400-5,100
SCE	G6 Alliance/Zim	China, South Korea, Panama, Jamaica	4,300-5,100
SVS	G6 Alliance/MOL	Viet Nam, China, Singapore, Spain, India	6,400-7,000
TA2	Maersk	Netherlands, England, Germany	4,200-4,300
Tango	Hamburg Sud/CSAV	Brazil, Argentina,	4,100-4,600
TAS1	CKYH-Green Alliance	Belgium, Germany, Netherlands, France	4,300-5,100
TP7	Maersk	Taiwan, China, Malaysia, Egypt, Morocco, Saudi Arabia	6,200-8,500
US Gulf	MSC	Belgium, Netherlands, England, Germany, France, Mexico, Bahamas	6,400-6,800
Victory Bridge/SAMEX	CMA CGM/CSAV	France, Belgium, Netherlands, Germany, Mexico	3,400-4,300

Notes:

G6 Alliance: APL, Hapag-Lloyd, HMM, MOL, NYK, OOCL
CKYH-Green Alliance: COSCON, Hanjin, Kline, Yang Ming
Source: Lloyd's List Intelligence (www.lloydslistintelligence.com accessed 04July14)

2.2.3 Existing Sailing and Design Drafts

Due to differences in the density of imports and exports, containerships often depart Charleston with drafts deeper than the vessel's arrival draft. For a multi-year sample (2010-2013) of more than 300 arrival and departure drafts for a service to Europe and the Middle East, departure drafts were greater than arrival drafts for all but one call. This particular service to Europe and the Middle East deploys mostly Post-Panamax Generation 1 and Post-Panamax Generation 2 vessels, with vessel TEU capacity ranging from 4,400 to 8,400. These vessels make extensive use of the tide to sail at drafts deeper than the unrestricted[3] 41-foot sailing draft indicated by the blue vertical line in Figure 2-7. The vessels on this service also load deeply relative to their design draft (Figure 2-8), which indicates that Post-Panamax Generation 1 and Post-Panamax Generation 2 vessels are currently being used to maximum efficiency on some calls at the Port.

Table 2-14. Selected routes: Port of Charleston vessel and capacity increases

Trade Route		Q1 2012	Q3 2014
Europe-North America	Total Route Capacity (TEUs)	333,099	530,878
	Number of Vessels	75	96
	Average Vessel (TEUs)	4,441	5,530
Mid-East Gulf/India-North America	Total Route Capacity (TEUs)	300,753	591,476
	Number of Vessels	63	101
	Average Vessel (TEUs)	4,774	5,856

Notes: Q1 2012 = first quarter of 2012; Q3 2014 = third quarter of 2014 (current)
Source: Lloyd's List Intelligence (www.lloydslistintelligence.com accessed 05July14

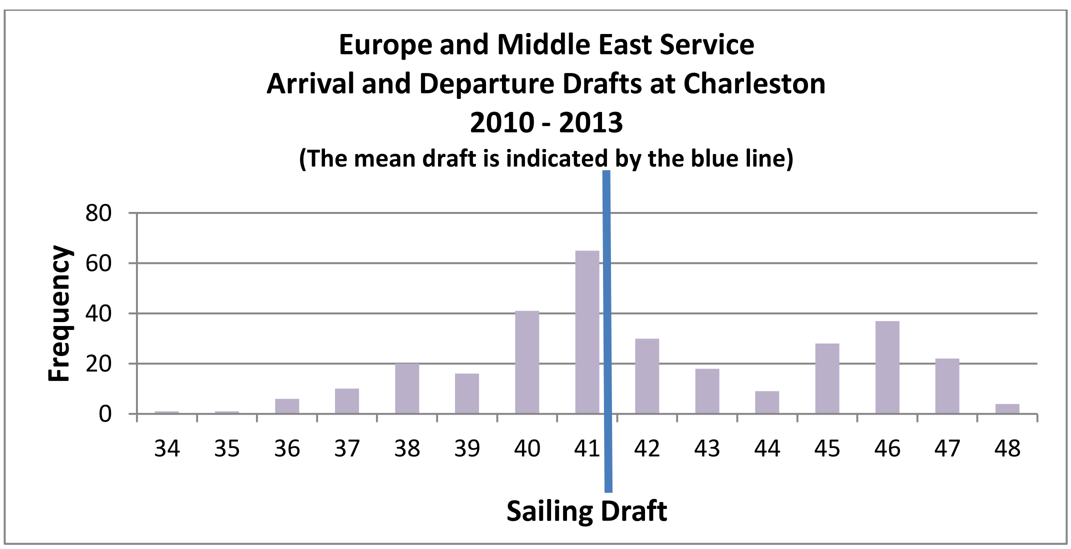


Figure 2-7. Port of Charleston draft data (2010-2013)

[3] The Port of Charleston has a controlling depth of 45 feet. Accounting for 4 feet of underkeel clearance for Post-Panamax vessels, indicates that any vessel sailing with a draft deeper than 41 feet would require tidal assistance to maintain a minimum of 4 feet of underkeel clearance.

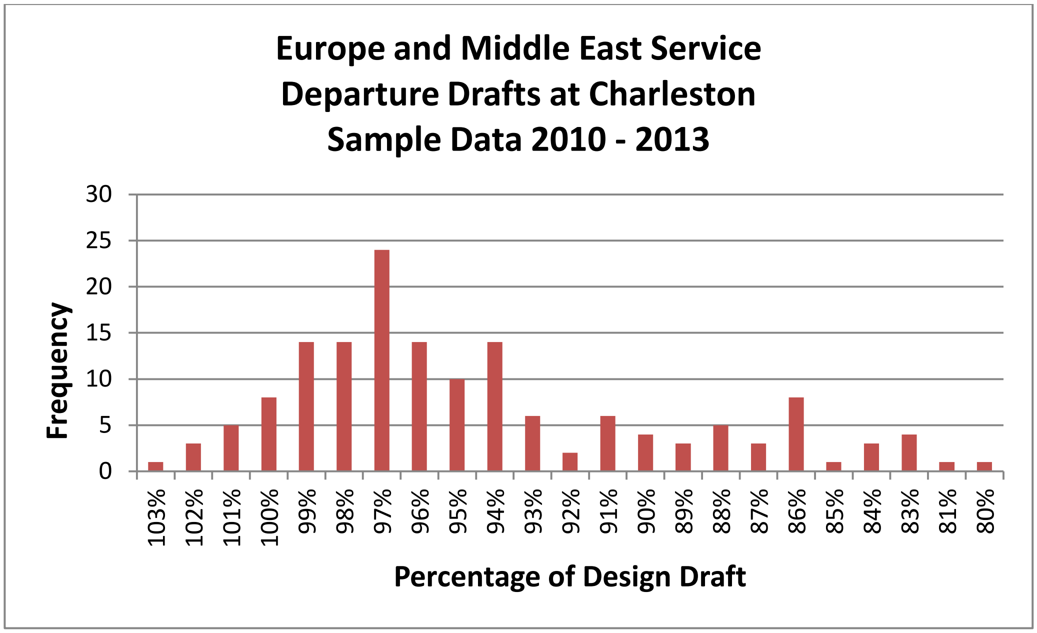


Figure 2-8. Port of Charleston sample departure draft data (2010-2013)

Future Vessel Fleet Characteristics

To develop projections for the future fleet calling on Charleston, a World Fleet forecast of containerships was obtained from Maritime Strategies Inc, (MSI). These projections provided a forecast of total capacity calling on Charleston Harbor and a breakdown of that capacity into containership size and TEU classes. The methodology developed by MSI was then linked to the commodity forecast presented earlier in this Report. Table 2-15 shows the fleet subdivision using common vessel labeling terminology and vessels specifications for beam, length over all (LOA), and design drafts. These classification criteria reflect the industry standards and vary slightly from the classification criteria by IWR.

Table 2-15. MSI fleet subdivisions based on draft, beam and LOA

		Feet	
		From	**To**
Sub Panamax	Beam	34.8	98.2
(TEU size brackets: 0.1-1.3, 1.3-2.9 k)	Draft	8.2	38.1
	LOA	221.7	813.3
		From	**To**
Panamax	Beam	98.4	106.3
(TEU size brackets: 1.3-2.9, 2.9-3.9, 3.9-5.2 k)	Draft	30.8	44.8
	LOA	572.0	967.5
Panamax Category 1 (to 899 ft LOA)	Beam	100.1	106.0
	Draft	30.8	38.9

		Feet	
		From	**To**
	LOA	572.0	899.0
Panamax Category 2 (900-967.5 ft LOA)	Beam	98.4	106.1
	Draft	39.1	44.8
	LOA	899.3	967.5
		From	**To**
Post-Panamax Generation I	Beam	120.0	138.8
(TEU size brackets:	Draft	35.4	47.6
1.3-2.9, 2.9-3.9, 3.9-5.2, 5.2-7.6 k)	LOA	660.8	1,044.7
		From	**To**
Post-Panamax Generation II	Beam	138.8	143.9
(TEU size brackets: 5.2-7.6, 7.6-12 k)	Draft	39.4	49.2
	LOA	910.7	1,205.0
		From	**To**
New Panamax Generation III	Beam	144.0	168.0
(MSI size brackets: 5.2-7.6, 7.6-12, 12 k +)	Draft	42.7	49.5
	LOA	1,036.7	1,200.8
		From	**To**
Post-Panamax Generation IV	Beam	168	185.0
(TEU size brackets: 7.6-12, 12 k +)	Draft	50.9	52.6
	LOA	1,140.0	1,304.8

A vessel allocation forecast was generated by combining information from the commodity forecast with MSI's forecasted fleet capacity, the number of Post-Panamax, Panamax, and Sub- Panamax vessels calls to Charleston's fleet. The 2011 fleet is shown by TEU bands in Table 2-16.

Table 2-16. World fleet by TEU Band- 2011

TEU Band	Count
0.1 k to 1.3k TEU	1,635
1.3 k to 2.9 k TEU	1,440
2.9 k to 3.9 k TEU	343
3.9 k to 5.2 k TEU	721
5.2 k to 7.6 k TEU	483
7.6 k to 12 k TEU	309
12 k TEU +	78
Total	**4,864**

The allocation to vessel classes was based on MSI's examination of historical utilization of Panamax vessels, current trends in vessel design, vessel replacement, orders for new vessels and the expected worldwide redeployment of vessels affected by the expansion of the Panama Canal. The number of transits, particularly those made by larger vessels, was a key variable in calculating the transportation costs. Details related to the vessel allocation forecast are provided in Appendix C.

Figure 2-9 shows the growth in selected fully cellular container (FCC) Post-Panamax TEU bands from the 2011 fleet. The figure shows the additional vessels expected to be added to the fleet.

These types of vessels and their operating characteristics are a key factor in the evaluation of port deepening studies like Charleston Harbor.

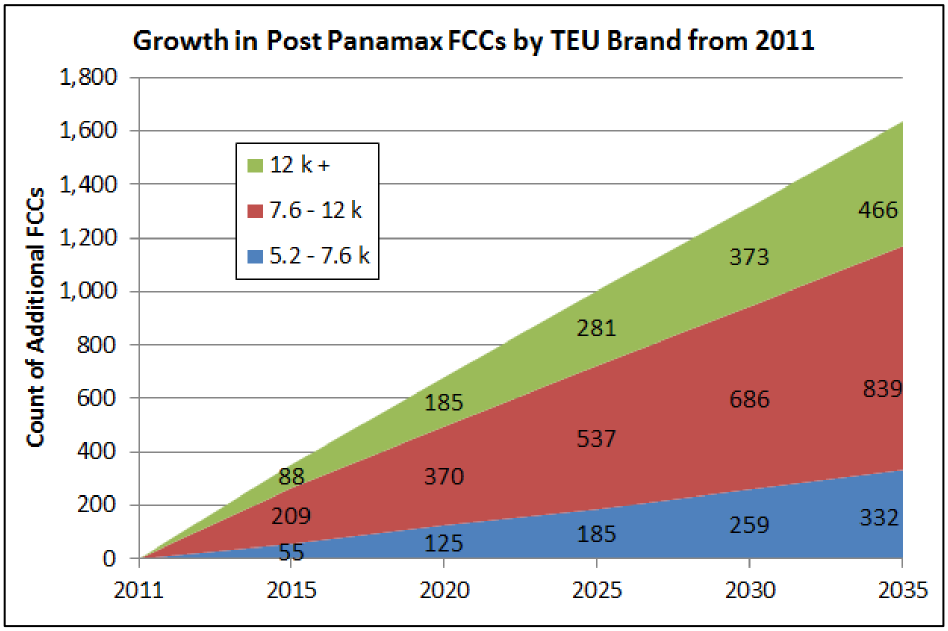
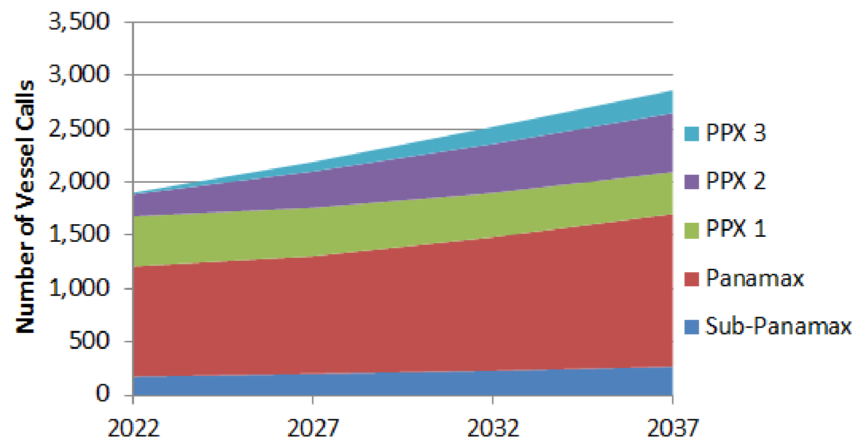


Figure 2-9. World fleet growth forecast of selected TEU bands

Figure 2-10 provides the initial forecast of containerized vessels through the year 2037. These values were input into HarborSym's[4] Container Loading Tool (CLT), which then estimated the number of vessel calls required to satisfy the commodity forecast, given the available fleet. The CLT data and loading algorithm is discussed in Section 4.1.2 of the Economics Appendix (Appendix C). It is worth noting that the without-project fleet forecast for the PPX3 container class is estimated to increase from 16 to 214 between 2022 and 2037. A review of maritime transport shows that in 2013, there were 163 vessels on the world's seas with a capacity over 10,000 TEU. However, 120 more are on order, including the Maersk's fleet of Triple Es. Triple E stands for energy efficiency, economies of scale and environmental improvement.

[4] The HarborSym Modeling Suite of Tools is USACE certified planning tool for estimating transportation cost savings benefits.



Vessel Class	2022	2027	2032	2037
Sub-Panamax	176	202	229	269
Panamax	1,035	1,103	1,255	1,434
PPX 1	470	456	416	392
PPX 2	206	342	460	555
PPX 3	16	89	161	214
Total	**1,903**	**2,192**	**2,520**	**2,863**

Figure 2-10. Initial forecast of vessel calls at Charleston

2.2.4 Port Hinterland and Clients

Existing Condition

The Port of Charleston has a favorable geographic location. It is located approximately half-way between New York City and Miami. Hence, it is well positioned to serve the broadest hinterland to the north, south, and west, especially the industry rich and fast-growing southeastern U.S. This also makes it an ideal fit as a first-in and last-out port of call for liner shipping services. Charleston offers customers the unique ability to consolidate operations and still efficiently serve the inland side from a central location.

The Port serves an extensive regional geography, with more than 20,000 companies in two dozen states using the Port of Charleston to access overseas suppliers and buyers. Charleston Harbor's hinterland is illustrated in Figure 2-11 along with the geographic regions that represent how container shipping lines importers and exporters tend to route their container cargo.

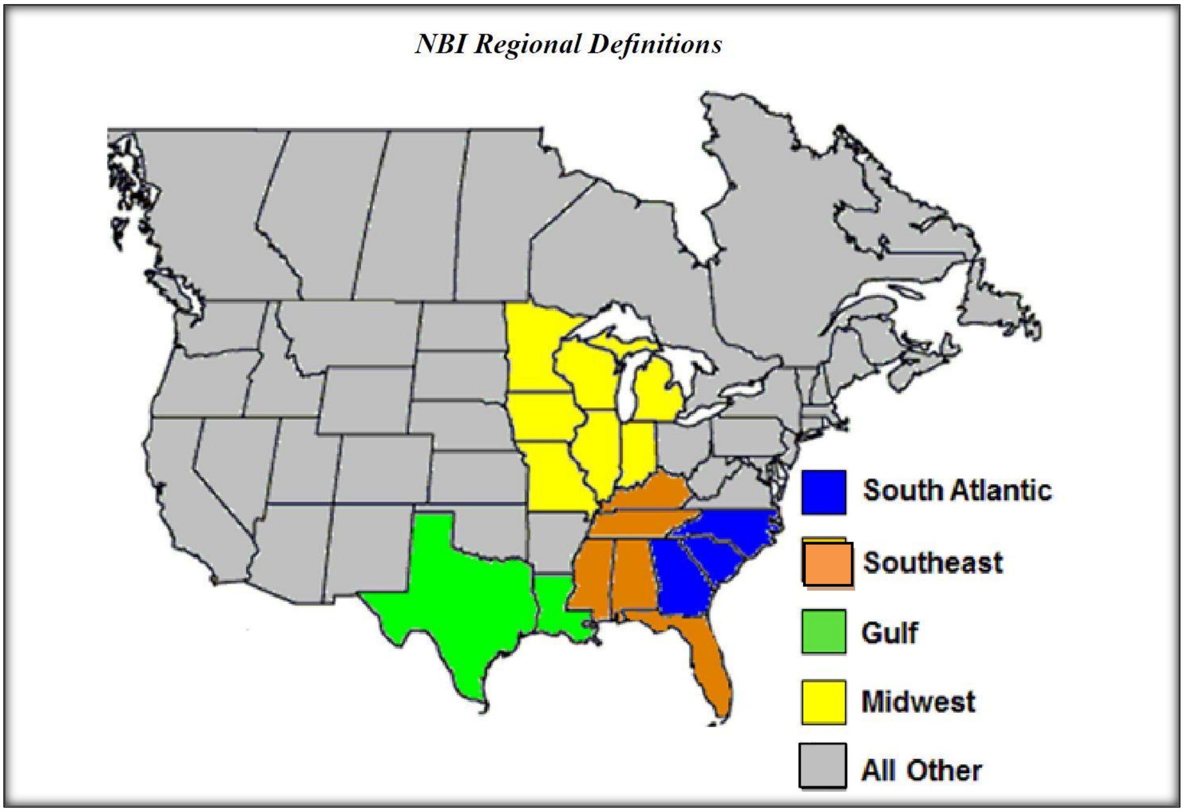


Figure 2-11. Geographic segmentation of Charleston Harbor hinterland (Source: Norbridge)

The South Atlantic and Southeast regions accounted for an estimated average 84 percent of the Port's loaded container traffic throughput during the period CY2008-CY2010. The remainder of the Port's loaded container traffic, on average, moved via three regions, i.e. the Midwest (8%), Gulf (4%), and All Other (4%) regions respectively.

The Port's container customer base includes global and North American centric manufacturers and retailers such as Toyota, Michelin, Lowes, Target, and Furniture Brands International. Figure 2-12 presents a representative cross section of container customers and locations.

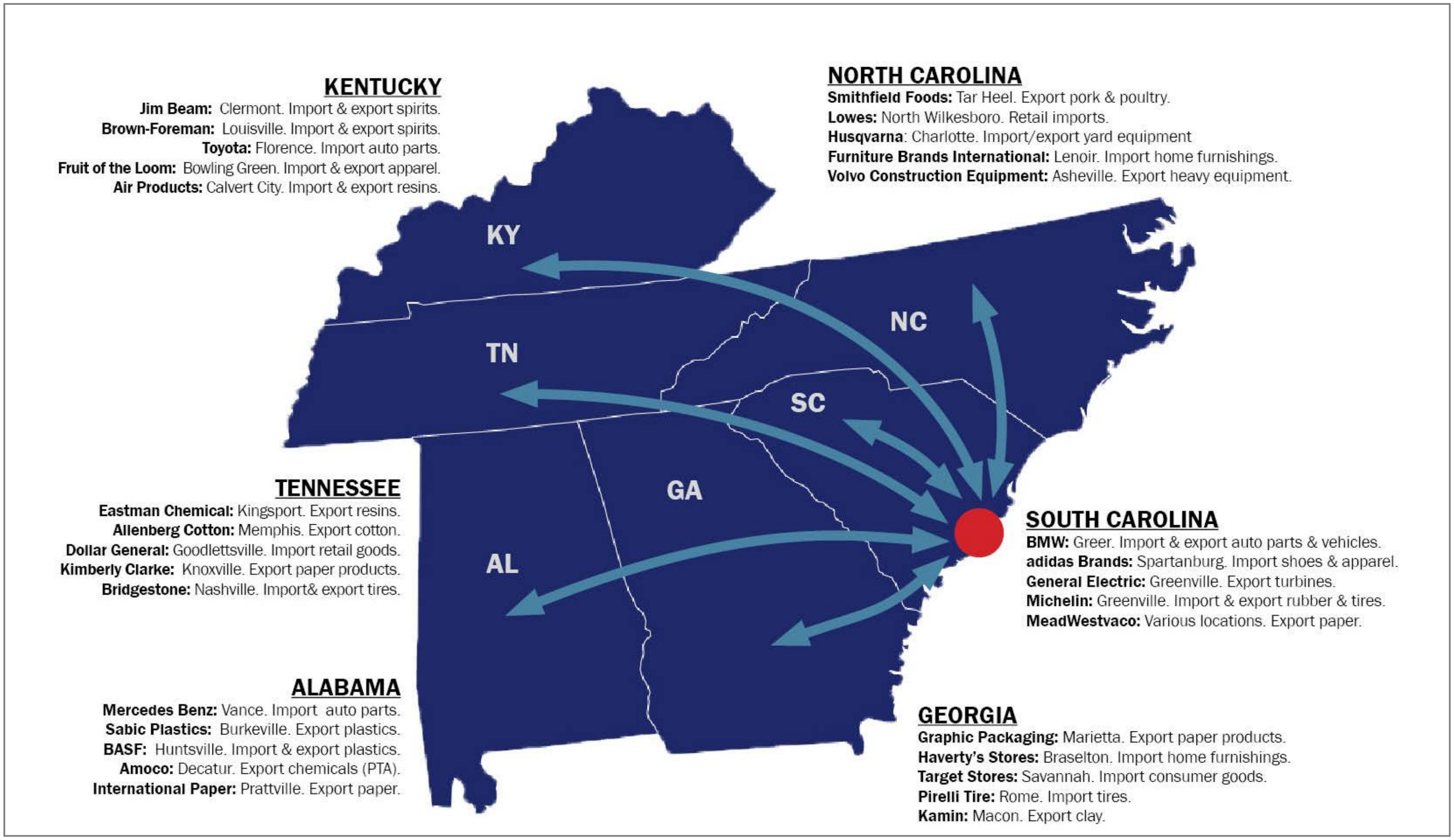


Figure 2-12. Port of Charleston representative container customers (Source: SCSPA)

The range in diversity of the Port's clients is represented by the variety of goods transferred via the Port and its hinterland infrastructure. As a port handling primarily containerized cargo, there are thousands of types of goods moving through the Port of Charleston. Tables 2-18 and 2-19 summarize the top commodities exported and imported through Charleston Harbor, respectively. A list of 20 top container export and import commodities for the Port of Charleston can be found in Appendix C (Economics).

Figure 2-13 illustrates the relative amounts of imports and exports associated with each region the port serves.

Future Without Project Condition

An essential step when evaluating navigation improvements is to analyze the types and volumes of cargo moving through the port and out to the hinterland. Trends in cargo history can offer insights into a port's long-term trade forecasts and thus the estimated cargo volumes upon which future vessel calls are estimated. As discussed earlier in this section, the future with-project and the without-project conditions use the same future cargo forecast. For the same reasons, the boundaries of Charleston Harbor's hinterland are not expected to change. However, a deepening project would allow shippers to load their vessels more efficiently or take advantage of larger vessels. This efficiency translates to savings and is the main component of the NED objective. Additional information related to the anticipated cargo and the potential impacts of cost savings on the hinterland are provided in Appendix C.

Imports are projected to increase from 6.4 million tons in 2015 to 14.8 million tons by 2037. Exports are projected to grow from 6.3 million tons in 2015 to 16.0 million tons by 2037. Dry bulk and containerized cargo have the highest share and are expected to grow faster over time relative to liquid bulk and general cargo. Containerized cargo is anticipated to be the most prominent import for the Port of Charleston over the period of analysis. Table 18 and Table 23, from Appendix C, provide details on the commodity growth rates and forecasted commodity TEUs by trade route from 2022 to 2037, respectively. The forecasted tonnages are based on a commodity forecast completed by Global Insight.

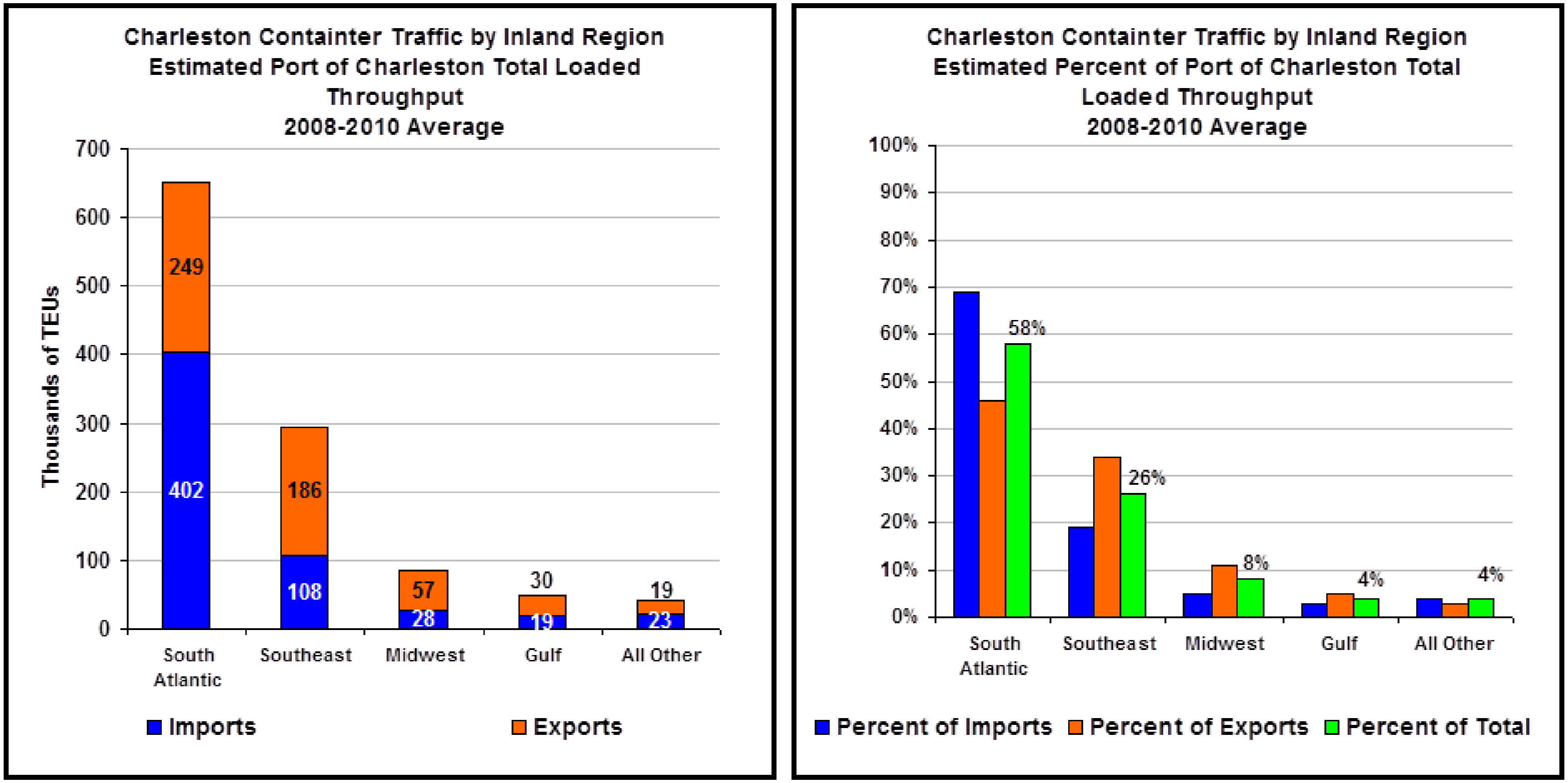


Figure 2-13. Charleston container traffic throughput

Source: Analysis of 2008-2010 Journal of Commerce PIERS DataNote: Redistributed an average of 181,000 not available import TEUs and 13,000 not available export TEUs between 2008-2010

2.3 Navigation Features

2.3.1 Navigation History

Federal involvement in the harbor began over 160 years ago when the River and Harbor Act (RHA) of 1852 initially authorized navigation improvements at Charleston. Federal participation in implementing major historical improvements at Charleston Harbor is summarized in Table 2-17.

Table 2-17. Federal participation in major improvements at Charleston Harbor

Year	Project	Authorization	Action
1852	Dredging	RHA of 1852	Harbor Deepening to 17' mean lower low water (MLLW)
1878	Deepen and jetties	RHA of 1878	Deepening to 21' MLLW through the Ocean Bar; constructed jetties to stabilize new channel
1899	Deepening	RHA of 1899	Harbor deepening to 26' MLLW
1904	Deepening	RHA of 1902	Harbor deepening to 30' MLLW
1940	Deepening & Extending	RHA of 1940	Deepen to 35' MLLW from ocean contour to North Charleston Terminal
1974 and 1980	Deepening and Extending	WRDA of 1986	Channel realignment, lower turning basins and Shipyard River to 38' MLLW, North Charleston Terminal to Entrance Channel to 40' MLLW, Entrance Channel to 42' MLLW.
1996	Deepening	WRDA of 1996	Adoption of Wando River for USACE maintenance; deepen from 35' to 40' MLLW
1999-2004	Deepening	WRDA of 1996	Deepen harbor to 45' MLLW (Entrance Channel extending to the 47-foot ocean contour) including +2' (allowable overdepth) +2' advanced maintenance

2.3.2 Existing Navigation Configuration and Dimensions

Existing Condition

The existing Federal Navigational Channel configurations were derived through a Feasibility Study completed in 1996. The important features and the vessel transit miles are illustrated on Figure 2-14 and the Section 2 Reference Aid at the end of this section. Detailed dimensions are provided in Table 2-18 and the typical Entrance Channel cross section is provided in Figure 2-15. Unless otherwise stated, all depths referenced in this Report are relative to MLLW.

Table 2-18. Maintained and authorized dimensions and maximum drafts for the Federal project

	Nominal Depth (MLLW)		Nominal Channel Width		
Reach or Segment	**Maintenance**	**Authorized**	**Maintenance**	**Authorized**	**Maximum Sailing Draft[1]**
Entrance Channel	47/42	47/42	42' at 1000'	42' at 1000'	47
Entrance Channel	47/42	47/42	47' at 800'	47' at 800'	47
Mount Pleasant Range	45	45	600-1000	600-1000	45
Rebellion Reach	45	45	600	600	45
Bennis Reach	45	45	600	600	45
Horse Reach	45	45	800	800	45
Hog Island Reach	45	45	600	600	45
Drum Island Reach	45	45	600	600	45
Myers Bend	45	45	VARIES	VARIES	45
Daniel Island Reach	45	45	880	880	45
Daniel Island Bend	45	45	700-780	700-780	45
Clouter Creek Reach	45	45	600	600	45
Navy Yard Reach	45	45	600-675	600-675	45
North Charleston Reach	45	45	500	500	45
Filbin Creek Reach	45	45	500	500	45
Port Terminal Reach	45	45	600	600	45
Ordnance Reach	45	45	1400	1400	45
Custom House Reach	45	45	Varies	Varies	45
Upper Town Creek	16	16	500	500	16
Lower Town Creek	45	45	400	400	45
Town Creek Turning Basin	35	35	300	300	35
Tidewater Reach	40	40	650	650	40
Wando Channel	45	45	400	400	45
Wando Turning Basin	45	45	1400	1400	45
Anchorage Basin	35	35	2250	2250	35
Shem Creek Channel	12	12	110	110	12
Shipyard River Entrance Channel	45	45	300	300	45
Shipyard River Basin A	45	45	700	700	45
Shipyard River Connector Channel	45	45	200	200	45
Shipyard River Basin B	30	30	600	600	30

[1] *The maximum sailing draft available during a flood tide condition of five to six feet (paragraph 2.4.2 Tides) to provide adequate underkeel clearance above the authorized project depth for a limited time during the flood tide cycle.*

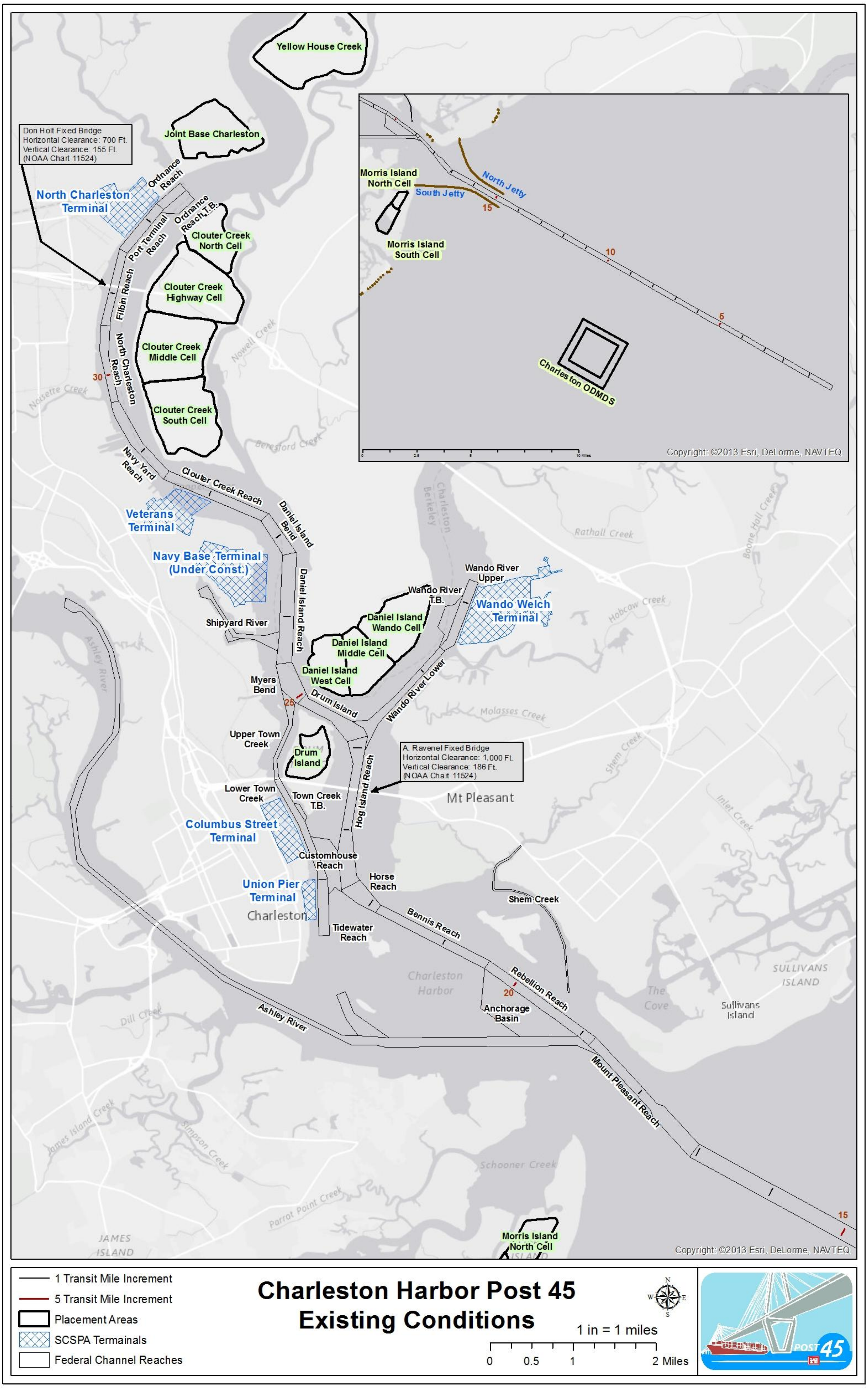


Figure 2-14. Charleston Harbor Navigation Features

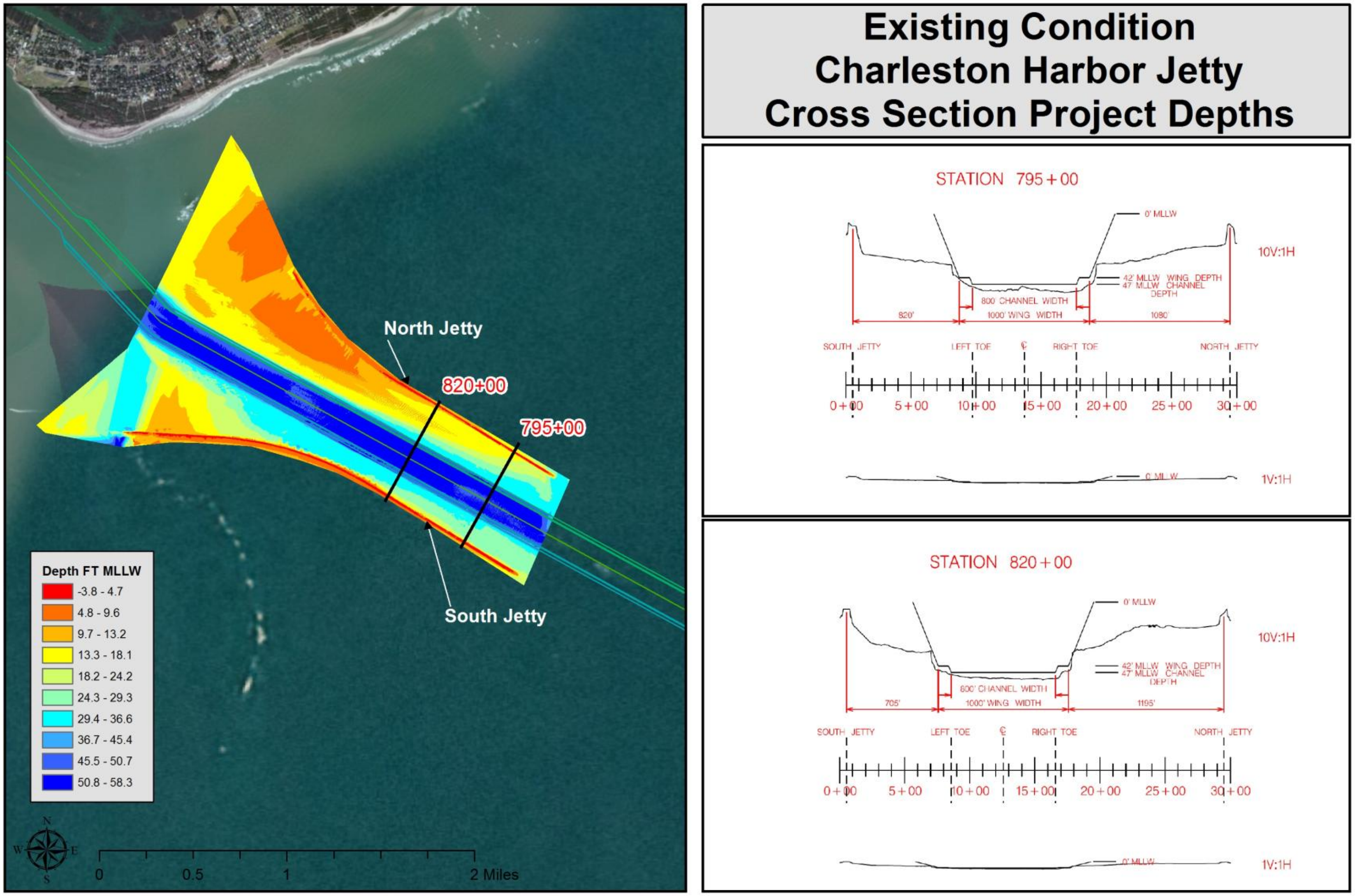


Figure 2-15. Typical Entrance Channel (Ft. Sumter Range) cross-section

Construction of the improvements authorized in 1996 Study was completed in 2004. The existing channels extend about 27 miles from the North Charleston Terminal on the Cooper River to the 47-foot ocean contour; the seaward 16 mile portion is considered the Entrance Channel.

The Entrance Channel is authorized and maintained to -47 feet MLLW. The depth of the Entrance Channel is 2 feet deeper than the inner harbor channels to account for wave action and vessel movement seaward of the inlet. Two-way traffic is permitted throughout the Entrance Channel.

Most of the of channels in the lower harbor are authorized and maintained to -45 feet MLLW (exclusive of advance maintenance and overdepth dredging) and 600 feet wide with a short reach south of Daniel Island that is 800 feet wide and a 2-mile reach from the Cooper River to the Wando Terminal that is 400 feet wide. Two-way traffic is permitted in the lower harbor except within the 400-foot-wide reach to the Wando Terminal, the Hog Island Reach under the Ravenel Bridge, and the Drum Island Turn from Drum Island Reach to Myers Bend. The Upper Harbor channel extends up the Cooper River to the North Charleston terminal and a 200 to 300 foot wide reach extends up the Shipyard River to a terminal that serves liquid and dry bulk vessels. The reaches extending up the Cooper River to the new Navy Base Terminal are from 600 to 880 feet wide. Upstream of the new terminal along the Cooper River, the channel is 500 feet wide. A small, 110-foot-wide by 12-foot-deep navigational channel extends through the northeastern portion of the lower harbor (behind Crab Bank) and up Shem Creek to Mount Pleasant.

A 35-foot deep (MLLW) anchorage basin exists but, due to limited funding, it has been dredged infrequently. It was last dredged in 2013 to 33 feet MLLW.

Future Without Project Condition

The federal project would remain as designed in its current dimensions in the FWOP condition. No changes to the footprint of the federal project, as described in Table 2-18, would occur.

2.3.3 Port Facilities

Existing Condition

The SCSPA operates five cargo terminals in the Port of Charleston and is constructing a sixth terminal (New Navy Base Terminal) that is expected to be operational by 2018:

- North Charleston Terminal (NCT): primarily containers, but can process break-bulk and roll-on/roll-off cargoes
- Wando Welch Terminal (WWT): containers
- Columbus Street Terminal (CST): roll-on/roll-off and project cargoes/heavy lift (transitioned from a container terminal, but containers capabilities remain on-site)
- Veterans Terminal: conventional break-bulk, roll-on/roll-off and project cargoes
- Union Pier Terminal (UPT): conventional break-bulk, roll-on/roll-off and project cargoes

The WWT, NCT and CST are located about 22, 28.5, and 20 miles from the sea buoy, respectively. The WWT, NCT, and CST can accommodate vessels drafting over 40 feet. The locations of the facilities are shown in Figure 2-14, above, and are further described below.

The Wando Welch Terminal is the port's largest terminal in both size and volume. With about 3,800 feet of berthing space, the terminal is served by ten container cranes (six super post-Panamax and four post-Panamax). The terminal offers about 250 acres of container storage space and a 4.6 acre Container Freight station. The terminal is about 22 miles (about 1.5 hours transit time) from the open ocean (sea buoy) and has close access to the I-526 highway interchange.

The Columbus Street Terminal was transitioned from container and project cargo/heavy lift operations to Roll on/Roll off, breakbulk, and project cargo/heavy lift operations in 2011. The CST retains its container handling capability and can be transitioned back to container operations if needed. The CST has about 3,300 feet of continuous berthing space, over 76 acres of open storage and almost 20 acres of sprinkler-protected warehouses with covered rail access as well as easy access to Interstate Highway 26. It is about 20 miles (about 1.5 hours transit time) to the open ocean.

The North Charleston Terminal is a modern container terminal with three berths totaling 2,500 feet, 130 acres of open storage area, a 9-acre Container Freight Station, and about 91,000 square feet of leased warehouse space located just outside the gate. It has an on-site rail yard direct access to Interstate highways 26 and 526. The terminal can also handle break-bulk and roll-on/roll-off cargoes. The terminal is about 28.5 miles (about two hour transit time) to the open ocean.

The Veterans Terminal is a bulk, break-bulk, roll-on/roll-off, and project cargo terminal. The terminal has about 110 acres of outside storage and covered sprinkler-protected warehouses. It has three piers with a total of almost 5,000 feet of berthing space. It is about 24 miles (about 1.5 hours transit time) to the open ocean.

The Union Pier Terminal (UPT) is dedicated to break-bulk and roll-on/roll-off cargoes. It has four berths totaling about 2,500 feet and almost 160 acres of sprinkler-protected transit shed. It has easy access (about 1.5 miles) to Interstate Highway 26, is served by multiple rail lines, and all warehouses have covered rail access. It is about 19.5 miles (about 1.5 hours transit time) to the open ocean.

Other Charleston Harbor Terminals: A new terminal (New Navy Base Terminal) is being constructed at the Charleston Naval Complex (CNC). It will be operated primarily as a container terminal. Terminal infrastructure is described under the FWOP condition, below.

Initial evaluations of the other terminal operations indicated that existing authorized federal channel depths meet the current and foreseeable needs and no deepening is needed at this time.

Future Without-Project Condition

New Navy Base Container Terminal Facilities and Infrastructure

A new container terminal facility, the new Navy Base Terminal (NBT), is currently under construction. The SCSPA has completed preliminary demolition, site preparation, and containment wall construction. The anticipated opening date of the terminal's 171-acre first phase is planned for 2018. At its completion, the NBT will be a state of the art, three-berth container facility. The terminal is located on the Cooper River at the south end of the former Charleston Navy Base, approximately 24 miles from the sea buoy. The completed terminal will cover about 290 acres and will support cargo marshalling areas, cargo processing areas, cargo handling facilities, and related terminal operating facilities including a 10.3-acre wharf structure (3,000 feet long and 150 feet wide). In addition to the container terminal, the project includes an 86.7-acre berthing area and turning basin adjacent to the wharf. Key features of the project include:

- Minimum 45 feet berth depth, ultimate depth will align with the Post 45 project
- 3,510 lineal feet of container berth
- 12 super Post-Panamax container cranes with an outreach (boom length) of 23 containers
- 286 gross terminal acres
- Direct access to I-26 via a new interchange

Container Terminal Use Plan (Operations). The SCSPA's future container terminal use plan will generally conform to its historical practices. The WWT and new NBT, given their locations, physical attributes, airdrafts and capacities will handle the largest carriers and the very large (including Generation 3 – New Panamax) container vessels in the existing and future world fleet. These terminals are the closest terminals to the open ocean, have the most berthing areas, have the largest capacities and capabilities, and the highest air drafts. Consequently, they will be the most efficient, productive terminals for the largest container shipping line customers and their largest vessels.

While SCSPA's competitive strategy is to have a Generation 3 (see Table 34 of Appendix-C, Fleet Subdivisions on Draft, Beam, and LOA) vessel capability at NCT in order to maintain a competitive vessel capability comparable to New York and Norfolk, the Don Holt Bridge airdraft restriction precludes the SCSPA from practically achieving this capability at NCT. Consequently, NCT will continue to serve individual shipping lines and consortia whose vessels can transit beneath the Don Holt Bridge.

Panama Canal Expansion (Operations). In 2006, the Panama Canal Authority (ACP) announced plans for expansion of the Panama Canal. Their announcement came at the end of a multi-year comprehensive study and analysis by the ACP. Design plans include lock chambers of 1,400 feet long, 180 feet wide and 60 feet deep. Accordingly, the expansion will provide the capacity to accommodate vessels up to 1,200 feet long, 160 feet wide, and 50 feet deep, or with a cargo volume up to 170,000 DWT and 12,000 TEU.

The original project schedule had construction being completed in 2014; however, contracting difficulties have extended the completion date. Construction of the Panama Canal expansion is underway. As of April, 2015, the project is reported as 88 percent complete and is scheduled to be complete by the end of 2015 (http://www.pancanal.com/eng/pr/press-releases/2015/04/09/pr545.html). The Panama Canal's expansion will pave the way for larger containerships to be deployed to the U.S. East Coast. Presently, the Panama Canal has restricted container traffic shipments to vessels drafting less than 39.5 feet. This essentially prevented any Far East/East Coast U.S. shipments from taking advantage of the economies of scale of loading larger vessels to deeper sailing drafts. In the evaluation of without-project conditions for the Charleston Post 45 Deepening study, it is assumed that the expansion of the Panama Canal would be completed prior to the start year of the period of analysis and that carriers would begin making adjustments to their fleet soon after. This assumption is supported by historical evidence (i.e., maximizing vessel size through the canal) and interviews with carriers. Additionally, new vessel orders are largely comprised of Post-Panamax vessels.

2.3.4 Maintenance Dredging/Dredged Material Disposal

2.3.4.1 Process and Schedule

Existing Condition

The existing project requires periodic maintenance dredging to maintain authorized depths. Historically, dredged material removed from Charleston Harbor has been placed within six upland disposal sites and an Ocean Dredged Material Disposal Site (ODMDS) (Figure 2-14). The average annual maintenance dredging needs of the federal channels is approximately 2,200,000 cubic yards (USACE 2009b). The Entrance Channel is typically dredged every two years by hopper dredge and the material is disposed of in the ODMDS. The reaches around the ocean bar require minimal maintenance due to naturally deep water. The Upper Harbor (upstream from Shipyard River) is typically dredged every 18 to 21 months by a hydraulic pipeline dredge and the material is usually placed in the Clouter Creek upland disposal area. Lastly, the Lower Harbor (downstream of Shipyard River to the Entrance Channel) is dredged every 12 to 15 months. Maintenance dredging of the Lower Harbor is performed by mechanical (clamshell) dredges and the material is generally transported in a scow for disposal at the ODMDS.

Shoaling Locations Within the Lower Harbor, shoaling and subsequent operations and maintenance dredging typically occurs within Hog Island Reach, Tidewater Reach, Lower Town Creek Reach, Town Creek Reach, Myers Bend Reach, Drum Island Reach, Lower Wando Reach, the Wando Turning Basin, and Upper Wando Reach. Within the Upper Harbor, shoaling and subsequent operations and maintenance dredging typically occurs within Shipyard River, Daniel Island Reach, Daniel Island Bend, Navy Yard Reach, Port Terminal Reach, Ordnance Reach, and Ordnance Reach Turning Basin.

Operations and maintenance dredging consists of the authorized depth, advanced maintenance, and allowable overdepth (due to the inexact nature of dredging) (see Section 2 Reference Aid). Advance maintenance is dredging to a specified depth beyond the authorized channel dimensions in critical and fast shoaling areas to avoid frequent re-dredging, in order to ensure the reliability and least overall cost of operating and maintaining the project authorized dimensions. This type of dredging lowers the cost of maintenance by reducing the frequency of dredging thereby avoiding several expensive mobilization and demobilization dredging equipment cycles, and at the same time minimizes the frequency of temporary environmental impacts associated with dredging. The Charleston Harbor federal navigation channel is approved for 2 ft of advanced maintenance and 2 ft of allowable overdepth within all areas of the harbor, and 4 to 6 ft of advanced maintenance in particular fast shoaling areas. The fast shoaling areas that are allowed 4 to 6 ft of advanced maintenance are: Ordnance Reach, Ordnance Reach Turning Basin, Drum Island Reach, Wando Turning Basin, Lower Wando River, and Lower Town Creek Reach. Typical shoaling areas and those receiving 4 to 6 feet of advanced maintenance are shown in Figure 2-16.

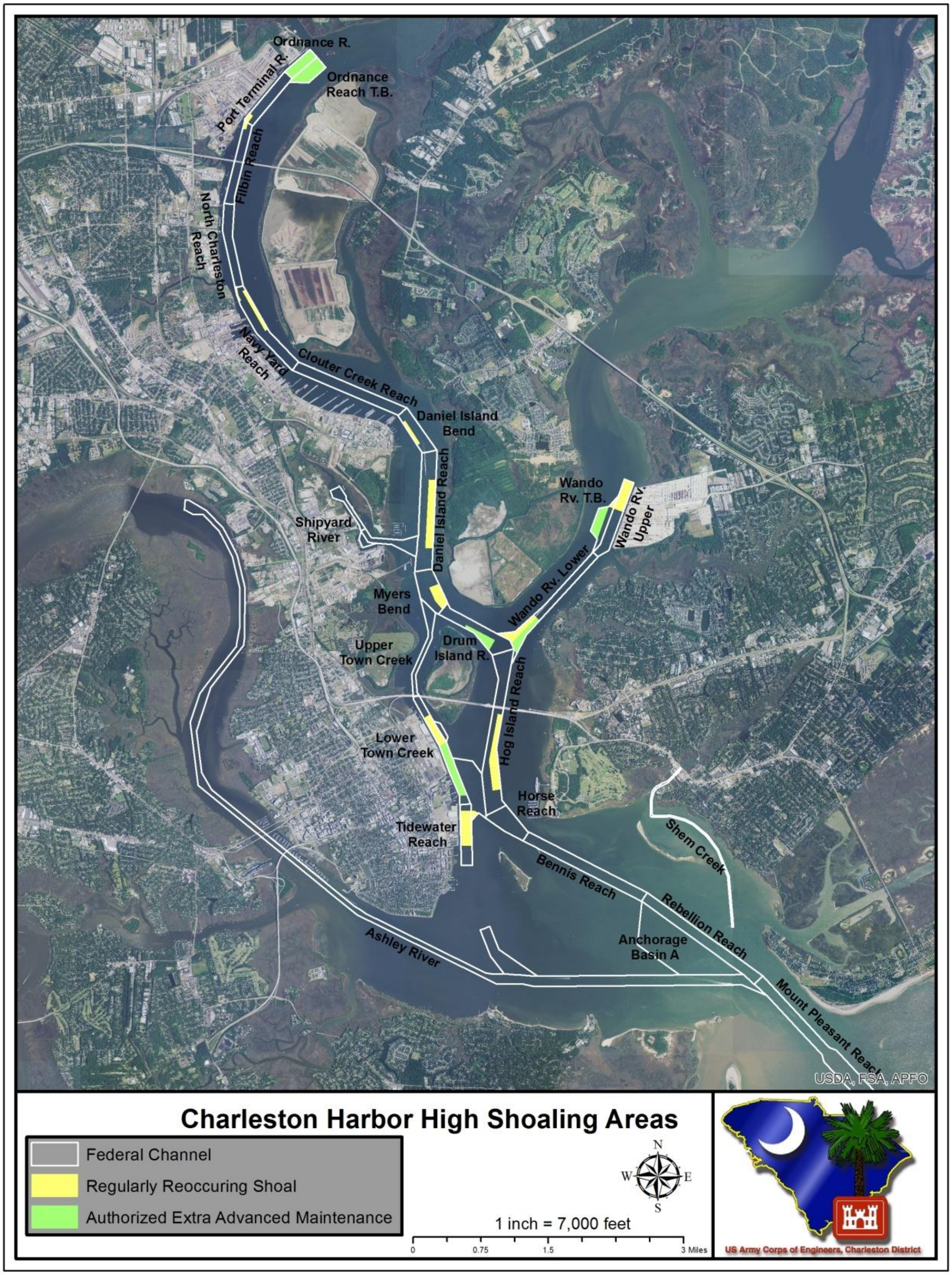


Figure 2-16. Charleston Harbor frequently dredged shoals and high shoaling areas requiring 4 to 6 feet advance maintenance dredging

Future Without-Project Condition

The existing maintenance dredging schedule and methods would continue under the FWOP condition. The same disposal areas would be used, although the use of other upland disposal areas would be considered.

2.3.4.2 Upland Disposal Sites

Existing Condition

The six confined upland disposal sites include: Yellow House Creek, Joint Base Charleston, Clouter Creek, Daniel Island, Drum Island, and Morris Island (Figure 2-14). Together, these sites cover over 3000 acres. The containment dikes for these sites are maintained and improved to increase storage capacity, as needed. Currently, only the Clouter Creek Disposal Areas is routinely used for the federal project.

Future Without-Project Condition

On-going dike raising efforts can continue to increase the capacity of the upland sites for the foreseeable future. It is expected that these sites would continue to be utilized as per the existing Charleston Harbor dredged material management practices. Based on recent analysis, assuming on-going dike raising efforts will continue, there is sufficient capacity for at least the next 20 years.

2.3.4.3Ocean Disposal

Existing Condition

The existing four square mile Charleston ODMDS is illustrated in Figure 2-14. It is one of the most active, frequently used sites in the South Atlantic region. The general area has been used for dredged material disposal activities since 1896 and was last configured in 1995 to avoid sensitive live bottom habitat. It is located approximately 3 miles south of the Entrance Channel and includes an L-shaped berm on the western side to prevent migration of material from the site. It originally had an estimated capacity of 77.4 million cubic yards. As of 2009, an estimated 32% of the capacity was remaining (roughly 24.8 million cubic yards). The site is managed and monitored under the 2005 Site Management and Monitoring Plan which can be found at http://epa.gov/region4 //water/oceans/sites.html. The need for additional capacity is being addressed concurrently with this Feasibility Study through a Section 102 (Marine Protection, Research, and Sanctuaries Act) site modification process. Currently, the USEPA and USACE Charleston District are preparing an Environmental Assessment (EA) to address the site modification. The EPA issued a Notice of Intent to prepare an EA in the Federal Register on 31 December 2012. The Draft EA is projected to be released in the summer of 2015. A public and agency review period of 30 days will follow the release of the Draft EA. It is anticipated that the EPA will issue a Final EA and final rule in the Federal Register in 2015. It should be noted that additional capacity at the ODMDS is needed with or without the proposed navigation project.

Future Without Project Condition

Although there is not an urgent need, this site will require modification to accommodate continued dredged material operations and maintenance in the future. As indicated above, this need is being coordinated along with this Feasibility Study.



2.4 Environmental Conditions

Many of the sections below relied upon data generated by a hydrodynamic model. The goals of the modeling effort were to characterize the existing hydrodynamic conditions, salinity, and dissolved oxygen (DO) concentrations, and sedimentation patterns in the Charleston Harbor estuary, and to estimate and analyze the effects of the alternatives on those parameters. In consultation with numerous resource agencies, the USACE ultimately selected the Environmental Fluid Dynamics Code (EFDC) to meet the modeling requirements for the project. EFDC is a state-of-the-art model that can be used to simulate aquatic systems in one, two, and three dimensions. It has evolved over the past two decades to become one of the most widely used and technically defensible hydrodynamic models in the world. The EFDC model has been used by SCDHEC and EPA Region 4 in other basins for evaluating surface water hydrodynamics, sediment transport and water quality problems. The water quality component of EFDC is based on water quality kinetics from the Chesapeake Bay Water Quality model (CE-Qual-ICM). The water quality component simulates the impacts of oxygen consuming loads from various sources in the watershed on dissolved oxygen in the impaired sediments. Details on the hydrodynamic modeling can be found within Appendix A (Engineering).

2.4.1 Wind and Wave Climate

Existing Condition

Wind and wave conditions are important considerations for navigation projects due to their potential impacts on navigation, as well as the erosive forces that impact harbor shorelines. Figure 2-17 presents a wind rose generated using the hourly averaged data (wind speed and direction) recorded between January 2010 and December 2011 at the National Oceanic and Atmospheric Administration (NOAA) data collection station in Charleston Harbor. As illustrated, winds are predominantly from the southwest, but the strongest winds (fastest 10%) are predominantly from the north-northeast.

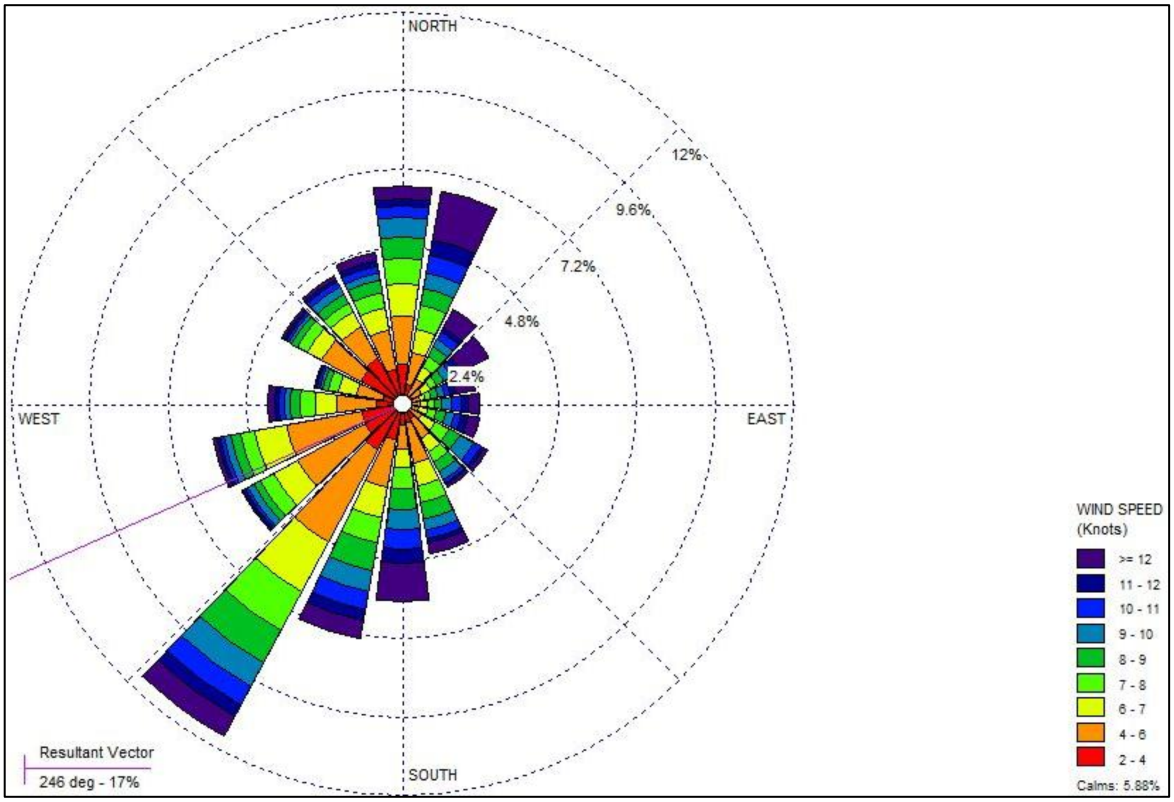


Figure 2-17. Wind rose for Charleston Harbor depicting wind direction and speed frequency

As winds move over water, friction generates waves. The distance of open water (fetch) a wind blows over affects the size of waves produced (USACE, 2008). At a given wind speed and duration, a longer fetch will generate larger waves. At large fetch lengths in deep water, the wave height becomes dependent only on duration of the wind. The heights and energies of wind generated waves increase as long as the wind blows over them until they eventually reach shore. Conversely, vessel wakes dissipate as they move away from the transiting vessel. The average waves generated by winds and the average waves generated by vessels in Charleston Harbor are estimated to be of similar heights, on average, but occur with extremely different distributions and frequencies.

Winds over Charleston Harbor and offshore are variable and can range up to 24 kt with gusts up to 40 kt. Based on the two-year sampling period (January 2010-December 2011), the average wind was 6.8 knots from 246 degrees. This average wind is capable of producing waves 0.18 feet high at Crab Bank, the area of concern with the longest fetch (~3.5 miles) from 246 degrees. Storms can also have significant impacts to shorelines and habitats over short periods of time. For example, the water level increased 6.9 ft above MHHW in 1989 from Hurricane Hugo and 1.9 ft above MHHW from Hurricane Floyd, remaining elevated for multiple days and exerting additional energy to sensitive regions above the high water line (Zervas et al., 2000).

In Charleston Harbor, the effect of waves (including vessel wakes) on Crab Bank, Shutes Folly island, Fort Sumter, and the southern shore of Sullivan's Island s of particular interest. Crab Bank and Shutes Folly are important bird habitat areas and have been experiencing erosion/changing shorelines over several decades. Fort Sumter and Fort Moultrie are National Historical Monuments and Sullivan's Island has extensive homes and infrastructure.

Coastal areas are subject to constantly changing erosion and accretion trends. Additionally, the natural variability of wind speed and direction combined with wave addition and cancelling effects make it difficult to reliably predict whether vessel- and wind-generated waves will cause erosion or accretion at specific locations. Tidal effects can cancel out over time due to back and forth flows. Vessels wakes follow a similar back and forth path as tides in Charleston Harbor but may be concentrated at certain tide stages and could have erosion and accretion effects that are difficult to predict.

Wave heights, equivalent wind generated waves and vessel generated wave frequencies were analyzed to characterize the existing conditions in Charleston Harbor and help quantify the relative importance of vessel- and wind-generated waves in determining overall erosion and accretion trends. Fort Sumter and Crab Bank currently experience maximum average wave heights from passing vessels equivalent to a 9.25 kt wind blowing over a 5000 ft fetch in the harbor. On average, equivalent or larger wind waves occur for about 107 days per year, and 29.4 days per year at the angles of concern for Fort Sumter. Equivalent or larger wind waves occur at the angles of concern for Crab Bank 47 days per year. Sullivan's Island (Fort Moultrie) and Shute's Folly Island, currently experience maximum average wave heights from passing vessels equivalent to a 13.25 kt wind over 5000 ft fetch. Equivalent or larger wind-generated waves occur at angles of concern for 14.6 days per year at Shute's Folly Island and 19.3 days per year within Sullivan's Island.

Figure 2-18 illustrates that the average significant wave heights calculated from the wave height distributions are higher than the significant wave heights calculated for an average wind condition, 6.8 knots and from 246 degrees, which demonstrates the impact of large wave outliers on potential impacts. Additional information about waves and vessel wakes is provided in Appendix A.

Future Without-Project Condition

The natural wind and wave climate will remain roughly the same with some potential changes related to sea level change. However, with the forecasted increase in vessel traffic, the number of vessel wakes and the associated impacts will increase over time. As the vessels get larger, wakes will become increasingly concentrated during high tides when their impacts would be highest.

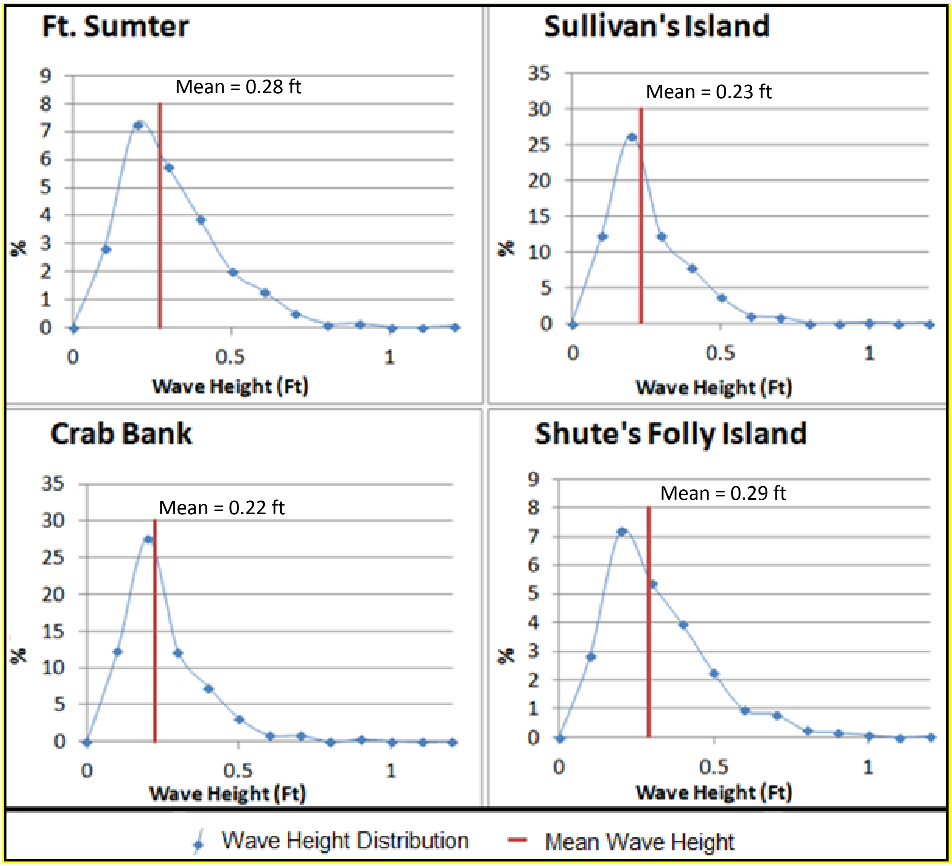


Figure 2-18. Distribution Significant Wave Height Hm0 based on fetch lengths at Area of Concern (as shown in purple and yellow in Figure 2.5.4) for Wind-generated Waves due to 51 min Duration Winds

2.4.2 Tides

Existing Condition

The tidal range throughout the interior channels is relatively uniform. The astronomically-generated high and low tides within the Federal channel range from about 5 to 6 feet above MLLW over the year. Vessels needing more depth than is available at low tide can time their transits to take advantage of the 5 to 6 feet of additional depth afforded during high tides. However, the transit needs to be completed before water levels drop again.

Future Without-Project Condition

Tidal range will generally remain the same as the existing condition, with some potential changes related to mean sea level rise projections (discussed in 2.4.4).

2.4.3 Currents

Existing Condition

Ebb (falling tide) currents near the entrance to Charleston Harbor are generally about 1 knot (about 1.69 feet/second) while ebb currents near Fort Sumter and Drum Island may reach 4 knots (6.75

feet/second). Crosscurrents during ebb tide at the confluence of the Cooper and Wando rivers and high ebb currents at the confluence of the Shipyard River with the Cooper River can create navigation problems. Normally currents pose the greatest problems to vessels during turning basin maneuvering.

Future Without Project Condition

Currents will generally remain the same as in the existing condition, but could experience some slight changes due to sea level changes. According to EFDC modeling results, the FWOP condition shows changes in current speeds in the estuary. These changes are mostly less than 0.1 feet/second; however, some increases in current speed are on the order of 0.1 to 0.2 feet/second in bends of the Cooper River upstream from the Federal navigation channel. These increases are attributed to sea level rise that increases the tidal prism of the harbor and rivers causing increased flow during the ebbing and flooding tides.

2.4.4 Relative Sea-Level Change/Salinity Intrusion

Existing Condition

Climate change and Global warming has been observed during the 20th and 21st centuries. NOAA bench marks are located in the vicinity of U.S. Custom House, along East Bay Street, and along Broad Street. Based on monthly mean sea level data from 1921 to 2006, sea level in the Study area has increased by approximately 1.03 feet over the last 100 years.

Future Without Project Condition

Recent climate research by the Intergovernmental Panel on Climate Change (IPCC) predicts continued or accelerated global warming for the 21st Century and possibly beyond, which would cause a continued or accelerated rise in global mean sea-level. Using the USACE Institute of Water Resources (IWR) online Sea-Level Rise calculator and spreadsheet (USACE Engineering Regulation (ER) 1110-2-8162), the historical trend at Charleston is estimated to be 2.94 mm (0.12 inches)/yr. The ER was also used to determine various rates of sea level change under different scenarios (low, intermediate, and high) and could result in 0.57 ft of sea level rise over 50 years. The analysis indicated that sea level rise would increase over 50 years 0.57 ft in the low scenario (based on the historical rate), 1.08 feet in the intermediate scenario, and 2.74 feet in the high scenario. Two primary concerns regarding sea-level rise include its impacts on salinity levels: (1) changes to marsh vegetation caused by changes in salinity regime; and (2) salinity alerts requiring increased freshwater releases from Pinopolis Dam to prevent salinity concentrations from rising in the inlet and in the Back River (also known as the Bushy Park Reservoir, an important freshwater supply for Charleston Water Systems).

Other potential impacts of rising sea levels include overtopping of, and damage to, structures near the water, increased shoreline recession, and flooding of low lying areas. In respect to the three sea-level rise scenarios, current tidal salt marsh areas adjacent to the project area would likely survive within their current range, with some transition from tidal freshwater to tidal saltwater marsh areas upstream in the rivers (discussed in more detail in Section 2.4.9 (Wetlands). Further discussion on the Bushy Park Reservoir and the salinity alert system can be found in Section 2.4.7.4.

2.4.5 Geology, Soils, and Sediments

2.4.5.1 Geologic Setting

Existing Condition

Charleston Harbor is within the outer Atlantic coastal plain, between the Cape Fear Arch and the Southeast Georgia Embayment. The near surface geologic stratigraphy consists of partially consolidated, southeast dipping estuarine-marine shelf Tertiary deposits, which are overlain by younger unconsolidated Quaternary barrier and nearshore deposits. The modern shore face, barrier island configuration, location of inlets and natural inland waterways are strongly influenced by the geologic setting and topographic expression of the strata (Harris et. al., 2005). Appendix B (Geotechnical) identifies relevant stratigraphy.

Future Without Project Condition

The geologic condition of the project area would not change in the FWOP condition.

2.4.5.2 Soils

Existing Condition

Nearly all of the surficial soils in the Charleston area are Quaternary in age, and they unconformably overlie the Tertiary strata. The soils generally consist of interbedded sequences of clay, clayey to clean quartz sand, and fossiliferous sand which may be overlain by Holocene peat, silt, clean sand, or tidal marsh deposits (Weems and Lemon, 1993).

Future Without Project Condition

The types of soils in the project area would not appreciably change in the FWOP condition.

2.4.5.3 Hydrogeologic Setting

Existing Condition

Six major aquifers underlie the Charleston area: the Cretaceous Cape Fear aquifer, Late Cretaceous Middendorf and Black Creek aquifers, the Paleocene-Early Eocene Black Mingo (sand aquifer), the Mid-Late Eocene Floridan (Santee-Cooper) aquifer, and a Quaternary surficial aquifer (Aucott and Speiran, 1985). Park (1985) mentions the presence of the Late Cretaceous Peedee aquifer, whose strata lies unconformably atop the Middendorf; however, water production and quality from this aquifer is poor. Porous limestone and/or sandy strata that are capable of storing and transmitting groundwater to wells and springs comprise most of the aquifers, with the exception of the producing strata of the Black Mingo. All of the deep aquifers are confined by fine-grained limestone or clayey strata, except for the Quaternary surficial aquifer, which is unconfined.

Inadequate ground-water supplies, declining water levels and saltwater intrusion have been problems since the early 1900s. Historically, the City of Charleston relied upon shallow wells and collected rainwater to supply the drinking water needs during the Colonial Era. As the population grew, the need for a clean, safe potable water source became apparent; therefore, the city commissioned the drilling of several deep wells to supply drinking water to the city's population. From 1823 to 1879, several attempts were made to drill to deep wells to tap into the deeper confined aquifer, which were more desirable in terms of water quality, yield, and sanitation. The first producing municipal well was completed in 1879 to a depth of 1,970 feet and had a yield of 486 gpm. Continual growth of the port city rapidly outpaced the drilled aquifer water supply, and so the City of Charleston commissioned the construction of dams to impound Goose Creek to provide a more reliable water supply (http://www.charlestonwater.com/164/The-Search-for-a-Suitable-Water-Supply) (Appendix B, Geotechnical). Primary drinking water for Charleston comes from two surficial sources: the Bushy Park Reservoir and the Edisto River. Municipalities still use well water in Charleston, however these are primarily from the Floridian aquifer (-200 to -500 feet msl) and the much deeper Cretaceous-aged aquifers.

Future Without Project Condition

Shallow aquifers would not change under the FWOP conditions as they already lie within the project dredging prism. These shallow, unconfined, aquifers have historically been susceptible to seasonal fluctuation due to rain and drought. Because there is no upper confining layer, the groundwater level follows the local topography. The hydrogeologic setting is not anticipated to significantly change in the FWOP condition, although continued water withdrawals could increase stress on shallow water aquifers. The municipalities of Folly Beach, Mt. Pleasant, Fort Sumter, and Porches Bluff have histories of salt water intrusion, as a result of overuse prior to harbor deepening activities in 1995 (Park, 1985).

2.4.5.4 Geotechnical

Existing Condition

Details related to the geotechnical investigations for the Study area are presented in the Geotechnical Appendix (Appendix B). Clouter Creek, the upper and lower harbor, and the Entrance Channel were specific targets of investigations. For the upper and lower harbor investigations, a total of 549 historic drilling logs were input into Bentley's gINT geotechnical software program, using a USACE report template. The predominant soil types for the upper and lower harbor reaches, and the Entrance Channel are summarized in the tables below (Tables 2-19 to 2-21). Please refer to the Reference map at the end of this Section or Figure 4-1 for Reach locations.

Table 2-19. Upper harbor stratigraphic summary

Reach	Predominant Soil
Ordnance & Port Terminal	Fat Clay, Lean Clay
Filbin Creek	Fat Clay, Lean Clay
North Charleston	Lean Clay, Inorganic Silt
Navy Yard	Fat Clay, Clayey Sand
Clouter Creek	Fat clay, Silt, Lean Clay
Daniel Island Bend & Reach	Inorganic Silt, Lean Clay

Table 2-20. Lower harbor stratigraphic summary

Reach	Predominant Soil
Daniel Island	Inorganic Silt, Lean Clay
Myers Bend	Lean Clay, Inorganic Silt
Wando River & Turning Basin	Lean & Fat Clay, Clayey Sand
Wando River	Fat Clay, Elastic Silt, Clayey Sand
Upper Hog Island	Inorganic Silt, Clayey Sand
Lower Hog Island & Horse	Fat Clay, Inorganic Silt, Silty Sand
Upper Town Creek	Fat Clay, Lean Clay
Lower Town Creek	Elastic Silt, Clayey Sand, Fat Clay
Tidewater Channel	Elastic Silt, Fat Clay, Clayey Sand
Bennis	Fat & Lean Clay, Silty Sand
Rebellion & Anchorage Basin	Clayey Sand, Fat & Lean Clay
Mount Pleasant	Lean Clay, Elastic Silt, Clayey Sand

An extensive drilling and subsurface investigation was performed in 2013. Fifty borings were drilled within the Entrance Channel, 2 to 14 miles offshore in water depths up to 60 feet. The Entrance Channel was divided into reaches approximately 1 mile in length to assist in planning, visualization, and analysis. Borings were drilled to a maximum elevation of -63 feet MLLW to characterize the materials that lie within and below the potential dredging prism. Analyses focused on particle grain size, Atterburg limits (e.g., the plastic and liquid limits of sediments), visual classification, and compressive and splitting-tensile tests. Results of the subsurface investigation are summarized in Table 2-21, below. Details are provided and Appendix B (Geotechnical).

Other supporting investigations for characterizing potential Entrance Channel substrates included 95 vibracores within the Charleston Harbor Entrance Channel in 1986, 159 borings within the Charleston Harbor Entrance Channel from 1988 to 1999, a 1998 NOAA diver survey of hardbottom habitat, a Great Lakes Dock and Dredging 1999 claim, a 2012 geophysical survey, and a washprobe exploration program in 2013.

Future Without Project Condition

No geotechnical changes are anticipated in the FWOP condition.

Table 2-21. Summary of Entrance Channel stratigraphy (Reaches correspond to those found in Appendix B – Geotechnical)

Reach	Predominant Material
Entrance Channel, EC-1	Inorganic Silt, Clayey Sand
Entrance Channel, EC-2	Inorganic Silt, Clayey Sand
Entrance Channel, EC-3	Inorganic Silt, Fat Clay, Silty Sand
Entrance Channel, EC-4	Inorganic Silt, Silty Sand
Entrance Channel, EC-5	Silty Sand, Sand, Limestone, Silt
Entrance Channel, EC-6	Limestone, Clayey-Silty Sand, Sand
Entrance Channel, EC-7	Limestone, Silty Sand, Sand, Silt
Entrance Channel, EC-8	Limestone, Silty-Clayey Sand, Sand
Entrance Channel, EC-9	Limestone, Fat Clay, Silty Sand
Entrance Channel, EC-10	Limestone, Silty Sand, Sand
Entrance Channel, EC-11	Limestone, Silty Sand, Sand
Entrance Channel, EC-12	Limestone, Silty Sand, Sand
Entrance Channel, EC-13	Limestone, Sand
Entrance Channel, EC-14	Sand, Gravel
Entrance Channel, EC-15	Sand, Gravel, Silt, Clay
Entrance Channel, EC-16	Fat Clay, Sand
Entrance Channel EC-17 to 19	No material data available

2.4.5.5 Sediment Quality

Existing Condition

This section summarizes the sediment grain size distribution and chemistry across the Study area as a whole and then specifically addresses sediments within the navigation channels. In addition to providing important habitats for aquatic organisms, sediment type and sediment contaminants play a significant role in determining the methods and equipment to be used to dredge and place the material. As outlined in the previous section, the material in the navigation channels is mostly fine grain sediments (silt) with some sand in the Entrance Channel (USACE 2009). Throughout the harbor, grain size varies from silt to sandy material and can be represented by the percent sand in a sample. The South Carolina Department of Natural Resources (SCDNR) has tested sediment composition and chemistry within Charleston Harbor for the last few decades through the South Carolina Estuarine and Coastal Assessment Program (SCECAP). Figure 2-19 depicts the average percent sand within Charleston Harbor sediments as interpolated from SCDNR SCECAP data and sediment testing data collected for this project.

The disturbance of aquatic sediments can create environmental problems if harmful contaminants are made more available to organisms. Sediment quality is important to the overall estuarine habitat quality because sediments support invertebrate communities, exchange gases and nutrients with overlying water, and serve as a sink for contaminants (Van Dolah et al., 2013). Sediments that have accumulated on the bottom of the Cooper River may contain contaminants that could negatively affect aquatic life. The most recent SCECAP report shows the integrated sediment quality scores for the Charleston Harbor area (Figure 2-20).

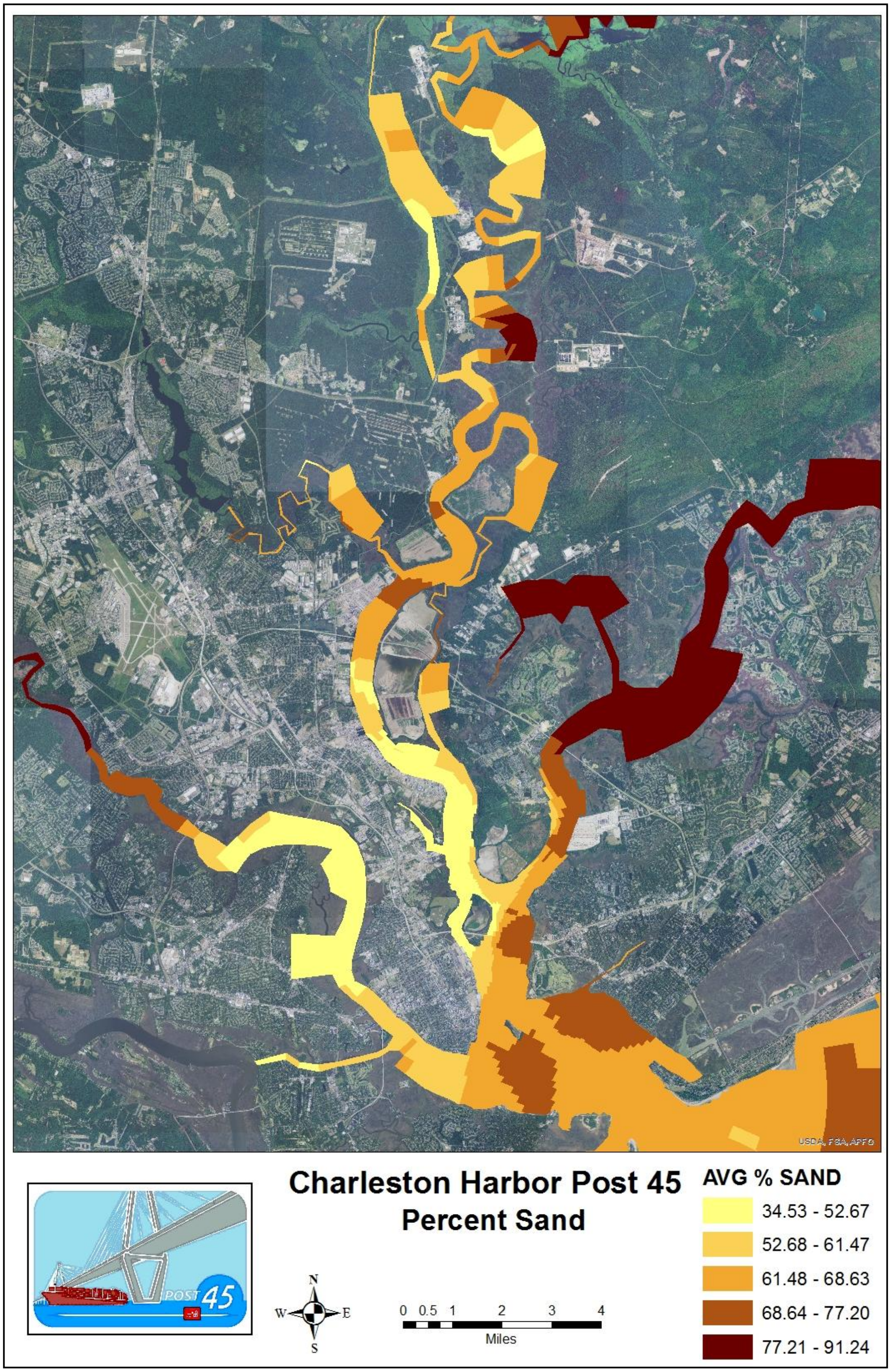


Figure 2-19. Charleston Harbor sediment composition

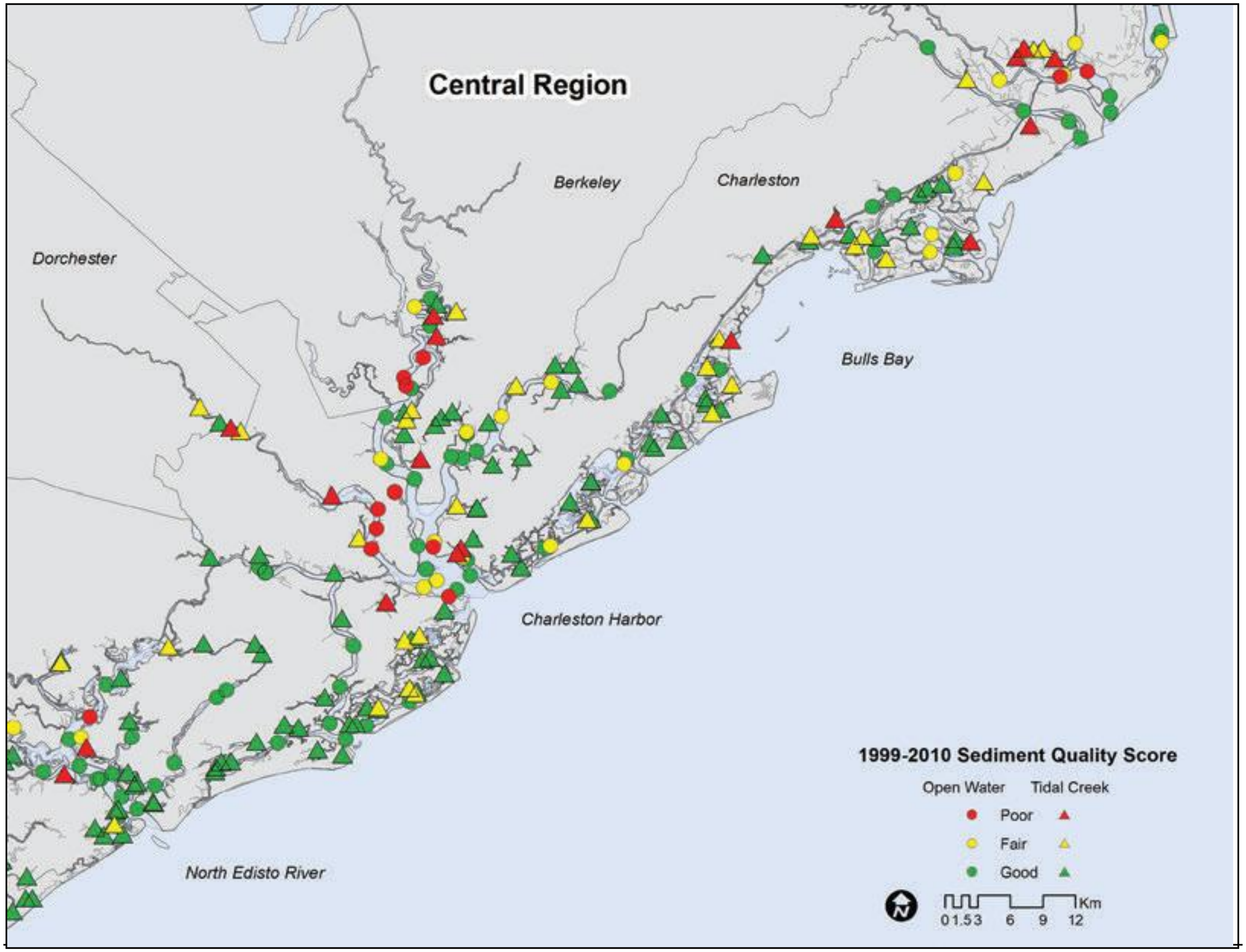


Figure 2-20. Charleston Harbor sediment quality

The scores combine the results of contaminant testing, toxicity testing, and total organic carbon testing to generate index scores. As evidenced in the figure, the Charleston Harbor area has scores ranging from poor to good, and is typical of an urbanized setting.

To determine sediment characteristics and address contaminant concerns related to dredging Charleston Harbor sediments and obtain a section 103 Marine Protection, Research, and Sanctuaries Act concurrence, samples were collected for chemical and biological evaluations. Prior to preparing the draft sediment sampling plan, USACE consulted with multiple natural resource agencies during an Interagency Coordination Team (ICT) meeting in November 2011. The ICT was also allotted time to review the draft sampling plan prior to commencing work. No significant contamination was encountered and results of physical and chemical testing show that all of the sediment that would be dredged by a deepening project is suitable for disposal in either an ocean disposal or upland disposal site. Details related to the investigation methodology, testing and results are provided in Appendix J (Section 103 Sediment Evaluation).

Future Without Project Condition

In the FWOP condition, the harbor would continue to be maintained as per current dredged material management practices. Sediment would be placed within upland and ocean disposal sites and would pose no increased risk to aquatic habitats.

2.4.5.6Shoaling Rates

Existing Condition

Shoaling occurs when sediments fall out of suspension and deposit on the bottom of a body of water. Sediments enter the harbor from overland runoff, shoreline erosion, discharge from Lake Moultrie, forestry and farming practices, etc. While shoals are generally favorable for fish habitat, they present a problem for navigation when they impede either recreational or commercial vessel traffic. Shoaling within the navigation channel does not occur in every reach of the channel; rather, it occurs in particular reaches and rates and magnitudes are higher in some reaches than others. The existing federal project is maintained to the authorized project depth of 45’ MLLW (47’ MLLW for the Entrance Channel) (See Section 2 Reference Aid). In addition, two feet of advanced maintenance and two feet of allowable overdepth are authorized throughout the federal navigation channel, while some specific reaches have either 4 feet or 6 feet of advanced maintenance authorized due to accelerated shoaling rates (Table 2-22).

Table 2-22. High shoaling areas requiring additional advanced maintenance dredging

Reach	Station Start	Station End	Required Depth	Authorized Advanced Maintenance	Allowable Overdepth
Drum Island Reach	1281+00	1296+00	45'	6'	2'
Lower Wando Reach	0+00	30+00	45'	4'	2'
Lower Town Creek Reach	41+69	73+45	45'	4'	2'
Ordnance Reach	1693+00	1720+53	45'	4'	2'
Ordnance Reach Turning Basin	1698+34	1720+53	45'	4'	2'
Wando Turning Basin	81+35	101+51	45'	4'	2'

Historic dredging records were analyzed to aid in determining maintenance dredging quantities for each reach. Maintenance dredging data for each reach and details of the analysis can be found in Appendix A (Engineering).

Future Without Project Condition

The EFDC sediment transport module was used to assess potential changes to shoaling rates. Results of the modeling effort, detailed in Appendix A, conclude that shoaling would continue in the FWOP condition in the same areas it occurs now. The model predicted that shoaling would decrease in the future by approximately 4 percent due to assumptions of sea level rise and the small changes that result in the hydrodynamics of the system (Appendix A). The existing maintenance dredging schedule and methods would continue for the FWOP condition.

2.4.6 Protected Managed Lands and Impoundments

Existing Condition

Numerous, regionally important, protected, and managed lands that provide buffers from development and other benefits to the aquatic environment surround Charleston Harbor. The southwestern corner of Francis Marion National Forest is only 10 miles upstream from Charleston Harbor (just past Mount Pleasant, SC) on the Wando River (See Figure 1-3). The Francis Marion National Forest consists of 258,816 acres in Berkeley County and northern Charleston County. It is owned by the U.S. Forest Service and is managed for multiple uses including watershed protection and improvement, timber and wood production, habitat for wildlife and fish species (including those that are threatened and endangered), wilderness area management, minerals leasing and recreation (USDA 2012). Cape Romain National Wildlife Refuge is located approximately 25 miles northeast of Charleston Harbor. Cape Romain surrounds Bulls Bay (Figure 1-3), just south of Francis Marion National Forest, and is bordered by the Atlantic Intracoastal Waterway on the north. The refuge consists of 66,287 acres and includes an expanse of barrier islands, salt marshes, intricate coastal waterways, long sandy beaches, fresh and brackish water impoundments, and maritime forests. Cape Romain is South Carolina's only Class I Wilderness Area, which affords the Refuge special air quality protection under the Clean Air Act (CAA) Amendments of 1977 (USFWS 2009a). The Santee Cooper Reservoir comprises a system of two lakes: Moultrie and Marion. Lake Moultrie is a 60,000-acre reservoir created in the early 1940s by the South Carolina Public Service Authority ("Santee Cooper") via construction of the Pinopolis Dam. The project was originally designed to route the Santee River flow down the Cooper River. However, since 1985 most of the flow has been re-diverted to the Santee River through a USACE canal and hydroelectric dam located near the town of St. Stephen. The St. Stephen Dam is equipped with a fish lift that allows passage upstream for anadromous fish species like American shad and blueback herring. The Pinopolis Dam has a boat lock that allows both boat traffic and anadromous fish passage (SCDNR 2011c).

The Cooper River watershed contains many historic ricefield impoundments. These ricefields are in various stages of ecological succession, and alterations in the watershed have affected the rate of succession. These areas were once important for rice growing and now they are primarily managed for waterfowl hunting, wildlife sanctuaries, and other commercial or preservation uses. These impoundments provide valuable habitat for many species of birds, and they serve as spawning, nursery and foraging areas for many fish species. At the same time, they affect water quality conditions in the larger waterbody. A detailed description of tidal ricefields/wetland impoundments can be found in Tufford (2005).

Future Without Project Condition

It is anticipated that land holdings within Francis Marion National Forest, Cape Romain NWR and other protected/managed lands will either stay the same or expand in the future based on local and national priorities. Impounded wetlands will continue to face rapid successional changes as sea level rise affects hydrodynamics and sedimentation patterns in the impounded areas.

2.4.7 Surface Water Quality

Existing Condition

Water quality in the harbor depends greatly on the water quality of the rivers (and reservoirs) that feed the estuary, as well as point and non-point effluent to the harbor. Characterizing these rivers is essential to assessing harbor water quality and the value of the rivers to environmental health and the area's fish and wildlife resources. This section will first describe the surface water conditions in the Ashley, Wando, and Cooper rivers, as well as the Harbor, followed by specific discussions related to dissolved oxygen, bacteria, nutrients, salinity, and suspended solids. South Carolina tidal saltwater classifications are described in Table 2-23. Waterbodies that do not meet water quality standards are placed on a Clean Water Act Section 303(d) list of impaired waterbodies. The purpose of the list is to identify impaired waters so that the source of impairment can be described and corrective actions can be implemented to improve water quality.

Table 2-23. South Carolina tidal saltwater classification

Classification Code	Uses
SA (Tidal Saltwater)	• tidal saltwater bodies suitable for the survival and propagation of a balanced indigenous aquatic community of marine fauna and flora • suitable for primary- and secondary-contact recreation, crabbing, and fishing • must maintain daily dissolved-oxygen averages of not less than 5.0 mg/L (milligrams per liter), with a minimum concentration of 4.0 mg/L • not protected for harvesting clams, mussels, or oysters for market purposes or human consumption
SB (Tidal Saltwater)	• same as Class SA water bodies, except dissolved oxygen averages must be maintained at or above 4.0 mg/L
SFH (Shellfish Harvesting)	• tidal saltwaters protected for shellfish harvesting due to the most stringent bacterial standards • uses listed in Class SA and Class SB • suitable for primary and secondary contact recreation, crabbing and fishing • suitable for the survival and propagation of a balanced indigenous aquatic community of marine fauna and flora

***Ashley River*.** The Ashley River originates in the coastal plain and flows into the western part of Charleston Harbor, generally from northwest of Charleston. Areas of the river are bordered by historic plantations, but a large portion of the Ashley River Basin is now occupied by residential or commercial development. The approximately 60 mile river is comprised of approximately 30 miles of tidal slough, which, under low-flow conditions, contributes little to no freshwater input to the harbor system. Waters of this approximate 30-mile reach (from Bacon Bridge/ Road 165 to the harbor) are classified by the South Carolina Department of Health and Environmental Control (SCDHEC) as SA (Table 2-25). A portion of the Ashley River was designated a South Carolina Scenic River in June 1998 and hence has special protections and specific issues are overseen by the Ashley Scenic River Advisory Council.

***Wando River*.** The Wando River originates in the coastal plain and flows into the eastern part of Charleston Harbor generally from the north and northeast (around Mount Pleasant, SC). Portions (approximately the lower 20 miles) of the Wando River are bordered by marsh which transitions to woodland in the upper reaches of the river. Development along the Wando River has increased over the years with the completion of the interstate highway system (I-526), which crosses the river approximately 3.5 miles upstream from its confluence with the Cooper River. Residences and subdivisions are present along stretches of the river as well as a shipyard and the State Port Authority's Wando-Welch Terminal. The Wando River is classified as a Shellfish Harvesting Area (SH) from its headwaters to a point approximately 2.5 miles above its confluence with the Cooper River. From this point to the Cooper River, it is classified as SA (Table 2-25) (SCDHEC 2002).

***Cooper River*.** The Cooper River has East and West Branches, and at their juncture (locally termed ''the Tee") flows 32 miles southward to its outlet in Charleston Harbor. The East Branch of the Cooper River extends some 20 miles inland in a northward direction to its origins as small ill-defined channels in a low-lying area of Berkeley County known as Ferguson Swamp. The West Branch of the Cooper River extends some 20 miles inland to Lake Moultrie where freshwater input to the river is regulated at a weekly average flow of 4500 cfs. The tail race canal, of Lake Moultrie's Pinopolis Dam and Lock, joins the West Branch of the Cooper River just south of the U.S. Hwy 17A Bridge. From just downstream of the Tee to its juncture with the Ashley River, the Cooper River is classified by SCDHEC as SB (Table 2-25). Upstream of the Tee, the river's waters are classified as freshwater for multiple uses. The Cooper River is the only tributary to the harbor that carries significant freshwater, this coming from the diversion of water from the Santee River basin to the Cooper River via the diversion canal between Lakes Marion and Moultrie and the tailrace canal which connects Lake Moultrie to the West Branch of the Cooper River (SCDHEC 2002).

***Charleston Harbor*.** The central harbor area itself (area surrounded by the Charleston Peninsula, the north shore of James Island, and the south and west side of Mount Pleasant, is an intertidal estuarine system, characterized by highly variable salinity and dissolved oxygen concentrations. Available information on these systems shows that dissolved oxygen concentrations frequently fall below the criteria established for such waters. These excursions are usually observed during high temperature periods whether or not there are anthropogenic (resulting from the influence of human beings on nature) sources of oxygen demand to the system (SCDHEC 2002). Water quality In Charleston

Harbor is classified by SCDHEC as SB (Table 2-25), and is considered water quality limited for the purposes of wasteload allocation (WLA) development (SCDHEC 2002). SCDHEC (2006) later added, "The Charleston Harbor system is not considered to be impaired under criteria of Section 303(d) of the Clean Water Act except for an area 0.5 miles southeast from the mouth of Shem Creek. The impairment is for copper related to potential impacts on aquatic life." More recently, SCDHEC (2013) has determined that, "currently available data and modeling indicate that regulated and unregulated stormwater and nonpoint sources do not contribute to the allowable DO depression on the mainstem segments including Charleston Harbor and the Cooper, Ashley, and Wando Rivers at existing conditions." Based on SCDHEC (2013), it appears that all areas in the project area are considered to "fully support" uses, albeit typical daily minimum DO averages are near 4 mg/L (vs. the desired 5 mg/L minimum used for other estuaries and upper reaches of rivers draining to Charleston Harbor). Dissolved oxygen is discussed in Section 2.4.7.1.

Dredged Material Disposal Regulation. A Section 401 Water Quality Certification (WQC) was issued to the USACE for disposal of dredged material associated with the project by the SCDHEC on May 2, 1995. This WQC covers the discharge of dredged material effluent from the existing disposal area outfalls. Special protocols are in place to manage the effluent, including turbidity increases, in an environmentally acceptable manner. Since the dredging and disposal methods have not changed and no new disposal locations have been added, the USACE considers the previous WQC to remain valid.

Future Without Project Condition

Operations and maintenance dredging activities would continue to cause temporary increases in turbidity along and adjacent to the navigation channel when dredging is occurring. Additionally, discharge of effluent from the upland disposal areas will continue during dredging. South Carolina DHEC water quality regulations require that water quality standards not be violated during dredging operations. The Charleston District would continue to maintain the harbor under the existing 401 water quality certification until such a time as DHEC requests new data as a result of a changed condition or new information. The existing 401 certification contains various protective measures and monitoring programs that would continue to ensure compliance with state water quality criteria. Additionally, the predicted sea level rise will cause surface water quality changes throughout the harbor and rivers and two important parameters are discussed individually (dissolved oxygen and salinity) below.

2.4.7.1 Dissolved Oxygen

Existing Condition

Oxygen is essential for the survival and propagation of aquatic organisms. If the amount of oxygen dissolved in water falls below the minimum requirements for survival, aquatic organisms or their eggs and larvae may die. In the Lower Cooper, Ashley, and Wando Rivers, as well as in Charleston Harbor, the DO concentrations are generally high during cool winter months and low during the warm summer months. The DO concentration depends on temperature (an inverse relationship), salinity, wind, water turbulence, atmospheric pressure, the presence of oxygen-demanding compounds and organisms, and photosynthesis. The major sources of oxygen-demanding substances to the Charleston Harbor system include stormwater runoff from the watershed, marshes along the river, point source pollution dischargers, river bottom sediments and the ocean.

Many coastal waters in South Carolina have DO levels below the established DO criteria (i.e., 4 to 5 mg/L) and anthropogenic sources contribute to lowering DO in these water bodies. SCDHEC (2013) states that, "the waters in and around Charleston Harbor are considered to be both naturally low in DO and further impacted by wastewater dischargers." In 2003, SCDHEC stated that, "available information indicates the upper Ashley River does not meet the applicable water quality standard for dissolved oxygen (DO) for significant periods of time due to natural conditions." These conditions were noted approximately 12 miles upstream of the U.S. Hwy 17 (now Ravenel) Bridge at Charleston. Within the Wando River, the drainage results in little freshwater input to the harbor, especially during low-flow periods and like the Ashley River, experiences depressed DO levels (SCDHEC 2003). In the Cooper River, the freshwater flows from Lake Moultrie affect vertical mixing and DO in the Lower Cooper River. The diversion of freshwater into the Cooper River beginning in the 1940s caused the river to shift from a vertically well mixed to a more stratified condition, which decreased DO concentrations along the bottom of the river and increased sedimentation and maintenance dredging requirements in the harbor. Following rediversion of flows and reduction of the freshwater flow into the Cooper River beginning in 1985 (see section on managed impoundments), this stratification and sedimentation was greatly reduced. SCDHEC monitoring data in the Lower Cooper River (Station MD-045 at Daniel Island Bend) show a noteworthy decreasing trend in DO concentration prior to rediversion, but no substantial trend in DO concentration when only post-rediversion data (1986-1998) were considered (USACE 2006)." Figure 2-21 shows the ambient water quality monitoring sites that were assessed for the 2012 303(d) list and which ones were listed as "impaired" for DO.

Many factors have likely contributed to low DO conditions in Charleston Harbor, including but not limited to organic matter loading from marshes, land use changes, point source (waste water) dischargers, stormwater discharge, instream modifications, progressive channel deepening, and many environmental variables (i.e., water flows, rainfall, temperature, etc.). SCDHEC determined that low DO conditions violating the DO standard would occur in the river even in the absence of point source pollution dischargers. This low DO condition occurs naturally in many southeast rivers during the summer due to natural loading of organic matter from floodplain swamps and marshes and, hence, causes high rates of ecosystem respiration. Where DO concentrations are naturally low, state water quality standards allow a lowering of DO of no more than 0.1 mg/l (SCDHEC, 2013). The water classifications for the Charleston Harbor have either a 4 mg/L minimum DO requirement only, or both the minimum and a 5 mg/L daily average requirement. SCDHEC developed a Total Maximum Daily Load (TMDL) to determine the maximum amount of loading that the harbor can assimilate while still meeting the water quality standards for DO. To perform this analysis, SCDHEC divided the harbor into TMDL segments (Figure 2-22), and developed a hydrodynamic model, Environmental Fluid Dynamics Code (EFDC) to establish Waste Load Allocations for National Pollutant Discharge Elimination System-permitted dischargers.

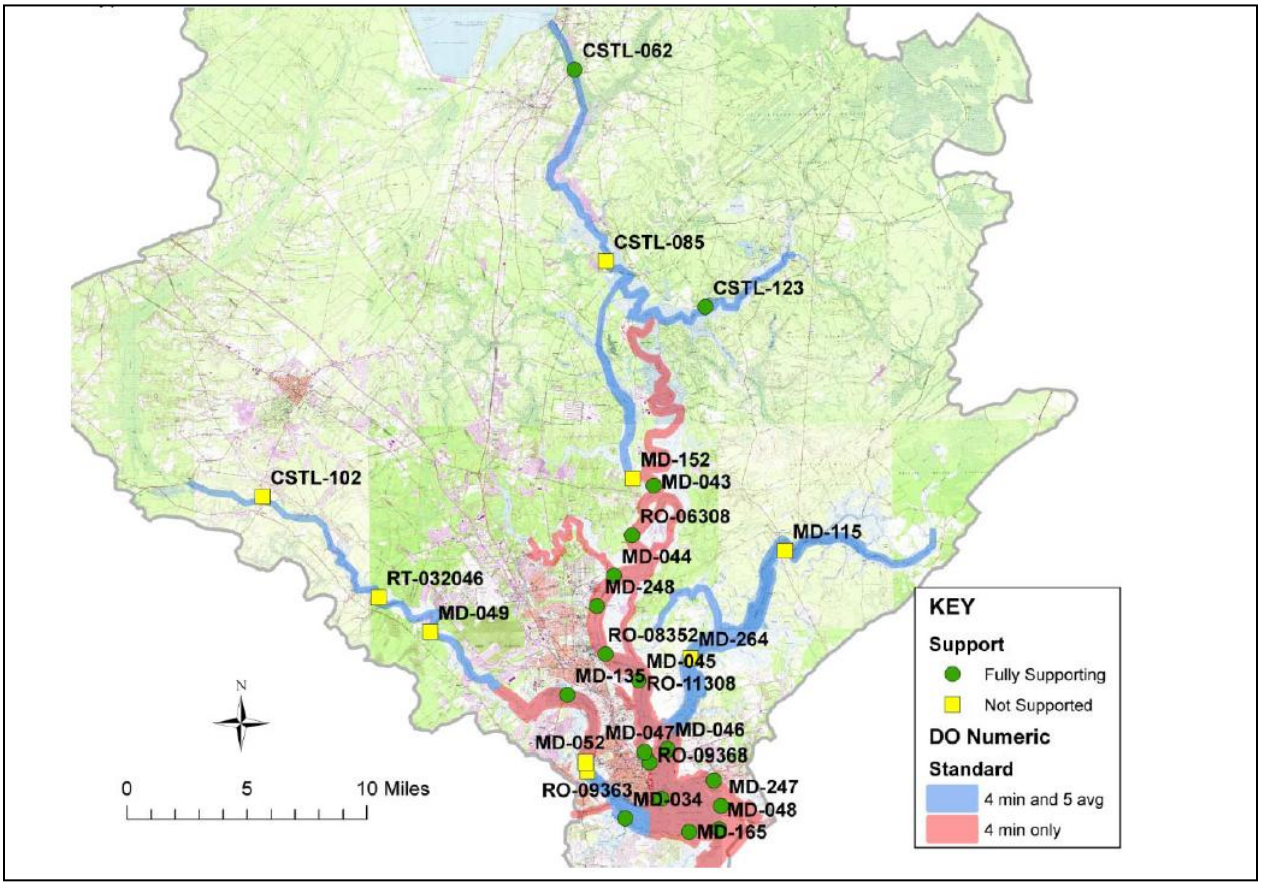


Figure 2-21. SCDHEC ambient sites assessed for the 2012 303(d) list (from SCDHEC 2013)

The relationship of the SCDHEC TMDL segments to river miles used in the EFDC model is shown in Table 2-24 and Figure 2-22. For the Post 45 study, the grid for this model was refined to add resolution and accuracy to the federal navigation channel, the model was recalibrated, and water quality for the TMDL was validated. As a result of the refined EFDC water quality model, the existing conditions were computed for the harbor and are shown below for a "typical" flow year, using actual loads from the NPDES dischargers, between March and October (SCDHEC critical months) (Table 2-25). The data are shown for the 10th, 50th, and 90th percentiles, which is similar to the lowest, average, and highest DO concentrations. As evidenced in the model outputs, many segments in the harbor and the rivers do not experience low DO (10th percentile) values below 4 mg/L and most of the harbor and Wando River has 10th percentile DO greater than 5 mg/L.

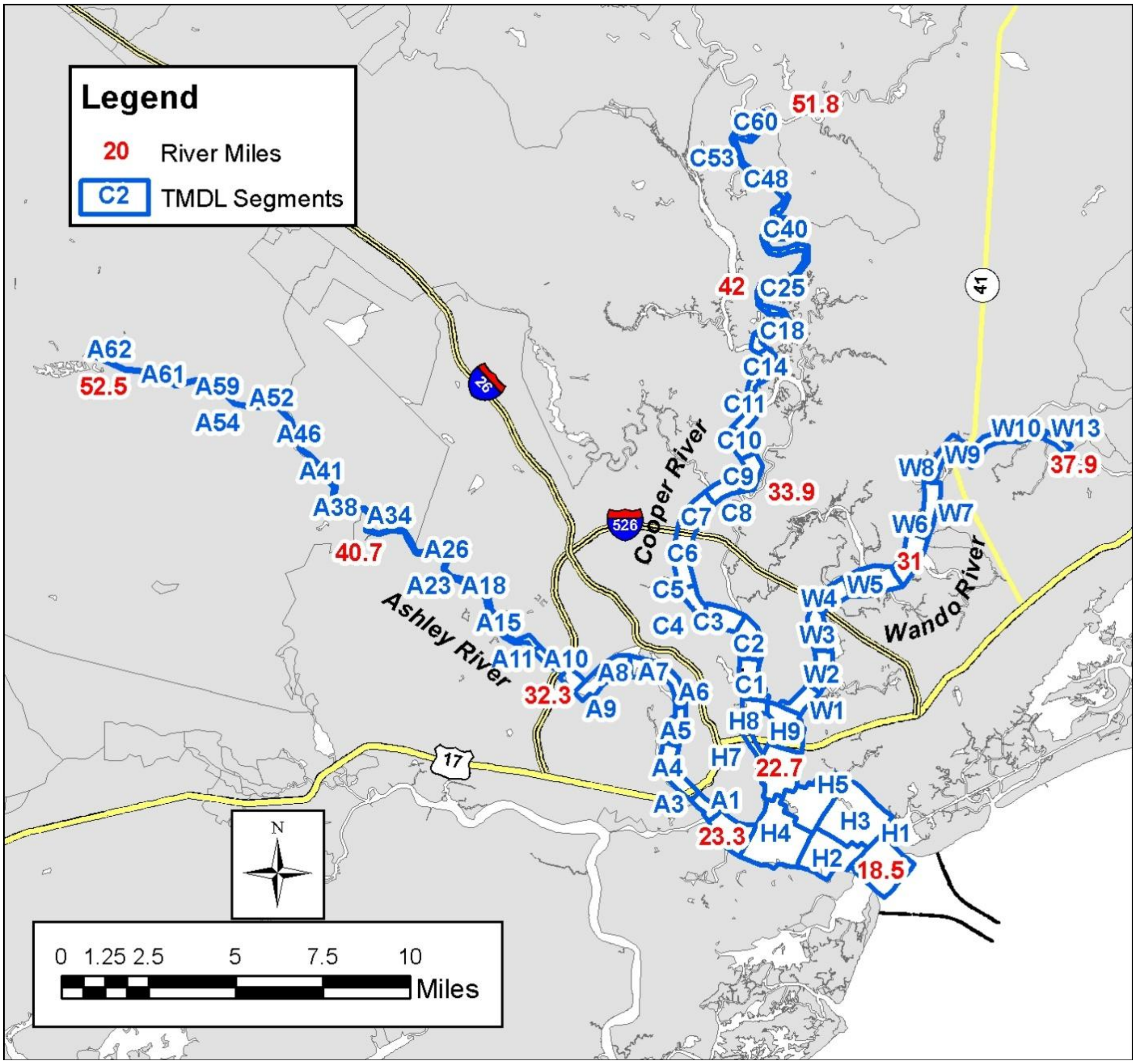


Figure 2-22. Charleston Harbor TMDL analysis segments

Table 2-24. Relationship of DHEC TMDL Segment to river miles from the EFDC hydrodynamic model

DHEC TMDL Segment	River Mile (from EFDC model)	DHEC TMDL Segment	River Mile (from EFDC model)	DHEC TMDL Segment	River Mile (from EFDC model)	DHEC TMDL Segment	River Mile (from EFDC model)
H1	18.5	**C32**	44.6	**W12**	37.2	**A39**	43.4
H2	20.2	**C33**	44.8	**W13**	37.9	**A40**	43.7
H3	20.0	**C34**	45.1	**A1**	23.3	**A41**	44.0
H4	21.9	**C35**	45.3	**A2**	24.3	**A42**	44.3
H5	21.4	**C36**	45.5	**A3**	25.2	**A43**	44.6
H6	22.7	**C37**	45.8	**A4**	26.1	**A44**	45.0
H7	23.8	**C38**	45.9	**A5**	27.2	**A45**	45.3
H8	24.6	**C39**	46.3	**A6**	28.5	**A46**	45.6
H9	23.9	**C40**	46.8	**A7**	29.6	**A47**	46.0
C1	25.7	**C41**	47.1	**A8**	30.6	**A48**	46.4
C2	26.9	**C42**	47.3	**A9**	31.5	**A49**	46.7
C3	28.0	**C43**	47.6	**A10**	32.3	**A50**	47.0
C4	28.9	**C44**	47.8	**A11**	33.1	**A51**	47.4
C5	29.9	**C45**	48.1	**A12**	33.9	**A52**	47.8
C6	30.8	**C46**	48.3	**A13**	34.4	**A53**	48.1
C7	31.9	**C47**	48.6	**A14**	34.7	**A54**	48.4
C8	32.9	**C48**	48.9	**A15**	35.0	**A55**	48.7
C9	33.9	**C49**	49.2	**A16**	35.3	**A56**	49.0
C10	34.9	**C50**	49.4	**A17**	35.6	**A57**	49.3
C11	35.8	**C51**	49.7	**A18**	36.0	**A58**	49.6
C12	36.5	**C52**	49.9	**A19**	36.3	**A59**	50.1
C13	37.0	**C53**	50.1	**A20**	36.6	**A60**	50.8
C14	37.6	**C54**	50.3	**A21**	36.9	**A61**	51.6
C15	38.2	**C55**	50.5	**A22**	37.3	**A62**	52.5
C16	38.7	**C56**	50.7	**A23**	37.6		
C17	39.3	**C57**	51.0	**A24**	38.0		
C18	39.8	**C58**	51.2	**A25**	38.2		
C19	40.4	**C59**	51.5	**A26**	38.5		
C20	40.8	**C60**	51.8	**A27**	38.8		
C21	41.1	**W1**	24.9	**A28**	39.2		
C22	41.5	**W2**	25.9	**A29**	39.7		
C23	41.8	**W3**	27.1	**A30**	40.0		
C24	42.0	**W4**	28.3	**A31**	40.4		
C25	42.4	**W5**	29.6	**A32**	40.7		
C26	42.7	**W6**	31.0	**A33**	41.1		
C27	43.0	**W7**	32.4	**A34**	41.5		
C28	43.3	**W8**	33.8	**A35**	41.9		
C29	43.7	**W9**	34.9	**A36**	42.2		
C30	44.0	**W10**	35.8	**A37**	42.6		
C31	44.3	**W11**	36.5	**A38**	43.1		

Table 2-25. Modeled Dissolved oxygen percentile concentrations in Charleston Harbor under typical flow conditions (data shown in mg/L)

Segment	10%	90%	Mean	Segment	10%	90%	Mean
A1	5.05	7.41	5.87	**C19**	4.55	7.50	5.65
A10	3.76	7.07	5.25	**C2**	4.84	7.48	5.78
A11	3.54	7.00	5.12	**C20**	4.56	7.51	5.66
A12	3.40	6.97	5.05	**C21**	4.57	7.52	5.66
A13	3.28	6.92	4.97	**C22**	4.58	7.53	5.67
A14	3.20	6.88	4.94	**C23**	4.59	7.54	5.68
A15	3.10	6.85	4.88	**C24**	4.60	7.56	5.69
A16	2.99	6.80	4.82	**C25**	4.61	7.58	5.71
A17	2.90	6.77	4.78	**C26**	4.61	7.59	5.72
A18	2.79	6.73	4.74	**C27**	4.62	7.61	5.73
A19	2.65	6.69	4.67	**C28**	4.63	7.62	5.74
A2	5.00	7.27	5.81	**C29**	4.64	7.64	5.75
A20	2.56	6.66	4.62	**C3**	4.81	7.48	5.76
A21	2.45	6.59	4.54	**C30**	4.65	7.65	5.77
A23	2.29	6.48	4.43	**C31**	4.67	7.67	5.79
A24	2.17	6.39	4.34	**C32**	4.68	7.68	5.80
A25	2.12	6.34	4.27	**C33**	4.69	7.69	5.81
A26	2.04	6.27	4.19	**C34**	4.70	7.70	5.82
A27	1.91	6.18	4.08	**C35**	4.71	7.71	5.83
A28	1.83	6.08	3.98	**C36**	4.74	7.71	5.84
A29	1.75	5.98	3.88	**C37**	4.73	7.76	5.85
A3	4.87	7.30	5.75	**C38**	4.73	7.80	5.86
A30	1.70	5.91	3.81	**C39**	4.75	7.83	5.88
A31	1.64	5.84	3.74	**C4**	4.75	7.46	5.72
A32	1.59	5.75	3.65	**C40**	4.76	7.88	5.89
A33	1.52	5.66	3.56	**C41**	4.77	7.91	5.91
A34	1.43	5.55	3.44	**C42**	4.78	7.94	5.93
A35	1.32	5.43	3.31	**C43**	4.80	7.96	5.95
A36	1.25	5.35	3.22	**C44**	4.81	7.98	5.96
A37	1.09	5.13	2.98	**C45**	4.81	8.00	5.98
A38	0.85	4.80	2.63	**C46**	4.82	8.01	5.99
A39	0.74	4.52	2.39	**C47**	4.83	8.03	6.01
A4	4.80	7.28	5.71	**C48**	4.85	8.05	6.03
A40	0.68	4.37	2.22	**C49**	4.87	8.07	6.05
A41	0.64	4.26	2.08	**C5**	4.72	7.46	5.71
A42	0.60	4.18	1.97	**C50**	4.88	8.08	6.06
A43	0.60	4.18	1.93	**C51**	4.89	8.09	6.07
A44	0.62	4.23	1.96	**C52**	4.89	8.11	6.09
A45	0.65	4.29	2.02	**C53**	4.91	8.13	6.11
A46	0.68	4.36	2.08	**C54**	4.92	8.15	6.12

Segment	10%	90%	Mean	Segment	10%	90%	Mean
A47	0.70	4.39	2.12	**C55**	4.93	8.17	6.14
A48	0.71	4.44	2.16	**C56**	4.95	8.20	6.16
A49	0.73	4.48	2.20	**C57**	4.97	8.23	6.18
A5	4.71	7.27	5.68	**C58**	4.99	8.26	6.21
A50	0.75	4.53	2.23	**C59**	5.01	8.29	6.23
A51	0.82	4.65	2.35	**C6**	4.68	7.45	5.68
A52	0.71	4.60	2.22	**C60**	5.03	8.31	6.25
A53	0.70	4.63	2.24	**C7**	4.63	7.43	5.65
A54	0.71	4.66	2.26	**C8**	4.60	7.42	5.63
A55	0.71	4.68	2.29	**C9**	4.56	7.42	5.61
A56	0.73	4.72	2.33	**H1**	4.83	7.37	5.67
A57	0.75	4.76	2.39	**H2**	4.99	7.45	5.79
A58	0.80	4.81	2.47	**H3**	4.89	7.42	5.73
A59	0.89	4.89	2.60	**H4**	5.04	7.47	5.84
A6	4.52	7.23	5.59	**H5**	4.97	7.46	5.78
A60	1.14	5.09	2.90	**H6**	5.01	7.48	5.82
A61	1.66	5.38	3.38	**H7**	4.96	7.49	5.82
A62	2.85	5.87	4.25	**H8**	4.94	7.49	5.82
A7	4.41	7.21	5.54	**H9**	5.02	7.49	5.85
A8	4.15	7.17	5.42	**W1**	5.07	7.51	5.88
A9	3.96	7.13	5.34	**W10**	5.11	7.57	6.00
C1	4.89	7.48	5.80	**W11**	5.09	7.57	5.99
C10	4.48	7.38	5.55	**W12**	5.07	7.57	5.99
C11	4.45	7.36	5.51	**W13**	5.04	7.58	5.97
C12	4.44	7.36	5.50	**W2**	5.07	7.51	5.89
C13	4.43	7.37	5.50	**W3**	5.09	7.52	5.92
C14	4.44	7.38	5.52	**W4**	5.12	7.53	5.94
C15	4.45	7.40	5.54	**W5**	5.15	7.53	5.95
C16	4.48	7.43	5.57	**W6**	5.17	7.53	5.97
C17	4.50	7.46	5.60	**W7**	5.17	7.54	5.98
C18	4.54	7.48	5.63	**W8**	5.15	7.55	5.99
				W9	5.13	7.56	5.99

Future Without Project Condition

Water quality is not expected to exceed the minimum reduction in DO resulting from anthropogenic affects in the FWOP condition. This is due to the existence of the TMDL and the reasonable assurance that SCDHEC will continue to implement the 401 water quality program in the future. However, for the FWOP condition, the model predicts a 0.08 mg/L average reduction of DO, and a 0.20 mg/L maximum reduction of DO (segment W2) throughout the harbor based on the historical rate of sea level rise alone. These findings demonstrate the sensitivity of the model to sea level rise.

2.4.7.2 Fecal Coliform Bacteria

Existing Condition

Coliform bacteria are present in the digestive tract and feces of all warm-blooded animals, including humans, poultry, livestock, wildlife, and domesticated animals. Fecal coliform bacteria are themselves generally not harmful, but their presence indicates that surface waters may contain pathogenic microbes. Diseases that can be transmitted to humans and animals through water contaminated by improperly treated human or animal waste are the primary concern.

Public health studies have established correlations between fecal coliform numbers in recreational and drinking waters and the risk of adverse health effects. Based on these data, the U.S. Environmental Protection Agency (EPA) and SCDHEC have developed enforceable fecal coliform standards to protect recreational and drinking water users from pathogens in surface waters. Proper waste disposal or sewage treatment prior to discharge to surface waters minimizes this type of pollution. The SCDHEC standard for fecal coliform bacteria in most SC waters, should, "not exceed a geometric mean of 200 counts/100 ml based on five consecutive samples during any 30-day period; nor shall more than 10 percent of the samples in any 30 day period exceed 400 counts/100 ml. For the portion of the Wando River that is classified as SFH, fecal coliform should, "not exceed an MPN fecal coliform median of 14 counts/100 ml nor shall more than 10 percent of the samples exceed an MPN of 43 counts/100 ml, where all tests are made using the five tube dilution method." The Charleston Waterkeeper has implemented a monitoring program for enterococcus bacteria (better indicator in saltwater) and posts the weekly sampling results on their website (http://charlestonwaterkeeper.org/water-quality/).

Future Without Project Condition

Water quality stressors, such as fecal coliform bacteria, will increase in the future due to increased development in the watershed. As urban development continues, the relative contribution of water quality impacts generated from non-point sources will likely increase. However, SCDHEC water quality initiatives and stormwater permitting requirements, including the appropriate use of best management practices, will minimize the impact of future development on the harbor. Predicting specific changes to the future water resources environment and land uses would be uncertain and speculative. Therefore, it is assumed that the continued management of this resource will minimize the potential impacts to water resources in the future.

2.4.7.3 Nutrients

Existing Condition

Nutrient parameters include forms of nitrogen (ammonia, organic nitrogen, nitrate nitrogen) and phosphorus. High amounts of nutrients can cause eutrophication (potentially causing depletion of DO needed by marine organisms, loss of habitats, and algal blooms), while low levels of nutrients can reduce plant growth and, for example, starve higher-level organisms that consume phytoplankton. Major sources of nutrient pollution to the Charleston Harbor estuary include point source discharges (e.g., wastewater treatment plants) and stormwater runoff (e.g., fertilizers and other pollutants).

In the Lower Cooper River, nitrogen is generally considered to be the "limiting nutrient" (i.e., the most important nutrient that actually controls plant growth in the system) because of its relatively low concentrations compared to other nutrients. However, the system is also light-limited because of the low transparency of the waters. The lack of submerged aquatic vegetation is a result of light limitation and unsuitable substrate.

As discussed previously, the marsh system in the estuary plays an important role in the nutrient dynamics of the estuary. The marshes consume inorganic nitrogen while exporting organic material and ammonia.

Future Without Project Condition

As urban development continues, the relative contribution of water quality impacts generated from non-point sources will likely increase. However, it is assumed that continued SCDHEC water quality initiatives and stormwater permitting requirements, including the appropriate use of best management practices, will minimize the impact of future development on the harbor. Predicting specific changes to the future water resources environment and land uses would be uncertain and speculative. Therefore, it is assumed that the continued management of this resource will minimize the potential impacts to water resources in the future.

2.4.7.4 Salinity

Existing Condition

Salinity concentrations in the river affect the estuarine habitat in many ways. Along with tidal inundation, salinity (and water surface elevation) generally determines the marsh vegetation species; it directly affects the fish, crustacean and clam populations; and it influences the DO concentrations. Salinity in the river is also of concern from a water usage perspective. Bushy Park (see Figure 1-3) is a freshwater reservoir located in the upper reaches of the Cooper River and used by local industry and the City of Charleston for water supply. Salinity intrusion to the estuary can cause periodic increases in chloride concentration above acceptable limits at the reservoir. These events typically occur during periods of drought, very high tides, sustained wind conditions, or storm events. To counter salinity intrusion events, there are several tide (water stage) and salinity monitoring stations in the harbor and the freshwater discharge from Lake Moultrie can be managed by increasing flow during these events to lower salinity concentrations in the Cooper River (USACE 2006).

In 1985, rediversion of the majority of flows from the Cooper River back to the Santee River was done to reduce shoaling and dredging quantities of Charleston Harbor. The maximum amount of freshwater inflow released from Lake Moultrie into the Cooper River, without causing stratification of sediment trapping density currents and still protecting the Bushy Park Reservoir from salinity intrusion was identified to be a 4500 cfs weekly average.

A salinity and tidal alert system (installed and monitored by U.S. Geological Survey) was developed to measure specific conductance which can be converted to salinity, and required discharges from Jefferies Hydroelectric Station at Pinopolis Dam to push the salinity down river and away from the entrance of the Bushy Park Reservoir. The system is monitored 24 hours a day, 7 days a week by

USGS with a validation by USACE staff. The system has successfully protected Bushy Park Reservoir from salinity since the construction of the Cooper River Rediversion Project in 1985 (see Appendix A for more detail). The two gages of primary concern are the Goose Creek gage located downstream of Bushy park entrance at Durham Canal and the Pimlico gage located upstream of Durham Canal. Historic percentiles at these gages show the minor increase in salinity over time since the rediversion (Table 2-26).

Table 2-26. Salinity percentiles (PPT)

USGS 02172050 Cooper River Near Goose Creek, SC

Salinity	Jul86-May88	Jun88-Apr92	May92-Jun99	Jul99-May04	Jun04-Dec11	Jul86-Dec11
1st percentile	0.019	0.030	0.027	0.029	0.033	0.029
10th percentile	0.041	0.036	0.034	0.041	0.042	0.042
50th percentile	0.066	0.059	0.049	0.071	0.075	0.063
90th percentile	0.154	0.142	0.123	0.166	0.207	0.188
99th percentile	0.370	0.378	0.339	0.403	0.458	0.405

USGS 02172020 West Branch Cooper River at Pimlico near Moncks Corner, SC

Salinity	Jul86-May88	Jun88-Apr92	May92-Jun99	Jul99-May04	Jun04-Dec11	Jul86-Dec11
1st percentile	0.025	0.030	0.026	0.025	0.029	0.026
10th percentile	0.033	0.033	0.029	0.030	0.033	0.033
50th percentile	0.048	0.039	0.037	0.050	0.039	0.039
90th percentile	0.053	0.052	0.044	0.063	0.055	0.055
99th percentile	0.058	0.060	0.062	0.068	0.062	0.065

Future Without Project Condition

The predicted sea level rise is expected to cause an increased frequency of tidal alerts (triggered by water levels at the Customs House gage near downtown Charleston) and possibly also result in an increase in salinity alerts (triggered by USGS gage specific conductivity readings). The tidal alert is not set on a specific water level height but rather a tide factor based on daily mean tide and tide range over a 24 hour period, and cannot be predicted for the future.

The EFDC model is not a reactive model and cannot capture the sequence of alert level that could be reached and the subsequent required discharge from Pinopolis. Thus, the model cannot be used to predict the increase in number of alerts. An analysis of the percentiles generated by the hydrodynamic model indicates that a typical flow year should not incur any salinity alerts at the Pimlico gage (USGS 02172020) and predicted sea level rise would not alter this. The Cooper River at Goose Creek gage (USGS 02172050) was predicted to experience a potential increase in the number of salinity alerts as a result of sea level rise (Appendix A, Section 3.7.4); however, an increase in the number of tidal alerts would likely mitigate the number of salinity alerts. Since the Cooper River Rediversion Project was constructed to benefit navigation within Charleston Harbor, if a significant increase in alerts occurs, the USACE will evaluate the feasibility of relocating the intake to Bushy Park Reservoir farther upstream along with reassessing the alert system.

2.4.7.5 Turbidity and Suspended Solids

Existing Condition

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

Concentrations of cadmium, chromium, copper, lead, mercury, and nickel in water are routinely measured by SCDHEC to compare to state standards intended to protect aquatic life and human health. These metals occur naturally in the environment, and many are essential trace elements for plants and animals. Human activities, such as land use changes and industrial and agricultural processes also have resulted in an increased flux of metals from land to water. Atmospheric inputs are recognized as important sources of metals to aquatic systems. Some metals can be released to the atmosphere from the burning of fossil fuels (coal, oil), wastes (medical, industrial, municipal), and organic materials. The metals are then deposited on land and in waterways from the atmosphere via rainfall and particulates (dry deposition). Water quality impacts from dredging, accidental spills, and bilge wastes have the potential to occur on occasion from existing port facilities, commercial shipping traffic, recreational traffic, military operations, and maintenance dredging operations.

Future Without Project Condition

Water quality impacts from dredging, accidental spills, and bilge wastes will likely continue in the future from existing port facilities, commercial shipping traffic, recreational traffic, military operations, and maintenance dredging operations. These impacts are already minimized due to strict enforcement and adherence to federal, state, and local water quality regulations and the use of best management practices. As urban development continues, the relative contribution of water quality impacts generated from non-point sources will likely increase. However, SCDHEC water quality initiatives and stormwater permitting requirements, including the appropriate use of best management practices, will minimize the impact of future development on the harbor. Predicting specific changes to the future water resources environment and land uses would be uncertain and speculative. Therefore, it is assumed that the continued management of this resource will minimize the potential impacts to water resources in the future.

2.4.8 Groundwater

Existing Condition

Groundwater is a common issue addressed in channel deepening studies due to the potential for impacts to aquifers used by the public and municipalities. The City of Charleston currently receives its drinking water from surface water (Bushy Park and Edisto River), and the major producing aquifers are deeper than the maximum dredge depth. Section 2.4.5.3 described the hydrogeological setting of the project area, and details on the many aquifers in the Study area and a discussion on deep aquifers and their use are provided in the Appendix B (Geotechnical). The surficial unconfined aquifer ranges from 40 to 65 feet thick within the Charleston area. Groundwater occurs at water-table depth, which ranges from 3 to 15 feet and annual fluctuation ranges from 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 yield is not consistent enough to be considered for widespread use. In addition, saltwater intrusion as a result of over-pumping has limited the use of this aquifer for municipal use (Park, 1985). Wells drilled into this aquifer mainly serve limited residential and irrigation use (Hockensmith and Doars, SCDNR, personal communication, 2012).

Future Without Project Condition

Future regional growth will create additional demand for potable water. The Charleston Water System and Lake Moultrie Water Agency use surface water (Edisto River and Lake Moultrie) for raw water supply, and therefore, growth in these service areas will not create additional impacts to groundwater resources. Continued use of smaller shallow water aquifers could stress groundwater resources; however, SCDHEC has designated the tri-county area as a Capacity Use Area, which requires a SCDHEC permit for wells drawing more than 3 million gallons per day. This will minimize impacts to groundwater resources from other potential future demands.

2.4.9 Wetlands

Existing Condition

Understanding the wetland distribution within Charleston Harbor is an important component of this project due to the influence that water quality and hydrodynamic changes resulting from a project can have on their distribution.

With the confluence of the Ashley, Cooper, and Wando Rivers, the harbor's contributing watersheds drain approximately 1,200 square miles (SCDHEC 2002). Historically, the Ashley, Wando, and Cooper Rivers were all tidal sloughs with limited freshwater inflow and extensive tidal marshes. Development in the watershed, principally the construction of upstream reservoirs and canals, has altered historic freshwater flows (which were historically very low). Also, in the 17th and 18th centuries, rice plantations were created in the upper Cooper and Ashley Rivers by extensive diking of intertidal wetlands. Remnants of these fields can be seen above the "Tee" where the Cooper River splits into the East and West Branches and along the upper Ashley River. Despite land use changes over time that have increased freshwater flows into the project area, large tracts of tidal marsh remain and are extremely important for both resident and migratory fish and wildlife. Additional elements of wetland function include: water purification, flood protection, shoreline stabilization, groundwater recharge, streamflow maintenance, retention of particles, surface water storage, subsurface storage, nutrient cycling, biodiversity, values to society, and fish and wildlife habitat.

Three broad types of marshes or wetlands within the project area include tidal saltwater marsh (meso- and poly-haline), brackish marsh (oligohaline), and tidal freshwater marsh. Figure 2-23 depicts the existing condition average annual surface water salinity concentrations for one flow year (low flow) (as determined by the EFDC model). Low flow conditions were used because Cowardin et al. (1979) based wetland habitat type partly on low flow conditions. Figure 2-24 indicates the distribution of these wetland types along a salinity gradient during low flow (or drought) (defined by Cowardin et al., 1979).

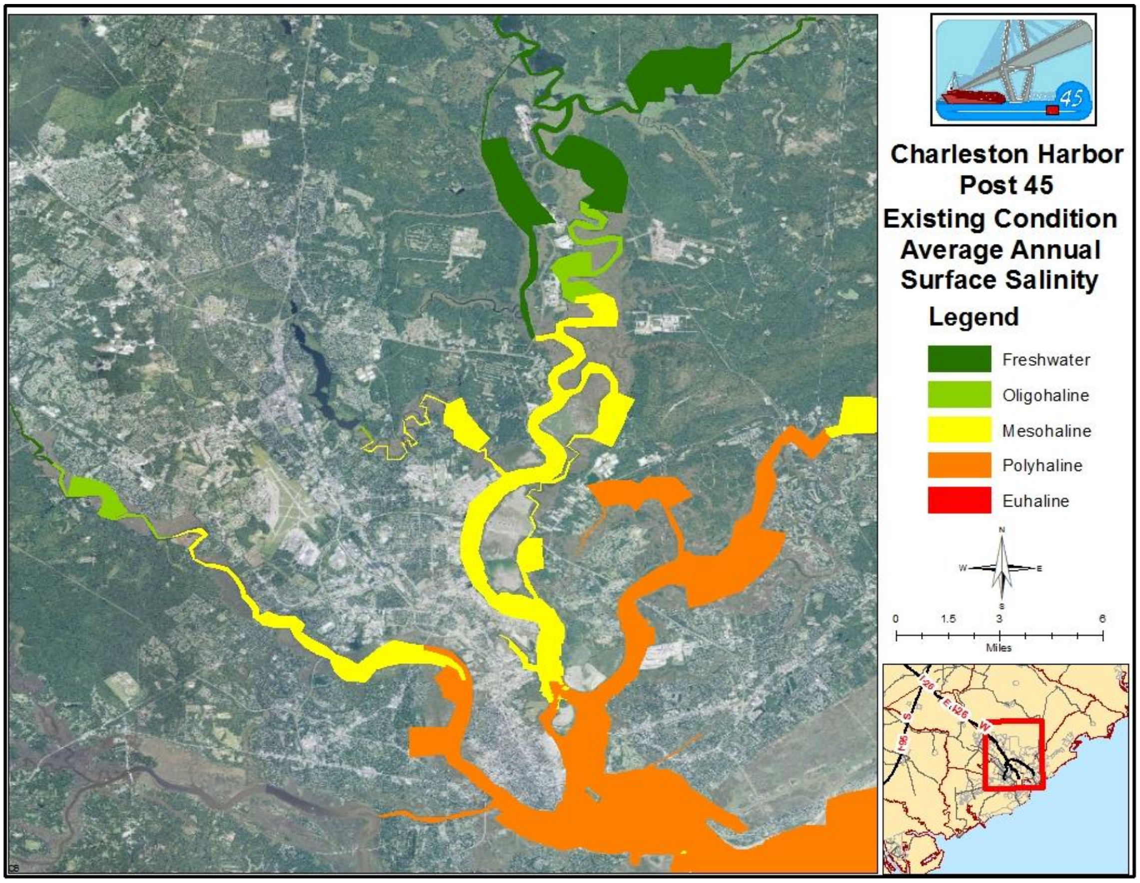


Figure 2-23. Existing condition average annual low flow surface salinity to represent different wetland salinity distributions within Charleston Harbor as modeled in EFDC

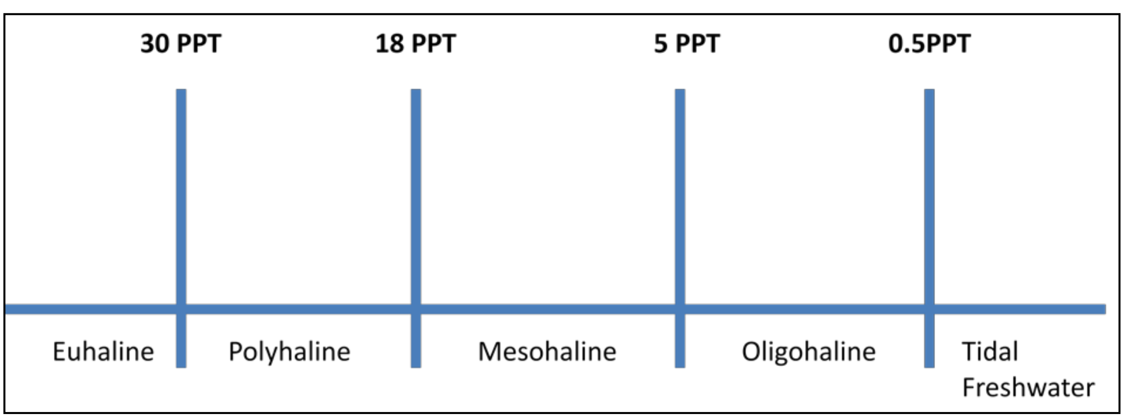


Figure 2-24. Salinity gradient for different wetland salinity distributions (PPT = Parts Per Thousand)

Tidal meso- and polyhaline wetlands in Charleston Harbor include estuarine emergent marshes dominated by cordgrass species (*Spartina sp.*) and black needlerush (*Juncus roemerianus*). Higher elevation emergent marsh areas contain sea oxeye (*Borrichia frutescens*), salt grass (*Distichlis spicata*), and salt meadow hay (*Spartina patens*). Estuarine scrub shrub wetlands are dominated by wax myrtle (*Myrica cerifera*), salt marsh elder (*Iva frutescens*), and groundsel tree (*Baccharis halimifolia*).

Tidal oligohaline wetlands are dominated by big cordgrass (*Spartina cynosuiroides*) and black needlerush. Other species include smooth cordgrass (*Spartina alterniflora)*, and salt-marsh bulrush (*Bolboschoenus robustus*). A number of freshwater species can occur within these marshes including including arrow-arum (*Peltandra virginica*), wild rice (*Zizania aquatica*), dotted smartweed (*Persicaria punctatum*), water primrose (*Ludwigia* sp.), bur-marigold (*Bidens* sp.), and salt-marsh aster (*Symphyotrichum* sp.). Within the lower stretches of oligohaline marshes, freshwater species are sparsely distributed, and within the upper stretches of these marshes freshwater species appear with increasing regularity.

These tidal wetland systems (estuarine emergent wetlands, or oligo-, meso-, and polyhaline marshes) are important for many wildlife species, including, but not limited to certain species managed under Essential Fish Habitat provisions (see EFH section below). For example, the majority of estuarine shrimp are found in close proximity to such shallow wetland systems. These wetlands are also important for many species of snapper, grouper, flounder, and certain migratory pelagic (living or occurring in the open sea) species as nursery areas. However, most juvenile managed fish found in the riparian salt/brackish marsh nurseries are spawned offshore and transported into the estuary through tidal inlets. Many commercial and managed species such as shrimp and summer flounder (*Paralichthys dentatus*) inhabit the tidal salt marsh edge, while adult spotted seatrout (*Cynoscion nebulosus*), flounder, and red drum (*Sciaenops ocellatus*) forage the grass line for shrimp and other prey. Nursery areas, for species such as black drum (*Pogonias cromis*), red drum, and spotted seatrout, can include soft bottom areas surrounded by salt/brackish marsh as well. Hence, the estuarine marshes are essential habitat to many managed species and serve multiple functions to various fish life-stages (Street et al., 2005).

Some of the most ubiquitous residents (permanent or transitory) of tidal/estuarine wetlands are migratory birds (see Migratory Birds section below). Bitterns, oystercatchers, rail, herons, pelicans, terns, ibises, egrets, and gulls are a small sampling of typical coastal wetland avian species. Wetlands and coastal areas provide important habitat for many protected species and species of special concern, including the red knot, which was recently listed as endangered under the Endangered Species Act.

Other common inhabitants of tidal/estuarine wetlands include blue crab (*Callinectes sapidus* Rathburn) and eastern oyster (*Crassostrea virginica*). These species, along with shrimp and various life stages of the bird and fish species noted above, form part of a broad base for the food-web that is necessary to support populations of larger consumers, such as bald eagles, ospreys, alligators, snakes, minks/weasels, bobcats, and other vertebrates, including humans.

Tidal freshwater emergent wetlands in the upper portion of the Cooper and Ashley Rivers include intertidal emergent species, floating leaf vegetation, and submerged aquatic vegetation. The excerpt below from US Fish and Wildlife Service (1984) defines the major characteristics of tidal freshwater Wetlands. "Tidal freshwater wetlands are a distinctive type of ecosystem located upstream from tidal saline wetlands (salt marshes) and downstream from non-tidal freshwater wetlands. They are characterized by (1) near freshwater conditions (average salinity of 0.5ppt or below except during periods of extended drought, (2) plant and animal communities dominated by freshwater species and (3) a daily lunar tidal function." Typically tidal freshwater wetlands/marshes are more species rich than their brackish or saltwater counterparts. In the Cooper River, tidal freshwater marsh species include white marsh/cutgrass (*Zizaniopsis miliacea*), wild rice, sawgrass (*Cladium sp.*) and bulrush (*Scirpus sp.*). Also present and often mixed in with these common freshwater plants are big cordgrass, black needlerush, and salt-marsh bulrush. These wetlands frequently have an understory of green arrow arum (*Peltandra virginica*); water-primrose (*Ludwigia sp.*); water hyacinth (*Eichhornia sp.*); pickerelweed (*Pontederia sp.*); sensitive fern (*Onoclea sensibilis*); arrowhead/duck potato (*Sagittaria sp.*); water hemlock (*Cicuta sp.*); lizard's tail (*Saururus cernuus*); alligator weed (*Alternanthera philoxeroides*); obedient plant (*Physostegia virginiana*); spider lily (*Lycoris radiata*); smartweed (*Polygonum sp.*); beard grass (*Andropogon sp.*); false indigo (*Amorpha sp.*); and groundnut (*Apios americana*). Submerged aquatic vegetation primarily includes hydrilla (*Hydrilla verticillata);* Brazilan elodea *(Egeria densa); p*ondweed (*potamogeton sp.);* and Carolina fanwort (*Cabomba sp.).* While floating leaf vegetation primarily includes species such as water-primrose, water hyacinth, pickerelweed, and smartweed

Also present along the freshwater portion of these river systems are bottomland hardwood forests. These areas are similar to <u>palustrine freshwater forested wetlands</u> and occur at the interface of tidal aquatic and terrestrial ecosystems (James et al., 2012). Cowardin et al., (1979) define palustrine wetlands as, "all nontidal wetlands dominated by trees, shrubs, persistent emergents, emergent mosses or lichens, and all such wetlands that occur in tidal areas where salinity due to ocean-derived salts is below 0.5ppt." James et al., (2012) indicated that palustrine freshwater forested wetlands exist at the landward extent of the head of tide and above the saltwater-freshwater interface, which theoretically occurs at the 0.5 ppt salinity boundary. Field et al., (1991) conservatively estimated that there are 40,000 hectares of tidal freshwater forested wetlands in South Carolina. EPA defines these systems as river swamps. "They are found along rivers and streams of the southeast and south central United States, generally in broad floodplains. These ecosystems are commonly found wherever streams or rivers at least occasionally cause flooding beyond their channel confines. They are deciduous forested wetlands, made up of different species of gum (*Nyssa* sp.) and oak (*Quercus* sp.) and bald cypress (*Taxodium distichum*), which have the ability to survive in areas that are either seasonally flooded or covered with water much of the year. Identifying features of these wetland systems are the fluted or flaring trunks that develop in several species, and the presence of knees, or aerial roots." (http://water.epa.gov/type/wetlands/bottomland.cfm). Also observed in these areas are tupelo, red maple, eastern red cedar, Atlantic white cedar, wax myrtle, sweet bay, red bay, pine, magnolias, etc. These wetlands offer many ecosystem services including storm water runoff mitigation, storm surge protection, and structure and support for animal habitats (James et al., 2012). The Cooper, Ashley, and Wando Rivers all have palustrine wetlands (tidal and non-tidal) within their watersheds that are included within the impact assessment discussed below.

Tidal freshwater wetlands are recognized as hotspots for biodiversity, valuable habitat, and nutrient exchange. In South Carolina, some common inhabitants of tidal freshwater marshes and forested wetlands are the great blue heron; great egret; American and least bittern; American coot; common moorhen; Virginia rail; spotted sandpiper; bald eagle; osprey; red-shouldered hawk; owls; and wild turkey. Common songbirds include the belted kingfisher; pileated woodpecker, red-bellied woodpecker, and several species of swallows, sparrows, and warblers. The forested wetlands in the study area provide critical winter food and cover for waterfowl. Many of the mast-producing trees provide high energy foods from acorns and other nuts. The abundance of invertebrates provides the necessary protein to get birds the nutrients they need for reproduction and migration. Common mammals associated with South Carolina wetland habitat include muskrat, beaver, raccoon, swamp rabbits, mink, white-tailed deer, and the river otter. Numerous reptiles and amphibians live in or use wetlands, including water snakes, cottonmouth moccasins, queen snake, eastern ribbon snake, and timber rattlesnake. Turtles found in these areas include slider, painted, mud, snapping turtles, and the diamondback terrapin. Common frogs include the wood frog, chorus frog, pickerel frog, green frog, bullfrog, and spring peeper.

Figure 2-25 depicts the existing wetland community structure in the Charleston Harbor as delineated by SCDHEC-OCRM (unpublished data) using imagery to determine the extent of high marsh versus low marsh (based primarily on the presence of *Juncus roemarianus* (high marsh) and *Spartina alterniflora* (low marsh)). Figures 2-26, 2-27, and 2-28 depict the existing wetland community structure for the Ashley, Cooper, and Wando Rivers, respectively. For details on the designations of the various wetland types and information on the wetland impact assessment methodology please see Appendix L (Wetlands Impact Assessment).

Figure 2-25. Overview of approximate high and low marsh wetland habitats in the vicinity of the proposed project

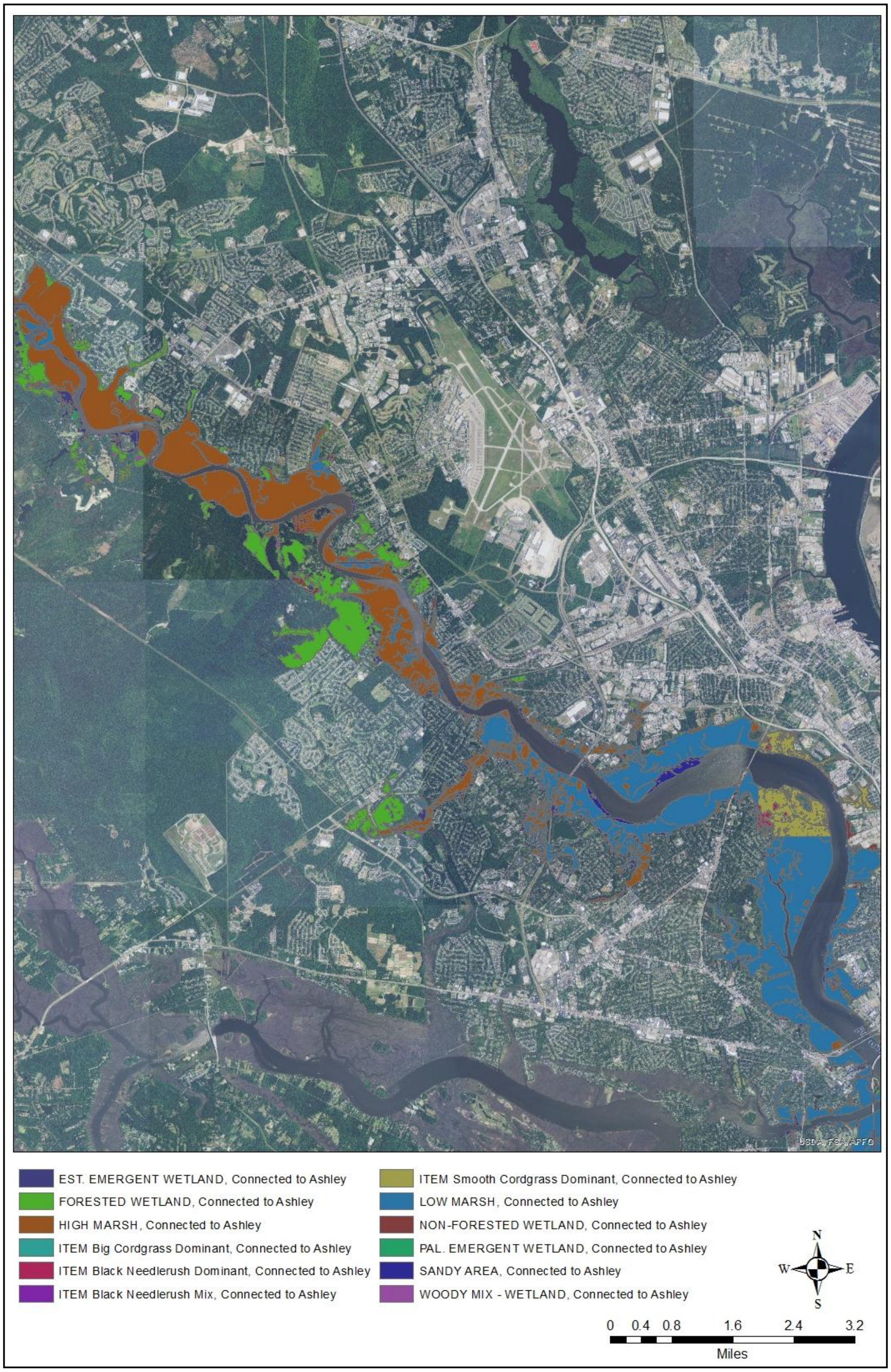


Figure 2-26. Wetland map resulting from USACE remote sensing study. Wetlands connected to the Ashley River (ITEM = Intertidal Emergent Marsh)

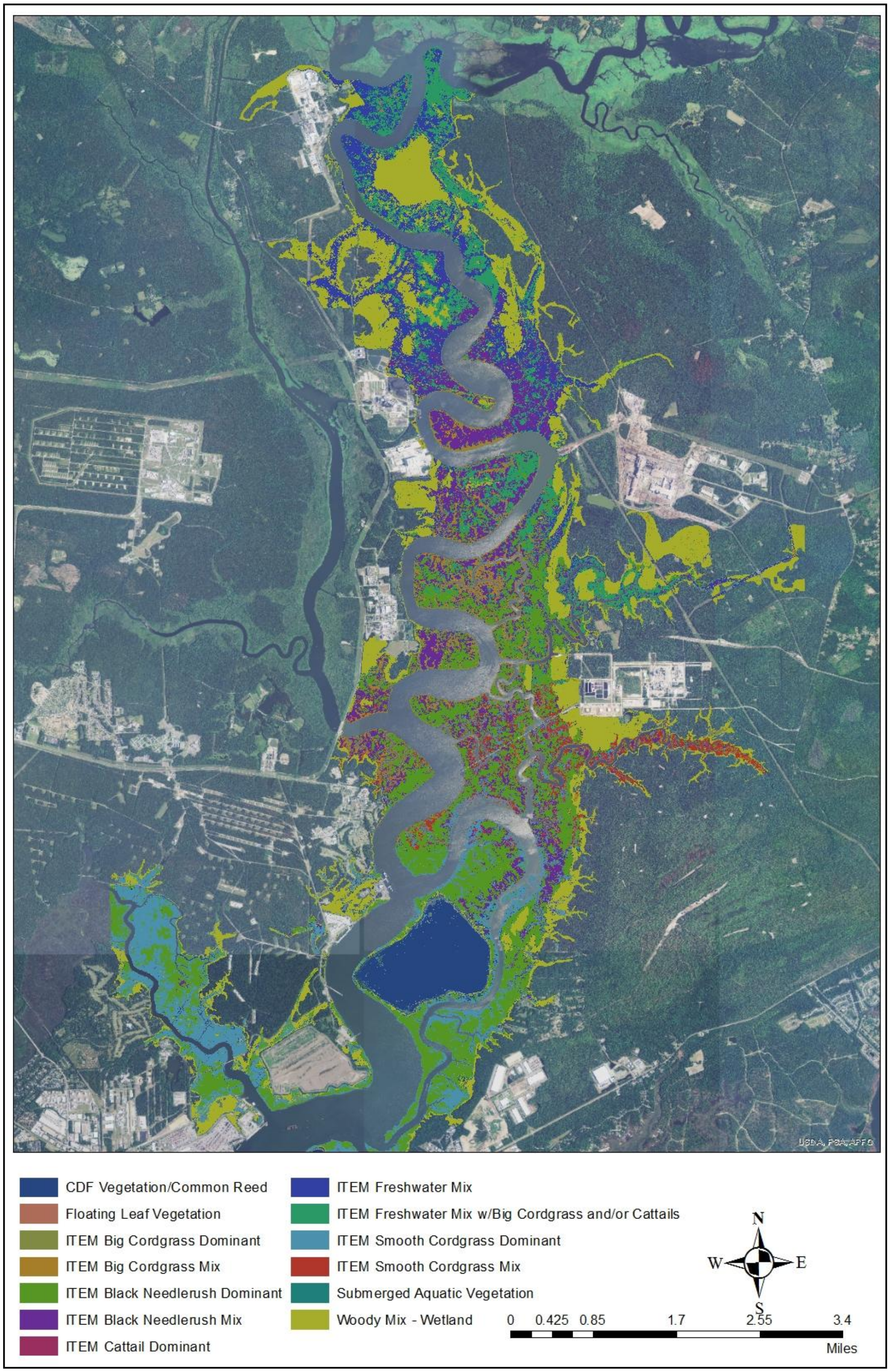


Figure 2-27. Wetland map resulting from USACE remote sensing study. Wetlands connected to the Cooper River (ITEM = Intertidal Emergent Marsh)

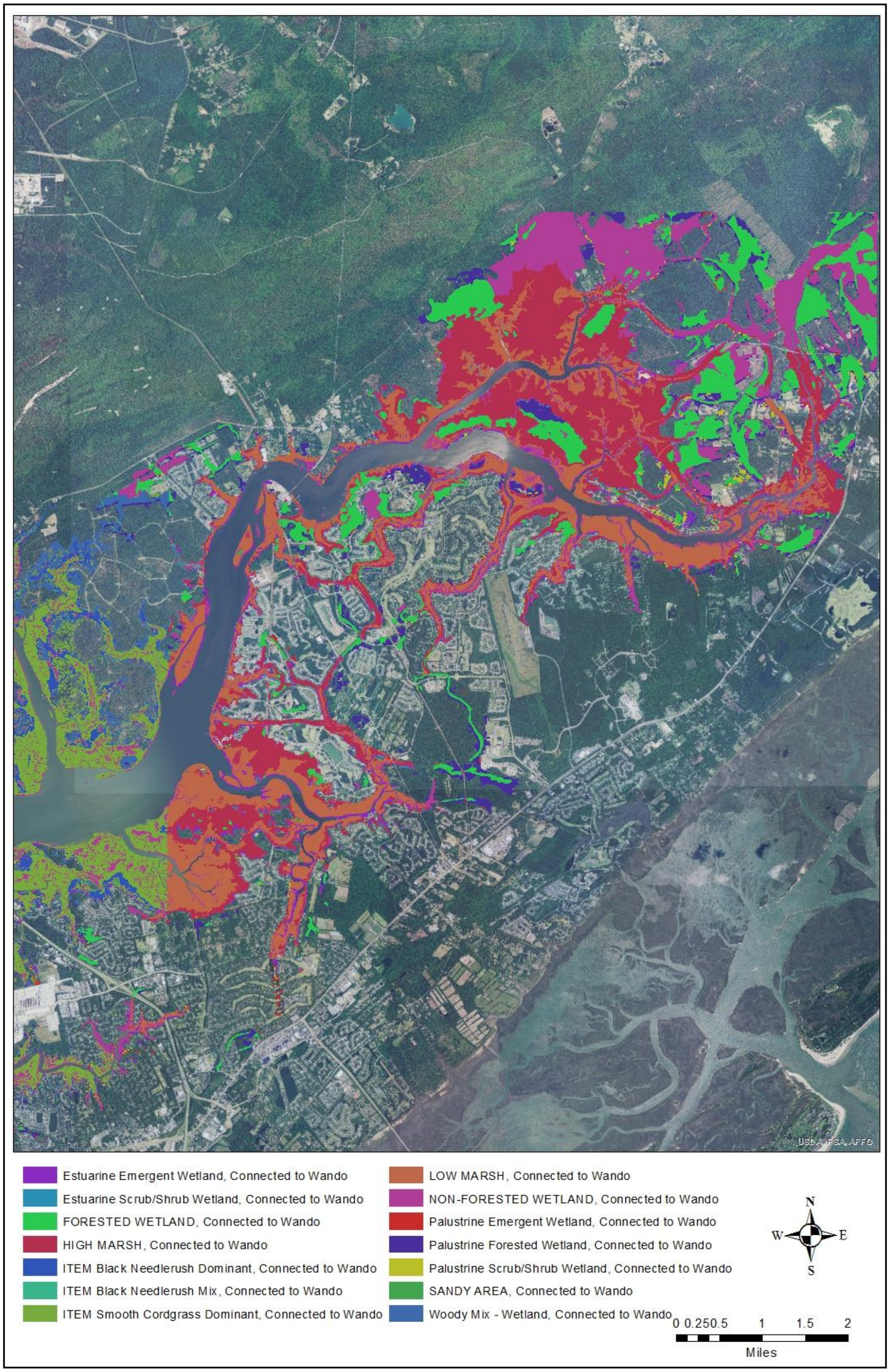


Figure 2-28. Wetland map resulting from USACE remote sensing study, wetlands connected to the Wando River (ITEM = Intertidal Emergent Marsh)

Future Without Project Condition

In the FWOP condition / No Action Alternative, operations and maintenance dredging will have no effect on existing wetlands in the Charleston Harbor or its rivers. However, the predicted sea level rise will cause saline water to propagate further up each of the rivers. Using the EFDC model, the affects of 50 years of the historic rate of sea level rise were estimated. That analysis and additional details are provided in Appendix L (Wetlands Impact Assessment).

Figures 2-29 and 2-30 show the affects of historic sea level rise on the movement of the 0.5 ppt salinity isopleths in the Cooper and Ashley River, respectively. Sea level rise is predicted to cause a 7,039 foot upriver shift of the 0.5 ppt isopleth in the Cooper River, and a 2,935 foot shift in the Ashley River. This shift would cause a change in the composition of freshwater wetland vegetation in these areas as they experience salinity stress and succumb to more salt tolerant vegetation, and it is predicted that approximately 634 and 167 acres of freshwater wetlands could be impacted by sea level rise alone in the Cooper and Ashley Rivers, respectively (see Appendix L for details). Sea level rise is predicted to shift the 5.0 ppt salinity isopleth approximately 8,248 feet and 2,572 feet up the Cooper and Ashley Rivers, respectively. Additionally, sea level rise would cause the 18 ppt salinity isopleth to shift 513 feet, 3,583 feet, and 3,071 feet up the Cooper, Ashley and Wando Rivers, respectively. It should be noted that the EFDC model is not a “reactive model”, and as such, the influence that the salinity and tidal alert system of freshwater releases from Pinopolis Dam are not factored into the model. It is assumed that this system would minimize the effects predicted by the model.

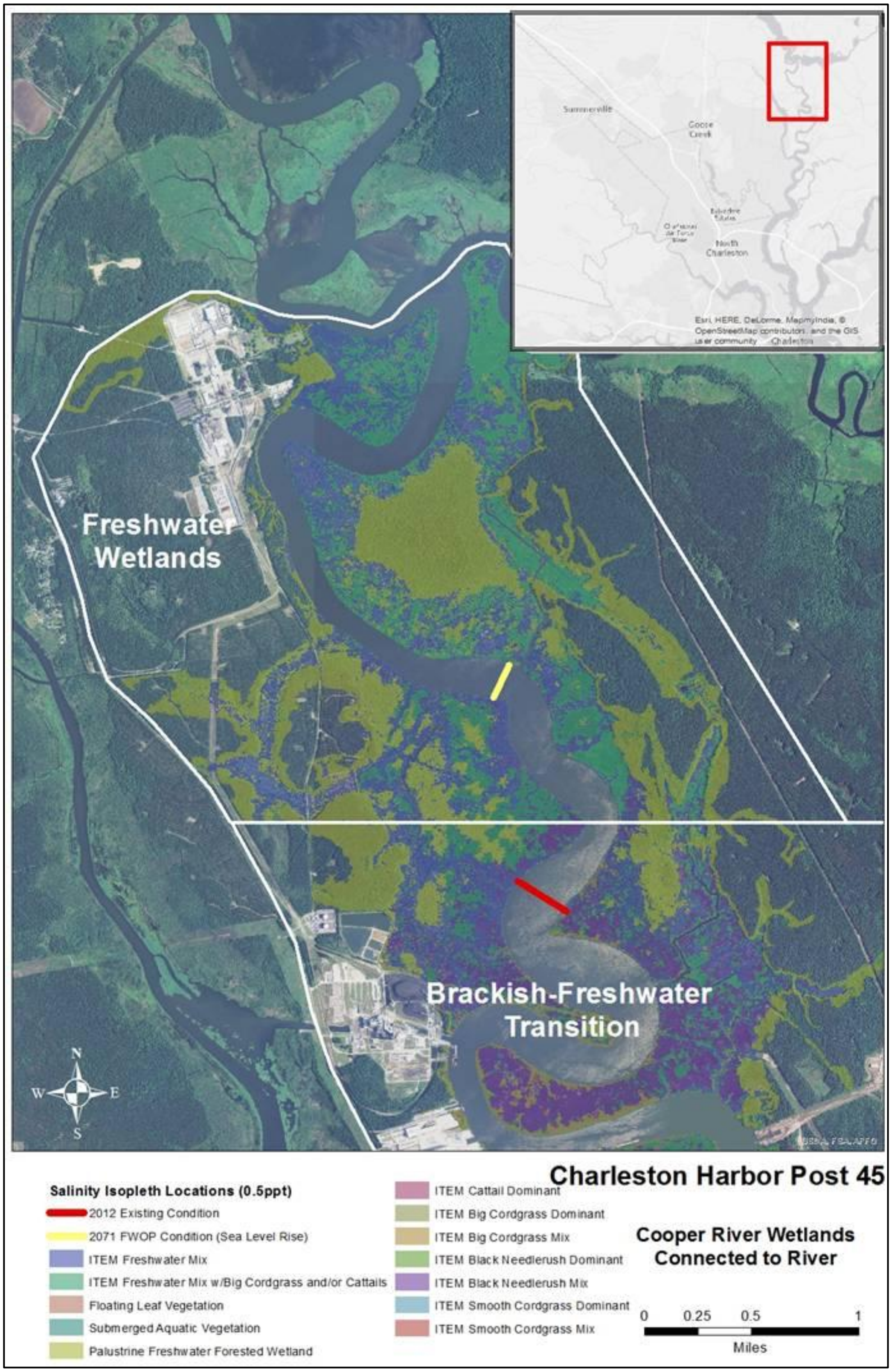


Figure 2-29. Cooper River freshwater (0.5ppt) salinity isopleths for the existing condition and FWOP condition in year 2071.

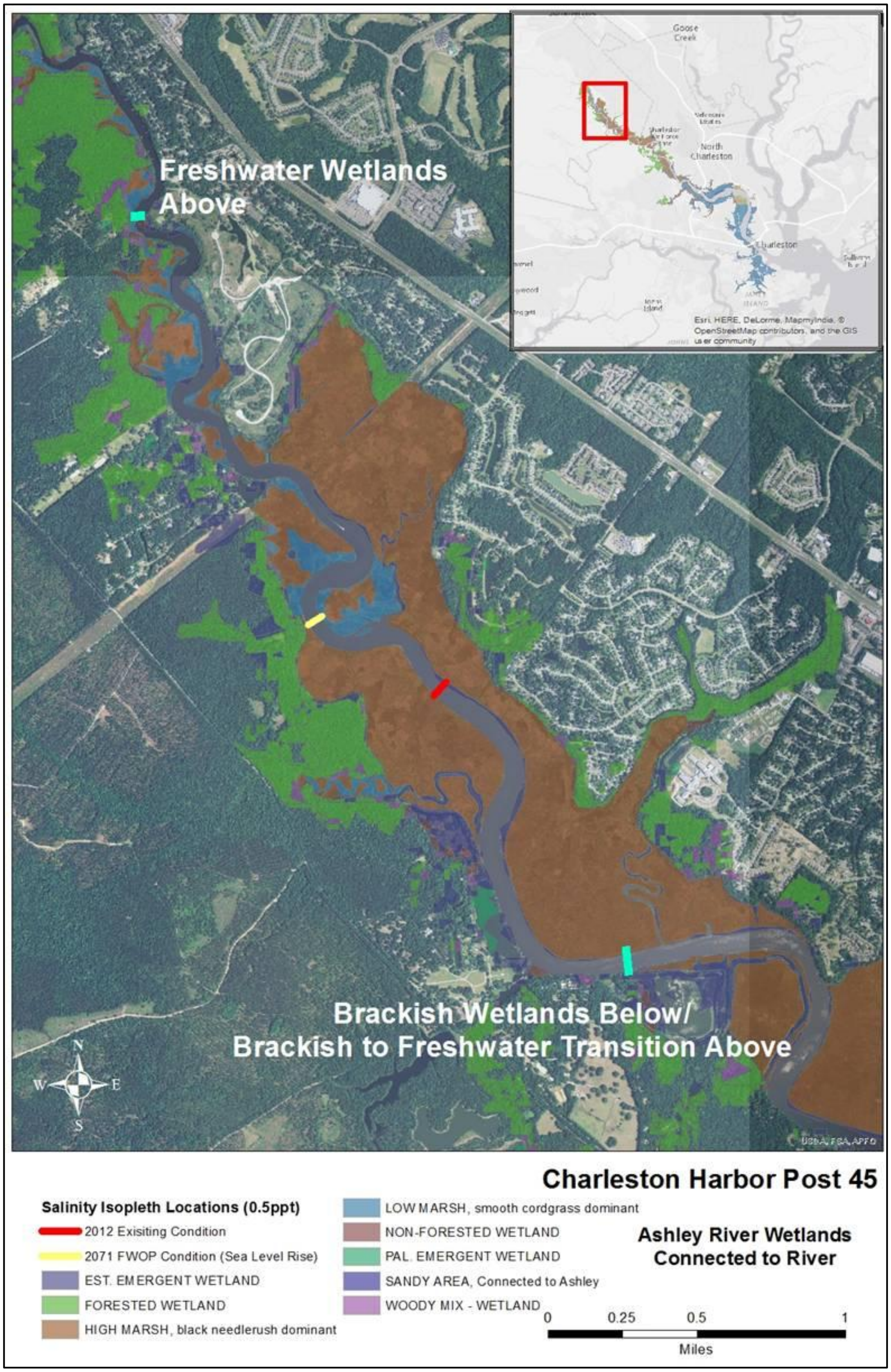


Figure 2-30. Ashley River freshwater (0.5ppt) salinity isopleths for the existing condition and FWOP condition in year 2071.

2.4.10 Hardbottom Habitat

Existing Condition

With almost any dredging project, it is important to consider impacts to subsurface features that serve as essential fish habitat or provide unique habitat features or services. Hardbottom habitat provides valuable structure for benthic (occurring at the bottom of a body of water) fauna and flora, as well as fish habitat. Hardbottom refers to a classification of coral communities that occur in temperate, subtropical, and tropical regions that lack the diversity, density, and reef development of other types of coral communities (SAFMC 1998). For the purposes of this investigation, hardbottom habitat is defined as exposed areas of rock or consolidated sediments, distinguished from surrounding unconsolidated sediments, which may or may not be characterized by a thin veneer of live or dead biota (the plant and animal life of a region), generally located in the ocean rather than in the estuarine system. These hardbottom reefs are an important component of South Carolina's offshore resources, which provide habitat and foraging grounds for a diverse array of invertebrate and fish species (Wenner et al. 1983; Sedberry and Van Dolah 1984). These communities support habitat-structuring sessile (non-mobile) epifauna (organisms living on the sea floor) such as sponges, corals, bryozoans, and ascidians (Burgess et al. 2011). Burgess et al. (2011) state that nearshore hardbottom habitat is typically patchy and surrounded by large expanses of sand, and that the reef organisms are often exposed to sediment movement resulting from winds, tides and storms.

Due to the structural complexity and more permanent nature of hardbottom habitat, it is particularly important to fish and invertebrate species. Jaap (1984) states that fish comprise a major portion of the animal biomass on hardbottom and are important to the overall trophic structure. The fauna of hardbottom can be characterized by wrasses, damselfish, snappers, grunts, parrotfish, and sea basses. Closer inshore hardbottom support large numbers of temperate fish species, such as black sea bass, spottail, pinfish, and estuarine-dependent migratory species (Huntsman and Manooch 1978). Hardbottom habitat serves these species by providing refuge, spawning grounds, and nursery habitat.

For these reasons, it was important to document areas of hardbottom habitat and to determine how the various alternatives would impact it. From late 2012 through early 2013, Coastal Carolina University performed offshore surveys in support of cultural/historic and hardbottom resource investigation for the Post 45 study. These surveys used side scan sonar, sub-bottom profiling, and magnetometer equipment coupled with ground-truthing via towed video transects. Habitat was classified as either "hardbottom", "probable hardbottom", "possible hardbottom", or no classification. Details on these classifications can be found in Gayes et al., (2013) or in Appendix I. Figures 2-31 (west portion of Entrance Channel) and 2-32 (the east) show the hardbottom and probable hardbottom habitat within the Study area. It was also determined that roughly 28.6 acres of hardbottom habitat occurs within a portion of the Entrance Channel that has not been impacted by past dredging (Figure 2-33).

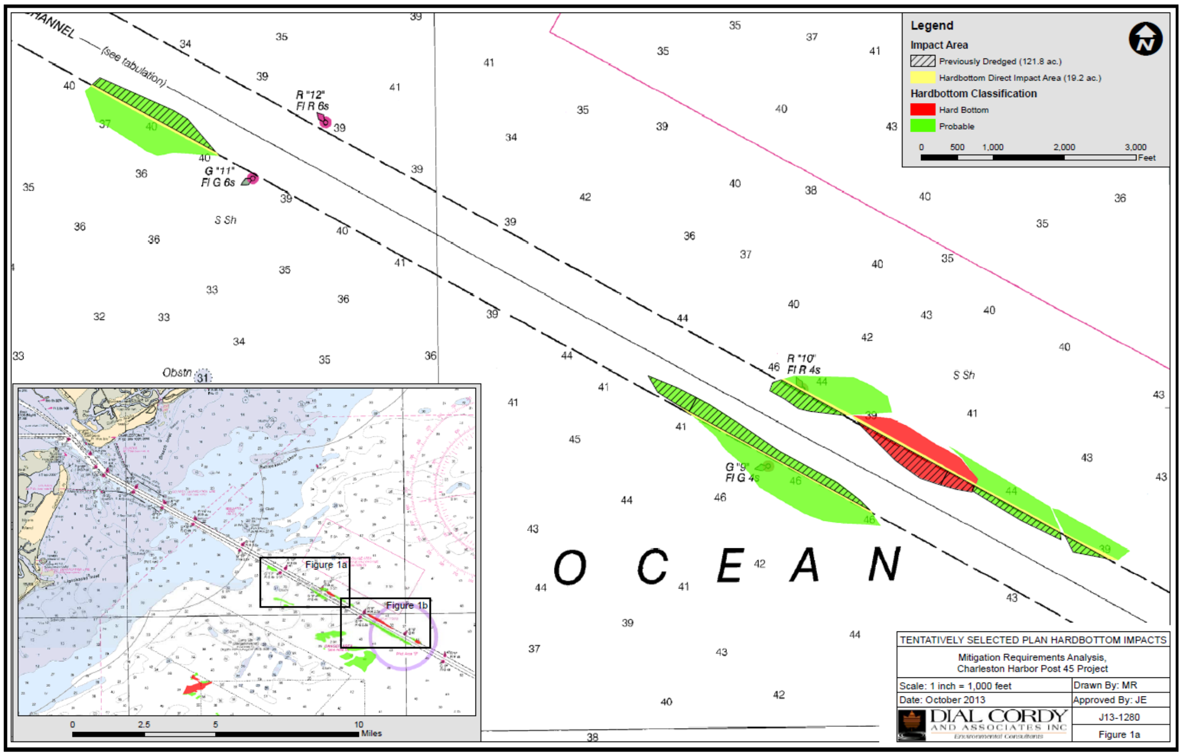


Figure 2-31. Hardbottom habitat adjacent to the navigation channel (west)

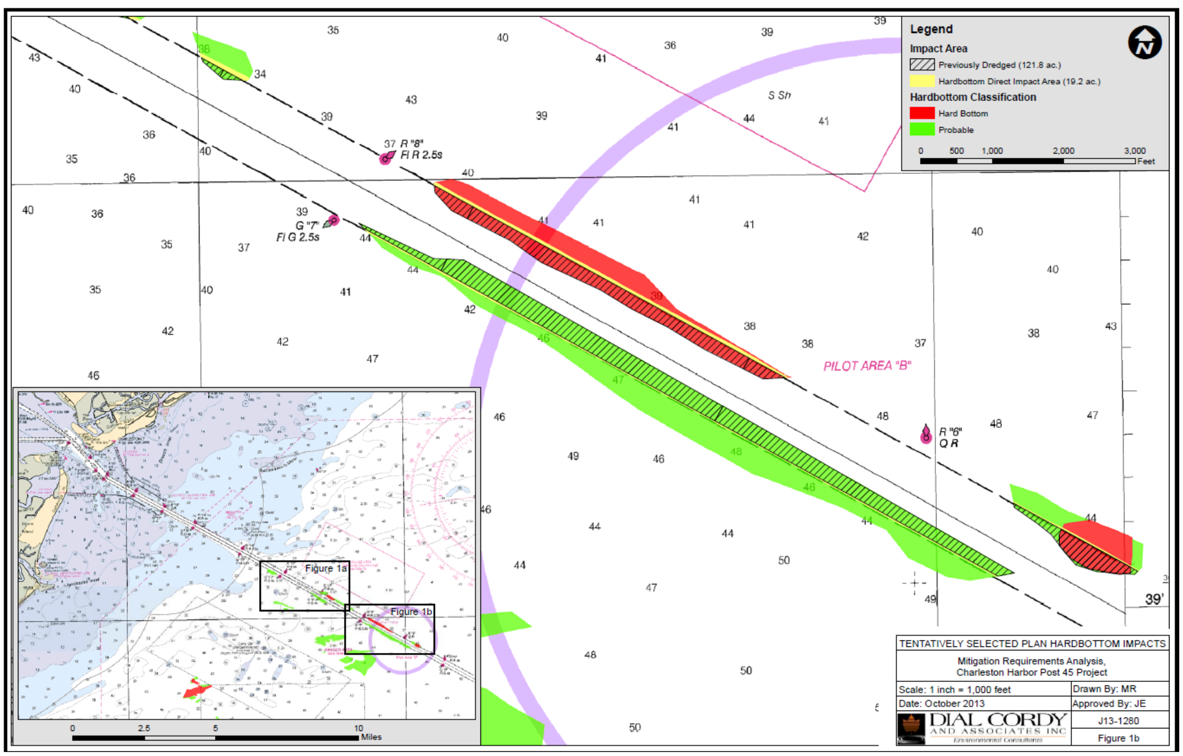


Figure 2-32. Hardbottom habitat adjacent to the navigation channel (east)

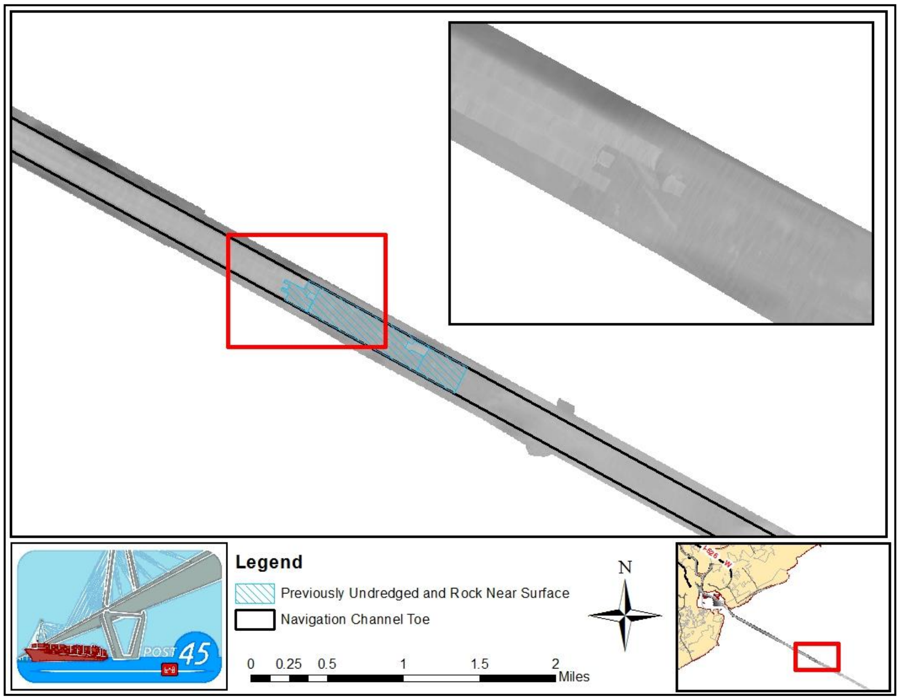


Figure 2-33. Location of previously undredged portion of channel that has rock at or near the surface and could contain live hardbottom communities

Future Without Project Condition

Continuing to perform O&M dredging at the currently authorized depths would result in minor indirect impacts to hardbottom benthos along the margins of the channel due to turbidity impacts. The bottom of the channels would normally be recolonized by organisms from adjacent similar habitats following completion of dredging events. No intentional impacts to hardbottom habitat would occur in the FWOP condition. A greater number of vessels are anticipated to call on the port in the FWOP condition. Therefore, more pressure wave and propeller wash impacts to hardbottom habitat would occur, which could limit the growth of this habitat.

2.4.11 Essential Fish Habitat

Existing Condition

The 1996 amendments to the Magnuson-Stevens Fishery Conservation and Management Act (Magnuson-Stevens Act) set forth a new mandate for the NMFS, regional fishery management councils (FMC), and other federal agencies to promote the protection, conservation, and enhancement of Essential Fish Habitat (EFH). The EFH provisions of the Magnuson-Stevens Act support one of the nation’s overall marine resource management goals to maintain sustainable fisheries. The Magnuson-Stevens Act’s final rule, to manage fishery resources and their habitats, was released on January 17, 2002. The National Marine Fisheries Service (NMFS) and affiliates, the South Atlantic Fishery Management Council (SAFMC) and the Mid-Atlantic Fishery Management Council (MAFMC), oversee the managed species and their habitats potentially found within the proposed project's footprint [National Oceanic and Atmospheric Administration (NOAA) 2009b, NOAA 2009c]. In addition, the Atlantic States Marine Fisheries Commission (ASMFC) serves as a roundtable for cooperative discussion between 15 Atlantic States, coordinating the protection and administration of the states' shared near shore fishery resources (ASMFC 2009).

The combination of fishery and habitat management with emphasis on healthy and diverse estuarine and marine ecosystems meets the EFH mandates of the Magnuson-Stevens Act. If a construction, permitting, funding, or other proposed action potentially affects EFH(s), then applicable federal permitting agencies must consult with the NMFS. The EFH consultation ensures the potential action considers the effects on important habitats and supports the management of sustainable marine fisheries (NOAA, South Atlantic Region 2008).

Charleston Harbor supports significant fish and wildlife resources including many marine and estuarine species. The estuary supports large populations of penaeid shrimp and blue crabs which are economically important species. Demersal (living near the bottom of the sea) fish species include Atlantic croaker; bay anchovy; Atlantic menhaden; spotted hake; weakfish; spot; blackcheek tonguefish; white catfish; and silver perch. Other fish of commercial or recreational value are commonly found in Charleston Harbor; including flounder; red drum; spotted seatrout; bluefish; spot; and black drum. Six anadromous fish species; Atlantic sturgeon; shortnose sturgeon; American shad; blueback herring; hickory shad; and striped bass; and one catadromous species; American eel; use Charleston Harbor and its tributaries as migration routes and spawning areas.

All of Charleston Harbor's tidally influenced reaches and adjacent wetlands are considered EFH. The NMFS provided USACE with a NEPA Scoping letter on November 2, 2011. In this letter NMFS indicated that EFH within the project area includes estuarine and marine emergent vegetation, tidal freshwater wetlands, tidal creeks, oyster reefs, water column, intertidal and subtidal mudflats (unconsolidated bottom), coastal inlets, coral and artificial reefs, and hardbottom." Many of these habitats foster growth and provide food and protection from predators and are integral to producing healthy populations of commercially and recreationally important species. Details on these habitat types can be found in the EFH Assessment (Appendix H). Species that may occur in the project area habitats are noted in Table 2-27, if managed by either SAFMC or NMFS or if either entity has developed fishery management plans for that species. The following paragraphs discuss these species' potential to occur in EFH within the project area (adapted from USACE 2006).

Table 2-27. Fishery management plans and managed species that may occur in the project area

Common Name	Species
Shrimp	
brown shrimp	*Farfantepenaeus aztecus*
pink shrimp	*Farfantepenaeus aduorarum*
rock shrimp	*Sicyonia brevirostris*
royal red shrimp	*Pleoticus robustus*
white shrimp	*Litopenaeus setiferus*
Snapper Grouper Complex	
Jack crevalle	*Caranx hippos*
gag grouper	*Mycteroperca microlepis*
black sea bass	*Centropristis striata*
mutton snapper	*Lutjanus analis*
red snapper	*Lutjanus campechanus*
lane snapper	*Lutjanus synagris*
gray snapper	*Lutjanus griseus*
yellowtail snapper	*Ocyurus chrysurus*
spadefish	*Chaetodipterus faber*
white grunt	*Haemulon plumieri*
sheepshead	*Archosargus probatocephalus*
hogfish	*Lachnolaimus maximus*
Coastal Migratory Pelagics	
king mackerel	*Scomberomorus cavalla*
Spanish Mackerel	*Scomberomorus maculatus*
cobia	*Rachycentron canadum*
Mid-Atlantic FMP species which occur in South Atlantic	
bluefish	*Pomatomus saltatrix*
summer flounder	*Paralichthys dentatus*
Federally Implemented FMP	
lemon shark	*Negaprion brevirostris*
bull shark	*Carcharhinus leucas*
blacknose shark	*Carcharhinus acronotus*
finetooth shark	*Aprionodon isodon*
dusky shark	*Carcharhinus obscurus*
bonnethead shark	*Sphyrna tiburo*
Atlantic sharpnose shark	*Rhizoprionodron terraenovae*

***Shrimp*.** In the southeastern United States, the shrimp industry is based on the white shrimp (*Litopenaeus setiferus*), brown shrimp (*Farfantepenaeus aztecus*), pink shrimp (*Farfantepenaeus duorarum*), and the deeper water rock shrimp (*Sicyonia brevirostri*). The royal red shrimp (*Pleoticus robustus*) also occurs in deeper water and sustains a limited harvest. For the above species, Habitat Areas of Particular Concern (HAPC) within the project area include estuarine and marine water columns within the inlet, which includes the navigation channel. These areas are the connecting water bodies between inshore estuarine nursery areas, offshore marine habitats used for spawning and growth to maturity. EFH for rock shrimp and royal red shrimp occurs in deeper offshore waters.

***Snapper Grouper Complex*.** This complex of 10 families of fishes containing 73 species is managed by the South Atlantic Fishery Management Council (SAFMC). There is variation in specific life history patterns and habitat use among the snapper grouper complex species. For specific life stages of estuarine dependent and nearshore snapper grouper species, EFH includes areas inshore of the 100-

foot-deep ocean contour, such as the salt and brackish marshes, tidal creeks, soft sediments found in Charleston Harbor, and unconsolidated bottom occurring in the navigation channel. EFH-HAPC for species of the complex is shown in Figure 2-34, including some notable offshore areas.

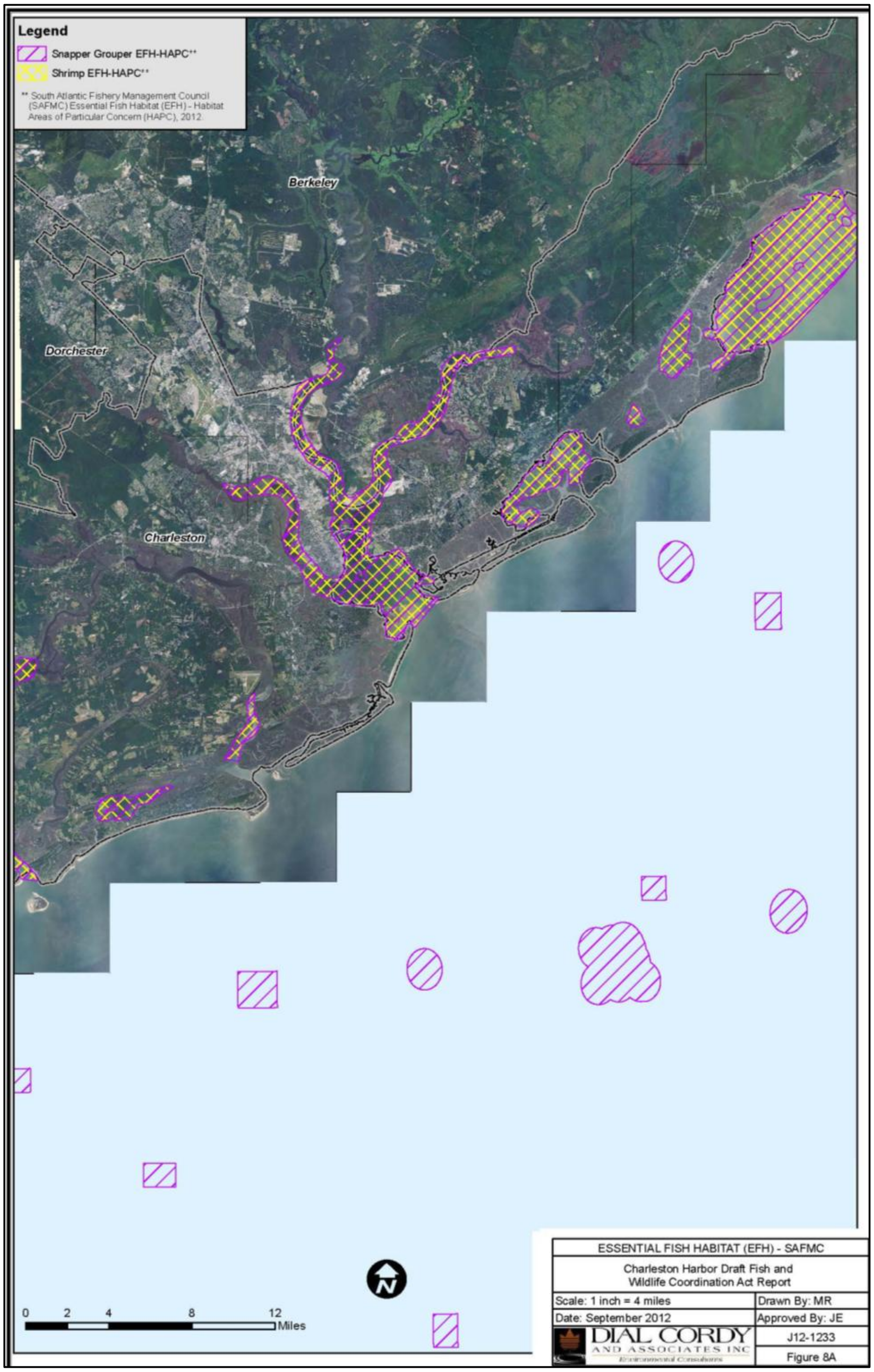


Figure 2-34. Habitat areas of particular concern for shrimp and snapper grouper complex species

***Coastal Migratory Pelagics*.** King and Spanish mackerel and cobia are coastal migratory pelagic species managed by the SAFMC. EFH for these species include the inlet and, in a more general sense, any high-salinity bays which may occur in the project vicinity. Many coastal pelagic prey species are estuarine-dependent in that they spend all or a portion of their lives in estuaries. Accordingly, the coastal pelagic species, by virtue of their food source, are to some degree also dependent upon estuaries and can be expected to be adversely affected if the productive capabilities of estuaries are greatly degraded.

Mid-Atlantic Species in South Atlantic Region. Bluefish and summer flounder are two species listed in the Mid-Atlantic Fisheries Management Plan that occur in the South Atlantic. Bluefish juveniles and adults are listed as using estuaries from North Carolina to Florida and are common in Charleston Harbor including the vicinity of the navigation channel.

***Highly Migratory Species*.** The sharks listed in Table 2-27 are included in the Highly Migratory Species (federal) Fishery Management Plan, and are relatively common in Charleston Harbor. EFH for the shark species include the inlet and estuarine and shallow coastal waters which all include navigation channels.

Future Without Project Condition

No new EFH areas would be dredged for federal navigation channels. Only previously dredged EFH (unvegetated, unconsolidated bottom and inlet substrates) would continue to be impacted through previously authorized operations and maintenance dredging activities that are needed to address shoaling. Due to projections of greater numbers of container vessels in the FWOP condition (compared to an action alternative), container vessel and tug movements would re-suspend sediments in the bottom of the channel with increasing frequency thereby increasing the effects of turbidity and sedimentation of habitats near the channels. This would temporarily adversely affect the estuarine (within harbor) water column EFH, although the effects would be minimal.

The continued maintenance dredging of the authorized channel depths would not have a substantial adverse impact on EFH or federally-managed fisheries along the coast of South Carolina as discussed in previous NEPA documents for Charleston Harbor operations and maintenance. Substrates within the project area are naturally dynamic and unconsolidated, and measures are implemented. Turbidity could affect vision of marine life within the sediment plume as well as those marine organisms with gills, but these effects would be temporary, as they would be limited to the actual dredging and placement operations. Routine maintenance dredging may suppress re-colonization of certain benthic organisms and therefore could impact other trophic levels within the food chain. However, the actual channel widths encompass a fraction of the entire water body, and similar habitat occurs immediately adjacent to the channels.

2.4.11.1 Other Marine/Estuarine Habitats

Benthic macrofauna serve as ecologically important components of the food web by consuming detritus, plankton, and smaller organisms living in the sediments and in turn serving as prey for finfish, shrimp, and crabs. Benthic macrofauna are also relatively sedentary, and many species are sensitive to changing environmental conditions. Dominant species in the harbor channels include mollusks, polychaetes, oligochaetes, nematodes, and amphipods (USACE 2006). Populations in the navigation channel are assumed to be not as stable and numerically abundant as nearby wetlands and mudflats due to the frequent disturbance by maintenance dredging.

2.4.12 Protected Species

2.4.12.1 Overview

The USFWS and NMFS have responsibilities under the Endangered Species Act of 1973 to protect certain species. There are many threatened and endangered (T&E) species known to occur near Charleston Harbor. However, not all of them would be affected by a proposed action. Accordingly, the USACE worked with USFWS Field Offices in Charleston, SC and Athens, GA, as well as the NMFS Southeast Regional Office in St. Petersburg, FL to focus on the species listed in Table 2-28. This list, which includes the federally-listed T&E species that could be present in the area based upon their geographic range. However, the actual occurrence of a species in the area would depend upon the availability of suitable habitat, the season of the year relative to a species' temperature tolerance, migratory habits, and other factors. The following sections summarize species-specific information relevant to the Study area. More detailed information can be found n Appendix F-1 (Biological Assessment of Threatened and Endangered Species) and F-2 (NMFS Biological Opinion).

2.4.12.2 Fishes

Fisheries Habitat Modeling

Fish habitat modeling was accomplished using Habitat Suitability Index (HSI) models. HSI models provide habitat information for evaluating impacts on fish and wildlife habitat from water or land use changes. Approved HSI models were used for this project and are described in Appendix K. All models are based on a numerical index of habitat suitability on a 0.0 to 1.0 scale, with 1.0 being the best habitat. Models were used for shortnose sturgeon, red drum, southern flounder, striped bass, and blueback herring. A pass/fail series of thresholds was used for the Atlantic sturgeon.

2.4.12.2.1 Shortnose Sturgeon

Shortnose Sturgeon

Photo: http://www.dnr.sc.gov/fish/species/assets/shortnosesturgeonlg.jpg

Existing Condition

The shortnose sturgeon spawns in the coastal rivers along the east coast of North America from the St. John River in Canada to the St. Johns River in Florida. Unlike Atlantic sturgeon that migrate more freely between freshwater, estuarine, and marine waters, shortnose sturgeon spend most of their adult life in fresh and brackish water. However, they venture into the lower coastal reaches and the ocean on rare occasions. In South Carolina, shortnose sturgeon are known to utilze the river systems that empty into Winyah Bay and the Santee/Cooper River complex that forms Lake Marion, as well as the Great and Little Pee Dee, Congaree, Wateree, Ashepoo, Edisto, Black, and Waccamaw River systems. One landlocked group exists in Lake Marion on the Santee River. The majority of the populations have their greatest abundance and are found throughout most of the year in the lower portions of the estuary and are considered to be more abundant now than previously thought (NMFS, 1998). Recent hydroacoustic studies have also noted that inter-basin movement via the ocean by shortnose sturgeon is more common than previously believed (B. Post SCDNR pers. comm.).

Table 2-28. Selected federally-threatened and endangered species potentially present in the vicinity of Charleston Harbor, Charleston, South Carolina

Common Name	Scientific Name	Status	Date Listed
Marine Mammals			
Humpback whale	*Megaptera novaeangliae*	E	12/2/1970
North Atlantic right whale	*Eubalaena glacialis*	E	12/2/1970
West Indian Manatee	*Trichechus manatus*	E	10/21/1972
Marine Turtles			
Kemp's Ridley turtle	*Lepidochelys kempii*	E	12/2/1970
Leatherback turtle	*Dermochelys coriacea*	E	6/2/1970
Loggerhead turtle	*Caretta caretta*	T	7/28/1978
Green turtle	*Chelonia mydas*	T	7/28/1978
Fish			
Shortnose sturgeon	*Acipenser brevirostrum*	E	3/11/1967
Atlantic sturgeon	*Acipenser oxyrhynchus*	E	4/6/2012
Birds			
American Wood stork	*Mycteria Americana*	E (proposed for downlisting to "T")	2/28/1984
Piping Plover	*Charadrius melodic*	T	12/11/1985
Red Knot	*Calidris canutus rufa*	E	1/12/2015
Plants			
Seabeach Amaranth	*Amaranthus pumilus*	T	4/7/1993

E – federally-endangered
T – federally-threatened
Endangered: A taxon "in danger of extinction throughout all or a significant portion of its range."
Threatened: A taxon "likely to become endangered within the foreseeable future throughout all or a significant portion of its range."

According to the Shortnose Sturgeon Recovery Plan (NMFS, 1998a) and Atlantic Sturgeon Status Review (Atlantic Sturgeon Status Review Team, 2007), projects that may adversely affect sturgeon include dredging projects, pollutant or thermal discharges, bridge construction/removal, dam construction, dam removal and relicensing, and power plant construction and operation. Other stressors on the populations are bycatch mortality, habitat impediments (e.g., dams on Santee-Cooper Rivers), riverine salinity alterations, and apparent vessel strikes. No critical habitat has been designated for the shortnose sturgeon within the project area.

In an effort to quantify impacts to shortnose sturgeon habitat, the Post 45 study evaluated impacts using a USFWS habitat suitability index (HSI) model. The model and its development are fully described within the Fisheries Habitat Impact Assessment Appendix of the EIS (Appendix K). The parameters for this species are velocity, temperature and substrate. At the request of the Post 45 Interagency Coordination Team, a salinity threshold of 0.5 ppt was added to the model. Essentially, if salinity was greater than 0.5 ppt, habitat was assigned a "0"; if salinity was less than 0.5 ppt, then the HSI model was applied. Using low flow (or drought) conditions, the model predicts that existing habitat for spawning is only suitable above a point approximately 2.7 miles south of the "Tee" in the Cooper River (Figure 2-35). Low flow conditions provide a conservative basis for habitat suitability due to lower velocities and higher salinities. Substrate appears to drive the relatively low (0.5 or less on a scale of 0 to 1) HSI results. This is because of the substrate classifications in the model and the relationship to the in situ substrate conditions. Substrates commonly used by spawning shortnose sturgeon include gravel, rubble, large rock, sand, logs, and cobble (Dadswell 1979, Taubert 1980, Kieffer and Kynard 1996, Kynard 1997). Duncan et al. (2004) and Cooke and Leach (2004) state that spawning was successful in the Cooper River despite the "non-traditional" (i.e., barren hard bottom with scattered pockets of clam shell and marl) spawning habitat. Also notable in the existing condition is that HSI numbers go down progressing up the east branch of the Cooper River, which is driven by the lower flows (i.e., less freshwater input) in the east branch than in the west branch. While spawning in the Cooper River has been confirmed by the presence of fertilized eggs (Duncan et al., 2004), a near total absence of larval and juvenile life stages casts doubt on whether the reproduction is successful (Bill Post, SCDNR, personal communication, Wirgin et al. 2009). Limited sampling at the base of the Pinopolis Dam and certain locations downriver in 1997-1998 indicated large numbers of mature shortnose sturgeon (spawning confirmed at the dam) and a sub-adult Atlantic sturgeon, but no mature adult Atlantic sturgeon and none less than 1 year of age. Suitable habitat as determined by the USFWS HSI model for foraging habitat is shown in Figure 2-36 for low flow (or drought) conditions.

Future Without Project Condition

In the FWOP condition, shortnose sturgeon will continue to be susceptible to lethal take from operations and maintenance dredging activities; however, historical take numbers do not indicate that this will result in a significant level of take. The results of HSI modeling of the FWOP condition indicates that shortnose sturgeon foraging habitat would increase slightly from 20,977 habitat units to 20,992 habitat units, and shortnose sturgeon spawning habitat would decrease slightly from 1,028 habitat units to 1,010 habitat units. These changes are attributable to the projected sea level change over the 50 year period of analysis (modeled as the year 2071).

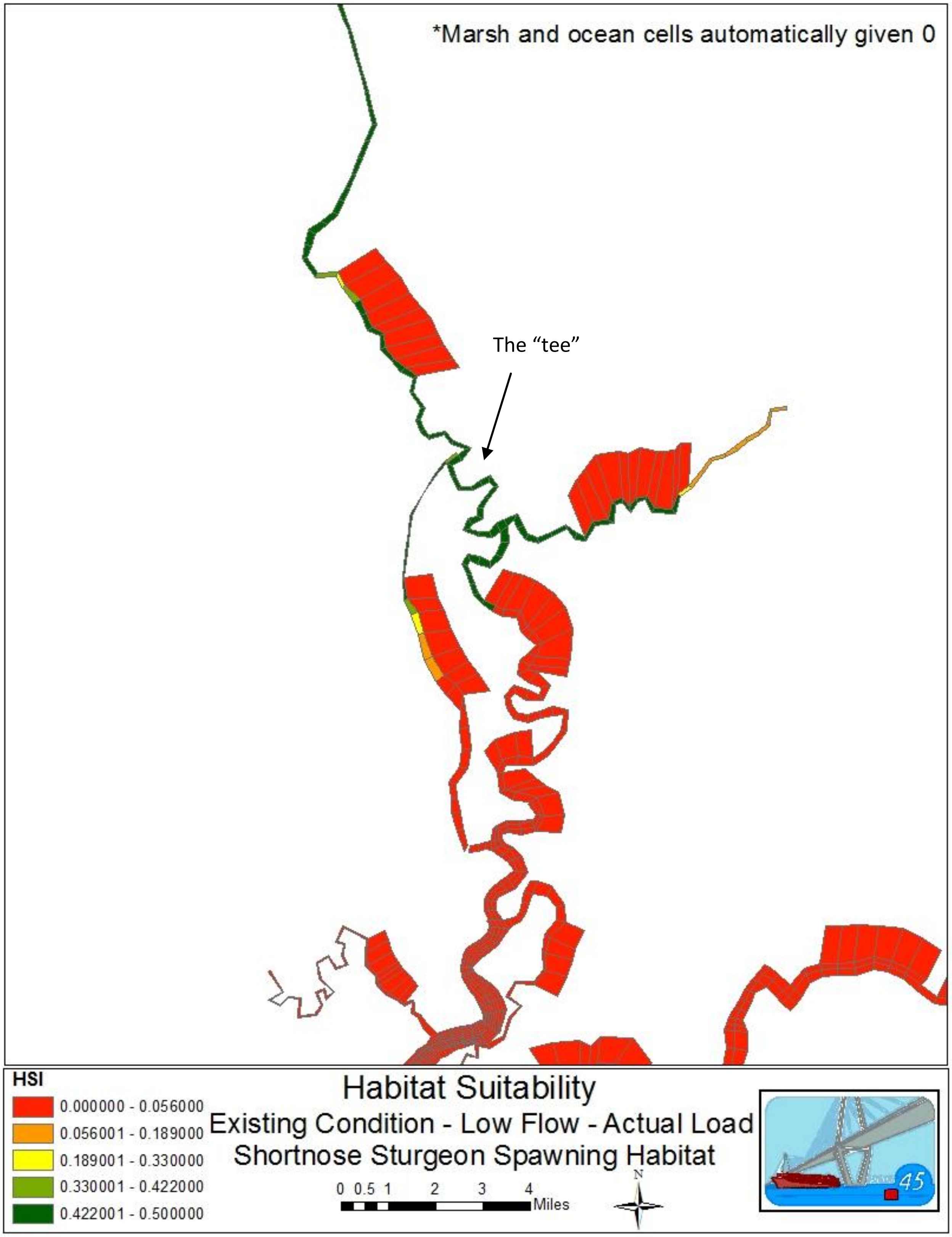


Figure 2-35. Shortnose sturgeon modeled (HSI) spawning habitat

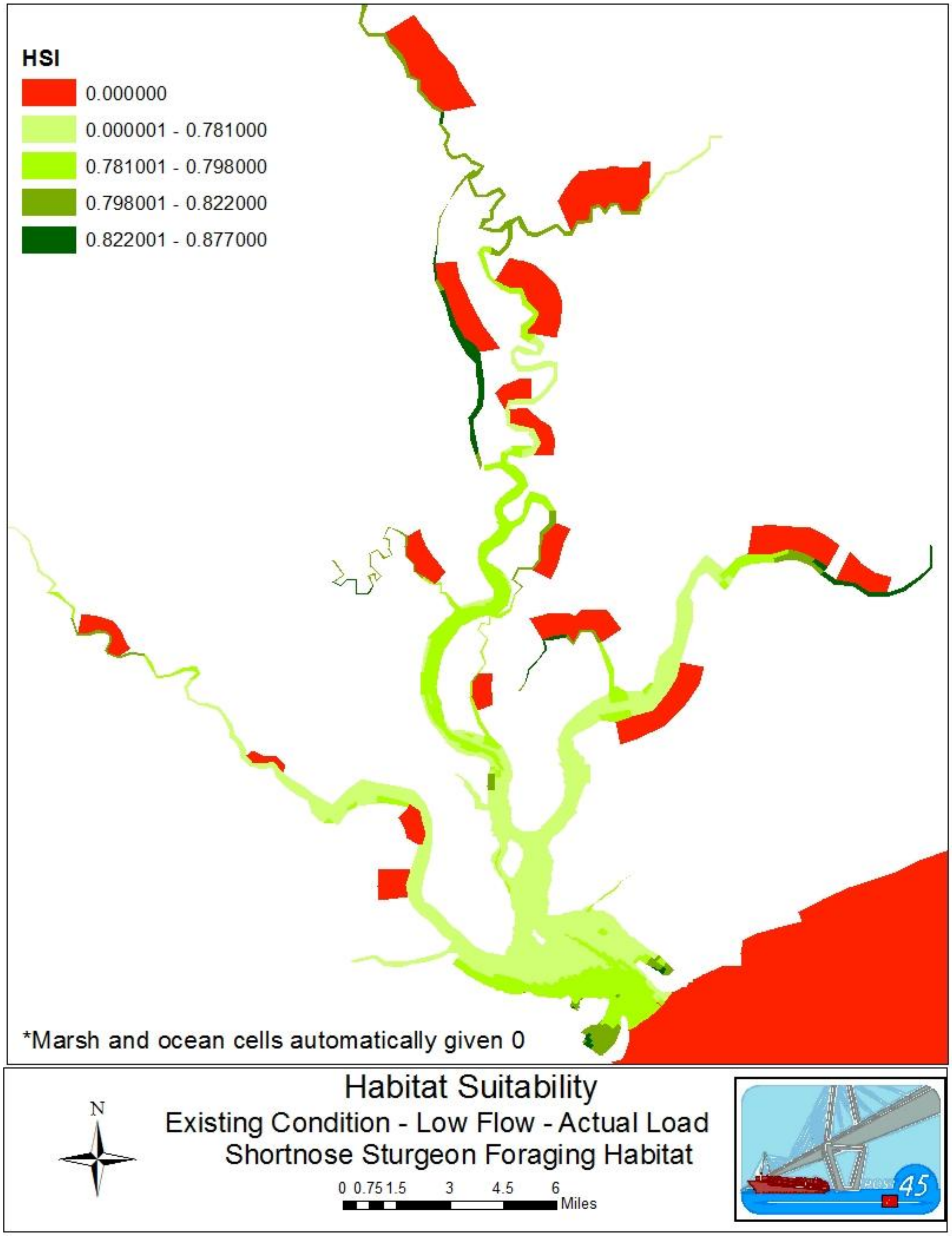


Figure 2-36. Shortnose sturgeon modeled (HSI) foraging habitat

2.4.12.2.2 Atlantic Sturgeon

Photo: http://www.dnr.sc.gov/fish/species/assets/atlanticsturgeon.jpg

Existing Condition

Atlantic sturgeon is a subtropical, anadromous species. Spawning adults migrate upriver in spring, beginning in February-March in the south, April-May in the mid-Atlantic, and May-June in Canadian waters. Historically, Atlantic sturgeons were likely present in many South Carolina river/estuary systems, including the Cooper River, but it is not known where spawning occurred. A reproducing population of Atlantic sturgeon is suspected in the Cooper River, but at the time, this had not been verified (Collins and Smith, 1997). Successful reproduction has since been documented in this population (SCDNR letter to USACE, November 2014). Viable eggs were collected in 1999 and a young-of-year individual was collected in 2014.

According to the Shortnose Sturgeon Recovery Plan (NMFS, 1998) and Atlantic Sturgeon Status Review (Atlantic Sturgeon Status Review Team, 2007), projects that may adversely affect sturgeon include dredging, pollutant or thermal discharges, bridge construction/removal, dam construction, dam removal and relicensing, and power plant construction and operation. Other stressors include: bycatch mortality, habitat impediments (e.g., Santee-Cooper rivers), riverine salinity alterations, and vessel strikes (e.g., Delaware and James rivers). No critical habitat has been designated for the Atlantic sturgeon in the project area.

The following maps (Figures 2-37 through 2-40) indicate the suitable habitat for various life stages of Atlantic sturgeon as determined by habitat inputs from Greene et al., (2009). Details on the modeling effort can be found in Appendix K. The model results indicate that, below the Pinopolis Dam, there is suitable habitat for sturgeon spawning, and not for the egg and larval stage. A review of the modeled data revealed that this is due to the temperature being below the identified threshold in Greene et al. (2009).

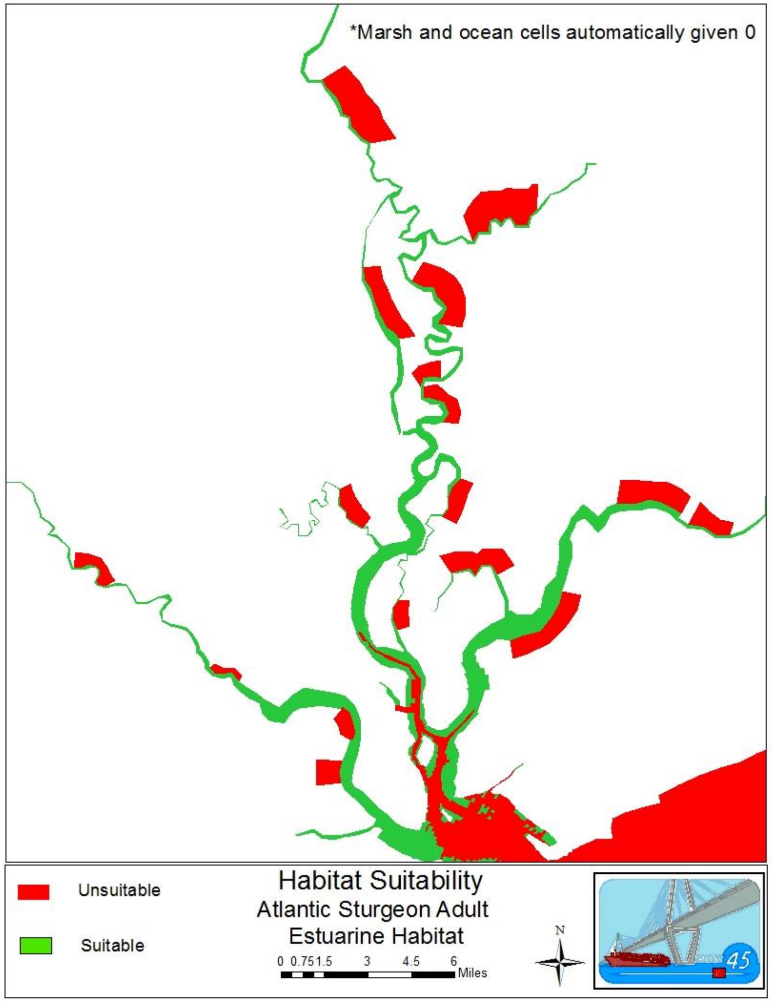


Figure 2-37. Atlantic sturgeon adult habitat as determined by modeled data

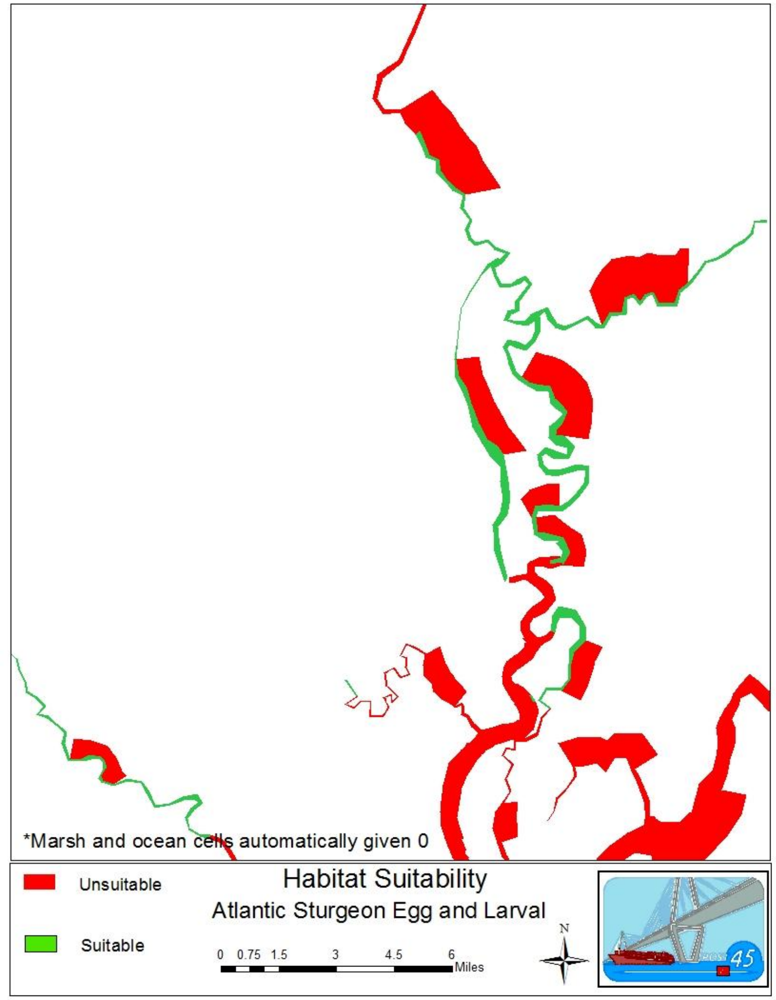


Figure 2-38. Atlantic sturgeon egg and larval habitat as determined by modeled data

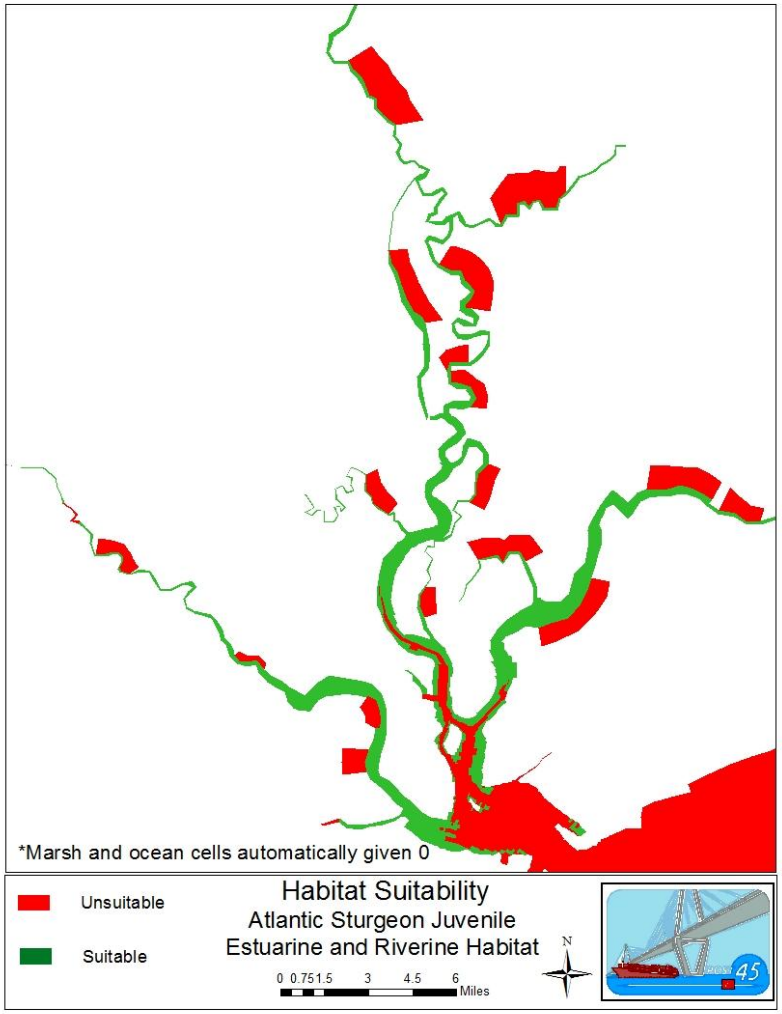


Figure 2-39. Atlantic sturgeon juvenile habitat as determined by modeled data

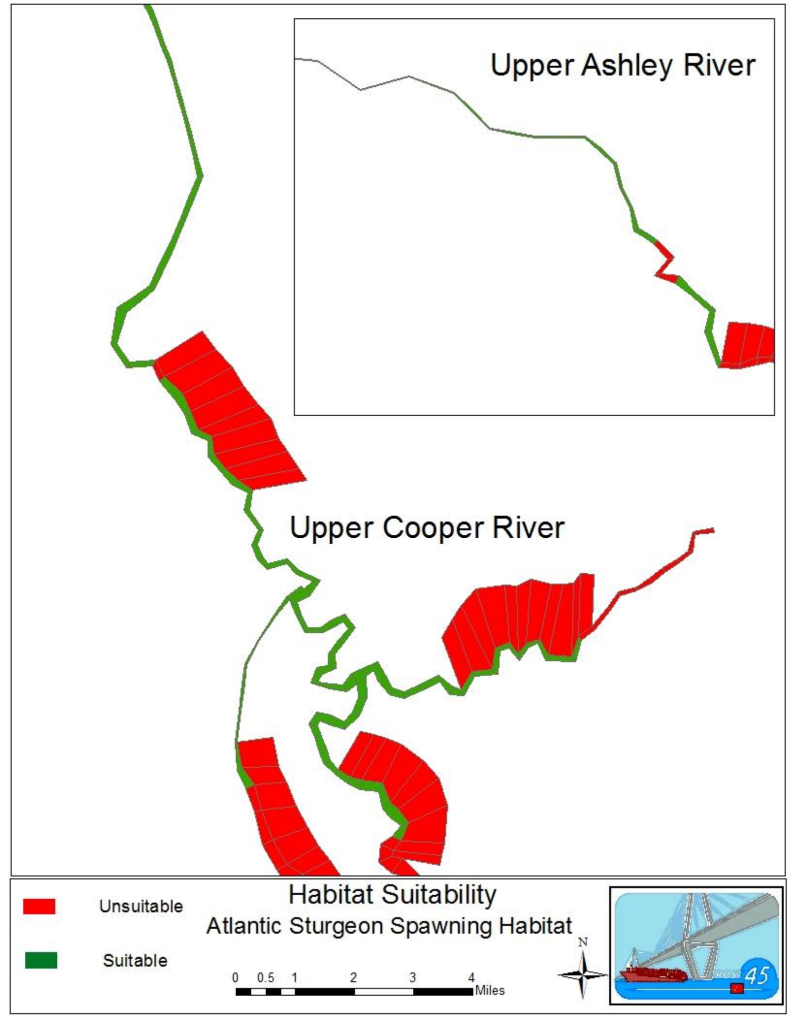


Figure 2-40. Atlantic sturgeon spawning habitat as determined by modeled data

Future Without Project Condition

In the FWOP condition, Atlantic sturgeon will continue to be susceptible to lethal take from operations and maintenance dredging operations; however, historical take numbers do not indicate that this will result in a significant level of take. As a result of the habitat modeling, the FWOP condition indicates the following changes in Atlantic sturgeon habitat for various life stages:

- Adult habitat will change from 19,643 acres to 19,170 acres
- Egg and larval habitat will change from 3,978 acres to 3,894 acres
- Juvenile habitat will change from 18,486 acres to 17,908 acres
- Spawning habitat will change from 2,154 acres to 1,969 acres

These changes are attributable to projections of the historical rate of sea level change over the 50 year (modeled as the year 2071) and its affect on water quality variables such as temperature, salinity, and dissolved oxygen.

2.4.12.3 Sea Turtles

Existing Condition

The following discussion on sea turtles will address them together, rather than individually, due to general similarities between the species and the potential impacts that could occur. Through consultation with NMFS, four species of sea turtles were discussed in the Biological Assessment (Appendix F): Kemp's Ridley, Leatherback, Loggerhead, and Green. Of the four species, the loggerhead is the most common in South Carolina waters. Table 2-29 shows the number of documented sea turtle nests in South Carolina for 2011- 2013. Anthropogenic factors that impact hatchlings and adult female turtles on land, or the success of nesting and hatching include: beach erosion, beach armoring, beach nourishment, artificial lighting, beach cleaning, human presence, recreational beach equipment, beach driving, coastal construction and fishing piers, exotic dune and beach vegetation, and poaching.

Table 2-29. Number of sea turtle nests in South Carolina for 2011-2013

Nesting Totals by Species by Year	Loggerhead	Green	Leatherback	Kemp's Ridley	Unknown
2011	4015	3	4	0	
2012	4616	7	1	0	
2013	5193	5	0	0	0

***Kemp's Ridley**.* Of the seven species of sea turtles in the world, the Kemp's Ridley has declined to the lowest population level. Adult Kemp's Ridley turtles are restricted to the Gulf of Mexico, but immature turtles have been observed along the Atlantic coast as far north as Massachusetts. Outside of nesting, the major habitat for Kemp's Ridley sea turtles is the nearshore and inshore waters of the northern Gulf of Mexico, especially Louisiana waters. Kemp's Ridley sea turtles are often found in salt marsh habitats. Kemp's Ridley sea turtles are not common off the coast of South Carolina; however, immature individuals are encountered in the nearshore and coastal waters of South Carolina (USFWS, 1998). At this time, no critical habitat has been designated for Kemp's Ridley sea turtles in the project area.

Dredging and beach renourishment projects present inherent dangers to all sea turtles. However, it is notable that of all sea turtles taken by the four U.S. Army Corps of Engineers' Divisions within the Kemp's Ridley's range (Mississippi Valley, North Atlantic, South Atlantic, and Southwestern), less than 13 percent were Kemp's Ridley sea turtles. The Charleston District has not taken any.

(http://el.erdc.usace.army.mil/seaturtles/index.cfm).

Leatherback. Leatherback sea turtles are widely distributed throughout the oceans of the world, and are found in waters of the Atlantic, Pacific, and Indian oceans (Ernst and Barbour, 1972). Leatherback turtles are the largest living turtles and have a larger migration range than any other sea turtle species. The leatherback is the most pelagic (open ocean) of the sea turtles and is often seen near the edge of the continental shelf; however, they are also observed just offshore of the surf line. They enter coastal waters on a seasonal basis to feed in areas where jellyfish are concentrated.

Zug and Parham (1996) pointed out that the main threat to leatherback populations in the Atlantic is the combination of fishery-related mortality (especially entanglement in gear and drowning in trawls) and the intense egg harvesting on the main nesting beaches. Boat strikes are also a threat and source of mortality for leatherbacks in South Carolina. While there is potential for leatherbacks to be present off the coast of South Carolina during migration, leatherbacks are not common nesters in South Carolina. No critical habitat has been designated leatherback turtles in the project area.

Loggerhead. In the Study area, the loggerhead is listed as the Northwest Atlantic Ocean Distinct Population Segment (DPS), and is the most common sea turtle in South Carolina. Loggerhead turtles are circumglobal, inhabiting continental shelves, bays, estuaries, and lagoons in temperate, subtropical, and tropical waters. South Carolina's shoreline is a migration path for loggerheads at all times of the year. Loggerhead turtles sporadically occur in the Charleston Harbor estuarine system, except in the Entrance Channel where they consistently occur during spring, summer, and fall (Van Dolah and Maier, 1993).

Loggerheads move into South Carolina inshore waters to nest on beaches from May through August. In South Carolina, the primary nesting beaches are between North Inlet and Prices Inlet (north of Capers Island), but other beaches between Kiawah Island and Hilton Head have moderate nesting densities. Due to its abundance in South Carolina compared to other sea turtles, the loggerhead is also the most common sea turtle to strand (i.e., to be found deceased on land or in water) in South Carolina. Critical habitat for the loggerhead exists south of the navigation channel in the nearshore environment off Folly Beach and Morris Island. Further descriptions can be found in Appendix F.

A trawling study was conducted within the Charleston Harbor shipping channel between 2004 and 2007 to evaluate loggerhead usage in the channel and document catch and recapture rates relative to prior trawling studies conducted in the early 1990's (Arendt et al, 2012). Two hundred and twenty loggerheads were captured, an increase in numbers and in size of the turtles from the 1991 study. Temporal and spatial variables appeared to exert the most influence on loggerhead catch rates and accounted for nearly half of model deviance in the study (Arendt et al., 2012). Within-channel spatial influences on catch in the present study were consistent with those from historic data and, as such, represent important sampling design considerations for future studies at this location. Satellite telemetry data collected for a subset of loggerheads tagged and released during this Study revealed greatest affinity for adjacent shoals and fidelity to the channel itself during spring (Arendt et al., 2012a), an affinity consistent with in situ tracking at this location during spring (Keinath et al., 1987) and summer (Maier et al., 2005). Arendt et al., (2012) suggest that these trends are encouraging for future species recovery, especially if they are indicative of a larger pattern of recovery.

Green. The nesting range of green sea turtles in the southeastern United States includes sandy beaches of mainland shores, barrier islands, coral islands, and volcanic islands between Texas and North Carolina, the U.S. Virgin Islands (USVI) and Puerto Rico (NMFS and USFWS, 1991). Green turtles are primarily herbivorous, feeding on algae and sea grasses, but also occasionally consume jellyfish and sponges. Green turtle foraging areas in the southeastern United States include any coastal shallow waters having macroalgae or sea grasses, including areas near mainland coastlines, islands, reefs, or shelves, and any open-ocean surface waters, especially where advection from wind and currents concentrates pelagic (open ocean) organisms (Hirth, 1997; NMFS and USFWS, 1991). While known to inhabit coastal South Carolina, there are no principal benthic foraging areas off of South Carolina. Adults of both sexes are presumed to migrate between nesting and foraging habitats along corridors adjacent to coastlines and reefs. No critical habitat has been designated for this species in the project area.

Future Without Project Condition

Effects on sea turtles resulting from operation and maintenance activities in the FWOP condition would not change. The Charleston District would continue maintenance dredging using hopper dredges within the Entrance Channel. These operations would continue to periodically result in the taking of sea turtles. Technological advancements would be implemented where appropriate and where authorized by the most up to date Regional Biological Opinion.

2.4.12.4 Whales

Existing Condition

North Atlantic Right Whale. North Atlantic right whales (NARW) are one of the most critically endangered whale species in the world and are protected under the Marine Mammal Protection Act (MMPA) and the Endangered Species Act (ESA). The NARW is highly migratory, summering in feeding and nursery grounds in New England waters and northward to the Bay of Fundy and the Scotian Shelf (Waring et al, 2001). They migrate southward in winter to the northeastern coast of Florida. The breeding and calving grounds for the right whale occur off of the coast of southern Georgia and northern Florida and have been designated as critical habitat under the ESA in 1994. During the winter months, NARW are routinely seen close to shore in the critical habitat area. A review of a database as it existed in July 2010 showed that 396 whales were known to be alive in 2007. This number does not include animals that were alive prior to 2007 but not recorded into the database nor calves that were known to be born during 2007, or any other whale seen during 2007 but not yet entered into the catalog at the time of the review. Subsequently, this number could increase as further analysis of unmatched photographs proceeds (Waring, 2011).

From 2007 to 2011, the minimum rate per year of human-caused mortality or serious injury to right whales averaged 4.0 in U.S. waters (Waring, 2014). However, this number is a factor of both incidental fishery entanglement and ship strikes. While ship strikes are known to be a major anthropogenic cause of mortality for North Atlantic right whales within several major shipping corridors on the eastern U.S. and southeastern Canadian coasts (NMFS, 1991c), they make up a smaller portion of the annual rate of human-caused mortality. The 2013 NOAA stock assessment states that from 2007 to 2011, the average mortality and serious injury to right whales due to ship strikes was 0.8 whales per year. Vessel strikes are known to be a major anthropogenic cause of mortality for NARW within several major shipping corridors on the eastern U.S. and southeastern Canadian coasts, as the behavior of this species, including its swimming speed, makes it particularly susceptible (NMFS, 1991). A review of Jensen and Silber (2003) as well as USACE records indicated no record of any vessel strike attributed to a USACE-owned or USACE-contracted vessel. Additional threats to NARW include fishery entanglement, habitat degradation, contaminants, climate and ecosystem change, and predators such as large sharks and killer whales. Disturbance from such activities as whale watching and noise from industrial activities may affect the population as well. In the United States, NMFS designated critical habit for the North Atlantic right whale in 1994 for the Northeast and Southeast U.S. There is currently no designated critical habitat within the project area. However, NMFS has proposed a rule to expand critical habitat for NARW (80 FR 9313 / NOAA-NMFS-2014-0085). When finalized the proposed rule would extend NARW critical habit to include marine waters from Cape Fear, NC southward to 29°N latitude (approximately 43 miles north of Cape Canaveral, Florida). The new critical habitat designation would include the Charleston Harbor area.

Humpback Whale. Humpback whales live in all major oceans from the equator to sub-polar latitudes. They typically migrate between tropical/sub-tropical and temperate/polar latitudes. In the Atlantic Ocean, humpback whales feed in the northwestern Atlantic during the summer months and migrate to calving and mating areas in the Caribbean. Six separate feeding areas are utilized in northern waters after their return. These areas are within the biologically important area defined by the 200 m (656-ft) isobath on the North American east coast. These areas are outside of the project's potential impact area.

The best available estimate for the number of individuals in the North Atlantic is 11,750 humpback whales. Recent estimates of abundance in the North Atlantic stock indicate continued population growth; however, the size of the humpback whale stock may be below the optimum sustainable population in the U.S. Atlantic Exclusive Economic Zone (NOAA Fisheries, Office of Protected Resources, (Waring, 2011).

Humpback whales face many threats due to human activity. They may become entangled in fishing gear, either swimming away with the gear after entanglement or by becoming anchored by it. Inadvertent vessel strikes can injure or kill humpbacks. Whale watching vessels may harass/stress or strike whales. Traffic through shipping channels, fisheries, and aquaculture may displace whales that normally aggregate in that area. A review of the "Whale Strike Database" found no recorded vessel strikes of humpback whales in South Carolina (database updated through 2011). No Critical Habitat has been designated for humpback whales.

Future Without Project Condition

Effects on whales from normal operations and maintenance dredging activities would continue to be discountable. The Charleston District has never had a documented right whale or humpback whale strike as a result of dredging operations. Dredging would continue to operate in accordance with the most up to date Regional Biological Opinion. No additional effects on the North Atlantic right whale or the humpback whale are anticipated in the FWOP condition.

2.4.12.5 West Indian Manatees

Existing Condition

Manatees have large, seal-shaped bodies with paired flippers and a round, paddle-shaped tail. They are typically grey (color can range from black to light brown) and are occasionally spotted with barnacles or colored by patches of green or red algae. Average adult manatees are about nine feet long and weigh about 1,000 pounds (http://ecos.fws.gov/speciesProfile/profile/speciesProfile.action?spcode=A007).

Manatees inhabit both salt and fresh water and can be found in shallow (usually <20 feet), slow-moving rivers, estuaries, saltwater bays, canals, and coastal areas (USFWS, 2001) throughout their range. In South Carolina, manatees occupy fresh, brackish and marine habitats and move freely between salinity extremes. Manatees will move up rivers until the water is too shallow for passage or is blocked by a dam. Manatees are thermally stressed at water temperatures below 18ºC (64.4ºF) (Garrott et al., 1995). For this reason, manatees are only seen in South Carolina in the summer months and there is no Critical Habitat in South Carolina for the West Indian manatee. Counties in South Carolina in which the manatee is known or believed to occur include: Beaufort, Berkeley, Charleston, Colleton, Dorchester, Georgetown, Horry, and Jasper. Since 1850 through 2004 1,117 manatee sightings have been reported in South Carolina (http://www.dnr.sc.gov/manatee/dist.htm).

The major threats to the West Indian manatee population are human related. They include watercraft strikes (impacts and propeller cuts), which can cause injury and death (Rommel et al. 2007; Lightsey et al. 2006); entrapment and crushing in water control structures (gates, locks, etc.); and entanglement in fishing gear. Natural threats include red tide and exposure to cold. To reduce potential construction-related impacts to the manatee to discountable and insignificant levels, the USFWS recommends implementing the *Standard Manatee Construction Conditions* (Fish and Wildlife Commission, 2005) during construction.

Future Without Project Condition

Dredges would continue to operate in accordance with the most up to date manatee protection specifications. Precautions coordinated with the USFWS for dredging would continue. No additional impact to manatees is anticipated in the FWOP condition/no action alternative.

2.4.12.6 Birds

Photo: http://www.dnr.sc.gov/wildlife/species/wadingbirds/gallery/WoodStorkFledgling.jpg

Photo: http://www.birdspix.com/wp-content/uploads/2012/03/Piping-Plover_8271-cr.jpg

http://imgc.allpostersimages.com/images/P-473-488-90/27/2705/VMGND00Z/posters/steve-winter-red-knot-sandpiper-eating-horseshoe-crab-eggs.jpg

Existing Condition

American Wood Stork. Wood storks are large, long-legged wading birds, about 50 inches tall, with a wingspan of 60 to 65 inches. The head and neck are largely unfeathered and dark gray in color. The bill is black, thick at the base, and slightly decurved. Immature birds are dingy gray and have a yellowish bill (http://ecos.fws.gov/speciesProfile/profile/speciesProfile.action?spcode=B06O).

Wood storks primarily inhabit freshwater and brackish wetlands, feeding in freshwater marshes, narrow tidal creeks, flooded tidal pools, and roadside ditches. Nests are commonly located in the upper branches of large cypress trees or in mangroves on islands. They are also known to nest in manmade structures. Breeding within the United States is limited to Florida, Georgia, and South Carolina. After breeding, birds along the east coast migrate as far north as North Carolina.

South Carolina Nesting Population: From 1981-2006, wood stork nesting increased from 1 colony with 11 nesting pairs to 13 colonies with 2,010 pairs. (Wood stork, 5-Year Review: Summary and Evaluation, USFWS, SE Region, Jacksonville Ecological Services Field Office, Jacksonville, FL). Wood storks have been known to occur in the following counties in South Carolina: Aiken, Allendale, Bamberg, Barnwell, Beaufort, Berkeley, Calhoun, Charleston, Clarendon, Colleton, Dorchester, Edgefield, Florence, Georgetown, Greenwood, Hampton, Horry, Jasper, Laurens, Lexington, Marion, McCormick, Newberry, Orangeburg, Richland, Saluda, Sumter, and Williamsburg.

Habitat loss, pollution and loss of prey base are the major threats to wood stork populations. Less significant factors known to affect nesting success include prolonged drought and flooding, raccoon predation on nests, and human disturbance of rookeries. No critical habitat for the American wood stork in the project area.

Piping Plover. Piping plovers are small, stocky shorebirds that resemble sandpipers. Piping plovers typically nest in sand depressions on un-vegetated portions of the beach above the high tide line on sand flats at the ends of sand spits and barrier islands, gently sloping foredunes, blowout areas behind primary dunes, sparsely vegetated dunes, and washover areas cut into or between dunes.

Loss and degradation of habitat from development and shoreline stabilization have been major contributors to the decline of piping plovers in the southeast. Commercial, residential, and recreational development has decreased the amount of coastal habitat available for piping plovers to nest, roost, and feed. Furthermore, beach erosion and an abundance of predators, including wild and domestic animals and feral cats, have further diminished the potential for successful nesting of this species. Historically the population was almost completely wiped out due to millinery practices.

Piping plovers do not nest in South Carolina; rather they use South Carolina beaches as foraging habitat during the winter months during migrations. There are 15 areas and a total of 5618 acres of designated piping plover critical habitat in South Carolina. These extend along beaches from Little River Inlet to Beaufort County near Hilton Head Island. South Carolina has 187 miles of sandy beach shoreline available, 56 miles of which are nourished within critical habitats, resulting in 30 percent of affected sandy shoreline in critical habitat units (USFWS, 2009b). Some critical habitat exists in Charleston County, but none exists in the project area.

Red Knot. The red knot (*Calidrus canutus rufa*) is a migratory shorebird that has recently been listed under the ESA. Although breeding and nesting does not occur in South Carolina, the state's barrier islands provide important habitat for migrating and wintering red knots. Along the South Atlantic coast, preferred foraging habitats include sandy beaches and tidal mud flats along the barrier islands. No critical habitat has been designated for this species within the study area.

Future Without Project Condition

In the FWOP condition, operations and maintenance dredging would continue, and there would be no additional impact to piping plovers, wood storks, or red knots from dredging activities. Since the number of vessels calling on the port under the FWOP conditions would be greater than the number of vessels that would call if the harbor were deepened and an increasing number of the vessels transits would occur during of high tide stages, there is an increased likelihood of shoreline erosion resulting from vessel wakes without a project. This could have a minimal negative influence on erosion at Crab Bank. If wood storks, red knots or piping plovers use this habitat in the future, it could have a minimal negative influence on winter stop-over/foraging habitat.

2.4.12.7 Seabeach Amaranth

Existing Condition

Seabeach amaranth is an annual plant found on the dunes of Atlantic Ocean beaches. Upon germination, the species forms a small unbranched sprig, but soon begins to branch profusely into a clump, which often reaches 30 cm in diameter and consists of five to 20 branches. Occasionally, a clump may get as large as a meter or more across, with 100 or more branches. The species is an effective sand binder, building dunes where it grows. http://www.fws.gov/nc-es/plant/seabamaranth.html. Seabeach amaranth occurs on barrier island beaches, where its primary habitat consists of overwash flats at accreting ends of islands and lower foredunes and upper strands of non-eroding beaches. The species appears to need extensive areas of barrier island beaches and inlets, functioning in a relatively natural and

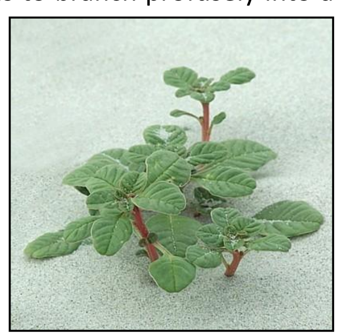


Photo: http://www.okeefes.org/Barrier_Islands/Bird_Island/Bird_Island/amaranthus_pumilus_%20rafinesque_102_7972.jpg dynamic manner. Seabeach amaranth (*Amaranthus pumilus*) is endemic to beaches on the Atlantic coast from Cape Cod, Massachusetts to Kiawah Island along the central South Carolina coast (58 FR 18035).

The most serious threats to the continued existence of seabeach amaranth include the construction of beach stabilization structures, beach erosion and tidal inundation, beach grooming, herbivory by insects and feral animals, loss of habitat to invasive plant species and, in certain circumstances, by off-road vehicles. Hurricanes and storms reduce and eliminate populations, but also create new habitat by reducing competing ground cover. They may also aid large-scale seed dispersal. There is no designated critical habitat for Seabeach amaranth within the Study area. No critical habitat rules have been published for the Seabeach amaranth. A survey conducted in 2013 found no Amaranth populations surviving in the Study area (personal communication, Mark Caldwell, USFWS- Charleston ES office, 24 Oct. 13). This may be a result of erosion, wash over, disease, or eradication by invasive plant species such as beach vitex.

Future Without Project Condition

Seabeach amaranth is not expected to become established in the Charleston Harbor area in the FWOP condition.

2.4.12.8 State Protected Species

Existing Condition

Several species not listed as protected by the federal government have special status in the State of South Carolina (Table 2-30).

Table 2-30. Additional state-protected species

Common Name	Species	State Status
Mammals		
Rafinesque's big-eared bat	*Corynorhinus rafinesquii*	E
Birds		
Bald eagle	*Haliaeetus leucocephalus*	T
Wilson's plover	*Charadrius wilsonia*	T
American swallow-tailed kite	*Elanoides forficatus*	E
Least tern	*Sterna antillarum*	T
Reptiles		
Spotted turtle	*Chlemmys guttata*	T
Gopher tortoise	*Gopherus polyphemus*	E
Amphibians		
Dwarf siren	*Pseudobranchus striatus*	T
Gopher frog	*Rana capito*	E

Future Without Project Condition

Since the number of vessels calling on the port would be greater than the action alternatives and the vessels calling would be limited to calling at higher tides to maintain effective underkeel clearance, there is an increased likelihood of some shoreline erosion resulting from vessel wakes. Some of the shorebirds could experience a decline in habitat if Crab Bank continues to migrate and/or diminish in size, which is an effect driven by multiple factors, including wind waves, storms, sea level change, commercial and recreational vessel wakes, etc.

2.4.13 Marine Mammals

Existing Condition

The Marine Mammal Protection Act, enacted in 1972 and substantially amended in 1996, provides federal protection to all marine mammals. Thirty-eight marine mammal species have been recorded in or adjacent to the Study area (DON, 2008). Those species include 33 cetaceans (whales, dolphins, and porpoises), 4 pinnipeds (seals, sea lions, and fur seals), and 1 sirenian. Only 24 of those species are expected to regularly occur in the region (Table 2-31). Some cetacean species occur in the Study area year-round (e.g., bottlenose dolphin, beaked whales), while others (e.g., right whale, humpback whale) occur seasonally as they migrate through the area. The marine mammal commission lists the bottlenose dolphin as a species of special concern due to the depletion of the western north Atlantic coastal migratory stock (http://mmc.gov/species/bottlenosedolphin.shtml). Several of these species are protected by the Endangered Species Act.

Future Without Project Condition

In the FWOP condition/No Action Alternative, operations and maintenance dredging would continue and vessels would continue to call at the Port. Many of the marine mammals, including the common bottlenose dolphin, are acclimated to commercial and recreational vessels that traverse the area. Increased impacts to marine mammals in the FWOP condition are not anticipated.

Table 2-31. Marine mammals found in the study area

Order Cetacea
Suborder Mysticeti (baleen whales)
Family Balaenidae
North Atlantic right whale *Eubalaena glacialis* ENDANGERED
Family Balaenopteridae (rorquals)
Humpback whale *Megaptera novaeangliae* ENDANGERED
Minke whale *Balaenoptera acutorostrata* RARE
Bryde's whale *Balaenoptera edeni* REGULAR
Sei whale *Balaenoptera borealis* ENDANGERED
Fin whale *Balaenoptera physalus* ENDANGERED
Blue whale *Balaenoptera musculus* ENDANGERED
Suborder Odontoceti (toothed whales)
Family Physeteridae
Sperm whale *Physeter macrocephalus* ENDANGERED
Family Kogiidae
Pygmy sperm whale *Kogia breviceps* REGULAR
Dwarf sperm whale *Kogia sima* REGULAR
Family Ziphiidae (beaked whales)
Cuvier's beaked whale *Ziphius cavirostris* REGULAR
True's beaked whale *Mesoplodon mirus* RARE
Gervais' beaked whale *Mesoplodon europaeus* REGULAR
Blainville's beaked whale *Mesoplodon densirostris* REGULAR
Sowerby's beaked whale *Mesoplodon bidens* EXTRALIMITAL
Family Delphinidae (dolphins)
Rough-toothed dolphin *Steno bredanensi*s RARE
Bottlenose dolphin *Tursiops truncatus* REGULAR
Pantropical spotted dolphin *Stenella attenuata* REGULAR
Atlantic spotted dolphin *Stenella frontalis* REGULAR
Spinner dolphin *Stenella longirostris* RARE
Striped dolphin *Stenella coeruleoalba* REGULAR
Clymene dolphin *Stenella clymene* REGULAR
Short-beaked common dolphin *Delphinus delphis* RARE
Fraser's dolphin *Lagenodelphis hosei* RARE
Risso's dolphin *Grampus griseus* REGULAR
Melon-headed whale *Peponocephala electra* RARE
Pygmy killer whale *Feresa attenuate* RARE
False killer whale *Pseudorca crassidens* RARE
Killer whale *Orcinus orca* RARE
Long-finned pilot whale *Globicephala melas* EXTRALIMITAL
Short-finned pilot whale *Globicephala macrorhynchus* REGULAR
Family Phocoenidae
Harbor porpoise *Phocoena phocoena* EXTRALIMITAL
Order Carnivora
Suborder Pinnipedia (seals, sea lions, walruses)
Family Phocidae (true seals)
Harbor seal *Phoca vitulina* EXTRALIMITAL
Hooded seal *Cystophora cristata* EXTRALIMITAL
Order Sirenia
Family Trichechidae (manatees)
West Indian manatee *Trichechus manatus* ENDANGERED RARESource: DON, 2008

2.4.14 Fisheries

Existing Condition

Common forage and gamefish. A study of the Charleston Harbor by Van Dolah et al. (1990) identified many important finfish species within the lower Cooper River, including high numbers of Atlantic menhaden (*Brevoortia tyrannus*); bay anchovy (*Anchoa mitchilli*); silver perch (*Bairdiella chrysoura*); weakfish (*Cynoscion regalis*); spot (*Leiostomus xanthurus*); Atlantic croaker (*Micropogonias undulatus*); and star drum (Stellifer lanceolatus). Summer flounder (*Paralichtys dentatus*) and southern flounder (*P. lethostigma*), two important recreational species, were caught in low numbers throughout the year.

Sharks, skates, and rays can be found in the project area. Schwartz (2003) reported that six species of sharks can pup their young in South Carolina waters during warm summer months: smooth dogfish, spiny dogfish, blacknose, Atlantic sharpnose, tiger, and dusky sharks. Although none are commercially harvested within the estuary, many are recreationally important.

The harbor system also supports large populations of white shrimp, brown shrimp, and blue crab, which are harvested both commercially and recreationally. Penaeid shrimp and blue crab are the most common large invertebrates in the creeks of Charleston Harbor (e.g., Shem Creek, Clouter Creek, Beresford Creek and Shipyard Creek). Dominant finfish species in these areas included spot, Atlantic menhaden, Atlantic croaker, southern flounder, and bay anchovy (Wenner 1997), which supported the findings of Van Dolah et al. (1990).

Many of the species listed above are recreationally important, such as flounder, spot, and Atlantic croaker. Other sciaenids (a family of fish), such as red drum (*Sciaenops ocellatus*) and spotted sea trout (*Cynoscion nebulosus*) are likewise sought. Given recreational fishing pressures, proper management of important areas just before and during spawning are crucial to maintain healthy stocks. Table 3-32 summarizes approximate spawning times and localities in the Charleston area.

Table 2-32. Sciaenid spawning in the Charleston Harbor estuarine system

Species	Spawning Period
Red drum	Early August through the end of September (Charleston Harbor Inlet)
Black drum	Late March through early May (Ravenel Bridge/Charleston Harbor Inlet)
Spotted seatrout	Late April through early September (Ravenel Bridge/Harbor Inlet/Ft. Johnson/JI Yacht Club Pier)
Weakfish	Late March through October (Coastal waters)
Silver perch	Late March through early May (Harbor Inlet/ smaller creeks throughout the estuary)
Star drum	Early May through June Deep water near the Charleston Harbor Inlet)

In addition to notable spawning locations in Table 2-32, certain other areas in the harbor provide habitat for recreational and other species. “The Grillage” and “Dynamite Hole” are popular fishing locales near the mouth of Charleston Harbor. The Grillage, where "the rock juts from the sand bottom like a ledge along a river, crumbling into boulders like a glacier calving (Peterson 2012)," is located off the tip of Sullivan's Island on the north side of the harbor's mouth. Dynamite Hole is closer to the south jetty. These locations are known for populations of redfish and such sharks as bonnetheads, sharpnose and blacktips (Kibler 2008).

A substantial fishery exists outside the harbor as well. The most popular species fished offshore include Atlantic croaker, bluefish, Atlantic sharpnose shark, southern kingfish, spot, weakfish, brown shrimp and white shrimp.

The USACE evaluated impacts to fish species using existing Habitat Suitability Index models that are approved by USACE and developed by the USFWS. After meeting with the resource agencies, a selected suite of species were identified and include shortnose sturgeon, southern flounder, red drum, blueback herring, and striped bass. Atlantic sturgeon was evaluated using data from Greene et al, 2009). Details on the development of the model application and the results of the existing condition for these species can be found in Appendix K.

Future Without Project Condition

The FWOP condition will not appreciably influence the continued suitability of fish habitat in the Charleston Harbor. Operations and maintenance dredging will continue to have short term and minor affects on fish distribution in the vicinity of the dredging equipment. The most notable change to fish habitat will be as a result of sea level rise. Modeling results for the FWOP condition / No Action Alternative indicate that the species used in the analysis will experience varying degrees of either increased or decreased habitat based on hydrodynamic changes from the historical rate of sea level rise in the year 2071 (Table 2-33)

Table 2-33. FWOP condition fish habitat suitability from HSI modeling

	Existing Condition (Habitat Units)	FWOP (Habitat Units)
Striped Bass Spawning	2,662.43	2,611.88
Striped Bass Egg	10,680.56	10,753.97
Striped Bass Larval	533.67	444.85
Striped Bass Adult and Juvenile	22,002.09	22,004.79
Blueback Herring Juvenile	539.61	523.93
Blueback Herring SAEL	3,747.54	3,747.54
Red Drum	5,805.57	5,530.60
Southern Flounder	15,409.70	15,358.32

2.4.15 Birds

Existing Condition

2.4.15.1 Shorebirds

Various areas within Charleston Harbor are utilized by many species of shorebirds for nesting and feeding. Species commonly observed are the American oystercatcher (*Haematopus palliatus*), plovers (*Charadrius sp.*), willet (*Catoptrophorus semipalmatus*), sandpipers (*Scolopacidae*), lesser/greater yellow-legs (*Tringa flavipes/T. melanoleuca*), and gulls/terns (*Laridae*). Shorebirds typically feed by foraging for invertebrates in mud flats and sandy beaches. Plovers are medium sized birds with short, thick bills. They run to feed on vulnerable invertebrates. Avocets are larger shorebirds with long recurved bills that feed by using both tactile and visual methods. Foraging activity is usually focused around periods of low tide, where they feed in the intertidal zone. During high tides, shorebirds roost in flocks on the high beach, marsh, and sometimes on docks (Sanders and Murphy 2009).

2.4.15.2 Seabirds

Seabirds nest on small coastal islands in mixed colonies. The three common families of seabirds are Pelecaniae (pelicans), Pynchopidae (skimmers), and Laridae (gulls and terns). Seabirds that frequent the South Carolina coast are the sandwich tern (*Thalasseus sandvicensis*), least tern (Sterna albigrons), royal tern (*Thalasseus maximus*), common tern (*Sterna hirundo*), eastern brown pelican (*Pelecanus occidentalis*), Forster's tern (*Sterna forsteri*), gull-billed tern (*Gelochelidon nilotica*), and black skimmer (*Rynchops nigra*). The least tern is listed as state threatened due to a loss of nesting habitat (Thompson et al 1997). All of the birds are subject to loss of suitable nesting habitat (Murphy et al., 2009). Seabirds usually nest on isolated coastal islands that are high enough to prevent over-washing, yet small enough to not support mammalian predators (Murphy et al 2009). They are picivorous and feed in nearshore and estuarine waters. During the nesting season, foraging occurs within 10 to 15 miles of their nesting sites including the nearshore and estuarine waters of Charleston Harbor.

2.4.15.3 Migratory Species

Migratory birds in South Carolina represent three families: Scolopacidae (sandpipers), Charadriidae (plovers), and Recurvirostridae (avocets). Migrations can span across continents. Migratory shorebirds in South Carolina may be transient on northbound flights in the spring, southbound in the fall, or even wintering birds. Surveys of migrant shorebirds over the last three decades indicate that populations are on the decline (Manomet 2004).

Several features within Charleston Harbor are notable for their importance for local biota. In fact, several sites in or near the harbor are so important for nesting migratory birds, the state of South Carolina has closed them to human access for all or part of the year. Deveaux Bank Seabird Sanctuary is closed year-round, while the Stono Seabird Sanctuary (on Bird Key Stono) and Crab Bank Seabird Sanctuary are closed from March 15 to October 15 for the protection of nesting birds and their young. Typical bird species using these sites include black skimmers, brown pelicans, willet, Wilson's plover, and various tern species (sandwich, least, royal, common, Forester's, and gull-billed). The sites are preferred due to both the availability of grounds for nest creation as well as forage, i.e., small fish for supplying the chicks.

SCDNR provided a nesting update for the above Charleston County sites (Sanders, 2012). For the 2012 nesting season, biologists observed 3,451 brown pelican, 4,198 royal tern, and 2,139 sandwich tern and 203 black skimmer nests across the three sanctuaries. SCDNR also noted that least terns (listed as "threatened" by the SCDNR) "attempted to nest on a few SCDNR properties, but many nests are not successful due to a variety of reasons including flooding, predation and human disturbance." Of these species, black skimmers tend to nest later in the season and tend nests and fledgling chicks to at least the end of August.

Although the seabird sanctuaries are known to provide necessary habitats for migratory bird species discussed above, many other species frequent the sanctuaries and other areas/habitats within and near the project area. Such birds roost and forage in surrounding coastal environments such as tidal flats, mud flats, and beaches during the winter months. Species likely to occur are listed in Table 2-34, along with their associated habitats. Some of the notable areas providing various habitat functions are detailed below. Many of these sites are not only used by bird species, but also by other vertebrate species that are associated with birds (in many cases preying on eggs, chicks, and fledglings).

Table 2-34. Migratory birds likely to occur in the project area

Common Name	Scientific Name	Sand/Beach	Mud-flat	Pond	Salt Marsh	Open Water
American avocet	*Recurvirostra americana*		X	X		
American bittern	*Botaurus lentiginosus*				X	
American coot	*Fulica americana*			X		
American oystercatcher	*Haematopus palliatus*		X	X	X	
Bald eagle	*Haliaeetus leucoephalus*			X		X
Belted kingfisher	*Ceryle alcyon*			X		X
Black rail	*Laterallus jamaicensis*				X	
Black skimmer	*Rynchops niger*	X		X		X
Black-backed gull	*Larus marinus*	X	X	X		X
Black-bellied plover	*Pluvialis squatarola*	X	X			
Black-crowned night heron	*Nyticorax nycticorax*			X	X	
Black-necked stilt	*Himantopus mexicanus*	X	X	X		
Brown pelican	*Pelecanus occidentalis*				X	X
Clapper rail	*Fallus longirostris*				X	
Common moorhen	*Gallinula chloropus*			X		X
Common tern	*Sterna hirundo*	X		X	X	X
Double-crested cormorant	*Phalacrocorax auritus*			X		X
Dunlin	*Calidris alpina*	X	X			
Foresters tern	*Sterna forsteri*	X		X	X	X
Glossy ibis	*Plegadis falcinellus*		X	X	X	
Great blue heron	*Ardea herodias*			X	X	
Great egret	*Ardea alba*			X	X	
Greater yellowlegs	*Tringa melamoleuca*		X	X	X	
Gull-billed tern	*Sterna nilotica*	X		X		X
King rail	*Rallus elegans*				X	
Laughing gull	*Larus atricilla*	X	X	X		X

Common Name	Scientific Name	Sand/Beach	Mud-flat	Pond	Salt Marsh	Open Water
Least tern	*Sterna antillarum*	X		X		X
Little blue heron	*Egretta caerulea*		X	X		
Long-billed dowitcher	*Limnodromus scolopaceus*		X	X		
Osprey	*Pandion haliateus*			X		X
Piping plover	*Charadrius melodus*	X	X			
Red knot	*Calidris canutus*	X	X		X	
Ring-billed gull	*Larus delawarensis*	X	X	X	X	X
Royal tern	*Sterna maxima*	X		X		X
Ruddy turnstone	*Arenaria interpres*	X	X			
Sanderling	*Calidris alba*	X	X			
Sandwich tern	*Sterna sandvicensis*	X		X		X
Semipalmated plover	*Charadrius semipalmatus*	X	X			
Snowy egret	*Egretta thula*		X	X		
Sora	*Porzana carolina*				X	
Spotted sandpiper	*Actitis macularia*	X	X			
Tricolored heron	*Egretta tricolor*					
Virginia rail	*Rallus limicola*					
Whimbrel	*Numenius phaeopus*	X	X		X	
White ibis	*Eudocimus albus*		X	X		
Willet	*Catoptrophorus*	X	X			
Wilson's plover	*Charadrius wilsonia*	X	X			
Wood stork	*Mycteria americana*			X		X
Yellow rail	*Coturnicops noveboracensis*				X	
Yellow-crowned night heron	*Nyctanassa violacea*			X		X

Migratory bird species using sand/beach and mudflat habitats for nesting adjacent to navigational channels and waterways may be particularly sensitive to human disturbance. During such times, disturbance could cause unsuccessful nesting and/or death to chicks. Terns, pelicans, willet, and skimmers typically nest from April through July, while wood storks and plovers nest from April through August.

Future Without Project Condition

Operations and Maintenance dredging activities would continue at the currently authorized project depths and are not expected to result in adverse impacts to the fish and wildlife resources described above. Since the number of vessels calling on the port would be greater than the action alternatives and the vessels calling would be limited to calling at higher tides to maintain effective underkeel clearance, there is an increased likelihood of some shoreline erosion resulting from vessel wakes. This could have a minimal negative influence on erosion at Crab Bank and Shutes Folly which are heavily utilized by a variety of shorebirds.

2.4.16 Invasive Species

Existing Condition

Invasive species can adversely impact native plant and animal populations by disrupting natural ecosystem functions. Impacts range from impaired recreational uses, fouled boat hulls, and reduced property value to degraded water quality, declines in finfish and shellfish population, and reduced biodiversity (SCDNR 2008). Aquatic invasive species that may occur in the project area or in the area of influence include:

- Freshwater Plants
  - *Phramites australis* (Common reed)
  - *Eichhornia crassipes* (Water hyacinth)
  - *Hydrilla verticillata* (Hydrilla)
  - *Pistia stratiodes* (Water lettuce)
  - *Salvinia molesta* (Giant salvinia)
  - *Alternanthera philoxeroides* (Alligatorweed)
  - *Egeria densa* (Brazilian elodea)
  - *Ludwigia uruguayensis* (Water primrose)
- Freshwater Animals
  - *Myocastor coypus* (Nutria)
  - *Trachemys scripta elegans* (Red-eared slider)
  - *Michropterus punctulatus* (Spotted bass)
  - *Pylodicis olivaris* (Flathead catfish)
  - *Ictalurus furcatus* (Blue catfish)
  - *Hypopthalmichthys molitrix* (Silver carp)
  - *Hypopthalmichthys nobilis* (Bighead carp)
  - *Mylopharyngodon piceus* (Black carp)
  - *Ctenopharyngodon idella* (Grass carp)
- Insects
  - *Aedes albopictus* (Asian tiger mosquito)
- Marine/Estuarine Animals
  - *Pterois volitans* (Lionfish)
  - *Megabalanus coccopoma* (Titan acorn barnacle)
  - *Synidotea laevidorsalis* (Isopod)
  - *Petrolisthes armatus* (Green porcelain crab)
  - *Charybdis hellerii* (Spiny hands crab)
  - *Perna viridis* (Asian green mussel)
  - *Mytella charruana* (Charrua mussel)

The major known pathways for non-native species to enter South Carolina are stocking (42%), aquarium releases (13%), shipping (10%), and bait releases (9%) (SCDNR 2008). Of these, commercial shipping is the only direct mechanism related to this project. SCDNR (2008) states that, "the principal way aquatic invasive species can enter state waters through shipping is by the discharge of ballast water while vessels are in port. Ballast water is pumped into the hull of a vessel to stabilize the vessel and keep it upright while carrying cargo. This water can be discharged at the receiving port as the cargo is loaded or unloaded. Each vessel may take on and discharge millions of gallons of water. Ballast water taken on in foreign ports may include an abundance of aquatic plants, animals, and pathogens not native to South Carolina. If discharged into state waters, these foreign species may become problematic.

In addition to ballast water discharge, another important source for the introduction of nonindigenous organisms is the fouling community that grows on the hull, rudder, propellers, anchor, anchor chain, or any other submerged structure of vessels that are not properly cleaned or maintained. Historically, such fouling communities were composed of massive layers of a variety of organisms, both attached and merely entrained in or living on that growth. Although such extensive growth is not as common on seagoing vessels in recent times, it still provides an opportunity for worldwide transport of fouling organisms, particularly on towed barges and other structures like - mothballed ships and exploratory drilling platforms. Recent invasions by a number of coastal invasive species offer evidence that hull fouling remains a viable pathway for non-indigenous introductions."

Future Without Project Condition

In the future without project condition, the potential will continue to exist for introduction of invasive species from stocking (42%), aquarium releases (13%), shipping (10%), and bait releases (9%) (SCDNR 2008). Recent federal regulations require the shipping industry to implement better controls to prevent the introduction of invasive species through the ballasts of vessels (US Coast Guard 2012). These new regulations should decrease the rate at which invasive species are introduced to the study area. The U.S. Coast Guard will continue to monitor, enforce, and revise regulations related to the discharge of ballast water while vessels are in port according to the U.S. Coast Guard Ballast Water Management Final Rule Published-March 23, 2012.

2.4.17 Air Quality

Existing Condition

The U.S. EPA Region 4 and the SCDHEC, Bureau of Air Quality regulate air quality in South Carolina. The Clean Air Act (42 U.S.C. 7401–7671q), as amended, gives EPA the responsibility for establishing the primary and secondary National Ambient Air Quality Standards (NAAQS) (40 CFR Part 50) that set acceptable concentration levels for six criteria pollutants: fine particulate matter (PM10), very fine particulate matter (PM2.5), sulfur dioxide, carbon monoxide, nitrous oxides (NO_x), ozone (O_3), and lead. Short-term standards (1-, 8-, and 24-hour periods) have been established for pollutants that contribute to acute health effects, while long-term standards (annual averages) have been established for pollutants that contribute to chronic health effects. On the basis of the severity of the pollution problem, areas that do not attain the standards are categorized as marginal, moderate, serious, severe, or extreme. Each state has the authority to adopt standards stricter than those established under the federal program; however, South Carolina uses the federal standards (USEPA 2009).

EPA has defined Class I areas as those areas designated as pristine or wilderness areas and require more rigorous safeguard to prevent deterioration of the natural pristine air quality. The Cape Romain Wildlife Refuge is the only Class I area located within 200 km of the proposed project. Class III areas are planning areas set aside for industrial growth and EPA sets higher increments in these areas. There are no Class III designations approved for South Carolina and specifically in the project area. Class II areas are all other areas of the state that are not either Class I or III.

The air quality in Charleston and surrounding counties, South Carolina, are designated by SCDHEC as an attainment area for all six criteria pollutants. Areas with concentrations of criteria pollutants that are below the levels established by the NAAQS are considered to be in attainment. The ambient air quality for Charleston County, South Carolina has been determined to be in compliance with the NAAQS (Table 2-35).

Table 2-35. USEPA's primary and secondary standards for the six principle criteria pollutants as of October 2011

Pollutant [final rule cite]	Primary/ Secondary	Averaging Time	Level	Form
Carbon Monoxide (76 FR 54294, August 31, 2011)	Primary	8-hour	9 ppm	Not to be exceeded more than once per year
		1-hour	35 ppm	
Lead (75 FR 66964, November 12, 2008)	Primary and Secondary	Rolling 3 month average	0.15 ug/m^3 (1)	Not to be exceeded
Nitrogen Dioxide (75 FR 6474, Feb 9, 2010 and 61 FR 52852, Oct 8, 1996)	Primary	1-hour	100 ppb	98th percentile, averaged over 3 years
	Primary and Secondary	Annual	53 ppb (2)	Annual Mean
Ozone (73 FR 16436, March 27, 2008)	Primary and Secondary	8-hour	0.075 ppm	Annual fourth-highest daily maximum 8 -hr concentration, averaged over 3 years
Particle Pollution (71 FR 61144, Oct 17, 2006) — $PM_{2.5}$	Primary and Secondary	Annual	12 ug/m^3	Annual mean, averaged over 3 years
		24-hour	35 ug/m^3	98th percentile, averaged over 3 years
Particle Pollution — PM_{10}	Primary and Secondary	24-hour	150 ug/m^3	Not to be exceeded more than once per year on average over 3 years
Sulfur Dioxide (75 FR 35520, Jun 22, 2010)	Primary	1-hour	75 ppb (4)	99th percentile of 1-hour daily maximum concentrations, averaged over 3 years
[38 FR 25678, Sept 14, 1973]	Secondary	3-hour	0.5 ppm	Not to be exceeded more than once per year

To determine impacts related to air emissions, an emission inventory and forecast was generated (Appendix N). The US EPA's "Current Methodologies in Preparing Mobile Source Port-Related

Emission Inventories, Final Report, dated April 2009 provided the framework to determine all air emissions at the Port of Charleston. The US EPA requested the analysis be expanded to include (1) the emissions from landside equipment that service these vessels, (2) the air toxins and greenhouse gases emitted by both the vessels and the landside equipment, and (3) similar analyses associated with the privately-owned terminals in the harbor. The US EPA also requested a comprehensive air quality assessment of the Charleston Harbor to be able to place any expected increase in emissions resulting from the proposed harbor deepening in its proper context. In addition to emissions occurring directly on SCSPA property, the inventory also included emissions from non-SCSPA terminals at the port. The USACE considered this request and included the analysis in Appendix N (Air Quality Emission Inventory). This inventory includes maintenance dredging, private vessels, cargo handling equipment (CHE), locomotives, and trucks that occur outside the SCSPA Port terminals but within the Charleston Tri-County area (i.e., Charleston, Berkeley, and Dorchester Counties). Vessel emissions were included from the sea buoy which is located approximately 12 nm from the Charleston harbor entrance, as shown below. The USACE used 2011 as the baseline year for emissions.

Summary results for the 2011 emissions inventory are presented in Table 2-36. The 2011 baseline emission included the following: SCSPA terminals, non-SCSPA (private) terminals, tugs, land based emissions (CHE, Trucks, Locomotives, etc.), and maintenance dredging of the harbor. The emission inventory includes criteria pollutants and greenhouse gases (CO_2). Toxic air pollutants are shown in Table 2-37 and greenhouse gases are shown in Table 2-38.

Table 2-36. Baseline emissions for the Port of Charleston (tons/year) in 2011

	NOx	CO	HC	PM10	PM2.5	SO2	CO2
OCEAN GOING VESSELS	1,604.42	175.47	100.75	192.64	173.24	1,498.52	85,295.64
TUGS	223.24	26.28	22.66	29.65	18.97	0.16	25,783.69
LAND BASED OPERATIONS (CHE, Trucks, Rail, etc.)	769.47	265.93	40.32	35.61	34.49	6.74	7,122.02
MAINTENANCE DREDGING	245.97	47.10	4.70	5.70	5.49	19.42	11,431.08
TOTALS	2,843.11	514.77	168.43	263.60	232.19	1,524.84	129,632.43

The USACE calculated emissions of air toxics at the Port of Charleston (including all 17 terminals, land based operations, dredging, ocean going vessels (OGVs), etc.) for the 28 air toxics in the 2011 base year by quantity. The following formula was used to covert hydrocarbon (HC) to volatile organic carbon (VOC), VOC = 1.005 HC. The total VOC's (tons/year) was 169.27 and PM10 (tons/year) was 263.60 (Table 5-36). All of these air toxic quantities are shown below in Table 2-37.

Table 2-37. Summary of air toxics emission for the Port of Charleston in the 2011 baseline

	AIR TOXIC		AIR TOXIC RATIOS TAKEN FROM NMIM "SCC TOXICS" DATABASE"	AIR TOXICS For Port In 2011 (TONS / YEAR)
1	Ethyl Benzene	VOC	0.0031001	0.5248
2	Styrene	VOC	0.00059448	0.1006
3	1,3-Butadiene	VOC	0.0018616	0.3151
4	Acrolein	VOC	0.00303165	0.5132
5	Toluene	VOC	0.014967	2.5334
6	Hexane	VOC	0.0015913	0.2694
7	Anthracene	PM10	0.00000043	0.0001
8	Propionaldehyde	VOC	0.0118	1.9974
9	Pyrene	PM10	0.0000029	0.0008
10	Xylene	VOC	0.010582	1.7912
11	Benzo(g,h,i)perylene	PM10	0.00000019	0.0001
12	Indeno(1,2,3,c,d)pyrene	PM10	0.000000079	0
13	Benzo(b)fluoranthene	PM10	0.00000049	0.0001
14	Fluoranthene	PM10	0.000017	0.0045
15	Benzo(k)fluoranthene	PM10	0.00000035	0.0001
16	Acenaphthylene	PM10	0.000084	0.0223
17	Chrysene	PM10	0.0000019	0.0005
18	Formaldehyde	VOC	0.118155	20
19	Benzo(a)pyrene	PM10	0.00000035	0.0001
20	Dibenzo(a,h)anthracene	PM10	2.90E-09	0
21	2,2,4-Trimethylpentane	VOC	0.00066	0.1117
22	Benz(a)anthracene	PM10	0.00000071	0.0002
23	Benzene	VOC	0.020344	3.4436
24	Acetaldehyde	VOC	0.05308	8.9848
25	Acenaphthene	PM10	0.0001	0.0265
26	Phenanthrene	PM10	0.00026	0.0689
27	Fluorene	PM10	0.0001	0.0265
28	Naphthalene	PM10	0.00046	0.1219

The USACE estimated the greenhouse gasses (GHGs) for all marine diesel vessels within the 17 terminals in the Port of Charleston for all depths. Marine diesel vessels include OGVs, tugs, pipeline and hopper dredges, etc. Table 2-38 provides this GHGs information.

Table 2-38. 2011 Estimated Greenhouse Gases for All Vessels (tons/year)

Year	# of Vessels	CO_2	N_20	CH_4	Carbon
2011	1902	122,510.41	395.19	5,833.83	170.55

Cape Romain NWR is a Class I Wilderness Area located approximately 20 miles northeast of Charleston. Under the Clean Air Act, Class I areas are afforded extra protection from deterioration of air quality from permitted stationary sources. Stationary sources include facilities such as power plants and industrial processing plants. As a participant in the federal Interagency Monitoring of Protected Visual Environments (IMPROVE) project, monitoring of particulate matter (PM-10 and PM-2.5) has been conducted at Cape Romain since September 1994. The U.S. Fish and Wildlife Service, which manages the NWR system, is part of this cooperative monitoring program, along with the

National Park System (NPS), the U.S. Forest Service, and the Bureau of Land Management. The IMPROVE project was established to ascertain visibility in Class I areas, identify sources of anthropogenic impairments to visibility, and determine trends in order to gauge progress toward fulfilling the long-term goal of no anthropogenic impairment of visibility or air quality in protected areas. The ambient concentrations within the Cape Romain NWR are well below the NAAQS of 150 g/m3 and 65 g/m3 for 24-hour average PM-10 and PM-2.5, respectively. The USACE consulted with the USFWS Branch of Air Quality early on in study process.

Future Without Project Condition

The numbers of vessels expected to call on the Port of Charleston for years 2022, 2027, 2032, and 2037 will be greater for the FWOP / No Action Alternative than any of the action alternatives considered (See Appendix C). In 2037, for the 45/45 and 52/48 foot depth alternatives, the numbers of vessels arriving in Charleston would change from 3,860 to 3,567, respectively. In 2037, the Fleet Forecast estimates 8 percent more vessels arriving in Charleston for the existing depth of45/45 feet than for the maximum proposed depth of 52/48 foot. More vessels calling on the Port for the existing 45 foot depth during this projected time (i.e., 2022 to 2037) would result in a greater amount of Criteria Pollutants, Air Toxics and Greenhouse Gases being discharged in project area. Table 2-39 shows the summary of emissions from each terminal in the FWOP/No Action Alternative.

Table 2-39. Summary of all terminal emissions for the FWOP/No-Action alternative (45 foot depth).

Alternatives	Years	Terminals	NOx	CO	HC	PM10	PM2.5	SO2	CO2
Baseline 45 ft	2011	North Charleston	406.90	133.85	20.23	24.10	22.75	90.70	12,222.37
Baseline 45 ft	2011	Navy/Veterans	166.39	96.45	12.36	9.44	9.01	16.24	7,742.03
Baseline 45 ft	2011	Columbus Street and Union Pier	171.77	30.44	6.78	15.62	14.46	108.44	6,536.85
Baseline 45 ft	2011	Wando Welch	739.24	207.72	33.90	44.47	41.99	173.38	17,191.31
No Action 45 ft	2022	North Charleston	551.10	200.40	30.42	22.84	21.98	13.78	18,257.68
No Action 45 ft	2022	Navy/Veterans	463.13	171.40	28.75	17.07	16.31	20.35	29,492.77
No Action 45 ft	2022	Columbus Street and Union Pier	72.52	9.65	3.36	1.59	1.51	3.39	5,574.44
No Action 45 ft	2022	Wando Welch	969.03	307.36	50.21	39.83	38.43	18.26	24,922.67
No Action 45 ft	2027	North Charleston	611.79	232.13	35.71	26.57	25.56	16.66	22,354.14
No Action 45 ft	2027	Navy/Veterans	469.40	199.97	34.20	20.13	19.23	24.63	35,936.81
No Action 45 ft	2027	Columbus Street and Union Pier	73.00	9.77	3.38	1.61	1.53	3.39	5,574.44
No Action 45 ft	2027	Wando Welch	1,061.24	354.51	58.30	46.01	44.39	21.68	29,798.82
No Action 45 ft	2032	North Charleston	667.60	263.14	40.74	30.18	29.03	19.27	26,000.59
No Action 45 ft	2032	Navy/Veterans	496.91	233.48	41.45	23.99	22.91	30.79	45,484.57
No Action 45 ft	2032	Columbus Street and Union Pier	39.62	9.88	3.40	1.63	1.55	3.39	5,574.44
No Action 45 ft	2032	Wando Welch	1,158.27	402.11	66.55	52.26	50.41	25.28	34,963.44
No Action 45 ft	2037	North Charleston	730.55	278.83	44.22	32.86	31.61	20.44	27,839.92
No Action 45 ft	2037	Navy/Veterans	514.67	239.35	42.66	24.91	23.79	30.80	45,484.57
No Action 45 ft	2037	Columbus Street and Union Pier	40.09	10.00	3.42	1.65	1.57	3.39	5,574.44
No Action 45 ft	2037	Wando Welch	1,279.01	434.10	73.15	57.53	55.49	27.33	38,137.71

The Port is forecasted to reach capacity in 2037 (see Appendix C). As such, emissions are predicted to remain constant from 2037 and through the remainder of the future without project condition. The FWOP condition would result in more air emissions (compared to the action alternatives) due to the necessity for more ships to deliver the same volume of cargo. Additionally, the vessels utilizing the harbor under the FWOP conditions would be more likely to be older and less efficient.

2.4.18 Hazardous, Toxic, and Radioactive Waste

Existing Condition

Charleston Harbor is highly developed. There are four SCSPA terminals handling containerized, roll on/roll off and breakbulk cargo: North Charleston Terminal which is 5+ miles upriver, the Columbus Street and Union Pier Terminals which are in downtown, peninsular Charleston, and the Wando Welch Terminal which is located on the Wando River. There are two petroleum terminals and one coal terminal in Shipyard Creek. Lastly, there are four petroleum terminals and one grain terminal near the North Charleston Terminal. The eastern edge of the Charleston peninsula is industrialized with the port terminals and various small businesses. However, Charleston relies heavily on tourism, so the majority of the peninsula proper, while developed with hotels, dining establishments, and retail stores, is not industrial. Two industrial sites, Macalloy (providing chromium products) and W.R. Grace (fertilizer products), have been closed and are being cleaned up as state and/or federal actions. Both of these sites are located along the headwaters of Shipyard Creek. A number of industries are located adjacent to or upstream of the North Charleston terminal. These include the Kapstone paper plant, Bayer Corporation, Amoco, and Nucor steel mill. All of the major storage facilities have confinement areas sufficient to contain any spills and no hazardous or toxic materials or waste have been identified within the project footprint.

An Environmental Data Resources (EDR) report was generated for the Study area which included Charleston Harbor and a 1-mile buffer around it. Often developed for Phase I Site Assessments, an EDR provides historical records by searching numerous federal and state databases. Sites containing potential environmental concern have been mapped in the EDR Radius Map Report if adequate information for mapping was available. Mapped properties are depicted with their location in relation to the subject property (Figure 2-41). Details on this assessment can be made available to interested persons upon request.

Previous maintenance dredging has been performed in the existing navigation channel on a 12 to 18 month rotation. Because of the frequent dredging activity, hazardous or toxic wastes are not encountered. Sediments to be dredged from the harbor have been tested most recently in 2012 for the purposes of ocean disposal (USACE 2013) and a 103 sediment disposal evaluation has been submitted to EPA which documents that the proposed dredging and disposal of sediments is suitable for ocean disposal. The analysis confirmed that hazardous and toxic materials are not present in the sediments at levels of concern.

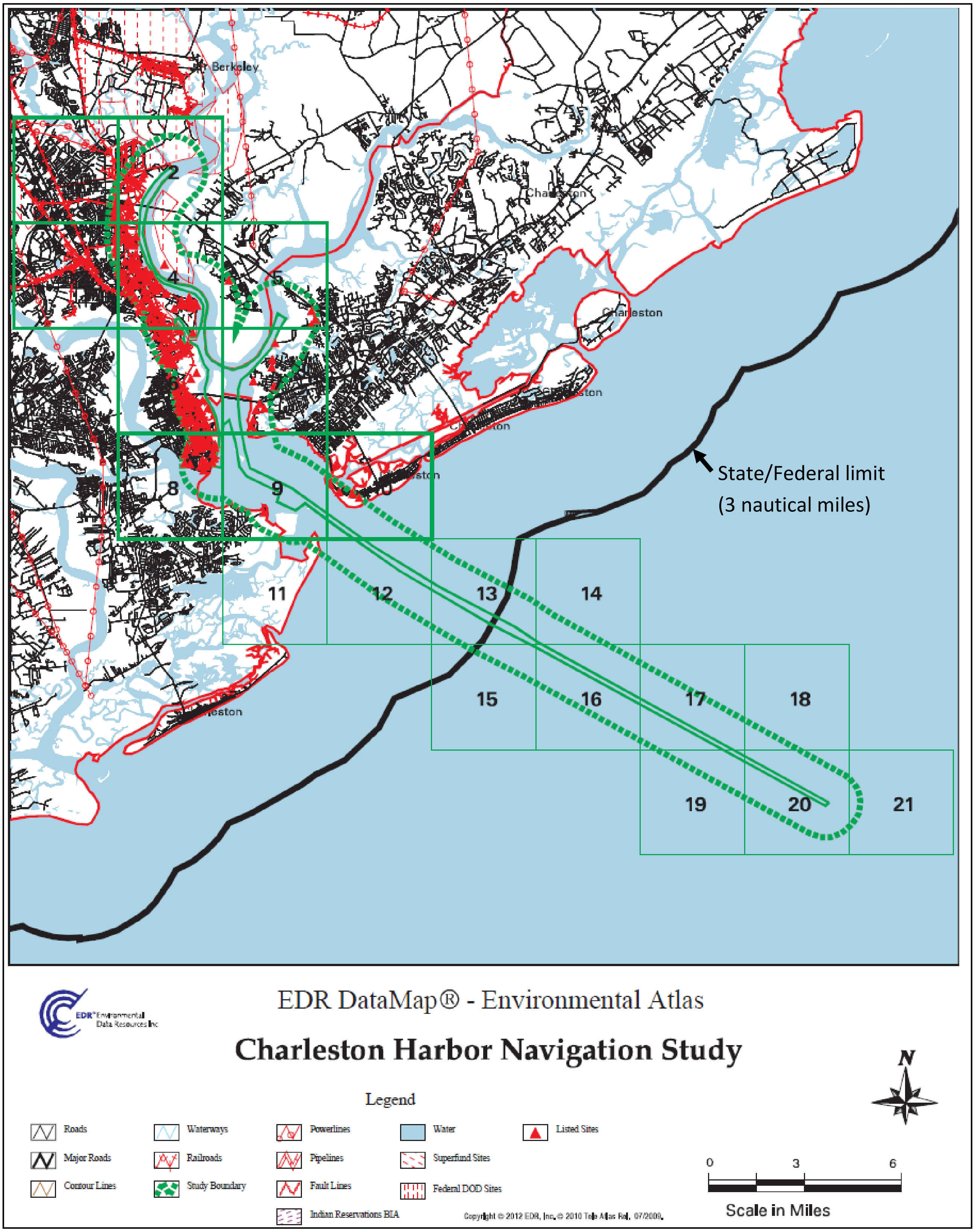


Figure 2-41. Charleston Harbor potential environmental sites of concern

Future Without Project Condition

There are no known sources of HTRW that affect the dredging areas. Continued operations and maintenance dredging would occur within the current navigational channel and dredging of sediments within the channel would continue to be operated in accordance with the most recent 401 water quality certification, dredged material management plan, and 404(b)(1) assessment.

2.4.19 Noise

Existing Condition

Noise is often defined as any sound that is undesirable because it interferes with communication, is intense enough to damage hearing, diminishes the quality of the environment, or is otherwise annoying. Response to noise varies by the type and characteristics of the noise source; distance from the source; receptor sensitivity, and time of day. Noise can be intermittent or continuous, steady or impulsive, and it may be generated by stationary or mobile sources. Noise is described by a weighted sound intensity (or level), which represents sound heard by the human ear and is measured in units called decibels (dB). The potential impacts of underwater sounds associated with dredging operations have come under increasing scrutiny by regulatory agencies.

Charleston Harbor has functioned as an international harbor since colonial times. Over the last 300 years, Charleston has evolved to accommodate the growing shipping industry as larger vessels continued to arrive. At the same time, recreational and other commercial boat traffic and industrial noise has continued to increase. Several sources of ambient noise are present in Charleston Harbor. The ambient noise level of an area includes sounds from both natural (wind waves, fish, tidal currents, mammals) and artificial (commercial and recreational vessels, dredging, pile driving, etc) sources. Tidal currents produce hydrodynamic sounds, which are most significant at very low frequencies (< 100 Hz). Vessel traffic, including vessels passing the immediate study area, generate sounds that can travel considerable distances, in frequencies ranging from 10 to 1000Hz. Sea state (surface condition of the water characterized by wave height, period, and power) also produces ambient sounds above 500 Hz. As a commercial and industrial area, Charleston Harbor experiences a wide range of noise from a variety of industrial activities. Biological sounds associated with mammals, fishes, and invertebrates can also generate broadband noise in the frequency of 1 to 10 kHz with intensities as high as 60 to 90 dB.

Charleston Harbor has the typical noise characteristics of a busy harbor. Sources include recreational and commercial vessel traffic, dredging vessels and dock side facilities. Noise sources for vessels include cranes, whistles and various motors for propulsion. Dockside noise sources include cranes, trucks, cars, and loading and unloading equipment. In addition to the noise in the water/marine environment, noise can impact the human environment. Background noise exposures change during the course of the day in a gradual manner, which reflects the addition and subtraction of distant noise sources. Ambient noise represents the combination of all sound within a given environment at a specified time. Humans hear sound from 0-140 dB. Sound above this level is associated with pain.

High intensity sounds can permanently damage fish hearing (Nightingale and Simenstad 2001). Dredging operations generally produce lower levels of sound energy but last for more extended periods of time than more intense construction activities (e.g., pile driving) (Nightengale and Simenstad 2001). These sounds have been documented to be continuous and low frequencies (< 1000 Hz) and are within the audible range of listed species of both whales (7Hz–22 kHz) and sea turtles (100-1000Hz) (Clarke et al., 2002).

Noise has been documented to influence fish behavior. Fish detect and respond to sound by utilizing cues to hunt for prey, avoid predators, and for social interaction. Fish produce sound when swimming, mating, or fighting and also noise associated with swimming. Fish use a wide range of mechanisms for sound production, including scraping structures against one another, vibrating muscles, and a variety of other methods. Sounds produced by spawning fishes, such as sciaenids, are sufficiently loud and characteristic for them to be used by humans to locate spawning locations.

Relative to exposure to anthropogenic noise, NOAA guidelines define two levels of harassment for marine mammals: Level A based on a temporary threshold shift (190 dB for pinnipeds and 180 dB for cetaceans), and Level B harassment with the potential to disturb a marine mammal in the wild by causing disruption to behavioral patterns such as migration, breeding, feeding, and sheltering (160 dB for impulse noise such as pile driving and 120 dB for continuous noise such as vessel thrusters) (http://www.nwr.noaa.gov/Marine-Mammals/MM-sound-thrshld.cfm). According to Richardson et al. (1995) the following noise levels could be detrimental to marine mammals:

- Prolonged exposure of 140 dB re 1 µPa/m (continuous man-made noise), at 1 km can cause permanent hearing loss.
- Prolonged exposure of 195 to 225 dB re 1 µPa/m (intermittent noise), at a few meters or tens of meters, can cause immediate hearing damage.

At the time this document was prepared, NOAA had released a draft report that provides guidance for assessing the effects of anthropogenic sound on marine mammal species under the jurisdiction of NMFS (NOAA 2013). The guidance will replace the current thresholds used by NOAA and described above. NOAA compiled, interpreted, and synthesized best available science to update the threshold levels for temporary and permanent hearing threshold shifts. Different target species for protection have widely divergent tolerance levels for sounds (owing to different hearing sensitivities, hearing integration times, etc.). This guidance has not yet been finalized but NOAA indicates that it will be finalized in late 2015 (http://www.nmfs.noaa.gov/pr/acoustics/faq.htm, accessed 07 April 2015). NOAA states that the guidance may necessitate new methodologies for determining impacts and the application of thresholds in the regulatory context under applicable statutes (NOAA, 2013). It should be noted that the application of thresholds is not addressed within the guidance (see Appendix G for more details).

Future Without Project Condition

Construction activity associated with maintenance dredging would continue. This dredging would result in a short term increase in noise over the existing background level though this would not cause a significant increase in the ambient noise levels. Charleston Harbor is within an urban setting and noises related to recreational and commercial vessel traffic, dredging vessels, and dock side facilities would continue similar to the existing conditions; however, the greater number of vessels expected to call in the FWOP would result in a minor increase in noise compared to an action alternative.

2.4.20 Coastal Barrier Resources

Existing Condition

The Coastal Barrier Resources Act (CBRA) was enacted by Congress in 1982. The CBRA was implemented to prevent development of coastal barriers that provide quality habitat for migratory birds and other wildlife and spawning, nursery, nesting, and feeding grounds for a variety of commercially and recreationally important species of finfish and shellfish. As a deterrent to development, federal insurance is not available for property within designated high-hazard areas. These high-hazard areas are called CBRA Zones.

CBRA Zones are areas of fragile, high-risk, and ecologically sensitive coastal barriers. Development conducted in these areas is ineligible for both direct and indirect federal expenditures and financial assistance. Along with CBRA Zones are otherwise protected areas (OPAs). OPAs are national, state, or local areas that include coastal barriers that are held for conservation or recreation. The only federal funding prohibition within OPAs is federal flood insurance.

There are several CBRA Zones located near Charleston Harbor, most notably the Morris Island Complex and the Bird Key Complex (Figure 2-42). The Morris Island Complex covers Morris Island and portions of James Island. The Bird Key Complex covers the southwest portion of James Island and the northeastern tip of Kiawah Island. The Bird Key Complex OPA covers the southwest tip of Folly Beach.

The Morris Island Complex is located between Lighthouse Inlet and Charleston Harbor in Charleston County, SC. The unit lies from the northeastern end of Folly Beach to the northern end of Morris Island. The Bird Key Complex is located between the south end of Folly Beach and the north end of Kiawah Island. The unit is approximately 7,094 acres, including roughly 687 acres of upland and 6,407 acres of aquatic habitat. Habitats in both units include intertidal sand shoals (estuarine intertidal unconsolidated shore wetlands), open water (estuarine subtidal unconsolidated bottom), marsh (estuarine intertidal emergent wetland), and uplands (dunes and maritime forest). Wetlands of the units provide important spawning, nursery, and feeding habitat for commercially and recreationally important species of estuarine-dependent finfish and shellfish. The units provide feeding, and resting areas for brown pelicans, terns, shorebirds, and wading birds.

Future Without Project Condition

The Coastal Barrier Resources Act (CBRA) zones and otherwise protected areas (OPAs) will continue to be protected without a project pending no changes in the current regulations.

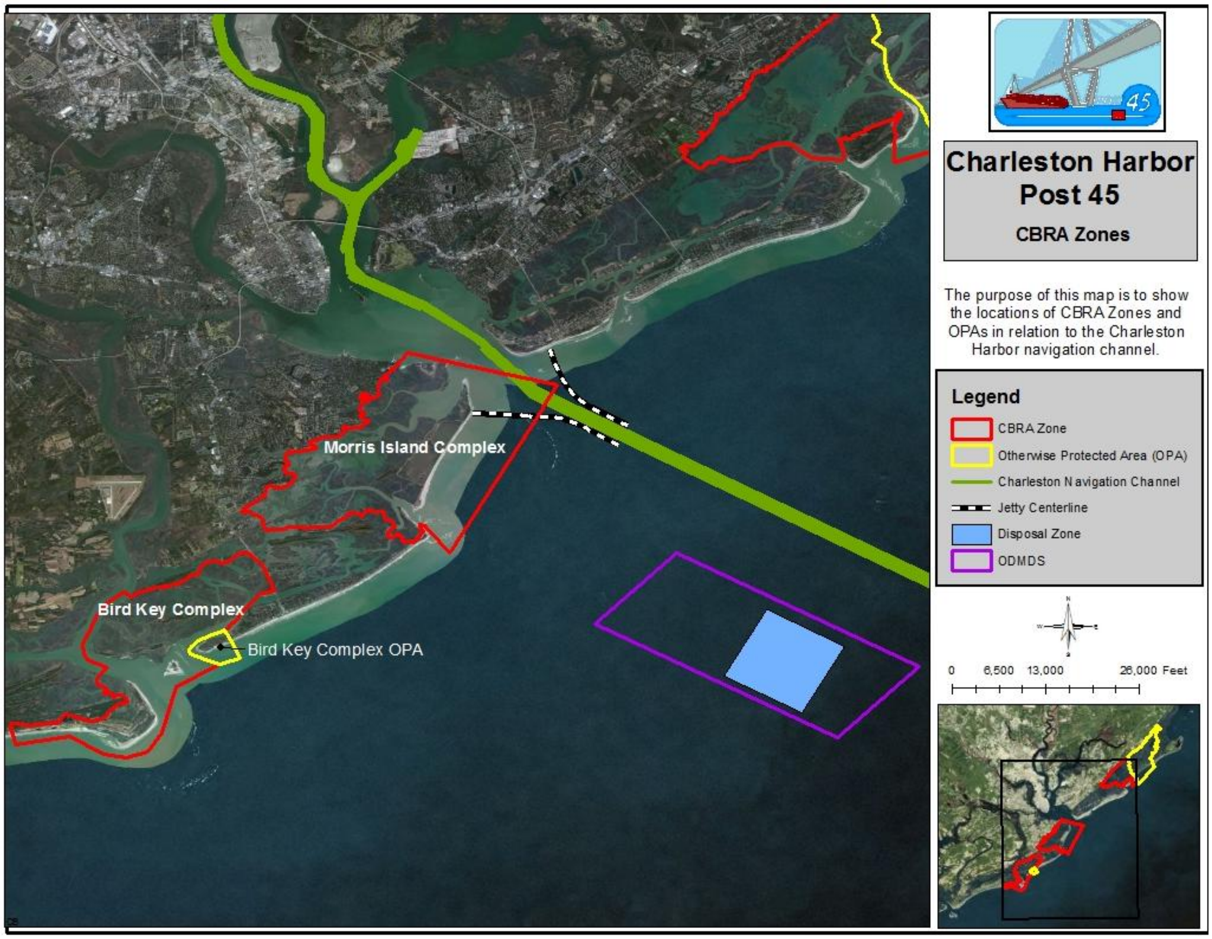


Figure 2-42. Charleston Harbor vicinity Coastal Barrier Resource Act zones

2.4.21 Cultural and Historic Resources

Existing Condition

Cultural resources are defined by the National Historic Preservation Act (NHPA) as prehistoric and historic sites, structures, districts, or any other physical evidence of human activity considered important to a culture, a subculture, or a community for scientific, traditional, religious, or any other reason. Several federal laws and regulations protect these resources, including the NHPA of 1966, the Archaeological and Historic Preservation Act of 1974, the American Indian Religious Freedom Act of 1978, the Archaeological Resources Protection Act of 1979, and the Native American Graves Protection and Repatriation Act of 1990. Documentation of historic/cultural resources is important for this project because Charleston Harbor provides an environment that is rich in prehistoric and historic human activity, and its geological setting is characterized by sediment types, especially heavy muds, that are well known for preserving shipwrecks and their contents.

Section 106 of the NHPA and its implementing regulations, 36 CFR Part 800, requires an assessment of the potential impact of an undertaking on historic properties that are within the proposed project's Area of Potential Effect (APE), which is defined as the geographic area(s) "within which an undertaking may directly or indirectly cause alterations in the character or use of historic properties, if any such properties exist." The APE for the direct impacts for the proposed project includes the areas where ground disturbing activities and the placement of dredged material would occur. This includes: 1) proposed channel and improvement areas of the Entrance Channel, Lower Harbor and Upper Harbor, 2) proposed outer channel extension, and 3) proposed expansion of the Ocean Dredged Material Disposal Site (ODMDS). The APE for the indirect impacts for the proposed project includes the shorelines and adjacent properties within the viewshed of Charleston Harbor (Figure 2-43).

There are 11 historic areas in the APE that are located in the Charleston Harbor Study area. These properties are listed on the National Register of Historic Places (NRHP) and include Fort Sumter National Monument, Fort Moultrie National Monument, Castle Pinckney, Old and Historic Charleston Historic District, Magnolia Cemetery, Mount Pleasant Historic District, Moultrieville Historic District, US Coast Guard Historic District, Charleston Navy Yard Historic District, Charleston Navy Yard Officers' Quarters Historic District, *USS Yorktown (CV-10), USS Laffey (DD724), and USS Clamagore (SS-343).* Since the Charleston Historic district, the USS Clamagore, and the USS Yorktown are National Historic Landmarks, Section 110(f) of the NHPA applies to these resources.

The Fort Sumter National Monument was established in 1948 and listed on the NRHP in 1966. The remnants of this masonry fort, associated with the Civil War defense of Charleston, stand on the south side of the mouth of Charleston Harbor, and are located approximately 2,925 ft from the Navigation Channel. The Fort has been experiencing erosion over the years and the south and east faces of the fort are particularly exposed to wave action. In a letter to the USACE dated 29 September, 2011, the NPS indicated that the gap in the existing stone breakwater allows waves to crash directly against the brick masonry especially at high tide. Fort Moultrie, fortifications on Sullivan's Island associated with the Revolutionary and Civil Wars as well as coastal defenses throughout the history of the United States, was added to the Fort Sumter National Monument in 1960 and listed on the NRHP in 1966. The shoreline of Sullivan's Island is located approximately 1,950 ft from the Navigation Channel.

Castle Pinckney stands on Shutes Folly near the center of Charleston Harbor approximately 1,950 ft south of the Navigation Channel. This brick fortification was built in 1808-1811 and listed on the NRHP in 1970. In 2000, the USACE constructed a rip rap embankment to protect the south side of the Fort from erosion.

The Charleston Historic District contains hundreds of eighteenth and nineteenth century buildings associated with the development of this historically important seaport since its founding in 1680. Listed on the NRHP in 1966, with a portion defined as a National Historic Landmark, the boundaries of the District were expanded in 1970 and 1978. Additional adjoining portions of the City are eligible for the NRHP as components of the District but have not been included within the current boundaries. The District contains most of peninsular Charleston south of US Highway 17, excluding recently constructed port facilities at its northeast corner.

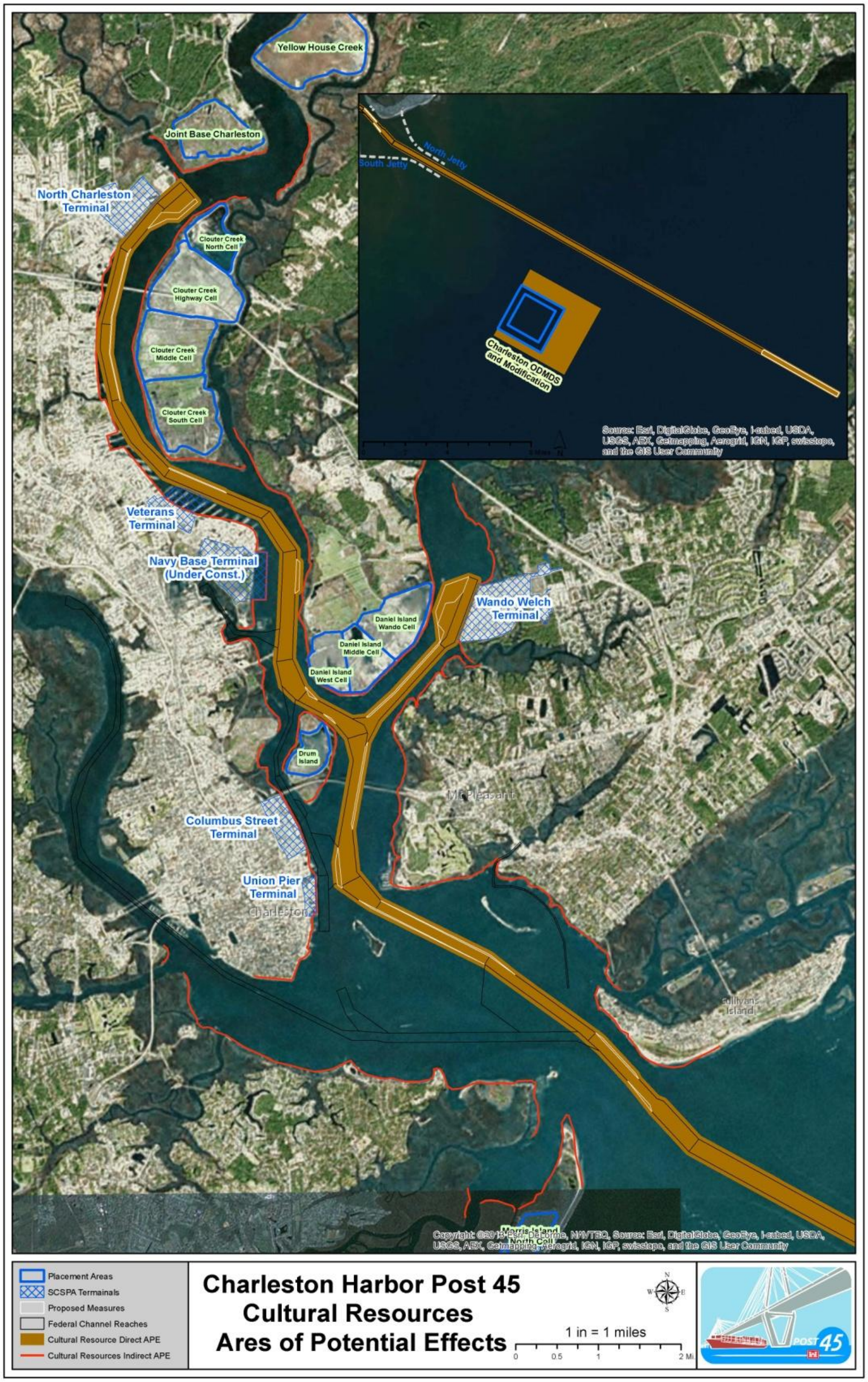


Figure 2-43. Direct and Indirect Impacts Area of Potential Effects

The Mount Pleasant Historic District includes numerous 18th century through early 20th century houses and buildings associated with this early summer resort community. The District extends along the east side of Charleston Harbor opposite the City of Charleston; Shem Creek forms the northern boundary of the District.

Moultrieville Historic District The Moultrieville Historic District is a relatively small collection of "island houses" that are located on the west end of Sullivan's Island. The district includes eighteen contributing buildings and one contributing site. All but one of the buildings are now residences, with the remaining building being Stella Maris Catholic Church, and the site is a small memorial park. There are also five noncontributing residences in the district. The period of significance for the district extends from circa 1830 through circa 1930 and reflects the construction dates of its earliest and latest contributing extant buildings.

The US Coast Guard Historic District consists of the Sullivan's Island Coast Guard Station, which is the oldest extant life saving installation on the South Carolina Coast. Shortly after the Civil War, the federal government recognized its obligation for the personal safety of citizens in the port area of Charleston with the establishment of the now defunct Morris Island Station.

Magnolia Cemetery lies on the west bank of the Cooper River. Extensive marshes lie between this nineteenth century cemetery and the river.

The Charleston Navy Yard Historic District is nationally significant as the core collection of historic resources illustrating the establishment, growth, and development of the Charleston Navy Yard (later the Charleston Naval Shipyard and still later the Naval Base Charleston) from 1903 through 1945. The historic district includes 57 contributing historic buildings, structures, and objects associated with the Charleston Navy Yard, which served the United States Navy from 1903 to 1996. The historic resources in the district include machine shops, storage facilities, a power house, drydocks, piers, administrative facilities, and other buildings and structures related to ship construction and repair.

The Charleston Navy Yard Officers' Quarters Historic District is nationally significant as a collection of historic resources representing the establishment, growth, and development of the upper echelon of senior military housing, support structures, sports facilities and recreational landscape features within a park setting at the Charleston Navy Yard (later the Charleston Naval Shipyard, and finally Naval Base Charleston) from 1901 through 1945. While some of the developments in housing were typical of those constructed at other navy yards elsewhere, the Charleston Navy Yard Officers' Quarters Historic District stands out as a singularly unique prototype for elite residential planned communities. This district is composed of forty buildings, structures, sites, and objects.

The three vessels listed on the NRHP are permanently berthed at the Patriots Point Maritime Museum on the east side of Charleston Harbor, approximately 3.5 miles along the Navigation Channel from the entrance to Charleston Harbor from the Atlantic Ocean. All three possess strong associations with World War II as well as continued service and associations with important historical events during the 1950s, 1960s, and 1970s. The aircraft carrier *USS Yorktown (CV-10)* served in all major conflicts of the 1940s through 1960s and recovered the crew of Apollo 8 space mission. The Destroyer *USS Laffey (DD-724)* served in World War II and the Korean War. Submarine *USS*

Clamagore (SS-343) saw action in World War II and was one of the last diesel-electric submarines in US Navy service.

Numerous terrestrial and underwater archeological resources exist in the Charleston Harbor Study area (Spirek 2013, Watts 1986, 1989, 1995a, 1995b, 1995c); however, none have been identified within the federal Navigation Channel or that could be impacted by potential vessel wakes from containerships. In order to determine if the proposed project alternatives could impact any submerged resource along the margins of the navigation channel, the Charleston District performed a detailed assessment of potential submerged archaeological resources within the footprint of the project study area.

Cultural patterns associated with prehistoric populations on the South Carolina coastal plain are demonstrated by archaeological evidence for consistent patterns of behavior in the Southern Atlantic states. Regional variations seem to reflect proximity to the Atlantic Ocean, and chronological divisions are correlated with environmental change and subsistence patterns, visible in artifacts as well as the remains of food and food-associated waste. Gayes et al., 2013 discuss the various prehistoric periods including the Paleoindian (14,000 – 10,000 years ago), Archaic (10,000 – 3,500 years ago), Woodland (3,500 – 1,100 years ago), and Mississippian (1,100 – 450 years ago) Periods. During the Paleoindian period and end of the Pleistocene Era, the South Carolina Coastal Zone and the rivers that drain into Charleston Harbor were submerged. Evaluation of erosion along recent shorelines, especially after major storms, suggests that material culture associated with both prehistoric and historic habitation of the Charleston Harbor region regularly is redeposited in the harbor or along the deeper bends and pockets of the rivers that flow into it. Although such geological features may harbor artifacts, most of the prehistoric submerged cultural resource contexts within the study area are likely to have been destroyed, resulting in isolated finds of artifacts that may indicate cultural affiliation and a chronological link (Albright 1980; Harris et al. 1993: 60; Watts 1986:6).

European exploration of coastal South Carolina and the Charleston area began with Spanish exploration during the middle 16th century. However, permanent settlement did not begin until 1663 when King Charles II made grants to the Lords Proprietors, who fostered settlement on Albemarle Point on the west bank of the Ashley River in 1670. In 1680, the town was moved down river to Oyster Point, the present location of Charleston.

The economic success of “Charles Town” (as it was previously called) depended, firstly, on naval stores and then on other labor intensive agricultural products such as rice, indigo, and cotton. Slave-based plantation agriculture remained the primary economic focus of coastal South Carolina and Charleston Harbor until the end of the Civil War in 1865.

Charleston’s importance as a port and political center grew rapidly, with development along the Cooper River leading the way. Despite wars, fires, and hurricanes, the waterfront continued to expand, with exports growing to nearly $11 million by 1817, making Charleston second only to New York. Agricultural products remained the leading exports. But the city was not immune to economic upheavals, and by the1820s, the city was experiencing a prolonged economic slow-down as other areas of the country prospered. However, nothing heaped misery on the city like the Civil War. Seen as the cradle of the insurrection by the United States, military actions were initiated against Charleston and South Carolina as soon as appropriate forces could be mustered. Despite nearly 2 years of shelling, the railroad and wharf installations remained operable until Confederate troops abandoned the city in mid-February of 1865. The Union Navy blockaded Charleston since it represented one of the busiest of southern ports at the time. The Confederate States Navy attempted to break the blockade at Charleston through the use of experimental vessels, like the submarine *H.L. Hunley*, which would become the first submarine to sink an enemy vessel during wartime. Shore batteries and storms accounted for other Federal losses, including the ironclads *Weehawken* and *Keokuk* off Morris Island, and the *Patapsco* east of Mount Pleasant Reach (see Reference Aid). The Federal blockade also resulted in the loss of a large number of private commercial vessels such as the side-wheel steamer *Flora* that attempted to run through the blockade.

A boost to the local and maritime economy of Charleston and South Carolina occurred in 1900, when the US Congress authorized the construction of a US Navy shipyard and repair facility. Land acquisition began in 1901 and facilities were complete by 1909 to permit the repair of a number of vessels, including the US Navy tug *Potomac*, hospital ship *Solace*, and the battleship *Texas*. As World War I began and the US was drawn closer and closer to the conflict, the US Navy continued to expand its many facilities including the Charleston Navy Yard. The outbreak of World War II and the subsequent expansion of the Charleston Navy Yard proved to be the city's salvation from the ravages of the Great Depression.

In the decades following World War II, the US Navy continued to use and expand the Charleston Navy Yard. At the same time, the SCSPA began to expand its facilities and capabilities in Charleston Harbor. By the 1990s, the US Navy closed the Charleston Navy Yard and its associated facilities, but the Harbor became one of the busiest container ports on the east coast of the United States. Three historic districts are listed in the National Register of Historic Places that encompass portions of the former Navy Yard: Charleston Navy Yard Historic District, Charleston Navy Yard Officers' Quarters Historic District, and Charleston Naval Hospital Historic District.

Future Without Project Condition

Without a project the extensive cultural and historic resources of the Charleston Harbor area would continue to be protected under several federal laws and regulations similar to the existing conditions descriptions. No impacts to cultural or historic resources are anticipated from continued operations and maintenance dredging. Ft Sumter National Monument is listed on the NRHP. The National Park Service indicated in a scoping letter at the onset of the Study that its value to American culture is inestimable. Wave action from an increase in vessel size and numbers could result in an increase in wave energy along the masonry walls of the fort; however, the main source of wave energy is from wind generated waves (see Appendix A). In the FWOP / No Action Alternative, a greater number of vessels of similar sizes to the action alternatives are anticipated to call on the Port when compared to the action alternatives. Therefore, the no action alternative is predicted to have greater impacts to the shoreline of Fort Sumter and other historic resources and shorelines.

2.4.22 Aesthetics and Recreation

Existing Condition

Aesthetic resources are perhaps more difficult to define than aesthetics itself. EPA (1973) stated the following:

> "A. G. Alexander Baumgarten (1714-62) is credited with coining the word AESTHETIC, in his work Aesthetica (dated 1750), to denote "that branch of science which deals with beauty" (Klien, 1966). Like beauty, then, the word has no clear and agreed-on definition that is operative--it remains a term that designates a vague concept…"

In the context of large infrastructure projects, aesthetics generally involves personal and subjective evaluations of the acceptability of visual scenes. The subject is often approached in terms of a "viewshed", which is the scene of the proposed project and consequences as viewed from various locations. Since the project involves a large landscape, this section will be addressed from a regional Charleston aspect.

Charleston is a historic seaport, and has been associated with vessels of increasing size for hundreds of years. A scenic setting is provided by the harbor and river and the numerous vessels common to these waters, including commercial and recreational boats as well as vessels calling on the Port. The estuarine environment provides opportunities for boating and fishing, as well as an escape from the faster pace of land-based activities. Several boat ramps and marinas are located in Charleston Harbor. The Port itself is situated in an urban/commercial setting.

Future Without Project Condition

Regardless of the implementation of the proposed project, in the FWOP condition / No Action Alternative, larger vessels will call at the port. One potential effect on local aesthetics could be that larger vessels would call at the port in the future and those ships may be visible from farther away (albeit typically for a short interval of time in any given position). This shift to larger vessels is already occurring, and will take place regardless of deepening. Apart from the shipping industry, other anthropogenic features have affected and continue to affect local aesthetics. These include roadways and railways, infrastructure, vehicular traffic, industrial complexes, and blighted properties. Dredge vessels and equipment used during operations and maintenance may temporarily affect aesthetics in Charleston Harbor, just as scaffolding and cranes temporarily obscure architectural features in an urban setting. There would continue to be temporary and minor impacts on recreational boating during continued maintenance dredging of the navigation channel but no more than there is now as the maintenance schedule is not expected to change. Since a greater number of containerships are anticipated to call on the Port in the FWOP condition, recreational use of the harbor would be more impacted in the FWOP condition than the action alternatives.

2.4.23 Socioeconomics

Existing Condition

This section provides information on existing population demographics. An understanding of the socioeconomic conditions in the project area is important to ensure that all Americans are afforded the same degree of protection from environmental health hazards and an equal opportunity to maintain a healthy environment in which to live and work. In addition to NEPA requirements, several Executive Orders (EOs), including EO 12898, Environmental Justice (EJ), and EO 13045, Protection of Children direct federal agencies to address the potential for proposed actions to disproportionately adversely impact sensitive, low income and minority populations. Environmental Justice includes the fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income in the implementation, and enforcement of environmental laws, regulations, and policies. The following sections summarize population and demographic information for the Tri-County region (Charleston, Berkeley, and Dorchester Counties) on a census tract and block group level, and then describe the outreach strategy used during this study.

In 2010, the U.S. Census Bureau estimated that the population of the Tri-County region was 664,607 people, with a density of roughly 257 persons per square mile. Population density varied significantly for the three counties from a low of 162 persons per square mile in Berkeley County, to a high of 382 persons per square mile in Charleston County (US Census Bureau 2010). A one-mile buffer around the project footprint was established as the Environmental Justice area of interest. Figure 2-44 was generated using EPA's EJView web tool (http://epamap14.epa.gov/ejmap/entry.html). It shows population density per within the area of interest.

Executive Order 12898 does not define the terms "minority" or "low-income". However, guidance provided by the Council on Environmental Quality (CEQ) describes these terms in the context of an environmental justice analysis. CEQ defines a minority individual as, "belonging to one of the following groups: American Indian or Alaskan Native, Asian or Pacific Islander, Black (not of Hispanic Origin), and Hispanic." CEQ guidance states that, "minority populations should be identified where either (a) the minority population of the affected area exceeds 50 percent, or (b) the minority population percentage of the affected area is meaningfully greater than the minority population percentage in the general population or other appropriate unit of geographic analysis." Low-income populations are identified where individuals have incomes below the U.S. Department of Health and Human Services poverty guidelines. A low-income population is either a group of low-income individuals living in proximity to one another or a set of individuals who share common conditions of environmental exposure or effect.

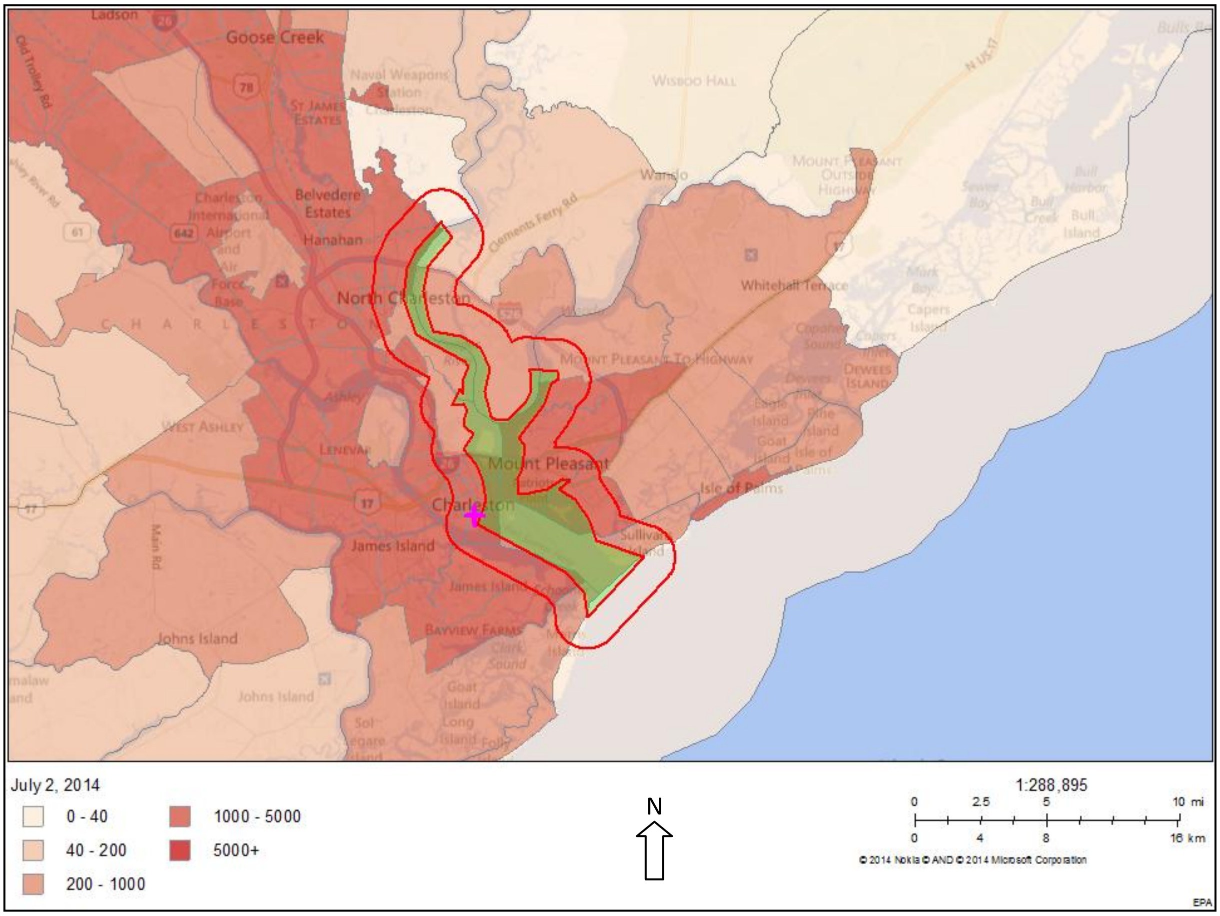


Figure 2-44. Population density by Census Tract

(A one-mile buffer zone around the project is outlined in red.)

Based on the Census America Community Survey (2012), the minority population for the Tri-County area is 36.6 percent. The minority population for the project's Environmental Justice area of interest (i.e. census tracts within a one mile buffer of the Harbor) is 26.4 percent. As a whole, the area of interest does not meet the CEQ criteria as serving minority populations. However, some individual tracts have higher (up to 89.7 percent) minority populations than the area as a whole (Census America Community Survey 2012). Figure 2-45, generated using EPA's EJView web tool, shows the percent of the population that is minority by census tract.

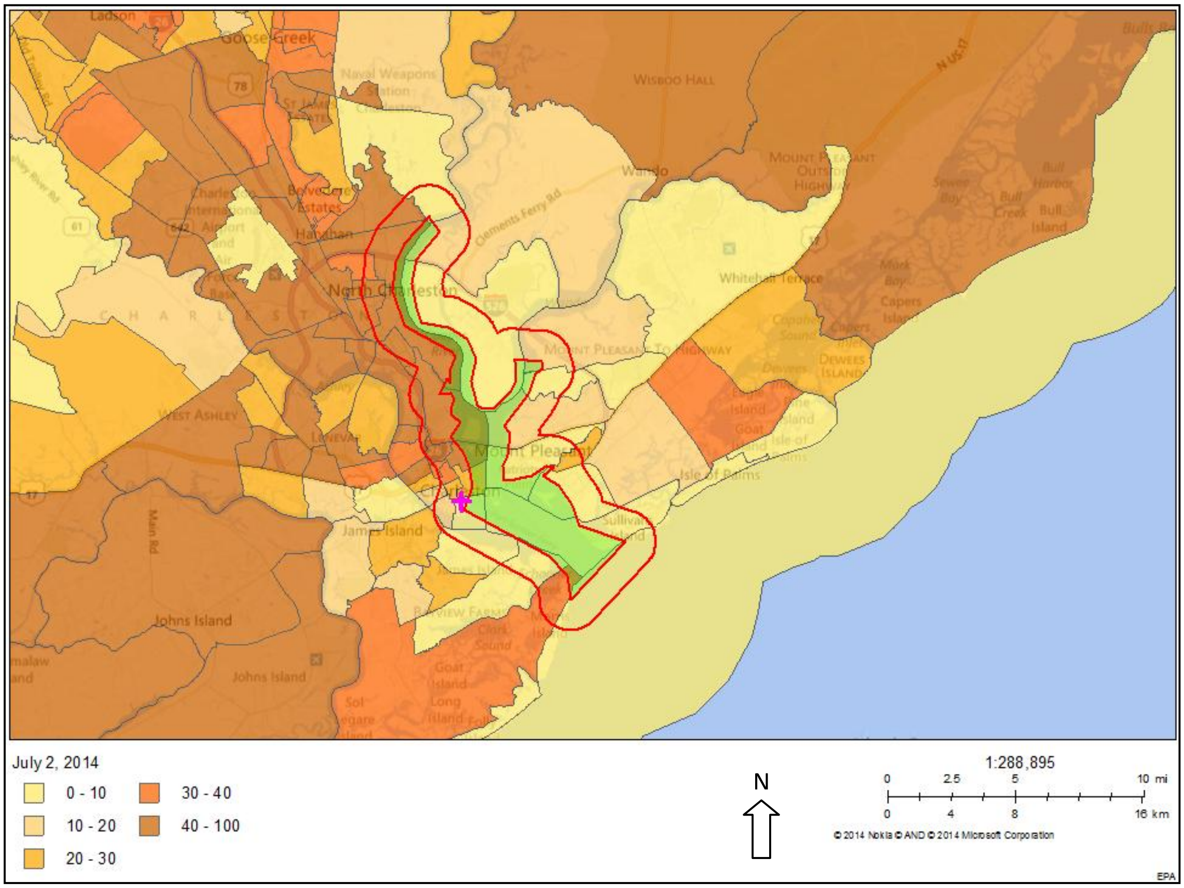


Figure 2-45. Percent Minority by Census Tract**.**

(A one-mile buffer zone around the project is outlined in red.)

Any individual with a total income less than the amount needed to purchase basic needs (food, shelter, clothing, and other essential goods and services) is classified as poor (US Census Bureau, 2012). The income necessary to purchase these basic needs is the poverty line or threshold. The 2012 poverty guidelines for an individual under 65 years of age is $11,170; for a three-person family with one child and two adults is $15,130; and for a family with two adults and two children the poverty line is $23,050 (Dept. of Health and Human Services, 2012). According to US Census Bureau data, 9.7 percent of families within the area of interest (i.e. census tracts within a one mile buffer of the Harbor) were below the poverty level (Census America Community Survey 2012). Figure 2-46 was generated in the EPA EJView web tool (http://epamap14.epa.gov/ejmap/entry.html) and shows the percent of the population below the poverty level by census tract.

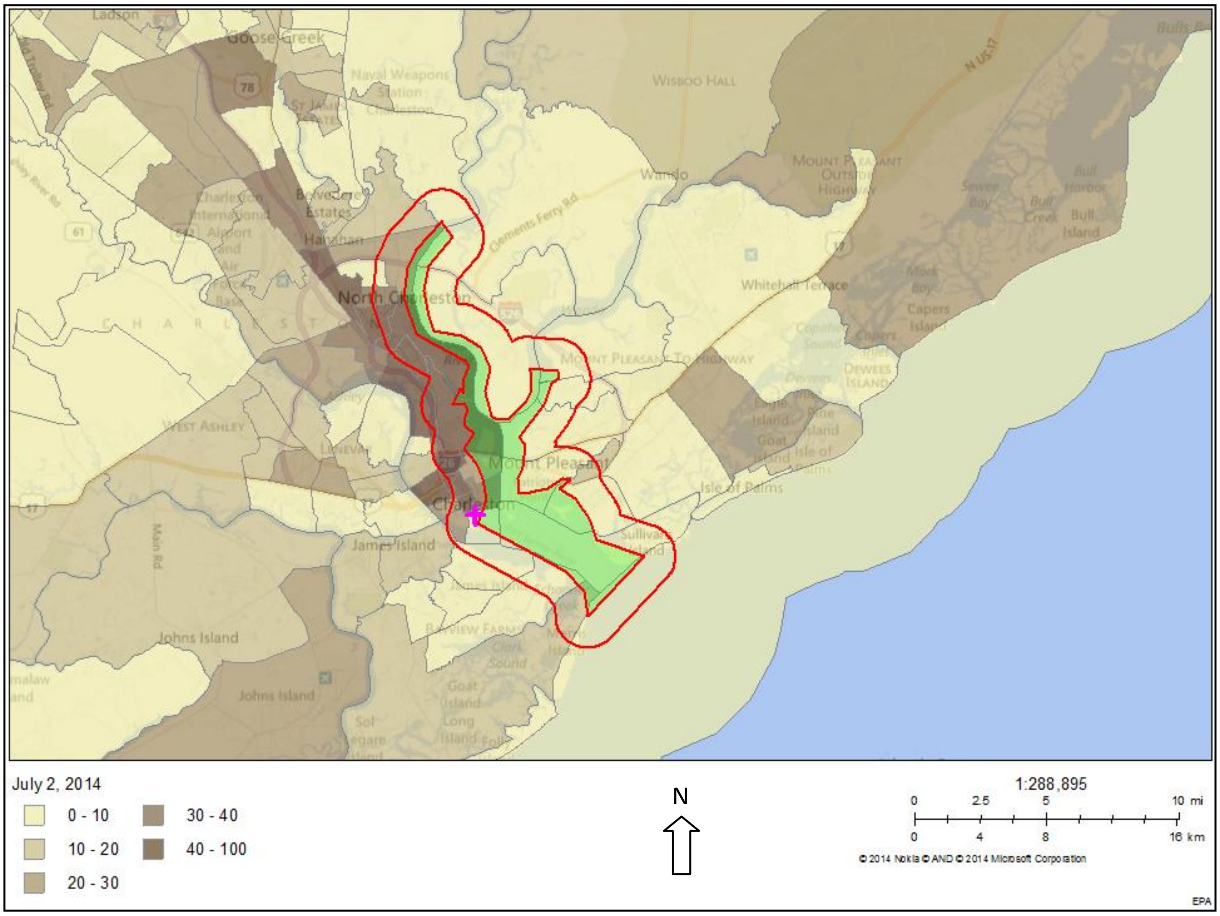


Figure 2-46. Percent of Population Below Poverty Level by Census Tract

(A one-mile buffer zone around the project is outlined in red).

Recognizing that the Census Tract data may not capture Environmental Justice communities on a finer scale, the analysis was expanded to include data at the Census block group level.

All census block groups that were fully or partly contained within the area of interest were included in the analysis. The analysis was conducted using U.S. Census Bureau 5-year Estimates from the American Community Survey (ACS) date 2006-2010. The percent minority of each census block group, within the area of interest, was obtained from the EPA's EJView geographic assessment tool. Because Census block group data was not available within EJView (the finest level of data available on EJView was census tracts), USACE utilized U.S. Census Bureau 5-year Estimates from the American Community Survey (ACS) date 2006-2010 to calculate percent of persons living in poverty for each Census block. In order to calculate the percent of people living in poverty, the total population who had income in the past 12 months below poverty level was divided by the total population for whom poverty status is determined. This value was then multiplied by 100 to convert to percent. As stated above, the environmental justice threshold is met for block groups where the minority or low-income population equals or exceeds 50 percent of the population in that block group. Figure 2-47 presents the results of the more detailed analysis to identify EJ communities. Similar to the initial analysis, the results show that EJ communities are concentrated within portions of North Charleston. The census blocks that are not highlighted in the figure do not meet the EJ criteria identified, above.

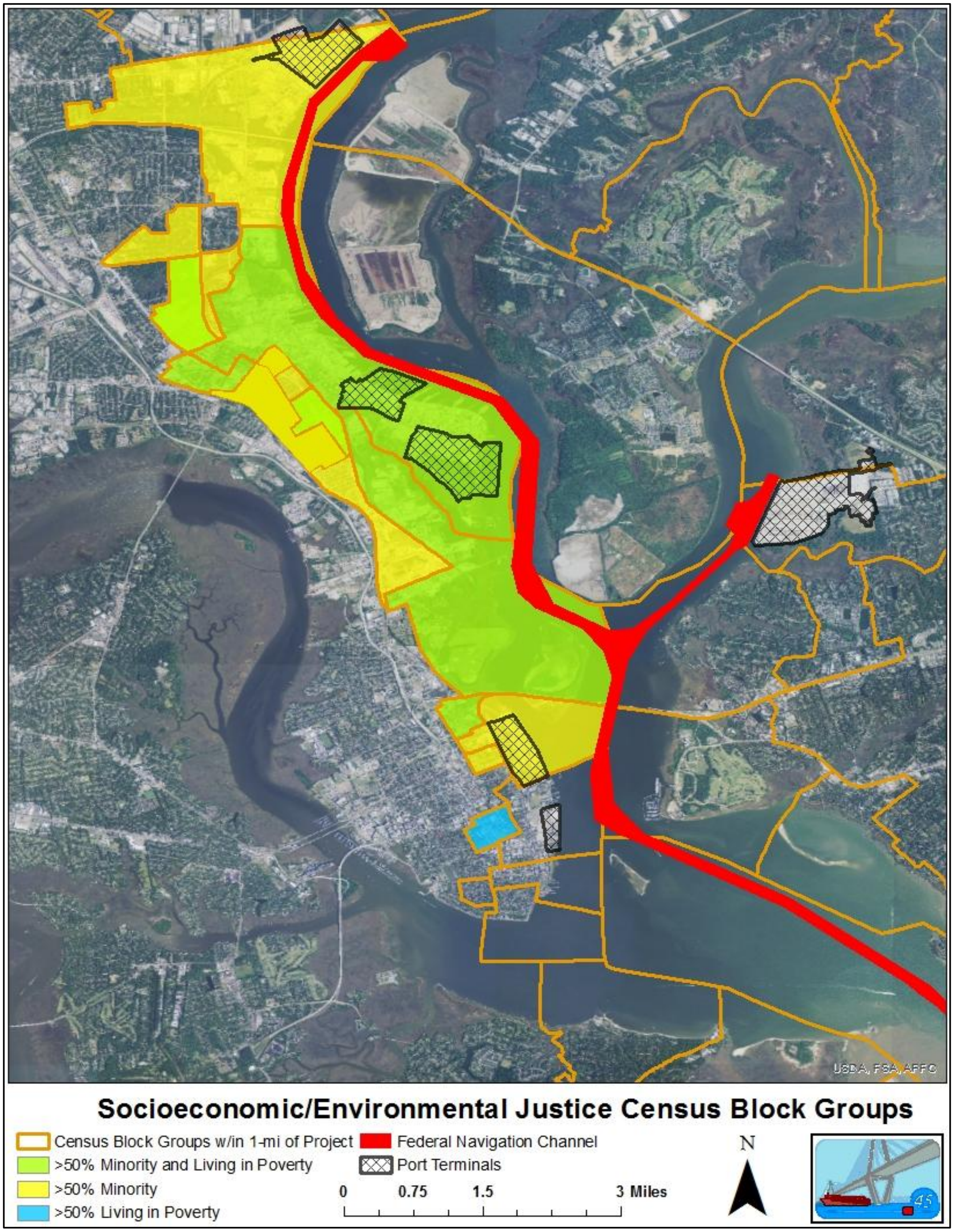


Figure 2-47. Locations of Environmental Justice Communities

According to data from the EPA EJView web tool, Charleston Harbor is within one mile of 64 schools/child care facilities and 3 hospitals (EPA, 2014). These facilities are dispersed throughout the region and are not located disproportionately near the navigation channel. Figure 2-48 was generated in the EPA EJView web tool (http://epamap14.epa.gov/ejmap/entry.html) and shows schools/child care facilities, and hospitals, in the tri-County area.

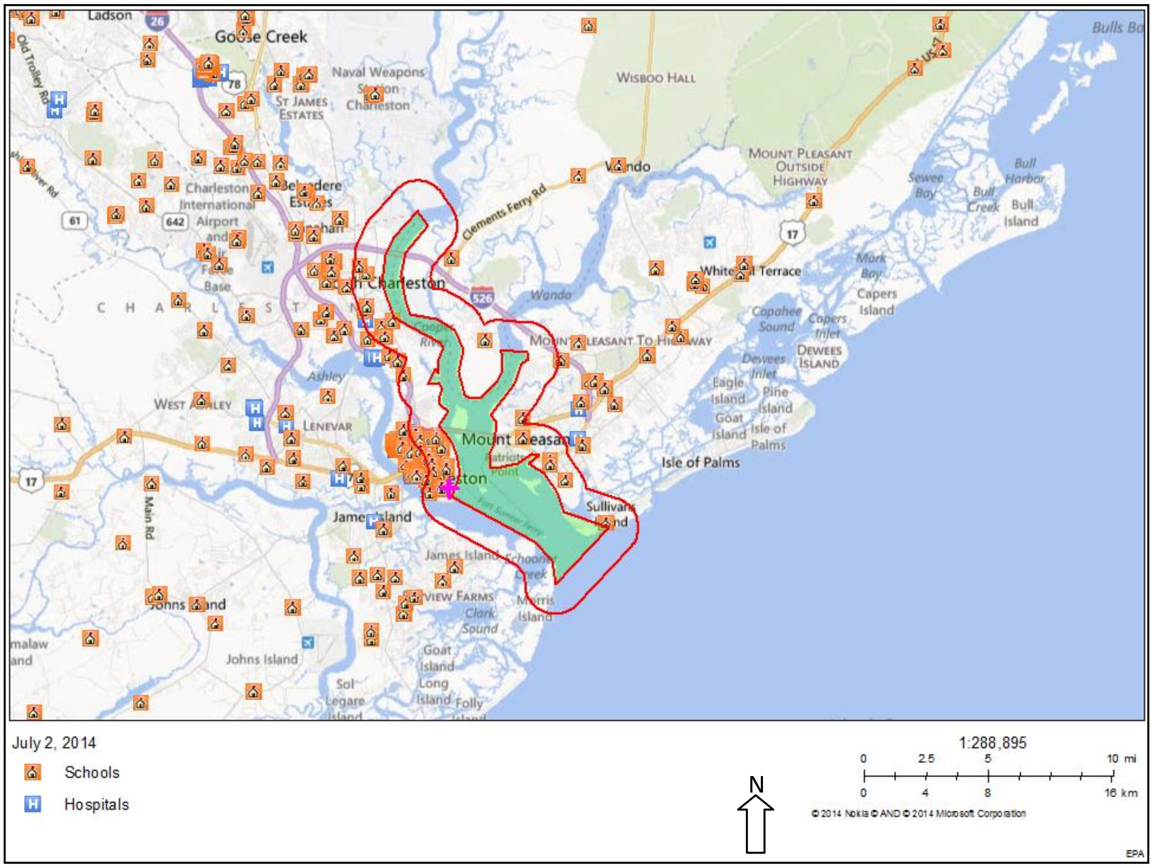


Figure 2-47. Locations of schools/childcare facilities, and hospitals

(A one-mile buffer zone around the project is outlined in red)

Based on an initial review of the data presented above, the City of North Charleston was identified as a community with potentially important Environmental Justice considerations. Early in the study, the USACE coordinated with, the North Charleston's Citywide Projects Manager, Department of Planning, to help identify specific neighborhood groups and associations within North Charleston with whom to coordinate (Figure 2-48). Additionally, the USACE worked with the SCHDEC Community Liaison Coordinator, and the Environmental Protection Agency to help identify other groups in the area and develop an outreach strategy to address environmental justice issues and concerns.

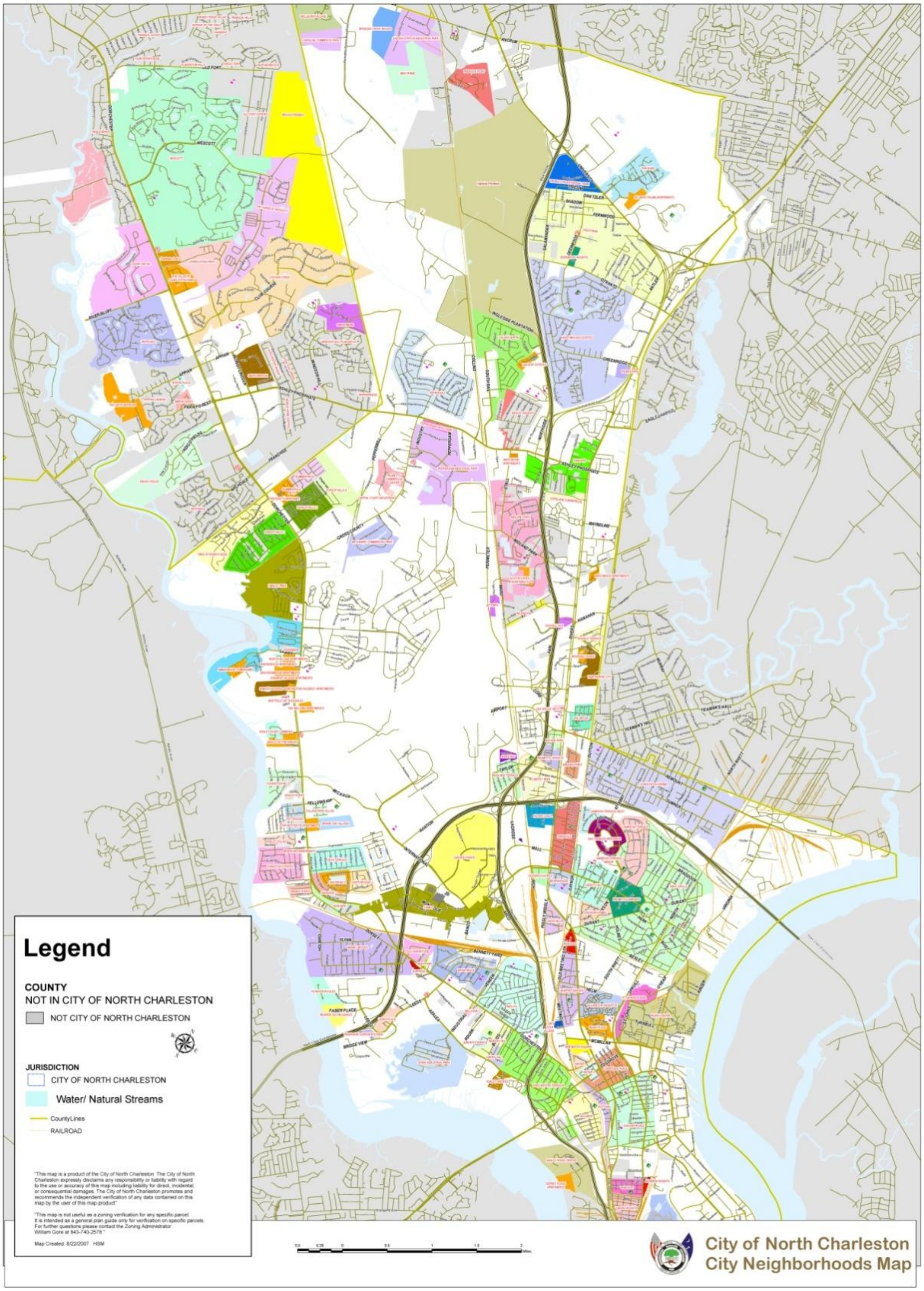


Figure 2-48. City of North Charleston Neighborhoods Map.

After identifying groups with potential EJ concerns, the USACE implemented an outreach effort to coordinate with these specific neighborhoods and potential EJ groups (email from Alan Powell to Mark Messersmith, 10/24/2011). Over 150 special notices of public meetings were mailed to various neighborhood associations, City Planners, Municipalities, Churches, Community Centers, Chapters of the National Association for the Advancement of Colored People, etc. to obtain feedback from groups and individuals with EJ-related concerns. Although no local groups or individuals expressed EJ-related concerns during the scoping or public review processes, the EPA expressed concerns that the deepening project could affect air emissions or truck traffic in a way that has adverse and disproportionate impacts on low-income or minority communities or sensitive population groups. A description of the analysis of potential impacts to Environmental Justice communities is provided in Chapter 5, Impacts of the Proposed Project.

Future Without Project Condition

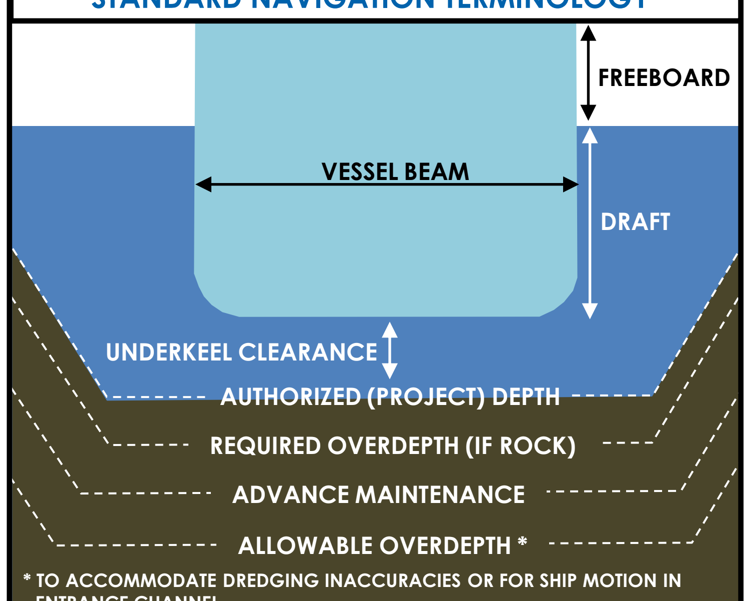
Cargo volumes at each terminal and the number of cargo vessels transiting the harbor are predicted to increase over time (Appendix C, Economics). Though the capacity and efficiency of cargo vessels would continue to increase, the largest vessels would not be able to load to capacity due to inadequate channel depths. Total air emissions (including air toxics), within the harbor and at each terminal are predicted to increase over time. However, no violations of the NAAQS are expected and the projected emissions may be reduced by technological advances. A detailed analysis of air emissions is provided in Appendix N (Air Emission Inventory). The projected increase in cargo entering the harbor is also expected to result in increased truck traffic. Over time, and due to tidal delays experienced by container ships, the truck traffic would become increasingly time-compressed and operate with less flexibility. Consequently, emissions from container ships would be concentrated around periods of high tide and the landside operations needed to accommodate the less flexible arrival/departure times would cause more concentrated emissions rather than dispersing them throughout the day.

When considered as a whole, the EJ area of interest, i.e., census tracts adjacent to the harbor, does not contain unrepresentative concentrations of minority, juvenile, elderly, or low-income communities. However, some census tracts within the area of interest contain concentrated populations of minority, juvenile, elderly, or low-income communities than the surrounding tri-county area. Since children can be more vulnerable to pollutants than adults due to differences in behavior and biology, they can be at greater risk of exposure and susceptibility to air pollutants. Schools/childcare facilities and hospitals are relatively evenly dispersed throughout the area and are not disproportionately located near the harbor, so disproportionate impacts to children are not expected. The socio-economic conditions in the area of interest are not expected to change in the foreseeable future.

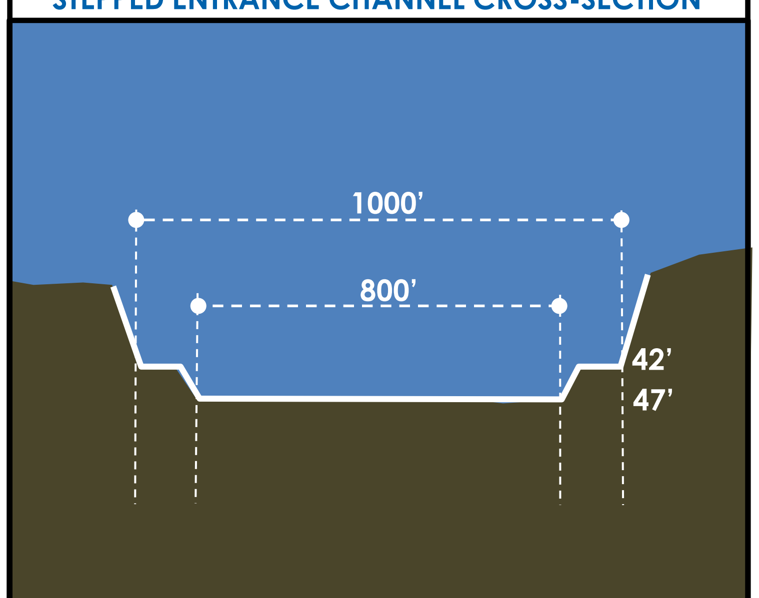
REFERENCE TABLE 1: CHARLESTON HARBOR EXISTING SEGMENT DIMENSIONS

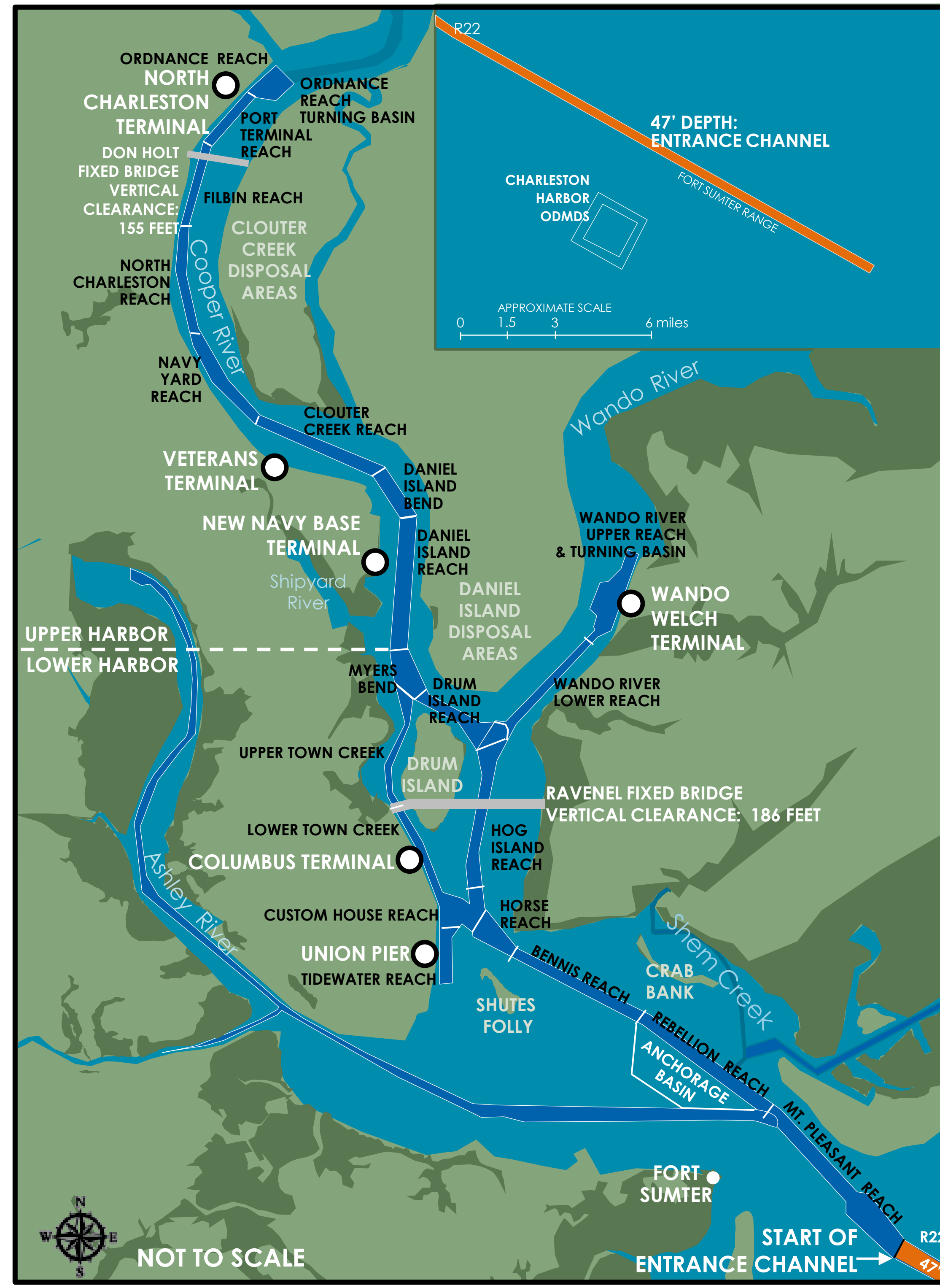
REACH/SEGMENT	NOMINAL DEPTH		NOMINAL WIDTH		MAX SAILING DRAFT (WITH 5 TO 6-FOOT FLOOD TIDE CONDITION)
	MAINTENANCE	AUTHORIZED	MAINTENANCE	AUTHORIZED	
Entrance Channel	47/42	47/42	42' at 1000'	42' at 1000'	47
Entrance Channel	47/42	47/42	47' at 800'	47' at 800'	47
ENTRANCE CHANNEL TO WANDO WELCH TERMINAL (LOWER HARBOR)					
Mount Pleasant Range	45	45	600-1000	600-1000	45
Rebellion Reach	45	45	600	600	45
Bennis Reach	45	45	600	600	45
Horse Reach	45	45	600	600	45
Hog Island Reach	45	45	600	600	45
Wando Channel Lower Reach	45	45	400	400	45
Wando Turning Basin (TB)	45	45	1400	1400	45
DRUM ISLAND TO NORTH CHARLESTON TERMINAL (UPPER HARBOR)					
Drum Island Reach	45	45	600	600	45
Myers Bend	45	45	VARIES	VARIES	45
Daniel Island Reach	45	45	880	880	45
Daniel Island Bend	45	45	700-880	700-880	45
Clouter Creek Reach	45	45	600	600	45
Navy Yard Reach	45	45	600-675	600-675	45
North Charleston Reach	45	45	500	500	45
Filbin Creek Reach	45	45	500	500	45
Port Terminal Reach	45	45	600	600	45
Ordnance Reach with TB	45	45	1400	1400	45
UNION PIER TO WEST OF DRUM ISLAND					
Custom House Reach	45	45	Varies	Varies	45
Upper Town Creek	16	16	250	250	16
Lower Town Creek	45	45	450	450	45
Town Creek Turning Basin	35	35	300	300	35
Tidewater Reach	40	40	650	650	40
OTHER FEDERAL CHANNELS					
Anchorage Basin	35	35	2250	2250	35
Shem Creek Channel	12	12	110	110	12
SHIPYARD RIVER					
Entrance Channel	45	45	300	300	45
Basin A	45	45	700	700	45
Connector Channel	45	45	200	200	45
Basin B	30	30	600	600	30

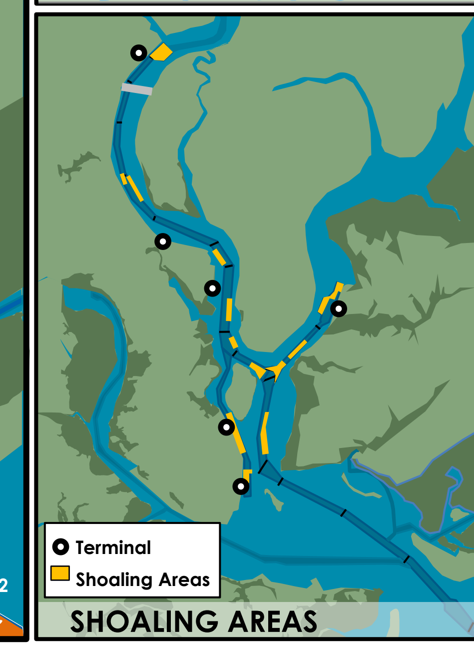
STANDARD NAVIGATION TERMINOLOGY



STEPPED ENTRANCE CHANNEL CROSS-SECTION







FEDERAL CHANNEL DEPTHS

LOWER HARBOR: 45 feet
Downstream of Shipyard River to Entrance Channel

UPPER HARBOR: 45 feet
North of Shipyard River

ENTRANCE CHANNEL: 42-47 feet

Wetlands (Generalized)

SEGMENT WIDTHS

Refer to Reference Table 1

TERMINALS AND INFRASTRUCTURE

North Charleston Terminal (NCT): primarily containers, but can process break-bulk and roll-on/roll-off cargoes

Wando Welch Terminal (WWT): containers

Columbus Street Terminal (CST): roll-on/roll-off and project cargoes/heavy lift (transitioned from a container terminal, but retained container capabilities)

Veterans Terminal: break-bulk, roll-on/roll-off, and project cargoes

New Navy Base Terminal: containers

Union Pier Terminal: conventional break-bulk, roll-on/roll-off, and project cargoes

MAXIMUM VESSEL (CONTAINER) SIZE TRANSITING PORT:

Generation III, New Panamax vessel but vastly light-loaded

3.0 PLAN FORMULATION

Note: A Plan Formulation: Section 3 Reference Aid at the end of this Section provides the reader with key information used throughout the discussions. It includes: names of channel reaches, depths, widths, sailing drafts, characteristics of container ships, a map of the planning segments, channel cross-section, standard navigation terminology, and port infrastructure.

The USACE plan formulation process identifies existing and anticipated problems and opportunities to develop planning objectives. It then identifies and refines specific measures that could be combined to assemble alternative plans that comprehensively meet the planning objectives. These alternatives are then repeatedly screened, refined, and compared with each other to identify the alternative that best balances the many factors that need to be considered to make a prudent decision. This is achieved through the six-step process summarized as follows:

Step 1: Identify Problems and Opportunities
Step 2: Inventory and Forecast Conditions
Step 3: Formulate Alternative Plans
Step 4: Evaluate Alternative Plans
Step 5: Compare Alternative Plans
Step 6: Select a Plan

During their repeated refinement, the alternatives are designed to be complete, effective, efficient, and acceptable in an effort to maximize overall benefits and minimize costs and adverse impacts. To select a plan, the alternatives are compared with each other from the perspectives of the National Economic Development (NED), Regional Economic Development (RED), Environmental Quality (EQ), and Other Social Effects (OSE) accounts to identify and recommend the alternative that provides the best and most balanced solutions, considering all four accounts.

National Economic Development.	Changes in the economic value of the national output of goods and services
Regional Economic Development.	Changes in the distribution of regional economic activity (e.g. income and employment)
Environmental Quality.	Non-monetary effects on ecological, cultural, and aesthetic resources
Other Social Effects.	Plan effects on social aspects such as community impacts, health and safety, displacement, energy conservation, and others

The USACE began implementing the modernization of its planning program in 2012. This feasibility study (FS) is one of the first navigation studies to be conducted using the new methodology from start to finish. The initiative applies a risk-based approach to shorten schedules and reduce the cost to complete the FS process by eliminating non-essential activities while still producing reports that make and adequately support prudent recommendations. The risk-based process concentrates on collecting and presenting information related to the factors that most influence the decisions being considered and minimizing the collection and reporting of information that does not meaningfully influence the decisions and recommendations. When appropriate, it also uses assumptions, professional judgment, and/or estimates instead of acquiring new data to support the decision-making process after considering the relative likelihood, nature, and magnitude of the impacts to the overall decision and the associated environmental, social, and economic consequences.

The new process is also intended to generate reports that are smaller, more concise, and easier to understand. Accordingly, this report (including the associated appendices) is substantially shorter than those from most recent USACE harbor improvement studies. It is anticipated that the shorter, more concise report will reduce review times and help maintain the project schedule by eliminating the need to extend review/comment periods beyond standard time frames.

3.1 Problems, Opportunities, and Constraints

The first step in the six-step planning process is the identification of problems and opportunities. A problem is an existing condition to be considered for change. An opportunity is a chance to create a future, more desirable condition. Constraints are resource, legal, or policy considerations that limit the actions that can be implemented. The identification and development of problems, opportunities, and constraints specific to Charleston Harbor resulted from internal discussions, external communication with stakeholders and resource agencies, and public meetings.

The National Environmental Policy Act (NEPA) scoping process played an important part in gathering information to help identify problems, opportunities, constraints, and stakeholder, public, and agency concerns. This information was also used to develop objectives for the FS. Details on the scoping process and documentation of all comments received can be found in Appendix Q. The following issues were identified as important considerations during the NEPA scoping process:

A. **NEPA-process Related.** It was stated that the USACE should avoid an overly restrictive statement of purpose in the Environmental Impact Statement (EIS) that limits the alternatives analysis.

B. **Economics.** The general public and agencies want to understand how the project will use updated economic data, including growth trends to evaluate alternatives.

C. **Salinity Impacts.** How any proposed deepening action may affect salinity levels within Charleston Harbor and nearby rivers and marshes generated concern and comments. Specifically, these concerns relate to impacts to wetland communities, the Bushy Park reservoir, and groundwater aquifers.

D. **Sea-level Rise.** Several citizens, stakeholders, and agencies expressed concerns about potential impacts of sea-level rise when those impacts are combined with the impacts of a proposed project.

E. **Dissolved Oxygen.** Several citizens, stakeholders, and agencies expressed concerns about the impact of the proposed project on the existing dissolved oxygen concentrations.

References were made to the existing Total Maximum Daily Load (TMDL) used to regulate the amount of oxygen-demanding substances that can be discharged into the harbor without contravening the water quality standard.

F. **Sediment Quality and Disposal.** Concerns were expressed regarding the potential for contaminated sediment to be dredged and the possible impacts of contaminated sediment on dredged material disposal options.

G. **Fish and Wildlife Habitat.** Several comments were received related to ensuring that the project will not significantly impact threatened and endangered species as well as other fish and wildlife resources, including bird habitat.

H. **Shoreline Erosion.** The general public and agencies are concerned with existing erosion problems facing many areas in Charleston Harbor and how the proposed deepening may affect those problems. Some stakeholders have also requested that the USACE place dredged material along certain shorelines to reduce the effects of erosion. Some example areas include Crab Bank, Morris Island, Shutes Folly Island, and Ft. Sumter.

I. **Air Quality.** The general public and resource agencies want to understand how the project will influence air quality in the region, including priority pollutants, toxics, and greenhouse gases. Also, the EPA expressed concern about the potential for the project to concentrate pollution in certain areas or cause disproportionate adverse impacts within environmental justice communities.

J. **Cultural Resources.** The general public and agencies were concerned about impacts to cultural and historic resources both in the water and on land.

3.1.1 Problems

Feedback from stakeholders, combined with knowledge of the existing and forecasted makeup of the vessel fleet servicing Charleston Harbor, indicates that the most pressing problems are related to meeting the needs of the growing size and increasing depth requirements of container vessels. These problems are causing transportation inefficiencies that will increase in the future if they are not addressed. Transportation inefficiencies occur when channels and maneuvering areas do not fully accommodate the vessels using them. Currently, large vessels are constrained by insufficient channel depths and under-sized turning areas and all vessels can be constrained by strong or unpredictable winds and currents or other conditions that affect safety. Meetings and coordination with the South Carolina State Ports Authority (SCSPA), terminal operators, the Charleston Branch (Harbor) Pilots' Association, the U.S. Coast Guard, the Charleston Harbor Navigation Safety Committee, maritime interests, environmental resource agencies, and interested individuals provided valuable information related to existing problems and opportunities for improvements. The most important problems identified at Charleston Harbor are summarized as follows:

A. Insufficient channel depths

1. Large vessels (requiring more than 45-foot depths) are experiencing inefficiencies. These inefficiencies cause the transportation industry to light load large vessels or wait for favorable tide conditions, or use smaller, less efficient vessels to transport the cargo. Depth-related problems are expected to be exacerbated by ongoing and forecasted shifts to the use of larger vessels, particularly for containerized cargo.

B. Strong and unpredictable currents, winds or other safety-related conditions at several locations

1. Limited visibility of vessels entering the harbor from the Intracoastal Waterway
2. Ebb currents near the confluence of the Wando and Cooper Rivers make turns difficult.
3. Limited visibility of on-coming vessels near Drum Island Turn
4. Complicated vessel traffic and proximity of the channel to docked vessels near the Shipyard Creek junction
5. Strong bank suction effects in the North Charleston and Filbin Creek reaches

C. Restrictive channel widths and undersized turning basins

1. Restrictive channel widths limit vessels to one-way traffic in several reaches
2. Some turning basins are too small to fully accommodate the larger vessels in the existing and forecasted fleet

3.1.1.1 Insufficient Channel Depths

According to Charleston Branch Harbor Pilots data, the average cargo vessel size in the Port of Charleston has grown by 26 percent between 2006 and 2013. Figure 3-1 presents average gross tonnage per vessel from 2006 to 2013.

In 2006, the average vessel was about 37,000 gross tons. In 2013 the average vessel had increased to about 46,500 gross tons. This rate of growth in average vessel gross tonnage, if sustained, indicates that the average vessel in Charleston could be in the Post-Panamax class as early as 2018. Through July 2014 Charleston Harbor had received 381 container vessels with sailing drafts of 41 feet or greater. This indicates that the shift to larger vessels maybe occurring faster than forecasts predicted. Forty one (41) feet of draft is an important consideration because, with 4-feet of underkeel clearance needed for safety, vessels at that draft begin to experience depth-related delays using the harbor.

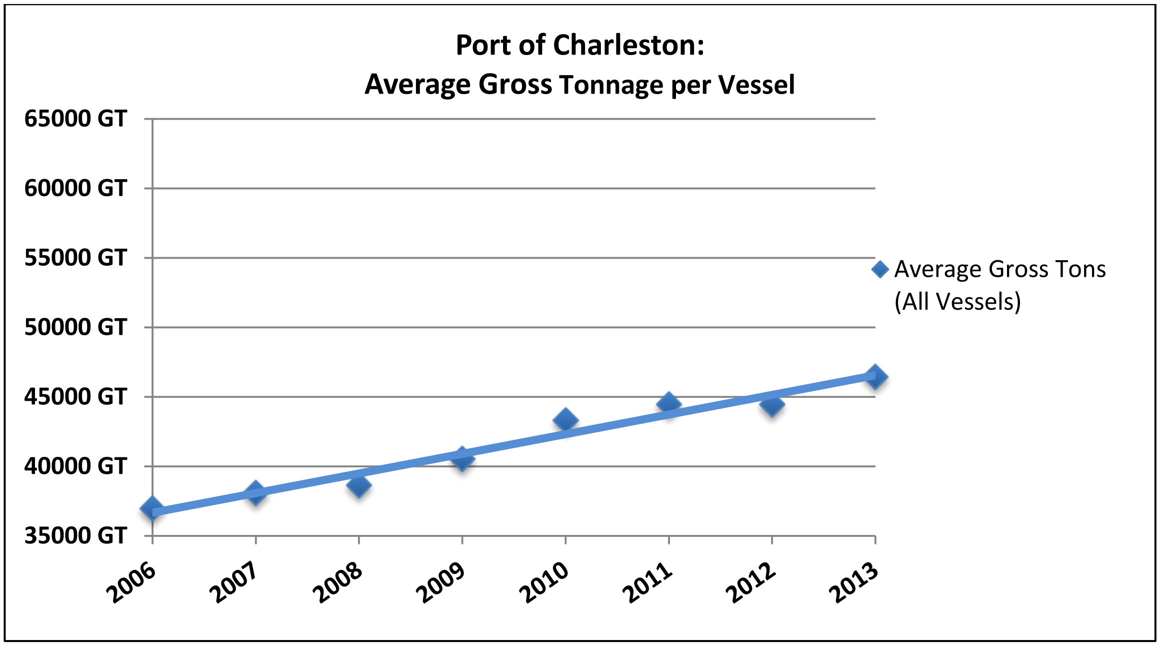


Figure 3-1. Average gross tonnage per vessel

Container vessels can be divided into development generations based on capacity, which is determined by number of TEUs that can be transported. Figure 3-2 shows the general evolution in containerships to illustrate relative vessel development over time. Modern vessels with capacities over 8,000 TEUs are operating together with smaller vessels with capacities ranging from a few hundred to a few thousand of TEUs.

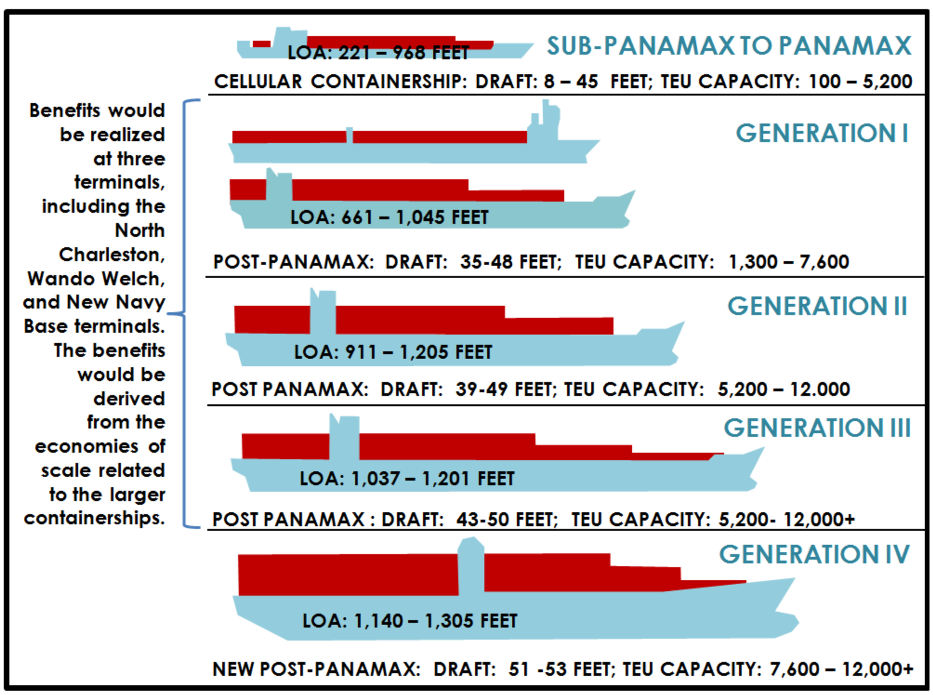


Figure 3-2. Generations of container vessels

Forecasts predict that container vessels ranging from 5.2K to 14K TEU will call on Charleston Harbor during the entire period of analysis (2022-2071). This range crosses the transition between Panamax vessels and post-Panamax vessels. The Maritime Strategies, Inc (MSI) forecast was used to divide post-Panamax vessels into the following classes: Generation I (5.2K-7.6K TEU), Generation II (7.6K-12K TEU) and Generation III (12K+ TEU). Even larger vessels are already in the World fleet and becoming increasingly important, particularly in light of increasing partnering and consolidation among vessel users that serves to maximize the cost savings potential of the largest vessels. However, those vessels are currently deployed on Asia-Europe trade lanes and are not forecasted to call on the USEC in the near future.

Existing channel depths accommodate vessels drafting up to about 48 feet, although at that draft they are limited to a tide window of about 2 hours per day while maintaining the necessary underkeel clearance. Vessels drafting more than about 41 feet may experience delays based on the tide conditions when they arrive or depart. To reach port terminals, these vessels must either be light loaded, wait for favorable tide conditions, or both. The depth limitation causes some vessel operators to utilize smaller vessels and forego the cost savings that would otherwise be realized with the use of larger vessels. In 2008 tide delays were estimated to be about $600,000/year. These costs are increasing annually as the number of larger vessels increases.

Figure 3-3 provides the arrival draft frequencies of containerized vessels from 2008-2013. As shown, the number of vessel arriving at Charleston drafting between 30 and 35 feet peaked in 2009. Vessels drafting between 36 and 40 feet dropped in 2009 but thereafter increased steadily through 2013. The number of containerized vessels arriving at a sailing draft 41 feet or greater dropped in 2009 but then more than tripled in 2010. The percentage of container vessels drafting 41 feet or more reached about 10 percent in 2012. That percentage dropped slightly to about 9 percent in 2013. However, it is expected to trend higher consistent with current trends in vessel use and orders for new vessels and with world-wide and regional fleet forecasts, all of which predict decreased use of the smaller vessels and increased use of larger vessels in the future.

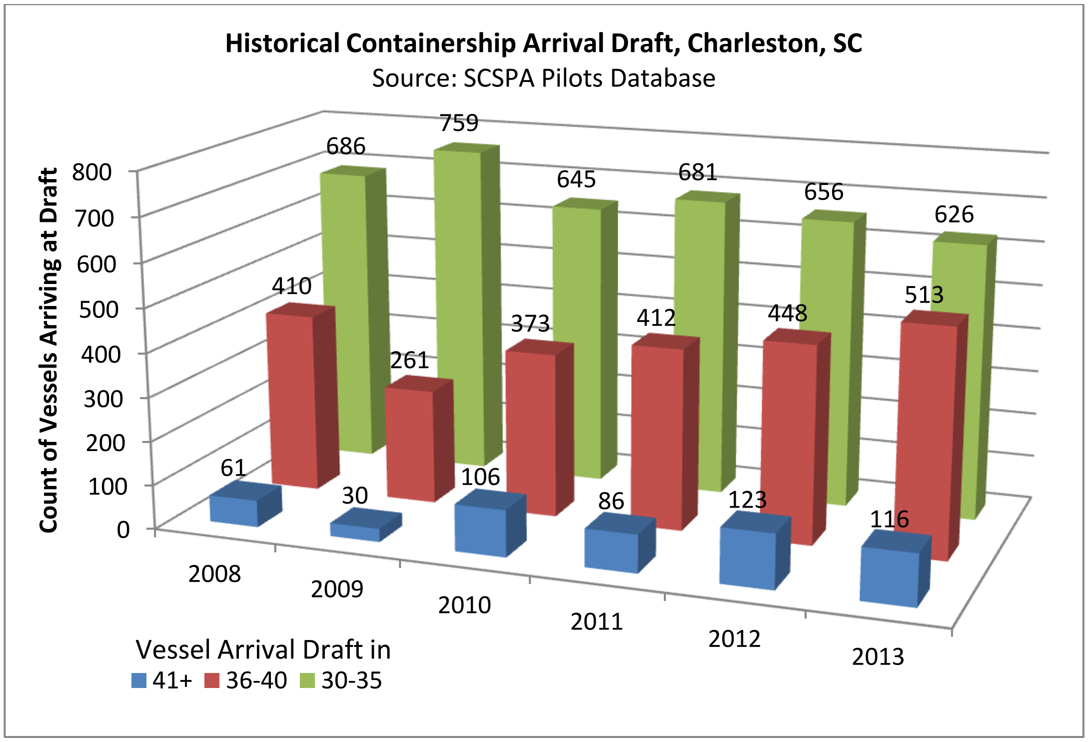


Figure 3-3. Historical vessel arrival draft – container vessels

It is notable that the recent decrease in the number of vessels drafting 35 feet and less and increases in the mid-range and deeper draft vessels occurred during a time that Charleston Harbor experienced major increases in total cargo throughput. These trends are expected to continue. Additional information related to historical and projected vessel and draft utilization is provided in Appendix C (Economics).

3.1.1.2 Safety Issues and Difficult Currents

The Charleston Harbor Pilots, U.S. Coast Guard representatives, the Charleston Harbor Navigation Safety Committee, NOAA Coast Pilot 4 (pages 240-241), and other maritime interests identified four areas of particular concern within Charleston Harbor. These areas include the mouth of the Atlantic Intracoastal Waterway (AIWW), Drum Island Turn, Shipyard Creek Junction, and the North Charleston and Filbin Creek reaches, which are illustrated in the Allisions (the running of one vessel against another), Collisions (two vessels striking each other), and Groundings map, Figure 3-4.

Figure 3-4. U.S. Coast Guard documented groundings, collisions, and allisions (1996-2014)

3.1.1.2.1 Atlantic Intracoastal Waterway

The AIWW intersects the navigation channel at Rebellion Reach. Westbound vessels entering Charleston Harbor from the waterway are not readily visible to inbound vessels until they clear the northernmost part of Sullivan's Island. The AIWW is extensively used by tows, and its junction with Charleston Harbor is subject to strong and unpredictable crosscurrents.

3.1.1.2.2 Drum Island Turn

Navigation of the Drum Island turn is complicated by (1) poor visibility caused by Drum Island blocking the view of oncoming vessels, (2) proximity (700 yards) to the Ravenel bridge span over Hog Island Reach, and the resultant vulnerability of the bridge to collisions when vessel control is lost, and (3) difficult crosscurrents on ebb tides from the confluence of the Cooper and Wando Rivers.

3.1.1.2.3 Shipyard Creek Junction

Navigation near the Shipyard Creek junction is complicated by vessel traffic in and out of Shipyard Creek and by ebb currents of unusually high velocity. In-bound, low-powered vessels, particularly tugs with deep-draft tows, are advised to avoid this area except on flood tides. Tankers moored at the oil terminal facing the lower portion of Daniel Island Reach are susceptible to current surges and suction from passing deep-draft vessels.

3.1.1.2.4 North Charleston and Filbin Creek Reaches

The main channel in the North Charleston and Filbin Creek reaches is adjacent to the pier heads of a number of oil terminals that receive bulk tanker vessels. The channel in these reaches is about 500 feet wide; thus, the passage of vessels often occurs in proximity to moored tanker vessels transferring bulk liquids including flammable, combustible, and hazardous cargoes. The presence of the Don Holt Bridge and its vertical structures, which are surrounded by a protective fender system, further restricts navigation. When tanker vessels are moored near these facilities, the problems are further complicated by wake and suction effects from passing vessels on cargo hose and mooring lines, as well as the occasional loss of visibility of the bridge due to water vapor emitted from nearby industrial facilities.

3.1.1.3 Restrictive Channel Widths

Restrictive channel widths limit vessel passage to one-way traffic in some reaches, and larger vessels are restricted by the size of some turning basins. One-way traffic restrictions in the Bennis and Hog Island reaches, in particular, cause congestion, inefficiencies, and delays.

3.1.2 Opportunities

Opportunities focus on desirable future conditions and potential ways to address specific problems within the study area. Several opportunities were identified in the initial planning process. Opportunities that may result over the 50-year period of analysis from management measures addressed in this FS include:

1. Transporting the forecast volume of goods into and out of the harbor on fewer vessels
2. Eliminating or reducing navigational restrictions and inefficiencies (*i.e.*, channel depth limitations) to enable maritime carriers to realize the transportation economies of scale without adversely impacting their shipping operations
3. Improving navigation safety by reducing congestion and/or risks of groundings or collisions
4. Protecting, restoring, and creating habitat using dredged material

3.1.3 Constraints

Constraints limit the range of measures that could be implemented to meet the study objectives. Constraints can be related to resource, legal, or policy considerations. The plan formulation process strives to efficiently meet the study objectives without violating the constraints. The study-specific constraints include:

- Compliance with maritime safety requirements (e.g. bridge air draft clearances)
- Avoid unacceptable impacts to important natural resources
- Avoid unacceptable impacts to important cultural and historical resources
- Avoid unacceptable impacts to landside infrastructure

3.2 Objectives

Planning objectives are summarized in statements that describe the desired results from solving or alleviating problems and realizing opportunities. These objectives must reflect the problems and opportunities and represent desired positive changes in comparison to the without-project conditions described in Section 2. The overall federal objective related to water and related land resources project planning is to contribute to National Economic Development (NED), consistent with protecting the Nation's environment, pursuant to national environmental statutes, applicable executive orders, and other federal planning requirements. Water resources project plans are formulated to alleviate problems and take advantage of opportunities in ways that contribute to this objective.

The need for modifications to the existing navigation system in Charleston Harbor is generated by physical constraints and the associated inefficiencies that limit the system's ability to safely and efficiently serve the forecasted vessel fleet and process the forecasted cargo volumes. The purpose of this FS is to identify and recommend a comprehensive set of navigation modifications that would reasonably maximize, consistent with protecting the Nation's environment, Charleston Harbor's contribution to net NED benefits by addressing those physical constraints and inefficiencies.

Developing specific, flexible, measurable, realistic, attainable, and acceptable objectives is critical to the success of the planning process. The study team worked with many stakeholders to develop a primary planning objective that also serves as the Purpose and Need statement for the NEPA process:

PRIMARY PLANNING OBJECTIVE/NEPA PURPOSE AND NEED STATEMENT.

To reasonably maximize Charleston Harbor's contribution to national economic development, consistent with protecting the Nation's environment, by addressing the physical constraints and inefficiencies in the existing navigation system's ability to safely and efficiently serve the forecasted vessel fleet and process the forecasted cargo volumes.

For clarity, and to assist in applying the objective, the primary planning objective is considered to include the following objective statements based on known problems and opportunities:

1. Reduce transportation costs of import and export trade through Charleston Harbor and contribute to the NED over the period of analysis
2. Reduce navigation safety-related constraints and operating practices including limited one-way traffic in some reaches
3. Develop an alternative that is environmentally acceptable and sustainable for the period of analysis

Contributions to the NED account represent the anticipated increase in the value of the national output of goods and services. In the case of navigation projects (such as Charleston Harbor), the increase in national output is in the form of reduced transportation costs (benefits). When people buy goods, the price includes the cost to have the goods transported from where they are produced to where they are sold. Where efficiencies are created, the lower cost of transporting the goods can be passed on to consumers in the form of lower prices. Efficiencies can also help promote exports. When goods made in the U.S. are transported more efficiently, they can be delivered to customers in other countries at a lower cost. This can make U.S. products more competitive and lead to greater employment in the U.S. The USACE does not attempt to predict what portion of project benefits would accrue to consumers versus shipping companies or manufacturers. Attributing benefits to specific entities would be extremely complex and speculative. Instead, the benefits are expressed in terms of transportation costs saved by all parties on all goods, whether they are imported or exported.

NED benefits are estimated by calculating the total costs to transport the forecasted cargo through the unmodified (without project) harbor system and through each alternative scenario using the HarborSym Modeling Suite of Tools. Benefits for each alternative are calculated by subtracting the total transportation costs for that alternative from the total transportation costs for the same cargo under the without-project conditions. Net benefits are then calculated by subtracting the total costs to implement each alternative from the benefits that would result from implementing that alternative. Positive net benefits (where cost savings exceed implementation costs) are considered contributions to the NED account. NED benefits are normally expressed in terms of average annual net benefits that are calculated over the 50-year period of analysis. The calculations consider the timing of the expenditures and benefits by applying a discount rate that converts the dollar value of costs and benefits received at different time periods to present value.

NED benefits include origin-to-destination benefits, meeting area benefits, and tide delay reduction benefits. Origin-to-destination benefits are primarily derived “at-sea” based on the ability to utilize different vessels or to load more cargo onto them based on differing harbor condition scenarios. For deepening alternatives, most origin-to-destination benefits result from efficiencies related to the ability to use the additional draft to deploy larger, more efficient vessels and/or to transport more cargo on the same vessels and reducing the total number of trips needed to transport a given volume of cargo. Meeting area and tide delay reduction benefits are derived near and within the harbor and result from a reduction in transit times needed to navigate the harbor. These benefits are normally smaller than the associated origin-to-destination benefits and are attributable to increased flexibility of harbor operations resulting from fewer tide delays, less concentrated traffic during high tides, and the ability of vessels to pass within the harbor (minimizing or eliminating the need for one-way traffic restrictions).

3.3 Assumptions

To facilitate analysis and screening, this FS utilized two sets of assumptions: (1) standard USACE deep draft navigation assumptions, and (2) project-specific assumptions. The assumptions related to the future without-project conditions described in the USACE Planning Guidance Notebook (ER 1105-2-100) for all deep draft navigation feasibility studies include:

A. Nonstructural measures within the authority and ability of port agencies, other public agencies, and the transportation industry to implement are assumed occur. These measures consist of reasonably expected changes in management and the use of existing vessels and facilities on land and water. Examples are lightering, tug assistance, use of favorable tides, split deliveries, topping-off, alternative modes and ports, and transshipment facilities, such as the Coast Guard's Vessel Separation Tracking System.

B. Alternative harbor and channel improvements available to the transportation industry over the planning period include those in place and under construction at the time of the study, and those authorized projects that can reasonably be expected to be in place over the planning period.

C. Authorized operation and maintenance is assumed to be performed in the harbors and channels over the period of analysis unless clear evidence is available that maintenance of the project is unjustified.

D. In projecting commodity movements involving intermodal movements, sufficient capacity of the hinterland transportation and related facilities, including port facilities, is assumed unless there are substantive data to the contrary.

E. A reasonable attempt should be made to reflect advancing technology affecting the transportation industry over the period of analysis. However, benefits from improved technology should not be credited to the navigation improvement if the technological change would occur both with and without the plan.

The following study-specific assumptions were also developed for the Charleston Harbor Post 45 FS:

A. Without a federal project, no channel deepening or widening would occur.

B. The assumption of underkeel clearance required for a vessel will be based on actual practices, not on USACE clearance standards.

C. Existing bridge clearances will not change:

   1. Ravenel Fixed Bridge: Horizontal Clearance 1000'/Vertical Clearance (air draft) 186'

2. Don Holt Bridge Fixed Bridge: Horizontal Clearance 700’/Vertical Clearance (air draft) 155’

D. The New Navy Base Terminal (under construction) will be operational before the 50-year period of analysis (2022-2071) starts.

E. The Ocean Dredged Material Disposal Site (ODMDS) will need to be expanded to meet the combined needs of the new work and 50 years of maintenance material. This will be accomplished through an EPA decision whether to change the boundary of the existing ODMDS.

F. The existing Bushy Park salinity monitoring system and associated water control actions would continue to be used to reduce impacts related to upstream salinity intrusion in the Cooper River. Additional information related to the system is provided in Appendix A.

G. The discharge from Pinopolis Dam to the Cooper River would remain relatively constant during the period of analysis due to contractual agreements between the USACE and South Carolina Public Service Authority.

3.4 Development of Management Measures

A management measure is a feature or activity that can be implemented at a specific geographic site to address one or more planning objectives. They are generally categorized as structural or nonstructural. Preliminary alternatives are formulated and refined by combining, adapting, and scaling management measures to best address the four criteria from the Principles and Guidelines:

- **Completeness.** Extent to which the alternative provides and accounts for all necessary investments or actions to ensure realization of the planning objectives
- **Effectiveness.** Extent to which the alternative contributes to achieving the planning objectives
- **Efficiency.** Extent to which the plan is the most cost-effective means of addressing the specified problems and realizing the specified opportunities, consistent with protecting the nation’s environment
- **Acceptability.** The extent to which the alternative plans are acceptable in terms of applicable laws, regulations and public policies

In accordance with 40 CFR 1502.14, the USACE will “rigorously explore and objectively evaluate all reasonable alternatives, and for alternatives eliminated from detailed study, briefly discuss the reasons for their having been eliminated.” For this Final IFR/EIS, a reasonable alternative is defined as an alternative that meets the objectives of the FS and is under USACE jurisdiction to implement. A measure that could be implemented by others can be considered as long as it meets the objectives on its own or it can be a component of an alternative that meets the objectives in a way that is complete, effective, efficient, and acceptable.

3.4.1 Structural Measures

After iterative discussions with stakeholders, the Project Delivery Team (PDT) developed widening and deepening measures to address the navigation problems. As previously discussed, navigation problems at Charleston Harbor are primarily related to: (1) insufficient federal channel depths, (2) difficult currents and winds, and (3) restrictive channel widths and turning basins. The following basic ***structural measures*** were initially identified to meet the objectives/purpose and need of providing transportation cost savings in Charleston Harbor: deepening channels, widening channels, and enlarging turning basins. The refinement of these measures to meet the needs of specific reaches and terminals are described in subsequent paragraphs.

3.4.1.1 Deepening Channels

Large vessels (with combined draft and underkeel clearances exceeding 45 feet) currently experience depth-related delays. Unless action is taken, these delays would increase over time. Deepening the channels would allow larger and deeper draft vessels to utilize the harbor more efficiently and safely. This measure was carried forward for detailed analysis based on potentially large transportation costs savings related to use of the harbor by the existing and forecasted vessel fleets.

3.4.1.2 Widening Channels

Vessel simulation analysis is normally performed during the feasibility phase of a study to refine the width components of proposed navigation features to ensure that safety and efficiency is maintained and adverse impacts are minimized. However, for this study, vessel simulation was deferred to the Preconstruction Engineering and Design (PED) phase to save time and money during the feasibility phase. To complete the study, a set of “maximum” widening measures was developed based on experience and professional judgment. The widening measures shown in Figure 3-5 and the Section 4 Reference Aid (at the end of Section 4) are considered to be the maximum needed to meet the project’s safety and efficiency objectives.

The “maximum” widening measures shown in Figure 3-5 were used to develop all cost estimates, modeling, and impact analyses for the study. The measures will be re-evaluated and, if possible, reduced based on the results of vessel simulations performed during the PED phase. The decision to assume “maximum” widening measures results in conservative cost and impact estimates that would be reduced if they are reduced during the PED phase.

The 50-foot widening measures for the North Charleston and Filbin Creek reaches represent the harbor pilots’ estimate of the additional width needed for the design vessel to traverse those reaches, one-way, and avoiding unacceptable bank suction impacts on docked vessels at the petroleum terminals as discussed in paragraph 3.1.1.2.4. Engineering Design Guidance found in Engineering Appendix-A, paragraph 2.1.2 Desktop Simulation, points 6 and 7, confirms the need for the additional width.

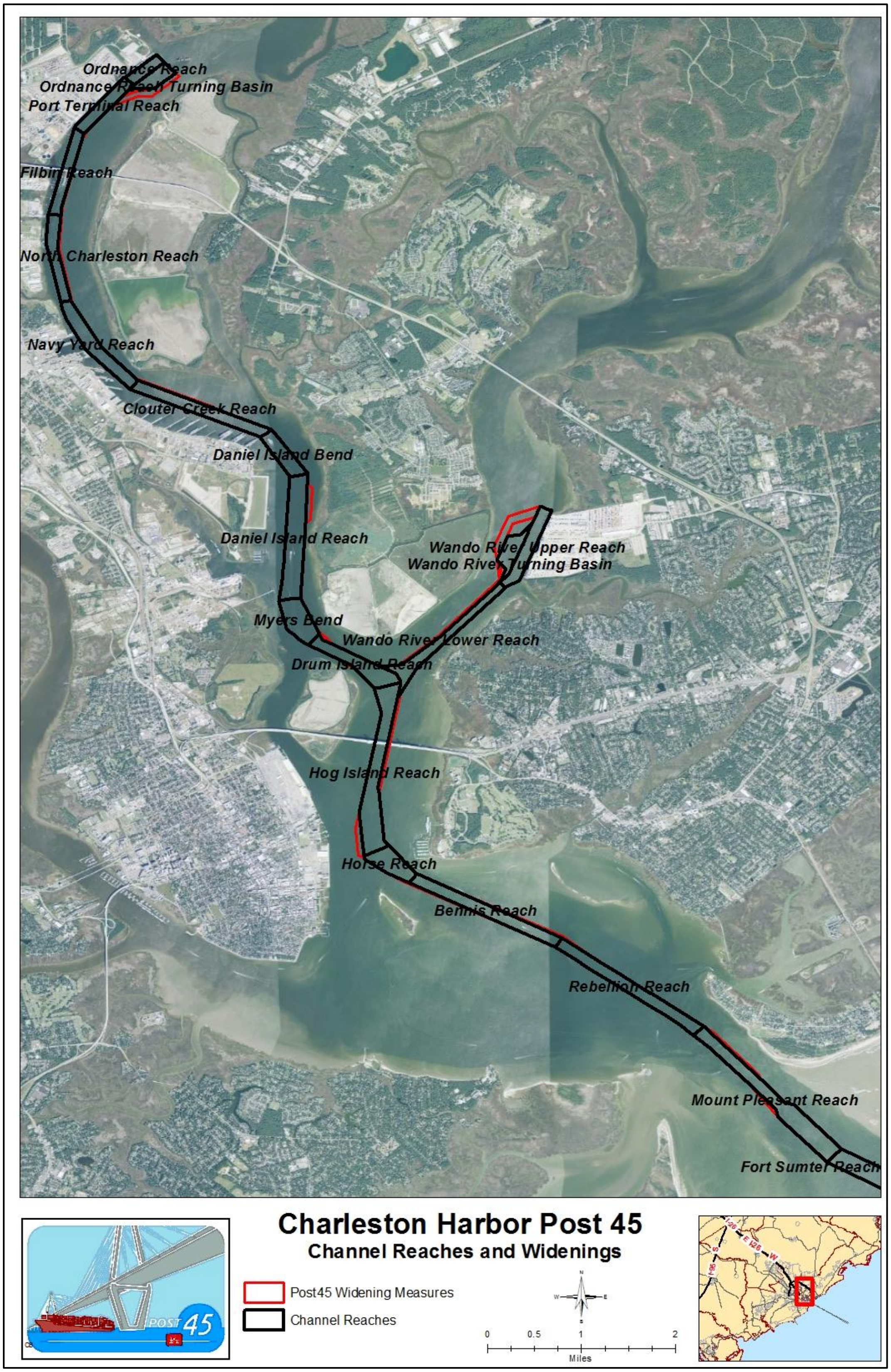


Figure 3-5. "Maximum" widening measures and project segments

3.4.1.3 Enlarging Turning Basins

Enlargement of turning basins is related to channel depths and widths. Similar to the channel widening measures, the "maximum" measures shown in Figure 3-5 are considered to be the maximum needed to meet the project's safety and efficiency objectives. These "maximum" measures were used to develop all cost estimates, modeling, and impact analyses for the study. The measures will be re-evaluated and minimized, if possible, based on the results of vessel simulations performed during PED.

3.4.2 Nonstructural Measures

The following nonstructural management measures were identified to improve navigation in Charleston Harbor: adding additional tugs, additional trucking, offshore port, light-loading of vessels to accommodate larger vessels under existing conditions, use of tides to transit large vessels under existing conditions, lightering, and designating and marking areas adjacent to the channel with natural depths that equal or exceed channel depths as widening measures (to accommodate vessel passing and two-way traffic without additional dredging).

3.4.2.1 Additional Tugs

The use of additional tugs was considered in place of widening in the Mt. Pleasant and Bennis reaches and in the southern segment of the Hog Island Reach where harbor pilots indicated widening would help alleviate difficult crosscurrents and winds. However, adding tugs to assist vessels in the Mt. Pleasant and Bennis reaches cannot be applied because the tugs in the current fleet are not able to operate at the speeds container vessels transit those reaches. The harbor and docking pilots indicated that tugs would not be able to assist container vessels until they reduce speeds as they approach terminals. Slowing the speeds of the container vessels in the lower harbor reduces maneuverability and operational efficiency. This measure was eliminated from further consideration during the feasibility phase based on efficiency and safety considerations associated with the existing tug fleet. However, additional discussions with the harbor and docking pilots indicated larger more powerful escort tractor tugs, not in the existing fleet, might provide some assistance with larger vessels making the transition from the Hog Island Reach after passing under the Ravenel Bridge on their way to the Wando Welch Terminal. Vessel simulation, to be performed during the PED phase, will allow harbor pilots to determine whether additional or more powerful tractor-escort tugs would prove effective.

3.4.2.2 Additional Trucking

Use of additional trucks to carry containers to provide the same amount of commodities throughout the hinterland served by Charleston Harbor would significantly increase truck traffic and congestion along the highway system, as well as adversely impact air quality. Waterborne transportation continues to provide the most efficient and economical means of transporting goods from one location to another. Information related to transportation costs by various methods is provided in Appendix C. This measure was eliminated from consideration based on a lack of economic efficiency and effectiveness, and the wide range of adverse safety, social, and environmental impacts that generally result from moving cargo over highways instead of over waterways.

3.4.2.3 Offshore Port

An offshore port, if an environmentally acceptable location could be found and it could be built to withstand the wind and weather conditions, would likely decrease the number of container vessels entering Charleston Harbor. But, it would increase the total number of vessels transiting the harbor. The containers would be unloaded at the offshore port, temporarily stored, and then transferred to smaller vessels or barges for transportation to other marine terminals prior to being transferred again and then transported to their final destinations. While the existing harbor infrastructure may not need to be changed, it would still be needed, and additional land-based infrastructure would be needed to support a less efficient system. For these reasons, an offshore port generally increases transportation costs and would likely require additional vessels or barges to carry the same number of containers. Such facilities are expensive to construct and maintain, and the existing harbor infrastructure would still be required. This measure was eliminated from consideration based on lack of economic effectiveness and efficiency.

3.4.2.4 Light-Loading of Vessels

This measure would limit the cargo-carrying capacity of vessels that could enter the port. Larger vessels would still enter the port but could not be loaded to their design draft. This would increase transportation costs due to the additional transits required to bring in the same amount of material as a fully loaded large container vessel, as well as the congestion and delays caused by the additional transits. Large container vessels are difficult to bring into the port under current conditions. It would take additional time to turn and transit these vessels. This measure is already being implemented by the shipping industry as needed. It would become an increasingly important factor in the future. This measure is considered and addressed within the models used to forecast future harbor utilization under various scenarios. See Appendix C for additional information.

3.4.2.5 Use of Tides

The tide range is about 5 to 6 feet in the lower harbor. Deeper drafting vessels can benefit from the extra depth afforded during high tides and sometimes wait or decrease their speed as they approach Charleston Harbor to allow time for an increase in available water depth. Deeper channels eliminate or lessen those tidal delays and reduce transportation costs. This measure is considered within the models used to forecast future utilization of the harbor under various scenarios. See Appendix C for additional information related to tide delays.

3.4.2.6 Lightering

Lightering involves the process of transferring cargo between vessels of different sizes, usually between barges and bulk carriers or oil tankers. Lightering reduces a vessel's draft enough to enable it to enter a port that cannot accommodate large vessels. Hong Kong Harbor uses lightering of containers to transfer containers from small container vessels to barges for transport to river ports that cannot accommodate the container vessels; the need does not exist in most U.S. and European deep draft ports (Alan Haig-Brown, July 2006). The double handling of containers would increase transportation costs and decrease safety. This measure was eliminated from consideration based on the combination of safety considerations and a lack of economic effectiveness and efficiency.

3.4.2.7 Use Existing Deep Water to Widen Channels

This is a nonstructural measure that would relocate navigation buoys to widen the channel into areas with natural depths greater than 46 feet along the existing Mt. Pleasant Reach. This would not require any dredging for the existing 45-foot project depth and potentially little or no dredging for proposed deeper authorized depths where naturally deep water exists.

The areas considered are illustrated in Figures 3-5 and 3-6. One area of existing deep water extends along the north side of the Mt. Pleasant Reach from west of the obstruction-to-navigation to the intersection of the Mt. Pleasant Reach with Rebellion Reach. Another area of existing deep water extends from the transition at Mt. Pleasant Reach from a 1,000-foot to a 600-foot width along the southern boundary of the federal channel. This measure was carried forward for consideration.

3.4.3 Development of Planning Segments

To simplify the development and presentation of measures and alternatives, the existing federal channels were divided into five planning segments based on which terminals are served, and physical factors and wave and current conditions that affect underkeel clearance requirements and vessel maneuverability. These segments are described below and illustrated in Figure 3-6.

Segment 1. Entrance Channel to Wando Turning Basin/Wando Welch Terminal

Segment 2. Drum Island to Daniel Island Reach/ New SCSPA Terminal

Segment 3. Daniel Island Bend to Ordnance Reach/N. Charleston Terminal

Segment 4. Custom House to Town Creek Lower Reach/Columbus Terminal

Segment 5. Anchorage Basin

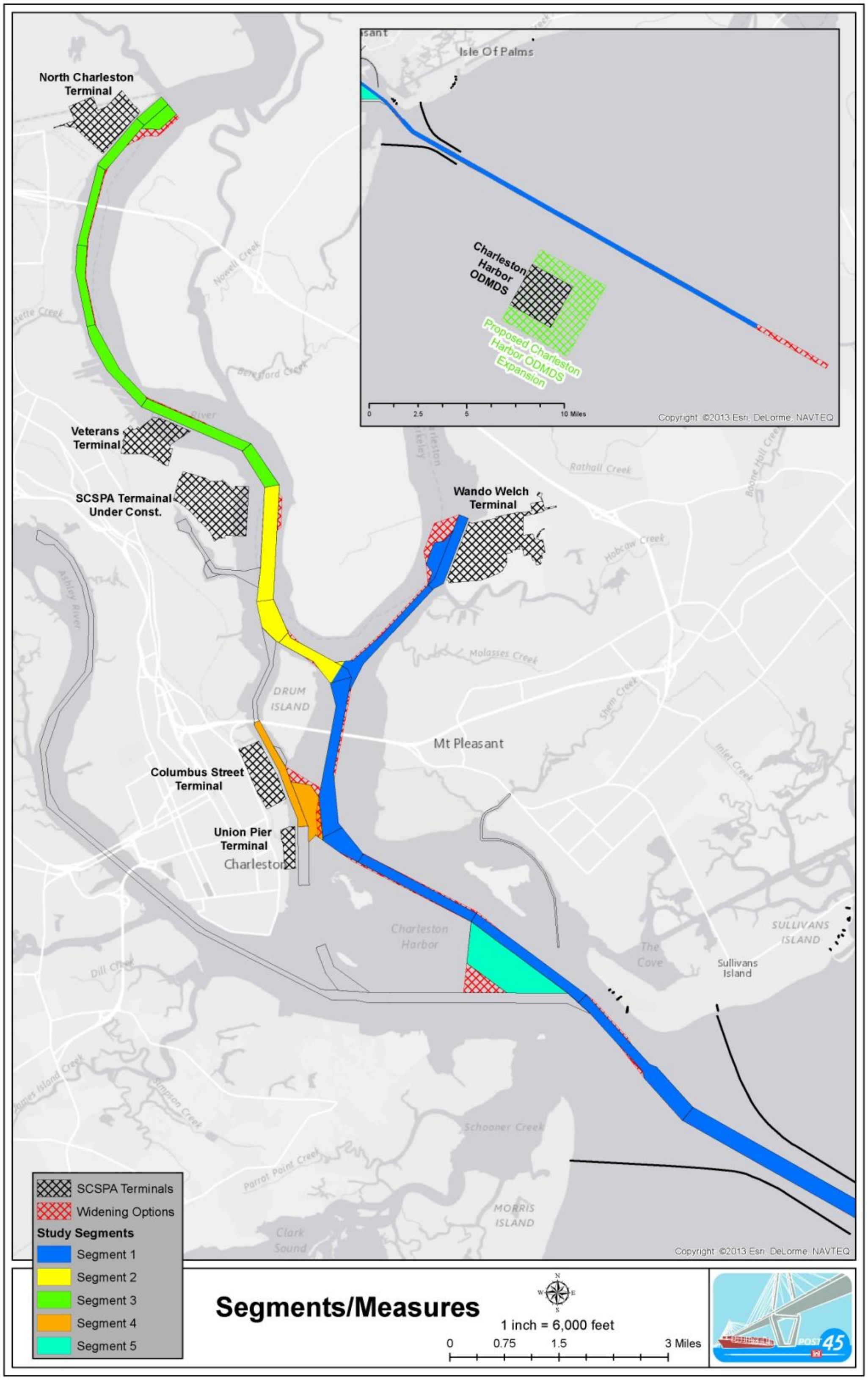


Figure 3-6. Project segments/measures

3.4.4 Screening of Measures

As outlined above, a wide variety of measures were considered. Each measure was assessed and a preliminary determination made whether it should be retained for consideration and formulation of alternatives. The measures retained for and those eliminated from further consideration and the rationales for doing so are summarized in Table 3-1.

As part of the measures screening process, dredged material disposal options included an evaluation of different locations for placement of dredged material, including potential beneficial use of dredged material sites. Table 3-5 and Sections 3.6.3.1 Environmental Minimization and Avoidance Measures include discussions related to alternative disposal sites and beneficial use of dredged material. Section 4.2.1 Material Placement Options, 4.2.6 Beneficial Use of Dredged Material, 4.2.6.1 ODMDS Berm Creation, 4.2.6.2 Hardbottom Habitat Creation, and 4.2.6.7 Beneficial Use Analyses provide more detail on dredged material placement options. Table 4-1 Cost Comparison for Least Cost Disposal also evaluates dredged material placement options based on normal disposal at the ODMDS and alternative sites for placement of rock material dredged from the Entrance Channel.

Table 3-1. Screening of Measures

Measure	Description	Technical Constraints	Policy/Legal Constraints	Acceptability	Efficiency	Effectiveness	Completeness	Other	Retain?	Reason for screening out
Structural										
S-1	***Deepening channels***									
S-1a	Evaluate project depths of 47, 48, 49, 50, 51, and 52 feet for Mt. Pleasant to Wando River Upper Reach with an additional two feet of depth for the Entrance Channel (Segment 1)	Ensuring disposal capacity. Availability of dredges. Air draft of bridges. Compliance with laws and regulations. etc	None	Acceptable	Long history of efficient operation and maintenance of the navigation channel(s) as progressively deeper depths	Would be effective in reducing transportation delays due to larger ships.	Complete	Meets the primary planning objective, objective 1 and the NEPA purpose and need	Yes	
S-1b	Evaluate project depths of 47, 48, 49, 50, 51, and 52 feet for Drum Island to Daniel Island Reach (Segment 2)	Ensuring disposal capacity. Availability of dredges. Air draft of bridges. Compliance with laws and regulations. etc	None	Acceptable	Long history of efficient operation and maintenance of the navigation channel(s) as progressively deeper depths	Would be effective in reducing transportation delays due to larger ships.	Not complete without implementation of Segment 1 to an equal or deeper depth	Meets the primary planning objective, objective 1 and the NEPA purpose and need	Yes	
S-1c	Evaluate project depths of 47 and 48 feet for Daniel Island Bend to Ordnance Reach or North Charleston Terminal (Segment 3)	Ensuring disposal capacity. Availability of dredges. Air draft of bridges. Compliance with laws and regulations. etc	None	Acceptable	Long history of efficient operation and maintenance of the navigation channel(s) as progressively deeper depths	Would be effective in reducing transportation delays due to larger ships.	Not complete without segments 1 and 2 to an equal or deeper depth	Meets the primary planning objective, objective 1 and the NEPA purpose and need	Yes	
S-1d	Evaluate the benefit of deepening Commercial Anchorage Area A (Segment 5)	Ensuring disposal capacity. Availability of dredges. Air draft of bridges. Compliance with laws and regulations. etc	None	Acceptable	Isn't an efficient use of money due to large volume of material to be removed and high cost for relatively small benefit and cost savings	Would not reduce transportation delays, but would provide opportunity for safe harboring.	Not complete	Partially meets objective 1. to allow vessels a place to safely anchor in case of weather event, mechanical difficulties or security issues	No	Costs of deepening the anchorage area precludes this action from being within the federal interest at this time. Doesn't meet the 4 criteria.
S-2	***Widening channels***									
S-2a	Extend Entrance Channel to the bathymetric contour coinciding with the selected Entrance Channel depth (2' greater than inner harbor depth)	Costs, Availability of dredges and dredged material disposal capacity. Air draft of bridges. Compliance with laws and regulations, Hardbottom habitat impacts.	None	Acceptable.	Efficient if necessary to meet objectives of project. Efficiency of the widening measure will be optimized during ship simulation in the Preconstruction Engineering and Design phase of the project.	Effective: extension of the Entrance Channel (sea buoy) will be required in order to ensure safe transiting of the channel. Harbor Pilots indicate that the measure will enable safe navigation of this reach of the harbor.	Complete w/associated deepening		Yes	

Table 3-1. Screening of Measures (Cont'd)

Measure	Description	Technical Constraints	Policy/Legal Constraints	Acceptability	Efficiency	Effectiveness	Completeness	Other	Retain?	Reason for screening out
S-2b	Widen Bennis Reach 100 feet along the south side of the reach	Costs, Availability of dredges and dredged material disposal capacity, Air draft of bridges. Compliance with laws and regulations. Don't increase erosion from wake action and/or displacement on valuable resources (Crab Bank, etc.)	None	Acceptable	Efficient if necessary to meet objectives of project. Efficiency of the widening measure will be optimized during ship simulation in the Preconstruction Engineering and Design phase of the project.	Effective: Harbor Pilots indicate that the measure will enable safe navigation of this reach of the harbor.	Complete-w/associated deepening	Time/cost increases resulting from lack of passing lanes will be exasperated with the appearance of Post-Panamax Ships. to allow an improvement from existing one way vessel traffic to two-way traffic	Yes	
S-2c	Widen Horse Reach 100 feet along the north side of the reach	Costs, Availability of dredges and dredged material disposal capacity. Air draft of bridges. Compliance with laws and regulations. Don't increase erosion from wake action and/or displacement on valuable resources (Crab Bank, etc.)	None	Acceptable	Efficient if necessary to meet objectives of project. Efficiency of the widening measure will be optimized during ship simulation in the Preconstruction Engineering and Design phase of the project.	Effective: Harbor Pilots indicate that the measure will enable safe navigation of this reach of the harbor.	Complete w/associated deepening		Yes	
S-2d	Extend the west side of the Hog Island Reach along the existing heading to intersect with Custom House Reach and evaluate a 275-foot widening measure parallel to the outbound side of Hog Island reach	Costs, Availability of dredges and dredged material disposal capacity. Air draft of bridges. Compliance with laws and regulations. Don't increase erosion from wake action and/or displacement on valuable resources (Shutes Folly Island, etc.)	None	Acceptable.	Efficient if necessary to meet objectives of project. Efficiency of the widening measure will be optimized during ship simulation in the Preconstruction Engineering and Design phase of the project.	Effective: Harbor Pilots indicate that the measure will enable safe navigation of this reach of the harbor by allowing for them to position for the turn to Hog Island Reach on the inbound and Horse Reach on the outbound.	Complete-w/associated deepening	The currents at the junction of the Wando and Cooper Rivers make for difficult piloting during ebb tide.	Yes	
S-2e	Widen Hog Island Reach 100 feet along the east side of the reach to two-way traffic	Don't compromise integrity of Ravenel Bridge footings, ensuring disposal capacity. Availability of dredges. Air draft of bridges. Compliance with laws and regulations. Don't degrade valuable resources (fish spawning hotspot at Ravenel Bridge)	None	Acceptable	Efficient if necessary to meet objectives of project. Efficiency of the widening measure will be optimized during ship simulation in the Preconstruction Engineering and Design phase of the project.	Effective: Harbor Pilots indicate that the measure will enable safe vessel passing	Complete w/associated deepening	to allow an improvement from existing one-way vessel traffic. to accommodate two-way traffic along the entire length of the	Yes	
S-2f	Widen Wando River Lower Reach 100 feet along the west side of the reach	Costs, Availability of dredges and dredged material disposal capacity, Air draft of bridges. Compliance with laws and regulations	None	Acceptable	Efficient if necessary to meet objectives of project. Efficiency of the widening measure will be optimized during ship simulation in the Preconstruction Engineering and Design phase of the project.	Effective: Harbor Pilots indicate that the measure will enable safe transit of this reach. The measure will increase visibility of the channel markers from the bridge of the ship	Complete-w/associated deepening	to improve safety of transits for existing and future container ship traffic. to minimize the necessity of ships having to crab during specific weather conditions (even with tug assistance), effectively increasing beam width.	Yes	

Table 3-1. Screening of Measures (Cont'd)

Measure	Description	Technical Constraints	Policy/Legal Constraints	Acceptability	Efficiency	Effectiveness	Completeness	Other	Retain?	Reason for screening out
S-2g	Widen Drum Island Reach and Myers Bend by a maximum width of 200 feet on the inbound side and by 100 feet on the outbound side of the reach	Costs, Availability of dredges and dredged material disposal capacity. Air draft of bridges. Compliance with laws and regulations. etc	None	Acceptable	Efficient if necessary to meet objectives of project. Efficiency of the widening measure will be optimized during ship simulation in the Preconstruction Engineering and Design phase of the project.	Effective: Harbor Pilots indicate that the measure will enable safe transit of this reach by reducing hazards associated with difficult ebb tidal currents at the confluence of the Cooper and Wando Rivers.	Complete w/associated deepening		Yes	
S-2h	Widen Clouter Creek Reach by 50 feet along the north side of the reach	Costs, Availability of dredges and dredged material disposal capacity. Air draft of bridges. Compliance with laws and regulations. etc	None	Acceptable.	Efficient if necessary to meet objectives of project. Efficiency of the widening measure will be optimized during ship simulation in the Preconstruction Engineering and Design phase of the project.	Effective: Harbor Pilots indicate that the measure will enable safe passing of smaller ships in this reach.	Complete- w/associated deepening	Pilots indicate smaller ships may have room to pass with the proposed 50-foot widening measure in the Clouter Creek Range.	Yes	
S-2i	Widen North Charleston Reach and Filbin Creek Reach 50' on the East side	Ensure larger ships don't increase existing bank suction effects on vessels. ensuring disposal capacity. Availability of dredges. Air draft of bridges. Compliance with laws and regulations. etc	None	Acceptable	Efficient if necessary to meet objectives of project. Efficiency of the widening measure will be optimized during ship simulation in the Preconstruction Engineering and Design phase of the project.	Effective: Harbor Pilots indicate that the measure will enable safe transiting of this area	Complete w/associated deepening	to reduce the bank suction effect on docked vessels. bank suction effects on docked ships at petroleum terminals in those reaches or shift the channel to avoid those impacts	Yes	
S-2j	Widen the intersection of the Filbin and Port Terminal Reaches by 100 feet on the east side of the channel	Costs, Availability of dredges and dredged material disposal capacity. Air draft of bridges. Compliance with laws and regulations	None	Acceptable	Efficient if necessary to meet objectives of project. Efficiency of the widening measure will be optimized during ship simulation in the Preconstruction Engineering and Design phase of the project.	Effective: Harbor Pilots indicate that the measure will enable safe transiting of this area	Complete- w/associated deepening		Yes	
S-2k	Widen Custom House Reach to the north	Costs, Availability of dredges dredged material disposal capacity. Compliance with laws and regulations	None	Acceptable	Not efficient because there are no draft restrictions and vessel turning is not an immediate concern	Not effective	Not complete, nor would it contribute to a complete alternative	for improved container ship access to Columbus Street Terminal	No	Costs exceed benefits due to lack of need by existing/forecasted users
S-2l	Evaluate the benefit of widening Commercial Anchorage Area A	Costs, Availability of dredges and dredged material disposal capacity, Compliance with laws and regulations	None	Acceptable	Isn't an efficient use of money due to large volume of material to be removed and high cost for little additional benefit and cost savings	Would not reduce transportation delays, but would provide opportunity for safe anchoring.	Not complete, nor would it contribute to a complete alternative	Partially meets objective 1. to allow vessels a place to safely anchor in case of weather event, mechanical difficulties or security issues	No	Costs of deepening the anchorage area precludes this action from being within the federal interest at this time. Doesn't meet the 4 criteria.

Table 3-1. Screening of Measures (Cont'd)

Measure	Description	Technical Constraints	Policy/Legal Constraints	Acceptability	Efficiency	Effectiveness	Completeness	Other	Retain?	Reason for screening out
S-3	Expand turning basins									
S-3a	Expand the existing Wando Turning Basin by increasing turning diameter to 1800 feet	Costs, Availability of dredges and dredged material disposal capacity. Air draft of bridges. Compliance with laws and regulations	None	Acceptable	Efficient if necessary to meet objectives of project. Efficiency of the widening measure will be optimized during ship simulation in the Preconstruction Engineering and Design phase of the project.	Effective: Harbor Pilots indicate that the measure will enable safe maneuvering in this area	Complete w/associated deepening	To accommodate new post panamax container ships	Yes	
S-3b	Expand the Turning Basin at Daniel Island Reach by creating turning diameter of 1800 feet.	Costs, Availability of dredges and dredged material disposal capacity. Air draft of bridges. Compliance with laws and regulations	None	Acceptable	Efficient if necessary to meet objectives of project. Efficiency of the widening measure will be optimized during ship simulation in the Preconstruction Engineering and Design phase of the project.	Effective: Harbor Pilots indicate that the measure will enable safe maneuvering in this area	Complete- w/associated deepening	To accommodate new Post-Panamax container ships	Yes	
S-3c	Expand turning basin at Ordnance Reach by enlarging turning diameter to 1650 feet.	Costs, Availability of dredges and dredged material disposal capacity. Air draft of bridges. Compliance with laws and regulations	None	Acceptable	Efficient if necessary to meet objectives of project. Efficiency of the widening measure will be optimized during ship simulation in the Preconstruction Engineering and Design phase of the project.	Effective: Harbor Pilots indicate that the measure will enable safe maneuvering in this area	Complete w/associated deepening	To accommodate new Post-Panamax container ships	Yes	
S-3d	Expand Custom House Reach to the east to allow an 1800' diameter turning basin	Costs, Availability of dredges and dredged material disposal capacity, Compliance with laws and regulations	None	Acceptable	Efficient if necessary to meet objectives of project. Efficiency of the widening measure will be optimized during ship simulation in the Preconstruction Engineering and Design phase of the project.	Not Effective: Measure is not needed to enable safe maneuvering in this area by existing or forecasted vessels	Complete- w/associated deepening	Time/cost increases will be exacerbated with the appearance of larger Post-Panamax Ships. Current turning basin will not accommodate larger Post-Panamax ships.	No	Not needed by existing or forecasted vessels
Non-Structural										
N-1	Additional tugs	USACE does not have the authority to require the use of more tugs	None	Acceptable	Would be cost efficient as it could decrease the need to deepen and widen as much	The current fleet of tugs would not be effective due to speeds containerships carry through most of the reaches and lowering speeds would decrease efficiency.	Incomplete: without deepening and widening alt		No	Additional tugs are part of the existing and future without condition. Options will be considered with ship simulation. The port and pilots indicate that tugs are used and will be used for safe navigation. Also, outside of USACE jurisdiction

Table 3-1. Screening of Measures (Cont'd)

Measure	Description	Technical Constraints	Policy/Legal Constraints	Acceptability	Efficiency	Effectiveness	Completeness	Other	Retain?	Reason for screening out
N-3	Offshore port	Costs, Environmental conflicts, Limited opportunity to reduce inefficiencies	None	Acceptable	Not efficient due to double handling requirements	Off-Loading vessels is not reliable due to weather and wind conditions offshore.	Incomplete: Significant additional infrastructure required	May not be feasible to construct, expensive to operate and maintain, risks from storms, new and significant environmental impacts	No	Inefficient, incomplete and outside USACE jurisdiction
N-4	Light loading of vessels	None	None	Acceptable	Not efficient	Carrying less cargo per transit equates to increased transportation costs due to increased transit for delivery of the goods.	Incomplete:	This is the source of a portion of the potential cost savings.	No	Ineffective, outside USACE jurisdiction
N-5	use of tide to transit larger vessels	Practical time limits to transit the harbor	None	Acceptable	Not efficient	Delays cause increased transportation costs	Incomplete:	Lowers overall safety	No	Inefficient/source of portion of modeled benefits for other measures
N-6	Lightering	None	None	Acceptable	Not efficient	Not effective because it doesn't address the problem of transportation cost savings.	Incomplete:	Lowers overall safety	No	Inefficient/double handling of cargo
N-7	Designate deep water areas for widening measures	Size, location and depth of natural conditions	None	Acceptable	Efficient if necessary to meet objectives of project. Efficiency of the widening measure will be optimized during ship simulation in the Preconstruction Engineering and Design phase of the project.	Effective	Incomplete:	cost efficient	Yes	
N-7a	Widen Mt. Pleasant Reach into existing deep water	Size, location and depth of natural conditions	None	Acceptable	Efficient if necessary to meet objectives of project. Efficiency of the widening measure will be optimized during ship simulation in the Preconstruction Engineering and Design phase of the project.	Effective	Incomplete	cost efficient	Yes	
N-8	No action	None	None	Acceptable	Not Efficient	Not Effective	N/A	The port indicated that with current and future growth, this plan would hinder opportunities for port development. Carried forward to compare alternative plans.	Yes	

3.4.4.2 Screening of Planning Reaches

Two of the five segments, Segments 4 and 5, initially considered for modification were eliminated early in the planning process. Segment 4, which would have modified the channel to the Columbus and Union Pier Terminals, and Segment 5, which would have modified the Anchorage Basin, were eliminated based on a lack of need for modifications. The vessels that utilize those terminals are primarily cruise vessels, Roll-on/Roll-off vessels, and other vessels that do not have draft requirements that exceed the existing authorized depths. In a letter dated July 13, 2012, the SCSPA indicated that no business plans exist that would require those segments to be deepened.

3.4.5 Measures Carried Forward

Working with the SCSPA, shipping industry experts, harbor pilots, and other stakeholders, the following structural and nonstructural measures were carried forward to develop alternatives within Segments 1, 2, and 3.

- Nonstructural wideners (use of existing deep water)
- Deepening
- Widening
- Enlarging turning basins

Figures 3-6-1 through 3-6-6 provide details related to the navigation problems, safety considerations, and delays in support of each area identified for channel widening and turning basin expansion.

Initially, the deepening measures included incremental depths of, 47, 48, 49, 50, 51, and 52 feet MLLW within the harbor, with the Entrance Channel being 2 feet deeper. When these measures were combined to assemble alternatives, the large number of possible combinations resulted in a very large number (294) of possible alternatives, which includes 98 deepening only plus 196 widening and turning basin expansion options. The Table Top (desktop exercise) involving ERDC ship simulation representatives and the Charleston Harbor and Docking Pilots helped reduce the 294 alternatives to a proposed ship simulation test matrix (scheduled for the Preconstruction, Engineering, and Design [PED] phase of the study) consisting of 128 ship simulation runs (84 runs involving no channel widening, 50-foot, and 100-foot widening increments plus 44 runs including 1350-foot, 1450-foot, 1650-foot, and 1800-foot turning basin diameters). With the exception of the Entrance Channel and Drum Island Reach, the widening alternatives were developed to examine incremental 50-foot widening measures. For example, if simulator-run Alternate 1 was deepening with no widening, simulator-run Alternate 2 would be 50 ft widening, and simulator-run Alternate 3 would be 100 ft widening. Preliminary cost and benefit analysis using the Transportation Cost Savings Model reduced the number of alternatives to 54 and then to 44. A decision to analyze alternative depths at 2-foot increments instead of 1-foot increments further decreased the number of alternatives.

INNER HARBOR
MT. PLEASANT REACH

EXISTING PROJECT DEPTH: 45 feet

EXISTING PROJECT WIDTH: 600-1000 feet

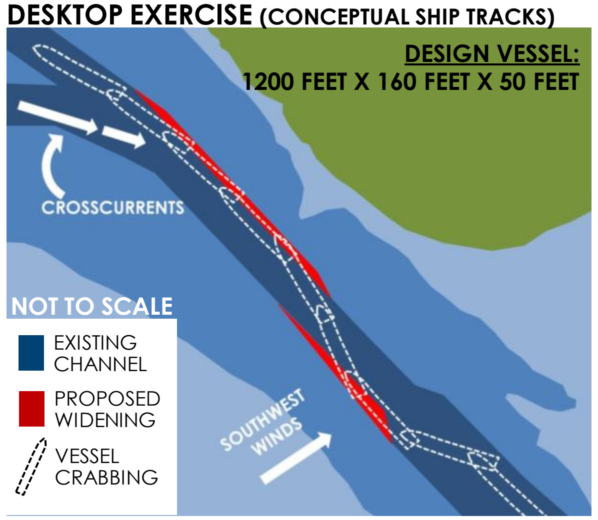
PROPOSED WIDTH: Widen reach into existing deep water (non-structural measure) – the outbound (southern) side by 200 feet & the inbound (northern) side by 100 feet

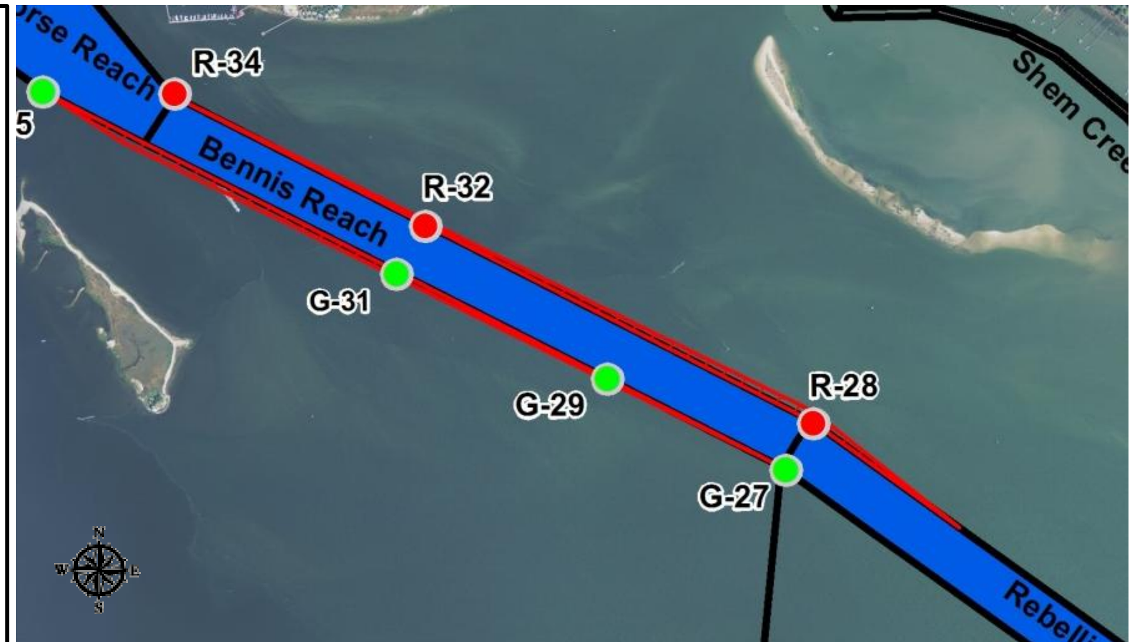
ISSUE(S):

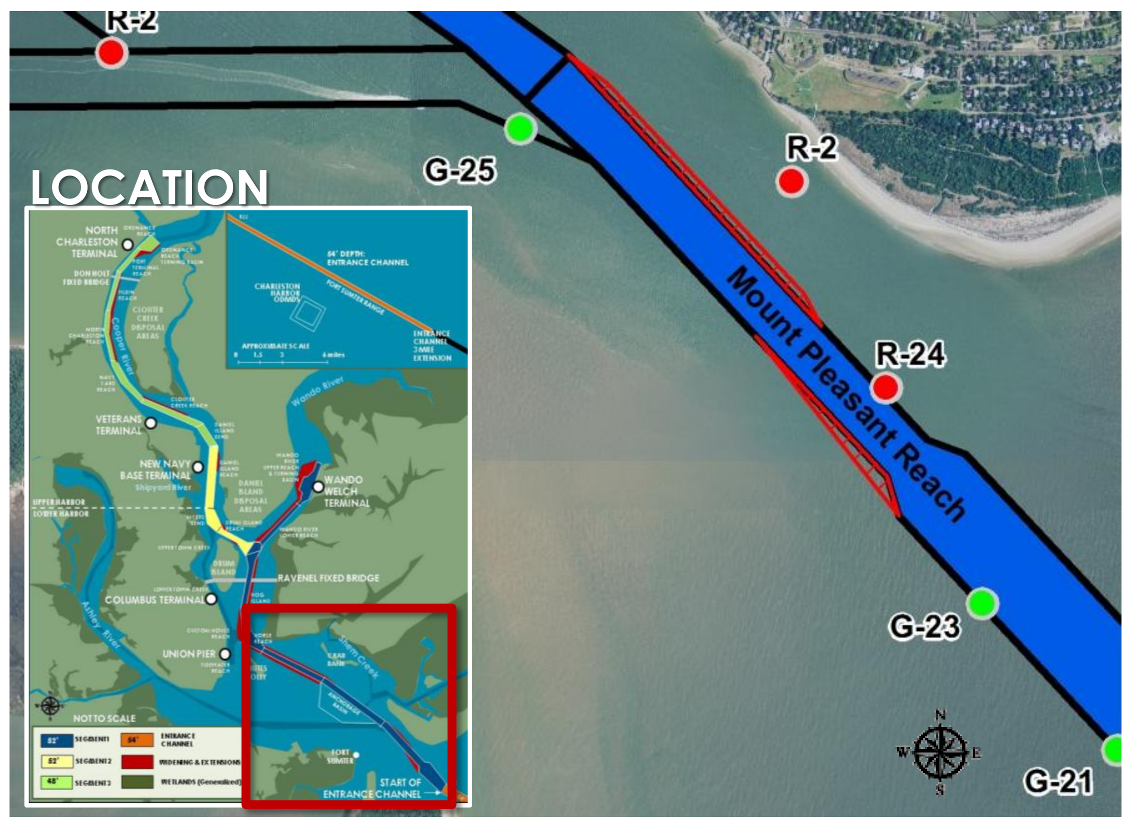
1) Tides & winds require pilots to crab inbound vessels into the wind or crosscurrents to avoid leaving the channel or colliding with outbound vessels.
2) Vision is restricted at the intersection of the Intracoastal Waterway, which is also subject to unpredictable crosscurrents.
3) U.S. Coast Guard letter dated April 1, 2013 provides for relocation of buoys and aids to navigation.

FOR ADDITIONAL INFORMATION: Refer to U.S. Coast Guard Pilot 4, 46th Edition, 2014, pages 238-239.

DESKTOP EXERCISE (CONCEPTUAL SHIP TRACKS)







INNER HARBOR
BENNIS REACH

EXISTING PROJECT DEPTH: 45 feet

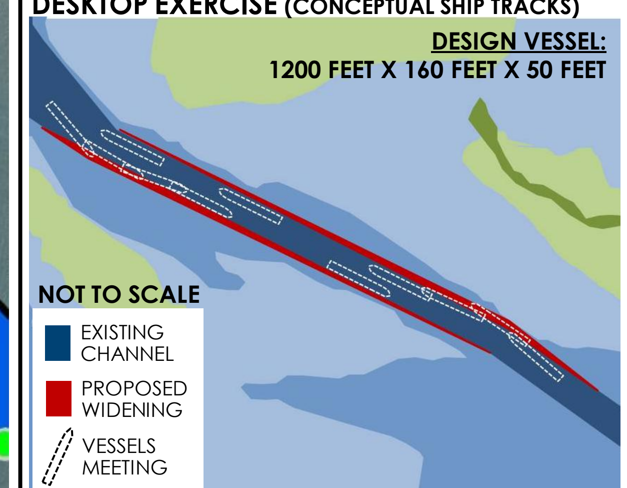
EXISTING PROJECT WIDTH: 600 feet

PROPOSED WIDTH: Widen the reach into existing deep water (non-structural measure) a maximum of 100 feet along its inbound (north) side between buoys R28 and R34, & a maximum of 100 feet along the outbound (south) side from buoys G27 to G35

ISSUE(S):

1) The existing vessel fleet is often limited to one-way traffic & the future vessel fleet will be limited to one-way traffic.
2) Under certain conditions, vessels must leave the channel & make use of existing deep water along the south side of Bennis Reach near Horse Reach & the north side of Bennis Reach near Rebellion Reach.
3) With increased vessel traffic, the timing of meeting & passing in these areas becomes more difficult.
4) Guidance for two-way traffic: 5.5 times the vessel beam for <1.5 knots; 6.5 times the vessel beam >1.5 knots (design vessel beam = 160 feet, resulting in a width requirement of 880 to 1400 feet depending on currents). Engineering Appendix A, paragraph 2.1.2.

DESKTOP EXERCISE (CONCEPTUAL SHIP TRACKS)



CHARLESTON HARBOR POST-45 WIDENING & TURNING BASIN EXPANSION MEASURES

Figure 3-6-1

INNER HARBOR
CUSTOM HOUSE REACH

EXISTING PROJECT DEPTH: 45 feet

EXISTING PROJECT WIDTH: varies

PROPOSED WIDTH: Extend the outbound (west) side of the reach a maximum of 275 feet between buoys G37 & G35

ISSUE(S):

1) Harbor Pilots indicate existing fleet vessels must leave the federal channel to make the difficult turn through Horse & Hogs Island reaches.

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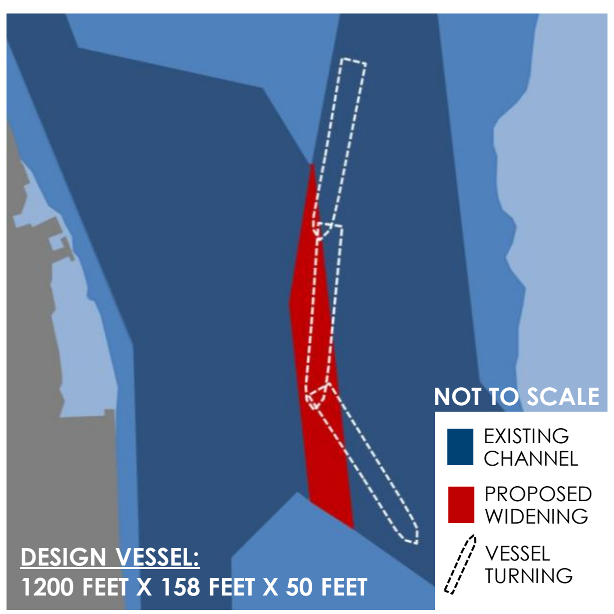
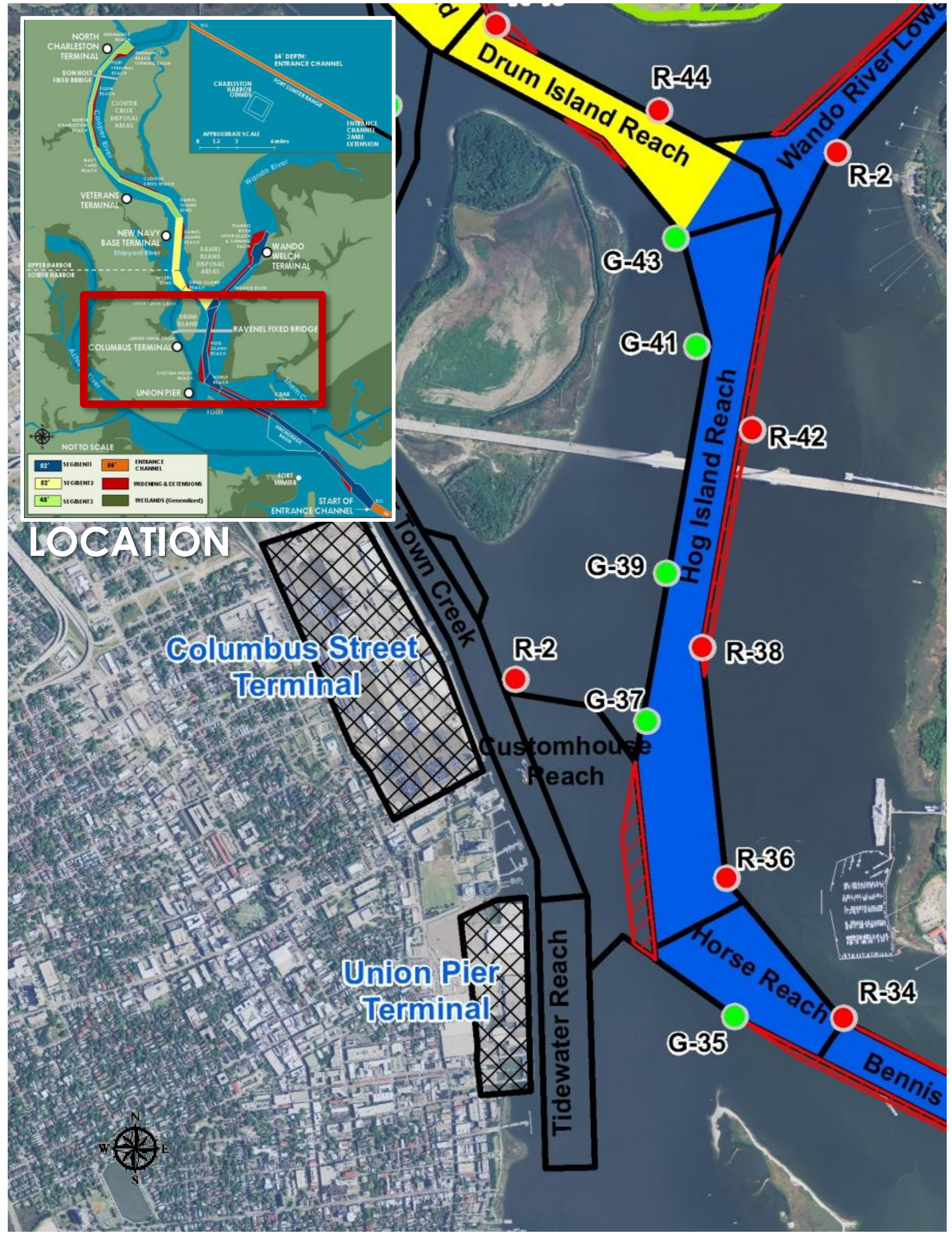
DESKTOP EXERCISE (CONCEPTUAL SHIP TRACKS)





INNER HARBOR
HOG ISLAND REACH

EXISTING PROJECT DEPTH: 45 feet

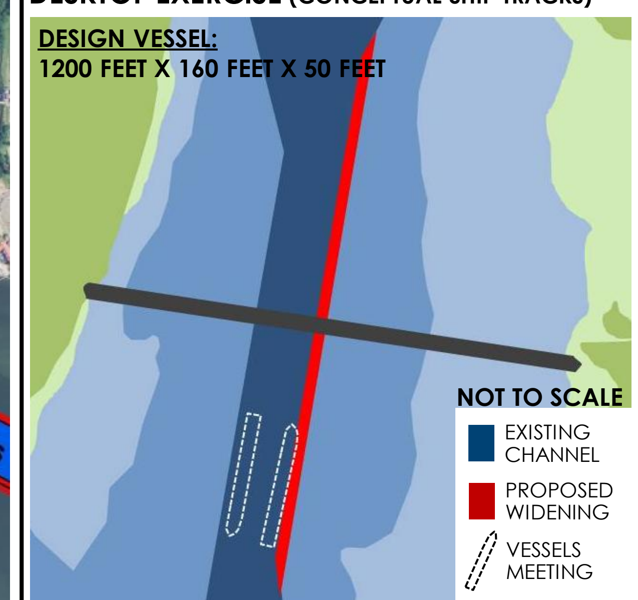
EXISTING PROJECT WIDTH: 600 feet (maximum)

PROPOSED WIDTH: Widen the reach along the entire length of its inbound (east) side by a maximum of 100 feet

ISSUE(S):

1) Two-way traffic is limited for the existing & future fleets.
2) Harbor Pilots indicate they try to avoid meeting and passing ships under the Ravenel Bridge.
3) For the existing fleet: At times vessels are able to meet or pass in the existing 600-foot wide channel.
4) For the future fleet (1200 feet x 167 feet or 1200 feet x 141 feet): With widening, meeting or passing would occur seaward of the Ravenel Bridge.
5) Guidance for two-way traffic: 5.5 times the vessel beam for <1.5 knots; 6.5 times the vessel beam >1.5 knots (design vessel beam = 160 feet, resulting in a width requirement of 880 to 1040 feet depending on currents) Engineering Appendix – A, paragraph 2.1.2

DESKTOP EXERCISE (CONCEPTUAL SHIP TRACKS)



CHARLESTON HARBOR POST-45 WIDENING & TURNING BASIN EXPANSION MEASURES

Figure 3-6-2

INNER HARBOR
WANDO RIVER LOWER REACH

EXISTING PROJECT DEPTH: 45 feet

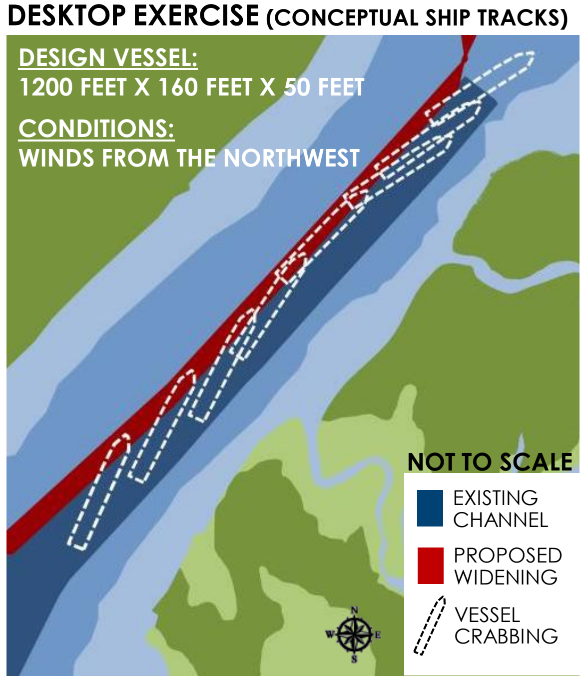
EXISTING PROJECT WIDTH: 400-foot minimum

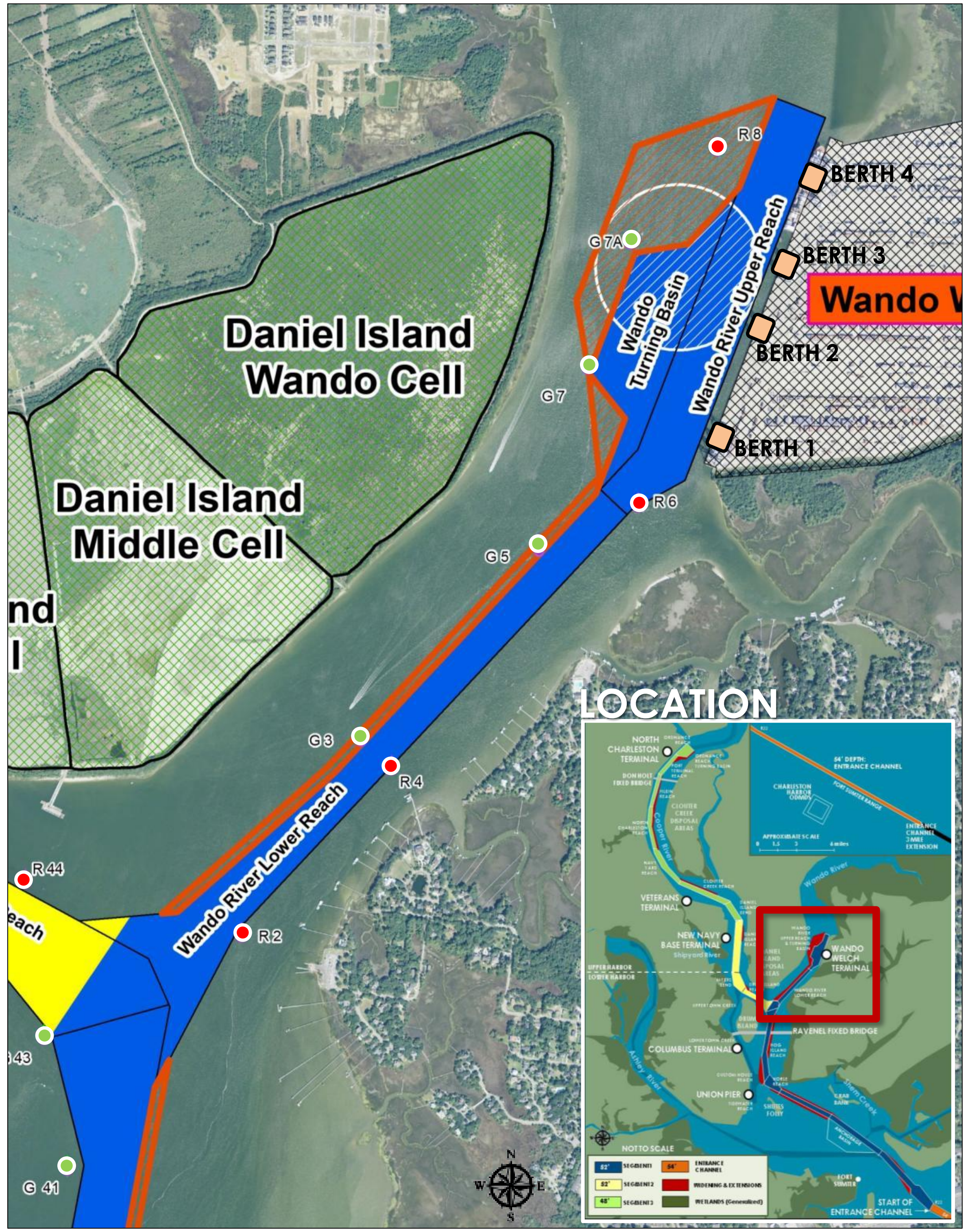
PROPOSED WIDTH: 500-feet (maximum 100-foot widening along the outbound or west side of the reach)

ISSUE(S):

1) Crabbing into the wind is required during extreme wind conditions (even with tug assistance).
2) Harbor Pilots indicate that crabbing increases with increases in the effective beam width of vessels.
3) Guidance : 3.25 or 4 times the vessel beam , which indicates the reach width could be 520 to 640 feet for a design vessel beam of 160 feet. Engineering Appendix – A, paragraph 2.1.2

DESKTOP EXERCISE (CONCEPTUAL SHIP TRACKS)





INNER HARBOR
WANDO RIVER UPPER REACH

EXISTING PROJECT DEPTH: 45 feet

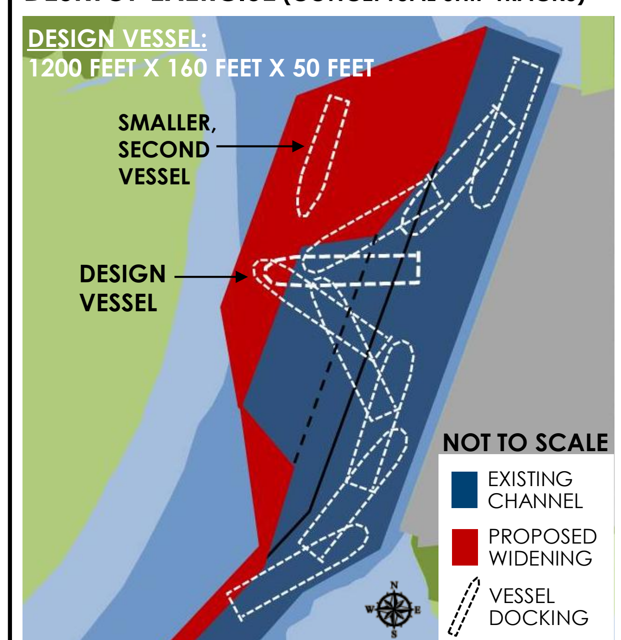
EXISTING TURNING BASIN DIAMETER: 1400 feet

PROPOSED TURNING BASIN DIAMETER: Maximum 1800-foot diameter to accommodate 1,200-foot long design vessel

ISSUE(S):

1) The recommended turning basin expansion accommodates the design vessel while maneuvering difficult currents and winds.
2) Guidance: 1.2 times the vessel length for currents < 0.5 knots & 1.5 times vessel length for currents 0.5 to 1.5 knots (>1.5 knots requires ship simulation). Refer to Engineering Appendix A, Section 2.1.2, Item 4) .
3) Docking pilots recommend locating the 1,800-foot turning diameter at the midpoint of the Wando Welch Terminal berthing area to provide better access to berths at either end of the terminal.
4) A centrally located turning basin allows another vessel (smaller) to remain in the turning basin, while a larger vessel backs into berths 3 or 4, potentially reducing turning times for both vessels.

DESKTOP EXERCISE (CONCEPTUAL SHIP TRACKS)



CHARLESTON HARBOR POST-45 WIDENING & TURNING BASIN EXPANSION MEASURES

Figure 3-6-3

INNER HARBOR
DRUM ISLAND REACH

EXISTING PROJECT DEPTH: 45 feet

EXISTING PROJECT WIDTH: 600 feet (minimum)

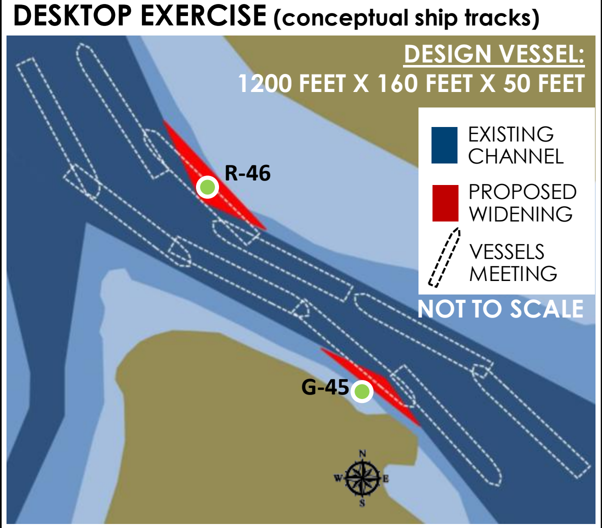
PROPOSED WIDTH: Widen the reach a maximum of 200 feet on its inbound (north) side (near buoy R46) & a maximum of 100 feet on its outbound (south) side

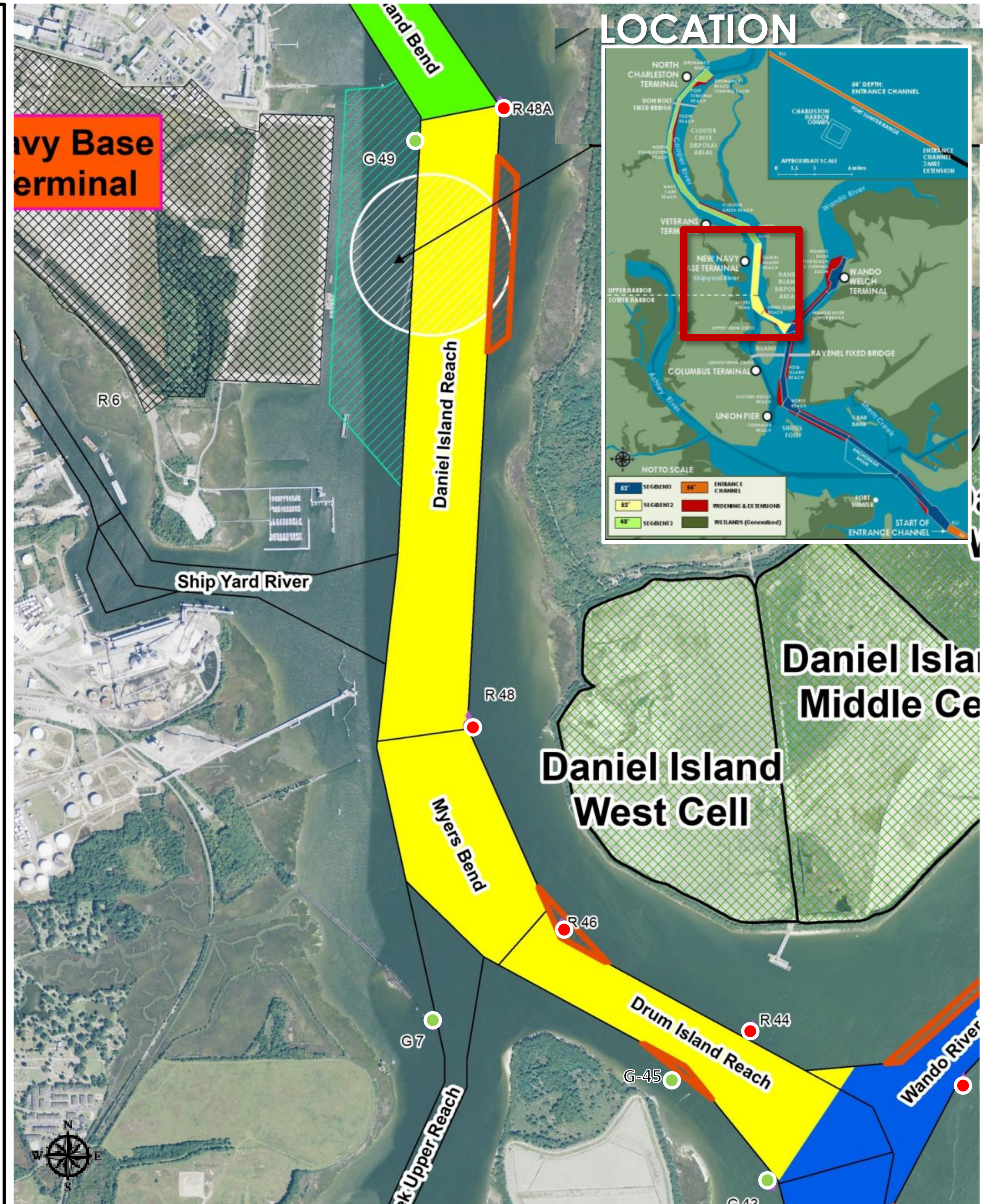
ISSUE(S):

1) Widening is needed to accommodate two-way traffic for both the existing & future fleets (Drum Island & Myers Bends).
2) Harbor Pilots restrict the existing fleet of petroleum tankers and bulk carriers to flood tide in the Drum Island Reach due to difficult ebb crosscurrents at the confluence of the Cooper & Wando Rivers.
3) Currently, U.S. Coast Pilot 4, 46th Edition, 2014 recommends that vessels avoid meeting at this turn, however with the proposed widening measures they will allow for two-way traffic in these areas for existing & future bulk & container vessels.
4) Guidance: Based on the channel centerline relative to reach angles, 0 to 2 times the vessel beam in additional width would be required (320 feet using a 160-foot design beam).

FOR ADDITIONAL INFORMATION: Refer to Engineering Appendix A, Section 2.1.2.

DESKTOP EXERCISE (conceptual ship tracks)





INNER HARBOR
DANIEL ISLAND REACH

EXISTING PROJECT DEPTH: 45 feet

EXISTING PROJECT WIDTH: 880 feet

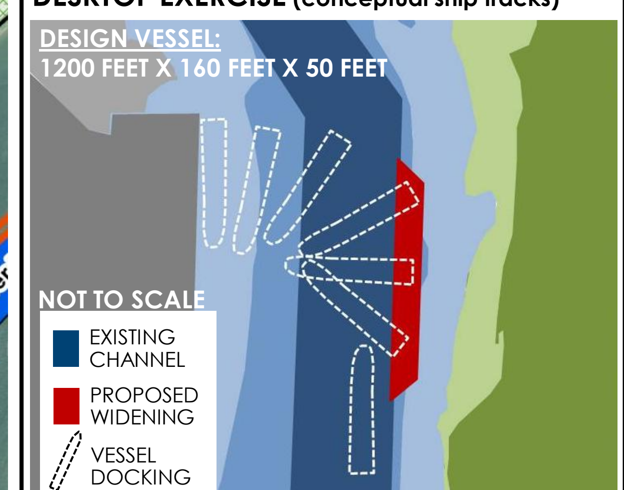
PROPOSED PROJECT WIDTH: Widen to a maximum 1800-foot diameter to accommodate the 1200-foot long design vessel

ISSUE(S):

1) A turning basin is needed for the new SCSPA Navy Base terminal.
2) Guidance: Widths should be 1.2 times the vessel length for currents 0.5 knots or less (highly unlikely) & 1.5 times the vessel length for currents 0.5 to 1.5 knots (currents greater than 1.5 knots requires ship simulation).
3) A turning basin was sized using a design vessel length of 1200 feet, resulting in 1440 & 1800-foot widths. Maximum size of 1800-foot turning diameter was used.

FOR ADDITIONAL INFORMATION: Refer to Engineering Appendix A, Section 2.1.2.

DESKTOP EXERCISE (conceptual ship tracks)



CHARLESTON HARBOR POST-45 WIDENING & TURNING BASIN EXPANSION MEASURES

Figure 3-6-4

INNER HARBOR
CLOUTER CREEK REACH

EXISTING PROJECT DEPTH: 45 feet

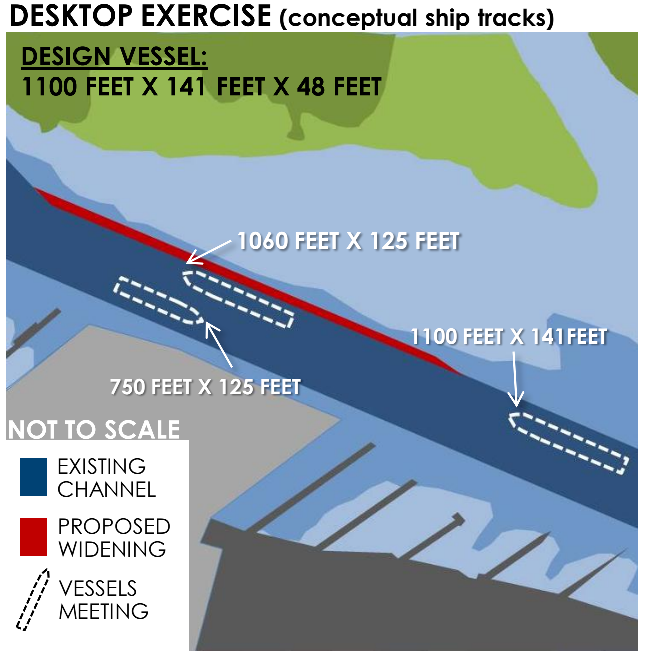
EXISTING PROJECT WIDTH: 600 feet

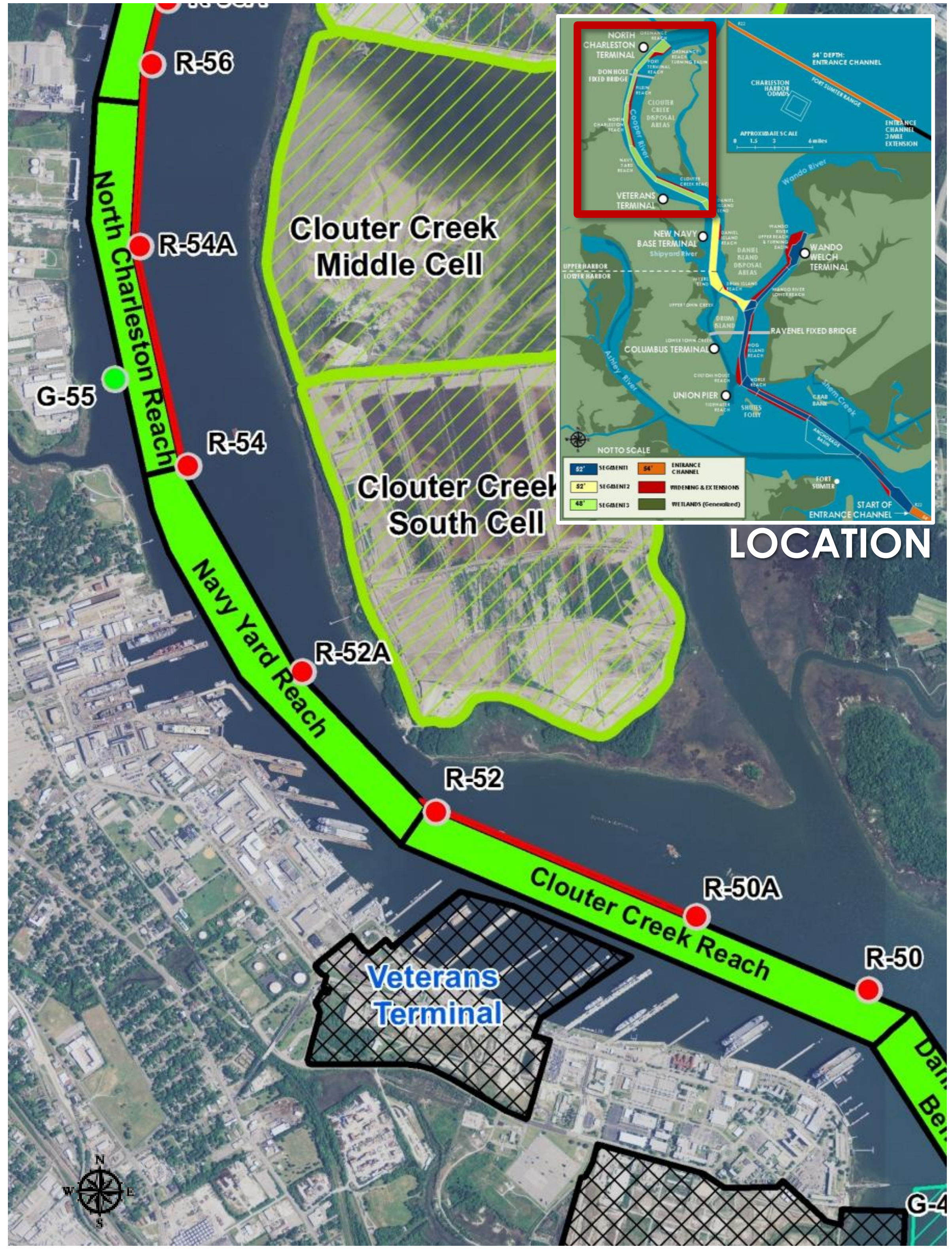
PROPOSED WIDTH: Widen reach a maximum of 50 feet along its inbound (north) side from buoy R50A to R52

ISSUE(S):

1) Two-way traffic in restricted.
2) Harbor Pilots indicate minor widening may allow two-way traffic.
3) Guidance for two-way traffic: 5.5 times the vessel beam (for1.5 knots) & 6.5 times the vessel beam (for greater than 1.5 knots.
4) Meeting the guidance for a vessel beam of 150 feet would require 825 to 975-foot channel widths, affecting shallow flats & necessitating a significant amount of new cut. Since a smaller ship can pass a larger ship with an additional 50 feet in channel width, 50 feet was used in the feasibility study. Ship simulation will determine if 50 feet is adequate. Engineering Appendix – A, paragraph 2.1.2, item 7

DESKTOP EXERCISE (conceptual ship tracks)





INNER HARBOR
NORTH CHARLESTON REACH

EXISTING PROJECT DEPTH: 45 feet

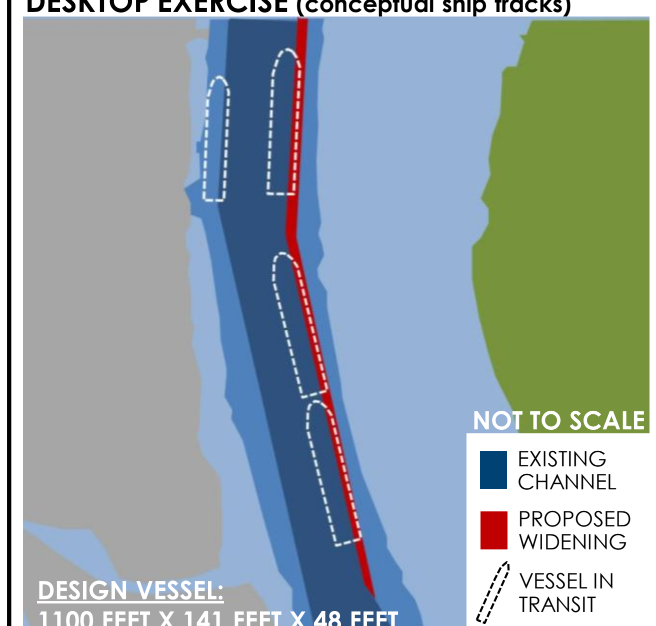
EXISTING PROJECT WIDTH: 500 feet

PROPOSED WIDTH: Widen reach a maximum of 50 feet along its inbound side

ISSUE(S):

1) Suction effects on docked vessels at petroleum terminals.
2) Shifting channel is an alternative measure to reduce suction effects.
3) Guidance requires 4 times the vessel beam width for safe transit. The design vessel (141-foot beam) would require a 564-foot width versus the existing width of 500 feet. Engineering Appendix – A, paragraph 2.1.2, item 6

DESKTOP EXERCISE (conceptual ship tracks)



CHARLESTON HARBOR POST-45 WIDENING & TURNING BASIN EXPANSION MEASURES

Figure 3-6-5

INNER HARBOR
FILBIN CREEK REACH

EXISTING PROJECT DEPTH: 45 feet

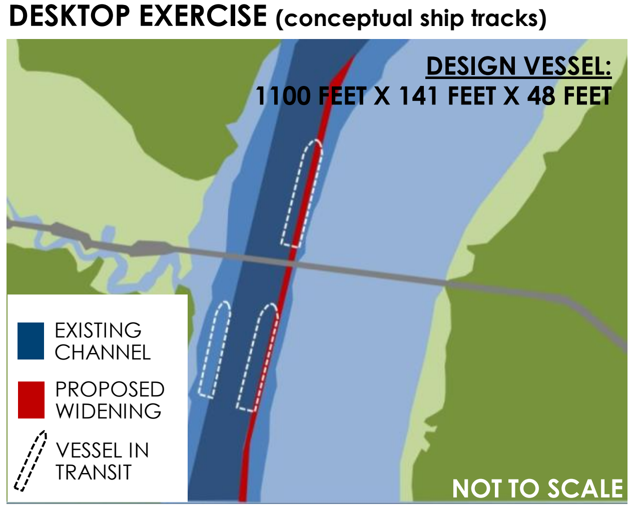
EXISTING PROJECT WIDTH: 500 feet

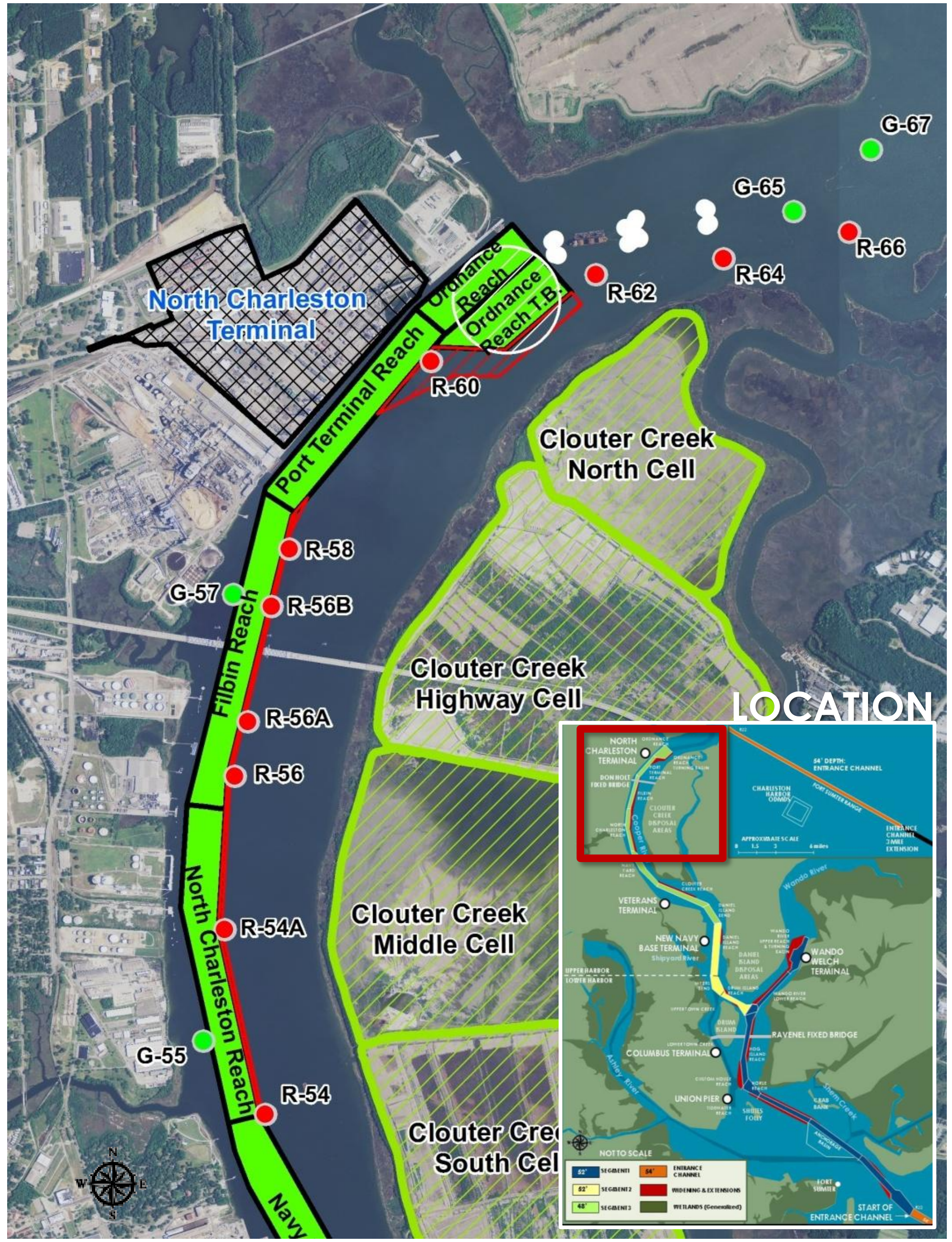
PROPOSED WIDTH: Widen the entire length of the Filbin Creek Reach by 50 feet on its inbound (east) side

ISSUE(S):

1) Wake & suction effects on docked ships at the petroleum terminals.
2) Shifting the channel to avoid the suction effects is an alternative measure.
3) U.S. Coast Pilot 4, 46th Edition, 2014 identifies this reach as an "Area of Particular Concern" warning transiting vessels to give due regard to their effects on docked vessels, & warning docked vessels to monitor transiting vessel communication (to have line handlers prepared to attend to mooring lines).
4) Guidance: 4 times the vessel beam requiring a 564-foot width based on a design vessel beam of 141 feet. Ship simulation will determine if 50 feet is sufficient. Engineering Appendix – A, paragraph 2.1.2, item 6

DESKTOP EXERCISE (conceptual ship tracks)





INNER HARBOR
PORT TERMINAL/ORDNANCE REACHES

EXISTING PROJECT DEPTH: 45 feet

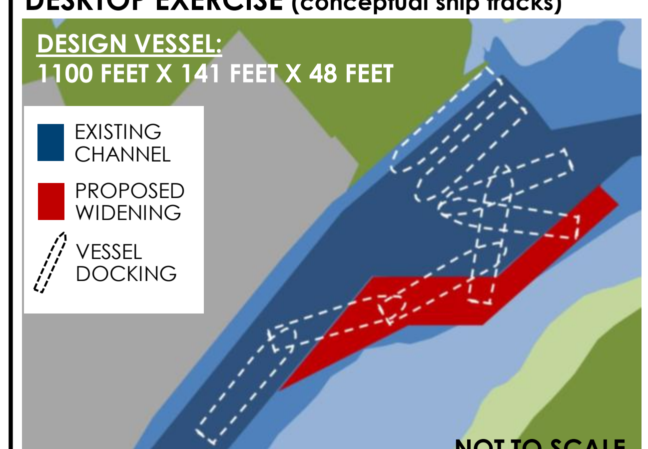
EXISTING PROJECT WIDTH: 600 feet/1400 feet

PROPOSED WIDTH: Expand Ordnance Reach & Turning Basin to a maximum diameter of 1650 feet

ISSUE(S):

1) Expansion will allow design vessels to safely navigate the turning basin based on Engineering Design Guidance for vessel lengths of 1100 feet.
2) Guidance: Widths should be 1.2 times the vessel length for currents 0.5 knots or less (highly unlikely) & 1.5 times the vessel length for currents 0.5 to 1.5 knots (currents greater than 1.5 knots requires ship simulation). Engineering Appendix – A, paragraph 2.1.2, item 4

DESKTOP EXERCISE (conceptual ship tracks)



CHARLESTON HARBOR POST-45 WIDENING & TURNING BASIN EXPANSION MEASURES

Figure 3-6-6

Additional decisions related to Entrance Channel width requirements (based on professional judgment) and screening of alternatives based on preliminary cost and benefit analysis, operational considerations, and environmental acceptability reduced the number of alternatives to six to be evaluated in greater detail. This early alternative screening process is summarized in Table 3-2. Table 3-2-1 presents the preliminary benefits and costs associated with deepening individual segments and simple combinations of segments. Table 3-2-2 presents the preliminary benefits and costs associated with deepening the channel directly to the New Navy Base Terminal and to the North Charleston Terminal without dredging the channels to the Wando Welch Terminal. Table 3-2-3 presents the preliminary benefits and costs associated with deepening channels according to logical depth combinations considering air draft limitations of the Don Holt Bridge that limit access by vessels larger than those requiring depths greater than 48 feet. In the tables, the inner harbor depths are identified with the Entrance Channel depths not indicated but are 2 feet greater than the inner harbor depths to account for vessel motion and heavier wave conditions. The depth combinations that generated the highest net benefits, based on preliminary Transportation Cost Savings Model results are highlighted in the tables. An incremental analysis of the widening measures is provided in Appendix C (Economics). This process resulted in the identification of a focused array of alternatives.

Table 3-2. Summary of initial alternatives screening process

Screening Date	# of Alternatives Considered	Estimated Net NED Benefits	Apparent NED Plan	BCR Ratio	Comments/Rationale
Dec-11	294	Not Calculated	N/A	N/A	Examined alternatives with all reasonable measures in all segments at 1-foot increments from 47’ to 52-foot depths, which resulted in 98 deepening only plus 196 widening and turning basin options or 294 total
Jan-12	128	Not Calculated	N/A	N/A	A Table Top (Desktop exercise) involving ERDC ship simulation representatives and the Charleston Harbor and Docking Pilots helped reduce the 294 alternatives to a proposed ship simulation test matrix (scheduled for the Planning, Engineering, and Design [PED] phase of the study) consisting of 128 ship simulation runs (84 runs involving no channel widening or deepening only, 50-foot, and 100-foot widening increments plus 44 runs including 1350-foot, 1450-foot, 1650-foot, and 1800-foot turning basin diameters).
Sep-12	54	$25,900,000	50'-48'	4.7	Determined Entrance Channel requirements based on design vessels from the fleet forecast; eliminated Segment 4 (Columbus and Union Pier Terminals) & Segment 5 (Anchorage Basin) based on a lack of cost effectiveness and a lack of need for modifications in those segments. Eliminated depths greater than 48 feet in the upper harbor (to the North Charleston Terminal or Segment 3) based on air draft limitations at the Don Holt Bridge that would prevent most of the largest vessels from reaching the North Charleston Terminal.
Nov-12	44	$85,200,000	50'-48'	6.8	Several alternatives were eliminated based on a lack of cost effectiveness (using Transportation Cost Savings Model screening results). Several alternatives that segregated Segments 1 and 2 to evaluate different depths to the Wando Terminal and the new Navy Base Terminal were considered. However, based on strong net benefits for both segments, and operational and logistical considerations involving the need to serve multiple customers utilizing vessels requiring deeper depths, a decision was made to apply the same depths to Segment 1 leading to the Wando Terminal and Segment 2 leading to the new Navy Base Terminal. See Table 3-2-1 and 3-2-2.
Oct-13	6	$81,300,000	52'-48'	5.6	The range of depth alternatives considered was limited to 48-52 feet based on HarborSym Model results indicating very large net benefit increases for each increment from 46 feet to 48 feet (which eliminated the need to study depths less than 48 feet). A decision to use 2-foot increments for Segments 1 and 2 instead of 1-foot increments based on the time and costs to run the models, relative to the precision associated with the forecasted vessel fleet and cargo volume data. The alternatives carried forward for more detailed evaluation included: 48’-48’, 50’-48’, 52’-48’, 48’-47’, 50’-47’, and 52’-47’. All of these alternatives assumed maximum widening measures. See Table 3-3 for the six alternatives.

Table 3-2-1. Preliminary Benefits and Costs for Segments 1-3 and simple segment combinations

Preliminary Benefits (TCSM) as of 17 Sep 2012 Preliminary Costs at FY12 (10-01-11 Price Levels) Federal Discount Rate FY12 = 4.00%				
Segment(s)	**First Costs**	**AAEQ Benefits**	**AAEQ Costs**	**AAEQ Net Benefits**
Segment 1	**(Entrance Channel to Wando Turning Basin/Wando Terminal)**			
47'	$164,614,035	$38,632,676	$7,662,816	$30,969,860
48'	$200,233,714	$43,352,867	$9,320,920	$34,031,947
49'	$235,765,377	$46,125,280	$10,974,926	$35,150,355
50'	$260,464,339	$48,338,131	$12,124,667	$36,213,464
51'	$311,244,997	$48,338,131	$14,488,517	$33,849,614
52'	$359,500,083	$48,338,131	$16,734,801	$31,603,330
Segment 2	**(Drum Island to Daniel Island Reach/ New Navy Base Terminal**)			
47'	$25,657,486	$27,042,873	$1,194,361	$25,848,512
48'	$27,786,059	$30,347,007	$1,293,447	$29,053,560
49'	$29,100,922	$32,503,328	$1,354,654	$31,148,675
50'	$30,680,892	$34,224,435	$1,428,202	$32,796,233
51'	$34,103,614	$34,224,435	$1,587,530	$32,636,905
52'	$37,544,292	$34,224,435	$1,747,694	$32,476,740
Segment 3	**(Daniel Island Bend to Ordnance Reach/N. Charleston Terminal)**			
47'	$20,304,278	$15,453,071	$945,168	$14,507,902
48'	$23,841,568	$17,341,147	$1,109,830	$16,231,317
49'	$23,841,568	$17,341,147	$1,109,830	$16,231,317
50'	$23,841,568	$17,341,147	$1,109,830	$16,231,317
51'	$23,841,568	$17,341,147	$1,109,830	$16,231,317
52'	$23,841,636	$17,341,147	$1,109,833	$16,231,314
Segments 1+2	**(Combination of Segments 1 + 2)**			
47'	$190,271,521	$65,675,550	$8,857,177	$56,818,372
48'	$228,019,773	$73,699,873	$10,614,366	$63,085,507
49'	$264,866,299	$78,628,609	$12,329,579	$66,299,029
50'	$291,145,231	$82,562,566	$13,552,869	$69,009,697
51'	$345,348,611	$82,562,566	$16,076,047	$66,486,519
52'	$397,044,375	$82,562,566	$18,482,495	$64,080,071
Segments 1+2+3	**(Combination of Segments 1 + 2 + 3) – Maximizes Preliminary Net Benefits)**			
47'	$210,575,799	$81,128,620	$9,802,346	$71,326,275
48'	$251,861,341	$91,041,020	$11,724,196	$79,316,824
49'	$288,707,867	$95,969,755	$13,439,409	$82,530,346
50'	$314,986,799	$99,903,713	$14,662,699	$85,241,014
51'	$369,190,179	$99,903,713	$17,185,877	$82,717,836
52'	$420,886,011	$99,903,713	$19,592,328	$80,311,385

Table 3-2-2 Preliminary Benefits and Costs for deepening channels to New Navy Base Terminal and North Charleston Terminal only

Preliminary Benefits (TCSM) as of 17 Sep 2012 Preliminary Costs at FY12 (10-01-11 Price Levels) Federal Discount Rate FY12 = 4.00%				
Segment	**First Costs**	**AAEQ Benefits**	**AAEQ Costs**	**AAEQ Net Benefits**
New Navy Base Terminal Only	**(Entrance Channel New Navy Base Terminal)**			
47'	$156,414,076	$27,042,873	$7,281,107	$19,761,767
48'	$195,584,940	$30,347,007	$9,104,518	$21,242,489
49'	$225,235,131	$32,503,328	$10,484,740	$22,018,588
50'	$247,751,943	$34,224,435	$11,532,903	$22,691,532
51'	$298,725,157	$34,224,435	$13,905,716	$20,318,719
52'	$345,172,992	$34,224,435	$16,067,872	$18,156,563
New Navy Base and N. Charleston Terminals	**(Entrance Channel to New Navy Base Terminal & North Charleston Terminal)**			
47'	$176,718,354	$42,495,944	$8,226,275	$34,269,669
48'	$219,426,508	$47,688,153	$10,214,348	$37,473,805
49'	$249,076,699	$49,844,475	$11,594,570	$38,249,905
50'	$271,593,511	$51,565,581	$12,642,732	$38,922,849
51'	$322,566,725	$51,565,581	$15,015,546	$36,550,036
52'	$369,014,628	$51,565,581	$17,177,705	$34,387,876

Table 3-2-3 Preliminary Benefits and Costs for logical depth combinations of Segments 1, 2 & 3

Wando Welch, Navy, and North Charleston Terminals Vertical Team Requested 48 and 50-foot Depth Analysis Preliminary Benefits (TCSM) as of 17 Sep 2012 Preliminary Costs at FY12 (10-01-11 Price Levels) Federal Discount Rate FY12 = 4.00%				
Segment	**First Costs**	**AAEQ Benefits**	**AAEQ Costs**	**Net Benefits**
Segments 1 & 2 @ 50-ft + Segment 3 @ 48-ft	$314,990,000	$99,900,000	$14,660,000	$85,240,000
Segment 1 @ 50-ft + Segments 2 & 3 @ 48-ft	$312,090,000	$96,030,000	$14,530,000	$81,500,000
Segment 2 @ 50-ft + Segments 1 & 3 @ 48-ft	$304,030,000	$94,920,000	$14,150,000	$80,770,000

3.4.6 Focused Array of Alternatives

Once the focused array of alternatives was identified, a naming convention was developed for the alternatives to be considered in greater detail. The alternatives are identified using a combination of two numbers separated by a "/" such as 48/48, 50/47 or 52/48. The numbers represent alternative depths in Segments 1 and 2 (Lower Harbor) and in Segment 3 (Upper Harbor), respectively and reference mean lower low water (MLLW). For example, the 50/48 alternative proposes authorized depths of 50 feet MLLW in the Lower Harbor and 48 feet in the Upper Harbor. In all cases, the Entrance Channel depths are 2 feet greater than the lower harbor depths to account for vessel motions due to wind and wave conditions in the Atlantic Ocean. In all cases, the stated channel depths are authorized depths and do not include any advanced maintenance or allowable overdepth. Details related to the measures within segments 1, 2, and 3 are illustrated in Figures 3-7, 3-8, and 3-9, respectively. All of these alternatives assumed maximum widening measures. Details related to advance maintenance and overdepth dredging are provided in Section 5 and Appendix A.

A more detailed analysis of the costs and economic benefits associated with the six remaining alternatives was performed. The results are summarized in Table 3-3.

Table 3-3. Economic summary of focused array of alternatives

Alternative	Costs	AAEQ Benefits	AAEQ Costs	Average Annual Net Benefits	Screening Result
52/48	$411,214,367	$98,820,000	$17,531,594	$81,288,406	Continue to Evaluate
50/48	$341,174,783	$94,150,000	$14,545,547	$79,604,453	Continue to Evaluate
48/48	$247,816,309	$81,540,000	$10,565,329	$70,974,671	Elimination considered but retained
52/47	$399,895,545	$84,410,000	$17,049,031	$67,360,969	Eliminated due to low net benefits
50/47	$330,287,683	$80,320,000	$14,081,389	$66,238,611	Eliminated due to low net benefits
48/47	$240,183,716	$67,140,000	$10,239,923	$56,900,077	Eliminated due to low net benefits

Preliminary Benefits Analysis (HarborSym - Origin to Destination) as of 8 Aug 2013
Preliminary Costs at FY14 (10-01-13 Price Levels)
Federal Discount Rate FY14 = 3.5%
AAEQ - average annual equivalent; (based on cost and benefits estimates from Aug 2013)

Based on relatively low differences in average annual costs (less than $500,000) and large differences in average annual net benefits (about $14,000,000), the alternatives that included a 47-foot depth in Segment 3 were eliminated from consideration. Additionally, the analysis shows that the alternatives with depths of 48 feet and greater in Segments 1 and 2 generate most of the benefits and each alternative depth is incrementally justified. Elimination of the 48/48 alternative was considered due to low net benefits. But it was carried forward to provide a third point to better define the trends in benefits and costs over a wider range. This step led to the final array of alternatives.

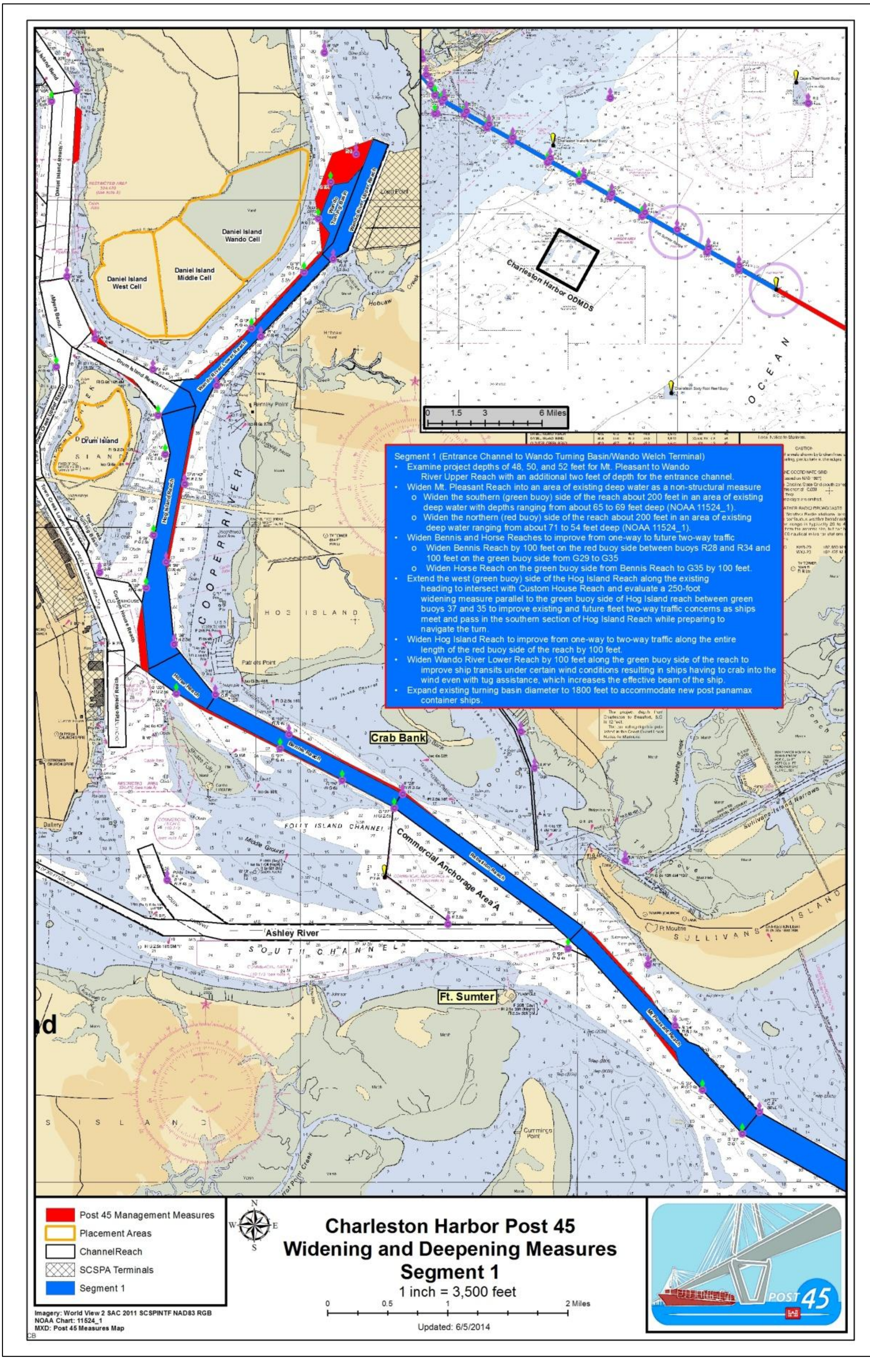


Figure 3-7. Segment 1 Deepening and Widening Measures Carried Forward

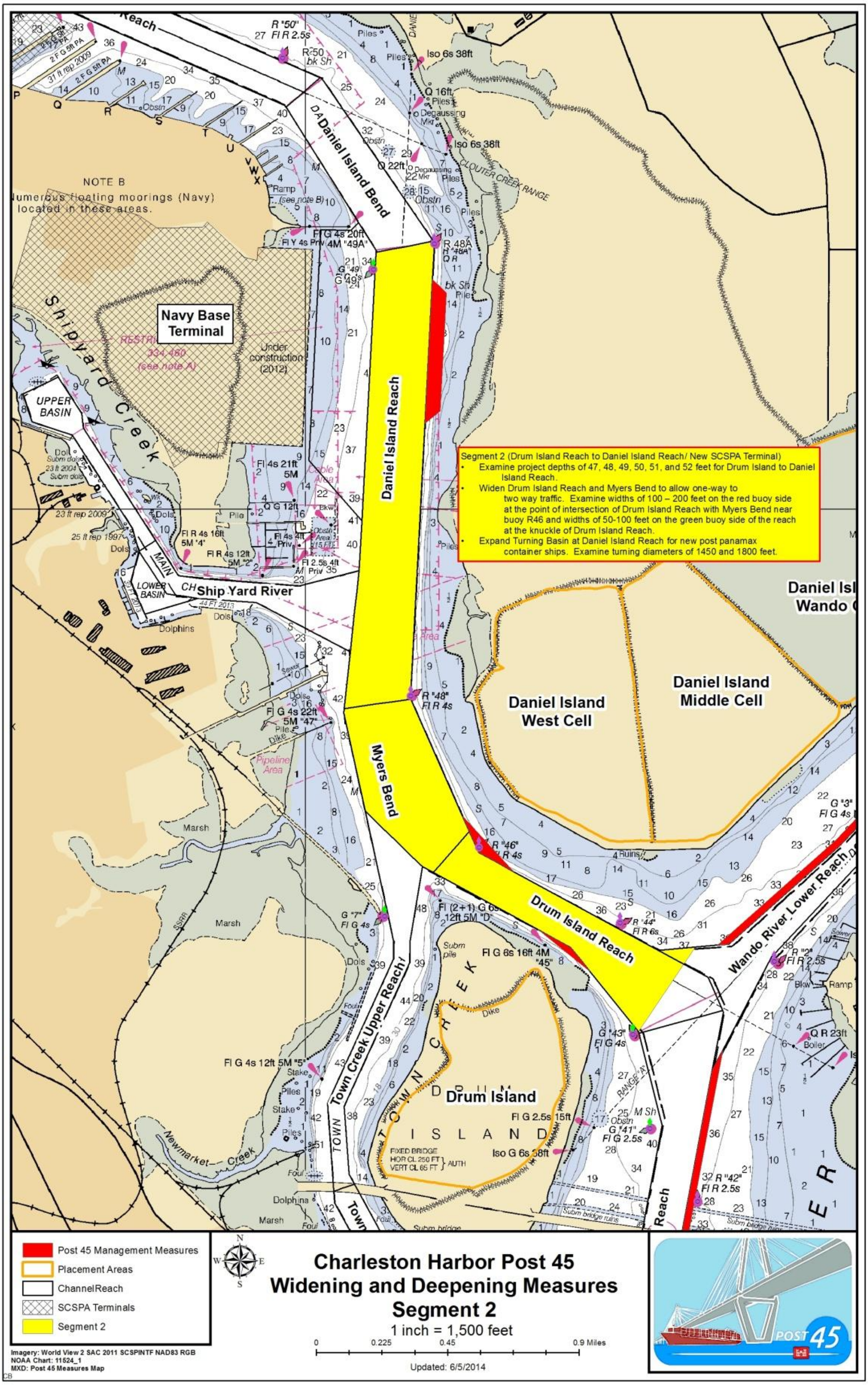


Figure 3-8. Segment 2 deepening and widening measures carried forward

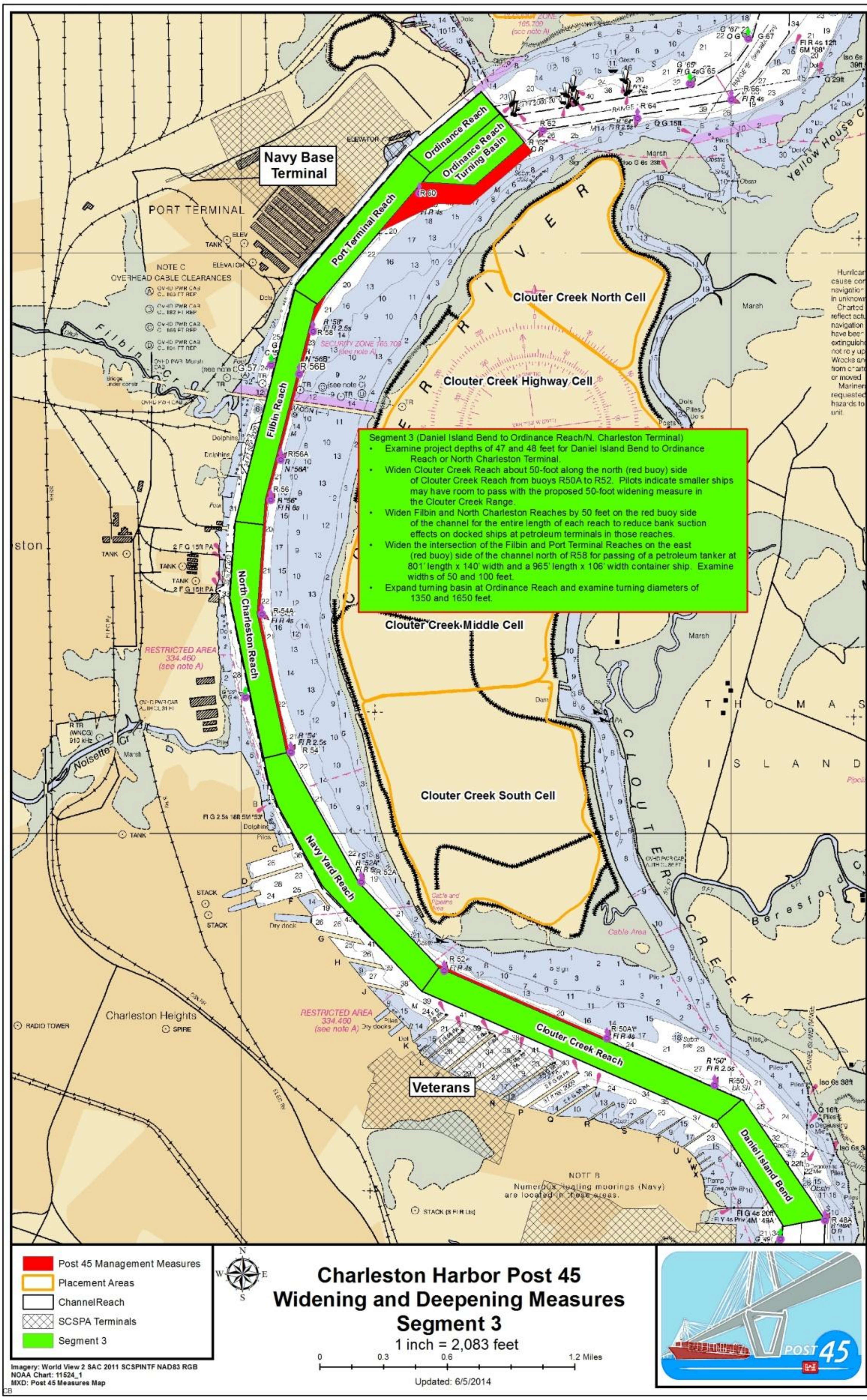


Figure 3-9. Segment 3 deepening and widening measures carried forward

3.5 Comparison of the Final Array of Alternatives

3.5.1 National Economic Development

Additional refinements were made to the cost and benefits analyses of the final array of alternatives based on more detailed analysis. The refined results are summarized in Table 3-4. Based on these results, the 48/48 alternative was eventually eliminated from further consideration.

Table 3-4. Cost and benefit summary of final array of alternatives

Alternatives	Costs	AAEQ Benefits	AAEQ Costs	Net Benefits	Incremental Net Benefits
52/48	$528,458,301	$107,492,499	$29,380,678	$78,111,821	$1,899,794
50/48	$457,055,248	$101,621,011	$25,408,984	$76,212,027	$9,854,886
48/48	$379,017,326	$87,614,201	$21,257,060	$66,357,141	-

AAEQ - average annual equivalent; (Based on May 2014 cost and benefits estimates and FY14 (3.5%) interest rate)

Throughout the screening process, non-NED factors are considered with the intent to identify those additional factors that should significantly contribute to the decision. These include regional economic development, environmental quality, and other social factors that could exhibit meaningful differences between alternatives.

3.5.2 Regional Economic Development

The RED account measures changes in the distribution of regional economic activity that would result from each alternative plan. Evaluations of regional effects are measured using nationally consistent projections of income, employment, output, and population.

3.5.2.1 Regional Economic Analysis

The USACE Online Regional Economic System (RECONS) is a system designed to provide estimates of regional, state, and national contributions of federal spending associated with Civil Works and American Recovery and Reinvestment Act Projects. Results are summarized below. Additional information related to the development of the model and its inputs is provided in Appendix C.

The RED impact analysis was evaluated at the local, state, and national levels. The local-level analysis represents the Charleston impact area, which encompasses the area within about a 50-mile radius of the project. The state-level analysis includes the State of South Carolina. The national-level includes the 48 contiguous U.S. states.

Total expenditures for the project range up to about $521,000,000 (52/48 alternative). Of this, up to $376,575,000 would be captured within the regional impact area, and the rest would flow to the state or the nation. The expenditures for various services and products would be expected to generate additional economic activity measured in jobs, income, sales, and Gross Regional Product (GRP). Impacts at the national level include a tremendous expansion due to the multiple times money turns over and ripples throughout the national economy. According to the RECONS, total economic impact for the State of South Carolina comprises up to $747.3 million in sales, 7,214 jobs,

$374 million in labor income, and a contribution of $494 million to GRP. The total economic impact for the Charleston-North Charleston - Summerville South Carolina Metropolitan Statistical Area comprises up to $49.55 million in output (sales), 398,686 jobs, $17.3 million in labor income, and a contribution of $26.25 million to GRP.

3.5.3 Environmental Quality

The environmental quality account considers non-monetary effects on ecological, cultural, and aesthetic resources. Under this account, the preferred plan should avoid or minimize environmental impacts and maximize environmental quality in the project area to the extent practicable considering other criteria and planning objectives.

Table 3-5 summarizes the environmental impacts of each alternative carried forward to the focused array. More detailed descriptions of the analysis and impacts can be found in Section 5 of this report and in the Appendices. For the purposes of alternatives analysis, all action plans were compared to the future without-project condition (i.e., NEPA No Action), which factors in 50 years of sea-level rise (to 2071). As negotiated by USACE and the Interagency Collaboration Team (ICT), upon selection of the Recommended Plan (RP), a sensitivity analysis was performed to more accurately represent potential impacts.

3.5.3.1 Environmental Minimization and Avoidance Measures

The first step in mitigation planning involves employing efforts to avoid adverse impacts. After the initial array of alternatives was determined, the PDT initiated coordination with resource agencies and held several ICT meetings. These meetings focused on the primary resources (cultural resources, DO, wetlands, salinity, fish habitat/endangered species, hardbottom habitat) that would be impacted by the proposed alternatives.

Cultural Resources. Cultural Resources investigations using side-scan sonar, sub-bottom profiling, and magnetometer surveys identified three anomalies. Subsequent diver investigations revealed that the three anomalies consisted of modern debris and did not represent significant historic or cultural items; however, one anomaly adjacent to Bennis Reach will require a cultural resources monitor on board when dredging occurs in that area to avoid potential cultural resource impacts.

Dredging Volume and Duration. The USACE will avoid unnecessarily extending construction durations and limit total disposal volumes by not dredging past the depths needed to construct and maintain the project. Many areas do not require frequent maintenance dredging. Therefore, environmental impacts can be minimized by limiting overdepth dredging (dredging to deeper depths in order to maintain the authorized depth between maintenance dredging efforts) in the outer Entrance Channel to 1-foot of required overdepth and 2-feet of allowable overdepth, instead of the typical 2-feet of required overdepth and 2-feet of allowable overdepth. The reduction of impacts includes a reduced footprint, reduced new construction dredging quantities, and the potential for decreased future maintenance dredging quantities.

Table 3-5. Summary of Environmental Impacts (Environmental Quality Account)

	Alternative						
Environmental Factor	**No Action**	**48/47**	**48/48**	**50/47**	**50/48**	**52/47**	**52/48**
General Consequences	A greater increase in ship transits (compared to action alternatives) are predicted due to need for more ships to carry same amount of cargo. This results in greater risk to threatened and endangered species, more of a shoreline erosion threat, and more air pollution. Year 2037 modeled to have 2,863 vessel calls.	Larger ships and increased ship transits are predicted. Deepening would result in predicted and anticipated increases in salinity, risks to threatened and endangered species, impacts to fish habitat. Year 2037 modeled to have 2,666 vessel calls.	Larger ships and increased ship transits are predicted. Deepening would result in predicted and anticipated increases in salinity, risks to threatened and endangered species, impacts to fish habitat. Year 2037 modeled to have 2,631 vessel calls.	Larger ships and increased ship transits are predicted. Deepening would result in predicted and anticipated increases in salinity, risks to threatened and endangered species, impacts to fish habitat. Year 2037 modeled to have 2,619 vessel calls.	Larger ships and increased ship transits are predicted. Deepening would result in predicted and anticipated increases in salinity, risks to threatened and endangered species, impacts to fish habitat. Year 2037 modeled to have 2,585 vessel calls.	Larger ships and increased ship transits are predicted. Deepening would result in predicted and anticipated increases in salinity, risks to threatened and endangered species, impacts to fish habitat. Year 2037 modeled to have 2,605 vessel calls.	Larger ships and increased ship transits are predicted. Deepening would result in predicted and anticipated increases in salinity, risks to threatened and endangered species, impacts to fish habitat. Year 2037 modeled to have 2,568 vessel calls.
Geology and Geomorphology	O&M of the federal navigation channel will result in no effect on geology and geomorphology	Increased channel depth, but no real effect on geology and geomorphology	Increased channel depth, but no real effect on geology and geomorphology	Increased channel depth, but no real effect on geology and geomorphology	Increased channel depth, but no real effect on geology and geomorphology	Increased channel depth, but no real effect on geology and geomorphology	Increased channel depth, but no real effect on geology and geomorphology
Tides	No impact to tidal range is predicted.	No impact to tidal range is predicted.	No impact to tidal range is predicted.	No impact to tidal range is predicted.	No impact to tidal range is predicted.	No impact to tidal range is predicted.	No impact to tidal range is predicted.
Currents	Currents will generally remain the same, but some changes could occur due to changing climate and weather patterns. Modeling predicts increase in currents of mostly <0.1ft/s. Some changes are between 0.1 and 0.2 ft/s.	Currents will generally remain the same. Modeling predicts increase in currents of mostly <0.1ft/s. Some changes are between 0.1 and 0.2 ft/s. Some areas of the harbor experience a reduction in currents due to wider deeper channels.	Currents will generally remain the same. Modeling predicts increase in currents of mostly <0.1ft/s. Some changes are between 0.1 and 0.2 ft/s. Some areas of the harbor experience a reduction in currents due to wider deeper channels. The magnitude of these changes is slightly greater than the 48/47 alternative.	Currents will generally remain the same. Modeling predicts increase in currents of mostly <0.1ft/s. Some changes are between 0.1 and 0.2 ft/s. Some areas of the harbor experience a reduction in currents due to wider deeper channels. The magnitude of these changes is slightly greater than the 48/48 alternative.	Currents will generally remain the same. Modeling predicts increase in currents of mostly <0.1ft/s. Some changes are between 0.1 and 0.2 ft/s. Some areas of the harbor experience a reduction in currents due to wider deeper channels. The magnitude of these changes is slightly greater than the 50/47 alternative.	Currents will generally remain the same. Modeling predicts increase in currents of mostly <0.1ft/s. Some changes are between 0.1 and 0.2 ft/s. Some areas of the harbor experience a reduction in currents due to wider deeper channels. The magnitude of these changes is slightly greater than the 50/48 alternative.	Currents will generally remain the same. Modeling predicts increase in currents of mostly <0.1ft/s. Maximum increases are between 0.1 and 0.2 ft/s. Some areas of the harbor experience a reduction in currents due to wider deeper channels (between 0.3 and 0.7 ft/s). The magnitude of these changes is slightly greater than the 52/47 alternative.
Sea level rise (SLR) / water levels	Sea level rise (historical rate) would cause water surface elevation to increase by approximately 0.57 feet over the 50 year period of analysis (represented as the year 2071). The intermediate and high rates would result in 1.08 and 2.74 feet of sea level rise, respectively. Sea level rise could cause impacts to existing infrastructure and have salinity effects on wetlands and the Bushy Park Reservoir.	Deepening would have no influence on SLR	Deepening would have no influence on SLR	Deepening would have no influence on SLR	Deepening would have no influence on SLR	Deepening would have no influence on SLR	Deepening would have no influence on SLR
Land Use	O&M of the federal navigation channel will result in no effect on land use.	Temporary effect in construction areas, otherwise no effect.	Temporary effect in construction areas, otherwise no effect.	Temporary effect in construction areas, otherwise no effect.	Temporary effect in construction areas, otherwise no effect.	Temporary effect in construction areas, otherwise no effect.	Temporary effect in construction areas, otherwise no effect.
HTRW	Encountering HTRW is not anticipated as a result of sediment evaluations.	Encountering HTRW is not anticipated as a result of sediment evaluations.	Encountering HTRW is not anticipated as a result of sediment evaluations.	Encountering HTRW is not anticipated as a result of sediment evaluations.	Encountering HTRW is not anticipated as a result of sediment evaluations.	Encountering HTRW is not anticipated as a result of sediment evaluations.	Encountering HTRW is not anticipated as a result of sediment evaluations.

Table 3-5. Summary of Environmental Impacts (Environmental Quality Account) (Cont'd)

	Alternative						
Environmental Factor	**No Action**	**48/47**	**48/48**	**50/47**	**50/48**	**52/47**	**52/48**
Wetlands (Impact acres are based on preliminary evaluations)	O&M of the existing federal navigation channel will have no direct effect on wetlands. Sea level rise (evaluated as 0.57ft SLR over 50 years [year 2071]) will cause indirect effects due to salinity increases and freshwater wetlands species transitioning to more salt tolerant species would impact an estimated 800.8 acres of herbaceous and forested wetlands. Greater rates of SLR would result in more impacts. Details of the impacts provided in below rows.	Dredging operations would not directly affect wetlands. An incremental increase (from the No Action) in the predicted indirect effects due to salinity increases and freshwater wetlands species transitioning to more salt tolerant species would impact an estimated 233.67 acres of herbaceous and forested wetlands. Details of the impacts provided in below rows. Mitigation and monitoring would be performed.	Dredging operations would not directly affect wetlands. An incremental increase (from the No Action) in the predicted indirect effects due to salinity increases and freshwater wetlands species transitioning to more salt tolerant species would impact an estimated 253.15 acres of herbaceous and forested wetlands. Details of the impacts provided in below rows. Mitigation and monitoring would be performed.	Dredging operations would not directly affect wetlands. An incremental increase (from the No Action) in the predicted indirect effects due to salinity increases and freshwater wetlands species transitioning to more salt tolerant species would impact an estimated 271.75 acres of herbaceous and forested wetlands. Details of the impacts provided in below rows. Mitigation and monitoring would be performed.	Dredging operations would not directly affect wetlands. An incremental increase (from the No Action) in the predicted indirect effects due to salinity increases and freshwater wetlands species transitioning to more salt tolerant species would impact an estimated 288.34 acres of herbaceous and forested wetlands. Details of the impacts provided in below rows. Mitigation and monitoring would be performed.	Dredging operations would not directly affect wetlands. An incremental increase (from the No Action) in the predicted indirect effects due to salinity increases and freshwater wetlands species transitioning to more salt tolerant species would impact an estimated 482.41 acres of herbaceous and forested wetlands. Details of the impacts provided in below rows. Mitigation and monitoring would be performed.	Dredging operations would not directly affect wetlands. An incremental increase (from the No Action) in the predicted indirect effects due to salinity increases and freshwater wetlands species transitioning to more salt tolerant species would impact an estimated 493.41 acres of herbaceous and forested wetlands. Details of the impacts provided in below rows. Mitigation and monitoring would be performed.
Ashley River forested wetlands	49.18 acres	4.88 acres	5.00 acres	5.46acres	5.50 acres	6.80 acres	7.21 acres
Ashley River marsh wetlands	118.11 acres	11.71 acres	11.99 acres	13.12 acres	13.20 acres	16.33 acres	17.30acres
Cooper River forested wetlands	261.45 acres	89.59 acres	97.46 acres	104.48 acres	111.28 acres	189.47acres	193.52 acres
Cooper River marsh wetlands	372.06 acres	127.49 acres	138.70 acres	148.69 acres	158.36 acres	269.62 acres	275.38 acres
Ground Water	No effect. However, sea level rise may cause slight increase in surficial aquifers.	No significant increase in salinity is anticipated within surficial aquifers.	No significant increase in salinity is anticipated within surficial aquifers.	No significant increase in salinity is anticipated within surficial aquifers.	No significant increase in salinity is anticipated within surficial aquifers.	No significant increase in salinity is anticipated within surficial aquifers.	No significant increase in salinity is anticipated within surficial aquifers.
Water Quality							
Salinity	Sea level rise will cause an increase in salinity.	Increases in depth averaged salinity, surface salinity and bottom salinity are predicted.	Increases in depth averaged salinity, surface salinity and bottom salinity are predicted.	Increases in depth averaged salinity, surface salinity and bottom salinity are predicted.	Increases in depth averaged salinity, surface salinity and bottom salinity are predicted.	Increases in depth averaged salinity, surface salinity and bottom salinity are predicted.	Increases in depth averaged salinity, surface salinity and bottom salinity are predicted.
Dissolved Oxygen	No effect; however sea level rise over 50 years will reduce oxygen concentration by an average of -0.084mg/L throughout the harbor.	The alternative will generally result in reduced oxygen concentration and saturation potential within the harbor. The average delta DO is -0.017mg/L throughout the harbor. The cumulative impact of this alternative and the NPDES dischargers will not contravene the state standard.	The alternative will generally result in reduced oxygen concentration and saturation potential within the harbor. The average delta DO is -0.019mg/L throughout the harbor. The cumulative impact of this alternative and the NPDES dischargers will not contravene the state standard.	The alternative will generally result in reduced oxygen concentration and saturation potential within the harbor. The average delta DO is -0.022mg/L throughout the harbor. The cumulative impact of this alternative and the NPDES dischargers will not contravene the state standard.	The alternative will generally result in reduced oxygen concentration and saturation potential within the harbor. The average delta DO is -0.023mg/L throughout the harbor. The cumulative impact of this alternative and the NPDES dischargers will not contravene the state standard.	The alternative will generally result in reduced oxygen concentration and saturation potential within the harbor. The average delta DO is -0.026mg/L throughout the harbor. The cumulative impact of this alternative and the NPDES dischargers will not contravene the state standard.	The alternative will generally result in reduced oxygen concentration and saturation potential within the harbor. The average delta DO is -0.027mg/L. The cumulative impact of this alternative and the NPDES dischargers will not contravene the state standard.

Table 3-5. Summary of Environmental Impacts (Environmental Quality Account) (Cont'd)

	Alternative						
Environmental Factor	**No Action**	**48/47**	**48/48**	**50/47**	**50/48**	**52/47**	**52/48**
Fecal Coliform	No significant change in bacteria concentration is expected as a result of the No Action Alternative; however, O&M will still result in temporary short term increase in bacteria resulting from sediment resuspension.	No significant change in bacteria concentration is expected as a result of the project. A temporary increase in bacteria during the construction may take place due to sediment resuspension.	No significant change in bacteria concentration is expected as a result of the project. A temporary increase in bacteria during the construction may take place due to sediment resuspension.	No significant change in bacteria concentration is expected as a result of the project. A temporary increase in bacteria during the construction may take place due to sediment resuspension.	No significant change in bacteria concentration is expected as a result of the project. A temporary increase in bacteria during the construction may take place due to sediment resuspension.	No significant change in bacteria concentration is expected as a result of the project. A temporary increase in bacteria during the construction may take place due to sediment resuspension.	No significant change in bacteria concentration is expected as a result of the project. A temporary increase in bacteria during the construction may take place due to sediment resuspension.
Nutrients	no significant change in nutrient concentration is expected as a result of the No Action Alternative; however, O&M will still result in temporary short term increase in nutrients resulting from sediment resuspension.	no significant change in nutrient concentration is expected as a result of the project. A temporary increase in nutrient concentration during the construction may take place due to sediment resuspension.	no significant change in nutrient concentration is expected as a result of the project. A temporary increase in nutrient concentration during the construction may take place due to sediment resuspension.	no significant change in nutrient concentration is expected as a result of the project. A temporary increase in nutrient concentration during the construction may take place due to sediment resuspension.	no significant change in nutrient concentration is expected as a result of the project. A temporary increase in nutrient concentration during the construction may take place due to sediment resuspension.	no significant change in nutrient concentration is expected as a result of the project. A temporary increase in nutrient concentration during the construction may take place due to sediment resuspension.	no significant change in nutrient concentration is expected as a result of the project. A temporary increase in nutrient concentration during the construction may take place due to sediment resuspension.
Air Quality	Greatest impact to air emissions due to more vessels needed to delivery same amount of cargo.	Reduction in vessel related emissions compared to FWOP. The alternative will have a temporary minor increase in emissions related to the construction of the project.	Reduction in vessel related emissions compared to FWOP. The alternative will have a temporary minor increase in emissions related to the construction of the project compared to the 48/47 alternative. Slightly less overall emissions than the 48/47 alternative.	Reduction in vessel related emissions compared to FWOP. The alternative will have a temporary minor increase in emissions related to the construction of the project compared to the 48/48 alternative. Slightly less overall emissions than the 48/48 alternative.	Reduction in vessel related emissions compared to FWOP. The alternative will have a temporary minor increase in emissions related to the construction of the project compared to the 50/47 alternative. Slightly less overall emissions than the 50/47 alternative.	Reduction in vessel related emissions compared to FWOP. The alternative will have a temporary minor increase in emissions related to the construction of the project compared to the 50/48 alternative. Slightly less overall emissions than the 50/48 alternative.	Reduction in vessel related emissions compared to FWOP. The alternative will have a temporary minor increase in emissions related to the construction of the project compared to the 50/47 alternative. Slightly less overall emissions than the 50/47 alternative.
Threatened and Endangered Species (Dredging/Long term)	KEY for acronyms: NE=No Effect, MANLAA=May Affect, Not Likely to Adversely Affect, MALAA=May Affect, Likely to Adversely Affect	KEY for acronyms: NE=No Effect, MANLAA=May Affect, Not Likely to Adversely Affect, MALAA=May Affect, Likely to Adversely Affect	KEY for acronyms: NE=No Effect, MANLAA=May Affect, Not Likely to Adversely Affect, MALAA=May Affect, Likely to Adversely Affect	KEY for acronyms: NE=No Effect, MANLAA=May Affect, Not Likely to Adversely Affect, MALAA=May Affect, Likely to Adversely Affect	KEY for acronyms: NE=No Effect, MANLAA=May Affect, Not Likely to Adversely Affect, MALAA=May Affect, Likely to Adversely Affect	KEY for acronyms: NE=No Effect, MANLAA=May Affect, Not Likely to Adversely Affect, MALAA=May Affect, Likely to Adversely Affect	KEY for acronyms: NE=No Effect, MANLAA=May Affect, Not Likely to Adversely Affect, MALAA=May Affect, Likely to Adversely Affect
Shortnose Sturgeon	O&M would continue to operate under the most up-to-date South Atlantic Regional Biological Opinion.	Dredging = MALAA; Long term =MANLAA	Dredging = MALAA; Long term =MANLAA	Dredging = MALAA; Long term =MANLAA	Dredging = MALAA; Long term =MANLAA	Dredging = MALAA; Long term =MANLAA	Dredging = MALAA; Long term =MANLAA
Atlantic Sturgeon	O&M would continue to operate under the current South Atlantic Regional Biological Opinion.	Dredging = MALAA; Long term =MANLAA	Dredging = MALAA; Long term =MANLAA	Dredging = MALAA; Long term =MANLAA	Dredging = MALAA; Long term =MANLAA	Dredging = MALAA; Long term =MANLAA	Dredging = MALAA; Long term =MANLAA
Loggerhead Sea Turtle	Would continue to operate under the current South Atlantic Regional Biological Opinion.	Dredging = MALAA; Long term =NE	Dredging = MALAA; Long term =NE	Dredging = MALAA; Long term =NE	Dredging = MALAA; Long term =NE	Dredging = MALAA; Long term =NE	Dredging = MALAA; Long term =NE
Kemps Ridley Sea Turtle	O&M would continue to operate under the current South Atlantic Regional Biological Opinion.	Dredging = MALAA; Long term =NE	Dredging = MALAA; Long term =NE	Dredging = MALAA; Long term =NE	Dredging = MALAA; Long term =NE	Dredging = MALAA; Long term =NE	Dredging = MALAA; Long term =NE

Table 3-5. Summary of Environmental Impacts (Environmental Quality Account) (Cont'd)

		Alternative					
Environmental Factor	**No Action**	**48/47**	**48/48**	**50/47**	**50/48**	**52/47**	**52/48**
Leatherback Sea Turtle	O&M would continue to operate under the current South Atlantic Regional Biological Opinion.	Dredging = MALAA; Long term =NE	Dredging = MALAA; Long term =NE	Dredging = MALAA; Long term =NE	Dredging = MALAA; Long term =NE	Dredging = MALAA; Long term =NE	Dredging = MALAA; Long term =NE
Green Sea Turtle	O&M would continue to operate under the current South Atlantic Regional Biological Opinion.	Dredging = MALAA; Long term =NE	Dredging = MALAA; Long term =NE	Dredging = MALAA; Long term =NE	Dredging = MALAA; Long term =NE	Dredging = MALAA; Long term =NE	Dredging = MALAA; Long term =NE
North Atlantic Right Whale (NARW)	Would continue to operate under the current South Atlantic Regional Biological Opinion.	Dredging = MANLAA; Long term =NE. Vessel transportation during construction may affect, but is not likely to adversely affect the NARW. Protective measures would be implemented.	Dredging = MANLAA; Long term =NE. Vessel transportation during construction may affect, but is not likely to adversely affect the NARW. Protective measures would be implemented.	Dredging = MANLAA; Long term =NE. Vessel transportation during construction may affect, but is not likely to adversely affect the NARW. Protective measures would be implemented.	Dredging = MANLAA; Long term =NE. Vessel transportation during construction may affect, but is not likely to adversely affect the NARW. Protective measures would be implemented.	Dredging = MANLAA; Long term =NE. Vessel transportation during construction may affect, but is not likely to adversely affect the NARW. Protective measures would be implemented.	Dredging = MANLAA; Long term =NE. Vessel transportation during construction may affect, but is not likely to adversely affect the NARW. Protective measures would be implemented.
Humpback Whale	O&M would continue to operate under the current South Atlantic Regional Biological Opinion.	MANLAA/NE Vessel transportation during construction may affect, but is not likely to adversely affect the humpback whale. Protective measures would be implemented.	Dredging = MALAA; Long term =NE. Vessel transportation during construction may affect, but is not likely to adversely affect the humpback whale. Protective measures would be implemented.	Dredging = MALAA; Long term =NE. Vessel transportation during construction may affect, but is not likely to adversely affect the humpback whale. Protective measures would be implemented.	Dredging = MALAA; Long term =NE. Vessel transportation during construction may affect, but is not likely to adversely affect the humpback whale. Protective measures would be implemented.	Dredging = MALAA; Long term =NE. Vessel transportation during construction may affect, but is not likely to adversely affect the humpback whale. Protective measures would be implemented.	Dredging = MALAA; Long term =NE. Vessel transportation during construction may affect, but is not likely to adversely affect the humpback whale. Protective measures would be implemented.
West Indian Manatee	O&M would continue to operate under the current South Atlantic Regional Biological Opinion.	Dredging = MANLAA; Long term =NE. Construction may affect, but is not likely to adversely affect the manatee. Protective measures would be implemented.	Dredging = MANLAA; Long term =NE. Construction may affect, but is not likely to adversely affect the manatee. Protective measures would be implemented.	Dredging = MANLAA; Long term =NE. Construction may affect, but is not likely to adversely affect the manatee. Protective measures would be implemented.	Dredging = MANLAA; Long term =NE. Construction may affect, but is not likely to adversely affect the manatee. Protective measures would be implemented.	Dredging = MANLAA; Long term =NE. Construction may affect, but is not likely to adversely affect the manatee. Protective measures would be implemented.	Dredging = MANLAA; Long term =NE. Construction may affect, but is not likely to adversely affect the manatee. Protective measures would be implemented.
American Woodstork	O&M would continue to operate under the current South Atlantic Regional Biological Opinion.	NE. Possible beneficial use alternatives could result in positive effects through habitat enhancement.	NE. Possible beneficial use alternatives could result in positive effects through habitat enhancement.	NE. Possible beneficial use alternatives could result in positive effects through habitat enhancement.	NE. Possible beneficial use alternatives could result in positive effects through habitat enhancement.	NE. Possible beneficial use alternatives could result in positive effects through habitat enhancement.	NE. Possible beneficial use alternatives could result in positive effects through habitat enhancement.
Seabeach Amaranth	Would continue to operate under the current South Atlantic Regional Biological Opinion.	NE	NE	NE	NE	NE	NE
Piping Plover	O&M would continue to operate under the current South Atlantic Regional Biological Opinion.	NE. Possible beneficial use alternatives could result in positive effects through habitat enhancement.	NE. Possible beneficial use alternatives could result in positive effects through habitat enhancement.	NE. Possible beneficial use alternatives could result in positive effects through habitat enhancement.	NE. Possible beneficial use alternatives could result in positive effects through habitat enhancement.	NE. Possible beneficial use alternatives could result in positive effects through habitat enhancement.	NE. Possible beneficial use alternatives could result in positive effects through habitat enhancement.
Rufa Red Knot	O&M would continue to operate under the current South Atlantic Regional Biological Opinion.	NE. Possible beneficial use alternatives could result in positive effects through habitat enhancement.	NE. Possible beneficial use alternatives could result in positive effects through habitat enhancement.	NE. Possible beneficial use alternatives could result in positive effects through habitat enhancement.	NE. Possible beneficial use alternatives could result in positive effects through habitat enhancement.	NE. Possible beneficial use alternatives could result in positive effects through habitat enhancement.	NE. Possible beneficial use alternatives could result in positive effects through habitat enhancement.

Table 3-5. Summary of Environmental Impacts (Environmental Quality Account) (Cont'd)

	Alternative						
Environmental Factor	**No Action**	**48/47**	**48/48**	**50/47**	**50/48**	**52/47**	**52/48**
Marine Mammals	Future maintenance dredging may impact marine mammals. Protective measures would be implemented.	Dredging and disposal may impact marine mammals. Protective measures would be implemented. Impact would be temporary and isolated to the dredging areas during the construction phase.	Dredging and disposal may impact marine mammals. Protective measures would be implemented. Impact would be temporary and isolated to the dredging areas during the construction phase.	Dredging and disposal may impact marine mammals. Protective measures would be implemented. Impact would be temporary and isolated to the dredging areas during the construction phase.	Dredging and disposal may impact marine mammals. Protective measures would be implemented. Impact would be temporary and isolated to the dredging areas during the construction phase.	Dredging and disposal may Impact t marine mammals. Protective measures would be implemented. Impact would be temporary and isolated to the dredging areas during the construction phase.	Dredging and disposal may impact marine mammals. Protective measures would be implemented. Impact would be temporary and isolated to the dreading areas during the construction phase.
Essential Fish Habitat							
Fish Habitat Suitability (% change in Habitat Units from No Action [Habitat Units are determined by multiplying the area by the habitat quality score {0-1 scale}])	The numbers below represent the % change between the No Action Alternative and the existing condition. Habitat suitability changes (+and-) are from small changes in water quality parameters (DO, salinity, temperature, velocity).	The numbers below represent the % change between the no action and the alternative. While there are some decreases in fish habitat, none of the predicted changes are significant enough to warrant mitigation. Habitat suitability changes (+and-) are from small changes in water quality parameters (DO, salinity, temperature, velocity).	The numbers below represent the % change between the no action and the alternative. While there are some decreases in fish habitat, none of the predicted changes are significant enough to warrant mitigation. Habitat suitability changes (+and-) are from small changes in water quality parameters (DO, salinity, temperature, velocity). Impacts slightly greater than the 48/47 alternative	The numbers below represent the % change between the no action and the alternative. While there are some decreases in fish habitat, none of the predicted changes are significant enough to warrant mitigation. Habitat suitability changes (+and-) are from small changes in water quality parameters (DO, salinity, temperature, velocity). Impacts slightly greater than the 48/48 alternative	The numbers below represent the % change between the no action and the alternative. While there are some decreases in fish habitat, none of the predicted changes are significant enough to warrant mitigation. Habitat suitability changes (+and-) are from small changes in water quality parameters (DO, salinity, temperature, velocity). Impacts slightly greater than the 50/47 alternative	The numbers below represent the % change between the no action and the alternative. While there are some decreases in fish habitat, none of the predicted changes are significant enough to warrant mitigation. Habitat suitability changes (+and-) are from small changes in water quality parameters (DO, salinity, temperature, velocity). Impacts slightly greater than the 50/48 alternative	The numbers below represent the % change between the no action and the alternative. While there are some decreases in fish habitat, none of the predicted changes are significant enough to warrant mitigation. Habitat suitability changes (+and-) are from small changes in water quality parameters (DO, salinity, temperature, velocity). Impacts slightly greater than the 52/47 alternative
Striped Bass Spawning	-1.90	-0.77	-0.93	-1.11	-1.26	-1.48	-1.76
Striped Bass Egg	0.69	-2.29	-2.30	-2.71	-2.72	-3.29	-3.30
Striped Bass Larval	-16.64	0.32	1.44	0.01	0.22	-2.08	-2.23
Striped Bass Adult and Juvenile	0.01	0.14	0.13	0.18	0.18	-0.27	-0.28
Blueback Herring Juvenile	-2.91	-3.48	-3.48	-3.48	-3.99	-4.36	-4.82
Blueback Herring SAEL	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Red Drum	-4.74	0.99	1.15	1.45	1.60	2.15	2.46
Southern Flounder	-0.33	-0.46	-0.47	-0.73	-0.64	-0.90	-0.95

Table 3-5. Summary of Environmental Impacts (Environmental Quality Account) (Cont'd)

	Alternative						
Environmental Factor	**No Action**	**48/47**	**48/48**	**50/47**	**50/48**	**52/47**	**52/48**
Shortnose Sturgeon Foraging	0.07	0.08	0.08	0.13	0.11	0.19	0.19
Shortnose Sturgeon Spawning	-1.74	-1.74	-1.73	-1.73	-2.62	-2.62	-3.44
Atlantic Sturgeon Adult	-2.40	-1.66	-1.68	-2.70	-2.80	-3.83	-3.97
Atlantic Sturgeon Egg and Larval	-2.11	-2.97	-3.31	-4.08	-4.96	-4.96	-4.96
Atlantic Sturgeon Juvenile	-3.13	-1.55	-1.77	-2.80	-3.21	-4.56	-4.56
Atlantic Sturgeon Spawning	-7.72	-0.96	-1.79	-1.79	-1.79	-2.70	-2.70
Birds	No new impactsfrom continued operations and maintenance of the existing federal navigation channel. Continued stress to sensitive bird areas (i.e., Crab Bank and Shutes Folly Island) will occur from sea level rise and erosive forces from wave action. Erosive forces from wave energy are predicted to be greater.	No effect is anticipated from construction. Beneficial use options may positively affect bird nesting/roosting/foraging habitat.	No effect is anticipated from construction. Beneficial use options may positively affect bird nesting/roosting/foraging habitat.	No effect is anticipated from construction. Beneficial use options may positively affect bird nesting/roosting/foraging habitat.	No effect is anticipated from construction. Beneficial use options may positively affect bird nesting/roosting/foraging habitat.	No effect is anticipated from construction. Beneficial use options may positively affect bird nesting/roosting/foraging habitat.	No effect is anticipated from construction. Beneficial use options may positively affect bird nesting/roosting/foraging habitat.
Benthic Resources	Complete removal of benthic infauna and epifauna will occur with every maintenance dredging event, followed by a recovery.	Complete removal of benthic infauna and epifauna followed by a recovery. No different than performing annual maintenance dredging.	Complete removal of benthic infauna and epifauna followed by a recovery. No different than performing annual maintenance dredging.	Complete removal of benthic infauna and epifauna followed by a recovery. No different than performing annual maintenance dredging.	Complete removal of benthic infauna and epifauna followed by a recovery. No different than performing annual maintenance dredging.	Complete removal of benthic infauna and epifauna followed by a recovery. No different than performing annual maintenance dredging.	Complete removal of benthic infauna and epifauna followed by a recovery. No different than performing annual maintenance dredging.
Hardbottom Habitat	O&M of the existing federal navigation channel will have no additional effect on undisturbed hardbottom habitats in the area.	Will result in the potential removal of hardbottom habitat along the slope of the Entrance Channel to support the new depth. The impacts will be from direct removal as well as a 5% injury to habitat resulting from turbidity and sedimentation from dredging operations. Total impacts to mitigate for are 28.6 acres	Will result in potential removal of hardbottom habitat along the slope of the Entrance Channel to support the new depth. The impacts will be from direct removal as well as a 5% injury to habitat resulting from turbidity and sedimentation from dredging operations. Total impacts to mitigate for are 28.6 acres	Will result in the potential removal of hardbottom habitat along the slope of the Entrance Channel to support the new depth. The impacts will be from direct removal as well as a 5% injury to habitat resulting from turbidity and sedimentation from dredging operations. Total impacts to mitigate for are 28.6 acres	Will result in the potential removal of hardbottom habitat along the slope of the Entrance Channel to support the new depth. The impacts will be from direct removal as well as a 5% injury to habitat resulting from turbidity and sedimentation from dredging operations. Total impacts to mitigate for are 28.6 acres	Will result in the potential removal of hardbottom habitat along the slope of the Entrance Channel to support the new depth. The impacts will be from direct removal as well as a 5% injury to habitat resulting from turbidity and sedimentation from dredging operations. Total impacts to mitigate for are 28.6 acres	Will result in the potential removal of hardbottom habitat along the slope of the Entrance Channel to support the new depth. The impacts will be from direct removal as well as a 5% injury to habitat resulting from turbidity and sedimentation from dredging operations. Total impacts to mitigate for are 28.6 acres

Table 3-5. Summary of Environmental Impacts (Environmental Quality Account) (Cont'd)

	Alternative						
Environmental Factor	**No Action**	**48/47**	**48/48**	**50/47**	**50/48**	**52/47**	**52/48**
Invasive Species	O&M of the existing federal navigation channel will have no additional effect on invasive species. However, the No Action results in an even greater number of vessels predicted to call on the Port.	This alternative will not cause additional threats from invasive species. Regulations will help control aquatic invasive species.	This alternative will not cause additional threats from invasive species. Regulations will help control aquatic invasive species.	This alternative will not cause additional threats from invasive species. Regulations will help control aquatic invasive species.	This alternative will not cause additional threats from invasive species. Regulations will help control aquatic invasive species.	This alternative will not cause additional threats from invasive species. Regulations will help control aquatic invasive species.	This alternative will not cause additional threats from invasive species. Regulations will help control aquatic invasive species.
Environmental Justice	O&M of the existing federal navigation channel will have no effect on EJ communities.	The alternative is not anticipated to have a disproportionately high and adverse impact on low income or minority communities from construction and/or secondary effects.	The alternative is not anticipated to have a disproportionately high and adverse impact on low income or minority communities from construction and/or secondary effects.	The alternative is not anticipated to have a disproportionately high and adverse impact on low income or minority communities from construction and/or secondary effects.	The alternative is not anticipated to have a disproportionately high and adverse impact on low income or minority communities from construction and/or secondary effects.	The alternative is not anticipated to have a disproportionately high and adverse impact on low income or minority communities from construction and/or secondary effects.	The alternative is not anticipated to have a disproportionately high and adverse impact on low income or minority communities from construction and/or secondary effects.
Noise	O&M of the existing federal navigation channel will have no additional effect on noise in the Harbor. However, the No Action results in an even greater number of vessels predicted to call on the Port.	Minor adverse impacts to aquatic species due to displacement. Temporary and minor impact to human populations due to the construction of project.	Minor adverse impacts to aquatic species due to displacement. Temporary and minor impact to human populations due to the construction of project. Slightly longer than 48/47.	Minor adverse impacts to aquatic species due to displacement. Temporary and minor impact to human populations due to the construction of project. Slightly longer than 48/48.	Minor adverse impacts to aquatic species due to displacement. Temporary and minor impact to human populations due to the construction of project. Slightly longer than 50/47	Minor adverse impacts to aquatic species due to displacement. Temporary and minor impact to human populations due to the construction of project. Slightly longer than 50/48.	Minor adverse impacts to aquatic species due to displacement. Temporary and minor impact to human populations due to the construction of project. Slightly longer than 52/47.
Aesthetics	O&M of the existing federal navigation channel will have no effect on area wide aesthetics. However, the No Action results in an even greater number of vessels predicted to call on the Port.	No effect to area wide aesthetics. Larger ships will transit more efficiently through the port. Not out of character for the Charleston area.	No effect to area wide aesthetics. Larger ships will transit more efficiently through the port. Not out of character for the Charleston area.	No effect to area wide aesthetics. Larger ships will transit more efficiently through the port. Not out of character for the Charleston area.	No effect to area wide aesthetics. Larger ships will transit more efficiently through the port. Not out of character for the Charleston area.	No effect to area wide aesthetics. Larger ships will transit more efficiently through the port. Not out of character for the Charleston area.	No effect to area wide aesthetics. Larger ships will transit more efficiently through the port. Not out of character for the Charleston area.
Coastal Barrier Resources	O&M of the existing federal navigation channel will have no effect on CBRA zones. Any future beneficial use projects, including nearshore placement off Morris Island would be a positive effect on the Morris Island Complex or other nearby CBRA zone.	No effect to CBRA Zones as a result of deepening. Beneficial use option for Morris Island, if identified during PED, would occur within the Morris Island Complex and would have positive effects.	No effect to CBRA Zones as a result of deepening. Beneficial use option for Morris Island, if identified during PED, would occur within the Morris Island Complex and would have positive effects.	No effect to CBRA Zones as a result of deepening. Beneficial use option for Morris Island, if identified during PED, would occur within the Morris Island Complex and would have positive effects.	No effect to CBRA Zones as a result of deepening. Beneficial use option for Morris Island, if identified during PED, would occur within the Morris Island Complex and would have positive effects.	No effect to CBRA Zones as a result of deepening. Beneficial use option for Morris Island, if identified during PED, would occur within the Morris Island Complex and would have positive effects.	No effect to CBRA Zones as a result of deepening. Beneficial use option for Morris Island, if identified during PED, would occur within the Morris Island Complex and would have positive effects.

Table 3-5. Summary of Environmental Impacts (Environmental Quality Account) (Cont'd)

	Alternative						
Environmental Factor	**No Action**	**48/47**	**48/48**	**50/47**	**50/48**	**52/47**	**52/48**
Cultural and Historic Resources	O&M of the existing federal navigation channel will have no effect on cultural and historic resources. As noted, more vessels are anticipated to call on the Port with the No Action Alternative.	No long term effect. No adverse alteration of eligibility characteristics of historic properties. Dredging in the Hog Island Reach will require an archaeologist on board due to potential artifact nearby the dredging area	No long term effect. No adverse alteration of eligibility characteristics of historic properties. Dredging in the Hog Island Reach will require an archaeologist on board due to potential artifact nearby the dredging area	No long term effect. No adverse alteration of eligibility characteristics of historic properties. Dredging in the Hog Island Reach will require an archaeologist on board due to potential artifact nearby the dredging area	No long term effect. No adverse alteration of eligibility characteristics of historic properties. Dredging in the Hog Island Reach will require an archaeologist on board due to potential artifact nearby the dredging area	No long term effect. No adverse alteration of eligibility characteristics of historic properties. Dredging in the Hog Island Reach will require an archaeologist on board due to potential artifact nearby the dredging area	No long term effect. No adverse alteration of eligibility characteristics of historic properties. Dredging in the Hog Island Reach will require an archaeologist on board due to potential artifact nearby the dredging area

No Anchorage Allowed Within Hardbottom Habitat During Construction. As a means to avoid or minimize effects of anchorage during dredging on hardbottom habitat, the design specifications will be written to require the contractor to avoid anchoring of equipment within adjacent hardbottom habitat. The approximate locations of these resources will be shown in the contract drawings. If the contractor is required to anchor outside the channel to utilize a cutterhead dredge, anchor placement shall be placed to avoid affecting any of the identified hardbottom habitat or any of the created hardbottom habitat reefs.

Hardbottom Habitat Impacts. To avoid direct impacts to hardbottom habitat in the Entrance Channel, an avoidance measure was coordinated with the ICT. This method involves maintaining the existing channel side slopes and extending them downward, rather than the more typical approach of maintaining the existing bottom width and extending the side slopes outward. The measure would avoid all direct impacts to hardbottom habitat along the margins of the Entrance Channel. This measure has the additional benefit of reducing the quantity of dredged material. The only impact to the Navigation Channel would be the movement of the toe of the ledge inward by roughly 20 feet on either side. The overall channel would be 944’ rather than 1000’ (Figure 1), with no loss of width in the main shipping channel.

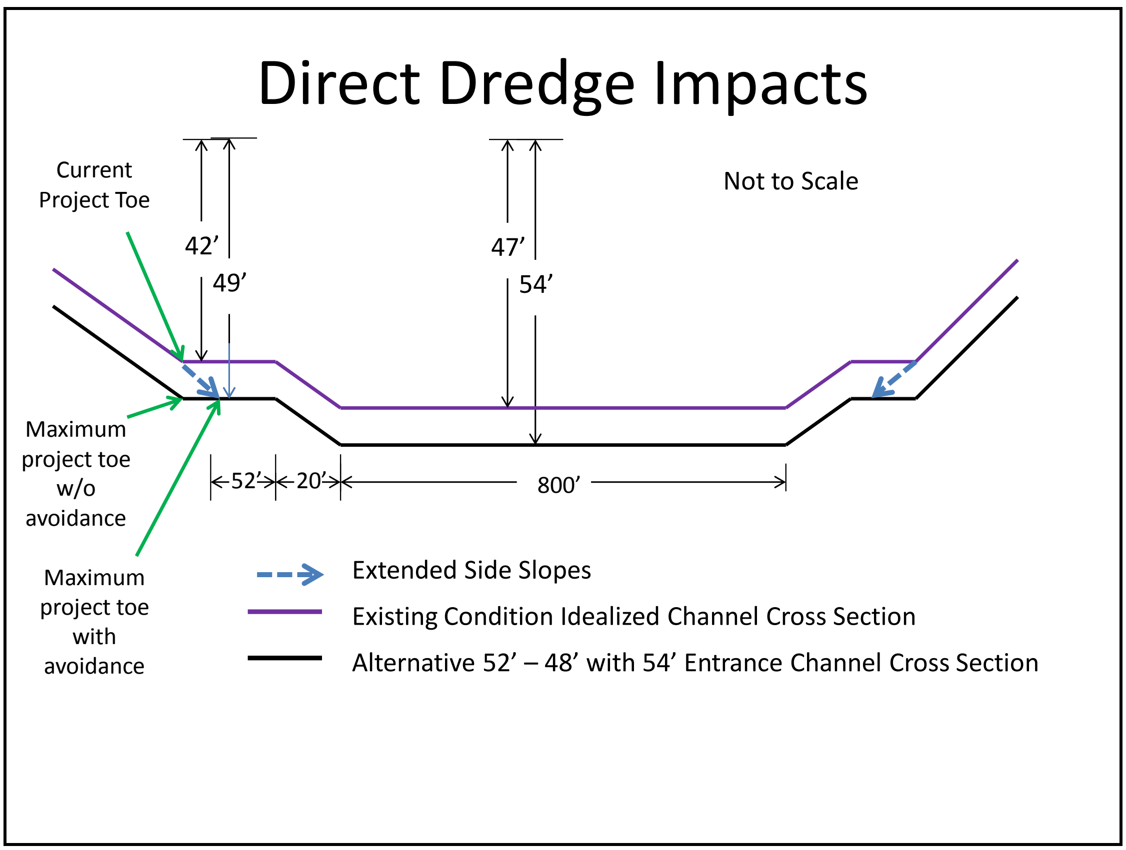


Figure 3-10. Avoidance of hardbottom habitat impacts 1,000 foot – 944-foot reduction

Biological Impacts from Rock Blasting. Geotechnical investigations involving rock strength analysis indicates the rock that requires removal to obtain the project depth can be removed with either a cutterhead dredge or a rock bucket clamshell dredge and will not require blasting. As a result of this analysis the District intends to avoid blasting as an option for rock removal, therefore eliminating any potential effects resulting from noise impacts to marine mammals and fish that blasting may cause.

PED Phase Channel Widening Reductions. During the Preconstruction Engineering and Design (PED) phase, the District will use ship simulation results to optimize the widening and turning basin expansion measures to the size necessary to safely maneuver vessels. For purposes of the impact assessment in the feasibility phase, these measures have been assumed to be at maximum size. The optimization of those measures during PED could reduce environmental impacts to DO, fish habitat, salinity intrusion, wetlands, and shallow subtidal habitat, as well as the projected increase in channel shoaling.

Use of Existing Upland Disposal Sites. Environmental impacts associated with any expansion of the footprint of upland confined disposal facilities (CDFs) in Charleston Harbor for the Post 45 project are avoided by the use of existing, previously-used disposal sites. New CDFs would necessitate direct impacts to and loss of estuarine wetlands. New CDFs would, however, increase the dredged material disposal capacity in the harbor and in the long-term would ease the coordination and scheduling necessary for the use of existing CDFs.

Alternative Disposal Sites and Beneficial Use of Dredged Material. The proposed project contemplates the use of materials from the navigation channels for various beneficial uses. These include the placement of materials for offshore hardbottom reefs, as well as within the Lower Harbor at Crab Bank and Shutes Folly Island. These materials would otherwise go into the ODMDS, decreasing the expected life of the disposal site and/or requiring either expansion of the site or consideration of a new site.

Use of Advanced Maintenance to Reduce Dredging Frequency. The continued use of advanced maintenance for portions of the navigation channel which experience more rapid shoaling serves to reduce the frequency of future maintenance dredging requirements after deepening. This, in turn, reduces the frequency of the temporary adverse impacts associated with maintenance dredging, such as increased turbidity, removal of sediment and benthos, and fish displacement.

3.5.3.2 Alternatives with the Maximum/Minimum Environmental Impact

The alternative with the maximum environmental impact is the 52/48 alternative, which is described above. The higher level of impacts is a result of having the deepest depths of any of the alternatives. Compared to the other depth alternatives, the greater impacts result from the larger project footprint and longer construction/dredging/disposal durations. The most noteworthy impacts are related to wetlands, DO, and fish habitat. The alternative with the least environmental impacts is Alternative 48/48, which is described above. As with the deeper alternatives, the impacts result from increased depths affecting various resources. Impacts to wetlands, DO, fish habitat, and hardbottom habitat are unavoidable if any one of the final array of alternatives is constructed.

3.5.4 Other Social Effects

An increase in the amount of cargo moving through the port over time is predicted. That increase is expected to occur with or without navigation improvements. Without improvements, more vessels would be required to transport the increased cargo volumes that are forecasted. However, with implementation of any of the deepening alternatives, the total number of vessels would decrease, compared to the without project conditions, with the 52/48 alternative having the lowest number of vessels transiting the harbor. Similarly, channel improvements would not induce additional growth including additional traffic, noise, or lighting.

Since the total throughput is not predicted to change as a result of deepening, no landside changes in overall air pollutant emissions would result from channel improvements. However, implementation of any of the alternatives results in a reduction in the number of vessels used to transport cargo. As a result, total air emissions within the harbor and at each terminal would decrease as a result of any of the alternatives, with the 52/48 alternative resulting in the lowest overall emissions and the lowest emissions at each terminal. Additionally, increased depths would reduce congestion and allow vessels more flexibility of movement than under the without project conditions. This would allow traffic to be spread over wider time ranges rather than concentrating all of the largest vessel traffic during high tide stages. Social effects of the alternatives considered are summarized in Table 3-6. Additional information about air quality impacts can be found in Appendix N.

As a whole, the area of interest does not contain disproportionate populations of minority, juvenile, elderly, or low-income communities. However, some census tracts within the area of interest contain disproportionate populations of minority, juvenile, elderly, or low-income communities when compared to the surrounding tri-county area (see Appendix C). Construction of any of the alternatives would not have a disproportionally high and adverse impact on areas with high concentrations of low-income, minority, juvenile, or elderly populations because the impacts of harbor deepening (to the extent upland areas are appreciably impacted) are spread proportionately among census tracts. Schools/childcare facilities and hospitals are dispersed throughout the area and are not disproportionately located near the harbor. Thus, no disproportionately high and adverse impacts to children are expected. The general absence of adverse impacts to human health, environmental health risks, and safety risk also indicates the proposed project would not have disproportionately high and adverse impacts to any communities, including environmental justice communities or children.

Table 3-6. Other Social Effects Comparison of Alternatives

	Alternative						
Social Factor	**48/47**	**48/48**	**50/47**	**50/48**	**52/47**	**52/48**	**No Action**
Life, Health, and Safety	No effect on life, health, or safety	No effect on life, health, or safety	No effect on life, health, or safety	No effect on life, health, or safety	No effect on life, health, or safety	No effect on life, health, or safety	No effect on life, health, or safety
Community Cohesion	No effect on community cohesion	No effect on community cohesion	No effect on community cohesion	No effect on community cohesion	No effect on community cohesion	No effect on community cohesion	No effect on community cohesion
Community Growth	Growth trends in population would be unaffected.	Growth trends in population would be unaffected.	Growth trends in population would be unaffected.	Growth trends in population would be unaffected.	Growth trends in population would be unaffected.	Growth trends in population would be unaffected.	Growth trends in population would be unaffected.
Traffic and Transportation	Traffic and transportation would be unaffected because the alternative does not induce more commodities to the Port of Charleston	Traffic and transportation would be unaffected because the alternative does not induce more commodities to the Port of Charleston	Traffic and transportation would be unaffected because the alternative does not induce more commodities to the Port of Charleston	Traffic and transportation would be unaffected because the alternative does not induce more commodities to the Port of Charleston	Traffic and transportation would be unaffected because the alternative does not induce more commodities to the Port of Charleston	Traffic and transportation would be unaffected because the alternative does not induce more commodities to the Port of Charleston	Traffic and transportation would be unaffected because the alternative does not induce more commodities to the Port of Charleston
Environmental Justice	The alternative is not anticipated to have a disproportionate impact on low income or minority communities from construction and/or secondary effects.	The alternative is not anticipated to have a disproportionate impact on low income or minority communities from construction and/or secondary effects.	The alternative is not anticipated to have a disproportionate impact on low income or minority communities from construction and/or secondary effects.	The alternative is not anticipated to have a disproportionate impact on low income or minority communities from construction and/or secondary effects.	The alternative is not anticipated to have a disproportionate impact on low income or minority communities from construction and/or secondary effects.	The alternative is not anticipated to have a disproportionate impact on low income or minority communities from construction and/or secondary effects.	No effect.
Noise	Dredging operations will result in insignificant to minor temporary increase in ambient noise in nearby communities along the Cooper River nearest to the federal channel. However, this area adjacnet to the River is predominantly industrial/commercial and is not disproportionate or out of place.	Dredging operations will result in insignificant to minor temporary increase in ambient noise in nearby communities along the Cooper River nearest to the federal channel. However, this area adjacnet to the River is predominantly industrial/commercial and is not disproportionate or out of place.	Dredging operations will result in insignificant to minor temporary increase in ambient noise in nearby communities along the Cooper River nearest to the federal channel. However, this area adjacnet to the River is predominantly industrial/commercial and is not disproportionate or out of place.	Dredging operations will result in insignificant to minor temporary increase in ambient noise in nearby communities along the Cooper River nearest to the federal channel. However, this area adjacnet to the River is predominantly industrial/commercial and is not disproportionate or out of place.	Dredging operations will result in insignificant to minor temporary increase in ambient noise in nearby communities along the Cooper River nearest to the federal channel. However, this area adjacnet to the River is predominantly industrial/commercial and is not disproportionate or out of place.	Dredging operations will result in insignificant to minor temporary increase in ambient noise in nearby communities along the Cooper River nearest to the federal channel. However, this area adjacnet to the River is predominantly industrial/commercial and is not disproportionate or out of place.	No effect.
Aesthetics	No effect to area wide aesthetics. Larger ships will transit through the port. Not out of character for the Charleston area.	No effect to area wide aesthetics. Larger ships will transit through the port. Not out of character for the Charleston area.	No effect to area wide aesthetics. Larger ships will transit through the port. Not out of character for the Charleston area.	No effect to area wide aesthetics. Larger ships will transit through the port. Not out of character for the Charleston area.	No effect to area wide aesthetics. Larger ships will transit through the port. Not out of character for the Charleston area.	No effect to area wide aesthetics. Larger ships will transit through the port. Not out of character for the Charleston area.	No effect to area wide aesthetics. An even greater number of ships are predicted to call on the port.

3.6 Plan Selection

The primary decision criteria for identifying the National Economic Development (NED) Plan includes reasonably maximizing net benefits while remaining consistent with the federal objective of protecting the nation's environment. Contributions to NED are increases in the net value of the national output of goods and services, expressed in monetary units. For this study, the contributions to NED are the direct net benefits that accrue in the planning area and the rest of the nation.

Based on a difference in average annual net benefits of about $10 million per year, between the 48/48 and the 50/48 plans compared with about a $2 million per year difference between the 50/48 and 52/48 plans, the 48/48 plan was dropped from further consideration prior to a final round of cost and benefit refinements. Table 3-4 presents the results of that analysis.

Table 3-7. Summary of FY15 (Price Levels 1 Oct 14) final cost dated 4-13-15 and benefits analysis at Federal Discount Rate of 3.375% [Revised with 4-18-15 IDC]

Item	50/48	52/48	Difference
Project Cost	$476,000,000	$521,000,000	$45,000,000
Average Annual Costs	$25,700,000	$28,000,000	$2,300,000
Average Annual Benefits	$103,100,000	$108,900,000	$5,800,000
Net Benefits	$77,400,000	$80,900,000	$3,500,000
Benefit Cost Ratio	4.01	3.89	-0.12

Reference: Also see, Table 49 in Economics Appendix C for benefits and costs

Table 3-7 above provides the total average annual equivalent (AAEQ) benefits, the AAEQ costs, and the net benefits for the 50/48 and 52/48 alternatives. ER 1105-2-100 (Appendix G, Exhibit G-1) states the following: "Identification of the NED plan is to be based on consideration of the most effective plans for providing different levels of output or service. Where two cost-effective plans produce no significantly different levels of net benefits, the less costly plan is to be the National Economic Development (NED) plan, even though the level of outputs may be less." While the 52/48 plan in Table 3-7 absolutely maximizes AAEQ net benefits at $80,900,000, the 50/48 plan provides AAEQ net benefits of $77,400,000 or an AAEQ difference of approximately $3,500,000.

The difference in net benefits is small enough to become subject to the interpretation of the meanings of "reasonably maximizing" and "significantly different" and closer consideration of the differences in the environmental impacts of each alternative. As presented, the cost estimate for each alternative includes the costs to mitigate for environmental impacts and the costs to monitor those impacts and ensure the performance of the mitigation actions during and after construction. Additionally, no unacceptable environmental impacts were identified for either alternative, and the environmental impacts are similar in nature and are not out of proportion in magnitude when compared with each other and the No Action Alternative. After careful consideration, the USACE decided to identify the 50/48 alternative as the NED Plan.

In accordance with ER-1105-2-100, study recommendations may deviate from the NED plan if requested by the non-Federal Sponsor and approved by the ASA (CW). If the sponsor prefers a plan more costly than the NED plan and the increased scope of the plan is not sufficient to warrant full federal participation, the ASA (CW) may grant a waiver from the requirement to recommend the NED Plan as long as the sponsor pays the difference in cost between the NED Plan and what is known as the Locally Preferred Plan (LPP). In this case, the LPP must have outputs similar in kind, and equal to or greater than the outputs of the NED Plan. It may also have other outputs. The incremental benefits, impacts, and costs of the LPP, beyond the NED Plan, must be analyzed and documented in the Final IFR/EIS.

3.6.1 Deviation from the NED Plan - Reasons for the LPP

Following the USACE decision to identify the 50/48 alternative as the NED Plan in the draft report the SCSPA submitted a letter (See Appendix Q), dated August 20, 2014, formally requesting that the 52/48 plan be considered as an LPP. Accordingly, the SCSPA acknowledged a willingness to pay for the incremental cost of the project ($45 Million – Table 3-7 above) to achieve the LPP if the USACE does not identify the 52/48 alternative as the NED Plan. The ASA(CW) approved the LPP in a memorandum dated October 1, 2014.

The SCSPA believes that modern containerships requiring 48 feet of draft and appropriate under keel clearance will be the dominant vessels calling within the next 5 years. The SCSPA wants the ability to handle this class of Generation II and III containerships without tidal restrictions. Additionally, the SCSPA has expressed a desire to avoid the need for, and costs associated with additional studies, separate construction, and environmental impacts that would result if a follow-up feasibility study and project were needed within the foreseeable future.

3.6.1.1 LPP Economic Considerations

The SCSPA has elected to pay for the additional 2 feet of project depth in Segments 1 and 2 based on its own assessment of the future utilization of Post-Panamax (Generation II and III) container vessels at Charleston Harbor. The SCSPA strongly believes that modern container vessels requiring 48-feet of draft with appropriate allowable under keel clearance will be the dominant service vessel calling at their facilities within the next 5 years. The SCSPA wants the ability to handle this class of Generation II and III container vessels without tidal restriction in order to serve one of the fastest growing regions in the country, which has experienced a resurgence of manufacturing and continued agricultural success.

The benefits are derived from the container vessel portion of the fleet. The LPP has more net benefits than the NED plan and the benefits of the LPP are similar in kind (i.e., transportation cost savings). The 52/48 alternative derives its higher net benefits from the Post-Panamax Generation III container vessel that is a portion of the future vessel fleet calling on the Port of Charleston, with a slight shift to a deeper draft depth compared with a 50-foot channel.

3.6.1.2 LPP Environmental Considerations

The LPP and NED plans have similar mitigation requirements, with the LPP requiring about 189.6 acres more wetland mitigation than the NED Plan. Adverse environmental impacts have been avoided and minimized as described in Section 3.6.3.1. Mitigation requirements for the unavoidable adverse environmental impacts related to the NED plan and the LPP are included in Table 3-8 below, which contains required acreages for the preservation of wetlands. Mitigation for impacts to approximately

28.6 acres of hardbottom habitat within the channel would be the same for both the NED plan and LPP. The least cost plan for placement of rock involves constructing eight new 33-acre reefs. Two of the reefs are to mitigate for hardbottom impacts within the navigation channel (1 required; 1 contingency). The LPP also has slightly higher impacts to water quality, fish habitat, and endangered species (due to more required dredging) than the NED plan. The project includes consideration of other potential beneficial uses of dredged material, which will be examined during the PED phase.

Table 3-8. Wetland impacts and wetland mitigation

Wetland Impacts	50/48	52/48
Ashley River forested wetlands	3.52 acres	4.36 acres
Ashley River marsh wetlands	10.86 acres	13.16 acres
Cooper River forested wetlands	89.65 acres	126.37 acres
Cooper River marsh wetlands	127.57 acres	179.83 acres
Total	**231.60 acres**	**323.72 acres**
Total Acres of Wetland Mitigation Required [2]	**476**	**665.6**

[1] Value derived from UMAM tool documented in Appendix P

3.6.2 Recommended Plan

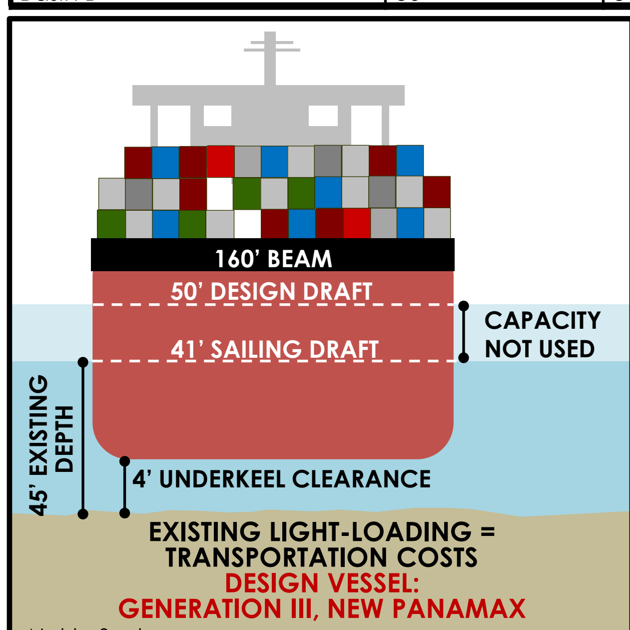
The Recommended Plan is the 52/48 plan or the sponsor's Locally Preferred Plan (LPP) as shown in Table 3-7. The non-Federal Sponsor has agreed to pay the additional cost or the difference between the LPP and NED Plan. The Recommended Plan: Section 4 Reference Aid at the end of section 4 illustrates the Recommended Plan.

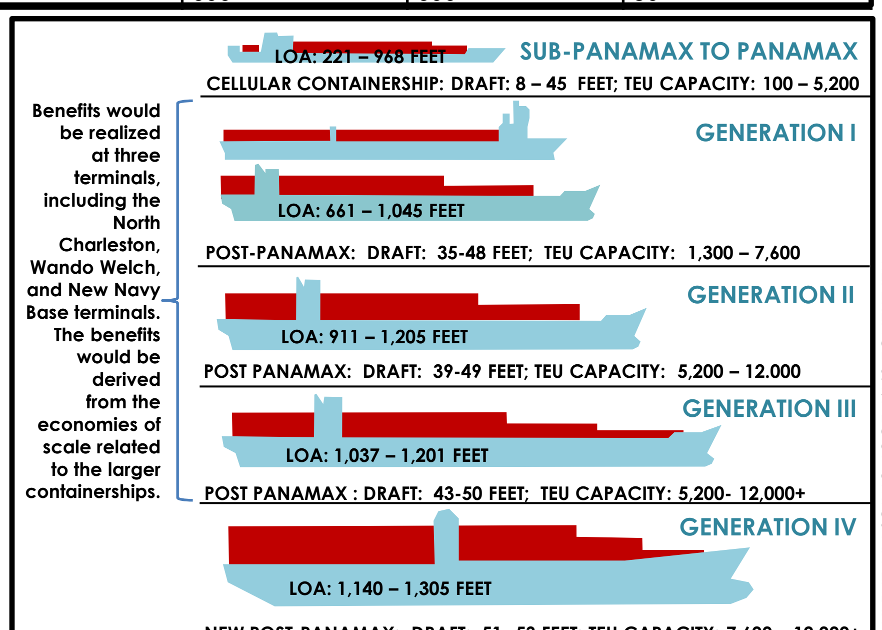
3.6.3 Optimization of the Recommended Plan

The depth of the proposed channel improvements are optimized based on economic benefits that are weighed against the costs and consideration of adverse environmental and social effects. This information was considered along with the comments received on the Draft IFR/EIS to select the Recommended Plan. However, widening measures are defined by safety considerations that were not fully analyzed during the feasibility phase. The assumed channel widening measures and turning basin sizes represent the best professional judgment of harbor and docking pilots to allow design vessels to access and utilize the terminals. These will undergo optimization with vessel simulation during the PED phase. If the widening measures and turning basins are reduced in size, the economic benefits would remain unchanged. However, the overall costs, and adverse impacts would be reduced. The Recommended Plan is further detailed in Section 4.

REFERENCE TABLE 1: CHARLESTON HARBOR EXISTING SEGMENT DIMENSIONS

REACH OR SEGMENT	NOMINAL DEPTH		NOMINAL CHANNEL WIDTH		MAXIMUM SAILING DRAFT (with a 5 to 6-foot flood tide condition)
	MAINTENANCE	AUTHORIZED	MAINTENANCE	AUTHORIZED	
Entrance Channel	47/42	47/42	42' at 1000'	42' at 1000'	47
Entrance Channel	47/42	47/42	47' at 800'	47' at 800'	47
ENTRANCE CHANNEL TO WANDO WELCH TERMINAL (LOWER HARBOR)					
Mount Pleasant Range	45	45	600-1000	600-1000	45
Rebellion Reach	45	45	600	600	45
Bennis Reach	45	45	600	600	45
Horse Reach	45	45	600	600	45
Hog Island Reach	45	45	600	600	45
Wando Channel Lower Reach	45	45	400	400	45
Wando Turning Basin (TB)	45	45	1400	1400	45
DRUM ISLAND TO NORTH CHARLESTON TERMINAL (UPPER HARBOR)					
Drum Island Reach	45	45	600	600	45
Myers Bend	45	45	VARIES	VARIES	45
Daniel Island Reach	45	45	880	880	45
Daniel Island Bend	45	45	700-880	700-880	45
Clouter Creek Reach	45	45	600	600	45
Navy Yard Reach	45	45	600-675	600-675	45
North Charleston Reach	45	45	500	500	45
Filbin Creek Reach	45	45	500	500	45
Port Terminal Reach	45	45	600	600	45
Ordnance Reach with TB	45	45	1400	1400	45
UNION PIER TO WEST OF DRUM ISLAND					
Custom House Reach	45	45	Varies	Varies	45
Upper Town Creek	16	16	250	250	16
Lower Town Creek	45	45	450	450	45
Town Creek Turning Basin	35	35	300	300	35
Tidewater Reach	40	40	650	650	40
OTHER FEDERAL CHANNELS					
Anchorage Basin	35	35	2250	2250	35
Shem Creek Channel	12	12	110	110	12
SHIPYARD RIVER					
Entrance Channel	45	45	300	300	45
Basin A	45	45	700	700	45
Connector Channel	45	45	200	200	45
Basin B	30	30	600	600	30





REFERENCE 3.4.1 ECONOMICS APPENDIX C

CHARLESTON HARBOR POST 45 PLAN FORMULATION: SECTION 3 REFERENCE AID

4.0 RECOMMENDED PLAN (RP)

Note: A Reference Aid at the end of this Section provides the reader with the following information about the Recommended Plan (RP): names of channel reaches, depths, widths, maximum widening measures and locations, planning segments, Entrance Channel extension, channel cross-section, standard navigation terminology, and port infrastructure.

This section provides a detailed description of the RP that was developed and selected through the plan formulation process. The details discussed in this chapter include plan components, design and construction considerations, operations and maintenance, dredged material placement, costs, benefits, risk and uncertainty, Non-Federal Sponsor's (NFS) view, Environmental Operating Principles (EOPs), and the USACE Campaign Plan. The RP represents the "proposed project" in the impacts analysis that is presented in Section 5 of this Final Integrated Feasibility Report and Environmental Impact Statement (IFR/EIS). However, as discussed in previous sections, many of the channel widening and turning basin enlargement measures are defined by safety considerations that will not be fully analyzed until the Preconstruction Engineering and Design (PED) phase. The assumed channel widening and turning basin sizes represent the maximum anticipated sizes based on the best professional judgment of harbor and docking pilots to allow design vessels to safely and efficiently utilize the terminals. These measures may be reduced in size following ship simulation studies that will be performed during the Preconstruction Engineering and Design (PED) phase. Reducing the size of these features would lower the environmental impacts and cost to construct and mitigate for the project.

The U.S. Army Corps of Engineers (USACE) process for selecting an alternative begins at the district and NFS level and expands, as products are developed, to incorporate the division and headquarters levels through a series of reviews and approvals, and at the same time allows for feedback and suggestions from resource agencies. For congressionally authorized projects, such as this, the final agency decision maker is the Secretary of the Army through the Assistant Secretary of the Army for Civil Works (ASA [CW]).

The navigation improvements included in the RP respond to local needs and desires as well as the economic and environmental criteria used to screen, evaluate, select, and refine measures and alternatives. If implemented, the RP would handle the current and forecasted vessel fleets and cargo volumes with improved safety, fewer delays, and less congestion and damages than under the No Action Alternative while avoiding all unacceptable adverse environmental impacts.

4.1 Description of the Recommended Plan (RP)

This section provides the details of the proposed changes and illustrates the general locations of the major features. Figures 3-7, 3-8, and 3-9 in Chapter 3 provide more detailed descriptions and locations of the RP features.

4.1.1 General Navigation Features

General navigation features include channels, jetties or breakwaters, locks and dams, basins or water areas for vessel maneuvering, turning, passing, mooring or anchoring incidental to transit of the channels and locks. Also included are dredged material disposal areas (except those for the inland navigation system, the Atlantic Intracoastal Waterway and the Gulf Intracoastal Waterway) and sediment basins.

The RP proposes to extend and deepen the Entrance Channel in combination with deepening and widening the inner harbor channels that primarily serve containerships. The proposed navigation improvements are described in more detail in the bullets and text that follow:

- Deepen the existing Entrance Channel from a project depth of -47 feet to -54 feet MLLW over the existing 800-foot bottom width, while reducing the existing stepped 1,000-foot width to 944 feet from an existing depth of -42 feet to a depth of -49 feet MLLW. The proposed deepening of the Entrance Channel also includes 1 to 2 feet of required overdepth dredging for Entrance Channel Segment 2 and advanced maintenance for Entrance Channel Segment 1 and up to 2 feet of allowable overdepth dredging as shown on Figure 4-1.
- Extend the Entrance Channel approximately three miles seaward to about the -57 foot MLLW contour.
- Deepen the inner harbor from an existing project depth of -45 feet to -52 feet MLLW to the Wando Welch Terminal on the Wando River and the new SCSPA Navy Base Terminal on the Cooper River, and from -45 feet to -48 feet MLLW for the reaches above that facility to the North Charleston Terminal (over varying expanded bottom widths ranging from 400 to 1,800 feet). The proposed deepening of the inner harbor also includes overdepth dredging and advance maintenance dredging as outlined in Appendix A (Engineering).
- Enlarge the existing turning basins to an 1,800-foot diameter at the Wando Welch and new Navy Base Terminals to accommodate Post-Panamax Generation 2 and 3 containerships and widen selected reaches as shown in the Recommended Plan: Section 4 Reference Aid at the end of this section.
- Enlarge the North Charleston Terminal turning basin to a 1,650-foot diameter to accommodate Post-Panamax Generation II and Generation III containerships. A turning basin at the new Navy Base Terminal will be part of the existing condition prior to the base year of the study (2022).
- Raise dikes and place dredged material from the upper harbor at the existing upland confined disposal facilities at Clouter Creek, Yellow House Creek, and/or Daniel Island; place material dredged from the lower harbor and sediment from the Entrance Channel at the expanded Ocean Dredged Material Disposal Site (ODMDS). Place some of the rock dredged from the Entrance Channel along the outside of the Entrance Channel and along the edges of the ODMDS to create hardbottom habitat.

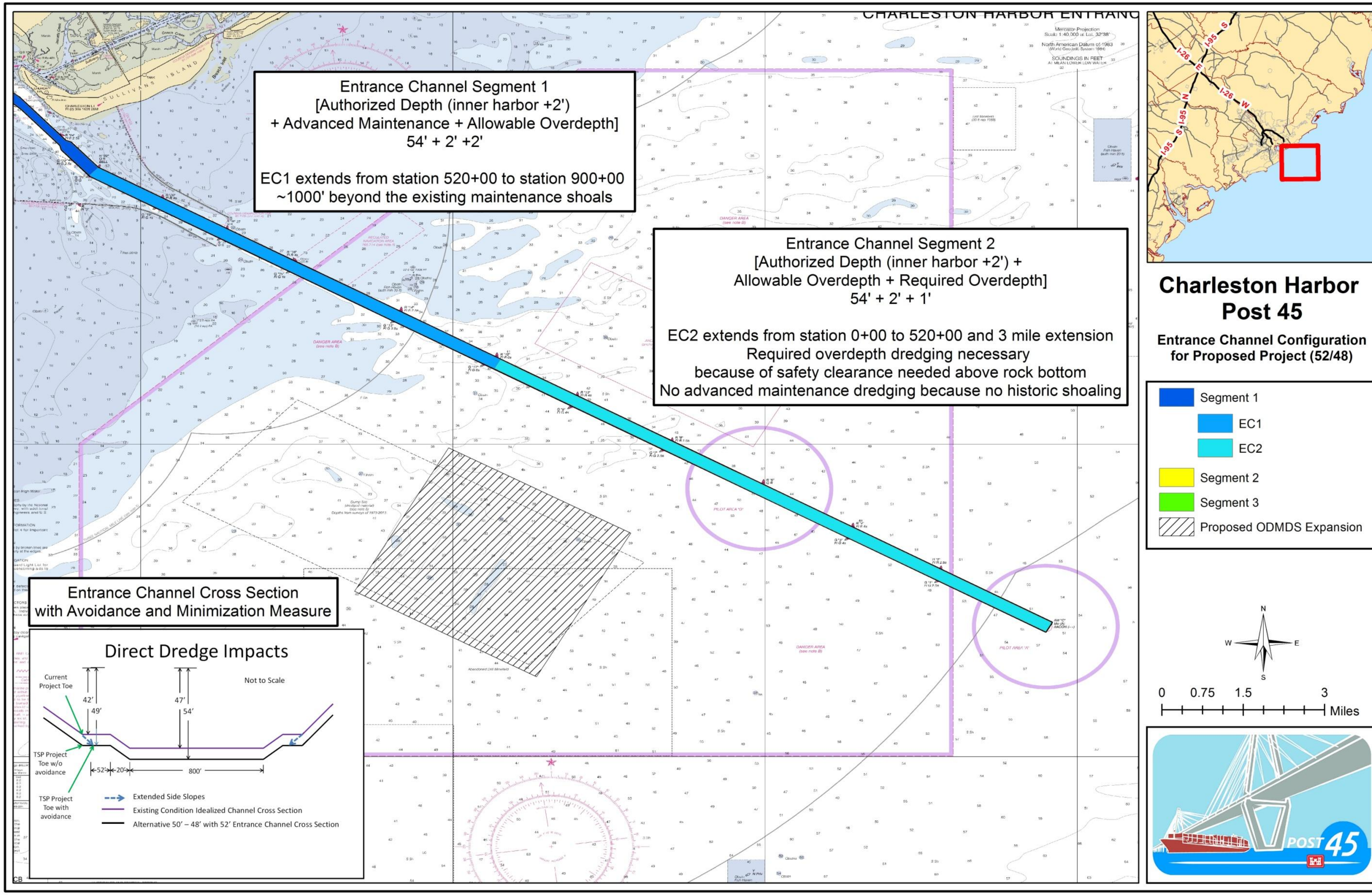


Figure 4-1. Proposed Entrance Channel modifications

4.1.2 Environmental Mitigation

This paragraph outlines the compensatory mitigation requirements associated with the RP. More detailed information about the impacts and the mitigation are provided in Section 4.3 and several supporting appendices (primarily Appendix P). The RP would indirectly impact about 323.72 acres of freshwater wetlands (emergent and forested) through changes in salinity, which could require compensatory mitigation in the form of preservation and conveyance of an estimated 665.56 acres to the US Forest Service (See Appendix P). Additionally, direct impacts to about 29 acres of hardbottom habitat within the Entrance Channel and extension footprint require mitigation. To compensate for impacts to hardbottom habitat, rock dredged from the Entrance Channel would be used to construct artificial reefs. Two reefs would be constructed as mitigation specifically to compensate for lost habitat in the channel and six reefs would be constructed as the least cost disposal method with an environmentally beneficial use of dredged material, as shown in Table 4-1. In total, 8 new 33-acre artificial reefs would be created along the margins of the Entrance Channel. Additionally, at the request of the South Carolina Department of Natural Resources (SCDNR), approximately 240,000 cy of rock material would also be placed at SCDNR's existing 25 acre Charleston Nearshore Reef. The total quantity of reef habitat created far exceeds the required mitigation. However, construction of the reefs near the Entrance Channel is less expensive than transporting the material to the ODMDS. The total amount of reef habitat created was limited based on conversations with SCDNR biologists in order to maintain an appropriate and productive balance of habitat types in the area.

4.2 Dredging and Dredged Material Management

Construction of the RP would generate about 40 million cubic yards (cy) of dredged material. To develop the least cost disposal plan, the most cost efficient methods to dredge and place the material from each reach was determined. The availability of multiple disposal areas near the channels and spaced throughout the project area allows significant flexibility and efficiency. However, the need to efficiently accommodate future maintenance dredging was also considered. To minimize the time and cost of transporting the material, resource agencies were engaged to consider placement of limestone rock to construct additional artificial reefs (beyond the amount required for mitigation) close to the channel and to construct a containment berm around the ODMDS.

4.2.1 Material Placement Options

The least cost disposal option is summarized in Table 4-1 and the relative costs are provided in Table 4-1-1. Figure 4-2 shows the locations of the proposed. New work material from channel deepening and widening could be efficiently distributed among the ODMDS, two mitigation-required reef construction sites, six beneficial use reef construction sites, an existing DNR reef construction site, and the upland confined disposal areas at Clouter Creek, Yellow House Creek, and/or Daniel Island. The improvements required to accommodate the material include raising dikes within the footprint of the existing upland confined disposal facilities and the expansion of the existing ODMDS to provide increased capacity for new work and maintenance material (*Action being addressed jointly by the US Environmental Protection Agency (EPA) and USACE in a Section 102 site modification Environmental Assessment (EA)*).

Table 4-1. Placement area, and dredge type summary

52'/48' Project with Max Wideners					
Channel Reach	Dredge Plant Type	# of Dredges	Placement Area	Deepening Dredge Quantity in Cubic Yards (CY)	Duration (Months)
Fort Sumter Reach EC1	Large Hopper	2	ODMDS	4,085,505	3.98
Fort Sumter Reach EC1	Medium Hopper	2	ODMDS	2,199,888	4.11
Fort Sumter Reach EC1	Rock cutter	1	ODMDS Berm	2,503,169	11.57
Fort Sumter Reach EC1	Rock cutter	1	DNR Site	60,000	0.28
Fort Sumter Reach EC1	Rock cutter	1	Reef Placement	420,000	1.81
Ft. Sumter - Reach EC1	Clamshell with bucket	1	ODMDS Berm	660,000	4.34
Ft. Sumter - Reach EC1	Clamshell w/ rock bucket	1	Mitigation Site	360,000	2.52
Ft. Sumter - Reach EC1	Clamshell w/ rock bucket	1	DNR Site	180,000	1.26
Fort Sumter Reach EC2	Large Hopper	2	ODMDS	3,644,084	3.85
Fort Sumter Reach EC2	Medium Hopper	2	ODMDS	1,214,695	2.46
Fort Sumter Reach EC2	Rock cutter	1	ODMDS Berm	3,371,033	13.73
Fort Sumter Reach EC2	Rock cutter	1	Reef Placement	420,000	1.81
Fort Sumter Reach EC2	Clamshell w/ rock bucket	1	Reef Placement	1,080,000	7.69
Mount Pleasant Reach	Clamshell	1	ODMDS	840,083	0.76
Rebellion Reach	Clamshell	1	ODMDS	1,081,341	0.98
Bennis Reach	Clamshell	2	ODMDS	1,942,858	1.12
Horse Reach	Clamshell	2	ODMDS	364,070	0.27
Hog Island Reach	Clamshell	2	ODMDS	2,096,920	1.46
Wando River Lower Reach	Clamshell	2	ODMDS	1,769,070	1.02
Wando River Upper Reach	Clamshell	2	ODMDS	636,251	0.52
Wando River Turning Basin	Clamshell	2	ODMDS	3,284,633	1.81
Segment 1 Total				**32,213,600**	**67.33**
Drum Island Reach	Clamshell	2	ODMDS	917,473	0.72
Myers Bend	Clamshell	2	ODMDS	853,689	0.60
Daniel Island Reach	Pipeline	2	Daniel Island	2,211,957	1.65
Segment 2 Total				**3,983,119**	**2.97**
Daniel Island Bend	Pipeline	2	Daniel Island	74,551	0.21
Clouter Creek Reach	Pipeline	2	Daniel Island	583,150	0.98
Navy Yard Reach	Pipeline	2	Clouter Creek	358,816	0.60
North Charleston Reach	Pipeline	2	Clouter Creek	532,693	0.50
Filbin Creek Reach	Pipeline	2	Yellowhouse	405,420	0.61
Port Terminal Reach	Pipeline	2	Yellowhouse	192,068	0.43
Ordnance Reach	Pipeline	2	Yellowhouse	118,091	0.26
Ordnance Reach Turning Basin	Pipeline	2	Yellowhouse	1,549,313	1.21
Segment 3 Total				**3,814,102**	**4.80**
North Charleston Terminal Berthing Area Dredging	Pipeline	1	Yellowhouse	41,001	0.16
Navy Base Terminal Berthing Area Dredging	Pipeline	1	Daniel Island	474,551	0.73
Wando Terminal Berthing Area Dredging	Pipeline	1	Daniel Island	157,633	0.24
Berthing Areas Total				**673,185**	**1.13**
Total Construction				**40,684,006**	**76.23**

Table 4-1-1 Cost Comparison for Least Cost Disposal

Cost Comparison for Least Cost Disposal								
Reach	**Dredge**	**Qty - CY**	**Selected Disposal Area**	**$/CY**	**Total Direct Cost***	**Default Disposal Area**	**$/CY**	**Total Direct Cost***
EC1 - Ft. Sumter Reach	Rock Cutter	60,000	DNR Site	$24.63	$1,477,800	ODMDS	$25.10	$1,506,000
EC1 - Ft. Sumter Reach	Rock Cutter	420,000	Reef Placement	$20.26	$8,509,200	ODMDS	$20.85	$8,757,000
EC1 - Ft. Sumter Reach	Clamshell w/ rock bucket	360,000	Mitigation Site	$19.16	$6,897,600	ODMDS	$19.85	$7,146,000
EC1 - Ft. Sumter Reach	Clamshell w/ rock bucket	180,000	DNR Site	$19.15	$3,447,000	ODMDS	$19.84	$3,571,200
EC2 - Ft. Sumter Reach	Rock Cutter	420,000	Reef Placement	$20.26	$8,509,200	ODMDS	$20.85	$8,757,000
EC2 - Ft. Sumter Reach	Clamshell w/ rock bucket	1,080,000	Reef Placement	$19.49	$21,049,200	ODMDS	$20.17	$21,783,600
			Total for Selected DA ----->		**$49,890,000**	Total for ODMDS		**$51,520,800**
			Cost Savings ---------------->		**$1,630,800**			
*Direct costs do not include any contingency or escalation								

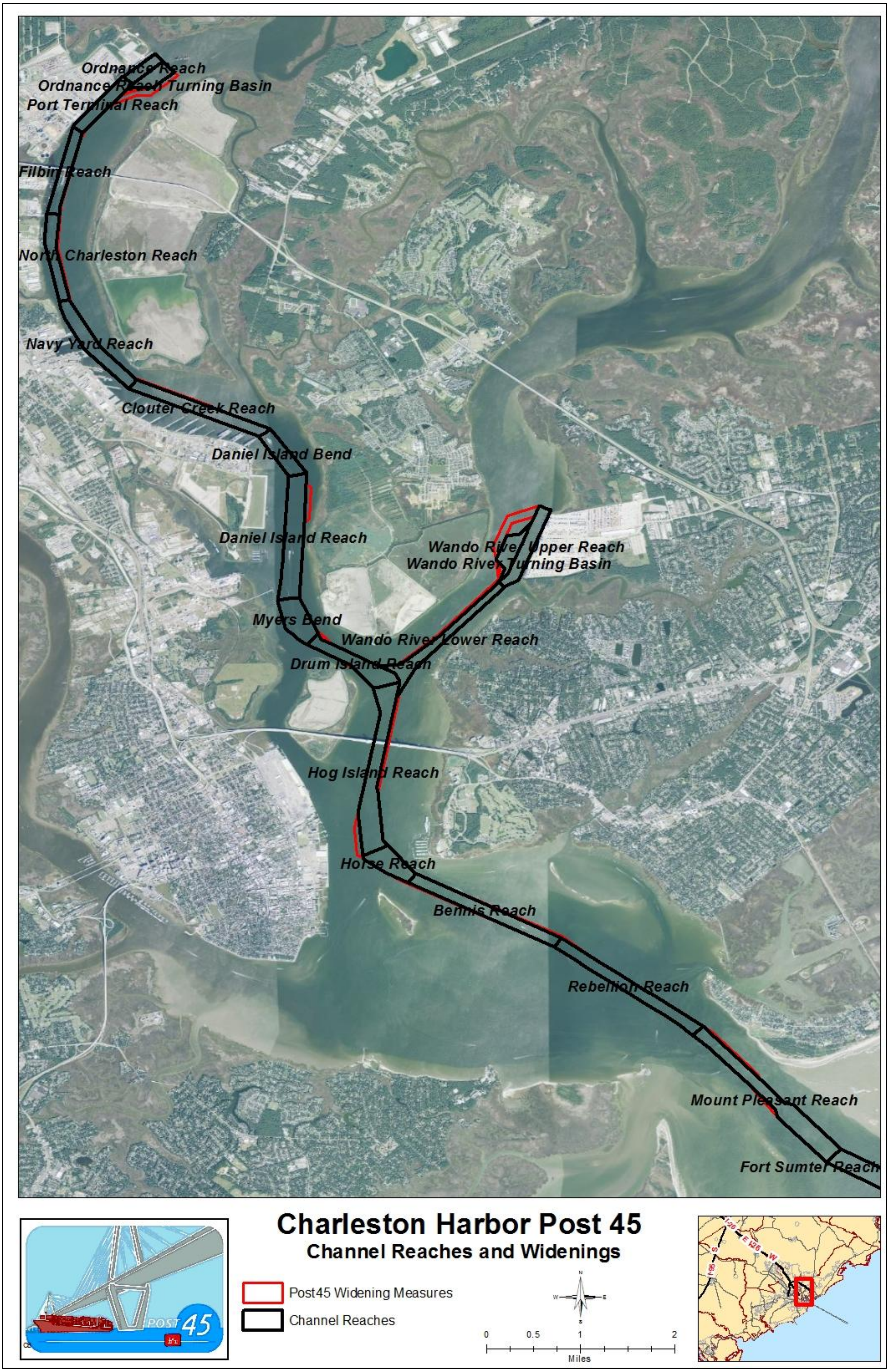


Figure 4-2. Proposed deepening and widening measures in the upper and lower harbor

Under the least cost disposal option, about 29 million cubic yards would be placed in the expanded ODMDS; 2.9 million cubic yards would be placed in Daniel Island Disposal Area; 900,000 cubic yards would be placed in Clouter Creek Disposal Area; 2.3 million cubic yards would be placed in Yellow House Creek Disposal Area; 360,000 cubic yards would be used for artificial reef mitigation; approximately 6.3 million cubic yards for ODMDS berm construction; 1.9 million cubic yards for reef construction along either side of the Entrance Channel; and 240,000 cubic yards would be placed at an existing SCDNR artificial reef site. Further evaluation of potential beneficial uses of dredged material would occur during the PED phase as discussed later in this section.

4.2.2 Construction Methodology

The exact construction methodology would be determined by the contractor selected through the contracting process. However, assumptions regarding various construction techniques that could be used were made for planning and estimating purposes. Dredged material from widening and deepening efforts would most likely be excavated using a hydraulic cutterhead dredge, hopper dredge, or mechanical excavator. Based on testing results, the rock material would not require blasting (see Appendix B). Thus, removal could be accomplished using a hydraulic excavator that loads scow barges for transport to the placement site.

4.2.3 Type of Dredging Equipment.

The type of dredging equipment considered depends on the type of material, the depth of the channel, the depth of access to the disposal or placement site, the amount of material, the distance to the disposal or placement site, the wave-energy environment, etc. A detailed description of types of dredging equipment, which includes mechanical-clamshell, hydraulic hopper, cutter-suction, dredges with spider barges for transportation of dredged material to designated disposal sites, can be found in Engineer Manual, EM 1110-2-5025, *Engineering and Design - Dredging and Dredged Material Disposal.*

Mechanical – Clamshell Dredging

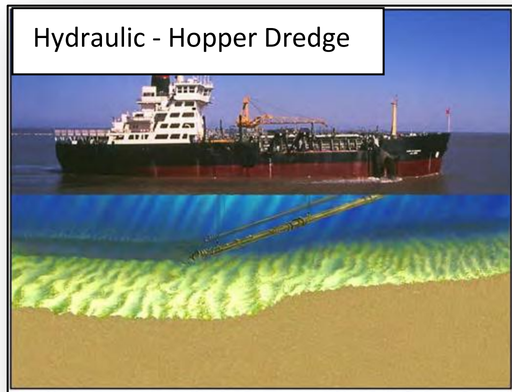
Mechanical dredges are classified by how the bucket is connected to the dredge. The three standard classifications are structurally connected (backhoe), wire rope connected (clamshell), and chain and structurally connected (bucket ladder). The advantage of mechanical dredging systems is that very little water is added to the dredged material by the dredging process and the dredging unit is not used to transport the dredged material. This is important when the disposal location is remote from the dredging site. The disadvantage is that mechanical dredges require sufficient dredge cut thickness to fill the bucket to be efficient and greater re-suspended sediment is possible when the bucket impacts the bottom and as fine-grained sediment washes from the bucket as it travels through the water column to the surface. Clamshell excavators are likely to be employed on portions of the


Mechanical Clamshell Dredge

Charleston Harbor project. These dredges are able to work in confined areas, can pick up large material, and are less sensitive to sea conditions than other dredges.

For cost estimating purposes, it was anticipated that a clamshell dredge would be used in two separate manners for the construction of this project. The first would be within the lower harbor. Material from these reaches would be placed in a scow or on a barge for transport to the ODMDS. The second area of would be in the Entrance Channel. Rock from this reach would be excavated and placed in a scow and transported to the hardbottom reef sites or the ODMDS to construct fish habitat or sediment containment berms.

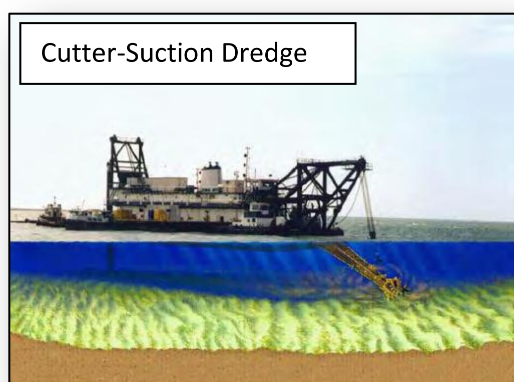
Hydraulic – Hopper Dredging



Hopper dredges include self-propelled ocean-going vessels that hydraulically lift dredged material from the bottom and deposit it into an open hopper within the vessel. The draghead(s) operates like a vacuum cleaner being dragged along the bottom. When the hopper is full, the dredge transits to a disposal location and releases the dredged material into an underwater disposal site by opening doors on the hopper bottom or in some cases the vessel is designed to split open longitudinally. Hopper dredges can also be designed to hydraulically pump the material from the hopper to an upland location. This is often used for beach nourishment projects. Since hopper dredges are self-propelled, they are more maneuverable than dredges that rely upon tug boats to move. However, they require numerous passes over the same area to remove the required material; they are inefficient in small confined dredging areas and are most effective in removing sand and other unconsolidated materials.

A hopper dredge is anticipated to be used to remove unconsolidated overburden material from the Entrance Channel. Material would be transported to the ODMDS and disposed of according to the Site Management and Monitoring Plan (SMMP) that is approved by the EPA.

Hydraulic – Cutter-Suction Dredge



Large cutter-suction dredges, or cutterhead dredges, are mounted on barges. The cutter suction head resembles an eggbeater with teeth. It mobilizes the dredged material as it rotates. The mobilized material is hydraulically moved into the suction pipe for transport. The cutter suction head is located at the end of a ladder structure that raises and lowers it to and from the bottom surface. The cutter suction dredge moves by means of a series of anchors, wires, and spuds. The cutter suction dredges as it moves across the dredge area in an arc as the dredge barge swings on the anchor wires. The discharge pipeline connects the cutter suction dredge to the disposal area. The dredged material is hydraulically pumped from the bottom, through the dredge, and through the discharge pipeline to the disposal location. Booster pumps can also be added along the discharge pipeline to move the material greater distances. Cutter-suction dredges are limited to dredging depths within reach of the ladder.

It is anticipated that a cutter-suction dredge would be used in two distinct areas for this project. The first area is the upper harbor reaches in the Cooper River (Figure 4-2 and Table 4-1-1). In this area of the Channel, material would be disposed of in upland confined disposal facilities (either Yellow House Creek or Clouter Creek Disposal Areas). The second distinct dredging area for a cutter-suction dredge would be in the Entrance Channel, where a rock cutterhead would be used to excavate consolidated limestone rock from the channel. Material would be placed in a spider barge and transported to the ODMDS for disposal. Material may also be placed at the mitigation site if rock size restrictions can be met.

Post-Dredging Operations

Since dredging equipment does not typically result in a perfectly smooth and even channel bottom (see discussion above); a drag bar, chain, or other item may be pulled along the channel bottom to smooth down high spots and fill in low spots. This finishing technique also reduces the need for additional dredging to remove any high spots that may have been missed by the dredging equipment. It may be more cost-effective to use a drag bar or other leveling device (and possibly less hazardous to sea turtles) than to conduct additional hopper dredging.

4.2.4 Dredge Material Transport Vessels

Three types of barges are generally used to transport dredged material to disposal sites, which include a split hull barge/scow, bottom dump barge/scow, or a flat top barge/scow. All three barge types are typically pushed or pulled to the disposal site by a tug.

4.2.5 Disposal Area Modifications

Yellow House Creek Disposal Area

Currently, there is about 1.9 million cubic yards (MCY) of capacity, accounting for one foot of freeboard and one foot of ponding. Because this area is used for both Joint Base Charleston channel maintenance dredging as well as select private use, a five foot dike raise is planned to increase the site’s capacity to 6.3 MCY. Because the area is large (589 acres), to increase effective use of the site, a cross dike would split the area into two cells (NE-SW), to allow better drainage and easier management. One cell would be used for the new work, leaving the other cells available for maintenance material.

Daniel Island Disposal Area

The current capacity of the Daniel Island Disposal Area - Wando Cell is about 0.87 MCY including one foot of freeboard and one foot of ponding. However, a five foot dike raise would increase the capacity to about 2.4 MCY.

Clouter Creek Disposal Area

New work material from the RP would be pumped via cutterhead pipeline dredge into the Middle and South Cells. The Middle Cell is about 197 acres and has an existing capacity of 1.3 MCY including one foot of freeboard and one foot of ponding. With a five foot dike raise, the capacity would increase to 2.9 MCY. The total cubic yardage from Clouter Creek Reach and Daniel Island Bend placed in Daniel Island Middle Cell is approximately 0.66 MCY. The South Cell is 412 acres and would have a capacity of approximately 6.1 MCY in 2020 according to the current Clouter Creek Maintenance Management Schedule. The cell is scheduled for dike maintenance in 2017 and would be designed for additional dike height to accommodate the new work material. The dike maintenance would be completed in time for the south cell to be opened for dredged material placement in 2020. Additionally, with proper management it would be able to accept maintenance material concurrently with the new work construction.

4.2.6 Beneficial Use of Dredged Material

The Federal Government has placed considerable emphasis on using dredged material in a beneficial manner. Statutes such as the Water Resources Development Acts of 1992, 1996, 2000, and 2007 demonstrate that beneficial use has been a Congressional priority. The USACE has emphasized the use of dredged material for beneficial use through such regulations as 33 CFR Part 335, ER 1105-2-100, and ER 1130-2-520 and by Policy Guidance Letter No. 56. (ER 1105-2-100 at E-69) states that "all dredged material management studies include an assessment of potential beneficial uses for environmental purposes including fish and wildlife habitat creation, ecosystem restoration and enhancement and/or hurricane and storm damage reduction". Opportunities for beneficial use of dredged material exist in the project vicinity. In accordance with ER 1105-2-100, the USACE is considering beneficial use of dredged material as a part of the project. During the PED phase, options for beneficial uses that are cost-effective and meet regulatory and environmental protection requirements would be pursued. The additional cost (above the least cost option described above) of most potential beneficial use options would need to be paid by a willing partner. Many beneficial use options were identified. During the NEPA scoping process, agencies, and the general public expressed interest in the following options:

- Crab Bank enhancement
- Sandbar complex between east end of southern jetty and Cummings Point
- Nearshore placement off Morris Island Lighthouse
- Protecting shoreline of Shutes Folly Island (Castle Pinckney)
- Feeder berms for barrier islands
- Offshore fish habitat berms
- Augmenting ODMDS berms
- Protecting shoreline of Fort Sumter and Fort Moultrie

After a meeting with the ICT and after external and internal prioritization the following options were identified and incorporated into the project or carried forward for additional consideration during the PED phase:

- ODMDS berm creation
- Hardbottom habitat creation
- Crab Bank enhancement
- Shutes Folly Island (Castle Pinckney) protection
- Fort Sumter/Fort Moultrie protection
- Nearshore placement off Morris Island

4.2.6.1 ODMDS Berm Creation

To protect hardbottom habitat, from being buried by sediment migrating from the ODMDS, limestone rock from the Entrance Channel would also be used to construct a "U"-shaped berm along the south, west, and east perimeters of the ODMDS (Figure 4-3).

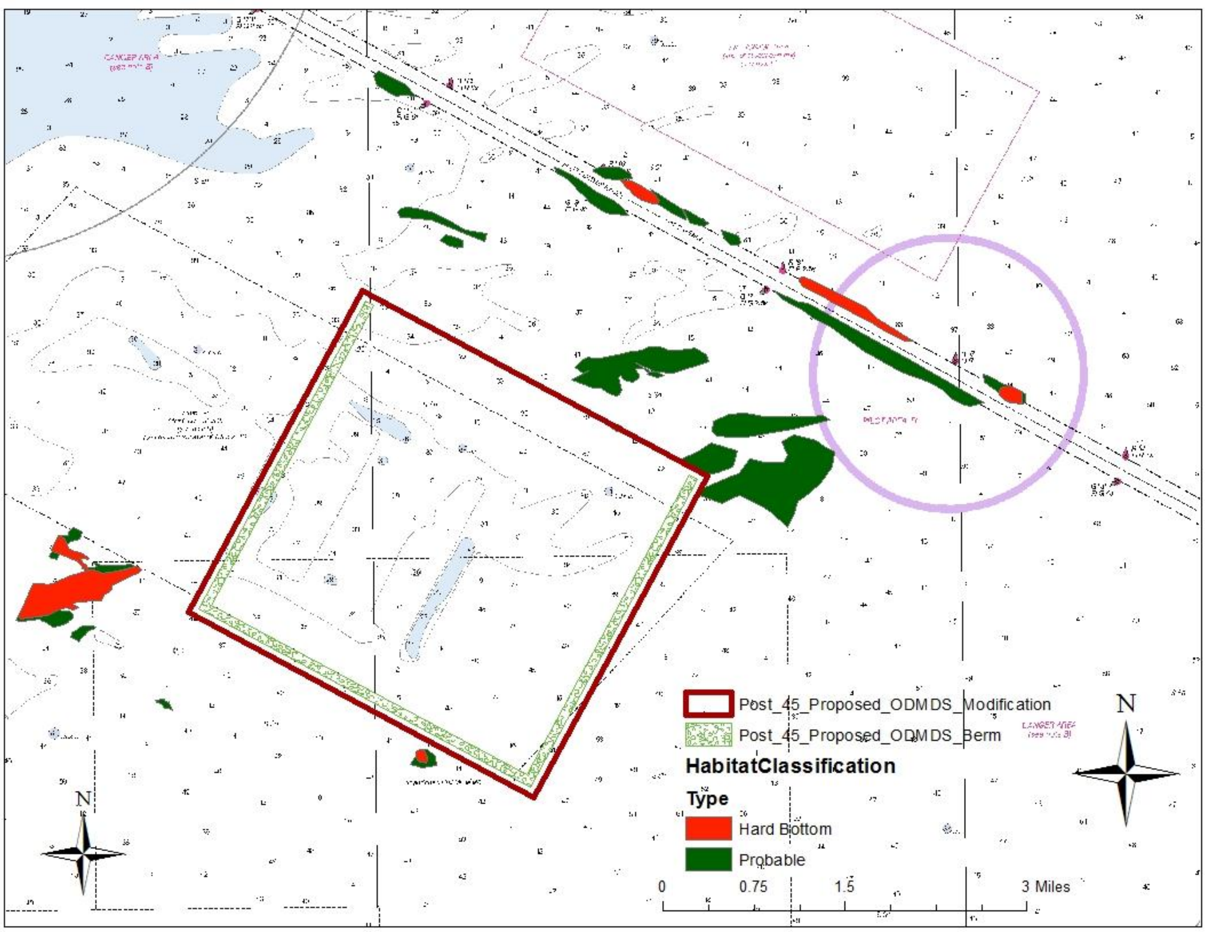


Figure 4-3. Proposed ODMDS and location of hardbottom habitat and containment berm

This area represents approximately 427 acres of the ODMDS. The dimensions would be roughly 15,000 ft x 16,000 ft x 15,000 x 400 ft. The berm would be built on roughly a 3:1 slope, and would rise to about 10 feet above the natural bottom elevation but no higher than -25 ft MLLW. The berm would serve multiple purposes, including hardbottom habitat, fish habitat, and sediment containment. An excavator or clamshell dredge would allow the largest material to be used to construct the berm; however, use of a cutterhead suction dredge could minimize costs and produce smaller size material. This beneficial use project would use smaller material dredged with a rock cutterhead dredge to create the base of the berm and the outer portion of the berm would be created with larger rock dredged with a clamshell dredge. This would serve to increase the surface area of the reef, thereby enhancing habitat value.

4.2.6.2 Hardbottom Habitat Creation

Limestone rock would be dredged from within the Entrance Channel and used to create as substrate for sessile invertebrates and structure for fish species after being placed within strategic locations nearby the channel. The USACE would construct 8 new 33-acre reef sites. Four would be located along the north side of the channel and 4 would be located along the south side of the channel. Figure 4-4 provides a conceptual depiction of the location of the reefs. Prior to construction the locations of these reefs would be refined and coordinated with the resource agencies. At the request of the SCDNR Artificial Reef Program, approximately 240,000 CY of rock material would also be deposited at the 25 acre Charleston Nearshore Reef site (Figure 4-4). These reefs would provide extensive bathymetric features located between about 6 and 10 miles offshore of Charleston Harbor. Two of the reefs would be constructed to optimize hardbottom habitat for mitigation sites (1 required; 1 contingency) and the other six least cost disposal sites would be specifically for beneficial use of dredged material. More detail on the hardbottom reef sites can be found in Appendix H (Hardbottom Resources) and Appendix P (Mitigation). The SCDNR Charleston Nearshore Reef site is discussed separately in Appendix M2 (404(b)(1) evaluation), because it is within state waters inside of the 3 nautical mile limit.

Two Mitigation Sites (1 required; 1 contingency): A grid-based approach would be used to construct the reef structures at the mitigation sites. Each site would consist of sixteen (16) 300-foot by 300-foot cells that combine to create a 33 acre patch reef area about 600 feet wide and 2,400 feet long. The cell arrangement would be two (2) across by eight (8) long. Each cell would each require 8,000 to 12,000 cubic yards of rock material. Therefore each site consisting of 16 cells would require 128,000 to 192,000 cubic yards of rock material to create the desired peak vertical relief of 3.5 – 4.5 feet (after settling) and the desired area coverage within each cell of 75%. All of the material used to construct the mitigation sites would be excavated using a clamshell dredge to maximize the size of the material used to construct the reef and minimize dispersal of the material.

Six Placement Sites: The six (6) 33-acre placement sites would each have the same dimensions as the mitigation sites (600 feet wide by 2,400 feet long). However, dredged material would be placed to cover the entire area to a peak relief height of about 10 feet (after settlement) and tapering to natural contours/conditions at the site margins. Each site would utilize about 320,000 cubic yards of material. Smaller material generated by the hopper dredges would be used to create a base that would be covered with larger material dredged using clamshell dredges to create the desired habitat. To estimate volumes it was assumed that the average height of material would be about 6 feet based on a peak relief height of about 10 feet and tapering to 0 feet at the margins of the sites.

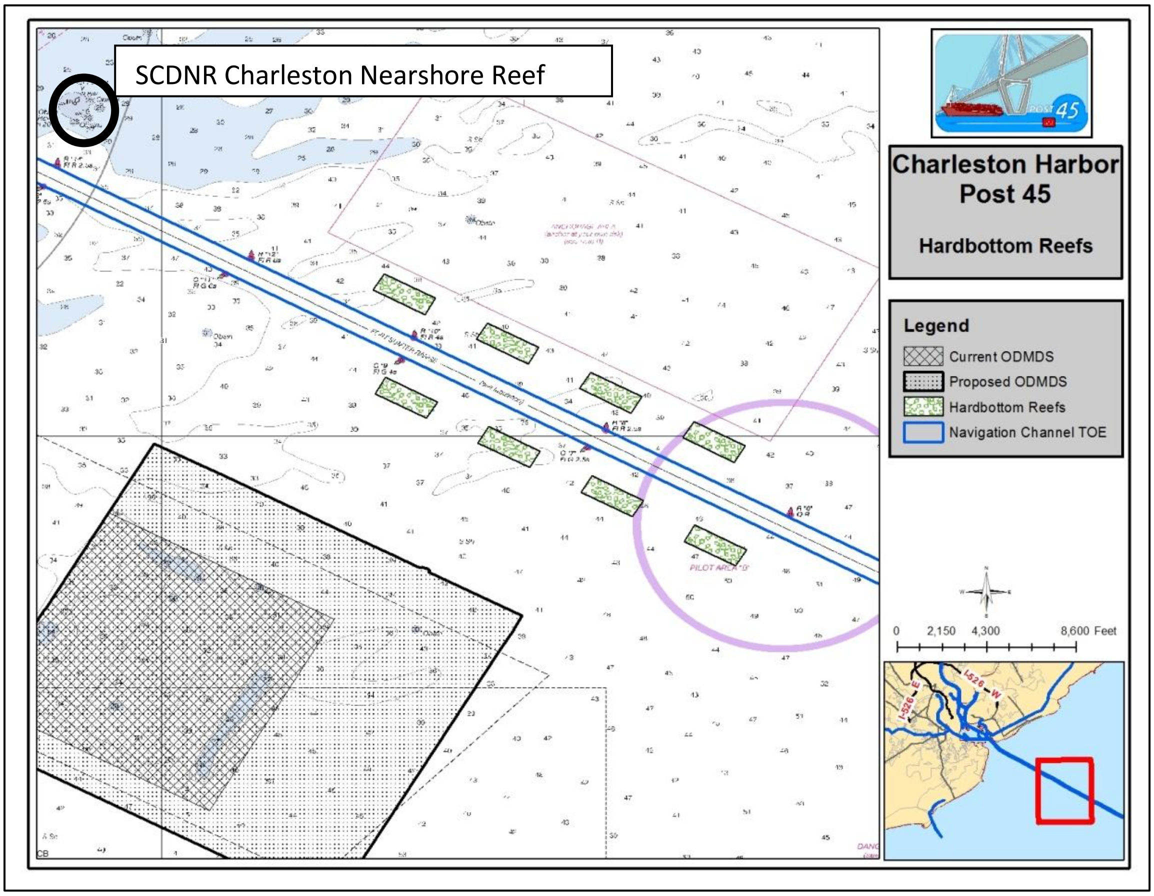


Figure 4-4. Theoretical depiction of locations for hardbottom reefs

4.2.6.3 Crab Bank Enhancement

Dredged material could be used to enlarge Crab Bank by placing material on the channel side of the island running from north to south. This would help support the avian species that utilize the island for nesting, roosting, and foraging (Figure 4-5). Crab Bank has been designated as an "Important Bird Area" in South Carolina and is established as "Crab Bank Seabird Sanctuary". SCDNR indicates that, "Crab Bank supports colonies of nesting waterbirds because of its isolated nature and lack of mammalian predators. Although all species may not nest on the island each year, examples of species that have used the island include: brown pelican, least tern, royal tern, black skimmer, gull-billed tern, sandwich tern, common tern, laughing gull, Wilson's plover, American oystercatcher, willet, great egret, snowy egret, tricolored heron and ibis. Besides providing nesting habitat, the sanctuary provides winter loafing and feeding areas for numerous species. (https://www.dnr.sc.gov/mlands/managedland?p_id=215). While the island fluctuates in size constantly, it has largely been migrating towards the north over the last 15 years. Further demonstrating a need for beneficial use of dredged material at Crab Bank, the USACE performed a shoreline change assessment and determined that the island has decreased in size from

17.94 acres of dry beach habitat in 1994 to 5.01 acres in 2011. (Appendix A). While not specifically studied during this project, this beneficial use concept could involve enlarging Crab Bank to roughly 58 acres at approximately +8 feet MLLW based on the southern shoreline of Crab Bank in the early 1990's (shown by the green line in Figure 4-5). The precise size and scope of the project would be determined during the PED phase, and would be dependent on a source of suitable material.

Figure 4-5. Crab Bank possible beneficial use site

4.2.6.4 Shutes Folly Island (Castle Pinckney) Enhancement

Placement of dredged material around Shutes Folly Island (Figure 4-6) and Castle Pinckney to prevent erosion could provide a beneficial use of dredged material option. Shutes Folly Island provides nesting habitat for colonial seabirds due to its isolated nature, small size, and lack of predators. It is one of only nine active nesting sites in the entire state. Skimmers and oyster catchers like the shell hash that effaces the eastern side of Shutes Folly Island. The USACE has an existing shoreline protection project at the site. It was designed and constructed primarily to protect Castle Pinckney. The island has been noted by the group Charleston Harbor Wildlife as being "often considered for restoration." They state that, "in 1997, wildlife biologists pressed for the island as a site for dredge spoil to boost the small seabird colony there…" (http://charlestonharborwildlife.com/iwa/cp-sf/). Additionally, Castle Pinckney, a historic site, sits atop the island. The size and scope of the project would be determined during the PED phase, dependent on a source of suitable material.

Figure 4-6. Shutes Folly Island possible beneficial use site

4.2.6.5 Bird Nesting Island Creation

There are a few locations near the mouth of the harbor that could support the creation of a bird nesting island. However, this alternative would be more expensive and more complicated from an environmental permitting perspective. The size, scope, and environmental benefits associated with this option would be determined during the PED phase and would depend on a source of suitable material.

4.2.6.6 Nearshore Placement off Morris Island

Dredged material could be placed offshore of Morris Island where natural processes could sort and transport it. However, this alternative would require extensive modeling and coordination with multiple resource agencies to resolve major and complex concerns. It would also be expensive and complicated from an environmental permitting perspective. The size, scope, and benefits associated with this option would be determined during the PED phase and would depend on a source of suitable material.

4.2.6.7 Fort Sumter Shoreline Protection

Fort Sumter National Monument is an important feature and resource in Charleston Harbor. A description of the history and importance of Fort Sumter can be found in Section 2.4.21 and in Gayes et al., 2013. Placement of dredged material around Fort Sumter to prevent erosion could provide a beneficial use of dredged material option. Long term trend data indicate that the island has been increasing in size due to accretion on its west side (see Appendix A). Due to the position of the island in the harbor, the eastern and southern sides are exposed to wind waves and wakes from recreational, commercial, and tour boats. While not specifically studied during this project, limestone rock from the Entrance Channel could be placed offshore of the shoreline of the Fort in an effort to trip waves prior to reaching the Fort. This beneficial use concept could involve more engineering to ensure the stability and integrity of the structure. The feasibility, size, and scope of the project would be determined during the PED phase, dependent on a source of suitable material and meeting all applicable laws and regulations.

4.2.6.8 Beneficial Use Analyses

Typically, design of beneficial use projects require a grain size/compatibility analysis and potentially modeling of sediment transport and fate to be completed for these types of projects. To meet the goals of accelerating the schedule and reducing study costs, this work is scheduled for the PED phase. As a result, the measures are discussed in the Feasibility Report/EIS without detailed analysis, but with a commitment to perform additional analysis during the PED phase and recoordinate all decisions with resource agencies to ensure environmental acceptability. Final designs, decisions to implement, and environmental considerations/clearances would take place during the PED phase.

4.2.7 Operations and Maintenance Considerations

Maintenance dredging would generally be conducted by hopper, clamshell and cutterhead dredges and would operate essentially the same as current practices documented in the 2009 Charleston Harbor DMMP Preliminary Assessment available upon request. Maintenance dredging would utilize the same placement areas as those utilized for existing conditions, and the duration and frequency of dredging events would be within the range occurring under current conditions. Dredging of the Entrance Channel would generally be performed by a hopper dredge, and material would be placed in the ODMDS located south of the navigation channel. Maintenance material from the lower reaches in the Harbor would be dredged with a clamshell and transported via scow to the ODMDS. Maintenance material from the upper reaches would be dredged with a pipeline cutterhead dredge and transported to upland confined disposal facilities, including Clouter Creek, Yellow House, Daniel Island, and Morris Island. The 50-year placement plan is summarized within Table 4-2, below.

Table 4-2. O&M quantities and placement areas for 50 years

Channel Reach	Shoaling Rate in CY/year	Placement Area (PA)	Dredge Type	Dredge Cycle (months)	Estimated Number of Cycles in 50 years	Quantity per Cycle (CY)	Total O&M Quantity in 50 years (CY)
Fort Sumter Reach/Entrance Channel	519,000	ODMDS	Hopper	24	25	1,038,000	25,950,000
Mount Pleasant Reach	0	ODMDS	Clamshell	15	40	0	0
Rebellion Reach	923	ODMDS	Clamshell	15	40	1,154	46,150
Bennis Reach	37,264	ODMDS	Clamshell	15	40	46,580	1,863,200
Horse Reach	16,035	ODMDS	Clamshell	15	40	20,044	801,750
Hog Island Reach	179,838	ODMDS	Clamshell	15	40	224,798	8,991,900
Wando River Lower Reach	69,984	ODMDS	Clamshell	15	40	87,480	3,499,200
Wando River Upper Reach	101,985	ODMDS	Clamshell	15	40	127,481	5,099,250
Wando River Turning Basin	263,097	ODMDS	Clamshell	15	40	328,871	13,154,850
Drum Island Reach	131,287	ODMDS	Clamshell	15	40	164,109	6,564,350
Myers Bend	55,119	ODMDS	Clamshell	15	40	68,899	2,755,950
ODMDS Total	**1,374,532**						**68,726,600**
Daniel Island Reach	231,652	Clouter Creek	Cutterhead	19	32	366,782	11,582,600
Daniel Island Bend	10,497	Clouter Creek	Cutterhead	19	32	16,620	524,850
Clouter Creek Reach	33,501	Clouter Creek	Cutterhead	19	32	53,043	1,675,050
Navy Yard Reach	21,520	Clouter Creek	Cutterhead	19	32	34,073	1,076,000
North Charleston Reach	5,104	Clouter Creek	Cutterhead	19	32	8,081	255,200
Filbin Creek Reach	10,742	Clouter Creek	Cutterhead	19	32	17,008	537,100
Filbin/Port Terminal Intersect		Clouter Creek	Cutterhead	19	32	0	0
Port Terminal Reach	14,581	Clouter Creek	Cutterhead	19	32	23,087	729,050
Ordnance Reach	166,433	Clouter Creek	Cutterhead	19	32	263,519	8,321,650
Ordnance Reach Turning Basin	532,713	Clouter Creek	Cutterhead	19	32	843,462	26,635,650
Upland Disposal Areas	**1,026,743**						**51,337,150**

4.3 Mitigation

Compensatory mitigation is intended to replace the ecological services lost as a result of unavoidable impacts. The RP would result in two significant impacts that would require compensatory mitigation: 1) wetlands and 2) hardbottom habitat (discussed in Sections 5.4.9 and 5.4.10, respectively). The RP would indirectly impact up to about 324 acres of wetlands due to changes in salinity and approximately 29 acres of hardbottom habitat in the footprint of the Entrance Channel. Mitigation for wetland impacts includes the preservation of approximately 665.56 acres of wetlands (See Appendix P). While some impacts to hardbottom habitat were avoided, a beneficial use plan for placement of rock involves constructing 2 mitigation reefs to mitigate for hardbottom areas impacted within portions of the Entrance Channel not previously dredged. Rock dredged from the Entrance Channel would also be used to construct 6 additional new 33-acre reefs as a part of the least cost disposal plan. The reef sites would be located outside and parallel to the Entrance Channel. Four would be located along the north side and four would be located along the south side of the channel. At the request of the SCDNR Artificial

Reef Program, approximately 240,000 cy of rock material would also be deposited at the 25 acre Charleston Nearshore Reef site, also a part of the least cost disposal plan as it is closer to the dredging site than the ODMDS. Details pertaining to the mitigation plan and associated monitoring and adaptive management of the project can be found in Appendix P. The following sections describe the two mitigation components in greater detail.

4.3.1 Freshwater Wetlands Mitigation

Indirect wetland impacts are predicted to occur through a shift from fresh/brackish wetland vegetation to brackish/salt wetland vegetation. The impacts result from converting one dominant type of wetland vegetation to another (freshwater to salt tolerant species). This presented a challenge to determining compensatory mitigation through the use of any current USACE Regulatory Standard Operating Procedure. Through coordination with the ICT, and after evaluating multiple tools/models, the USACE selected the Uniform Mitigation Assessment Method (UMAM), as defined in Florida Administrative Code (FAC) 62-345, to quantify the necessary amount of compensatory mitigation. After evaluating numerous mitigation options consistent with the 2008 Mitigation Rule (33 CFR Parts 325 and 332), including mitigation bank credits, restoration, creation, and enhancement, it was determined that preservation of wetlands in the Cooper/Wando watershed would be appropriate to mitigate for the indirect impacts to freshwater wetlands (Table 4-3). Details on the mitigation planning are provided in Appendix P.

Table 4-3. RP wetland impacts and mitigation summary

Wetland Impacts	52/48
Ashley River forested wetlands	4.36 acres
Ashley River marsh wetlands	13.16 acres
Cooper River forested wetlands	126.37 acres
Cooper River marsh wetlands	179.83 acres
Total	**323.72 acres**
UMAM functional loss	73.46 units
Total Acres of Mitigation Required to offset function loss	**665.56**

The USACE determined that preservation of land within the proclamation boundary of the Francis Marion National Forest best meets the compensatory mitigation requirements. The preserved lands would provide important physical, chemical, and biological functions for the Cooper River Basin and would contribute to the sustainability of the watershed by ensuring the functions of bottomland hardwood wetlands and emergent wetlands on these properties are sustained in perpetuity. The preservation parcels would also enhance lands already within the Francis Marion National Forest by functioning as a buffer to future development. The region will continue to experience population growth, industrial/commercial development, and changes in land use. Preservation of any of these parcels would include the recording of conservation restrictions with conveyance of the property to the USFS. Using the UMAM tool, the proposed project would require approximately 665.56 acres of freshwater forested and emergent wetlands throughout these parcels. Presently, there is sufficient acreage available to cover this need for compensatory mitigation.

4.3.2 Hardbottom Habitat Mitigation

As a result of deepening and/or extending the Entrance Channel beyond its current, authorized depth of 47 feet, hardbottom areas not previously dredged and within the navigation channel would be affected. In addition to direct impacts, the indirect effect of sedimentation from potential turbidity plumes was examined. The USACE anticipates mitigating for the loss of 28.8 acres of hardbottom habitat within the extended Entrance Channel.

The selected mitigation alternative involves depositing dredged limestone rock from the Entrance Channel within a designated mitigation area between the Charleston ODMDS and the Entrance Channel. Water depths in the mitigation area are between 35 and 50 feet. The objective of the mitigation is to create a marine patch reef feature in mound formations that would replace the functions of the hardbottom dredged from the Entrance Channel. The material would be placed or discharged, likely by scow or barge to reach the designed configuration. An excavator or clamshell dredge would permit the largest diameter material to comprise the reef; however, a cutterhead suction dredge could also be used. Each placement would be surrounded by a halo of sand or native material. The ring of sand along with the hard substrate feature provides landscape and edge diversity, and foraging area. Reef morphology and material influences the relative value of refuge and forage functions, and reef utilization by benthic, epibenthic, and nektonic organisms.

A simple patch reef design and operational plan compatible with dredge plant and transportation capabilities would be required. Accordingly, a grid placement plan would be used. The grid would consist of 300-foot by 300-foot cells. The cells would be two (2) across by eight (8) long. This would create approximately 33 acres of patch reef habitat (project footprint). The patch reef area would be 600 feet by 2,400 feet long. One or two scow loads of material dredged from rock areas would be discharged at about the center of each cell. Accordingly, the 16 cells combined would require 32 scow loads of 4,000 to 6,000 cubic yards of rock material or approximately 128,000 to 192,000 cubic yards for each reef site. Filling the scows to maximum capacity with each load is not a likely occurrence. The desired peak vertical relief is 3.5 – 4.5 feet and the desired coverage within each cell is 75 percent coverage. However, placing the load directly on top of each other would be a challenge. Placing more than two loads in each cell can be done in order to make a higher mound or to cover more area. Additional loads could be placed on specific cells if the single load did not achieve desired coverage. This would be monitored during construction and if necessary, would be adapted. Details on this can be found in Appendix I (Hardbottom Resources) and Appendix P (Mitigation, Monitoring, and Adaptive Management).

4.4 Lands Easements Rights of Way and Relocation Considerations

No acquisition of real estate interest is required for deepening and widening the Entrance Channel and the inner harbor or enlarging the existing turning basins. As the project has a nexus to commerce and navigation, the Government will exercise its rights under navigation servitude for those features.

In accordance with ER 1105-2-100, USACE will consider beneficial use of dredged material as a part of the project. The features are Ocean Dredged Material Disposal Area (ODMDS) berm creation, hardbottom habitat creation, Crab Bank enhancement, Shutes Folly Island enhancement, and nearshore placement off Morris Island. Construction of these features will be under exercise of navigation servitude and all work will be coordinated with resource agencies.

Existing upland disposal sites and an existing ODMDS will be used for the project. The ODMDS is a designated EPA site that is more than 3 nautical miles offshore. Dredge from the upper harbor reaches would go to Yellowhouse Creek Disposal Area, Clouter Creek Disposal Area and Daniel Island Disposal Area. Dredge from the lower harbor and Entrance Channel would go to the ODMDS. The Corps performed a cost analysis on alternative methods of material disposal. The current plan is the least cost alternative that accommodates all of the new work material while also supporting the future disposal requirements for maintenance material.

As a result of the project, indirect impacts are expected to occur through a shift from fresh/brackish marsh to brackish/salt marsh. Through the UMAM analysis it was determined that approximately 324 acres of wetlands are impacted and that approximately 665.6 acres of mitigation lands would need to be acquired to offset the wetlands impacts. For planning purposes we are estimating that 665.6 acres will need to be acquired at an estimated land value of $2,995,200. One landowner will be impacted and the total cost of Real Estate including land and administrative costs is estimated at $3,033,000. Lands meeting the needs for compensatory mitigation and proposed for preservation would be acquired in fee by the non-federal sponsor and then conveyed to the United States of America. Those lands would then be under the administrative control of the USFS for operational and management purposes. Appendix E (Real Estate) provides detailed information pertaining to LERRs required for the project.

4.5 Detailed Cost Estimates and Benefits

The Cost Engineering and Risk Analysis Attachment of Appendix D contain detailed information on project costs, cost assumptions, and the associated risks that factored into the contingency. Appendix C (Economics) includes detailed discussions of the transportation cost savings and benefit analysis.

4.5.1 Project Costs and Cost Sharing NED Plan and LPP

Tables 4-4 and 4-5 contain project cost sharing guidelines, and schedule. Tables 4-6 and 4-7 present the application of USACE cost sharing guidelines to the NED Plan and Locally Preferred Plan (LPP). The estimates used for the cost sharing tables shown in Tables 4-6 and 4-7 are based on the Project First Cost (Constant Dollar Basis") (second column) on the Total Project Cost Summary (TPCS) spreadsheet (Appendix D – Cost Engineering/Cost Engineering and Risk Analysis Attachment). USACE regulations require use of the Constant Dollar Cost estimate at current price levels for feasibility reports and the Chief of Engineers Report. The Constant Dollar Costs at current price levels serve as the basis for the cost of the project for authorization and represents the Project First Cost. Project First Cost include planning, engineering, and design costs, construction management costs, construction costs of the general navigation features (GNF) with both federal and non-Federal Sponsor in-kind contributions as applicable, LERR values, and contingencies determined through the Cost and Schedule Risk Analysis (CSRA). The Total Project Cost is the Constant Dollar Cost fully funded with escalation to the estimated midpoint of construction.

As detailed in Table 4-6, the NED plan (50/48) has a project cost of $476,000,000. Project cost includes project first costs, which include General Navigation Features (GNF), LERR, local service facilities, and aids to navigation. GNF costs are cost shared 50%/50% during construction. An additional 10% of the GNF costs, less the amount of LERR credit afforded to the sponsor for the value of LERR, can be paid by the non-Federal Sponsor over a period not to exceed 30 years with interest. However, in this case, there is no LERR adjustment credit since the sponsor has no related costs. The average annual costs were determined to be approximately $25.7 million for the NED plan. The average annual benefit for the NED plan is approximately $103.1 million. Therefore, the benefit-to-cost ratio is estimated at 4.01 to 1 for the NED plan. Also see, Table 49 in Economics Appendix C for costs and benefits.

The project cost for the RP (52/48), Table 4-7, which is an LPP, is estimated at $521,000,000 and includes project first costs with General Navigation Features (GNF) plus an additional 10% of the GNF costs to be paid by the non-Federal Sponsor over a period not to exceed 30 years with interest, no cost sharing for the LERR adjustment credit for the non-Federal Sponsor (not to exceed 10% of the general navigation features, which in this case is $0, since the sponsor desires a Locally Preferred Plan), and non-Federal local service facility improvements for berthing area dredging and bulkhead modifications, and USCG aids to navigation costs. The average annual costs shown in Table 4-8 were determined to be approximately $28 million for the LPP. The average annual benefit for the LPP is approximately $109 million. Therefore, the benefit-to-cost ratio is estimated at 3.89 to 1 for the LPP. Also see, Table 49 in Economics Appendix C for costs and benefits.

As a result of the abbreviated cost risk analysis, an 18 percent contingency was used for the NED and RP. The nature of Monte Carlo simulation is that different modeling runs result in slightly different contingency values. This is commonly +/- 0.1 for a contingency percentage value. As a result, a portion of the percentage difference in contingency percentage values between 50 feet and 52 feet is not likely to be statistically significant.

The following cost estimates reflect all project features, including the advance maintenance plan, real estate costs, and local service facility costs. Environmental windows for turtle nesting factored into construction windows and construction sequencing. Cost assumptions for mitigation conservatively assumed an impact approximately 324 acres of wetlands due to changes in salinity, which require mitigation for 665.6 acres in the form of preservation of wetlands. Reduction of the stepped area of the Entrance Channel avoids some impacts, but approximately 30 acres of hardbottom habitat in the extended footprint of the Entrance Channel require mitigation along with risk contingencies. The Cost

Effective Incremental Cost Analysis (CEICA), located in Appendix-P, provides an analysis of cost effectiveness for wetland and hardbottom mitigation, which were subsequently used in the cost estimate.

4.5.2 Project Schedule and Interest during Preconstruction Engineering and Design (PED)/Construction

Table 4-5 presents the approximate project milestone schedule durations. The overall schedule and durations depend on the time required to obtain congressional authorization and timely funding. Other areas of schedule uncertainty include the availability of dredging equipment to complete the work and to comply with environmental requirements for endangered species, and delays due to unexpected severe weather conditions. Based on these uncertainties the construction duration is estimated to range from 40 to 76 months. For Interest During Construction (IDC) calculations a 30 month duration was assumed for PED and a 76 month duration was assumed for construction.

Interest During Construction (IDC) accounts for the opportunity cost of expended funds before the benefits of the project are available and is included among the economic costs that comprise the NED project costs. The amount of the pre-base year cost equivalent adjustments depends on the interest rate; the construction schedule, which determines the point in time at which costs occur; and the magnitude of the costs to be adjusted. The PED durations are included in the IDC, as well as the construction durations. The current construction schedule assumes authorization of the project in a future Water Resources Development Act (WRDA). Assuming Congress provides funding subsequently to authorization of the project, the proposed schedule of activities would follow resulting in benefits starting in the base year of the proposed project. The IDC was computed with the 2015 fiscal year interest rate of 3.375 percent. Total PED and construction duration includes 106 months with the PED activity taking about 30 months and the construction taking about 76 months (6 years, and 4 months). Table 4-5 summarizes the PED and construction activities for the 52/48 LPP. For a detailed work breakdown structure and activity listing of the PED and Construction activities see the Critical Path Method Network, found in the Cost Engineering Appendix D. To maintain the completion of construction schedule by the middle of 2022 or the base year, the sponsor has expressed a willingness and capability to accelerate some critical path PED activities such as ship simulation, which is currently planned to begin later in the PED phase. For IDC calculations the conservative estimate of 30 months of PED was used.

Table 4-4. Cost sharing allocation for construction, operations and maintenance

	For Project Depths < 45 feet		
Construction	**Federal**	**Non-Federal**	
General Navigation Features (GNF)	50%	50 +10% 1/	
Aids to Navigation	100%	0%	
Service Facilities	0%	100%	
LERR	0%	100%	
Mitigation (included above in GNF)	50%	50%	

Operations and Maintenance	Federal	Non-Federal	Federal	Non-Federal
GNF (including mitigation)	100% 2/	0% 2/	0% 3/	100% 3/
Aids to Navigation	100%	0%	100%	0%
Local Service Facilities	0%	100%	0%	100%
LERR	0%	100%	0%	100%
1/ Ten percent (10%) post-construction contribution is reduced by credit amount for LERR				
Note: Table derived from ER-1105-2-100, Table E-12, Navigation, Construction, and O&M, pages E-62 and E-63.				
Note: ER 1105-2-100, Table E-11 Navigation PED, pages E-61 and E-62				
PED - All preconstruction, engineering, design, and planning accomplished after the feasibility study is cost shared				
at 50% Federal and 50% Non-Federal, CECW-PC Memorandum on Modification of non-federal contribution in Design Agreement, 24 May 2013, which changed PED cost sharing to the same as project construction				
2/ Pending implementation guidance, WRRDA 2014 changes cost sharing of O&M to 0% for the non-Federal sponsor for depths < 50 feet				
3/ Normally 50% Federal and 50% Non-Federal would be required for O&M, but the Sponsor requests a LPP and is required to pay 100% of the additional O&M costs above that required for the NED Plan.				

Table 4-5. Approximate PED and construction durations used to compute IDC for the 52-foot/48-foot RP

Description	Duration in Months	Cumulative Months
Division Engineer's Transmittal (S = PED Start)	0	S
Design Agreement	3	S+3
Plans and Specifications	18	S+21
Project Partnership Agreement (PPA) Initiated	4	S+25
Advertise (Contingent upon funding) Contract	2	S+27
Award Contract	3	S+30
Construction Start (C = Construction Start)	0	C
Construction Complete	76	C+76

Table 4-6. Cost summary for the 50-foot/48-foot NED Plan – Charleston Post 45 Navigation Study

Federal/Non-Federal Cost Apportionment - NED Plan			
(October 2014 Price Levels -13 Apr 2015)			
Segment 1 @ 50' + Segment 2 @50' + Segment 3 @ 48'			
Maximum Widening and Turning Basin Expansion Measures with 800-foot Entrance Channel with 944-foot Wings			
Cost sharing for > 45 feet	**Total Cost**		
	Allocated	**Federal Share**	**Non-Fed**
General Navigation Features (GNF) [50% Fed / 50% Non-Fed]	**50'+50'+48'**	**GNF**	**GNF**
Dredging --			
Mob & Demob (included in segment costs)			
Segment 1 @ 50' Inner Harbor / 52' Entrance Channel	$349,860,000	$174,930,000	$174,930,000
Segment 2 @ 50' Inner Harbor	$21,370,000	$10,685,000	$10,685,000
Segment 3 @ 48' Inner Harbor	$30,690,000	$15,345,000	$15,345,000
Disposal Area Dike Improvements	$16,780,000	$8,390,000	$8,390,000
Environmental Monitoring-9 Yrs (cultural hist. shoreline erosion)	$5,310,000	$2,655,000	$2,655,000
Environmental Monitoring-9 Yrs (wetlands/hardbottom)	$10,620,000	$5,310,000	$5,310,000
Real Estate, Admin (costs associated with mitigation)	$37,500	$18,750	$18,750
Real Estate Land Payments by NFS - 476 Acres Wetland Mitigation	$2,140,000	$1,070,000	$1,070,000
Preconstruction, Engineering, Design, & Planning	$5,600,000	$2,800,000	$2,800,000
Construction Management (S&I)	$6,280,000	$3,140,000	$3,140,000
Total GNF	**$448,687,500**	**$224,343,750**	**$224,343,750**
Subtotal - Project First Costs (rounded)	**$448,700,000**	**$224,340,000**	**$224,340,000**
Additional 10% of (NED) GNF	**$0**	-$44,870,000	$44,870,000
Non-Federal Sponsor's Amount for Payment over 30 years	**$0**	-$44,870,000	**$44,870,000**
Non-Federal Local Service Facilities [100% Non-Federal]			
Berthing Area Dredging (Segments 1, 2, & 3)	$4,760,000	$0	$4,760,000
Port Bulkhead Const. (Segment 1 - Wando Terminal)	$22,000,000	$0	$22,000,000
Total Non-Federal Local Service Facilities	$26,760,000	$0	$26,760,000
USCG Aids to Navigation (100% USCG Federal Cost)	$620,000	$620,000	$0
Project Costs (rounded)	**$476,000,000**	**$180,000,000**	**$296,000,000**

Table 4-7. Cost summary for the 52-foot/48-foot LPP – Charleston Post 45 Navigation Study

Federal/Non-Federal Cost Apportionment – Locally Preferred Plan			
(October 2014 Price Levels -13 Apr 2015)			
Segment 1 @ 52' + Segment 2 @52' + Segment 3 @ 48'			
Maximum Widening and Turning Basin Expansion Measures with 800-foot Entrance Channel with 944-foot Wings			
Cost sharing for > 45 feet	**Total Cost**	**Federal Share**	**Non-Fed**
	Allocated	**GNF**	**GNF Difference**
General Navigation Features (GNF) [Sponsor pays 52'-50' difference]	**52' Project**	**50' Project**	**52' minus 50'**
Dredging --			
Mob & Demob (included in segment costs)			
Segment 1 @ 52' Inner / 54' Entrance Channel	$390,720,000	$174,930,000	$215,790,000
Segment 2 @ 52' Inner	$23,630,000	$10,685,000	$12,945,000
Segment 3 @ 48' Inner Harbor	$30,690,000	$15,345,000	$15,345,000
Disposal Area Dike Improvements	$16,780,000	$8,390,000	$8,390,000
Environmental Monitoring-9 Yrs (cultural hist. shoreline erosion)	$5,310,000	$2,655,000	$2,655,000
Environmental Monitoring-9 Yrs (wetlands/hardbottom)	$10,620,000	$5,310,000	$5,310,000
Real Estate, Admin (costs associated with mitigation)	$37,500	$18,750	$18,750
Real Estate Land Payments by NFS - 665.6 Acres Wetland Mitigation	$2,995,000	$1,070,000	$1,925,000
Preconstruction, Engineering, Design, & Planning	$5,600,000	$2,800,000	$2,800,000
Construction Management (S&I)	$6,930,000	$3,140,000	$3,790,000
Total GNF	**$493,313,000**	**$224,344,000**	**$268,969,000**
Subtotal – Project First Costs (rounded)	**$493,300,000**	**$224,300,000**	**$269,000,000**
Additional 10% of (NED) GNF	**$0**	-$44,870,000	$44,870,000
Non-Federal Sponsor's Amount for Payment over 30 years	**$0**	-$44,870,000	**$44,870,000**
Non-Federal Local Service Facilities [100% Non-Federal]			
Berthing Area Dredging (Segments 1, 2, & 3)	$4,970,000	$0	$4,970,000
Port Bulkhead Const. (Segment 1 - Wando Terminal)	$22,000,000	$0	$22,000,000
Total Non-Federal Local Service Facilities	**$26,970,000**	**$0**	**$26,970,000**
USCG Aids to Navigation (100% USCG Federal Cost)	**$620,000**	**$620,000**	**$0**
Project Costs 52/48 Plan (rounded)	**521,000,000**	**180,000,000**	**341,000,000**

Table 4-8. Average Annual Equivalent (AAEQ) benefits and costs for the 52-foot/48-foot LPP Charleston Harbor Post 45 Navigation Study

Element	Cost/Benefit (Average Annual $)
Federal Discount Rate FY15 = 3.375%, October 2014 (FY15) Price Levels, Capital Recovery Factor = 0.041677, 50-Year Period of Analysis	
Project Costs	$521,000,000
Interest During Construction	59,800,000
Economic Investment (rounded)	580,800,000
AAEQ Costs	
Economic Investment	24,200,000
Increased O&M Dredging	3,740,000
Increased O&M for Navigation Aids	$50,000
Total AAEQ Costs (rounded)	28,000,000
Benefits (Transportation Cost Savings)	
Origin to Destination Deepening	$105,300,000
Channel Widening & Tidal Delay	$3,600,000
Total AAEQ Benefits (rounded)	$108,900,000
AAEQ Net Benefits (rounded)	**80,900,000**
Benefit to Cost Ratio (computed at 3.375%)	**3.89**

4.5.2.1 Fully Funded Total Project Costs

The total project costs are constant dollar costs fully funded with escalation to the estimated midpoint of construction. The total project cost is $538 Million, including GNF and LERRs. When other associated costs of $30 Million are included such as local service facilities and aids to navigation, the total project cost is $568 Million. See the Total Project Cost Summary (TPCS) in (Appendix D – Cost Engineering Considerations, Cost Engineering and Risk Analysis Attachment).

4.5.3 Operation, Maintenance, Repair, Rehabilitation, and Replacement (OMRR&R)

Increased Operation and Maintenance (O&M) costs over the existing project O&M costs result from deepening and widening of the federal navigation channel. Appendix A (Engineering) describes the use of the sediment transport module of EFDC to assess potential changes to suspended sediment concentration in the water column and deposition rates in the federal navigation channel. The greatest increase in sedimentation caused by the project alternatives would occur in the Wando River Upper Reach, Turning Basin and Terminal. The next largest predicted increase in sedimentation occurs in the Ordnance Reach & Turning Basin. Sedimentation is also predicted to increase along Hog Island Reach, Drum Island Reach, Meyers Bend Reach and Daniel Island Reach. Note there are four areas in which the model estimated shoaling that historical records do not support. These are Rebellion Reach, Bennis Reach, Clouter Creek Reach and North Charleston reach. For these reaches the model predicted sedimentation rates were used in estimating dredging quantities. It is estimated that the Wando TB increases 89 percent over its existing size, Ordnance TB increase 76 percent over its existing size. Thus the majority of increased shoaling is due to the increase in footprint. The increased annual cost for O&M dredging between the existing condition (45-foot project depth) and the future with project condition for the 52/48 plan amounts to $3,740,000. O&M costs for the NED depth increment of 50 feet is a 100% federal expense. All O&M costs for depths in excess of 50 feet as part of the LPP are a 100% non-federal responsibility. The annual cost attributable to O&M for the depth in excess of 50 feet is estimated at $210,000 with the non-federal sponsor solely responsible for this cost.

Advanced Maintenance

Advanced maintenance is dredging to a specified depth and/or width beyond the authorized channel dimensions in critical and fast-shoaling areas to avoid frequent dredging and ensure the reliability and least overall cost to operate and maintain the project's authorized dimensions. Engineering Appendix A, paragraph 3.8.3, contains a discussion of shoaling rates and advanced maintenance requirements. The existing advanced maintenance areas identified in Final Environmental Assessment, Charleston Harbor Additional Advanced Maintenance Dredging, Charleston Harbor, South Carolina, September 2009 are justified. Since the relatively minor changes in shoaling rates predicted are based on maximum widening assumptions that will be optimized prior to construction and no significant changes in channel alignment are proposed, the existing project footprint would continue to be maintained at project depth plus 2 feet of advanced maintenance and 2 feet of allowable overdepth and the areas that have high shoaling rates are not expected to change. Due to higher shoaling rates the following reaches will continue to be maintained at project depth plus 4 feet of advanced maintenance and 2 feet of allowable overdepth or project depth plus 6 feet of advanced maintenance and 2 feet of allowable overdepth. Ordnance Reach and Turning Basin, Lower Wando River Reach, Wando Turning Basin, and Lower Town Creek Reach are all dredged to project depth plus 4 feet of advanced maintenance and 2 feet of allowable overdepth. Drum Island Reach is dredged to project depth plus 6 feet of advanced maintenance and 2 feet of allowable overdepth. The USACE will monitor shoaling rates after construction to determine if adjustments to advance maintenance practices are needed. The USACE would monitor the shoaling rate after construction to determine if more or less advance maintenance is needed.

The other increase in annual O&M costs shown in Table 4-8, above, Average Annual Equivalent (AAEQ) Benefits and Costs for the RP includes $50,000 for increased annual maintenance of U.S. Coast Guard Aids to Navigation. The U.S. Coast Guard reviewed proposed plans containing the widening and turning basin navigation improvements to develop an estimated cost for the increased maintenance to navigation aids in a letter dated April 1, 2013.

No utilities were identified as requiring relocation due to project deepening based on contact with the sewage, water, electrical, and communication utilities. The South Carolina State Ports Authority (SCSPA) would provide staging areas for the dredging contractor during construction. The USACE would be responsible for the post-construction monitoring of the hardbottom and wetland mitigation areas as outlined in the Monitoring and Adaptive Management Section of Appendix P. The SCSPA would be responsible for any additional mitigation and monitoring that is required. The USACE would include preconstruction monitoring of the hardbottom and wetland mitigation sites in the plans and specifications used for project construction.

4.5.4 Financial Analysis of Non-Federal Sponsor's Capabilities

The non-federal sponsor, the South Carolina Ports Authority, concurs with the financial responsibility as it pertains to the cost sharing rules as outlined in Table 4-7, above. Under the Water Resources Development Act (WRDA) 1986, as amended by Section 201 of WRDA 1996, federal participation in navigation projects is limited to sharing costs for design and construction of the general navigation features (GNF) consisting of breakwaters and jetties, entrance and primary access channels, widened channels, turning basins, anchorage areas, locks, and dredged material disposal areas with retaining dikes.

Non-federal interests are responsible for and bear all costs for acquisition of necessary lands, easements, rights-of-way and relocations; terminal facilities; as well as dredging berthing areas and interior access channels to those berthing areas. Current policy requires the sponsor to document their ability to pay through submission of a self-certification of financial capability as described in CECW-PC memorandum dated 12 June 2007. Appendix Q, Correspondence, contains this certification.

4.5.5 View of Non-Federal Sponsor

The South Carolina State Ports Authority (SCSPA) fully supports the RP and has agreed to the cost sharing as outlined above. Appendix Q, Correspondence, contains the sponsor's letter of intent. The letter of intent contains the non-Federal Sponsor's acceptance of, or desired departures from, the terms of the applicable model Project Partnership Agreement (PPA), including: 1) applicable cost sharing and financial policies; 2) policies regarding provision and valuation of non-federal lands, easements, rights-of-way, and disposal areas provided by the non-Federal Sponsor; 3) policies governing non-federal project construction; and 4) other provisions required by law and policy for new start construction projects.

In general, the SCSPA believes the ongoing shift to larger containerships on the east coast will occur faster than forecasted. The SCSPA believes that modern containerships requiring 48 feet of draft and appropriate underkeel clearance will be the dominant vessels calling on their facilities by 2020. The SCSPA wants the ability to handle this class of Generation II and III containerships without having to wait on tidaladvantage. Additionally, the SCSPA has expressed a desire to avoid the need for, and costs associated with additional studies, separate construction, and environmental impacts that would result if a follow-up feasibility study would be needed within the foreseeable future.

4.5.6 Summary of Accounts

The federal process incorporates four accounts to facilitate evaluation and display of effects of alternative plans. The four accounts are national economic development (NED), environmental quality (EQ), regional economic development (RED), and other social effects (OSE). They are established to facilitate evaluation and display of effects of alternative plans.

The NED account is required. Other information that is required by law or that would have a material bearing on the decision-making process should be included in the other accounts, or in some other appropriate format used to organize information on effects. The federal objective is to determine the project alternative that reasonably maximizes net benefits while protecting the nation's environment. The environmental effects of the RP were evaluated under the environmental quality account and are detailed in Section 5. The economic analysis used NED to measure the benefits of the RP; regional shifts in economics are not expected for the RP. In regard to the RP, the OSE account includes the effects of the project on the homeowners in the region. The opinions of these homeowners have been noted in the report and are documented in Section 7.

The NED account displays changes in the economic value of the national output of goods and services. Under this account, the NED plan (50/48) generates average annual equivalent (AAEQ) net benefits of about $77.4 million with a benefit-cost ratio (BCR) of 4.01 and the RP (52/48) generates AAEQ net benefits of about $80.9 million with a BCR of 3.89.

4.5.7 Risk and Uncertainty

Risk and uncertainty exists in the potential fluctuation of the federal interest rate, changes in vessel operating costs, changes in mitigation costs, and deviations from vessel or cargo forecasts. Interest rates, forecasts, and vessel operating costs are discussed further in the Appendix C (Economics). Cost contingencies, incremental costs, and estimates for the mitigation plan are discussed in Appendices D (Cost Engineering) and P (Mitigation). There are also risks which were addressed during the study using a Risk Register. The purpose of the register is to apply a risk-based decision making approach throughout the study. The register was used to highlight areas of study risks and identify ways to address those risks, such as reducing the schedule, optimizing the study area, and identifying the optimum amount of modeling to make a risk-based decision.

Several assumptions applied to analyses during the study result in conservative cost and impact estimates and reduce cost risks. Of particular note is the application of the "maximum" widening measures. This one assumption generates the "maximum" dredging quantities, construction cost estimates, and construction duration times. The same assumptions were also applied to all of the engineering and environmental modeling efforts and generated the "maximum" shoaling rates and impacts to water quality, wetlands and all other habitat types and species. If some or all of these measures are reduced through additional analysis during PED, meaningful reductions across a broad range of cost and adverse environmental impacts would be expected. Additionally, a comparison of the forecasted data with the information that has become available since the forecasts were generated has not identified differences that indicate a risk to the use of the results. To the contrary, the actual containerized cargo volumes that are the primary driver of the economic benefits analysis have exceeded forecasts by significant margins (19%-23%) each year from 2012 - 2014.

4.5.8 With-Project Sea Level Change

Assuming construction is completed in 2022, and a 50 year period of analysis and starting with a 2012 baseline elevation (increase over a 59 year period) - the "low" rate of change indicates a relative rise of

0.57 feet, the "intermediate" indicates a relative rise of 1.08 feet and the "high" indicates a relative rise of 2.74 feet. For details on the calculation of the sea level change rates see Appendix A - Engineering, paragraph 2.2 Sea Level Change.

The total regional sea level rise predicted by the three scenarios (baseline, intermediate, and high) would not have a significant impact on the performance of the Charleston Harbor federal navigation project. Potential impacts of rising sea levels include overtopping of waterside structures, increased shoreline erosion, and flooding of low lying areas. A positive potential impact of sea level rise on the project is a reduction in required maintenance due to increased depth in the channel. In general, regional sea level rise (baseline, intermediate, and high) would not adversely affect the function or safety of the existing federal navigation project or the alternatives considered in detail. Additionally, differences in the projections would not meaningfully influence the selection of one alternative over another. While there small increases in tidal surge and penetration would be expected for all alternatives, the structural aspects of the project would be either unaffected or can be easily adapted to accommodate the change.

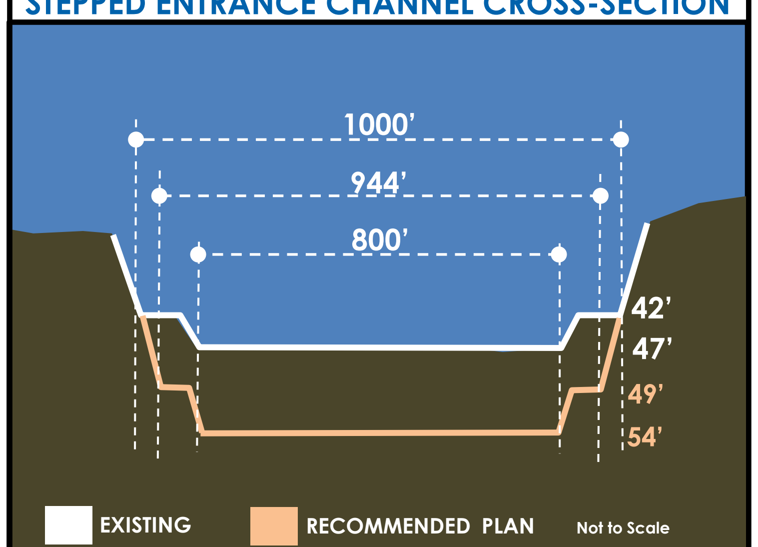
4.5.9 Storm Surge and Coastal Erosion

Storm surge modeling and coastal erosion analysis would occur during the PED phase in an effort to streamline the study phase and reduce the overall duration of critical path activities prior to generating plans and specifications and obtaining final approvals.

REFERENCE TABLE 1: CHARLESTON HARBOR EXISTING COMPARED TO RECOMMENDED PLAN SEGMENT DIMENSIONS

REACH OR SEGMENT	NOMINAL DEPTH		NOMINAL CHANNEL WIDTH		RECOMMENDED PLAN
	MAINTENANCE	AUTHORIZED	MAINTENANCE	AUTHORIZED	
Entrance Channel	47/42	47/42	42' at 1000'	42' at 1000'	49' at 944' width
Entrance Channel	47/42	47/42	47' at 800'	47' at 800'	54' at 800' width
ENTRANCE CHANNEL TO WANDO WELCH TERMINAL (LOWER HARBOR)					
Mount Pleasant Range	45	45	600-1000	600-1000	52 at 600-1000
Rebellion Reach	45	45	600	600	52 at 600-700
Bennis Reach	45	45	600	600	52 at 700
Horse Reach	45	45	600	600	52 at 700
Hog Island Reach	45	45	600	600	52 at 700
Wando Channel Lower Reach	45	45	400	400	52 at 500
Wando Turning Basin (TB)	45	45	1400	1400	52 with 1800 TB
DRUM ISLAND TO NORTH CHARLESTON TERMINAL (UPPER HARBOR)					
Drum Island Reach	45	45	600	600	52 at 700-800
Myers Bend	45	45	VARIES	VARIES	52 at VARIOUS
Daniel Island Reach	45	45	880	880	52@880 &1800' TB
Daniel Island Bend	45	45	700-880	700-880	48 at 700-880
Clouter Creek Reach	45	45	600	600	48 at 600-650
Navy Yard Reach	45	45	600-675	600-675	48 at 600-675
North Charleston Reach	45	45	500	500	48 at 550
Filbin Creek Reach	45	45	500	500	48 at 550
Port Terminal Reach	45	45	600	600	48 at 600
Ordnance Reach with TB	45	45	1400	1400	48 at 1650
UNION PIER TO WEST OF DRUM ISLAND					
Custom House Reach	45	45	Varies	Varies	45
Upper Town Creek	16	16	250	250	16
Lower Town Creek	45	45	450	450	45
Town Creek Turning Basin	35	35	300	300	35
Tidewater Reach	40	40	650	650	40
OTHER FEDERAL CHANNELS					
Anchorage Basin	35	35	2250	2250	35
Shem Creek Channel	12	12	110	110	12
SHIPYARD RIVER					
Entrance Channel	45	45	300	300	45
Basin A	45	45	700	700	45
Connector Channel	45	45	200	200	45
Basin B	30	30	600	600	30

STEPPED ENTRANCE CHANNEL CROSS-SECTION



ITEM	NED (50/48)	LPP (52/48)	DIFFERENCE (LPP – NED)
Project Cost	$476,000,000	$520,900,000	+$44,900,000
Average Annual Costs	$25,700,000	$28,000,000	+$2,300,000
Average Annual Benefits	$103,100,000	$108,900,000	+$5,800,000
Net Benefits	**$77,400,000**	**$80,900,000**	**+3,500,000**
Benefit Cost Ratio	4.01	3.89	-0.12

CHARLESTON HARBOR POST 45 RECOMMENDED PLAN: SECTION 4 REFERENCE AID

5.0 IMPACTS OF THE PROPOSED PROJECT

This section explains how the proposed project (Recommended Plan or RP), as described in the previous section, would affect the economic conditions, the navigation system components, and the environmental resources in the study area. Impacts of other alternatives are summarized in Table 3-5. The section headings are organized to mirror the relevant resources presented in Section 2 of this report.

5.1 General Setting

Neither the future without-project condition (FWOP) /No Action Alternative nor the proposed project would change the current general setting within the project area.

The proposed project would not directly affect land use, including by the conversion of additional natural areas to urban use. The analysis supporting this conclusion considered the existing throughput capacity estimated for the Port of Charleston, which includes landside constraints. The proposed navigation channel improvements are not directed at increasing the capacity of the harbor to process cargo, but rather at enabling the port to do so more efficiently. The economic analysis determined that the channel improvements would only result in cargo transiting through the Port of Charleston more efficiently, and did not conclude that the project would result in an increase in total cargo that transits the harbor. Therefore, the project would have no material effect on the conversion of additional natural area. The project would also not result in any landside transportation changes since the commodities entering the port are not anticipated to change with or without the project.

The dredging templates lie entirely within the water column of Charleston Harbor. The project would not include dredging any upland or wetland areas. Maintenance dredging under the no-action alternative, as well as new work project dredging, would place dredged material in existing upland CDFs or in the Charleston ODMDS, actions which would not affect land use. Beneficial use options would not impact land use.

Project construction would require upland staging areas for equipment and crew transfer to the dredge and support vessels. Staging would likely occur on land already designated for industrial or commercial land use. Regardless, any effect on upland use from staging activities would occur temporarily for the duration of construction.

5.2 Economic Conditions

Transportation cost savings would result primarily from the more efficient use of the anticipated larger vessels, more efficient use of large vessels that are currently transiting the harbor, reduced vessel calls, and reduced congestion in the harbor.

5.2.1 Trade Volume

For the purposes of this study, the same throughput tonnage was used for the with and without project condition. This is due to the fact that the cargo volume forecasted to transit through Charleston Harbor is the same with or without the proposed improvements. As stated in Section 2.2.1, the forecasted increases in cargo do not depend on changes to the existing navigation system. The primary reasons the navigation improvements do not significantly affect cargo forecasts include the following considerations (not in any specific order): 1) The existing navigation system is capable of handling the forecasted cargo volumes without modification; 2) for most cargo, even with major constraints and inefficiencies, transportation by water is far less costly than by any alternative mode of transportation; 3) historically, most viable ports make the improvements needed to meet the needs of the shipping industry (this avoids major shifts in cargo volumes between ports); and 4) landside infrastructure changes and other factors such as development of industries, distribution centers, and population shifts tend to have a greater influence on cargo volumes than changes in marine navigation systems. As such, no shift in destination, mode of transportation, or any induced movement of cargo is expected due to the proposed navigation improvements. Charleston's share of East Coast tonnage transported through the harbor is anticipated to remain constant throughout the period of analysis. Additional information on forecasting is provided in Appendix C (Economics).

The Port's container capacity is forecast to be around 4.2 million TEUs. The TEU forecast is estimated at just over 4 million TEUs in 2037; therefore, the long-term forecast was constrained beyond that point. The containerized cargo import forecast is presented in Table 5-1. As shown in the table, ISC/ME, NEUR and the FE trade is forecasted to make up a significant share of Charleston Harbor imports over the forecast period, growing from approximately 3.7 million tons in the 2011 baseline to just over 10.6 million tons in 2037. Imports from NEUR region service is expected to lead all Charleston Harbor services in total trade, closely followed by ISC/ME.

Table 5-1. Containerized Trade forecast - imports (tons)

Imports	**2011 Baseline**	**2022**	**2027**	**2032**	**2037**
Africa	95,405	138,969	161,125	182,961	208,030
CAR CA	30,443	44,907	51,491	58,428	67,038
ECSA	278,052	470,383	598,230	719,658	849,981
FE (Panama)	590,199	1,115,993	1,453,203	1,737,205	1,991,441
FE (Suez)	407,463	770,461	1,003,265	1,199,335	1,374,855
FE ECUS NEUR PEN	431,981	712,634	875,775	1,022,811	1,169,702
ISC/ME	608,002	1,385,121	1,897,996	2,330,735	2,707,374
MED	138,327	211,832	252,678	296,609	350,406
NEUR	1,626,139	2,319,978	2,642,871	2,984,639	3,401,183
WCSA	145,935	182,191	199,524	218,797	241,315
Total	**4,351,946**	**7,352,472**	**9,136,158**	**10,751,178**	**12,361,323**

The export forecast shown in Table 5-2. As with imports, exports to ISC/ME, NEUR and the FE are forecast to make up a significant portion of the Charleston Harbor export trade over the period of the forecast, growing from 3.4 million tons in 2011 to 12.0 million tons in 2037, a 252 percent growth over that time period. As with imports, the NEUR service route is expected to lead all Charleston Harbor services in total trade volume, closely followed by ISC/ME.

Table 5-2. Containerized Trade forecast - exports (tons)

Exports	2011 Baseline	2022	2027	2032	2037
Africa	242,659	422,155	504,836	587,945	683,259
CAR CA	45,179	75,192	89,738	105,609	124,566
ECSA	402,062	691,363	834,855	994,715	1,190,048
FE (Panama)	550,828	1,249,974	1,783,317	2,217,322	2,543,131
FE (Suez)	336,718	764,102	1,090,132	1,355,436	1,554,602
FE ECUS NEUR PEN	551,458	1,038,408	1,356,054	1,631,356	1,879,789
ISC/ME	712,638	1,567,489	1,979,887	2,386,932	2,804,933
MED	230,483	385,196	466,153	551,062	652,923
NEUR	1,244,733	2,003,978	2,375,791	2,743,156	3,179,841
WCSA	365,899	558,178	649,789	743,531	857,564
Total	**4,682,658**	**8,756,034**	**11,130,552**	**13,317,063**	**15,470,654**

5.2.2 Port Hinterland and Clients

The Charleston Harbor hinterland includes the South Atlantic, Southeast, Gulf, and Midwest regions. The South Atlantic and Southeast regions account for an estimated average 84 percent of the Port's loaded container traffic throughput during calendar years (CY) 2008 through 2010. The remainder of the Port's loaded container traffic, on average, moved via three regions, i.e., the Midwest (8 percent), Gulf (4 percent), and All Other (4 percent) regions, respectively.

The Port serves a diverse customer base, both geographically and industrially. The Port's container customer base includes global and North American centric manufacturers and retailers such as Toyota, Michelin, Lowes, Target, and Furniture Brands International.

5.2.3 Fleet Characterization

Currently, the largest containership ever to call on the Port of Charleston was the MSC Bruxelles, a 9,200 TEUs vessel with a design draft of 49 feet, which required the vessel to transit the Port of Charleston during high tide. Vessels of this size and larger are anticipated to call with increased frequency during the period of analysis on six of the ten trade lanes evaluated in the economic analysis. The Panama Canal expansion will increase the frequency of Post-Panamax vessels calling on the Port of Charleston. These vessels are expected to call on East Coast and Gulf Coast ports.

Post Panamax container vessels with capacities ranging from about 5.2 K to about 14 K TEU are expected to call on Charleston in increasing numbers over the period of analysis. Table 5-3 presents the forecasted capacity calling on Charleston Harbor allocated to Post-Panamax vessel classes according to MSI's forecast. It indicates a significant transition of capacity from Panamax and Sub-Panamax vessels to Post-Panamax vessels over the period of analysis. In addition to the capacity attributed to Post

Panamax vessels increasing from 31% to 94% over the 25 year period from 2012 to 2037, the portions attributable to the larger Generation II and Generation III vessels is predicted to increase from 11% to 47% and from 0% to 25%, respectively.

Table 5-3. Forecasted share of Post-Panamax vessel capacity

Vessel Class	TEU Bands	2012	2015	2020	2025	2030	2035	2037
Gen I	5.2 - 7.6 k	21%	36%	45%	39%	31%	24%	22%
Gen II	7.6 - 12.0 k	11%	19%	26%	33%	40%	45%	47%
Gen III	12.0 k +	0%	0%	0%	10%	17%	23%	25%
TOTAL		**31%**	**55%**	**71%**	**83%**	**88%**	**92%**	**94%**

Source: MSI

Non-Containerized Cargo Vessels

The non-container fleet forecast was developed using historical calls from 2008 to 2011. The growth rate in the fleet was derived from that period and found to be 2.6 percent. This growth rate was assumed in bulk traffic until 2037 and then assumed constant from 2037 to 2071. Table 39 provides the resulting bulk vessel fleet.

Table 5-4. Non-containerized vessel fleet forecast

Vessel Class	2022	2027	2032	2037
General Cargo	145	165	187	213
Large Passenger	14	16	19	21
Large RoRo	241	274	312	354
Large Tanker	34	39	45	51
Larger Bulker	49	56	64	72
Medium Tanker	172	196	223	253
Small Bulker	23	25	29	33
Small Dry Cargo	7	9	9	10
Small Passenger	72	81	93	105
Small RoRo	68	78	88	101
Small Tanker	1	2	2	2
Total	**826**	**941**	**1071**	**1215**

In general, the non-container vessel fleet is not projected to experience the shift in size or require the increased channel dimensions to operate efficiently. Thus the analysis concentrates on the containership fleet that is impacted by the existing constraints and benefits from the proposed modifications.

5.3 Navigation Environment

5.3.1 Navigation History

See section 2.3.1

5.3.2 Navigation Configuration and Dimensions

The configuration and dimensions of the proposed project are detailed in the Plan Formulation Section (Section 3). Key details of the proposed project are shown in the Figures 3-7, 3-8, and 3-9. Table 5-4 summarizes the with-project dimensions.

Table 5-5. With-project dimensions

General Navigation Feature	Depth (Feet)	Width (Feet)	Length (River Miles)
Entrance Channel	54	800 - ~1000	20
Segment 1	52	400 - ~1000	9.3
Wando Turning Basin	52	1800-Diameter	0.9
Segment 2	52	600 – 1500	2.7
New SPA Terminal	52	1800-Diameter	0.9
Segment 3	48	500 - 800	5.9
North Charleston Turning Basin	48	1650-Diameter	0.3

5.3.3 Port Facilities

The port would continue improvements to the existing Wando Welch Terminal, North Charleston Terminal, and construction of the new SCPA Terminal [Charleston Naval Complex Marine Container Terminal (CNCMCT)], scheduled to open in 2018. The port would also realize immediate benefits in repairing, upgrading, and expanding their existing facilities.

5.3.4 Dredged Material Disposal

5.3.4.1 Process and Schedule

The transfer of federal channel dredged material from the proposed project would differ from that for the Future Without project condition (primarily comprising transfer of material for maintenance dredging). Key differences are the following:

Operations and maintenance (O&M) dredged material does not contain rock, while new construction material would contain both rock and non-rock material. Much of the rock material from new construction dredging would be used in a beneficial way and placed in multiple locations as mitigation for hardbottom impacts and to provide additional artificial hardbottom reef habitat. ODMDS berm expansion and hardbottom habitat development is discussed in paragraphs 4.2.7.1 and 4.2.7.2. See paragraph 4.2.1 and 4.2.6 for material quantities and placement options. Other potential beneficial uses of dredged material would be evaluated further during the Preconstruction, Engineering, and Design phase as discussed in paragraphs 4.2.6.3 – 4.2.6.7.

5.3.4.2 Upland Disposal Sites

Use of upland disposal sites may differ whether the proposed project is constructed. To handle the additional new construction material, costs have been included for raising the dikes of the Clouter Creek, Daniel Island, and Yellow House Creek confined upland disposal facilities. The dike raising would allow for future without and with-project O&M dredged material as well as the additional new construction quantities.

5.3.4.3 Ocean Disposal

Use of the Charleston ODMDS may differ whether the proposed project is constructed. Under the future with-project condition, the ODMDS would be modified as discussed in paragraph 4.2.7.1. As stated in Section 2.3.4.3, the modified ODMDS will be need in the future regardless of the proposed project. The modification is being addressed jointly by USACE and EPA through Section 102 of the Marine Protection, Research, and Sanctuaries Act. The EPA issued a Notice of Intent to prepare an Environmental Assessment in the Federal Register on 31 December 2012. It is anticipated that the EPA will issue a Final EA and final rule in the Federal Register in 2015.

5.4 Environmental Conditions

5.4.1 Wind and Wave Climate

5.4.1.1 Offshore Waves

The artificial reefs to be created along the Entrance Channel are the only project features that could affect the wave climate in the area. USACE consulted with SCDNR as to potential effects of the proposed artificial reefs. SCDNR does not typically perform wave analyses for projects constructed under the artificial reef program, as they are commonly known not to affect wave dynamics when created in relatively deep water. Since the reefs would be in water greater than 35 feet deep and would not be constructed higher than -25 feet MLLW, there is likely to be a negligible effect on the wave climate in offshore waters. USACE will conduct detailed coastal modeling during the PED phase to verify offshore wave assumptions.

5.4.1.2 Impact on Shorelines

Erosion of shorelines within Charleston Harbor is affected by a variety of external factors including tides and sea level change, river currents, vessel wakes, tropical and subtropical storms, shoreline changes (riprap protection). A study of shoreline erosion near Hobcaw Point on the Wando River in Charleston Harbor considered there to be five possible causes of shoreline retreat: shoreline construction, channel modifications, the Cooper River Re-diversion, vessel wakes, and wind generated waves (Teeter et al. 1997).

While none of the five factors assessed could be ruled out, the study concluded that, "waves produced by container vessels do not appear to be as important as wind waves or even waves produced by smaller displacement vessels in generating shear stress forces on the sediment bed. Vessel waves are solitary and infrequent in comparison to wind waves." The authors also determined that the rising sea level in the Harbor also contributes to land loss along the shoreline.

Charleston Harbor is transited by many vessels each year. As waves (wakes) produced by vessels travel outward from the sides of vessels, they would contact shorelines if there is not a long enough distance for the waves to dissipate beforehand. The size of waves created by vessel movement is affected by the size of the vessel, shape of vessel hull, direction of tidal current, speed of travel, and shape of the channel.

During the NEPA scoping process, various entities wanted to understand how the project may influence the wave climate in the Harbor and potential erosion to surrounding shorelines. In order to address the impact of the proposed project on valuable resources and shorelines (including Crab Bank, Fort Sumter, Castle Pinckney/Shutes Folly, and the south end of Sullivan's Island), an assessment of wind generated waves and a study on vessel wakes and energy distribution was performed. The methods and detailed results are presented within the Engineering Appendix (Appendix A). The analysis compared vessel wakes from the current vessel fleet in the existing harbor to the predicted future vessel fleets in an unchanged and several deepened conditions. The relative wave power, which represents the power/energy imparted on the Harbor system, was calculated for the alternatives and vessel classes (i.e., vessel size). Variations of wave power for each alternative and year are shown in Figure 5-1. If no deepening occurs, wave power would still be approximately 34 percent higher in 2022 (estimated time of construction) than in 2011 and approximately 90 percent higher in 2037 than in 2011.

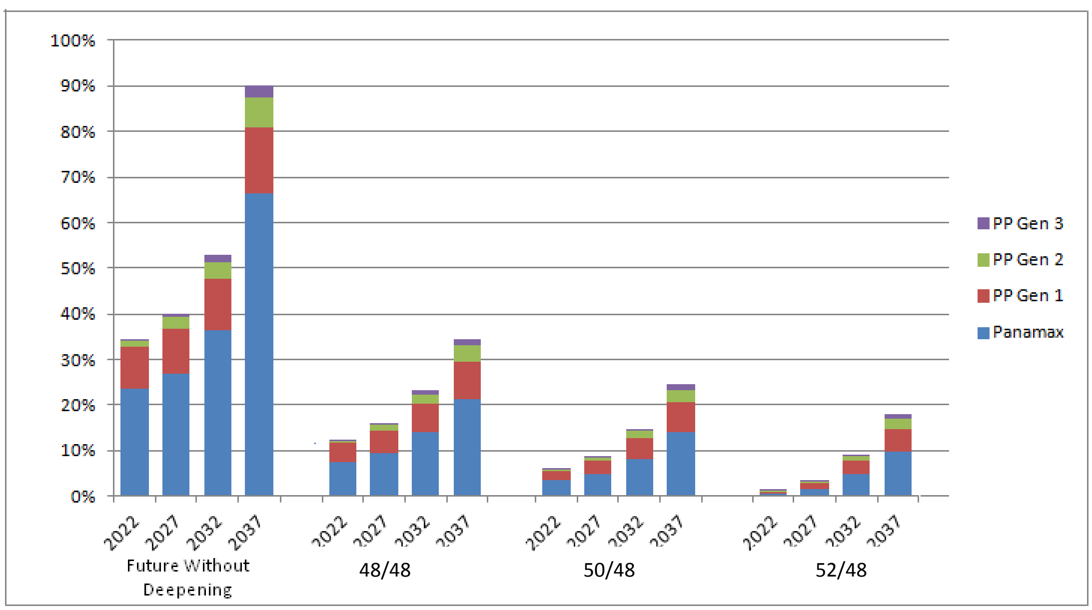


Figure 5-1. Predicted vessel-generated wave power increase by alternative for Lower Harbor relative to 2011 vessel-generated wave power for all vessel classes

During high tide, waves would impact regions higher on the shore, as depicted in the cross-section drawing in Figure 5-2. The period of high tide, corresponding to the period of transit of large vessels, is therefore of interest at Crab Bank and other sensitive regions. If vessels are restricted to calling on Charleston Harbor only at the highest tides (e.g., under the FWOP condition), vessel wakes would have a greater influence on the surrounding shorelines. The largest waves which reach the shore are smaller with the deeper alternatives (Table 5-6). This is largely attributable to the largest wakes from vessel wakes in the lower harbor being associated with Panamax class vessels since they transit the harbor at the highest speeds of all vessel classes (Appendix A). Since the proposed project and other action alternatives reduce the number of Panamax vessel calls, these larger waves decrease when compared to the future without project condition (see fleet forecasts in Appendix C). Additionally, economic analysis indicates that fewer total vessels would call on Charleston Harbor under the with project conditions compared to the FWOP condition (No Action Alternative).

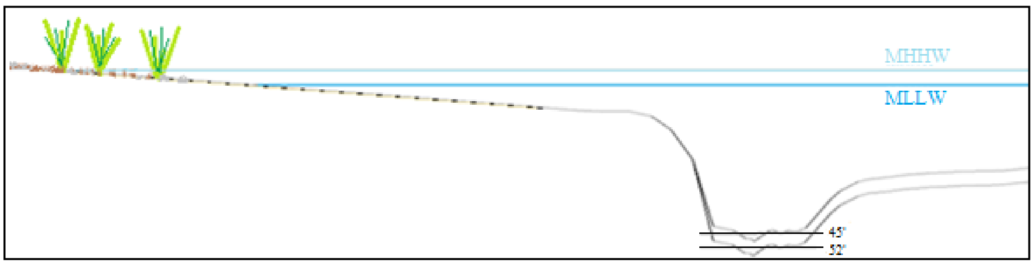


Figure 5-2. Crab Bank Cross-section with authorized depth of 45 feet compared with the 52/48 alternative at low tide and high tide

Table 5-6. Vessel wave height estimates at areas of concern in the lower harbor

Area of Concern	Scenario	Distance to Shore from Channel (ft)	Wave Height Near Shore (ft)
Fort Sumter	Existing	2,925	0.31
	2037 Without Deepening		0.31
	2037 (52/48 Project)		0.25
Shute's Folly Island	Existing	1,950	0.44
	2037 Without Deepening		0.44
	2037 (52/48 Project)		0.35
Crab Bank	Existing	2,925	0.31
	2037 Without Deepening		0.31
	2037 (52/48 Project)		0.25
Sullivan's Island	Existing	1,950	0.44
	2037 Without Deepening		0.44
	2037 (52/48 Project)		0.35

Overall, erosion of Charleston Harbor shorelines is controlled predominantly by wind waves and tidal currents. The relative infrequency of cargo vessel wakes compared with wind waves makes them a minor factor contributing to shoreline changes and erosion. Deepening the federal navigation channel would reduce the shoreline impact of vessel wakes by reducing the number of vessels and increasing the range of tides during which vessels can transit the harbor. Therefore, the deeper alternatives have a progressively smaller vessel wake impact on surrounding shorelines. Vessel wake impacts to shorelines decreased with increasing depth and the FWOP condition (or No Action Alternative) had the greatest predicted impact to surrounding shorelines in the Harbor.

Previous studies indicated that the creation and maintenance of the Charleston Harbor navigation channel and jetties has affected the adjacent coastal shorelines and altered the pattern of sediment transport from the natural condition. Additional channel deepening is not anticipated to change the overall pattern of regional sediment transport and no additional significant impacts to adjacent shorelines is anticipated. This conclusion would be verified by a more detailed coastal analysis for the proposed project that would be performed during the PED phase.

5.4.2 Tides

In the harbor, the Cooper River, the Ashley River, and the Wando River, changes in water surface elevation between the proposed project and the future without condition (2071 condition) are very small (0.07 feet or less increase in 99th percentile water level (highest tides)). Therefore, the proposed project is expected to cause only a small increase in high tide water levels within the harbor and the rivers. The largest anticipated increase in the Cooper River occurs near the 526 bridge where the 99th percentile water surface elevation is predicted to be 0.07 feet higher than the FWOP condition. In the Cooper River near the “tee” where there start to be numerous freshwater impoundments, the 99th percentile water surface elevation is predicted to be only 0.03 feet higher than the FWOP condition. In regard to the Bushy Park Reservoir salinity intrusion alert system, it is expected that sea level rise would increase the frequency of alerts triggered by the Customs House water levels (i.e., tidal alerts). However, the proposed project is not expected to increase the frequency of tidal alerts (see Appendix, Engineering).

5.4.3 Currents

The impact that the proposed project would have on currents was determined by using the Environmental Fluid Dynamics Code (EFDC) hydrodynamic model of Charleston Harbor (introduced in Section 2.4). Modeling of impacts resulting from the project alternatives occurred for both the FWOP condition/No Action (based on 2071 sea level), and the Time of Construction Condition/No Action (based on 2022 sea level). An analysis of currents is important because they are used during the PED phase to perform ship simulations of vessels transiting the harbor, and because current/velocity is an important variable for various life stages of different fish species (discussed in Section 5.4.14 and Appendix K).

A good indicator of potential changes to currents comes from evaluating the 95th percentile (e.g., fastest currents) occurring within the water column. Changes in the 95th percentile depth-averaged simulated current speeds caused by the proposed project resulted in very small increases in current speeds in the lower harbor. The maximum increases were on the order of 0.1 to 0.2 feet/second. Some areas of the navigation channel show a reduction in current speed as a result of the channel deepening and widening. The largest reductions are between 0.3 and 0.7 feet/second and occur in the turning basin expansion areas at the Wando Welch, new Navy Base, and North Charleston Terminals. Figure 5-3 shows the proposed project compared with the future without project condition in the year 2071. The detailed analysis of these minor changes would be addressed during ship simulations to be performed in the PED phase of this project; however, 0.2 feet/second changes are not expected to have a significant impact on vessel maneuverability.

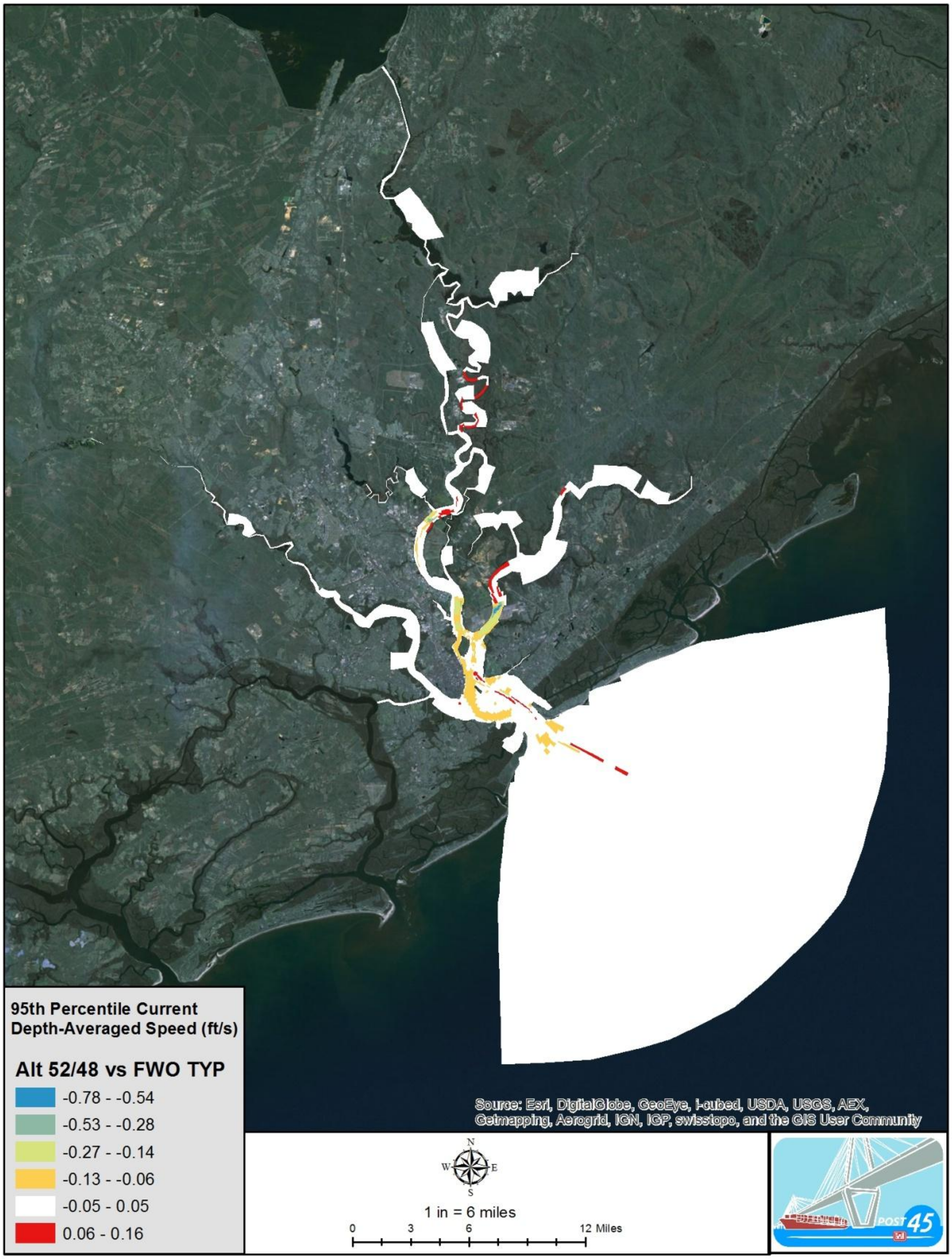


Figure 5-3. Delta of the 95th percentile current- depth Averaged speed between proposed project and FWOP

5.4.4 Relative Sea Level Change

The proposed project would not appreciably alter sea level (water surface elevation), but sea level change must be considered in conjunction with project impacts to predict how the two factors cumulatively impact hydraulics, water depths, and other environmental characteristics. Potential impacts of rising sea level include overtopping of waterside structures, increased shoreline erosion, and flooding of low lying areas. A positive potential impact of sea level rise on the project is a reduction in required maintenance due to increased depth in the channel. Using USACE guidance on sea level change (see Appendix A for explanation), the historic trend was estimated to be 2.94 mm/year of relative sea level rise. USACE guidance requires an estimation of an intermediate and high rate of sea level rise based on various National Research Council sea level change curves (Figure 5-4). The total regional sea level rise predicted by the three scenarios (baseline, intermediate, and high) at the end of the 50-year life of the project were projected to be 0.57 feet, 1.08 feet, and 2.74 feet, respectively, and would not have a significant impact on the performance of the Federal Navigation Project.

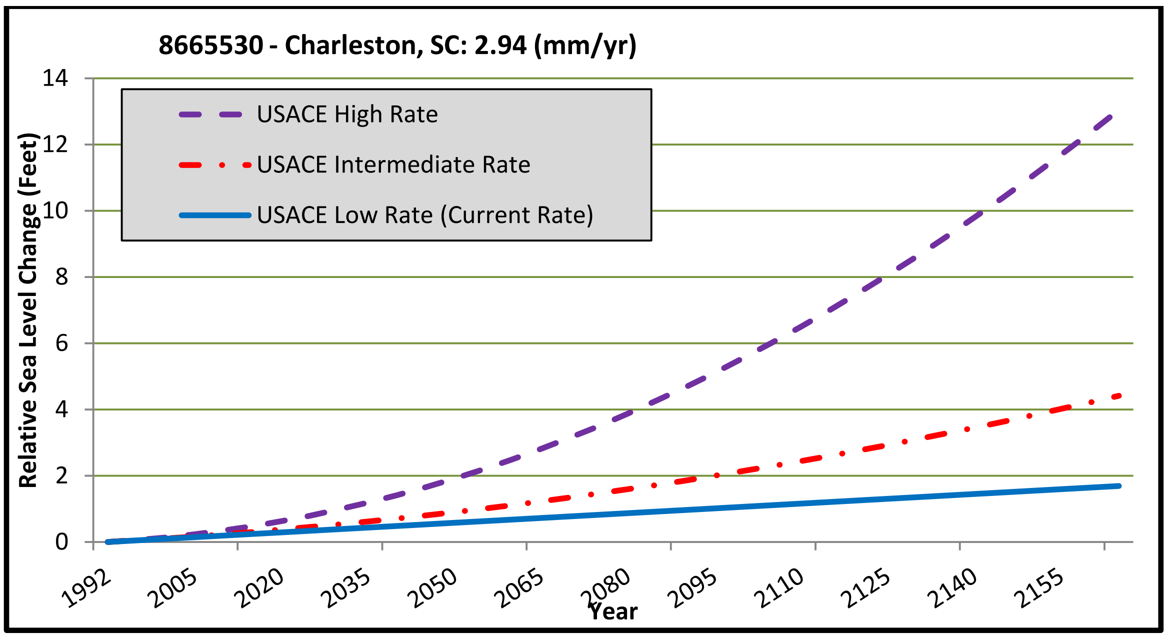


Figure 5-4. Relative sea level changes for Charleston Harbor

As previously discussed, the proposed project would cause a small incremental increase in high tide water levels along the Cooper River (0.07 feet or less increase in 99th percentile water level). In regard to the Bushy Park Reservoir salinity intrusion alert system, it is expected that sea level rise would increase the frequency of both tidal and salinity alerts triggered by the monitoring system.

The hydrodynamic modeling results indicate that the proposed project is not expected to incrementally increase the frequency of tidal alerts beyond what could be experienced as a result of sea level rise (Appendix A, Section 3.8.1). Since the model is not a reactive model, it cannot capture the sequence of alert level reached or the subsequent required discharge. If a significant increase in alerts occurs, the

USACE would evaluate the relocation of the intake to Bushy Park Reservoir farther upstream along with reassessing the alert system.

5.4.5 Geology, Soils, and Sediments

5.4.5.1 Geological Resources

The proposed project would not significantly affect any geological resources in the project area. Approximately 9.7 million cubic yards of rock are anticipated to be moved from the dredging area to offshore artificial reef area and potentially to the ODMDS. The rock is characterized as a soft, weak-moderately cemented, fossiliferous limestone, having an unconfined compressive strength that ranges from 73 to 416 psi, which enables it to be excavated without requiring blasting (see Appendix B).

5.4.5.2 Soils

Terrestrial soils are not anticipated to be altered or affected due to the proposed project.

5.4.5.3 Hydrogeology

The project would not affect the primary deep well aquifers in the Charleston area. Dredging activities associated with deepening of the harbor will intersect the Cooper Group, portions of the Edisto Formation, and possibly some of the surficial Quaternary deposits. There are no hydrologic concerns for dredging into these units. Dredging activities associated with deepening of the harbor will intersect the Cooper Group, portions of the Edisto Formation, and possibly some of the surficial Quaternary deposits. There are no hydrologic concerns for dredging into these units. The primary Floridian aquifer will not be encountered since the Floridian and deeper aquifers are isolated from the impacts of dredging by over 200 feet of impermeable strata (the Cooper Group). Dredging a deeper channel into the Cooper Formation may expose occasional sand horizons and perched water tables; however, these are limited in extent and are not used for water resources (Park, 1985; Brainard, et. al., 2009). Surficial aquifers are primarily used for irrigation. Project impacts to ground water are addressed in greater detail within Appendix B. Further discussion on effects to ground water is addressed in Section 5.4.8 below.

5.4.5.4 Geotechnical

Material in the project footprint would be removed. The composition of the material is detailed in Section 2.4.5.4. The vast majority of the unconsolidated materials are comprised of relatively fine-grain sediments including silts and fine sands with clay. Limestone bedrock belonging to the Edisto Formation occurs within portions of the Entrance Channel. This rock will be encountered to varying degrees with any of the project alternatives. A geotechnical analysis of rock strength characteristics indicate that the limestone bedrock is generally constrained to 450 psi or less which enables it to efficiently be dredged without requiring blasting. The Details on the sediment types can be found in Appendix B.


Deploying drilling rig

5.4.5.5 Sediments

Sediments in the project footprint proposed for removal during dredging provide some habitat value, particularly in non-silty areas. Infaunal communities in these areas would recover within several months following dredging due the high reproductive rates of resident invertebrates.

Example of a sediment sample taken for this project

As stated in Section 2.4.5.5, the disturbance of aquatic sediments can create environmental problems if contaminants of concern are made available to organisms through various pathways. Sediment quality is important to the overall estuarine habitat quality because sediments support invertebrate communities, exchange gases and nutrients with overlying water, and serve as a sink for contaminants (Van Dolah et al., 2013). Sediments that have accumulated on the bottom of the Cooper River may contain contaminants that may negatively affect aquatic life.

In order to determine sediment characteristics and contaminant concerns from dredging Charleston Harbor sediments and to obtain a Section 103 Marine Protection, Research, and Sanctuaries Act concurrence, samples were collected for chemical and biological evaluations from October 20 through November 19, 2012. The work, including the characterization of sediments based on dredging/characterization depth and sample compositing for dredging units, was consistent with the guidance in a 2007 Memorandum of Understanding between USACE and USEPA and the Southeastern Regional Implementation Manual. The sampling effort revealed that while there are trace levels of some contaminants in the sediments, there is no significant threat to the health of aquatic organisms, the overall estuarine environment, or the human environment. Please reference Appendix J and ANAMAR, 2013 for details on the sediment sampling, and the 404(b)(1) evaluation in Appendix M1 for a description of upland disposal of sediments. On September 4, 2014, USEPA sent a letter to the USACE confirming that the dredged material was suitable for ocean disposal (Appendix J).

5.4.5.6 Shoaling Rates

The sediment transport module of EFDC was used to determine the effect of the alternatives and ultimately the proposed project on shoaling rates. Specifically, the model assesses potential changes to suspended sediment concentration in the water column and deposition rates in the federal navigation channel and other areas of the harbor within the model domain. A shoaling analysis is important in order to determine predicted increases/decreases in shoaling and associated maintenance dredging costs for various alternatives, and because NEPA Scoping comments expressed a desire to understand the potential impact of the project on shoaling in various portions of the Harbor.

There are numerous recreational sites, private and public docks and boat landings, and other water resource interests that could be affected by large changes in shoaling in the future. As noted in the Appendix A (Engineering), changes in hydrodynamics resulting from the proposed project may redistribute depositional locations throughout the harbor. As shown in Section 2.4.5.6 (Future Without

Project) of this report, shoaling rates are anticipated to decrease in the future as a result of sea level rise increases contributing to hydrodynamic changes in the harbor. Figure 5-5 demonstrates the incremental change in annual shoaling that is expected as a result of the project compared with the future without project condition. As shown, the majority of the harbor is predicted to experience only a minor increase or decrease in shoaling (-0.04 to 0.05 ft/year) as a result of the proposed project. These changes are not anticipated to adversely affect areas outside of the navigation channel from either an increase or decrease in shoaling. Very few cells in the model grid and located outside of the navigation channel experience an increase in shoaling greater than 0.06 ft/year (Figure 5-5).

In order to address project related dredging increases in the navigation channel (excluding the Entrance Channel), the relative change in the sedimentation rate was used in conjunction with long-term dredging records to determine the change in expected shoaling due to the alternatives. The project effects are presented as shoaling rate indices in Table 5-7, below, and estimated quantities by reach for the proposed project can be found in Table 4-2.

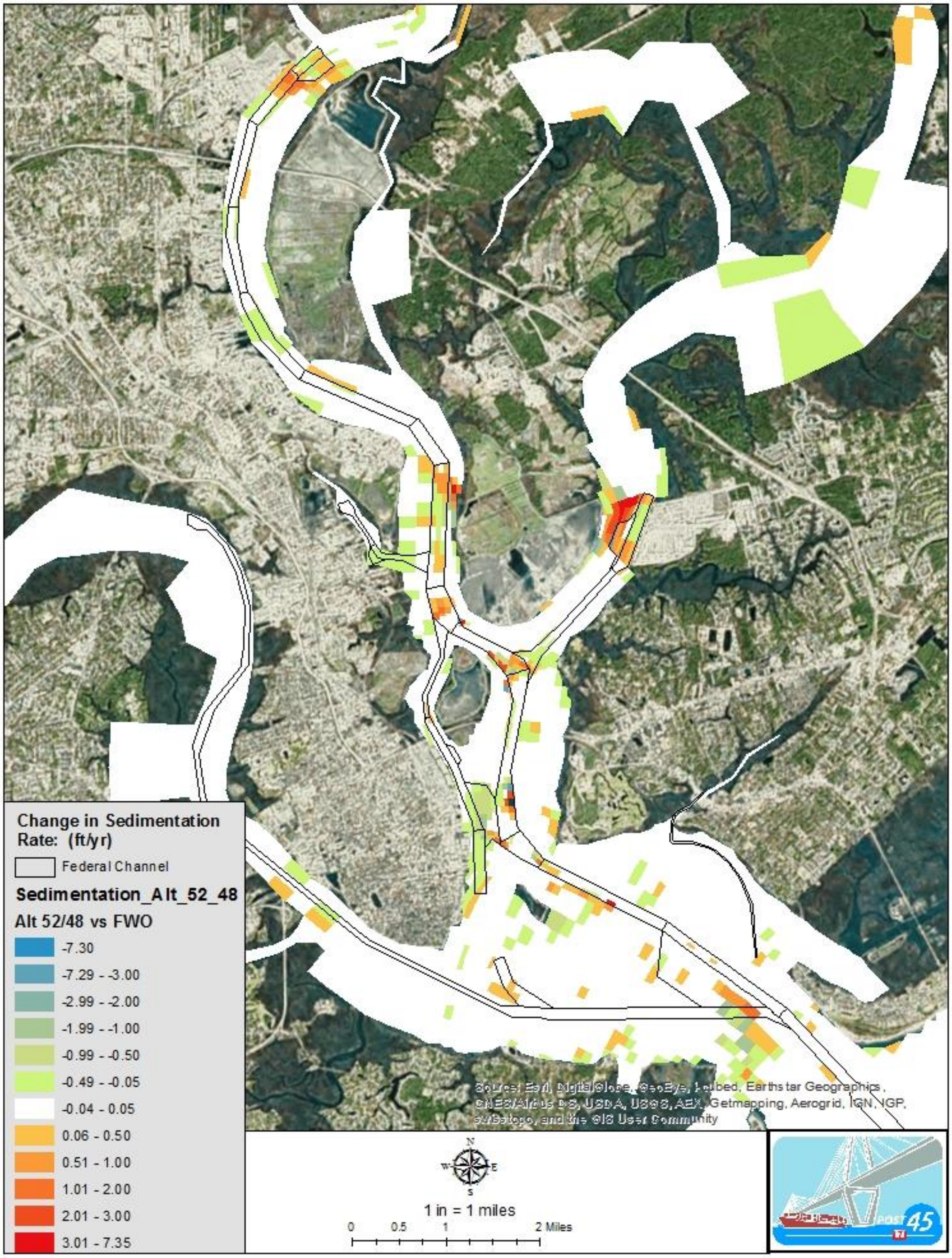


Figure 5-5. Sedimentation rate delta between proposed project and FWOP

Table 5-7. Shoaling rate indices predicted from sedimentation module within EFDC

Shoaling Rate Indices	Future Without Project	Alt 52-48
Mount Pleasant Reach	1.0	1.00
Rebellion Reach	1.0	1.00
Bennis Reach	1.0	4.48
Horse Reach	1.0	0.95
Hog Island Reach	1.0	1.53
Drum Island Reach	1.0	1.43
Meyers Bend Reach	1.0	2.33
Daniel Island Reach	1.0	1.32
Daniel Island Bend	1.0	1.00
Clouter Creek Reach	1.0	12.79*
Navy Yard Reach	1.0	0.75
North Charleston Reach	1.0	1.61
Filbin Creek Reach	1.0	1.65
Port Terminal Reach	1.0	3.29
Ordnance Reach	1.0	1.15
Ordnance Reach Turning Basin	1.0	1.63
Wando River Lower Reach	1.0	1.20
Wando River Upper Reach & Terminal	1.0	1.09
Wando River Turning Basin	1.0	3.08
Tidewater Reach & Union Pier	1.0	0.92
Custom House Reach	1.0	0.66
Town Creek Lower Reach	1.0	1.11

*Historical dredging records indicate that Clouter creek reach does not have any annual shoaling. While the EFDC model did generate a small shoaling rate there (less than 2% of total shoaling), the widening measure in the model overestimates the increase that would actually occur. This is a result of the grid cell representing the widening measure being smaller than adjacent cells. The actual model generated quantity was used for cost estimating to be conservative.

Further analysis of the outputs from the EFDC model determined that over 90 percent of the increase in shoaling within the navigation channel is attributable to the widening measures, and roughly 9 percent was attributable to deepening only. The largest increase in shoaling/sedimentation resulting from the proposed project would be in the Wando River Upper Reach, Turning Basin, and Terminal. The next largest predicted increase would occur in the Ordnance Reach and Turning Basin (see Appendix A for a detailed discussion). Since the alternatives assumed maximum wideners, the increase in shoaling is a conservative estimate for presentation within this Feasibility Report/EIS. An engineering assessment of whether advanced maintenance locations would change based on shoaling rates concluded that the existing maintenance practices were justified and no changes were recommended (Appendix A). As mentioned previously in this document, an evaluation of the necessity for various wideners will be evaluated during the PED phase of this project and minimization will occur, where practicable. For the purposes of assessing impacts, maximum wideners are assumed.

As noted above, the sedimentation module did not evaluate Entrance Channel shoaling. In order to estimate shoaling increases within the Entrance Channel, historical dredging records and previous trends from sedimentation increases from past deepenings were evaluated. Dredging records since last deepening estimated that 407,000 cy of material were dredged annually from the Entrance Channel. Prior to the last deepening project the annual volume of material dredged from the Entrance Channel was 328,400 cy. The difference of roughly 80,000 cy of material equates to approximately 16,000 cy per foot of depth increase (the project deepened the Entrance Channel from 42 to 47 feet. Therefore, the proposed project (Alternative 52/48, which would have a 54’ authorized Entrance Channel) is expected to increase shoaling by roughly 112,000 cy per year (7 feet x 16,000 cy = 112,000 cy) to around 519,000 cy per year. The increase in shoaling is expected to result from a deeper channel changing the settling rate of riverine and ocean derived sediments.

5.4.6 Protected Managed Lands and Impoundments

The proposed project would have no impact on protected lands as there are no changes to any landside facilities resulting from the project. Impounded wetlands in the upper Cooper River would not be adversely affected since the project would not appreciably increase water surface elevation (Section 5.4.2 and Appendix A) and salinity would not increase in the impounded areas of the Cooper River above the “tee”. As discussed above, the proposed project is not anticipated to increase impacts to shorelines (i.e., Fort Sumter, Crab Bank, etc.) when compared with the future without project condition. Cape Romain National Wildlife Refuge was identified during NEPA scoping as an area of concern, specifically related to air quality and potential increase in priority pollutants and/or hazardous air pollutants. No increased adverse affects are expected from the proposed project compared with the without project condition (No Action Alternative). Air quality is discussed further in Section 5.4.17 below.

5.4.7 Surface Water Quality

Surface water quality can be affected by the proposed project directly or indirectly and temporarily or permanently. Direct, temporary effects on water quality may occur during dredging operations (project construction); increased turbidity is primary among these effects. Long term effects are anticipated from changed hydrodynamics within the system that could affect parameters such as salinity and dissolved oxygen. These are discussed immediately below. On 16 March 2015, SCDHEC finalized a Water Quality Certification in Accordance with Section 401 of the Clean Water Act, as amended, with conditions pursuant to R. 19-450 et. seq., 19976 SC Code of Laws. The conditions of this certification are shown in Section 6 and will be adhered to as a commitment of this project.

5.4.7.1 Dissolved Oxygen

Deepening and widening of federal navigation channels can result in lower dissolved oxygen (DO) concentrations due to changes in water dynamics. As discussed in Section 2.4.71, DO is important to aquatic species. Dissolved oxygen concerns relating to harbor deepening can be divided into three issues: (1) as the channel depth increases, the ability of oxygen to reach the river bottom decreases, causing lower average concentrations of dissolved oxygen at the bottom, (2) as the channel prism enlarges, additional saltwater is moved to the upper portions of the harbor and into the estuary, decreasing the ability of those waters to accept oxygen from the air, and (3) as the channel prism enlarges, the average velocity decreases, reducing the mixing of oxygen throughout the water column. If DO concentrations decrease to unacceptable levels, it could have deleterious effects on fish and other aquatic organisms. Lower DO concentrations also reduce the ability of the estuary to handle the point- and non-point source loads of pollutants entering the estuary.

DO impacts were modeled using the Environmental Fluid Dynamics Code (EFDC) hydrodynamic and water quality model. While the project would cause minor (average of 0.03 mg/L) reductions in DO, the project must comply with the existing Total Maximum Daily Load (TMDL) established for the system. This TMDL allocates the amount of oxygen demanding substances that an industry can discharge into the waterbody. In accordance with the SC Pollution Control Act, the proposed project must comply with the TMDL even though the project is not a point source discharge. In doing so, the cumulative effect of the dischargers and the project must not exceed at any point in the waterbody a reduction greater than 0.149 mg/L.

SCDHEC released a total maximum daily load (TMDL) in 2013 that revised and combined the existing 2002 Cooper River-Wando River-Charleston Harbor TMDL ("Cooper TMDL") and the 2003 Ashley River TMDL ("Ashley TMDL"). The revised TMDL is for Charleston Harbor, Cooper, Ashley and Wando Rivers DO TMDL ("Charleston Harbor TMDL"). The basis for this revision was a new 3-Dimensional Environmental Fluid Dynamics Code (EFDC) model covering the entire system completed in 2008, a revised DO standard as amended in the South Carolina Pollution Control Act in 2010 (adopted in South Carolina Regulation 61-68), and subsequent reallocation of the TMDLs led by the Berkeley-Charleston-Dorchester Council of Governments (BCDCOG, see http://www.bcdcog.com/).

The USACE performed an evaluation of DO throughout the project area to ensure compliance with the TMDL. EFDC modeling results indicate the proposed project would not have a significant effect on the TMDL waste load allocation (WLA). Although the methodology used by DHEC is a common wasteload allocation practice, the TMDL is conservative because it was calculated based on the assumption that all of the discharges are constantly and simultaneously discharging at the maximum permitted load. This assumption does not recognize the time-varying nature of the individual point-source discharge loading rates, which is particularly important for a system with multiple point-source dischargers. In general, point-source discharges tend to have a wide range of discharge rates that occur over time. The probability of all dischargers being at the maximum load at the same point in time is extremely small, and it is even less likely that these discharges would be sustained at that constant maximum permitted load over the entire TMDL analysis time period (March through October). Although DHEC used the conservative assumption of constant discharges for the purposes of establishing the WLA for the TMDL, a new method was coordinated through DHEC and EPA that provides a more accurate approach to characterize the point-source discharges. Specifically, in order to incorporate the time-varying nature of the point-source discharges, the USACE analysis uses time-varying discharge loading rates input to the TMDL model that are based on measured daily discharge data collected by the existing dischargers.

The methodology used for this analysis includes several steps. First, the available daily discharge monitoring data for the past 10 years was solicited from each of the major dischargers. This data was then analyzed to develop a statistical characterization of the discharge flows and pollutant concentrations that affect DO (specifically, biochemical oxygen demand (BOD) and ammonia nitrogen). This data was then used to randomly generate a long-term 50-year record of discharge flows and pollutant loads into the harbor. This long-term record was created so that a wide range of possible combinations of discharge loading rates into the harbor could be evaluated.

For each discharge, the loading rate time series was then multiplied by a scaling factor so that the 99^{th} percentile of the monthly-averaged ultimate oxygen demand (UOD) was equal to the monthly permit limit allocated in the TMDL. The resulting time series of loading rates incorporates daily variations consistent with the measured data while representing the maximum loading rate given by the TMDL wasteload allocation. The synthesized time-varying daily loading rates were then input to the same EFDC model used for the 2013 TMDL study in order to model the effects of the point-source discharge loading rates on DO concentrations in the estuary.

After modeling the DO impacts resulting from the time-varying discharges, the impacts were combined with the impacts resulting from the proposed project (previously modeled by the USACE Charleston District) in order to estimate the cumulative effects on DO. The results indicate that the cumulative DO impacts resulting from both the point-source pollution discharges into the estuary and the proposed project would not cause cumulative DO impacts greater than the 0.1 mg/L allowed by DHEC's anti-degradation rule. Although the greatest cumulative impacts are estimated to be 0.14 mg/L, this is less than the 0.1499 mg/L allowed in practice.

The cumulative DO reduction is shown in Figures 5-6 through 5-8. These figures show the reduction in DO (delta DO) resulting from (1) the NPDES dischargers, (2) the proposed project, and (3) the cumulative impact of the project and dischargers. To calculate the cumulative impacts, the time-series of daily delta DO for the NPDES dischargers was added to the daily delta DO for the Post 45 project, resulting in a time-series of daily cumulative delta DO values. The 90th percentile of this time series of daily cumulative delta DO was calculated as the cumulative impact. Based upon the results of this analysis, mitigation for DO impacts should not be required to offset project impacts in order to comply with the anti-degradation rule. Details on the analysis can be found within Appendix A, Section 3.8.5. Because of this and the habitat suitability index (HSI) models showing that DO does not significantly affect various fish species (discussed in Section 5.4.14, below, and Appendix K), the USACE anticipates that long-term impacts from reductions in DO would not significantly adversely affect aquatic species. In an email on August 18, 2014, DHEC indicated that the revised analysis and modeling effort documented and sent to the DHEC office appropriately represents the TMDL wasteload allocations including the effluent DO limits, and that the cumulative impacts of the proposed project and the NPDES dischargers are within the 0.1 mg/L DO deficit specified by the antidegradation rule in SC Regulation 61-68. This was further substantiated in the 16 March 2015 Water Quality Certification issued by DHEC.

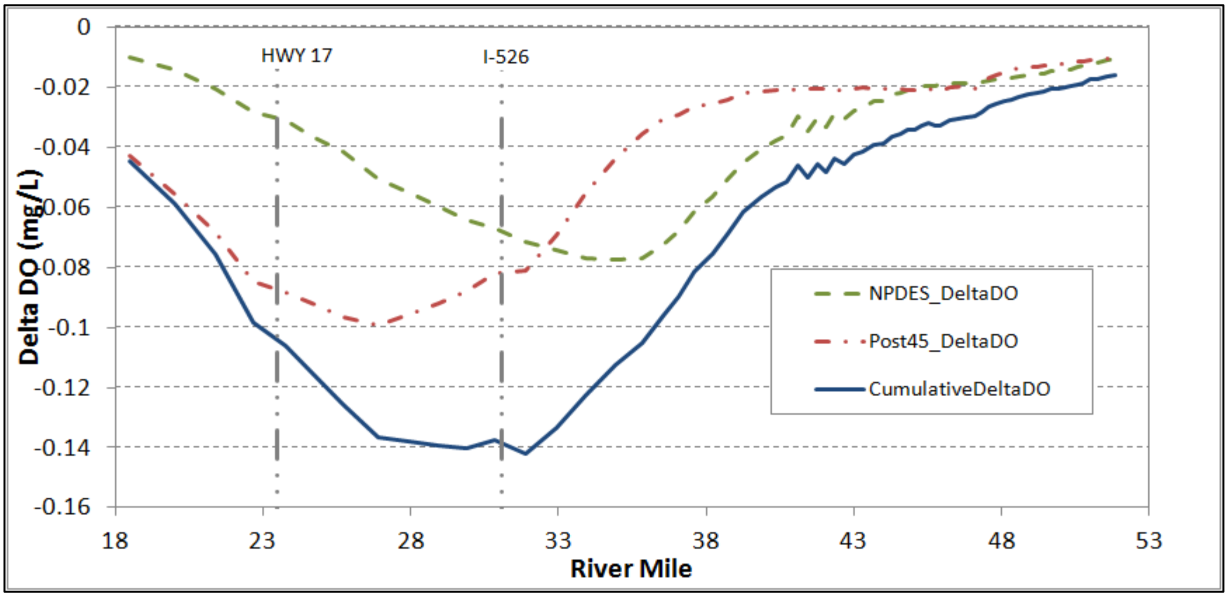


Figure 5-6. Longitudinal plot of 90th percentile delta DO along the Cooper River

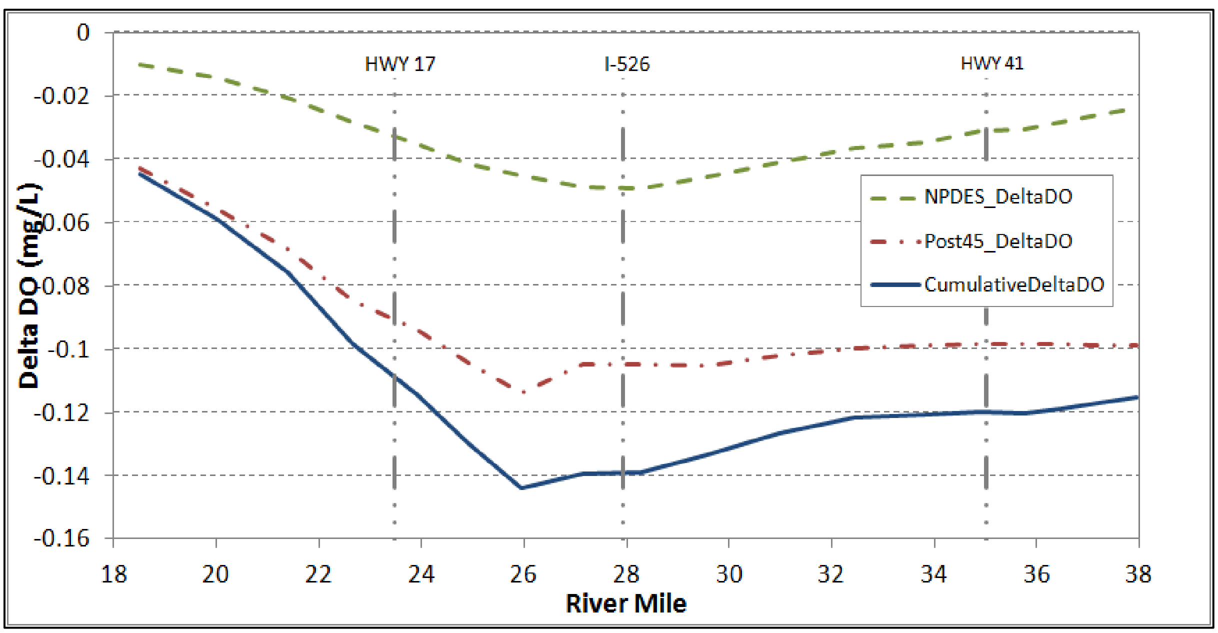


Figure 5-7. Longitudinal plot of 90th percentile delta DO along the Wando River

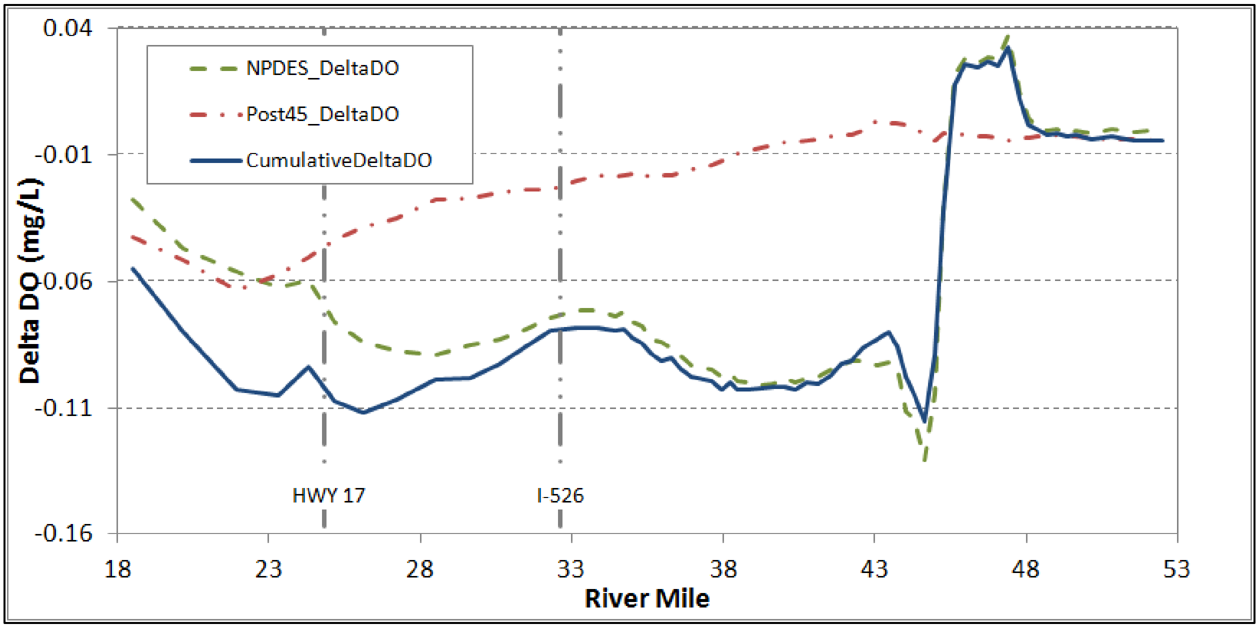


Figure 5-8. Longitudinal plot of 90th percentile delta DO along the Ashley River

The predicted magnitude of the project-induced DO reductions are small and would not significantly impact aquatic organisms or require mitigation to comply with the TMDL. However, the impact of the proposed project would contribute to a significant portion of the allowable DO deficit within the Charleston Harbor system and causes a long-term change in condition that affects all permitted discharges. In the future, when distributing the 0.1 mg/L total allowable DO reduction, the impacts could become more important if demands on the system increase. As DHEC allocates the remaining assimilative capacity, the amount available for new development and growth could be reduced.

Even though the project's DO impacts are not biologically significant (see Appendix K – Fish Habitat Assessment and Appendix F2 - NMFS Biological Opinion), they are important in regard to 401 Water Quality Certification and thereby cause the project to be tied to future load allocations for the Charleston Harbor TMDL. It is important to note that DHEC acknowledges that this analysis does not explicitly change the TMDL and the existing TMDL wasteload allocations are unchanged. The existing TMDL does not need to be revised. In DHEC's staff assessment regarding the water quality certification, they indicate that the USACE analysis provides a, "more accurate representation of the discharges and has demonstrated that the cumulative impacts meet the DO standard". Regardless, the Charleston District acknowledges the significance of DO to the water quality impaired system and the Charleston District is committed to monitoring the impacts of the project and ensuring that they are similar to those predicted by the EFDC model. If monitoring determines that the impacts are greater than predicted, the District has considered several options to mitigate for the excess DO deficit. Please see Appendix P for a description of these measures and details related to monitoring and adaptive management.

5.4.7.2 Fecal Coliform Bacteria

The proposed project would not result in an increase of bacteria into Charleston Harbor waters. However, dredging operations have been noted to significantly increase fecal coliform concentrations in the immediate vicinity of the dredge (Grimes 1974). The increase was attributable to disturbance of bottom sediments and a release of sediment-bound bacteria. Maintenance dredging has been ongoing in Charleston Harbor for the last century and this potential release of fecal coliform is a short-term but unavoidable impact of dredging operations. Since shellfish harvesting is prohibited in Charleston Harbor, the short-term impacts are considered to be minor adverse and temporary, with no significant effects.

5.4.7.3 Nutrients

Similar to fecal coliform bacteria, sediment bound nutrients can be disturbed from dredging. The proposed project would not affect nutrient concentrations, nutrient loading, or nutrient cycling within Charleston Harbor waters. The affect of releasing sediment bound nutrients would be temporary and minor.

5.4.7.4 Salinity

The proposed channel deepening would increase the salinity concentrations in the estuary. Two primary concerns regarding salinity changes are: (1) changes to marsh vegetation caused by changes in the salinity regime (discussed in Section 6.14, below); and (2) the need for increased freshwater releases from Pinopolis Dam to prevent any salinity from reaching the inlet to the Back River (also known as the Bushy Park Reservoir). The EFDC model predicted salinity changes resulting from the various alternatives. Figure 5-9 demonstrates the predicted changes to salinity due to the proposed project.

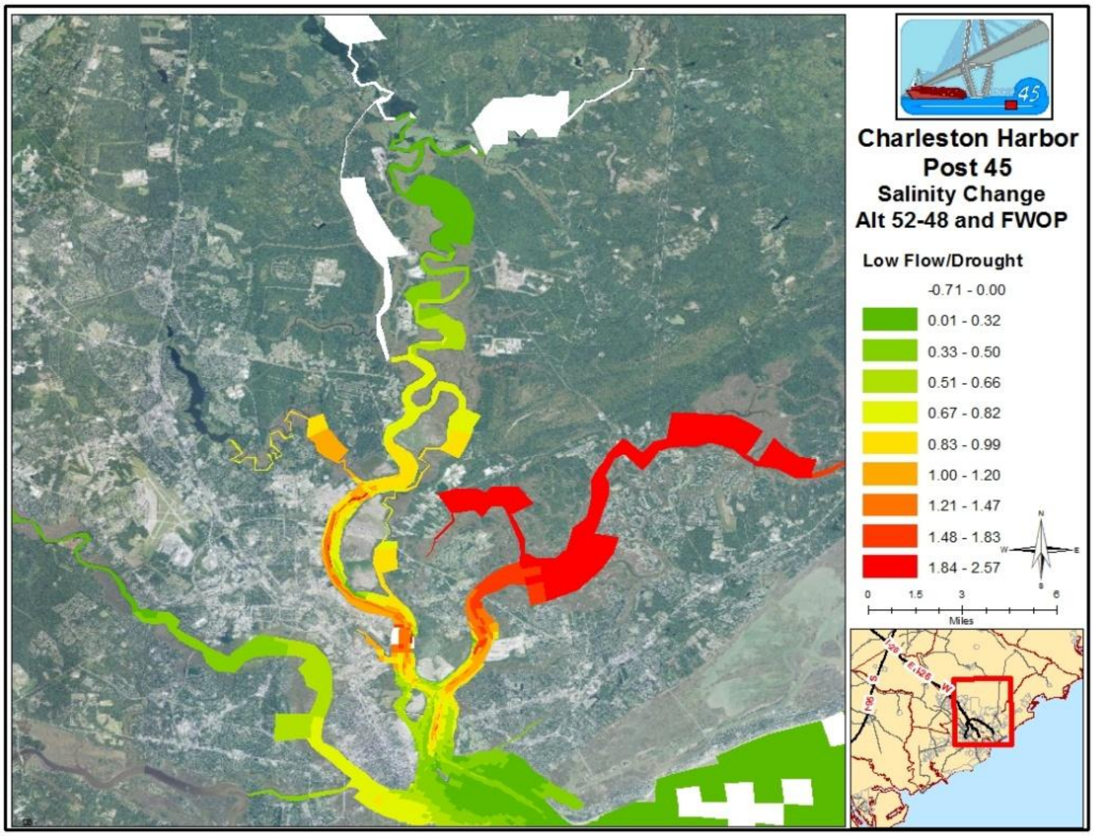


Figure 5-9. EFDC model predicted changes in salinity resulting from the 52/48 alternative.

In order to evaluate salinity changes and potential impacts to the Bushy Park Reservoir, typical flow conditions were modeled using EFDC as described in the Engineering Appendix. The model indicated there was not an increase in alert levels at USGS 02172020 West Branch Cooper River at Pimlico gage, whose alert criteria is 180 micro mhos/cm or approx 0.08 ppt. The USGS 02172050 Cooper River near Goose Creek, whose alert criteria is 1550 micro mhos/cm or 0.76 ppt, indicted an increase of alert levels would occur under a typical year for all project alternatives compared to the future without condition.

Details on the salinity percentiles (indicating the predicted change in relative concentration) for each of the gages can be found in Table 5-8. It is important to reiterate that the alternatives were evaluated based on their change from the future without-project condition, which factors in 50 years of various sea level rise rates (year 2071). The EFDC model is not considered a "reactive model", which means that it cannot respond to the salinity alert system similar to what occurs in reality. Without a reactive model analysis that includes tidal alert responses, as well as salinity alert responses, there is no way to accurately determine if, or by how much, an increase in salinity alerts would occur due to the project; however, modeling results indicate that salinity levels would increase minimally within the harbor, and it is likely that the proposed project would increase the number of salinity alerts for the Bushy Park Reservoir. Since the number of alerts would increase over time as a result of sea level rise, it is difficult to attribute the change to the proposed project versus environmental conditions. The USACE would continue the salinity alert monitoring and the protection of Bushy Park Reservoir.

Table 5-8. Predicted salinity (ppt) percentiles at USGS gages in Charleston Harbor for various conditions

	USGS 02172020 West Branch Cooper River at Pimlico near Moncks Corner, SC		**USGS 02172069.8 Wando River above Mt. Pleasant**	
Salinity Percentile	**FWO**	**Proposed Project**	**FWO**	**Proposed Project**
1st percentile			19.48	21.86
10th percentile			20.49	22.7
50th percentile			22.13	24.13
90th percentile			24.63	25.87
99th percentile	0.05	0.05	26.11	27.16
	USGS 02172050 Cooper River near Goose Creek, SC		**USGS 02172070.9 Cooper River at Hwy 17**	
	FWO	**Proposed Project**	**FWO**	**Proposed Project**
1st percentile			20.97	21.85
10th percentile			22.62	23.39
50th percentile	0.05	0.05	25.73	26.23
90th percentile	0.35	0.6	28.47	28.77
99th percentile	2.05	2.58	30	30.2
	USGS 02172053 Cooper River at Mobay		**USGS 02172086.9 Ashley River near North Charleston**	
	FWO	**Proposed Project**	**FWO**	**Proposed Project**
1st percentile	0.12	0.19	12.37	12.75
10th percentile	1.76	2.23	14.74	15.17
50th percentile	6.92	7.81	17.35	17.77
90th percentile	10.91	11.89	19.11	19.54
99th percentile	13.2	14.09	20.15	20.64
	USGS 02172067.7 Cooper River at I-526		**USGS 02172100 Charleston Harbor at Fort Sumter**	
	FWO	**Proposed Project**	**FWO**	**Proposed Project**
1st percentile	10.27	11.3	20.38	21.05
10th percentile	12.29	33.15	23.15	23.7
50th percentile	15.65	16.9	28.04	28.28
90th percentile	19.38	20.78	31.34	31.42
99th percentile	21.38	22.68	32.87	32.9

5.4.7.5 Turbidity and Suspended Solids

Dredging operations are likely to have a temporary and minor impact to water quality nearby the dredge plant. The proposed project would have dredges operating in various areas of the channel for roughly 3 years.

Hopper dredges are also often associated with increased turbidity from their overflow discharges. The suction drag arms of the hopper dredge hydraulically remove sediment from the dredged site and discharge the material into storage hoppers on the dredge. During filling, fine sediments (primarily silt, clays, and fine sands) are allowed to wash overboard (overflow) to maximize the load of sediment for transport to the placement area. This overflow process is one source of turbidity plumes and sedimentation generated by the hopper dredge. Hitchcock and Drucker (1996) summarized values for material lost through the overflow process on a typical 4,500 ton hopper dredge operating in UK waters. Results from this study indicate that during an average loading time of 290 minutes, 4,185 tons of dry solids are retained as cargo, while 7,973 tons of dry solids are returned overboard from overflow. Sand sized particles fall directly to the seabed and are reduced to background levels over a distance of 200 to 500 meters (m) and smaller silt-sized particles have a typical settling velocity of 0.1 to 1.0 millimeters per second (mm/s) and are reduced to background values of 2 to 5 milligrams per liter (mg/l) over a similar distance. According to Neff (1981 and 1985), concentrations of 1000 mg/l immediately after discharge decreased to 10 mg/l within 1 hour. The minimal impact of settling particles from hopper dredge turbidity plumes was further supported by a study from Partech (1982), which found that the initial hopper dredge overflow concentrations of 3,500 mg/l were reduced to 500 mg/l within 50 meters.

The distance that sediment plumes may extend is dependent upon the type of dredge, how it is operated, currents, and the nature of the sediments within the dredged area. A study performed by Newell and Siederer (2003) in the UK (high current velocities) showed that, in most cases, coarse material up to sand-size particles settles within 200 to 600 m of the point source of discharge, depending on depth of water, tidal velocity, and the velocity of flow from the discharge pipe. During hopper dredging operations in the Baltic, Gajewski and Uscinowicz (1993) noted that the main deposition of sand from hopper dredge overflow was confined to distances within 150 m on each side of the dredge. This study further supported that the initial sedimentation associated with overflow material behaves like a density current where particles are held together by cohesion during the initial phase of the sedimentation process and are mainly confined to a zone of a few hundred meters from the discharge chutes. According to a plume dispersion model developed by Whiteside et al. (1995) (based on field study measurements obtained while hopper dredging in Hong Kong waters), the contours for sediment deposition remain as a narrow band extending for approximately 100 m on each side of the vessel, consistent with that recorded by Gajewski and Uscinowicz. As a component of the sedimentation associated impacts to hardbottom from hopper dredging in adjacent borrow areas offshore of Bal Harbor, Florida, Blair et al. (1990) recorded elevated sediment levels at about 335 m (1,100 ft) from the borrow area. For the proposed project, all hopper dredging will take place in the ocean and will consist of mostly sands and soft rock (see Appendix B, Geotechnical).

For cutterhead suction dredges, turbidity is only generated at the seafloor by the cutterhead where sediment suspension occurs during the process of removing sediments from the seafloor. However, sediments are usually confined to the immediate vicinity of the cutterhead and do not reach the sea surface (LaSalle et al., 1991). Studies performed by D. F. Hayes in 1986 on a hydraulic cutterhead dredge operating in Savannah Harbor indicated that average suspended sediment concentrations within 488 m (1,600 ft) of the dredge were generally raised less than 200 mg/l in the lower water column and less than 100 mg/l and 50 mg/l in the middle and upper water column, respectively.

5.4.8 Ground Water

Based upon the geologic setting, depth, and thickness of the local stratigraphy, there is no impact anticipated to the Floridian Aquifer System, as a result of the proposed Charleston Harbor deepening. The Floridian Aquifer System is effectively isolated from any dredging activity by a thick (200-260 ft) sequence of impermeable strata. Furthermore, this strata and the Floridian Aquifer System dips and thickens seaward to the southeast, which further isolates it from the relatively shallow dredging.

There is little to no impact anticipated to the shallow surficial aquifer system. Much of this aquifer system already lies within the depth prism of the present project, and no problems relating to the 1995 harbor deepening have been reported. Because these aquifers are not confined and are prone to drought-related fluctuation, they are not considered consistent sources of water. In addition, many of the shallow wells in close proximity to Charleston Harbor have already been designated unusable or abandoned due to saltwater intrusion. The leading cause for saltwater intrusion in the shallow aquifer system is population growth and overuse by residential irrigation systems, not dredging activities (Appendix B).

5.4.9 Wetlands

The USACE has determined that dredging operations for the proposed project would not directly affect existing wetlands; however, if determined necessary due to high O&M costs, the construction of two or three contraction dikes would directly affect a relatively small acreage of tidal fringing saltmarsh at the southern end of Daniel Island across from the Wando Welch Terminal. The exact acreage of these impacts is not yet determined because the exact locations of the dikes are uncertain. Indirect effects are predicted as a result of the deepening and widening of the channel, though not in terms of the loss of any waters of the United States. Specifically, slight changes in the vegetation assemblages may occur due to marginal increases in salinity of the Cooper and Ashley Rivers. Wetland distribution may also be influenced by water elevation, which fluctuates in response to daily tides, rainfall, freshwater discharges, and winds. The proposed Charleston Harbor deepening would, however, have negligible effect on water elevation, and therefore, salinity changes are the focus of this impact analysis.

For wetlands within the oligohaline (0.5 – 5.0 ppt), polyhaline (>18 ppt) and mesohaline (5 – 18 ppt) areas, effects of moderate salinity increases would not typically have an effect on plant survival within the systems, as they are adapted for higher salinities and the slight elevations in concentration would not be significant enough to cause a change. Although some reductions in growth and nutrient uptake could occur with increased levels of salinity, species such as saltmarsh cordgrass are capable of surviving this scenario (Brown, 2006). Most of the vegetation is salt-tolerant and is adapted to tolerate higher salinity levels, but some effects may occur with elevated salinity levels in combination with extreme environmental circumstances such as drought.

The US Forest Service (USFS) indicates that within the freshwater portion of the Cooper River system there are approximately 16,842 acres of freshwater tidal streams, wetlands, and forests (Figure 5-10).

Changes in the salinity level of a wetland can alter the vegetative composition, soils, and habitat function of the system. Research conducted on the impacts of increased salinity of naturally functioning tidal freshwater wetlands indicates that intrusion by salt water has negative impacts on tidal freshwater wetlands. For wetlands in the tidal freshwater area of impacts, minor salinity changes would only cause extremely minor changes in vegetation composition or structure, including tree stress or senescence. McKee and Mendelssohn (1989) conducted field and lab experiments to examine the impacts of salinity and elevation changes to freshwater marsh vegetation. Three dominant species (*Panicum hemitomon Schultes*, *Leersia oryzoides*, and *Sagittaria lancifolia*) succumbed to increases in salinity of 15 percent. However the areas were quickly re-colonized by more salt tolerant species. Flynn et. al., (1995) exposed freshwater marsh vegetation in a green house to a simulated salt water intrusion event. Virtually all species present experienced a loss of above ground vegetation. Sharpe and Baldwin (2012) found that periodic salt water intrusions did not reduce species richness, but consistent exposure reduced species richness of freshwater tidal marshes. It is anticipated that the loss of freshwater herbaceous wetland species would be replaced with salt tolerant species such as *Spartina sp*., *Juncus roemarianus*, etc., thereby resulting in a transition of the percent of tidal freshwater marsh vegetation, primarily a reduction in freshwater vegetation and an increase in salt tolerant vegetation.

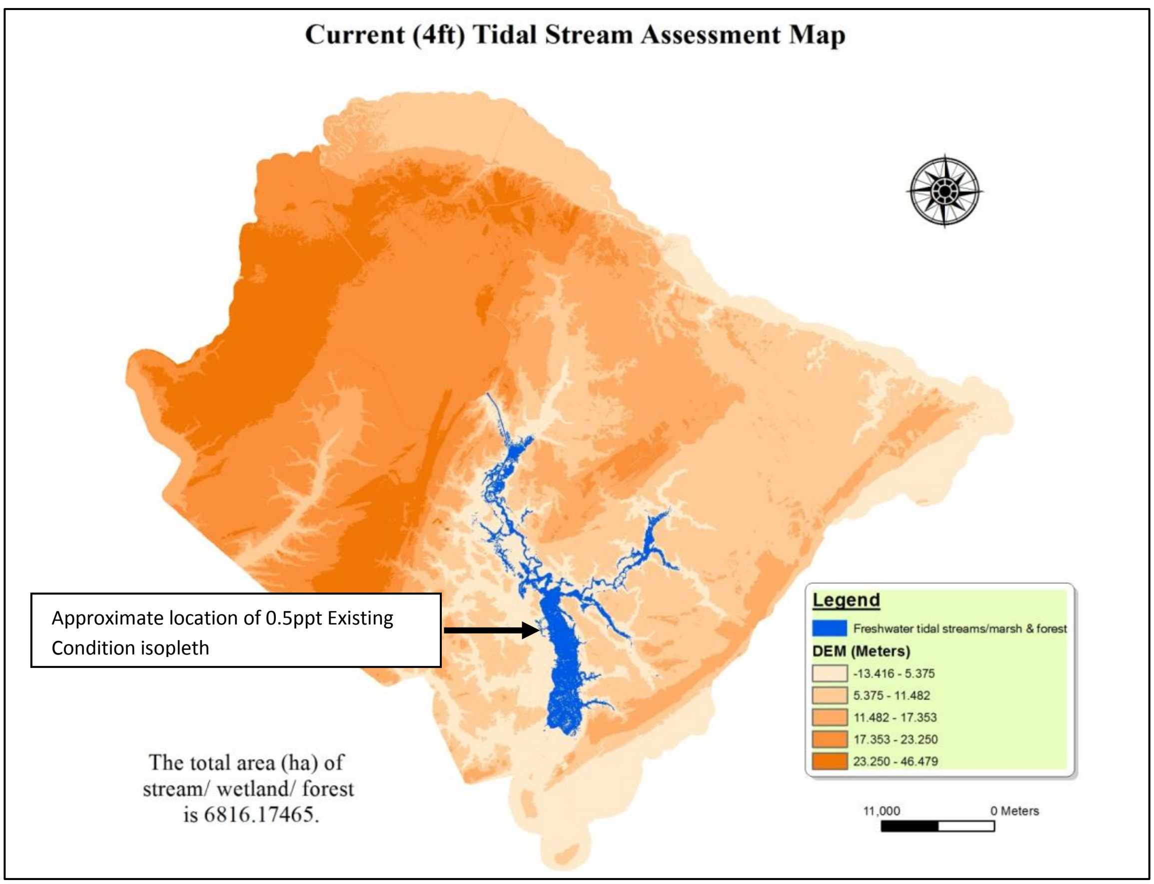


Figure 5-10. Extent of tidal freshwater area within the Cooper River (Carl Trettin, US Forest Service)

In addition to potential marsh impacts, there is a chance that the slightly altered salinity distribution in the harbor could affect tidal and non-tidal palustrine freshwater forested systems, as these systems are not typically adapted to experience high salinity concentrations for increased frequencies or durations. James et al., (2012) found that the hydrology of tidal freshwater forested wetlands is regulated mainly by tidal fluctuations and that they "may be more alike coastal marsh systems than non-tidal bottomland upland habitats." Within the marshes and the palustrine freshwater forested systems, plants that are not adapted to tolerate higher salinities would generally succumb and be replaced by those with higher tolerances. There is an abrupt change in vegetative communities between marsh and palustrine habitat which is primarily due to a salinity gradient (James et al., 2012). Higher salinities can increase the mineralization of nitrogen and phosphorous in soils, leading to "tree stress and senescence" as well as conversion to oligohaline marsh (Noe 2013). Increases in sulfate reduction can decrease organic matter content in the soil, reducing elevations and increasing flooding. Long-term increases in salinity resulting from sea level rise or other factors has shown to cause vegetation stress, mortality, and retreat of palustrine freshwater forested wetland communities which are then replaced by freshwater or brackish marsh vegetation (Doyle et al., 2010). Pezeshki et.al. (1989) conducted lab experiments to test the impacts of additional flooding and saltwater intrusion on seedling tupelo-gum seedlings. When salinity was increased, seedlings experienced declines in height and growth among other adverse impacts. Pezeshki et.al. (1990) found that "increased flooding and saltwater intrusion, a problem facing U.S. Gulf Coast bottomland forests, can cause drastic reduction in net carbon assimilation, leaf burning and seedling mortality. The stress at sublethal levels can lead to weaker seedlings and, consequently, reduced survival rates, and the potential for long-term habitat changes thus limiting the existing natural range of these forests." In North Carolina, following deepening of the Cape Fear River channel, Hackney (2013) monitored wetland vegetation, salinity, pore-water sulfate, and other parameters at riverine and estuarine sampling stations. Monitoring occurred over a 10-year period at a series of sites influenced by a variety of salinity and flooding regimes. The monitoring data suggested that wetland transition from tidal swamp (forested) to tidal marsh (nonforested) was caused by increasing sulfate in the soil as a result of inundation with sulfate-laden saline water. These changes can subsequently cause sediment accretion to be reduced, limiting the ability of a system to recover from land subsidence.

As discussed above, increased salinity has an adverse impact to cypress tupelo swamps and tidal freshwater wetlands. Both habitat types exhibit some tolerance to slight increases in salinity or brief exposures to salinity, but long-term or high levels of exposure to increased salinity are lethal. In summary, it is anticipated that if the proposed project is constructed in Charleston Harbor, salinity increases would have negligible impacts to tidal poly-, meso-, and oligohaline marshes. However, tidal freshwater marshes would experience a shift in the vegetative community toward species that are more salt-tolerant. Palustrine freshwater forested wetlands would experience some tree senescence and die-off as pore-water salinity increases. This could result in freshwater and brackish herbaceous species re-colonizing those areas.

For these reasons, it was important for this project to quantify the potential impacts of the alternatives on salinity distribution and wetland response in the Charleston Harbor. With input from the Interagency

Coordination Team, the USACE developed a method to determine indirect impacts to freshwater marshes in the system (see Appendix L for details). The method involved the following rough steps: (1) Performing wetland delineation and classification, (2) Determining assessment reaches, (3) Determining length of river in assessment reaches, (4) Determining wetlands per river foot ratios, (5) Determining habitat coverage associated with assessment reaches, (6) Determining locations of various salinity concentrations (0.5, 5.0, and 18.0 ppt), and (7) Assessing wetland areas affected by the alternatives. Alternatives were evaluated based on the future without project condition, which assumes 50 years of historic sea level rise. Results of this analysis can be found Section 3, Plan Formulation. It is important to note that the presence of the Cooper River salinity and tidal alert system that protects Bushy Park by requiring freshwater releases from Pinopolis at certain thresholds, would likely minimize the impacts predicted using this method.

Isopleths are lines that connect similar points. In this case, isopleths are lines across the river that represents salinity of a certain concentration. This method was vetted through the ICT and deemed appropriate to determine indirect impacts to wetlands. Isopleth shifts were calculated for the 0.5, 5.0 and 18 ppt contours. However, wetland impacts were only assumed to occur as a result of the shift of the 0.5 ppt contour. As discussed and shown in Section 3, alternatives were evaluated under the FWOP condition (year 2071; 50 years of sea level rise). The recommended plan (52/48) resulted in the greatest predicted indirect impacts to wetlands. After determining that these impacts could be mitigated for and possibly minimized in PED due to reduced widening measures, the PDT determined that the impacts should account for the natural variability of salinity within the system. Recognizing that the baseline condition of the isopleth was a large determining factor in the predicted salinity shift upriver, USACE, in conjunction with the wetland ICT, developed a plan to perform a sensitivity analysis on the modeled results that would account for the modeled variability that occurs depending on the year and scenario that is modeled. Since the movement of an isopleth is affected by many model variables, including river morphology, sea level/water surface elevation, river gradient, etc it is important to evaluate a range of scenarios to average out anticipated impacts that could occur based on the baseline isopleth. When calculating a range of potential scenarios, it is important to evaluate the full spectrum of potential scenarios. For this analysis, USACE and members of the wetland ICT agreed to evaluate impacts under four different sea level rise and project scenarios:

1. Impacts at the time of construction based on 10 years of sea level rise from the model base year (year 2022)
2. 50 years of historic sea level rise (These impacts were used to evaluate alternatives – see Section 3)
3. 50 years of intermediate sea level rise
4. 50 years of high sea level rise

Each scenario was anticipated to result in a different baseline isopleth (e.g., location in the river) for the without project condition, and therefore the modeled project impacts were anticipated to be variable and dependent on the location in the river where the baseline isopleth occurs. Based on guidance from USACE Engineering Regulation (ER) 1110-2-8162, sea level rise scenarios were calculated for Charleston

Harbor. The analysis indicated that sea level rise would increase over 50 years by 0.57 ft in the low scenario, 1.08 ft in the intermediate scenario, and 2.74 feet in the high scenario (See Appendix A of the Final IFR/EIS). The analysis also factors in the model uncertainty because individual results are only shown for one particular flow year and isopleths are not static.

Table 5-9 displays the results of the wetland impacts analysis for both the recommended plan and the NED for comparison. The proposed project alternatives affect salinity to differing degrees depending on the location of the baseline isopleth (Figure 5-11). The 2071 historic sea level rise scenario has a baseline 0.5 ppt isopleth in a very straight and relatively narrow portion of the river. In this case, the proposed project would cause the salinity to migrate further up the river than the other scenarios. On the other end of the spectrum, the wetland impacts were predicted to be smallest in the 2071 intermediate sea level rise scenario. The above referenced averaging method factors in the variability of salinity in the river system and accounts for the fact that salinity is not stagnant and it changes continuously based on tide, wind, rainfall, etc. Regardless of the scenario, it is important to note that sea level rise and its subsequent increase in salinity in tidal systems will contribute significantly to this same wetland conversion. For example, in the 2022 scenario, sea level rise contributes to almost 1/3 of the salinity change. Under the high sea level rise scenario in 2071, only 5 percent of the salinity impacts are predicted to be attributable to the project (see Appendix L for more details). This is important when determining monitoring for the project. Sea level rise and other watershed changes will also be contributing to changes in the community structure. One factor not accounted for in the modeling is the extent to which sea level rise and water surface elevations will shape the community structure of the wetlands. Douglas (2001) found that wetlands will convert to shallow, open-water habitat through interior marsh breakup if they do not build vertically at a pace equal to sea level rise. With or without the project, changes will be occurring throughout the watershed that will result in a constant change in the community structure in these variable environments.

Table 5-9. Wetland impacts for the proposed project averaged across all four future scenarios.

Average Wetland Impacts (All Four Scenarios)		
Wetland Impacts	**50/48**	**52/48**
Ashley River forested wetlands	3.52 acres	4.36 acres
Ashley River marsh wetlands	10.86 acres	13.16 acres
Cooper River forested wetlands	89.65 acres	126.37 acres
Cooper River marsh wetlands	127.57 acres	179.83 acres
Total	**231.60 acres**	**323.72 acres**

The 52/48 alternative (the recommended plan) is anticipated to impact approximately 323.7 acres of wetlands along the Ashley and Cooper Rivers combined. These impacts would affect both palustrine forested wetlands and freshwater marshes and would likely start to occur just after construction of the project. The impacts would be indirect and would not occur immediately (but likely within a few years) because the salt stress will slowly change portions of the plant assemblage. The impacts are also conservative estimates because forested palustrine wetlands were noted using the delineation methodology (described above) along every assessment reach in the rivers (salt through freshwater). Additionally, the method and the EFDC model do not account for additional releases of freshwater from the Pinopolis dam, which would inhibit the movement of saltwater up the Cooper River. As shown in the data sheets attached below, sea level rise represents the greatest source of change to wetlands within the impacted waterbodies. The project, as presented, will have no direct impacts to wetlands resulting from dredging or disposal. Compensatory mitigation will be provided to offset these impacts, and is discussed in detail in the Appendix P (Mitigation Appendix) of the main report.

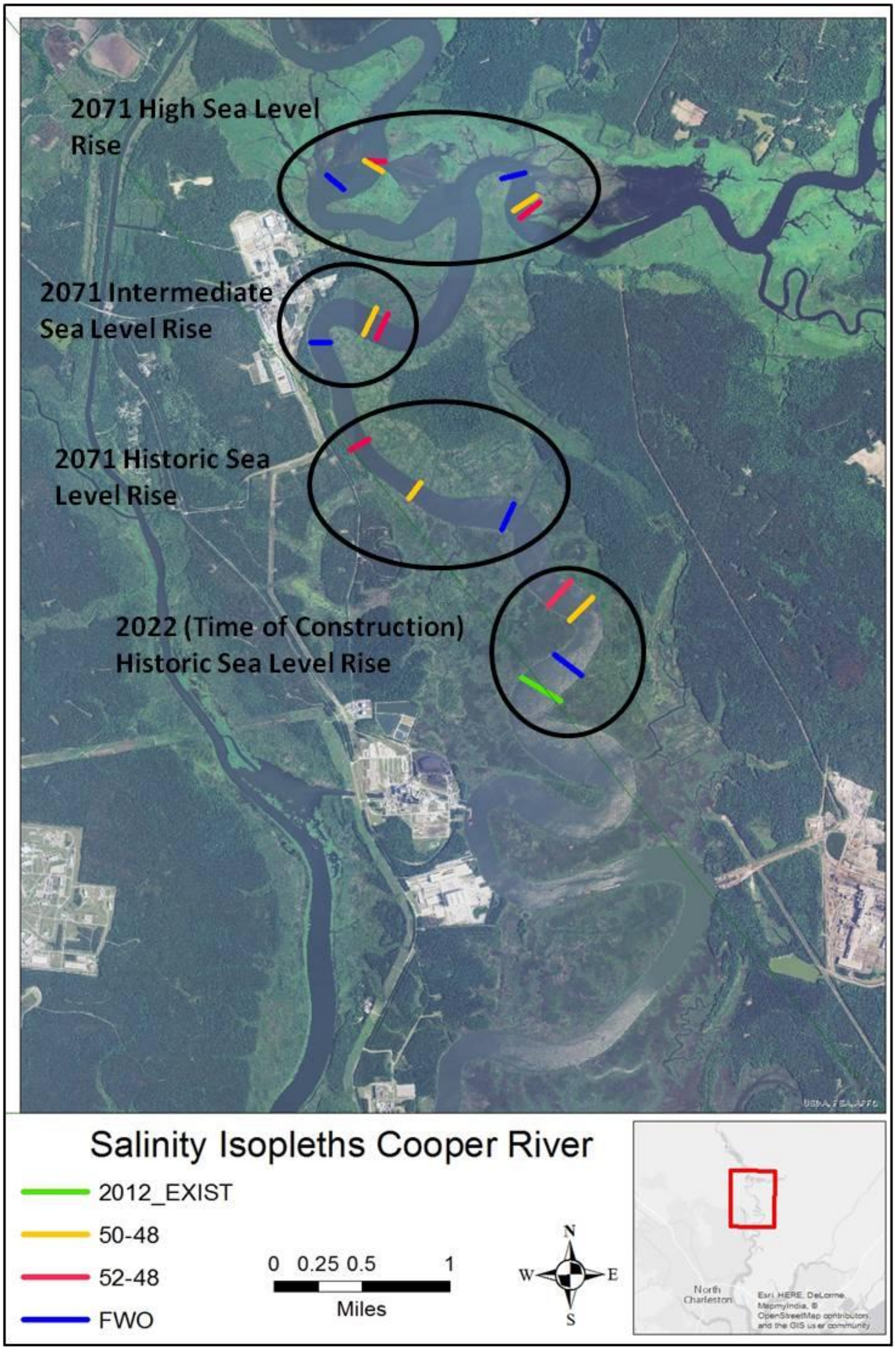


Figure 5-11. Salinity isopleths under various sea level rise scenarios

5.4.10 Hardbottom Habitat

As discussed in Section 2.4.10, hardbottom habitat is present along the side slopes/margins of the Entrance Channel and within the existing channel.

Side Slope Impacts

New impacts to hardbottom along the margin of the channel would result from extending the channel toe vertically down to the newly authorized depth. Doing this would result in the channel slope extending further outward. When this occurs in an area of hardbottom or probable hardbottom habitat, a direct dredging impact would occur. Early coordination with resource agencies resulted in the selection of an avoidance method that involved continuing the same side slope from the existing channel down to the new proposed depth (Figure 5-12). This measure is discussed in more detail in Section 4 (Proposed Project). By doing this, all direct impacts to hardbottom habitat along the side slopes would be avoided. Impacts avoided range from roughly 8.5 acres to 19.2 acres of hardbottom habitat.

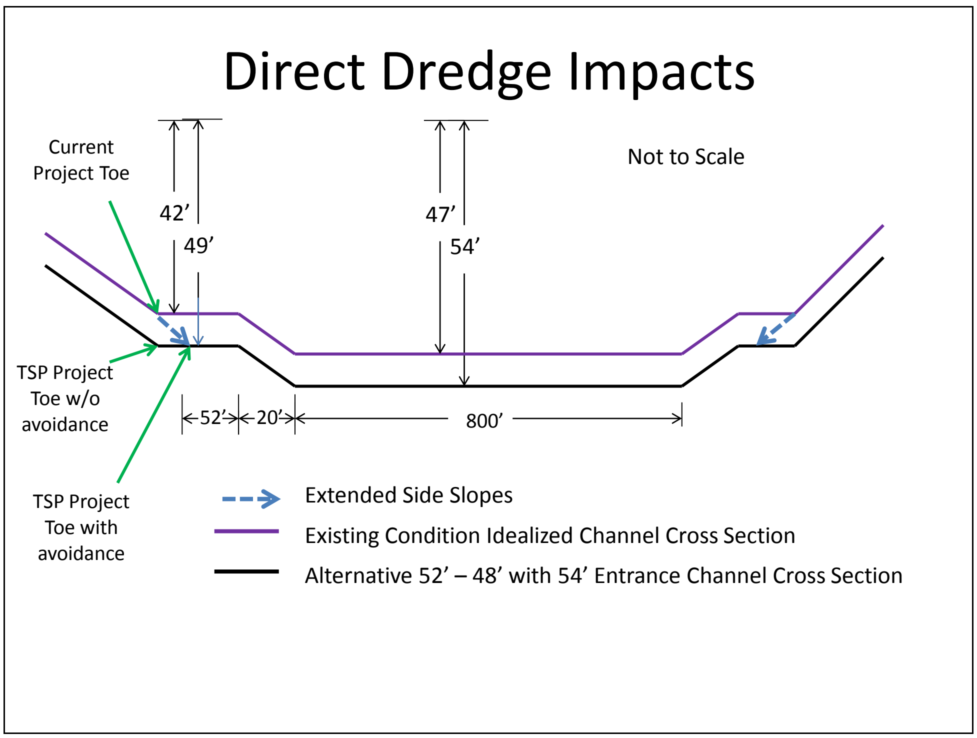


Figure 5-12. Avoidance measure for side slope impacts to hardbottom habitats

In-Channel Direct Impacts

As discussed in Section 2.4.10, an estimated 28.6 acres of previously undredged hardbottom habitat would be affected by the proposed project. This habitat occurs within an existing navigation channel and is subjected to frequent (~7 trips/day) passing of large vessels. Prop wash and pressure wakes from these vessels generate turbulence which likely affects the growth of sessile invertebrates. These frequent impacts are similar to the less frequent effects from major storm events (i.e., hurricanes and nor'easters) that generate significant wave action. In a study by Mitchell et al. (1993), hurricane events were noted to have caused high mortality of octocoral colonies on reefs at 22 m and 1-1.5 m depth. The study further states that, "…it seems likely that each storm had an impact on gorgonian (sea whips and sea fans) populations."

Indirect Impacts

Indirect impacts to hardbottom habitats near the dredging within the Entrance Channel are expected to be minimal and short term. These impacts would be due in large part to any turbidity resulting from the dredging of material from the Entrance Channel and any subsequent sedimentation that could occur on these reefs. These impacts would result in sub-lethal effects (injury, decreased fecundity, etc.) on the macroinvertebrate community. In a study of hardbottom habitat impacts from the Grand Strand Nourishment Project in 2007, SCDNR concluded that the temporal variability of macroinvertebrates at reference vs. impact sites made detection of significant impacts from the nourishment difficult to determine. Over the course of the study, macroinvertebrate cover increased similarly at the reference and impact sites. They indicate that this suggests a lack of impact, but qualify that by restating the inability to detect significant differences because of the natural variability in the environment. (Burgess et al. 2011) (CCU's monitoring). Additionally, a seven-year biological monitoring effort documented reef community changes before and during beach nourishment activities in Broward County. Results showed no effect of sand placement activities or dredging of borrow areas on corals or other biological components of adjacent reefs. In sum, the above reports suggest that corals were not measurably affected by adjacent dredging activities or sand placement during and after these activities. Because of this and the documented hardbottom communities in areas where dredging occurs the impacts from turbidity as a result of the construction phase would result in minor adverse temporal impacts (discussed in Appendix I). Along the margins of the channel (within 75 m buffer) there are 186.3 acres of hardbottom habitat that would experience minor temporary stress due to increased sedimentation.

Habitat Equivalency Analysis

Due to the impacts occurring within the previously undredged portion of the channel (28.6 acres) and the indirect impacts to hardbottom habitats (186.3 acres) within 75 m of the channel, the USACE performed a Habitat Equivalency Analysis (HEA) to determine the appropriate amount of mitigation. HEA factors in the service level of the impacted area, the extent of impacts (direct and indirect), and the recovery time of the impacted site, as well as similar variables for the mitigation site. For this project, it was assumed that the direct impacts would result in a reduction of habitat value from 100% to 0% and no recovery. This is a very conservative analysis for the impacts because it does not factor in a recovery. For the indirect impacts, it was assumed that a 5% reduction in habitat quality would occur during the period of new work dredging, and that this habitat would return to existing condition quality within the period of recovery. For this project, the period of recovery was assumed to be 3.5 years based on a review of applicable literature (see Appendix I for details). The analysis was also run based on a 10 year recovery time in order to determine a range of potential recovery rates and compensatory mitigation needs. The result of the HEA is a recommended amount of compensatory mitigation, which in this case, for the proposed project, is 29.8 acres. The mitigation plan consists of the creation of two 33-acre reefs with limestone rock dredged from the Entrance Channel and is discussed in Section 4 of this report and details of the HEA and mitigation description can be found in Appendices I (Hardbottom Habitat) and P (Mitigation). One of the reefs is required compensatory mitigation and the other one is a contingency in case success criteria are not met as anticipated.

As mentioned in Section 4, in addition to the two mitigation reefs (1 required, 1 in addition), the USACE would construct six other similar reefs for a total of eight new 33-acre reefs that would be accomplished as a beneficial use of dredged material. Four would be located along the north side of the channel and four would be located along the south side of the channel. For a conceptual depiction of the location of these reefs see Figure 4-3. Prior to construction, the locations of these reefs would be refined and coordinated with the resource agencies based on cultural and natural resource surveys. At the request of the SCDNR Artificial Reef Program, approximately 240,000 cy of rock material would also be deposited at the 25-acre Charleston Nearshore Reef site and would be accomplished as a beneficial use of dredged material. These reefs would provide extensive bathymetric features located between approximately 6 nm offshore of Charleston Harbor out to approximately 10 nm. The locations of these reefs were coordinated with local shrimping interests in order to ensure that they don't interrupt or interfere with their typical trawling lines. The construction of these reefs would create diverse, high relief, hardbottom habitat in an area of the coast that does not typically have high relief habitat. This diversity would be beneficial to macroinvertebrates and fish species that would utilize the sites. It is anticipated that these reefs would reduce fishing pressure on other nearshore reefs in the area and would provide valuable habitat to recreational and commercial fisherman.

5.4.11 Essential Fish Habitat and Managed Species

The proposed project would impact EFH including hardbottom habitat (discussed in detail above, Section 5.4.10), freshwater wetlands (discussed in Section 5.4.9), and water column (discussed in Section 5.4.7). An additional direct impact to EFH would occur from the removal of sediments classified as shallow sub-bottom habitat (between 0 and -2m MLLW), and EFH for penaeid shrimp. The impacts occur to approximately 2.84 acres of habitat primarily on the Daniel Island side of the new Navy Base Terminal and are a result of the proposed turning basin in that area. The impacts occur directly across from large container terminals and along a section of shoreline adjacent to upland sediment disposal facilities. Additionally, adjacent marshes in the area of impacts are only small fringing salt marshes and are not likely prime habitat for managed species. Considering the location of these impacts and the abundance of this habitat within Charleston Harbor, the impact is not significant to warrant compensatory mitigation (Figure 5-13).

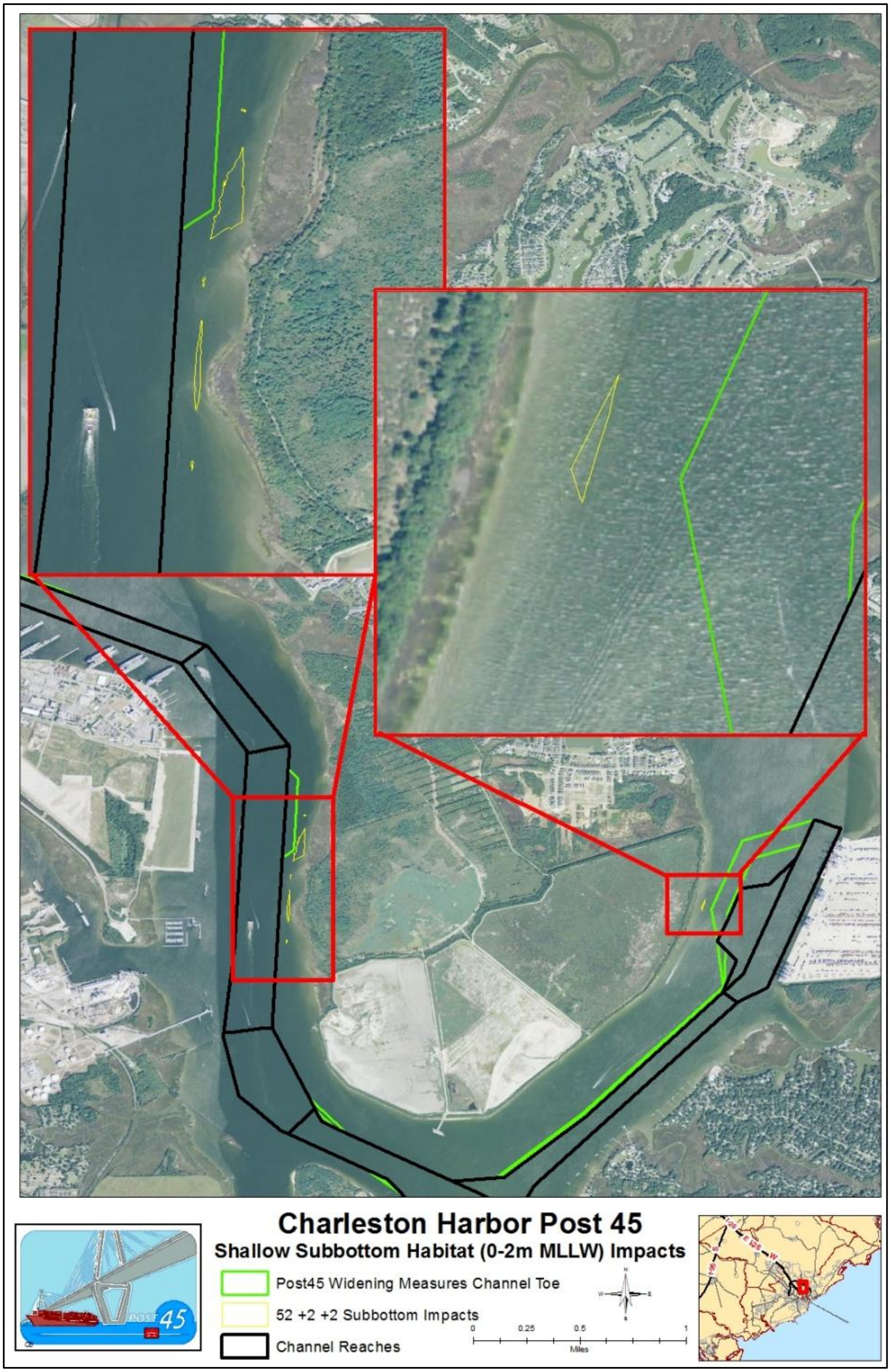


Figure 5-13. Shallow sub-bottom habitat impacts

Effects of the proposed project include death and injury of fishes and forage during dredging operations and subsequent maintenance dredging operations. Direct removal of softbottom habitats will occur, but indirect impacts due to changes in water quality will affect the widest geographic effect in the project area. These effects have been modeled by USACE and results are detailed in the wetland assessment appendix (Appendix L of the Final IFR/EIS), and affect both the estuarine water column as well as some tidally influenced wetlands upstream in the Cooper and Ashley Rivers. The below list summarizes potential effects of the proposed project on EFH and managed species. Details on the effects to specific groups of managed species associated with certain essential fish habitats can be found in Appendix H of the Final IFR/EIS.

1. Directly affecting mortality or injury of individual fishes (adults, subadults, juveniles, larvae, and/or eggs, depending on species, time of year, location, etc.) due to dredge equipment during construction (various areas of the channel for approximately 3 years) and maintenance dredging (an effect temporary in duration). No one area would experience an extended duration of effects.
2. Indirectly affecting foraging behavior of individuals through production of turbidity at construction/maintenance dredging sites (an effect temporary in duration).
3. Indirectly affecting movements of individuals around/away from dredging sites due to construction equipment and related disturbed benthic habitats (an effect temporary in duration).
4. Indirectly affecting foraging and refuge habitats by removal of benthic habitat (i.e., hardbottom) (an effect temporary in duration); mitigation areas would compensate for functional losses, and new hardbottom may be exposed due to dredging.
5. Directly, but slightly, affecting water column DO and salinity in certain parts of the estuary (a permanent effect)
6. Indirectly affecting some fishes and invertebrates (not currently identified), which may move a short distance upstream if they are intolerant of slight increases in salinity, or to other positions/microhabitats in the estuary if they are intolerant of slight shifts in DO. (a permanent effect)
7. Indirectly affecting plant species composition and/or relative percent coverage in certain riparian wetlands due to slight shifts in pore water salinity (a permanent effect). Wetland mitigation would be provided to compensate for functional losses of tidal freshwater wetlands.

Many of the dredging related impacts would occur on a temporary scale in the FWOP condition; however, the proposed project involves a longer duration of these temporary impacts. As noted, the affects would only be felt in the area of dredging activity which would not be taking place at all locations at all times. Individually or in sum, the above are not anticipated to significantly adversely affect managed species or most EFHs, except hardbottom habitat and freshwater wetlands. Where possible, the above effects have been minimized via project design (see Section 3.6.3.1). An EFH Assessment was prepared for this project and is presented in Appendix H. The EFH Assessment was coordinated with

NMFS concurrent with the review of the Draft IFR/EIS. On 24 November 2014, NMFS provided USACE with EFH conservation recommendations, and responses to those recommendations can be found in Appendix H and Appendix Q.

5.4.11.1 Other Marine/Estuarine Habitats

Dredging activities can impact benthic assemblages either directly or indirectly and may vary in nature, intensity, and duration depending on the project, site location, and time interval between dredging operations. Direct catastrophic impacts include physical removal or smothering by the settlement of suspended materials (Morton 1977; Guillory 1982). Recovery in dredged sites occurs by four basic mechanisms: remnant (undredged) materials in the sites, slumping of materials with their resident fauna into the site, adult immigration, and larval settlement. Remnant materials, sediments missed during the dredging operation, act as sources of “seed” populations to colonize recently removed sediments. Suspended materials may also interfere in the feeding respiration or reproduction of filter feeding benthos and nekton (Sherk and Cronin 1970). Though initial loss of benthic resources are likely, quick recovery between 6-months (McCauley et al. 1977; Van Dolah et al. 1979; Van Dolah et al. 1984; and Clarke and Miller-Way 1992) to two years (Bonsdorff 1980; Ray 1997) is expected. Recent benthic studies in Savannah Harbor, just prior to annual maintenance dredging, have shown primarily healthy benthic communities both inside and outside the channel. For most sediment types, average abundance and biomass were found to be higher inside the channel compared to locations outside the channel with the exception of silt-sand substrates (USACE 2008).

For benthic assemblages in estuarine and riverine systems, the distribution of individual species is consistent with their known sediment and salinity preferences (polyhaline, mesohaline, and oligohaline). The distribution of each of these assemblages varies depending on the intensity of river flow, often correlated with season (Ray 1997; Posey et al. 1996). Therefore, in addition to the anthropogenic dredging impacts to benthic assemblages, natural community shifts are correlated with river flow rates. Considering the ephemeral nature of this environment, the benthic assemblages consist of opportunistic species which are capable of adapting to natural fluctuations in the environment (Ray 1997). In an environmental baseline study of benthic habitat conducted by SCDNR for this project (Sanger et al., 2013), the authors conclude that the macroinvertebrate community in the upper Cooper River was most influenced by the sediment composition and that salinity was not as strong of a factor when assessing the entire community. After comparing species composition at sites studied in the 1980’s and in this study, the authors found that the macroinvertebrate community compositions were similar. In contrast to results in the Cooper River, the Ashley River macroinvertebrate community was found to be most influenced by salinity, but the communities were similar when compared to data from the 1980’s study. The communities sampled within the Wando River were diverse and abundant and no salinity or sediment influence was observed. Due to these findings and the relatively minor salinity increases predicted from the project, benthic communities are not anticipated to be significantly affected except for the short term affect resulting from sediment removal during project construction.

5.4.12 Protected Species

5.4.12.1 Overview

A biological assessment of threatened and endangered species (BATES) evaluating the potential impacts of the proposed project on listed species was prepared as part of this report (Appendix F). A summary of effect determination for Threatened and Endangered Species is in Table 5-10. The biological assessment resulted in a determination that the proposed project, "may affect, but is not likely to adversely affect" (MANLAA) piping plover, wood stork, West Indian manatee, North Atlantic right whales and humpback whales, nor will the project adversely modify critical habitat for North Atlantic right whales or loggerhead sea turtles. During project construction, dredging operations, "may affect, and are likely to adversely affect" sea turtles, shortnose sturgeon, and Atlantic sturgeon. Project plans have been refined to minimize potential effects to the extent feasible. The National Marine Fisheries Service completed their Biological Opinion on 22 April 2015. In the accompanying letter to USACE (dated 22 April 2015), NMFS states, "The Opinion considers the effects of the proposed action on the following listed species: sea turtles (loggerhead, green, leatherback, hawksbill, and Kemp's ridley sea turtles), whales (North Atlantic right and humpback), sturgeon (Atlantic and shortnose), and the recently proposed critical habitat for the North Atlantic right whale. NMFS also concludes that the proposed action is not likely to jeopardize the continued existence of sea turtles (loggerhead, green, and Kemp's rid ley sea turtles), and sturgeon (Atlantic and shortnose) and is not likely to adversely affect proposed North Atlantic right whale critical habitat, North Atlantic right and Humpback whales, and leatherback and hawksbill sea turtles."

5.4.12.2 Fish (Atlantic and shortnose sturgeon)

Considering their similarities in habitat use, distribution within the proposed project area, foraging behavior and prey base, and subsequent risk of take relative to dredging and trawling operations, this section considers the impacts of the proposed project to shortnose and Atlantic sturgeon together. Potential direct and indirect impacts associated with dredging that may adversely impact sturgeon include entrainment and/or capture of adults, juveniles, larvae, and eggs by dredging and trawling activities, short-term impacts to foraging and refuge habitat, water quality, and sediment quality, and disruption of migratory pathways.

Hopper dredges are the most likely dredging practice to result in sturgeon takes. Hopper dredges are used within known sturgeon habitat throughout the proposed project area and have been known to directly impact adult, juvenile, and larval sturgeon species through entrainment in the draghead. Since 1990, five takes have occurred in the Charleston District. Considering that Atlantic sturgeon primarily lead a marine existence, with the exception of their spawning migration, and hopper dredging operations are often utilized in ocean bar channels or offshore borrow areas, it is likely that the risk of entrainment by hopper dredges is higher for Atlantic sturgeon than shortnose sturgeon.

Table 5-10. Summary of Effect Determination for Threatened and Endangered Species. Details can be found in Appendix F.

	*Effect Determination											
	Sea Turtle				Large Whales		Birds					
Proposed Activity	*Leatherback*	*Loggerhead*	*Green*	*Kemp's Ridley*	*NARW*	*Humpback*	*American Wood Stork*	*Piping Plover*	*Red Knot*	*West Indian Manatee*	*Sturgeon sp.*	*Seabeach Amaranth*
Hydraulic Hopper	NE	MALAA	MALAA	MALAA	NE	NE	NE	NE	NE	MANLAA	MALAA	NE
Hydraulic Cutterhead	NE	MANLAA	MANLAA	MANLAA	NE	NE	NE	NE	NE	MANLAA	MALAA	NE
Mechanical Dredge	NE	MANLAA	MANLAA	MANLAA	NE	NE	NE	NE	NE	MANLAA	MALAA	NE
Bed Leveling	NE	MANLAA	MANLAA	MANLAA	NE	NE	NE	NE	NE	MANLAA	NE	NE
Transportation - Hopper, Tug/Scow, Barge	NE	NE	NE	NE	MANLAA	MANLAA	NE	NE	NE	MANLAA	NE	NE
Ocean Disposal	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
Confined Disposal	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
Beneficial Use - Crab Bank Placement	NE	NE	NE	NE	NE	NE	MANLAA	MANLAA	MANLAA	NE	NE	NE
Trawling	MANLAA	MANLAA	MANLAA	MANLAA							MALAA	
Tissue Sampling	MANLAA	MANLAA	MANLAA	MANLAA								
Tagging	MANLAA	MANLAA	MANLAA	MANLAA								
Dredge Lighting	MANLAA	MANLAA	MANLAA	MANLAA								
Channel Modification Impacts	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	MANLAA	NE
Critical Habitat		NLAM			NLAM			NLAM				

****Not Applicable (grey); No Effect (NE – green); May Affect Not Likely to Adversely Affect (MANLAA – orange); May Affect Likely to Adversely Affect (MALAA – red); and Not Likely to Adversely Modify (NLAM - Yellow)***

The use of the "turtle deflecting draghead" reduces the potential for take of benthic oriented species (i.e., sea turtles and sturgeon) by creating a sand wave in front of the draghead and pushing animals out of the way that were otherwise at risk of entrainment. Though the use of the "turtle deflecting draghead" likely reduces potential risk of sturgeon entrainment based on the understanding of its operating conditions, it is likely that takes can still occur due to dragtender operator error, uneven bottom contours, difficult dredging conditions (currents, slope, etc…).

Impacts to sturgeon as a result of cutterhead and clamshell dredges are rare, but do occur. Though five shortnose sturgeon takes by a pipeline (hydraulic cutterhead) have been documented, the potential for significant numbers of adult and juvenile fish being hit by the cutterhead is fairly low. Since 1990, for all mechanical dredging operations throughout the North Atlantic, South Atlantic, and Gulf waters a total of three sturgeon (one shortnose and two Atlantic) have been reported as captured by clamshell dredge operations, but none known within the project area. Given the mobility of sturgeon, the lack of a suction field from mechanical dredging, and the small area of active dredging by a bucket during each load, the likelihood of mechanical dredging practices to incidentally take sturgeon species is relatively small. Furthermore, compared to other hydraulic dredging techniques, mechanical dredging is often recommended by NMFS as the preferred dredging technique for minimizing incidental takes of sea turtles and sturgeon. The proposed project intends to use a clamshell in portions of the Entrance Channel in order to create hardbottom habitat and the ODMDS sediment containment berm. These measures reduce the need for other, more impactful, dredging methods.

At individual dredged channels and ports throughout the South Atlantic, it is not known how extensively the channels and turning basins are used by sturgeon as feeding areas. Furthermore, specific aggregation areas for spawning, feeding, resting, etc… have not been identified for all dredging locations throughout the distribution range for shortnose and Atlantic sturgeon. However, based on the current understanding of the variables required (i.e., salinity regime, depth, substrate, etc...) for various stages of the sturgeon life cycle (i.e., spawning, migrating, foraging, etc...), dredging activities presumably create some level of disruption based on their location relative to the life stage requirements. Channels maintained at frequent dredging intervals are not expected to be used extensively for feeding or other activities. As identified in the 2007 Status Review of Atlantic Sturgeon, it was tested whether dredging operations affected Atlantic sturgeon behavior by comparing Catch Per Unit Effort (CPUE) before and after dredging events in 1999 and 2000. The Review documented a three to seven-fold reduction in Atlantic sturgeon presence after dredging operations began, indicating that sturgeon avoid these areas during operations.

Sturgeon foraging sites with soft mud bottoms and oligohaline or mesohaline salinities tend to recover quickly, likely due to the dominance of opportunistic species assemblages (e.g., *Streblospio benedicti, Capitella capitata, Polydora Ligni*) (Ray 1997). During periods of extreme conditions (i.e. extreme temperature regimes, low dissolved oxygen, etc.), sturgeon may become relatively immobile and forage extensively in one area. Therefore, considering that limited mobility would not allow for sturgeon to move to more productive foraging grounds following dredging activities, it is possible that reduced benthic assemblages during site and time specific conditions could have an impact to foraging behavior. Assuming that natural benthic community shifts are an inherent component of sturgeon foraging behavior, it is possible that post dredging movements to more productive foraging grounds are not far outside of the normal foraging behavior response to natural benthic community shifts.

As previously discussed, the Charleston District performed modeling of affected sturgeon habitats. The modeling results are discussed below based on the FWOP condition / No Action Alternative in 2071. Details can be found in Appendix K.

Atlantic Sturgeon – Spawning Habitat

The Atlantic sturgeon spawning life stage is most impacted by salinity in the habitat models. The only salinity changes occurred in cells approximately three miles south of "The Tee". Anticipated impacts for the 52'/48' project alternative are for three cells to change from "suitable" to "non-suitable." These cells represent a habitat loss of 2.70 percent from the FWOP condition suitable habitat. SCDNR has determined that spawning does occur in the Cooper River in the tailrace canal near the Pinopolis Dam. While spawning in the Cooper River has been confirmed by the presence of fertilized eggs (Duncan et al, 2004), a near total absence of larval and juvenile life stages casts doubt on whether the reproduction is successful (Bill Post, SCDNR, personal communication, Wirgin et al. 2009). Because the impact of the project, as described above, occurs over 20 river-miles downstream of where spawning is known to occur, this change is unlikely to impact this species.

Atlantic Sturgeon – Adult Habitat

The proposed project resulted in relatively small change in suitable habitat for adult Atlantic Sturgeon habitat (-3.97 percent from the FWOP condition). The cause of this decrease in habitat is a minor increase in salinity and most of the changes occur in or near the navigation channel (see Appendix K). The impacts are small and essentially only take portions of the harbor that had a salinity of just under the 28.6 ppt threshold to just over that threshold. SCDNR has documented the occurrence of Atlantic and shortnose sturgeon within the harbor, and it's unlikely that the small changes to temperature that occur in and along the navigation channel would impact this species life stage. More details can be found in Appendix K (Fish Habitat Assessment) and Appendix F (Biological Assessment of Threatened and Endangered Species). Importantly, in their Biological Opinion, NMFS states that, "There are no studies indicating that adult shortnose sturgeon are sensitive to salinity."

Atlantic Sturgeon – Egg and Larval Habitat

The model predicted that egg and larval habitat would be decreased by 4.96 percent from the time of construction in 2022. The areas of impact were below the "tee". The locations of these are not in proximity to spawning locations. Therefore it is not likely that these potential changes would adversely affect this life-history stage. More details can be found in Appendix K (Fish Habitat Assessment) and Appendix F (Biological Assessment of Threatened and Endangered Species).

Atlantic Sturgeon – Juvenile Habitat

The model predicted that juvenile habitat would be decreased by 4.56 percent from the time of construction in 2022. Large areas in the Wando River are anticipated to decrease in juvenile habitat quality. Other areas of decreased quality are scattered throughout the project area. More details can be found in Appendix K (Fish Habitat Assessment) and Appendix F (Biological Assessment of Threatened and Endangered Species).

Shortnose Sturgeon – Spawning Habitat

The model predicted that spawning habitat would be decreased by 3.44 percent from the time of construction in 2022. The decrease in habitat is attributed to salinity going above a 0.5 ppt threshold in model cells south of the "tee" in the Cooper River. SCDNR has determined that spawning does occur in the Cooper River in the tailrace canal near the Pinopolis Dam. The success of this spawning is unknown (Bill Post, SCDNR, pers. com., 10/29/13). Because the impact of the project is over 20 river-miles downstream of where spawning is known to occur, this change is unlikely to impact this species. More details can be found in Appendix K (Fish Habitat Assessment) and Appendix F (Biological Assessment of Threatened and Endangered Species).

Shortnose Sturgeon – Foraging Habitat

The model predicted that foraging habitat would be increased by 0.19 percent from the time of construction in 2022. The positive changes in individual cells are small and are affected by velocity and temperature changes predicted by the model. Since the bottom temperatures are slightly lower with the proposed project compared to the FWOP, temperature positively benefits shortnose sturgeon foraging in the HSI within many cells, and negatively in fewer cells. More details can be found in Appendix K (Fish Habitat Assessment) and Appendix F (Biological Assessment of Threatened and Endangered Species).

In their Biological Opinion to USACE on the project, NMFS stated that, "Due to the very small magnitude of the anticipated changes in salinity throughout portions of the action area which are used by shortnose sturgeon, and the related conclusion that the effects will not alter the current conditions that already impede successful recruitment, we anticipate that any direct effects to shortnose sturgeon will be insignificant." Additionally, in support of the not likely to adversely affect determination, NMFS also states that, "Due to the very small magnitude of the anticipated changes in DO throughout portions of the action area which are used by shortnose sturgeon, we anticipate that any direct effects to shortnose sturgeon will be insignificant."

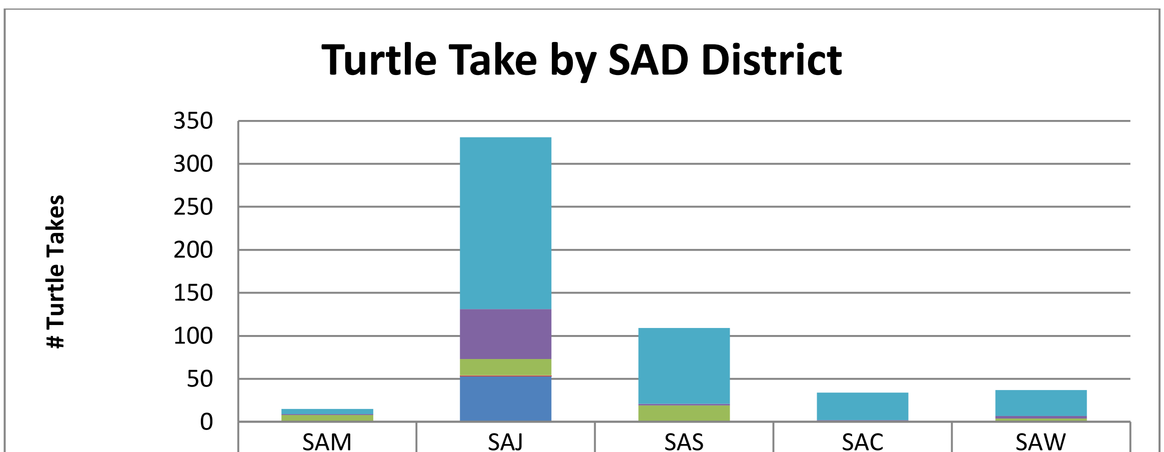
5.4.12.3 Sea Turtles

5.4.12.3.1 Construction Related Effects

Although the overall impacts to sea turtles from dredging activities is relatively small and continues to decrease, the USACE and the dredging industry is committed to the continued pursuit of efforts to further reduce dredging impacts on sea turtles. Current conservation measures implemented by the USACE to reduce impacts to sea turtles during hopper dredging operations are discussed in the Biological Assessment and the RPMs and T&Cs of the Biological Opinion addressed in Section 6 of this report (Environmental Compliance). The following sections summarize specific effects from various components of construction.

Hopper Dredging

Hopper dredges include self-propelled ocean-going vessels that hydraulically lift dredged material from the bottom surface and deposit it into an open hopper within the ship. The draghead(s) operates like a vacuum cleaner being dragged along the bottom. When the hopper is full, the dredge transits to a disposal location and releases the dredged material into an underwater disposal site by opening doors on the hopper bottom or in some cases the vessel is designed to split open longitudinally. The impacts (lethal and many non-lethal impacts are restricted by the "take" provisions in the Endangered Species Act) to sea turtles by hopper dredges was first identified as a problem in the late 1970's and in Charleston District five species of threatened or endangered sea turtles could potentially be impacted – loggerhead, green, Kemp's ridley, leatherback, and hawksbill. However, since take observations began in 1980, records indicate that only 32 takes of loggerheads and two takes of green sea turtles (Figure 5-13) have occurred in Charleston District (SAC) (1991-2012). That number is less than 7 percent of the total number of takes (n=526) for the South Atlantic Division during the period (http://el.erdc.usace.army.mil/seaturtles/index.cfm). South Atlantic Division is comprised of five districts: Mobile (SAM), Jacksonville (SAJ), Savannah (SAS), Charleston (SAC), and Wilmington (SAW). NMFS concurs with USACE that there is a low possibility of adverse affect to leatherbacks and the impact is discountable, but that hopper dredging is likely to adversely affect loggerheads, greens and kemp's ridleys.



	SAM	SAJ	SAS	SAC	SAW
Loggerhead	6	200	88	32	30
Green	1	58	2	2	3
Kemp's Ridley	8	19	18		4
Leatherback		1			
Unknown		53	1		

Figure 5-14. Comparison of total number of turtle takes in the South Atlantic Division (SAD); SAM (2002-2013); SAJ (1980-2013); SAS (1988-2013); SAC (1991-2012); SAW (1992-2013).

Hydraulic Cutterhead

The potential impacts of hydraulic cutterhead dredging on sea turtles was considered by NMFS in their 1991, 1995, and 1997 South Atlantic Regional Biological Opinions (SARBO), as well as the 2003 (revised in 2005) Gulf of Mexico Regional Biological Opinion (GRBO), for USACE hopper dredging activities. Under each biological opinion the NMFS determined that cutterhead pipeline dredging may affect but is not likely to adversely affect sea turtles. In contrast to hopper dredges, pipeline dredges are relatively stationary and therefore act on only small areas at any given time. In the 1980s, observer coverage was required by the NMFS at pipeline outflows during several dredging projects deploying pipeline dredges along the Atlantic coast. No turtles or turtle parts were observed in the outflow areas. Additionally, the USACE's SAD office in Atlanta, Georgia, charged with overseeing the work of the individual USACE Districts along the Eastern Seaboard from North Carolina through Florida, provided documentation of hundreds of hours of informal observation by USACE inspectors during which no takes of listed species were observed. Additional monitoring by other agency personnel, conservation organizations or the general public has never resulted in reports of turtle takes by pipeline dredges (NMFS 1991).

Mechanical Dredging

The impacts of mechanical dredging operations on sea turtles were previously assessed by the NMFS (NMFS 1991; NMFS 1995; NMFS 1997; NMFS 2003) in the various versions of the SARBO and the 2003 (revised in 2005) GRBO. The 1991 SARBO states that "clamshell dredges are the least likely to adversely affect sea turtles because they are stationary and impact very small areas at a given time. Any sea turtle injured or killed by a clamshell dredge would have to be directly beneath the bucket. The chances of such an occurrence are extremely low…" (NMFS 1991). NMFS also determined that "Of the three major dredge types, only the hopper dredge has been implicated in the mortality of endangered and threatened sea turtles." This determination was repeated in the 1995 and 1997 SARBO's (NMFS 1995 and 1997). No new information is available that suggests increased risk of sea turtle take by clamshell dredges since the 1991, 1995, and 1997 SARBO's were received.

Dredge Turbidity Plume

Mechanical dredges could be used throughout the proposed project area, including the lower harbor and portions of the Entrance Channel. Turbidity could be generated when the full bucket travels through the water column to the surface and is emptied into an adjacent barge. However, turbidity within the open water system would be quickly dissipated due to currents, wind and wave action.

Dredge Lighting

The presence of artificial lighting on or within the vicinity of nesting beaches is detrimental to critical behavioral aspects of the nesting process including nesting female emergence, nest site selection, and the nocturnal sea-finding behavior of both hatchlings and nesting females. Though hatchlings use directional brightness of a natural light field (celestial sources) to orient to the sea, light from artificial sources interferes with the natural light cues resulting in misdirection (Witherington and Martin 2003). Female sea turtles approaching nesting beaches and neonates (i.e., hatchlings) emerging from nests and exiting their natal beaches, may be adversely affected by lighting associated with dredges and equipment operating in the nearshore (0-3 nm) environment. For dredging vessels, appropriate lighting is necessary to provide a safe working environment during nighttime activities on deck (i.e. general maintenance work deck, endangered species observers, etc.). In compliance with the US Army Corps of Engineers Safety and Health Requirements Manual (USACE 2011), a minimum luminance of 30 lm/ft^2 is required for outside work performed on board the dredge during nighttime dredge operations. In order to reduce potential disorientation effects on female sea turtles approaching the nesting beaches and sea turtle hatchlings making their way seaward from their natal beaches, while still adhering to minimum luminance requirements, light emanating from offshore equipment would be minimized through reduced wattage, shielding, lowering, and/or use of low pressure sodium lights to the extent practicable. Shielded low-pressure sodium vapor lights have been identified by the Florida Fish and Wildlife Conservation Commission (FWCC) as the best available technology for balancing human safety and security, roadway illumination, and endangered species protection. They provide the most energy efficient, monochromatic, long-wavelength, dark sky friendly, environmentally sensitive light of the commercially available street lights and would be highly recommended for all lights on the beach or on offshore equipment (Gallagher 2006).

Trawling

Although not a common practice within Charleston Harbor, modified shrimp trawling equipment and techniques are used to capture and relocate threatened and endangered sea turtles from hopper dredging sites. Charleston District would use this technique as a risk management tool to limit takes, if necessary. With respect to trawling and sea turtle interactions, the effects of trawling during capture and handling can result in raised levels of stressor hormones. Based on past observations obtained during similar research-trawling for turtles, these effects are expected to dissipate within a day (Stabenaua and Vietti 1999). Routinely, when a sea turtle is captured, and before it is released, the turtle is tagged and a tissue sample is taken for diagnostics.

Considering that NMFS approved and permitted observers who would be handling sea turtle species and adherence to the permit conditions to ensure the safety of the turtles, it is expected that tagging activities would have minimal and insignificant effects on the animals. All animals would be handled with care, kept moist, protected from temperature extremes during sampling, and later returned to the sea in accordance with the sea turtle handling permit conditions.

Conservation Measures for the Proposed Project

The USACE will use the following conservation measures outlined below during the construction of the proposed project (described in detail in Appendix F, Biological Assessment and Appendix F2, Biological Opinion):

a. Relocation and abundance trawling
b. Use of draghead deflector
c. Environmental windows
d. Inflow/overflow screening
e. Endangered species observers

f. Use of National Dredging Quality Management Program (DQM)
g. Sea turtle community of practice

5.4.12.3.2 Long Term Effects

Impacts to sea turtles were evaluated based upon effects of the project on food supply, habitat, and life period. The proposed project is likely to adversely affect benthic food supply but these effects are expected to be temporary in nature. Though initial loss of benthic resources is likely, quick recovery, between 6 months (McCauley et al. 1977; Van Dolah et al. 1979; Van Dolah et al. 1984; and Clarke and Miller-Way 1992) to 2 years, (Bonsdorff 1980; Ray 1997) is expected. A small increase in turbidity and some suction from dredging activities may affect some species of aquatic organisms or vegetation that loggerheads may feed on. These sediment disturbance impacts are expected to be minimal in nature and are not expected to have a measurable effect on water quality beyond the frequent natural increases in sediment load. The proposed project may affect but is not likely to adversely affect other sources of food supply for sea turtles since those prey species are motile or not likely to be in the project area.

The USFWS has designated critical habitat for nesting loggerheads in South Carolina (Federal Register/ Vol. 79, No. 132. July 10, 2014). Folly Island includes the only beach in the proposed project area included in the listing. All 11.2 miles of Folly Beach is designated from the mean high water (MHW) line to the toe of the secondary dune or developed structure. According to the Federal Register Notice, special management measures may be needed to protect physical biological features (PBFs) and primary constituent elements (PCEs) present. A total of 22 units are proposed for listing in South Carolina. In the Federal Register, USFWS stated that "it is unlikely that the critical habitat designation would result in additional management efforts resulting from future section 7 consultations with the USFWS." The proposed project would not adversely modify this critical habitat.

The NMFS has designated critical habitat for the Northwest Atlantic Ocean loggerhead sea turtles DPS (Federal Register/ Vol. 79, No. 132. July 10, 2014). Nearshore waters off of Folly Beach are the closest areas designated as critical habitat. The proposed project would not adversely modify this critical habitat.

The Charleston District believes the proposed project would have no long term affect on sea turtle habitat as a result of channel modifications. Loggerhead sea turtles are most frequently found in SC waters. A study published by Arendt et al. (2011) documented loggerhead captures by trawling in the shipping channel between May and August during 2004-2007. Two hundred and twenty loggerheads were captured during the study. Eight of the turtles were recaptured during the study, only two tagged turtles were reported as recaptured away from the channel implying loggerheads may have an affinity for the shipping channel even though it is dredged every year for operations and maintenance. The authors contend that loggerheads in the shipping channel have increased since the late 1990's. The shipping channels may be important for transient use by juvenile loggerheads migrating between foraging and overwintering areas.

The long term impacts of the proposed project would have no effect on the life period or food supply of the green, leatherback, Kemp's ridley, and loggerhead sea turtles. More details on these determinations can be found in Appendix F (Biological Assessment of Threatened and Endangered Species).

5.4.12.4 Whales

5.4.12.4.1 Construction Related Effects

Both of the two species of large whales being considered under this assessment, the North Atlantic right whale and the humpback whale, may be present in the project area. Direct and indirect impacts from dredging operations and dredge plants are similar for mechanical or hydraulic type dredges.

Impacts from dredging operations have the potential to occur offshore during a dredge plant's transit to and from an ocean disposal site but such interactions are rare. Since consultations with NMFS were completed in the SARBO (1991, 1995, and 1997), (1) the estimated number of right whales has increased based on the data presented in the NMFS annual stock assessments, (2) the annual support for the Right Whale Early Warning System associated with operations near or within the calving grounds has been ongoing, and (3) the USACE's involvement with and awareness of right whale issues has increased significantly. Based on these factors, the USACE expects that dredging operations would have a minimal effect on right or humpback whales. Additionally, a review of the NMFS large whale strike database does not indicate any records of large whale vessel strikes associated with any dredging equipment. There is an account of a dredge/whale interaction observed in 1988 when a dredge approached within 100 yards of a right whale and another incident in 2005. This situation is unlikely to occur in the future, since dredges now maintain a distance of 500 yards from the known position of right whales, consistent with federal marine mammal approach regulations. Specific observer requirements throughout the South Atlantic are outlined in Table 3 of the 1997 SARBO. For the construction of the proposed project, one hundred percent dedicated daytime whale observer coverage will be required on the bridge between November 1 and April 30 when the dredge is transiting to and from the ODMDS. Pursuant to the most current SARBO, by requiring slow down procedures, using dedicated observers, as well as being a partner in aerial surveys of high use whale areas, USACE continues to demonstrate significant successful efforts to greatly diminish the potential interactions between large baleen whales and dredging equipment.

Noise generated from the dredging equipment has the potential to harm marine mammals, including large whales. Although behavioral impacts are possible (i.e., a whale changing course to move away from a vessel), the number and frequency of vessels present within a given project area is small and any behavioral impacts would be expected to be minor. Furthermore, for hopper dredging activities, endangered species observers (ESOs) would be on board and would record all large whale sightings and note any potential behavioral impacts. For details on impacts from dredge and vessel noise please see Appendix G (Noise Assessment).

Conservation Measures for the Proposed Project

The USACE has established precautionary collision avoidance measures to be implemented during dredging and disposal operations that take place during the time North Atlantic right whales are present in waters offshore of USACE projects. For the construction of the proposed project, these precautionary measures were negotiated between USACE and NMFS and include:

a. Before the initiation of each project, at the pre-construction/partnering meeting, the USACE briefs the contractor on the presence of the species, and reviews the requirements for right whale protection,

b. Each contractor will be required to instruct all personnel associated with the dredging/construction project about the possible presence of endangered North Atlantic right whales in the area and the need to avoid collisions. Each contractor will also be required to brief his personnel concerning the civil and criminal penalties for harming, harassing or killing species that are protected under the Endangered Species Act of 1973 and the Marine Mammal Protection Act of 1972. Dredges and all other disposal and attendant vessels are required to stop, alter course, or otherwise maneuver to avoid approaching the known location of a North Atlantic right whale. The contractor will be required to submit an endangered species watch plan that is adequate to protect North Atlantic right whales from the impacts of the proposed work.

c. Dredge-related vessel speed reductions to protect whales: From November 1 through April 30, all project vessels operating in the Atlantic Ocean that are greater than or equal to 65 ft in overall length will maintain a speed of 10-knots or less during right whale migration/calving season while in specified areas designated as proposed right whale critical habitat and slow to 5 knots or the minimum safe navigable speed when visibility is reduced by night, fog, precipitation, or if sea state is greater than 3 ft. As set forth in this proposed action, the speed limits for project vessels shall only apply until a new SARBO is signed, at which time the project would abide by the conditions set forth in the new SARBO.

d. Whale observers: From November 1 through April 30, one observer with at-sea large whale identification experience will be on watch 100% during daylight hours (30 mins before sunrise to 30 mins after sunset).

e. Operational Automatic Identification System (AIS) transmitters powered on and transmitting: The USACE shall provide NMFS's Southeast Regional Office (takereport.nmfsser@noaa.gov with reference to this Opinion) with an end-of-project report including all AIS data with any deviances from (a) within 30 days of completion of the North Atlantic right whale migration and calving season (April 30). This report may be incorporated into the final report summarizing the results of the hopper dredging project.

These protective measures were negotiated between USACE and NMFS during the consultation period for this project and have been determined to be agreeable to both agencies. Based on the implementation of these protective measures, the proposed project may affect but is not likely to adversely affect the North Atlantic right whale or humpback whale. Furthermore, the proposed project and potential beneficial uses of dredged material will not adversely modify North Atlantic right whale critical habitat.

5.4.12.4.2 Long Term Effects

Due to the relatively minor extension of the Entrance Channel, the proposed project would have no effect on the food supply, habitat, or life period of the North Atlantic right whale or the humpback whale. Since the forecasts and analysis indicate that the proposed project would result in fewer vessel transits than the No Action Alternative, the risks related to vessel strikes would not be expected to increase.

5.4.12.5 West Indian Manatee

The proposed project may affect, but is not likely to adversely affect the manatee. The contractor would adhere to the standard manatee conditions during construction in order to avoid vessel strikes. The Contractor may be held responsible for any manatee harmed, harassed, or killed as a result of vessel collisions or construction activities. Failure of the Contractor to follow these specifications is a violation of the Endangered Species Act and could result in prosecution of the Contractor under the Endangered Species Act or the Marine Mammals Protection Act. The standard manatee conditions apply annually from 1 June to 30 September, however in order to take precaution for the early and late sightings noted by SCDNR reporting, these protective measures would be implemented if construction occurs between April 1 – October 31. The Contractor will be instructed to take the necessary precautions to avoid contact with manatees. If manatees are sighted within 100 yards of the dredging activity, all appropriate precautions would be implemented to insure protection of the manatee. The Contractor would stop, alter course, or maneuver as necessary to avoid operating moving equipment (including watercraft) any closer than 100 yards of the manatee. Operation of equipment closer than 50 feet to a manatee shall necessitate immediate shutdown of that equipment. These conditions are similar to the USFWS recommendations and the conditions of SCDHEC as stated in the 401 Water Quality Certification.

5.4.12.6 Birds

5.4.12.6.1 Wood Stork

Most aspects of the proposed project construction and O&M dredging would have no effect on the wood stork. Since dredging would not occur in shallow water habitat, the proposed project would have no effect on food supplies for wood storks. Wood storks forage in the area but no nesting sites are within the proposed project area. If beneficial use of dredged material occurs at any of the sites identified in Section 3, the project may affect but is not likely to adversely affect this species food supply, life stage, or habitats.

5.4.12.6.2 Piping Plover

Most aspects of the proposed project construction and O&M dredging would have no effect on the piping plover. If beneficial use of dredged material occurs at any of the sites identified in Section 3, the project may affect but is not likely to adversely affect this species food supply, life stage, or habitats. Piping plovers feed along sandy shorelines digging for small macroinvertebrates. There are no survey records of piping plovers utilizing the Charleston Harbor upland confined disposal facilities (CDFs) (Clouter Creek and Daniel Island) but it is possible the species occasionally forages in the area. This would likely be a rare occurrence. The project would not adversely modify critical habitat for the species, because there is none within the project area.

5.4.12.6.3 Red Knot

Most aspects of the proposed project construction and O&M dredging would have no effect on the red knot. If beneficial use of dredged material occurs at any of sites identified in Section 3, the project may affect but is not likely to adversely affect this species food supply, life stage, or habitats. Little or no evidence of nesting or foraging of this species has been found at the project's upland confined disposal areas.

The red knot is one of the longest-distance migrants, flying approximately 9,300 miles from southern Argentina north to the Arctic Plains every spring and then reversing the trip in the autumn. The red knot makes stopovers along flyways along the Atlantic Coast, including in South Carolina, to rest and forage on sandy beaches/mudflats and bays. The proposed project would have no effect on red knot habitat and no critical habitat for the species is expected to be designated within the project area. Since the red knot was officially listed as threatened on 12 January 2015, proposed critical habitat may be released by USFWS in the future. Presently, it is uncertain where these critical habitats will occur.

5.4.12.7 Seabeach Amaranth

Project construction would have no effect on seabeach amaranth because it is not found in the study area. Additionally, no impacts are expected as a result of channel modifications. Distribution of the species would not be affected by changing currents.

5.4.12.8 State Protected Species

For species listed as protected by SCDNR but not listed by the federal government (described in Section 2.4.12.8), no adverse effects due to the proposed project are anticipated.

5.4.13 Marine Mammals

A study conducted on the effects of dredging noise on bottlenose dolphins determined that frequencies generated from dredging activities were not unlike those generated from shipping, tourist, and recreational boat traffic (NAVFAC 2008). Bottlenose dolphins are most sensitive to frequencies from 4 to 20 kHz and although source frequencies generated from a dredging vessel can fall in this range, noise effects are unlikely to acoustically mask bottlenose dolphin sound, particularly when generated within 100 meters of a dredging vessel (Applied Ecology Solutions 2006). In addition, dolphins are highly mobile and are likely to only be in the vicinity of dredging operations for a short period of time. Although bottlenose dolphins are common in the study area, the USACE has never documented a direct effect on bottlenose dolphins from dredging activities during its numerous dredging projects throughout the United States; therefore, an Incidental Harassment Authorization in accordance with the MMPA is not anticipated for this project. In the April 25, 2005, notice in the Federal Register (70 FR 21174) for the issuance of an Incidental Harassment Authorization for blasting at the Port of Miami, NMFS concluded, “According to the Corps, bottlenose dolphins and other marine mammals have not been documented as being directly affected by dredging activities and, therefore, the USACE does not anticipate any incidental harassment of bottlenose dolphins. NMFS concurs”.

On the basis of (1) the predicted noise effect thresholds noted by Richardson et al. (1995) presented in Section 2.4.19, (2) the background noise that already exists in the marine environment (approximately 120 dB), and (3) the ability of marine mammals to move away from the immediate noise source, noise generated by bucket, cutterhead, and hopper dredge activities would not be expected to affect the migration, nursing/breeding, feeding/sheltering or communication of marine mammals. Although behavioral effects are possible (i.e., a whale changing course to move away from a vessel), the number and frequency of vessels present in a given project area would be small, and any behavioral impacts would be expected to be minor. The dredging operations for the proposed project would not take place in every area of the channel at one time. While multiple dredges may be used at any given time, they would operate at distances that allow enough space for the movement of marine mammals and other species around the vessels. Furthermore, for hopper dredging activities, endangered species observers would be on board and would record all large whale sightings and note any potential behavioral impacts. In light of the factors listed, the proposed project is not expected to result in more than minimal and temporary adverse impacts to marine life as a result of dredging and dredge equipment noise. Therefore, no additional coordination under the MMPA is anticipated for this project.

5.4.14 Fisheries

Direct impacts from construction are anticipated to be minimal. Motile species can avoid the dredge equipment. However, there would be some entrainment of slow-moving benthic individuals, larvae and eggs (for both fishes and shellfishes) suspended in the water column. When practicable, seasonal “windows” for dredging would be observed to ensure the availability of critical spawning and foraging locations and periods. For the proposed project, the USACE would adhere to a seasonal window at two noted SCDNR identified sciaenid fish species spawning hot spots. These two areas are at “the Grillage” and the base of the Ravenel Bridge.

- The Grillage: From April through September, dredging would not occur within Mt. Pleasant, Rebellion Reach or in the Entrance Channel between the jetties.
- Ravenel Bridge: From April through September, dredging would not occur within Hog Island Reach within a distance of 1000 ft on either side of the Bridge.

Since O&M dredging has been occurring on a regular cycle for many years with no identified adverse impacts to spawning grounds, O&M dredging would not be required to adhere to these seasonal windows, but SCDNR and NMFS would be notified of the dredging prior to commencement of work. It should also be noted that these areas were identified as spawning "hot spots" in the existing condition of the Harbor, which consists of yearly O&M dredging. Therefore, continued O&M dredging will not contribute to any additional adverse impacts. In order to determine the long term affects of the alternatives, the USACE investigated potential impacts to several fish species using habitat suitability index (HSI) model outputs and SCDNR fishery data. Species used in analyses included Atlantic and shortnose sturgeon (discussed in Section 5.4.12.2), red drum (*Sciaenops ocellatus*), striped bass (*Morone saxatilis*), blueback herring (*Alosa aestivalis*), and southern flounder (*Paralichthys lethostigma*). These species are representative of important families of fishes in the project area, and their respective life-history phases and behaviors require/use various niches within the inshore ecosystem. Impacts determined for these species (by modeling future habitat suitability based on anticipated physical habitat change in salinity, water depth, DO, etc. and comparing to existing actual use by species) may also occur to other similar species in the estuary. The USACE concluded the following in relation to potential impacts to these fishes from the proposed project:

1. For larval and juvenile red drum, there are many areas where habitat may *benefit* due to the proposed project. Many of these locations involve sites without species presence data. However, some of these habitats are located at or near locations where the species has been previously captured.
2. Due to the proposed project, habitat suitability was predicted to *increase* for adult and juvenile striped bass at one location (comprising approximately a dozen model cells). The site/area did not correspond to a known capture site. Future-with-project conditions in approximately two-dozen model cells indicated decreases in striped bass spawning habitat suitability. No adult or juvenile bass were captured in the vicinity of those cells during two SCDNR sampling programs.
3. Inconsequential amounts of habitat critical for juvenile blueback herring would be adversely affected by the proposed project.
4. The proposed project may result in extremely slight adverse changes in southern flounder habitat for several areas, including some areas where the species was captured. However, there are no anticipated habitat changes for most/numerous locations where the species was captured.

Many of the above conclusions were in part based on EFDC model predictions that future with-project conditions would involve very small changes to various water quality parameters when compared to future without project conditions. These minor changes may result in positive and/or negative alterations to water temperature, salinity, DO, and/or velocity (or no alterations in some cases). Subsequently, changes in these parameters affect modeled habitat suitability for various life-history phases and behaviors of studied fishes according to dredge depth (i.e., alternative). The modeled changes are likely smaller than the year-to-year variation in salinity zones, DO, temperature, etc. No habitats are anticipated to be adversely affected on a widespread basis throughout the project area due to the proposed project. Typically, the proposed project was predicted to affect habitat suitability in isolated model cells or in a small cluster of adjacent cells (resulting in the findings noted in the bullet list above). A detailed description of the HSI modeling and results can be found in Appendix K.

5.4.15 Birds

As discussed in Section 2.4.15, a very large and diverse bird community exists in the Charleston Harbor area. The USACE does not anticipate that avian species, including shorebirds, seabirds, and migratory birds, would be adversely (directly or indirectly) affected by the proposed project. The proposed project would cause only temporary impacts to the bird community as individuals avoid active construction areas due to noise and general activity. Since dredging would occur in open and deep water, impacts to the bird community are expected to be temporary and minor. Placement of dredged material within the upland disposal areas may displace individuals using the sites for foraging and resting.

The shoreline impacts assessment (Appendix A, Section 2.5) indicated that shorelines used by birds within the Harbor would not be eroded any more in the future-with-project condition (proposed project) than in the without-project-condition. Moreover, the proposed project includes the option for possible beneficial uses to mitigate inshore shoreline losses and increase available nesting areas for beach-nesting species. The USACE would continue to operate its agreement with the Town of Folly Beach regarding any losses of coastal (i.e. on the ocean-side of the barrier islands) material due to downdrift sand shortages (due to interference from the jetties and Entrance Channel) in cooperation with the local sponsor. Both harbor and coastal beaches are important nesting, foraging, and loafing/roosting habitats for migratory birds. USACE is committed to monitoring the assumptions of the project to ensure that additional impacts to natural and historic resources in the harbor are not incurred.

5.4.16 Invasive Species

As mentioned in Section 2.4.16, the major known pathways for non-native species to enter South Carolina are stocking (42%), aquarium releases (13%), shipping (10%), and bait releases (9%) (SCDNR 2008). Of these, commercial shipping is the only direct mechanism related to this project. SCDNR (2008) states that, “the principal way that aquatic invasive species can enter state waters through shipping is by the discharge of ballast water while vessels are in port. Ballast water is pumped into the hull of a vessel to help stabilize the vessel and keep it upright while carrying cargo. This water can be discharged at the receiving port as the cargo is loaded or unloaded. Each vessel may take on and discharge millions of gallons of water. Ballast water taken on in foreign ports may include an abundance of aquatic plants, animals, and pathogens not native to South Carolina. If discharged into state waters, these foreign species may become problematic.

In addition to ballast water discharge, another important source for the introduction of nonindigenous organisms is the fouling community that grows on the hull, rudder, propellers, anchor, anchor chain, or any other submerged structure of vessels that are not properly cleaned or maintained. Historically, such fouling communities were composed of massive layers of a variety of organisms, both attached and merely entrained in or living on that growth. Although such extensive growth is not as common on seagoing vessels in recent times, it still provides an opportunity for worldwide transport of fouling organisms, particularly on towed barges and other structures like mothballed vessels and exploratory drilling platforms. Recent invasions by a number of coastal invasive species offer evidence that hull fouling remains a viable pathway for non-indigenous introductions.

Similar to the FWOP condition, recent federal regulations require the shipping industry to implement better control of the invasive species introduction pathway through the ballasts of vessels (US Coast Guard, 2012). These new regulations should decrease the rate at which invasive species are introduced to the study area. Project economics show that the No Action Alternative would actually result in a greater increase in the number of vessels anticipated to call on the Port of Charleston. The proposed project would result in fewer vessels than what is anticipated in the No Action Alternative, which should reduce the potential for the introduction of invasive species.

5.4.17 Air Quality

Air impacts resulting from Criteria Pollutants, hazardous air pollutants (HABs), and greenhouse gases were evaluated. The US Environmental Protection Agency's (EPA's) "Current Methodologies in Preparing Mobile Source Port-Related Emission Inventories, Final Report, dated April 2009 provided the framework to determine all air emissions for the study. The detailed air emissions inventory and analysis is presented in the Air Quality Appendix (Appendix N). The results are summarized in this section.

Appendix N notes that any impacts to air quality resulting from construction activities would be temporary and that the total increases in temporary air pollutants would be relatively minor to the existing point- and mobile-source emissions in the tri-county area. The proposed action would result in fewer vessels making calls on the port, which, in combination with more efficient vessels and cleaner fuels has been determined to decrease the total amount of air pollution resulting from vessels and cargo handling equipment when compared to the future without project (no action) alternative. Table 5-11 shows the summary of all terminal emissions for the proposed project (52/48-foot depth).

Table 5-11. Summary of all terminal emissions for the proposed project (52/48)

ALTERNATIVE	YEAR	TERMINALS	NOx	CO	HC	PM10	PM2.5	SO2	CO2
52/48	2022	North Charleston	546.43	199.81	30.20	22.75	21.89	13.55	17,882.22
	2027	North Charleston	605.64	231.01	35.30	26.39	25.39	16.24	21,650.30
	2032	North Charleston	661.89	261.71	40.22	29.95	28.81	18.73	25,102.70
	2037	North Charleston	723.47	277.06	43.58	32.57	31.33	19.77	26,727.03
	2022	Navy/Veterans	458.62	170.83	28.54	16.97	16.22	20.13	29,129.73
	2027	Navy/Veterans	457.89	197.88	33.44	19.78	18.91	23.83	34,620.33
	2032	Navy/Veterans	460.90	224.47	38.17	22.52	21.52	27.35	39,824.07
	2037	Navy/Veterans	500.56	235.81	41.38	24.33	23.24	29.45	43,265.57
	2022	Columbus Street and Union Pier	72.52	9.65	3.36	1.59	1.51	3.39	5,574.44
	2027	Columbus Street and Union Pier	52.42	9.77	3.38	1.61	1.53	3.39	5,574.44
	2032	Columbus Street and Union Pier	39.62	9.88	3.40	1.63	1.55	3.39	5,574.44
	2037	Columbus Street and Union Pier	40.09	10.00	3.42	1.65	1.57	3.39	5,574.44
	2022	Wando Welch	961.06	306.34	49.84	39.67	38.28	17.87	24,281.33
	2027	Wando Welch	1,054.94	353.36	57.88	45.82	44.21	21.25	29,078.52
	2032	Wando Welch	1,152.70	400.71	66.04	52.03	50.19	24.75	34,087.34
	2037	Wando Welch	1,271.57	432.24	72.47	57.22	55.20	26.62	36,968.04

Comparing Figures 5-15 and 5-16, it is apparent that the No-Action (45/45 foot depth) emissions (in tons/year) are greater than the proposed project (52/48 foot-depth) emissions for all criteria pollutants and greenhouse gases (CO_2). Air emissions (including criteria pollutants, air toxics and greenhouse gases) and vessel traffic would not be increased as a result of the proposed deepening. Therefore, the proposed harbor deepening would have no significant adverse impacts on the air quality of the Port of Charleston. If the Port of Charleston is not deepened (or remains at the existing 45-foot depth), the overall terminal emissions would be greater than if the port is deepened to the 52/48-foot depth (proposed project). No increase in emissions over the No Action Alternative is expected, overall, or at any of the individual terminals within Charleston Harbor.

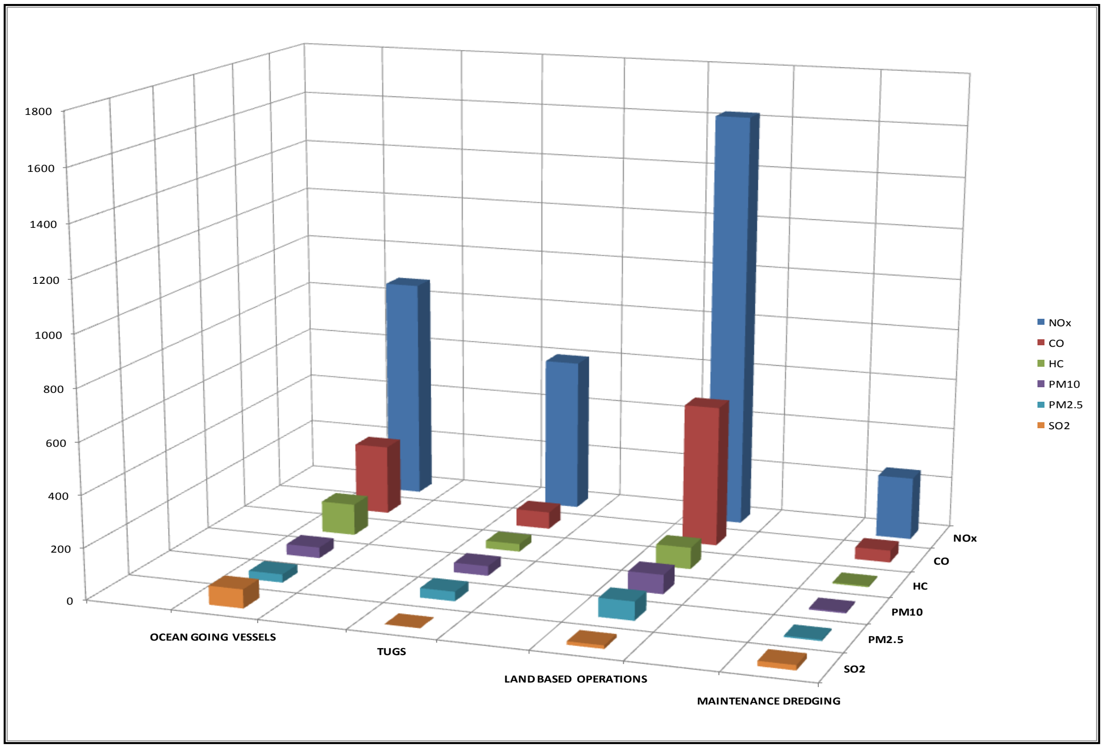


Figure 5-15. 2037 air emissions for the No Action Alternative (all units in tons/year)

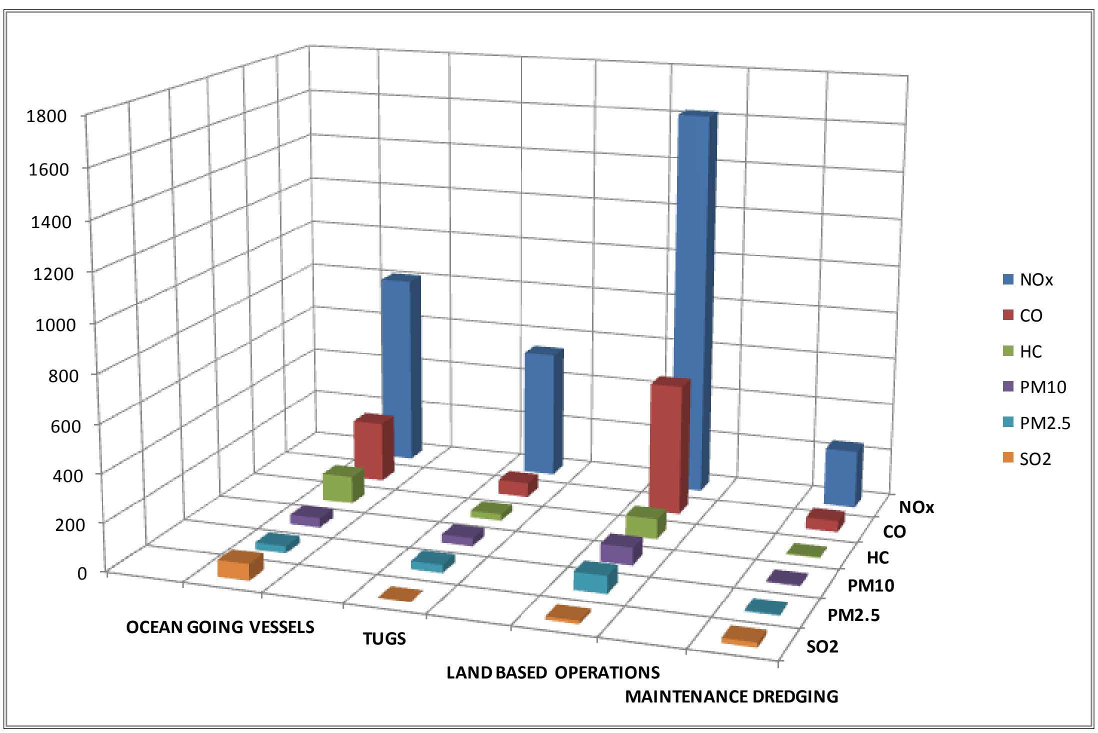


Figure 5-16. 2037 air emissions for proposed project (all units in tons/year)

The proposed project has been analyzed for conformity applicability pursuant to regulations implementing Section 176(c) of the Clean Air Act. It has been determined that the activities proposed under this proposed project would not exceed *de minimis* (a level of risk to small to be concerned with) levels of direct or indirect emissions of a criteria pollutant or its precursors and are exempted by 40 CFR Part 93.153. For these reasons a conformity determination is not required for this proposed project.

5.4.18 Hazardous, Toxic, and Radioactive Waste

Based upon the dredging history of the Charleston Harbor Federal Navigation Channel, the proposed project is not expected to encounter HTRW. Neither the channel(s) nor the disposal sites would be affected by HTRW during dredging/disposal operations. The proposed project would not change or affect the ability for federal regulations, U.S. Customs, and Port Security to continue to address the transportation of any HTRW.

5.4.19 Noise

5.4.19.1 Impacts of Dredging Noise on Marine Life

Reine et al (2012) found that the majority of underwater sounds produced by hydraulic cutterhead dredging operations were of relatively low frequency (< 1000 Hz). Their study was conducted during rock fragmentation and therefore represented a worst case scenario. The source level was estimated to be between 170 and 175 dB re 1uPa @1m. These sound levels decreased with increasing distance from the source. The authors determined that the area of influence was limited to less than 100 m from the source. At 100 m received levels were less than 150 dB re 1 uPa rms. While NMFS is currently developing guidelines for determining sound pressure level thresholds for fish and marine mammals, based on existing studies, the NMFS current thresholds for determining impacts to marine mammals is between 180 and 190 dB re 1 uPa for potential injury to cetaceans and pinnipeds respectively, and 160 dB re 1 uPa for behavioral disturbance/harassment from an impulsive noise source, and 120 dB re 1 uPa from a continuous source. Reine et al (2012) found that the 120 dB re 1uPa proposed threshold was exceeded by ambient noises in their study area. Based on reviews by Popper et al (2006) and Southall et al (2007) it is unlikely that underwater sound from conventional dredging operations can cause physical injury to fish species. Some temporary loss of hearing could occur if fishes remain in the immediate vicinity of the dredge for lengthy durations, although the risk of this outcome is low (CEDA 2011). Fish would likely respond to dredging by using avoidance techniques. Avoidance is defined as an effect that causes fish to not occupy an area that is periodically or infrequently occupied. Dredging is likely to cause avoidance due to noise (and increased suspended sediments and other temporary water quality changes).

NMFS interim criterion for physical injury to fish is 206 dB peak, regardless of fish size. However, dredging operations would likely cause the temporary displacement of fish species as a behavioral response to the noise. This would not likely have an effect on populations of fish as they would be able to use areas outside of the navigation channel to traverse to and from spawning and feeding grounds.

The sediment within Charleston Harbor is predominantly sand/silt/mud mixture, with the exception of soft rock in portions of the Entrance Channel. According to the Clarke et al (2002), the peak amplitude for the bucket hitting the rocky, gravel, cobble bottom at Cook Inlet, Alaska was about 120 dB. Both Doug Clarke and Charles Dickerson, US Army ERDC, stated that this peak amplitude of the bucket hitting sand/silt/mud substrate would be significantly less than 120 dB. Since the substrate composition of Charleston Harbors is predominantly sand/silt/clay material, it is reasonable to assume that the Charleston Harbor dredging would have a similar sound level.

5.4.19.2 Impact of dredging noise on the human environment

Maintenance dredging and periodic new work dredging has occurred in Charleston Harbor for over 100 years. For continued maintenance dredging, the dredging equipment is usually present in the Harbor on a 12 to 18-month frequency and that frequency is not expected to change with the proposed project. While there would be an increase in the ambient noise level during the dredging phase of the project, the source of noise is at a distance far enough away from any sensitive receptors that no impact is anticipated. The closest the dredging would be to any sensitive receptors would be along the Cooper River portion of the channel. Most of these communities are buffered from the river by the old Naval Base. Since dredging does not occur in one position for any extended period of time, there will be no disproportionate adverse impact on any communities. Noise generated by this project would not be substantially different from other ambient noise levels of a typical harbor.

5.4.19.3 Impact of underwater noise from vessel traffic

Most vessels produce low frequency sound (below 1 kHz) from onboard machinery, hydrodynamic flow around the hull, and from propeller cavitations. This frequency relates to vessel size, speed, load, condition, age, and engine type. Low frequency sound can travel hundreds of miles and can increase ambient noise in large areas of the ocean. Additionally, Okeanos (2008) showed that shipping noise does not exceed 100 dB. The economic assessment from this project has determined that the number of vessels transiting in and out of Charleston Harbor would decrease as a result of the proposed project and that the same number of larger vessels would call on the Harbor regardless of channel depth. The difference being that with a deeper channel, the larger vessels can fully load their cargo and be unrestricted by tide. Without the project, a greater number of vessels would be required to deliver the same amount of commercial containers which would have a greater impact on marine noise. While it is true that the number of vessels would increase in the future and therefore, potential for increased sound production would increase, the rate of increase would be less in the future if larger vessels can fully load their cargo when calling on Charleston Harbor. As a result of this, no adverse impact is anticipated from underwater noise resulting from vessel activity as a result of deepening the Harbor.

5.4.19.4 Indirect impact of noise from port operations as a result of deepening the Harbor

Noise from ports can come from port services and facilities, cranes, cargo handling equipment, warehousing, vessel repair or maintenance, engine noise from vessels at berth. The proposed project would not cause an increase in the number of containers anticipated to arrive in the Port of Charleston. Therefore, there would be no increase in the amount of truck traffic from the various port terminals. The only change would be in the timing of vessel unloading and container movements. In light of these factors, the proposed Harbor deepening is not expected to result in adverse noise impacts as a result of port operations.

5.4.20 Coastal Barrier Resources

The proposed project would not affect the Morris Island CBRA Unit located to the south of the channel. As per 16 U.S.C. § 3505(a), the following exemption criteria is met: “the maintenance or construction of improvements of existing federal navigation channels (including the Intracoastal Waterway) and related structures (such as jetties), including the disposal of dredge materials related to such maintenance or construction.” One possible beneficial use of dredged material is the nearshore placement of material off of Morris Island. This action would not violate CBRA either, as it would not induce development on Morris Island. Morris Island is predominantly a disposal area for dredged material and the rest of it is protected land. The nearshore placement of dredged material off Morris Island is generally favorable to the US Fish and Wildlife Service.

5.4.21 Cultural and Historic Resources

Analysis of potential impacts to historic and cultural resources considered both direct and indirect effects (see Section 2.4.21). Direct effects may result from physically altering, damaging, or destroying all or part of a historic or cultural property, or changing the character of physical features within the property's setting that contribute to its historic significance. An effects analysis focuses on the characteristics of a historic property that qualify it for inclusion in the National Register, and assesses the potential to alter historically significant characteristics and diminish the integrity of a historic property. There may also be cultural resources of value which are not eligible for inclusion in the National Register. The area of potential affects (APE) for direct affects was defined as being within 75 meters of the toe of the navigation channel (Figure 2-43). Indirect effects are reasonably foreseeable effects caused by an undertaking that may occur later in time, be farther removed in distance or be cumulative. In the case of harbor deepening, indirect effects would include those that may occur as a result of a change in the wave action or currents in the vicinity of the resource due to dredging and construction, as well as a result of wakes from the number and size of vessels entering the Harbor. The APE for indirect affects is defined as shorelines of Charleston Harbor and adjacent properties within the viewshed of Charleston Harbor (Figure 2-43).

In consultation with the South Carolina Department of Archives and History and the South Carolina Institute for Archaeology and Anthropology (SCIAA), a background investigation and a remote sensing survey was conducted for the proposed project. While background research revealed numerous shipwrecks within the project vicinity, no previously identified historic or prehistoric resources were located within the area of potential effects (APE) (Gayes et al. 2013). A total of 421 magnetic and acoustic anomalies were identified by Coastal Carolina University during a Phase 1 survey conducted during the fall and winter of 2012 and 2013 (Gayes et al. 2013, Appendix M). Of this total, three targets (LH1-001, LH1-009, and LH5-013) with magnetic and acoustic signatures were recommended for additional investigation to determine historical significance (Figure 5-17).

Figure 5-17. General location of Charleston Harbor anomalies found for the Post 45 study

A magnetometer, sidescan sonar, and subbottom profiler refinement survey and diver investigation was conducted in September 2013 to assess the three anomalies. Targets LH1-009 and LH5-013 were determined to be modern debris with no historical significance (Figures 5-18 and 5-19). In fact a close up review of a portion of the anomaly LH5-013 reveals what appears to be a section of the old bridge bent cribbing (Figure 5-20). Investigation of target LH1-001 revealed a large buried anomaly with no acoustic signature (Figure 5-21). The anomaly appears to represent a small, ferromagnetic object such as dredge cable with the main magnetic area outside of the APE (Pan American Consultants, Inc. 2013). Extensive hydroprobing failed to locate the source of the anomaly's magnetic signature indicating it is too small or buried too deep to locate through probing (Pan American Consultants, Inc. 2013). However, given the anomaly was not contacted through subbottom profiling or probing, the investigator recommended an archaeologist monitor dredge operations in the vicinity of the anomaly (Pan American Consultants, Inc. 2013). By letter dated October 3, 2013, the SCIAA concurred with the findings and recommendations and had no objections to dredging operations associated with the proposed Charleston Harbor Post 45 study (Appendix Q).

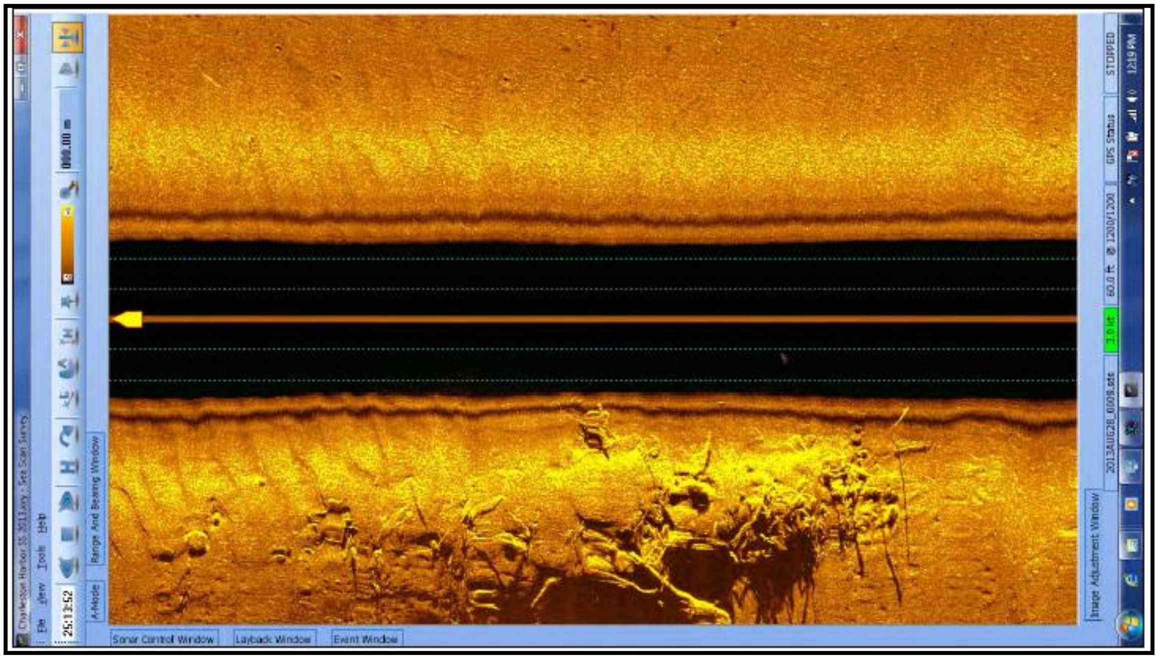


Figure 5-18. Side scan image of target LH1-009

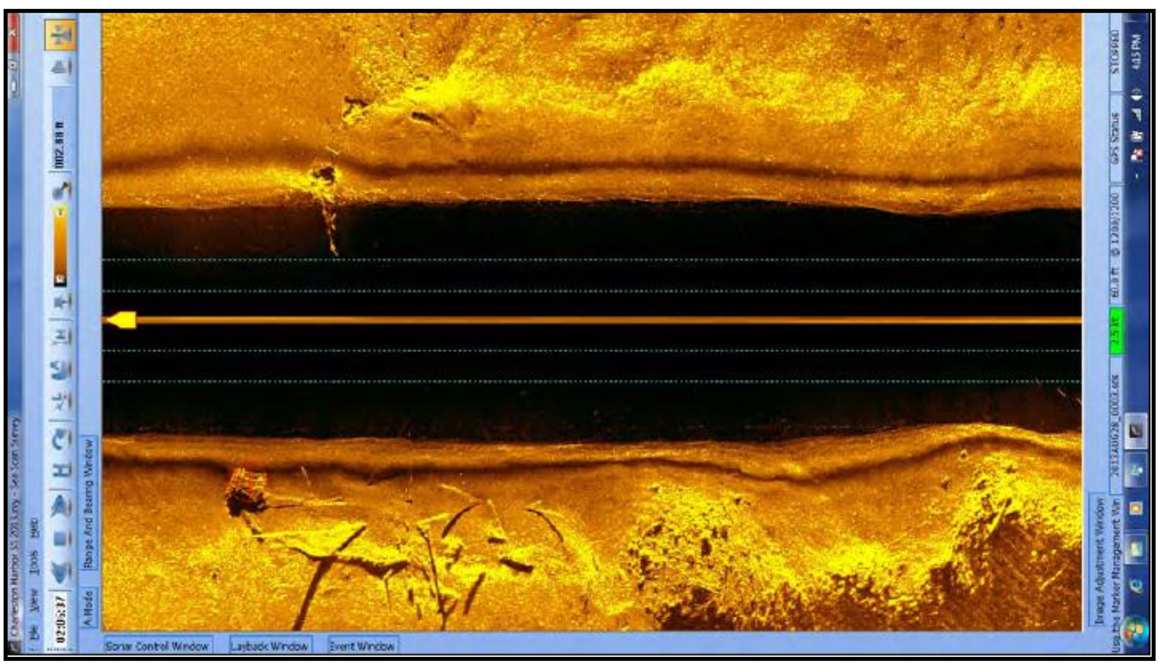


Figure 5-19. Side scan image of LH5-013

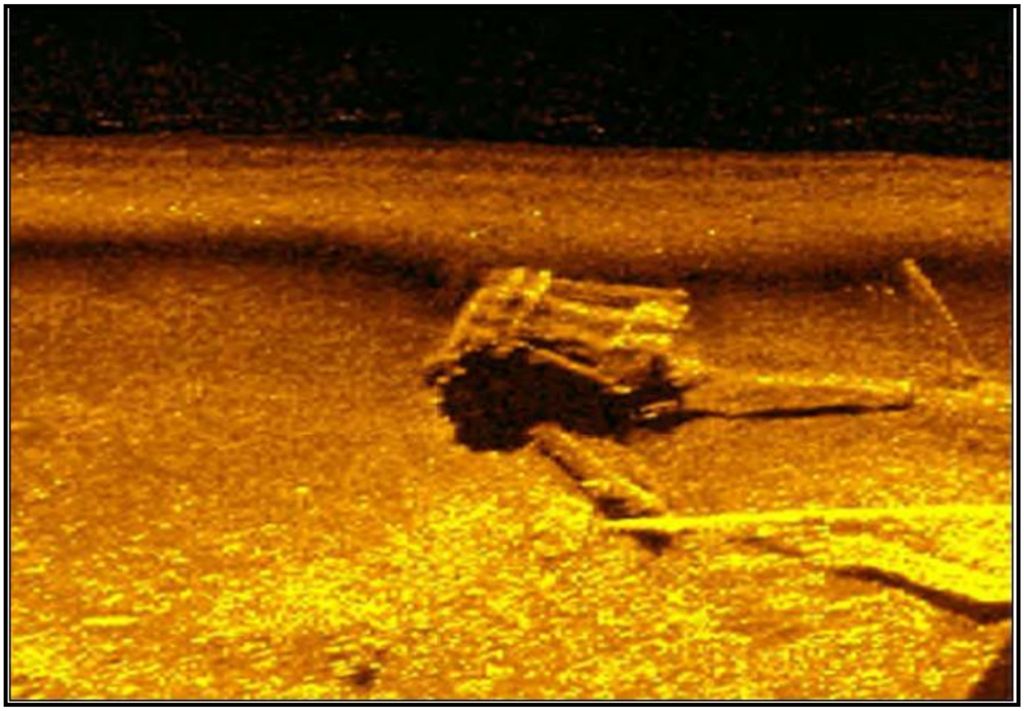


Figure 5-20. Close up side scan image of LH5-013. Reveals old bridge bent cribbing

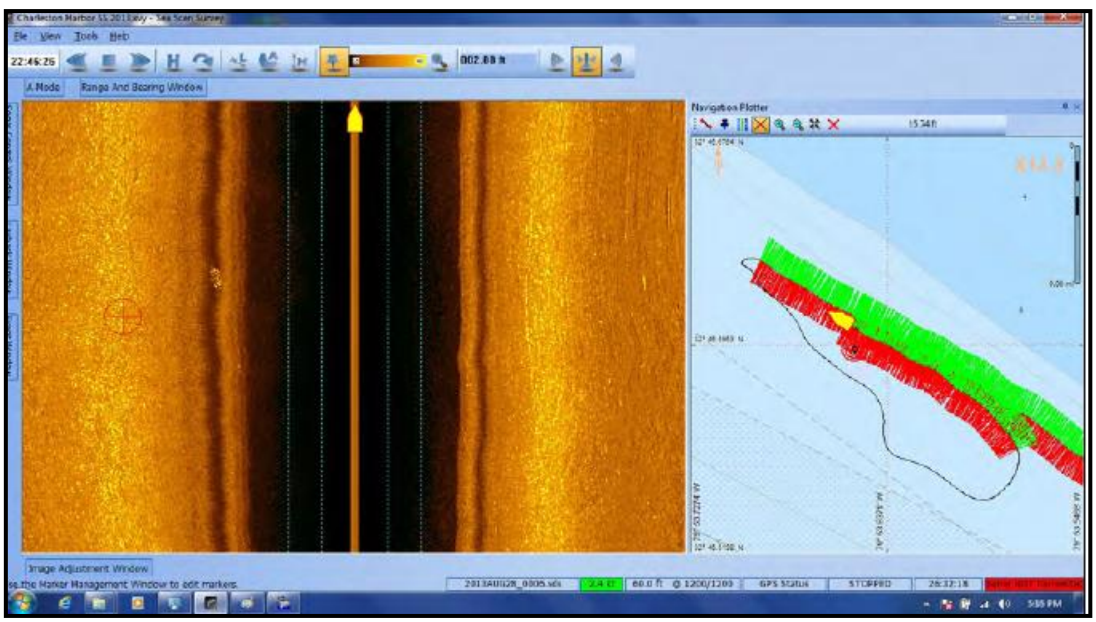


Figure 5-21. Side scan image of LH1-009 revealing no surface debris and thus potentially a buried artifact

Submerged prehistoric sites have been successfully located by applying the techniques used on terrestrial sites through remote sensing, bathymetry, and archaeological transect surveys. Successful practices include locating ridges in the landscape that overlook less elevated areas, and identifying nearby drowned resources such as potential water sources including springs and streams. Contour maps developed through underwater bathymetry provide the same type of information that is reviewed on land, and seeking these sites, even when submerged, can provide deposits of artifacts that may be identified as part of the same assemblage, even if stratigraphic coherence is sometimes obscured (Ruppé 1979).

No areas within the project area contain such geological markers, and with the current state of technology, it is extremely difficult to actively locate skin or wooden watercraft such as those that are known to have been used by native inhabitants of the Carolina coast, perhaps as early as 8000 years before present, which is the date of the oldest known logboats in North America (Leshikar 1988). It is also not yet possible to use remote sensing devices operated from a boat to detect the types of small scatters of small artifacts often associated with inorganic site components such as ceramic sherds and stone tools or weapons. Nonetheless, such artifacts are known to exist on the harbor bottom, in secondary deposition, though no specific sites or artifacts of cultural significance within Charleston Harbor have been brought to the attention of professional archaeologists (Albright 1980; Harris et al. 1993). Prehistoric sites were considered as possible cultural resources in the harbor, but were not actively sought out since characteristic geological features are not present and there are no reports of in situ prehistoric finds (Gayes et al., 2013).

As a result of this study, the Charleston District has determined that there would be no direct impact to any cultural/historic/prehistoric resource as a result of any of the project alternatives. In order to comply with the recommendation made by PanAmerican, SHPO, and SCIAA, the USACE would ensure that an archaeologist monitor the dredging in the vicinity of LH1-001, which is still about 150 feet outside the footprint of both the 52/48 and the 52/47 alternatives (Figure 5-22). In the event of an inadvertent discovery during the proposed project implementation, all work would cease in the immediate area. The USACE would be notified immediately and work would not continue within the area of the finding until examination and consultation by both the USACE and SHPO is complete.

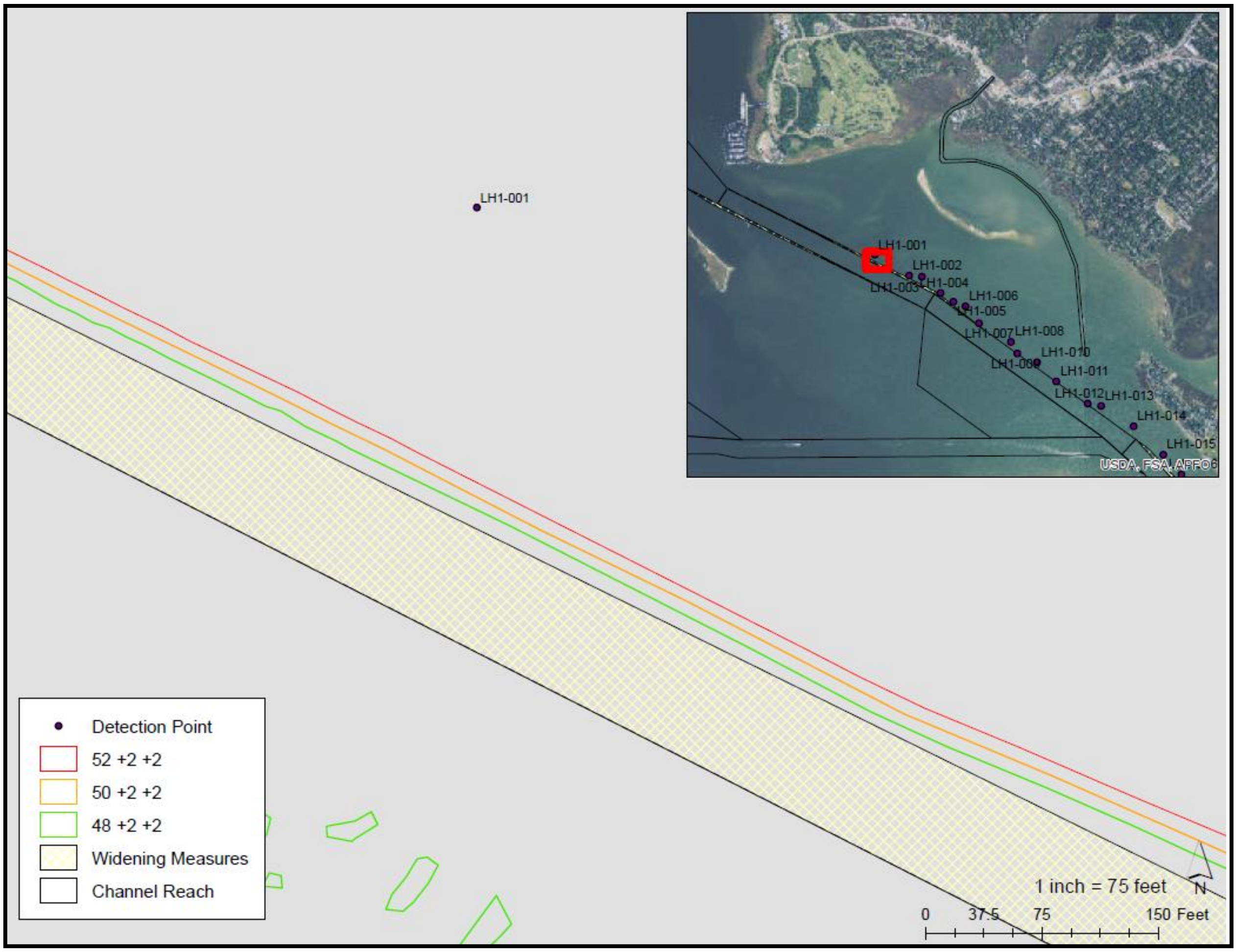


Figure 5-22. Approximate location of target LH1-001 compared to the existing Navigation Channel and the engineered top of slope

Many of the historic resources along the shoreline of the harbor are impacted by wave energy in the harbor and are therefore included in the APE (Section 2.4.21). This energy is comprised of wind waves, tidal energy, commercial and recreational boat wakes, etc. While each of the project alternatives would result in the ability for vessels to draft deeper water, the ability to do so would result in fewer vessels calling on Charleston Harbor than the without project condition/No Action Alternative. The larger vessels would generate larger wakes; however, since the ships would not be constrained to arrival only at high tide, the effect of the wakes would be less than the without project condition. Because of this, it has been determined that all of the deepening alternatives would generally result in lower impacts to shorelines, and no adverse shoreline impacts to Fort Sumter, Castle Pinckney, Patriots Point, etc (see Appendix A, Engineering, for more details) are anticipated. Although the general conclusions can be supported by the predicted lowering of the total energy imparted to the harbor, coordination with resource agencies identified outstanding concerns related to the ability to reliably predict the results of complex wave and current dynamics at specific locations. Consequently, if the project is constructed, the USACE will implement a monitoring program designed to verify the assumptions and results of analysis and to implement corrective actions should unanticipated adverse effects attributable to the project occur. The monitoring program is part of a programmatic agreement between the USACE, the South Carolina Department of Archives and History (SCDAH), and the National Park Service. The signed agreement is included in Appendix Q and is described further in Section 6 of this report.

Since fewer vessels would be calling on the port with the proposed project and the vessels that do call would be of comparable size (just able to carry more containers), compared to the FWOP/no action, there would be no additional issues related to viewshed concerns from the Charleston or Mount Pleasant Historic Districts. None of the project alternatives would result in a change in the existing use of Charleston Harbor, which is an historic seaport and would continue to remain so. Commercial and recreational vessel traffic patterns, shoreline land uses, and natural resources that define the aesthetic (including noise and visual) characteristics of the harbor would remain subject to the traffic and use trends that would govern the with- and without-project future conditions. Accordingly, the historic resources in or nearby the APE would not be adversely affected by any of the project alternatives.

5.4.22 Aesthetics and Recreation

The proposed project would not change the aesthetic resources of Charleston Harbor, nor the numerous recreational opportunities. Although the definition of aesthetics is fluid (see Section 2.4.22), for the purposes of the present evaluation, the principal aesthetic "targets" include the visual perception of Charleston Harbor's land- and seascapes, historic features, and certain architecture. The degree to which any adverse feature affects aesthetics is frequently based on scale, position, and proximity relative to the viewer. Commercial and recreational vessel traffic patterns, shoreline land uses, and natural resources that define the aesthetic characteristics of the area would not be adversely affected. The economic analysis for this project determined that fewer vessels would call on the port with the proposed project. The same size vessels would call on Charleston Harbor with or without a project; however the larger vessels would be able to load more fully with a project than without. This would reduce the number of container vessels visible within the harbor, Wando and Cooper Rivers, as well as the many parks, cultural resource sites, and natural resource areas in and around the Harbor. One notable change would be an increase in the elevation of the dikes surrounding the upland disposal areas. These changes would occur with or without a project, but would occur sooner to accommodate material from the proposed project. Additionally, if the beneficial use project of placing dredged material on Crab Bank or other options discussed in Section 4, the resource(s) would notably increase in size, but would not contribute to a reduction in the aesthetic appeal of the harbor.

As a public safety measure, boating would be prohibited near the operating construction equipment (and sediment placement locations). Recreational access to these areas would return to pre-construction conditions following completion of the project. Although short-term impacts could occur, no long-term adverse effects are anticipated. Commercial shipping would continue in the federal navigation channel. Information would be provided to the USCG so they could issue a "Notice to Mariners" prior to initiation of construction and for each major change in the construction activities. This would alert public boaters of areas to avoid and the possibility of limited and restricted access. No significant adverse impacts to public safety are expected from the proposed project.

5.4.23 Socioeconomics

The USACE collected and analyzed information to consider the potential impacts of the proposed action on minority and low-income populations, the elderly, and children. The information and analyses presented below demonstrates that the proposed action complies with Executive Orders 12898 and 13045 and would not cause disproportionately high and adverse impacts to minority populations, low-income populations, and sensitive populations such as the elderly, or children.

The USACE specifically sought input from groups, individuals, and elected officials from communities with potential EJ concerns in order to obtain input related to the those concerns. Although no local groups, elected officials, or individuals expressed EJ-related concerns during the scoping or public review processes, the EPA expressed concerns that the deepening project could affect air emissions or truck traffic in a way that adversely and disproportionately impacts low-income or minority communities or sensitive population groups.

Many of the port terminals accessible from the federal navigation channel are along the Charleston Peninsula and along the Cooper River corridor of North Charleston. Within this corridor there are numerous EJ communities as identified in Section 2.4.23. Possible factors that could impact EJ communities include those resulting directly from the construction of the project and the secondary effects that could occur as a result of the navigation channel improvements. These factors include, but are not limited to the following:

- Construction-related impacts
    - Construction equipment through neighborhoods
    - Noise from construction
    - Air emissions from construction
    - Affects to subsistence fishermen
    - Increasing exposure to contaminants
    - Decreasing water quality
    - Effects from sediment disposal
- Possible impacts resulting from navigation improvements
    - Changing terminal infrastructure
    - Increased truck traffic resulting from an increase in cargo
    - Increased emissions resulting from an increase in cargo and subsequent effects
    - Increasing exposure to contaminants
    - Decreasing water quality
    - Effects from sediment disposal
    - Affects to subsistence fishing

5.4.23.1 Construction Related Impacts

The proposed action consists almost entirely of the deepening and widening of existing navigation channels and berthing and maneuvering areas used by large container vessels. As such, the construction and operational activities are almost entirely limited to the existing water-based navigation system and some of the existing upland sediment disposal sites that are located near industrial and port-related facilities. The construction and operational work areas are located far from residential communities, schools, and hospitals; therefore, impacts from noise, air, and other inconveniences would not significantly impact identified communities. Compared to most large land-based projects, there is little potential for direct adverse impacts to minority populations, low-income populations, the elderly, or children. As indicated in previous sections of this document, during construction there would be temporary and minor impacts resulting from increase turbidity (decreased water quality) from dredges in and around the construction zone. These impacts would be most strongly noticed at the site of the construction and would dissipate away from the dredge depending on the tidal direction. Since the dredge will not be operating in one area for more than a few days, these impacts will be temporary and minor and will not disproportionately impact low-income, minority, juvenile, or elderly populations. Additionally, the potential exists for subsistence fishing within the harbor and Cooper and Wando Rivers; however these practices will not be significantly impacted by the proposed project due to the impacts being temporary and minor in nature. No significant impacts to fish populations are expected to result from the construction of the project. Lastly, since the disposal of sediments will occur within existing dredge material disposal facilities (Clouter Creek, Daniel Island and Yellow House Creek) or at the ODMDS, there will be no affects to any EJ communities from the disposal of dredged material from this project. In summary, there will be no disproportionately high and adverse impact on low-income, minority, juvenile, or elderly populations resulting from the construction of the project.

5.4.23.2 Impacts Resulting from Navigation Improvements

As reported in Appendix C (Economics), the proposed harbor deepening would not increase the number of containers moving through the port in a given year. Although an increase in the number of containers moving through the port is expected, that increase is expected to occur in the without project condition independent of a harbor deepening project. The Port is expected to reach its landside cargo handling capacity of 4.2 million TEUs per year by 2037. Recent port expansion projects constructed to meet the expected demand evaluated the potential impacts of those projects and included appropriate mitigation for unavoidable adverse impacts, including impacts to EJ communities. federal participation in the proposed action is justified by efficiencies that would result from the use of a smaller number of larger, newer, and more efficient vessels. Those efficiencies are expected to save over $100M per year in cargo transportation costs. No increase in the amount of cargo moved through the port would result from the harbor deepening. Instead the project would simply increase the efficiency and safety related to the transportation of the existing and projected cargo volumes. As a result, the project would not affect the number of containers that move through the areas and EJ communities that surround the port. With the proposed harbor deepening project, the total number of vessels needed to transport the forecasted cargo volumes would decrease, compared to the without project conditions, as individual vessels would be able to load more cargo with a deeper navigation channel. Regardless, vessel related noise and vessel traffic within the navigation channels have little noticeable landside impacts away from industrial facilities.

Effects from changing landside cargo handling practices, and specifically effects to regional and local air quality was a concern generated during the public review of the Draft IFR/EIS. Since large vessel access to the port terminals will not be restricted to times with high tides, some of the non-monetary benefits of the proposed action include reduced and less concentrated air emissions, noise, and vessel traffic. Additionally, since the number of containers per year is not predicted to increase as a result of deepening, no landside increases in emissions would occur as a result of the deepening. Under the with-project condition, the USACE predicts a reduction in the number of vessels used to transport containers each year. As a result, total air emissions within the harbor and at each terminal would decrease in a given year as a result of harbor deepening. Additionally, since there would be an overall decrease in emissions (including air toxics), no National Ambient Air Quality Standards (NAAQS) violations would result from the proposed project. Therefore, a risk-based assessment of the health effects associated with the proposed action is not warranted. Any adverse effects resulting from the presently permitted air emissions would be reduced if the harbor is deepened because of the reduction in the number of vessels as well as a shift to more modern and more efficient vessels. Additionally, when compared to the without-project conditions, the proposed project would have positive impacts resulting from reduced and less concentrated air emissions. Larger vessels would be able to enter the harbor and off load at any time. Current conditions and the without project conditions require large vessels to wait until high tide to enter the harbor to load and offload containers, thereby creating a large influx of vessel traffic during high tides. Construction of the proposed project would not induce additional growth, including additional traffic, noise, or lighting. Considering all effects to air quality together, the proposed action would benefit the general area and minority populations, low-income populations, the elderly, and children by lowering emissions, increasing safety, flexibility and operational efficiency and allowing newer, larger, and more modern vessels to replace older, smaller and less efficient vessels.

Additional environmental impacts of the project include the long term but minor reduction in dissolved oxygen, minor changes in fish habitat (both positive and negative), conversion of freshwater wetland community structure, etc. Modeling data indicates that the long term affects to fish habitat are spread out throughout the harbor and will not disproportionately affect any area outside of the navigation channel. The largest changes to water quality are associated with portions of the navigation channel nearest the navigation channels and turning basins around port terminals. Since use of these areas by subsistence fishermen is likely minimal, there will be no disproportionately adverse impacts to any user of the harbor and its tributaries.

Schools/childcare facilities and hospitals are dispersed throughout the area and are not disproportionately located near the harbor, so disproportionate impacts to children are not expected. The data indicates that while some communities within this area meet environmental justice criteria, there is a diversity of communities situated within the area immediately surrounding or adjacent to the channels to be deepened. Although four of the six major port terminals are located near EJ communities, the prevailing winds are from the southwest and generally move pollutants emitted from the navigation channel and port facilities away from the EJ communities and towards non-EJ communities. An analysis of the relative growth in air emissions at individual terminals shows that the growth rates across the container terminals would be similar. In general when the predicted initial and long term growth rates are considered over the period of analysis, there is no meaningful difference in the predicted relative growth rates of the terminals and they all are predicted to reach capacity around 2037. In summary, there would be no disproportionately high and adverse impact on low-income, minority, juvenile, or elderly populations resulting from any secondary changes from the navigation improvements of the proposed project.

5.4.23.3 Summary of Project Effects on Environmental Justice Populations and Children

When considered as a whole, the area immediately surrounding or adjacent to Charleston Harbor does not contain disproportionate populations of minority, juvenile, elderly, or low-income communities. As discussed above, construction of the proposed project and changes resulting from the navigation improvements would not have a disproportionately high and adverse impact on low-income, minority, juvenile, or elderly populations. The proposed project would not (a) exclude persons from participation in, (b) deny persons the benefits of, or (c) subject persons to discrimination because of their race, color, or national origin, nor would the proposed action adversely impact "subsistence consumption of fish and wildlife." Therefore, the project is in compliance with this Executive Order 12898, Environmental Justice.

5.4.23.4 Public Engagement during Construction

An important component of any project is informing the public at all stages of the project (i.e., planning, design, construction, and maintenance). USACE engaged in many public outreach efforts through the media and public information meetings during the feasibility phase (planning phase). Additionally, as stated earlier, personal letters were mailed to communities, churches, and other groups (including EJ communities) within the North Charleston area. In an effort to engage local communities and inform interested persons of the construction of the project USACE will commit to initiating a number of outreach strategies. First, USACE will hold a public meeting in the North Charleston area to present information on the project, the design phase, the construction phase, and future operations and maintenance. Then, USACE will develop a public website with an interactive GIS viewer to allow interested persons to view the progress of the project construction. This will allow for an almost real-time depiction of where the project construction is spatially occurring. Finally, USACE will provide a contact information link on the public website for anyone with concerns about, or related to, the project. Depending on the level of local interest, these plans may be modified in the future.

5.4.24 Summary of Cumulative Impacts

The National Environmental Policy Act (NEPA), as implemented by Council on Environmental Quality (CEQ) regulations (40 CFR §§ 1500 -1508) requires federal agencies, including the USACE, to consider cumulative impacts in rendering a decision on a federal action under its jurisdiction. According to 40 CFR § 1508.7, a *cumulative impact* is the impact on the environment that results from the incremental impact of the proposed project when added to other past, present, and reasonably foreseeable future actions regardless of the agency (federal or non-federal) or person that undertakes such other actions; cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time. An inherent part of the cumulative impacts analysis is the uncertainty surrounding actions that have not yet been fully developed. The regulations provide for the inclusion of uncertainties in the Final IFR/EIS analysis, and state that "when an agency is evaluating reasonably foreseeable significant adverse effects on the human environment in an IFR/EIS and there is incomplete or unavailable information, the agency shall always make clear that such information is lacking" (40 CFR Part 1502.22). However, the CEQ has also recognized that "the complexities of cumulative effects problems ensures that even rigorous analyses will contain substantial uncertainties about predicted environmental consequences" (*Considering Cumulative Effects Under the National Environmental Policy Act*, CEQ 1997).

Potential cumulative impacts on many resources were considered as part of this study and are included as an appendix to this Final IFR/EIS (Appendix O). The majority of resources were determined to have little risk of being cumulatively impacted. These included land use, terrestrial natural resources, threatened or endangered species, other fish and wildlife, anadromous fishes, the estuarine water column, certain water quality parameters (turbidity and hazardous and toxic constituents), sediments (hazardous and toxic constituents), coastal barrier resources, harbor shorelines (of properties adjacent to the project), dredged material, air quality, noise, aesthetics, cultural and historic resources, native American resources, environmental justice, and recreation. Those resources determined to have the highest likelihood of being impacted cumulatively impacts to some degree are listed below:

- **Dissolved oxygen**. Because the greatest cumulative impacts are estimated to be 0.14 mg/L, the project will contribute slightly to cumulative effects on dissolved oxygen. However, it is inconclusive whether the future-with-project level is more or less than DO levels prior to development of the watershed (i.e., early 18th century) or during the 18th and 19th century. Furthermore, the results indicate that the cumulative DO impacts resulting from both the point-source pollution discharges into the estuary and the proposed Post 45 project navigation channel expansion will not cause cumulative DO impacts greater than the 0.1 mg/L allowed by DHEC's anti-degradation rule.
- **Salinity**. Salinity will be increased slightly in some parts of the estuary with the proposed action. This may add to cumulative effects. However, it is likely that the new levels of salinity are less than they were historically in the Cooper River due to the modifications of freshwater inflow resulting from the Santee-Cooper lakes. Therefore, whether the project is likely to contribute to cumulative effects on water salinity is not conclusive and depends on which baseline is used for analysis.

- **Essential Fish Habitat: Wetlands**. Some freshwater wetlands will be indirectly affected by slight increases in pore water salinity in some areas. This effect will be compensated through mitigation, and therefore the proposed project may contribute to cumulative effects to freshwater palustrine forested wetlands and tidal freshwater marsh associated with the upper and middle reaches of Ashley and Cooper Rivers. However, given that the harbor and tributaries were historically brackish, whether this constitutes a cumulative impact is based on the time interval used to assess they system.

- **Essential Fish Habitat: Hardbottoms**. Some cumulative effects due to impacting hardbottom habitat would occur due to the proposed project, as expanding the channel during the past 80 years has incrementally affected such habitats. However, the proportion of hardbottom that will be, and has been, affected via dredging is small relative to the hardbottoms available in the region, including artificial reefs and mitigation habitats that are being created in the vicinity. At least as much hardbottom will be produced as will be lost if the proposed project is constructed, in addition to the proposed compensatory mitigation project. Therefore, the contribution of the Proposed Action to cumulative effects on hardbottoms will be minimal.

- **Other Essential Fish Habitats**. Approximately 2.84 acres of shallow sub-tidal habitat comprising two areas. This constitutes a minor contribution to cumulative impacts on this resource type.

- **Sediments**. The total inner harbor (navigation channel and other areas of the harbor within the model domain) shoaling rate is predicted to increase by roughly 50% for proposed project. Hence there is an anticipated contribution to sediment loading cumulative impacts. Based on the average maintenance dredging in the inner harbor between 2004 and 2012, and the predicted changes estimated by the model, proposed project is estimated to increase the inner harbor shoaling rate by approximately 0.7 million cubic yards per year, the majority of which will occur in the navigation channel.

USACE has determined that the net contribution to cumulative adverse impacts due to the proposed project and the overall cumulative adverse impact will be appropriately minimized based on (1) efforts to avoid and minimize the environmental impact of the proposed action, (2) compensatory mitigation actions that will be carried out for the proposed project, and (3) federal and state permitting requirements and mitigation sequencing that will be required for ongoing present and any future actions.

5.4.25 Irreversible and Irretrievable Commitment of Resources

Section 102(2)(c)(ii) of the National Environmental Policy Act (NEPA) requires that an environmental impact statement (EIS) include information on any adverse environmental effects that cannot be avoided, should the proposed action be implemented. An irreversible commitment of resources is one in which the ability to use a resource is lost forever. An irretrievable commitment of resources means that opportunities for other uses are foregone for the period of the proposed action.

Typically, it refers to the use of renewable resources, including human effort, and to other utilization opportunities foregone in favor of the proposed action. In the case of Post 45, examples of such resources include the fossil fuels that would be required to run the equipment to construct the project and the loss of biological resources (entrained fish, invertebrates, reptiles, other aquatic life, including but not limited to threatened and endangered species) that could be incurred during construction. The loss of biological resources during construction would be mainly confined to the immediate construction area (i.e., the navigation channel). This impact is not generally irreversible or irretrievable because recovery of the benthic community would occur after construction. In areas where losses of habitat functions would occur, they would be recovered through mitigation measures. As evidenced by the SCSPA lease to remove sediments from the ODMDS, the removal of sediment from the channel and placement in the ODMDS would not necessarily irreversibly commit those sediment resources. An irretrievable commitment of resources stems from the use of fossil fuels, equipment, man-power, etc that would be incurred during construction. The effect of salinity intrusion on an estimated 324 acres of naturally functioning freshwater wetlands would not be an irreversible or irretrievable commitment of resources because, despite a transition to a community structure consisting of a greater percentage of salt-tolerant vegetation, these wetlands will continue to provide valuable aquatic resource functions and services to the estuary.

6.0 ENVIRONMENTAL COMPLIANCE AND COMMITMENTS

Compliance with the following environmental laws (and implementing regulations) and Executive Orders is required for all alternative channel deepening plans under consideration (note: this is not necessarily an exhaustive list of all applicable environmental requirements).

6.1 Table of Compliance

Relationship of the Proposed Action to Federal Laws and Policies		
Public Laws		
Title of Public Law	**US Code**	**Compliance Status**
Abandoned Shipwreck Act of 1987	43 USC 2101	Full Compliance
American Indian Religious Freedom Act	42 USC 1996	Not Applicable
Agriculture and Food Act (Farmland Protection Act) of 1981	7 USC 4201 et seq.	Not Applicable
American Folk life Preservation Act of 1976, as amended	20 USC 2101	Not Applicable
Anadromous Fish Conservation Act of 1965, As Amended	16 USC 757 a et seq.	Full Compliance
Bald Eagle Act of 1972	16 USC 470	Full Compliance
Clean Air Act of 1972, As Amended	42 USC 7401 et seq.	Full Compliance
Clean Water Act of 1971, As Amended	33 USC 1251 et seq.	Full Compliance
Coastal Barrier Resources Act of 1982	16 USC 3501-3510	Full Compliance
Coastal Zone Management Act of 1972, As Amended	16 USC 1451 et seq.	Full Compliance
Comprehensive Environmental Responses, Compensation and Liability Act of 1980	42 USC 9601	Not Applicable
Conservation of Forest Lands Act of 1960	16 USC580 mn	Not Applicable
Deepwater Port Act of 1974, As Amended	33 USC 1501	Full Compliance
Emergency Flood Control Funds Act of 1955, As Amended	33 USC 701m	Not Applicable
Emergency Wetlands Resources Act	16 USC 3901-3932	Not Applicable
Endangered Species Act of 1973	16 USC 1531	Full Compliance
Estuary Program Act of 1968	16 USC 1221 et seq.	Full Compliance
Farmland Protection Policy Act	7 USC 4201 et seq.	Not Applicable
Federal Environmental Pesticide Act of 1972	7 USC 136 et seq.	Full Compliance
Fish and Wildlife Coordination Act of 1958, As Amended	16 USC 661	Full Compliance
Flood Control Act of 1944, As Amended, Section 4	16 USC 460b	Full Compliance
Flood Security Act of 1985 (Swampbuster)	16 USC 3811 et seq.	Not Applicable
Land and Water Conservation Fund Act of 1965	46 USC 4601	Not Applicable
Magnuson Fishery Conservation and Management Act	16 USC 1801	Full Compliance
Marine Mammal Protection Act of 1972, As Amended	16 USC 1361	Full Compliance
Marine Protection, Research and Sanctuaries Act of 1972	33 USC 1401	Full Compliance
Migratory Bird Conservation Act of 1928, As Amended	16 USC 715	Full Compliance
Migratory Bird Treaty Act of 1918, As Amended	16 USC 703	Full Compliance
National Environmental Policy Act of 1969, As Amended	42 USC 4321 et seq.	Full Compliance
National Historic Preservation Act of 1966, As Amended	16 USC 470	Full Compliance
National Historic Preservation Act Amendments of 1980	16 USC 469a	Full Compliance

Title of Public Law	US Code	Compliance Status
Native American Religious Freedom Act of 1978	42 USC 1996	Not Applicable
Native American Graves Protection and Repatriation Act	25 USC 3001	Not Applicable
National Trails System Act	16 USC 1241	Not Applicable
Noise Control Act of 1972, As Amended	42 USC 4901 et seq.	Full Compliance
Rehabilitation Act (1973)	29 USC 794	Not Applicable
Reservoir Salvage Act of 1960, As Amended	16 USC 469	Not Applicable
Resource Conservation and Recovery Act of 1976	42 USC 6901-6987	Not Applicable
River and Harbor Act of 1888, Sect 11	33 USC 608	Full Compliance
River and Harbor Act of 1889, Sections 9, 10, 13	33 USC 401-413	Full Compliance
River and Harbor and Flood Control Act of 1962, Section 207	16 USC 460	Full Compliance
River and Harbor and Flood Control Act of 1970, Sections 122, 209, and 216	33 USC 426 et seq.	Full Compliance
Safe Drinking Water Act of 1974, As Amended	42 USC 300f	Full Compliance
Shipping Act	46 USC 883	Full Compliance
Submerged Lands Act of 1953	43 USC 1301 et seq.	Full Compliance
Superfund Amendments and Reauthorization Act of 1986	42 USC 9601	Not Applicable
Surface Mining Control and Reclamation Act of 1977	30 USC 1201-1328	Not Applicable
Toxic Substances Control Act of 1976	15 USC 2601	Not Applicable
Uniform Relocation and Assistance and Real Property Acquisition Policies Act of 1970, As Amended	43 USC 4601 et seq.	Not Applicable
Executive Orders		
Title of Executive Order	**Exec. Order Number**	**Compliance Status**
Protection and Enhancement of Environmental Quality	11514/11991	Full Compliance
Protection and Enhancement of the Cultural Environment	11593	Full Compliance
Floodplain Management	11988	Full Compliance
Protection of Wetlands	11990	Full Compliance
Federal Compliance with Pollution Control Standards	12088	Full Compliance
Environmental Effects Abroad of Major Federal Actions	12114	Not Applicable
Offshore Oil Spill Pollution	12123	Full Compliance
Procurement Requirements and Policies for Federal Agencies for Ozone-Depleting Substances	12843	Full Compliance
Federal Compliance with Right-To-Know Laws and Pollution Prevention	12856	Full Compliance
Federal Actions to Address Environmental Justice and Minority and Low-Income Populations	12898	Full Compliance
Implementation of the North American Free Trade Agreement	12889	Not Applicable
Energy Efficiency and Water Conservation at Federal Facilities	12902	Not Applicable
Federal Acquisition and Community Right-To-Know	12969	Full Compliance
Protection of Children from Environmental Health Risks and Safety Risks	13045	Full Compliance
Coral Reef Protection	13089	Not Applicable
Invasive Species	13112	Full Compliance
Marine Protected Areas	13158	Not Applicable
Consultation and Coordination with Indian Tribal Governments	13175	Full Compliance
Responsibilities of Federal Agencies to Protect Migratory Birds	13186	Full Compliance
Executive Order Facilitation of Cooperative Conservation	13352	Full Compliance

6.2 National Environmental Policy Act of 1969 (NEPA), as amended, 42 U.S.C. 4321 *et seq*.

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 sciences in planning and decision-making that could have an impact on the environment. NEPA requires the preparation of an environmental impact statement (EIS) for any major federal action that could have a significant impact on quality of the human environment. NEPA regulations issued by CEQ provide for a scoping process to identify and the scope and significance of environmental issues associated with a project. The process identifies and eliminates from further detailed study issues that are not significant. As previously stated, the USACE used this process to comply with NEPA and focus this Final IFR/EIS on the issues most significant to the environment and the decision making process.

The Draft IFR/EIS was submitted for a 45 day review period from 10 October 2014 to 24 November 2014. All comments/edits were addressed in the development of the Final IFR/EIS, and responses to the comments are provided in Appendix Q (Correspondence). The Final IFR/EIS, including all appendices and supporting studies fulfill all requirements of the National Environmental Policy Act for the Charleston Harbor Post 45 FS. Upon completion of the Final IFR/EIS, the project will be in full compliance with the NEPA.

6.3 Clean Water Act

The USACE has obtained a water quality certification from the State of South Carolina pursuant to the Clean Water Act (CWA) for the discharge of dredged or fill material into navigable waters by the proposed activity. All state water quality standards would be met. This Final IFR/EIS contains sufficient information to demonstrate that the recommended plan is in compliance with the CWA. A joint public notice was filed for the release of the Draft IFR/EIS and the 401 certification. On 16 March 2015, SCDHEC issued a certification in accordance with Section 401 of the CWA, with conditions pursuant to R. 19-450 et. seq., 1976. The conditions of the 401 are stated below and the USACE is committed to adhering to all conditions of the Certification:

1) "No more than 90 days after the issuance of the Record of Decision (ROD), the Corps shall convene the Interagency Coordination Team (ICT) to develop the Mitigation, Monitoring and Adaptive Management Plan (MMAMP) for wetland vegetation monitoring. The Corps will work with the ICT to solicit input and develop the framework for wetland vegetation monitoring to include monitoring schedules, frequencies, data parameters, monitoring placement and data reporting. The Corps shall also work with the ICT to determine the corrective action plan should the wetland impacts exceed those predicted by the Draft Environmental Impact Statement (DEIS).

2) Wetland vegetation monitoring shall be conducted during years I, 3, and *5* post construction. If DHEC determines, based on review of the data reported as required in condition #1 above, that additional monitoring is required, DHEC will require additional biannual monitoring during years 7 and 9 as needed.

3) No more than 90 days after issuance of the ROD, the Corps shall convene the ICT to develop the MMAMP for DO water quality monitoring. The Corps will work with the ICT to solicit input and develop the DO monitoring framework to include monitoring schedules, frequencies, data parameters, placement of monitors and data reporting. The Corps shall work with the ICT to determine the corrective action plan should the DO impacts exceed those predicted in the DEIS.

4) Four new water quality monitors shall be installed as discussed in the DEIS to monitor for specific conductivity, dissolved oxygen, temperature, water level and pH. The monitors will be maintained for a period of 5 years post-construction. If DHEC determines, during review of the data reported as required in condition #3 above, that additional monitoring is required, DHEC shall require up to *5* additional years of monitoring.

5) Mitigation for wetland impacts from the project shall be provided through the preservation of the US Forest Service tract identified as parcel B-28 in Appendix P of the DEIS. No more than 90 days after the issuance of the ROD, DHEC shall be provided with a copy of the signed recorded plats and conservation easements for the mitigation property.

6) The permittee shall instruct all personnel associated with the project of the potential presence of manatees and the need to avoid collisions with manatees. All construction personnel must monitor water-related activities for the presence of manatees during May 15-October 15.

7) Any collisions with and/or injury to manatee shall be reported immediately to Jim Valade of the U.S. Fish and Wildlife Service, North Florida Field Office, at (904) 731-3116.

8) If manatee(s) are seen within 100 yards of the active construction area, all appropriate precautions shall be implemented to ensure protection of the manatee. These precautions shall include the operations of all moving equipment no closer than 50 feet to a manatee. Operation of any equipment closer than 50 feet to a manatee shall necessitate immediate shutdown of that equipment.

9) The permittee shall advise all construction personnel that there are civil and criminal penalties for harming, harassing, or killing manatees, which are protected under the Marine Mammal Protection, act of 1972 and the Endangered Species Act.

10) Any siltation barriers used during the project shall be made of material in which manatees cannot become entangled and must be properly secured, and regularly monitored to avoid entrapment.

11) All vessels associated with the project shall operate at "no wake/idle" speeds to the extent practicable while in the construction area and while in the water where the draft of the vessel provides less than four foot clearance from the bottom. All vessels will follow routes of deep water whenever possible.

12) When practicable, the use of hopper dredges should be limited to winter months to avoid impacts to manatees and sea turtles.

13) Dredging of ecologically sensitive areas should be limited to cooler months, when possible.

14) Dredge operators shall not turn on suction until the draghead is at or near the sea/river bottom and shall turn off suction as close to sea/river bottom as possible.

15) The Corps shall comply with all terms and conditions of the National Marine Fisheries Service's (NMFS) Final Biological Opinion.

16) To the greatest extent practicable, all lighting for dredging equipment, barges, and support vessels should be directed downward toward the work during nighttime dredging activities, to minimize the effects on migrating birds.

17) Monitoring of the hard bottom reefs will occur within 6 months of completion of the reefs and will continue once a year for 4 years. If success criteria are not met by the end of 4 years, the Corps will meet with South Carolina Department of Natural Resources and the NMFS to determine corrective actions.

18) The final plans for beneficial uses of the dredged spoil material shall be provided to the DHEC for final approval prior to finalizing the Pre-construction Engineering and Design or PED.

19) If the Tentatively Selected Plan as identified in the DEIS (54-52-48 foot plan, which will deepen the Entrance Channel to - 54 feet, the harbor channel to the Wando Welch and Navy Base terminals to – 52 feet, and the channel to the North Charleston terminal to -48 feet) is selected as the recommended plan in the Final Environmental Impact Statement, the following conditions shall apply:

    a. No later than 60 days after the issuance of the ROD, the South Carolina State Ports Authority (SCSPA) shall provide the South Carollna Aquarium with the sum of One Hundred Twenty-five Thousand Dollars ($125,000) to be dedicated to public education about sea turtles in the Charleston Harbor area and/or turtle rehabilitation.

    b. No later than 90 days after initiation of dredging, the SCSPA will provide DHEC with documentation of the deposit of Five Million Dollars ($5,000,000) in an escrow account or other acceptable security along with an irrevocable letter of credit.

    c. The $5,000,000 identified above shall be utilized for preservation efforts within the Cooper River Corridor. The SCSPA shall provide DHEC with an accounting of the land preservation efforts secured with such funds within 90 days after all such funds are expended.

    d. The information reported to DHEC above shall include a preliminary jurisdictional determination specifying the quantity and type of wetland at each preservation site.

    e. If DHEC determines, after reviewing the wetland vegetation impact data required in condition #I, that there is insufficient wetland mitigation, the preservation sites identified above shall be evaluated for mitigation purposes."

6.3.1 Wetlands

CWA Section 404 and implementing USACE regulations at 33 C.F.R. 336(c)(4) and 33 C.F.R. 320.4(b) require the USACE to avoid, minimize, and mitigate impacts to wetlands. The mitigation process has been fully documented in this Final IFR/EIS and in Appendix P (Mitigation, Monitoring, and Adaptive Management).

6.3.1.1 Section 404 (b)(1) Guidelines

All of the harbor deepening alternatives under consideration involve discharges of dredged and fill material into waters of the United States. All sites designated to receive dredged or fill material, excluding those sites governed solely by separate authorization criteria (the ODMDS site covered under Section 103 (of the MPRSA) and artificial reef sites seaward of the Territorial Sea subject to the National Fishing Enhancement Act of 1984), have been evaluated using the CWA Section 404 (b)(1) Guidelines and found to be in compliance with the requirements of these guidelines. An additional 404(b)(1) evaluation was completed for the discharge/placement of dredged rock from the Entrance Channel at the SCDNR Charleston nearshore artificial reef site. Both Section 404 (b)(1) Evaluations can be found in Appendix M. The purpose of the Guidelines is to direct the specification of disposal sites for dredged or fill material. The 404(b)(1) evaluations address the following four tests in order to be in compliance:

1) **40 CFR 230.10 (a):** Whether there is a practicable alternative to the proposed discharge that would have less adverse impact on the aquatic ecosystem, so long as the alternative does not have other significant adverse environmental consequences. The alternative identified by this test is referred to as the *least environmentally damaging practicable alternative* or the LEDPA. The evaluation of the proposed Post 45 Project with respect to this compliance test is found in Section 4.1, “Finding of Practicable Alternatives” of Appendices M1 and M2.

2) **40 CFR 230.10 (b):** Whether the discharge would violate any applicable state water quality standards, Section 307 of the CWA, the Endangered Species Act (ESA), or federal laws concerning marine sanctuaries. The evaluation of the proposed Post 45 Project with respect to this compliance test is found in Section 4.2, “Restrictions on Discharge” of Appendices M1 and M2.

3) **40 CFR 230.10 (c):** Whether the discharge would cause or contribute to significant degradation of waters of the U.S. The evaluation of the proposed Post 45 Project with respect to this compliance test is found in Section 4.3, “Finding of No Significant Degradation” of Appendices M1 and M2.

4) **40 CFR 230.10 (d):** Whether appropriate and practicable steps have been taken that would minimize potential adverse impacts of the discharge on the aquatic ecosystem. The evaluation of the proposed Post 45 Project with respect to this compliance test is found in Section 4.4, “Minimization of Potential Adverse Impacts” of Appendices M1 and M2.

6.4 Federal Coastal Zone Management Act (CZMA), 16 U.S.C. 1451 et seq.

This Act requires each federal agency activity performed within or outside the coastal zone (including development projects) that affects land or water use, or natural resources of the coastal zone to be carried out in a manner which is consistent to the maximum extent practicable, i.e. fully consistent, with the enforceable policies of approved state management programs unless full consistency is prohibited by existing law applicable to the federal agency.

To implement the CZMA and to establish procedures for compliance with its federal consistency provisions, the US Department of Commerce, National Oceanic and Atmospheric Administration (NOAA), promulgated regulations which are contained in 15 C.F.R. Part 930. As per 15 CFR 930.37, a federal agency may use its NEPA documents as a vehicle for its consistency determination.

The South Carolina Coastal Management Program was established under the guidelines of the national Coastal Zone Management Act (1972) as a state-federal partnership to comprehensively manage coastal resources. It was authorized in 1977 under SC's Coastal Tidelands and Wetlands Act (CTWA) with the goal of achieving balance between the appropriate use, development, and conservation of coastal resources in the best interest of all citizens of the state. DHEC's Office of Ocean and Coastal Resource Management is the designated state coastal management agency and is responsible for the implementation of the state's Coastal Management Program. Implementation includes the direct regulation of impacts to coastal resources within the critical areas of the state including coastal waters, tidelands, beaches and beach dune systems; and indirect certification authority over federal actions and state permit decisions within the eight coastal counties.

The goals of the South Carolina Coastal Management Program are attained by enforcement of the policies of the State as codified within the South Carolina Code of Regulations. "Policy" or "policies" of the South Carolina Coastal Management Program means the enforceable provisions of present or future applicable statutes of the State of South Carolina or regulations promulgated duly there under (SC Code of Regulations Chapter 30). The statutes cited as policies of the Program were selected because they reflect the overall Program goals of developing and implementing a balanced program for the protection of the natural resources, as well as promoting sustainable economic development of the coastal area. Each section of the South Carolina coastal management laws are discussed separately in this section, in numerical order. In accordance with the CZMA, it has been determined that the proposed deepening of the federal navigation channel would be carried out in a manner that is fully consistent with the enforceable policies of the SC CMP. With conditions, the SCDHEC – concurred with the USACE consistency determination on 8 December 2014. The following conditions were stated in the DHEC-OCRM determination:

1) The Corps shall comply with all terms and conditions of the National Marine Fisheries Service's Final Biological Opinion.
2) The Corps shall implement best management practices to include, but not limited to, efforts to reduce the potential of organism(s) entrainment; (i.e. not turning on suction until draghead is at or near the sea/river bottom).

3) The Corps shall comply with all terms and conditions of the Department's final 401 Water Quality Certification, including but not limited to the final mitigation plan.

4) The Corps shall receive final approval for the expansion of the ODMDS from EPA to allow for adequate disposal of dredged material prior to construction.

5) The final plans for beneficial uses of the dredged spoil material shall be provided to the Department for final approval.

6) The Corps shall continue to work with the Department to provide adequate mitigation for the project. The final, detailed mitigation plan should include, but not be limited to, the following:

    a. Detailed site description, including location and acreage breakdown of habitat types (i.e. forested wetlands, emergent wetlands, scrub/shrub wetlands, uplands, etc).

    b. Site protection measures (Restrictive Covenants, Conservation Easement, or other similar legal document) to protect the property in perpetuity.

    c. Long-term management plan to be implemented by the steward of the property. The management plan should include details for public access, management for invasive species, management of upland buffers, utilization of Best Management Practices for any work needed, agreements for land/ water use and hunting rights on the property.

    d. Updated Uniform Mitigation Assessment Method (UMAM) calculation worksheets for the mitigation property, which accurately reflect those existing habitats and their potential improvement. These worksheets should include a detailed explanation for the scoring, and wetland systems should be scored individually based on their own ecological functions and values.

7) An archaeologist should be present on the dredge and should monitor the dredging operation in the vicinity of magnetic anomaly LH1-001. In the event that an inadvertent discovery is made, all work should cease in the immediate area and should not continue until examination and consultation with the South Carolina Institute of Archaeology and Anthropology and the State Historic Preservation Office is complete. Archaeological remains consist of any materials made or altered by man, which remain from past historic or prehistoric times (i.e., older than 50 years). Examples include old pottery fragments, metal, wood, arrowheads, stone implements or tools, human burials, historic docks, structures, or non-recent vessel remains. Paleontological remains consist of old animal remains, original or fossilized, such as teeth, tusks, bone, or entire skeletons. In the event that archaeological or paleontological remains are found during the course of work, the Corps should notify the South Carolina Institute of Archaeology and Anthropology (Mr. James Spirek at 803-777 - 8170) pursuant to South Carolina Underwater Antiquities Act of 1991, (Article 5 Chapter 7, Title 54, Code of Laws of South Carolina, 1976).

6.4 Clean Air Act (CAA), as amended, 42U.S.C. 7401 *et seq.*

All harbor deepening alternatives are in compliance with the CAA. An Air Emission Inventory (Appendix N) is provided as part of this Final IFR/EIS. The analysis determined that air emissions from port operations would be less if the harbor is deepened when compared to the No Action Alternative. The study area is in an attainment area for all air quality criteria and the proposed project will not cause the study area to go out of attainment.

6.5 US Fish and Wildlife Coordination Act, 16 U.S.C.661-666(c)

This project is in compliance with this Act. The project has been fully coordinated with the US Fish and Wildlife Service and other State and federal natural resource agencies. The Final Section 2 (b) Report is a reference of this report. The Report included the following 16 recommendations intended to balance the impacts resulting from the project with natural resource conservation:

1) "USACE must make all practicable efforts to avoid collisions between dredging equipment (and support vessels) and West Indian manatee, particularly during construction activities occurring during summer months, and engage measures to minimize the risks of collisions. Measures may include the use of task-dedicated marine mammal observers/spotters on all vessels who alert vessel operators of the presence of the species. Any collision with and/or injury to a manatee shall be reported immediately to Jim Valade of the U.S. Fish and Wildlife Service, North Florida Field Office, at (904) 731-3116."

2) "USACE must make all practicable efforts to avoid collisions, entrainment in dredging equipment, and other disturbances affecting loggerhead, green, leatherback, and Kemp's Ridley sea turtles. In the event that a turtle is injured or killed, USACE must contact the SCDNR stranding hotline in Charleston at 1-843-633-1639."

3) "USACE must make all practicable efforts to avoid collisions, entrainment in dredging equipment, and other disturbances affecting the shortnose sturgeon and Atlantic sturgeon, and adopt measures to minimize the risk of such disturbances and any resulting casualties."

4) "USACE must make all practicable efforts to avoid noise and other disturbances affecting wood stork, particularly during its nesting season (March through August), and adopt measures to minimize the risk of such disturbances."

5) "USACE must make all practicable efforts to avoid effects to piping plover due to dredging and disposal activities (noise and other disturbances, as well as habitat alteration) within or near potential wintering areas, and adopt measures to minimize the risk of such effects."

6) "USACE must make all practicable efforts to avoid effects to the red knot, as it is proposed for listing under the ESA and may gain full federal protection prior to construction of the proposed project."

7) USACE reconsider the option to construct contraction dikes, as these may result in barriers for sturgeon and manatee movement.

8) USACE should coordinate with local, state, and federal resource agencies to investigate opportunities for reusing non-contaminated, dredged material to restore coastal habitats such as Crab Bank, Castle Pinckney (Shutes Folly), and Morris Island.

9) USACE should continue to use the Unified Mitigation Assessment Method (UMAM) in order to determine functional value of wetlands to be affected by brackish water intrusion and to calculate compensation for the anticipated functional loss of wetlands. Adaptive management techniques for use following construction should be in part based on the UMAM effort to ensure adequate compensation and long-term consistency in determining both impacts and mitigation success.

10) To minimize effects on migratory birds during nighttime dredging activities, all lighting for dredge equipment, barges, and support vessels must be directed downward toward the work area. No omni-directional or skyward pointed lights may be utilized.

11) USACE should reconsider the option to construct contraction dikes, as these may result in navigation safety issues, unpredictable sedimentation and erosion effects, and oyster and wetland impacts.

12) USACE will seek consultation with NMFS Habitat Conservation Division if EFH is adversely affected in order to develop EFH avoidance and minimization measures. Where avoidance and minimization is not feasible, restoration for lost EFH or improvements to existing EFH should be considered and implemented.

13) USACE must provide assurances that the deposition of sediments in spoil areas will not exceed the boundaries of the spoil areas either directly or via subsequent overflow/repose of material.

14) USACE must provide that it will use best available technology to confine any fine material to designated Confined Upland Disposal Facilities (CDFs) if upland disposal is determined to be necessary for the project.

15) USACE must never use any unconfined areas for spoil disposal (except for renourishment at such areas as Crab Bank, Castle Pinckney, or Morris Island (using dredged material comparable to the native sediments in grain-size, mineralogy, and organic carbon content. Only beach compatible sand should be used for Morris Island).

16) USACE should limit dredging in sensitive areas (i.e. The Grillage) to the cooler months of the year to protect juvenile shrimp, crabs and finfish, as well as to avoid periods of peak recreational fishing activity near the inlet, the Grillage and other congregating areas.

Responses to these recommendations are provided in Appendix Q. USACE will comply with all of these recommendations.

6.6 Endangered Species Act

A Biological Assessment of Threatened and Endangered Species (BATES) evaluating the potential impacts of the proposed action on endangered and threatened species and their critical habitat were prepared (Appendix F). The assessment was coordinated with the USFWS (jurisdiction over the West Indian manatee, piping plover, wood stork, and nesting sea turtles) and NMFS (jurisdiction over sturgeon, sea turtles, whales, and other protected marine and aquatic species which may occur in the project vicinity) pursuant to Section 7 of the ESA. USFWS concurred with the no effect and not likely to adversely affect determinations in the BATES and no formal consultation was initiated. Formal consultation was requested with NMFS for impacts to sea turtles and shortnose and Atlantic sturgeon on 10 October 2014. NMFS issued a Biological Opinion on the project on 22 April 2015 where they concluded that the proposed project is not likely to jeopardize the continued existence of sea turtles (loggerhead, green, and Kemp's ridley sea turtles), whales (North Atlantic right and humpback), sturgeon (Atlantic and shortnose) and is not likely to adversely affect proposed North Atlantic right whale critical habitat, North Atlantic right and humpback whales, and leatherback and hawksbill sea turtles. NMFS provided an Incidental Take Statement that describes reasonable and prudent measures and nondiscretionary terms and conditions that NMFS considers necessary or appropriate to minimize the impact of incidental take. The NMFS Biological Opinion is documented in Appendix F2 of this Final IFR/EIS. The following two RPMs were identified:

1) The USACE shall implement best management measures, including the use of date-based dredging windows, sea turtle deflector dragheads, intake and overflow screening, and relocation trawling to reduce the risk of injury or mortality of listed species and lessen the number of sea turtles killed by the proposed action.
2) The USACE shall have measures in place to detect and report all interactions with any protected species (ESA or Marine Mammal Protection Act) resulting from the proposed action. These measures include endangered species observers aboard the hopper dredge and relocation trawlers, screening of dredged material to allow discovery of any entrained turtles and sturgeon, and handling procedures for incidentally taken animals.

The following 14 T&C's are required to implement the RPM's:

1) Hopper Dredging (RPM 1): Hopper dredging is allowed in accordance with the SARBO dredging window, November 1 through May 31 or outside of this period only if water temperatures are below 11°C.
2) Non-hopper Type Dredging (RPM 1): Mechanical, pipeline or hydraulic dredges, because they are not known to take turtles, must be used whenever possible.
3) Observers (RPM 2): The USACE shall arrange for NMFS-approved protected species observers to be aboard the hopper dredges to monitor the hopper bin, screening, and dragheads for sea turtles, sturgeon, and their remains. Observer coverage sufficient for 100 percent monitoring (i.e., 2 observers) of hopper dredging operations is required during all hopper dredging.

4) Operational Procedures (RPM 1): During periods in which hopper dredges are operating and NMFS-approved protected species observers are not required (December 1 through March 31), the USACE must:
   a) Advise inspectors, operators, and vessel captains about the prohibitions on taking, harming, or harassing sea turtles and sturgeon.
   b) Instruct the captain of the hopper dredge to avoid any turtles or sturgeon encountered while traveling between the dredge site and offshore disposal area, and to immediately contact the USACE if they are seen in the vicinity.
   c) Notify NMFS immediately by email (takereport.nmfsser@noaa.gov) if a sea turtle, sturgeon, or other threatened or protected species is taken by the dredge, and reference this Opinion (F/SER/2015/15433).
5) Dredging Pumps (RPM 1): Standard operating procedure shall be that dredging pumps shall be disengaged by the operator when the dragheads are not firmly on the bottom, to prevent impingement or entrainment of sea turtles within the water column. This precaution is especially important during the cleanup phase of dredging operations when the draghead frequently comes off the bottom and can suck in turtles resting in the shallow depressions between the high spots the draghead is trimming off.
6) Dredge Lighting (RPM 1): From May 1 through October 31, sea turtle nesting and emergence season, all lighting aboard hopper dredges and hopper dredge pumpout barges operating within 3 nmi of sea turtle nesting beaches shall be limited to the minimal lighting necessary to comply with U.S. Coast Guard and/or Occupational Safety and Health Administration requirements. All non-essential lighting on the dredge and pumpout barge shall be minimized through reduction, shielding, lowering, and appropriate placement of lights to minimize illumination of the water to reduce potential disorientation effects on female sea turtles approaching the nesting beaches and sea turtle hatchlings making their way seaward from their natal beaches.
7) Sea Turtle-Deflecting Draghead (RPM 1): A state-of-the-art solid-faced deflector that is attached to the draghead with chains and an adjustable leading chain at the apex of the deflector must be used on all hopper dredges at all times. The use of alternative, experimental dragheads is not authorized without prior written approval from NMFS, in consultation with the USACE Engineering Research and Development Center (ERDC). Slotted draghead deflectors are currently not authorized.
8) Training Personnel on Hopper Dredges (RPM 1): The USACE must ensure that all contracted personnel involved in operating hopper dredges (whether privately-funded or federally-funded projects) receive thorough training on measures of dredge operation that will minimize takes of sea turtles. It shall be the goal of the hopper dredging operation to establish operating procedures that are consistent with those that have been used successfully during hopper dredging in other regions of the coastal United States, and which have proven effective in reducing turtle/dredge interactions. Therefore, USACE ERDC experts or other persons with expertise in this matter shall be involved both in dredge operation

training, and installation, adjustment, and monitoring of the rigid deflector draghead assembly.

9) Screening (RPM 2): When sea turtle or sturgeon observers are required on hopper dredges, 100% inflow screening of dredged material is required and 100% overflow screening is recommended. If conditions prevent 100% inflow screening, inflow screening may be reduced gradually, as further detailed in the following, but 100% overflow screening is then required.
    a) Screen Size: The hopper's inflow screens should have 4-in by 4-in screening. If the USACE, in consultation with observers and the draghead operator, determines that the draghead is clogging and reducing production substantially (other than in sand borrow areas), the screens may be modified sequentially. Mesh size may be increased to 8-in by 8-in; if that fails to solve the clogging problem, then 16-in by 16- in openings may be used. Clogging should be greatly reduced or eliminated with these options; however, further clogging may compel removal of the screening altogether, in which case effective 100% overflow monitoring and screening is mandatory. The USACE shall notify NMFS beforehand if inflow screening is going to be reduced or eliminated, what attempts were made to reduce the clogging problem, and provide details of how effective overflow screening will be achieved.
    b) Need for Flexible, Graduated Screens: NMFS believes that this flexible, graduated screen option is necessary, since the need to constantly clear the inflow screens will increase the time it takes to complete the project and therefore increase the exposure of sea turtles to the risk of impingement or entrainment. Additionally, there are increased risks to sea turtles in the water column when the inflow is halted to clear screens, because this results in clogged intake pipes, which may have to be lifted from the bottom to discharge the clay by applying suction.

10) Dredge Take Reporting and Final Report (RPM 2): Observer reports of incidental take by hopper dredges must be emailed to the Southeast Regional Office (takereport.nmfsser@noaa.gov with reference to this Opinion - F/SER/2015/15433) by onboard NMFS-approved protected species observers, the dredging company, or the USACE within 24 hours of any sea turtle, sturgeon, or other listed species take observed. A final report summarizing the results of the hopper dredging and any documented sea turtle, sturgeon, or other listed species takes must be submitted to NMFS (takereport.nmfsser@noaa.gov with reference to this Opinion) within 60 working days of completion of the dredging project. The reports shall contain information on project location (specific channel/area dredged), start-up and completion dates, cubic yards of material dredged, problems encountered, incidental takes and sightings of protected species, mitigative actions taken (if relocation trawling, the number and species of turtles relocated), screening type (inflow, overflow) utilized, daily water temperatures, name of dredge, names of endangered species observers, percent observer coverage, and any other information the USACE deems relevant.

11) Sea Turtle Strandings (RPM 2): The USACE Project Manager or designated representative shall notify the STSSN state representative (contact information available at: http://www.sefsc.noaa.gov/seaturtleSTSSN.jsp) of the start-up and completion of hopper dredging operations and bed-leveler dredging operations and ask to be notified of any sea turtle strandings in the project area that, in the estimation of STSSN personnel, bear signs of potential draghead impingement or entrainment, or interaction with a bedleveling type dredge. Information on any such strandings shall be reported in writing within 30 days of project end to NMFS's Southeast Regional Office (takereport.nmfsser@noaa.gov with reference to this Opinion) with a report detailing incidents, with photographs when available, of stranded sea turtles that bear indications of draghead impingement or entrainment. Because the deaths of turtles, if hopper dredge related, have already been accounted for in NMFS's jeopardy analysis as turtles not observed being taken during hopper dredging operations, these strandings will not be counted against the USACE's take limit. NMFS and the USACE will use these stranding reports to assess whether they suggest a greater extent of effects than predicted in this Opinion.
12) Conditions Requiring Relocation Trawling (RPM 1): The USACE shall require relocation trawling to start as soon as possible within 72 hours if either:
    a) 2 or more turtles are taken by hopper dredges in a 24-hour period, or
    b) Total dredge takes in the project approach 75% (rounded-down) of any of the incidental take limits from Section 9.1 of this Opinion. Relocation trawling may be suspended if no relocation or dredge takes occur within 14 days unless take limits for any species have been reached.
13) Closed-net Relocation Trawling (RPM 1): Any relocation trawling conducted or contracted by the USACE to temporarily reduce abundance of these listed species during hopper dredging in order to reduce the possibility of lethal hopper dredge interactions, is subject to the following conditions:
    a) The net must be closed at all times during trawling.
    b) Trawl Time: Trawl tow-time duration shall not exceed 42 minutes (measured from the time the trawl doors enter the water until the time the trawl doors are out of the water) and trawl speeds shall not exceed 3.5 knots.
    c) Protected Species Handling During Trawling: Handling of sea turtles and sturgeon captured during relocation trawling in association with the dredging project shall be conducted by NMFS-approved protected species observers. Sea turtles and sturgeon captured pursuant to relocation trawling shall be handled in a manner designed to ensure their safety and viability, and shall be released over the side of the vessel, away from the propeller, and only after ensuring that the vessel's propeller is in the neutral, or disengaged, position (i.e., not rotating). Sea Turtle Research Techniques Manual is attached (Appendix A) http://www.sefsc.noaa.gov/turtles/TM_579_SEFSC_STRTM.pdf. Any handling of Atlantic sturgeon captured in the relocation trawling will comply with the attached NMFS's Protocol for Use of Shortnose, Atlantic, Gulf, and Green Sturgeons (Attachment B) http://www.nmfs.noaa.gov/pr/pdfs/species/kahn_mohead_2010.pdf.

d) Captured Sea Turtle Holding Conditions: Sea turtles may be held briefly for the collection of important biological information, prior to their release. Captured sea turtles shall be kept moist, and shaded whenever possible, until they are released, according to the requirements of T&C No. 13-e, below.

e) Biological Data Collection: When safely possible, all sea turtles and Atlantic sturgeon shall be measured, tagged, weighed, and a tissue sample taken prior to release. Any external tags shall be noted and data recorded into the observers' log and take forms. Only NMFS-approved protected species observers or observer candidates in training under the direct supervision of a NMFS-approved protected species observer shall conduct the tagging/measuring/weighing/tissues sampling operations. Tissue samples will be sent to NMFS for processing and analysis. For sea turtles, collect tissue samples following the protocols above, the remaining specimen(s) or body parts of dead sea turtles must be preserved (preferably iced or refrigerated or frozen if necessary) until sampling and disposal procedures are discussed with the NMFS contact identified below. If it is not possible to retain the carcass, please scan the carcass for PIT tags and flipper tags, collect a tissue sample, and photograph the animal. Mark the carcass, if possible, and dispose of carcass near original site of capture.

   Dr. Brian Stacy
   NOAA/NMFS and University of Florida
   2187 Mowry Road, Building 471
   Gainesville, FL 32611
   Brian.Stacy@noaa.gov
   PH: 352-283-3370

   For sturgeon, mark the carcass (in order to identify in the case of recapture), if possible, and dispose of carcass near original site of capture. Send samples, copy of Protected Species Incidental Take Form and supporting data within 1 month of the date the sample is taken.

   Tim King in West Virginia
   USGS Leetown Science Center, Aquatic Ecology Branch
   11649 Leetown Road
   Kearneysville, WV 25430
   PH: 304-724-4450

f) Take and Release Time During Trawling – Turtles: Turtles shall be kept no longer than 3 hours prior to release and shall be released no less than 3 nmi from the dredge site. If 2 or more released turtles are later recaptured, subsequent turtle captures shall be released not less than 5 nmi away. If it can be done safely, turtles may be transferred onto another vessel for transport to the release area to enable the relocation trawler to keep sweeping the dredge site without interruption. The 3 hour holding time may be extended up to 24 hours only for sea turtles that require monitoring after resuscitation.

g) Injuries: Injured sea turtles shall be immediately transported to the nearest sea turtle rehabilitation facility. Minor skin abrasions resulting from trawl capture are considered non-injurious. The USACE shall ensure that logistical arrangements and support to accomplish this transport are pre-planned and ready. The USACE shall bear the financial cost of any subsequent treatment, rehabilitation, and release if the observer or State Sea Turtle Coordinator determines that the injuries were caused by the project.

h) Flipper Tagging: All sea turtles captured by relocation trawling shall be flipper tagged prior to release with external tags which shall be obtained prior to the project from the University of Florida's Archie Carr Center for Sea Turtle Research. This Opinion serves as the permitting authority for any NMFS-approved protected species observer aboard these relocation trawlers to flipper-tag with external tags (e.g., Inconel tags) captured sea turtles. Columbus crabs or other organisms living on external sea turtle surfaces may also be sampled and removed under this Opinion's authority.

i) PIT-Tag: This Opinion serves as the permitting authority for any NMFS-approved protected species observer aboard a relocation trawler to PIT-tag captured sea turtles and sturgeon. Tagging of sea turtles and sturgeon is not required to be done if the NMFS-approved protected species observer does not have prior training or experience in said activity; however, if the observer has received prior training in PIT tagging procedures, then the observer shall tag the animal prior to release (in addition to the standard external tagging):

    i. Sea turtle PIT tagging must be performed in accordance with the protocol detailed in Appendix A.
    ii. PIT tags used must be sterile, individually-wrapped tags to prevent disease transmission. PIT tags should be 125 kHz, glass-encapsulated tags–the smallest ones made. Note: If scanning reveals a PIT tag and it was not difficult to find, then do not insert another PIT tag; simply record the tag number and location, and frequency, if known. If for some reason the tag is difficult to detect (e.g., tag is embedded deep in muscle, or is a 400 kHz tag), then insert one in the other shoulder.
    iii. All sturgeon handled shall be scanned for a PIT tag; codes shall be included in the take report submitted to NMFS. The PIT tag reader shall be able to read both 125 kHz and 134 kHz tags. Sturgeon without PIT tags will have one installed per guidance in Attachment B. Previously PIT-tagged fish must not be re-tagged.
    iv. All unmarked sturgeon less than 300 mm in total length would be tagged using 11.9 mm x 2.1 mm PIT tags injected using a 12-gauge needle at an angle of 60º to 80º in the dorsal musculature (left and just anterior to the dorsal fin) with the copper antenna oriented up for maximum signal strength. No fish would be double-tagged with PIT tags. The last step after injecting PIT tags would be to verify and record the PIT tag code with a tag reader. PIT tags may also be inserted under scutes after discussing with NMFS.

j) Sea Turtle PIT-Tag Scanning and Data Submission Requirements: All sea turtles captured by relocation trawling or dredges shall be thoroughly scanned for the presence of PIT tags prior to release using a multi-frequency scanner powerful enough to read multiple frequencies (including 125-, 128-, 134-, and 400 kHz tags) and read tags deeply embedded in muscle tissue (e.g., manufactured by Trovan, Biomark, or Avid). Turtles whose scans show they have been previously PIT tagged shall nevertheless be externally flipper tagged. Sea turtle data collected (PIT tag scan data and external tagging data) shall be submitted to NOAA, National Marine Fisheries Service, Southeast Fisheries Science Center, Attn: Lisa Belskis, 75 Virginia Beach Drive, Miami, Florida 33149. All sea turtle data collected shall be submitted in electronic format within 60 days of project completion to Lisa.Belskis@noaa.gov. Sea turtle external flipper tag and PIT tag data generated and collected by relocation trawlers shall also be submitted to the Cooperative Marine Turtle Tagging Program (CMTTP), on the appropriate CMTTP form, at the University of Florida's Archie Carr Center for Sea Turtle Research.

k) Handling Fibropapillomatose Turtles: NMFS-approved protected species observers are not required to handle viral fibropapilloma tumors if they believe there is a health hazard to themselves and choose not to. When handling sea turtles infected with fibropapilloma tumors, observers must maintain a separate set of sampling equipment for handling animals displaying fibropapilloma tumors or lesions.

l) Additional Data Collection Allowed During the Handling of Sea Turtles, Sturgeon, and Other Incidentally Caught ESA-listed Species: The USACE shall allow NMFS approved protected species observers to conduct additional investigations that may include more invasive procedures (e.g., blood-letting, laparoscopies, external tumor removals, anal and gastric lavages, mounting satellite or radio transmitters) and partake in or assist in research projects but only if (1) the additional work does not interfere with any project operations (e.g., dredging activities, relocation trawling); (2) the observer holds a valid federal research permit (and any required state permits) authorizing the activities, either as the permit holder, or as designated agent of the permit holder; (3) the additional work does not incur any additional expenses to the USACE or the USACE approves of the expense; and (4) the observer has first coordinated with USACE Charleston District and notified NMFS's Southeast Regional Office, Protected Resources Division. Limitations are as follows:

   i. Leatherback sea turtles cannot be retained and should be returned to the water as soon as possible.

   ii. In instances of hardshell sea turtle capture, observers or may retain incidentally captured animals for species research projects if the person(s) conducting the research, is on board or nearby, and holds a valid federal research permit (and any required state permits) authorizing the activities, either as the permit holder, or as designated agent of the permit holder. All additional procedures performed on retained animals must be authorized through the research permit(s).

Collaborative research activities must begin within 1 hour of capture and the animal should be returned to the water within 5 hours (of time of capture). If required, animals may be held on board for up 12 hours provided that conditions during holding meet all research permit requirements and safe handling practices are followed. If research does not commence within 1 hour, the animal must be returned to the water. The intent of this provision is to minimize impacts to sea turtles by allowing, where appropriate, incidentally captured sea turtles to be used as research subjects. This reduces the need for additional animals to undergo the stress of capture associated with permitted scientific research.

14) Relocation Trawling Report (RPM 2): The USACE shall provide NMFS's Southeast Regional Office (takereport.nmfsser@noaa.gov with reference to this Opinion) with an end-of-project report within 30 days of completion of any relocation trawling. This report may be incorporated into the final report summarizing the results of the hopper dredging project.

NMFS also provided discretionary conservation recommendations which can be found in Appendix F2.

6.7 Magnuson-Stevens Fishery Conservation and Management Act (MSA), 16 U.S.C.1801 *et seq*.

This Act requires federal action agencies to consult with the National Marine Fisheries Service (NMFS) if a proposed action may affect Essential Fish Habitat (EFH). The USACE evaluated potential project impacts on NMFS-managed fish species and their Essential Fish Habitats (Appendix H). Impacts would occur to the water column, shallow sub-bottom habitat, hardbottom habitat, wetlands, and unconsolidated bottom. Implementation of the mitigation and monitoring plans for this project would bring all channel deepening alternatives under consideration into compliance with the provisions of the MSA. NMFS provided EFH Conservation Recommendations which are evaluated and either adopted or declined with explanation in Section 9.0 of Appendix H (EFH Assessment).

6.8 Anadromous Fish Conservation Act, 16 U.S.C. 757, *et seq.*

All channel deepening alternatives under consideration are in compliance with this Act. The project considered habitat impacts to sturgeon sp., striped bass, and blueback herring. Mitigation would not be required for the minor adverse affects on these species due to water quality changes and/or habitat displacement. The project has been coordinated with NMFS and is in compliance with the Act.

6.9 Marine Mammal Protection Act (MMPA), 16 USC 1631 et seq.

The MMPA prohibits the take of marine mammals including the West Indian manatee, North Atlantic right whale, humpback whale, and sperm whale. Protective measures for marine mammals would be implemented. The project is being coordinated with USFWS and NMFS. The project, as conditioned, is in compliance with this act and no incidental harassment would occur.

6.10 Section 106 and 110(f) of the National Historic Preservation Act (NHPA), 16 U.S.C. 470 *et seq.*

The USACE evaluated the potential for adverse impacts to archaeological or historic resources. One potential historic/cultural resource target was identified in the lower harbor. The associated reports were coordinated with SC Department of Archives and History (SCDAH) and the SC Institute for Archaeology and Anthropology (SCIAA). In order to comply with Section 106, SCIAA and SCDAH provided correspondence requesting that an archaeologist be on board the dredge when dredging the channel reach nearest the anomaly, and USACE will commit to this measure during project construction. As is this case in this study, section 110(f) review is generally accomplished under the procedures implementing Section 106. The project would not adversely affect historic properties included in or eligible for inclusion in the National Register of Historic places. The project is in compliance with applicable requirements. The SHPO concurred with the finding of no effect; however, due to uncertainties with the analysis used in the no effect determination as identified by SHPO, USACE, the National Park Service, and SCDAH have entered into a Programmatic Agreement whereby all parties agree that compliance with the procedures established in the agreement will satisfy the USACE NHPA Section 106 responsibilities. As stated in the agreement, the Charleston District will ensure that the following measures are carried out:

1. In consultation with the South Carolina SHPO and the NPS, the Charleston District shall prepare and implement a monitoring plan to confirm the accuracy of the assumptions and analysis associated with the predicted changes in the wave climate in Charleston Harbor that would result from the undertaking. The plan shall meet all requirements contained in the Monitoring Plan section of this agreement.
2. The Charleston District will review the information, conclusions and recommendations presented in the 1999 report "Fort Sumter Armor Stone and Outer Wall Structural Study" prepared by the Charleston District for Fort Sumter National Monument. The Charleston District will assess the conclusions and recommendations in the report to determine if material dredged for the undertaking could be used as recommended in the report or in another manner to address the erosion-related concerns. If dredged material could be used to address the concerns, the Charleston District will prepare conceptual construction cost estimates for the beneficial use of dredged material that will identify what portion of the project the District would commit to funding and what portion of the funding would be the responsibility of the NPS. This work will be completed prior to dredging the rock that that could be used to implement a beneficial use of dredge material project. Cost sharing arrangements will be sought by the South Carolina SHPO and the NPS if any options are identified that are mutually agreed to by the parties.
3. Anomaly LH1-001, which is about 150 feet outside the dredging footprint, will be monitored by an archaeologist meeting the Secretary of Interior's Professional Qualifications (48 FR

44716) during dredging activities in its vicinity. In the event of an inadvertent discovery during construction, all work would cease in the immediate area. The Charleston District would be notified immediately and would not restart work within the area of the finding until examination and consultation by the Charleston District and the South Carolina SHPO is complete.

6.11 Resource Conservation and Recovery Act (RCRA), as amended, 42 U.S.C. 6901 *et seq*.

RCRA controls the management and disposal of hazardous waste. Dredged material from USACE civil works projects is excluded from the definition of hazardous waste under 40 CFR 261.4(g), 33 CFR 336.1 and 33 CFR 336.2.

6.13 Comprehensive Environmental Response, Compensation and Liability Act (CERCLA or Superfund), 42 U.S.C. 9601 *et seq*.

CERCLA governs the liability, compensation, cleanup, and emergency response for hazardous substances released into the environment and the cleanup of inactive hazardous substance disposal sites. As discussed in Section 6.24, Hazardous and Toxic Wastes, none of the sediments that would be excavated or dredged during the project would be considered a hazardous substance under CERCLA or addressed under that law.

6.14 Marine Protection, Research and Sanctuaries Act

In order to determine sediment characteristics and contaminant concerns from dredging Charleston Harbor sediments and to obtain a section 103 Marine Protection, Research, and Sanctuaries Act concurrence, samples were collected for chemical and biological evaluations from October 20 through November 19, 2012. On September 4, 2014, USEPA sent a letter to the USACE confirming that the dredged material was suitable for ocean disposal (Appendix J). Additionally, as per conditions of the 401 water quality certification and the coastal zone consistency determination, prior to initiating construction, the EPA must have completed the Section 102 (MPRSA) process for the modification of the existing Offshore Dredged Material Disposal Site (ODMDS). It is anticipated that this will be completed in 2015.

6.15 Executive Order 11988, Floodplain Management

This EO states that federal agencies shall provide leadership and shall take action to reduce the risk of flood loss, to minimize the impact of floods on human safety, health and welfare, and to restore and preserve the natural and beneficial values served by floodplains in carrying out agency responsibilities. As indicated by hydrodynamic modeling (Appendix A), the proposed project would have no adverse impacts to flood plain management.

6.16 Executive Order 11990, Protection of Wetlands

This EO directs all federal agencies to minimize the destruction, loss, or degradation of wetlands; and preserve and enhance the natural beneficial values of wetlands in the conduct of the agency's responsibilities. Indirect wetland impacts resulting from riverine salinity changes caused by the proposed deepening have been evaluated, and would be mitigated for.

6.17 Executive Order 13112, Invasive Species

Under this EO, the introduction of invasive species has been evaluated in Section 6.22. The project would not induce the introduction of invasive species to the project area.

6.18 Executive Order 12898, Federal Actions to Address Environmental Justice in Minority Populations and Low Income Populations

In accordance with this EO, the USACE has determined that no group of people would bear a disproportionately high share of adverse environmental consequences resulting from the proposed work.

6.19 Executive Order 13045, Protection of Children from Environmental Health Risks and Safety Risks

This EO ensures that all federal actions address the unique vulnerabilities of children. In accordance with this EO, the USACE has determined that no children would bear a disproportionately high share of adverse environmental consequences resulting from the proposed work.

6.20 Migratory Bird Treaty Act, 16 U.S.C. 703 *et seq.*; Executive Order 13186, Responsibilities of Federal Agencies to Protect Migratory Birds

This Act makes it illegal for anyone to take, possess, import, export, transport, sell, purchase, barter, or offer for sale, purchase, or barter, any migratory bird, or the parts, nests, or eggs of such a bird except under the terms of a valid permit issued pursuant to federal regulations. The USACE does not anticipate that migratory birds would be adversely (directly or indirectly) affected by the proposed action. For a detailed description of this assessment please see the US Fish and Wildlife Service Coordination Act Report (USFWS, 2014).

6.21 Executive Order 13653, Preparing the United States for the Impacts of Climate Change

This EO requires all federal agencies to use their authorities to engage in climate preparedness and resilience. Consistent with ETL 1100-2-1, Procedures to Evaluate Sea Level Change, Impacts, Responses, and Adaptation (Feb. 2014), and in conjunction with the USACE Responses to Climate Change (RCC) Program, the Final IFR/EIS, Appendix A (Engineering) includes a robust consideration of the potential impacts of sea level change (SLC) on navigation features and associated structures and the possible adaptations that can be developed to counteract these impacts.

6.22 Environmental Commitments

The USACE commits to completing or implementing the following analyses prior to construction and ensuring the following environmental protection measures are implemented during construction:

Timing of Commitment	Title of Commitment	Description of Commitment
Pre-Construction Engineering and Design	Beneficial Use of Dredged Material	Evaluation of the feasibility for various beneficial use projects will be explored during PED and coordinated with the resource agencies. Options include all those identified in this Feasibility Report/EIS, as well as new concepts that may arise
	Ship Simulation	Ship simulation will be performed during PED phase. Ship simulation has been identified as an action that is required in order to minimize widening measures, where practicable.
	Coastal Modeling	Coastal modeling will be performed during PED phase to ensure that channel improvements and artificial reef creation do not exacerbate coastal wave and sediment transport dynamics and to ensure no impacts to nearby coastal communities.
	Wetland Mitigation	A detailed evaluation of wetland mitigation will occur during PED. This evaluation will involve the use of UMAM on the selected parcel proposed for mitigation, and subsequent review by resource agencies. If wetland preservation alone won't account for functional losses identified with UMAM, other mitigation options will be explored.
Construction	Dredge Window	Sciaenid spawning hotspot: The Grillage: From April through September, dredging will not occur within Mt. Pleasant, Rebellion Reach or in the Entrance Channel between the jetties.
	Dredge Window	Sciaenid spawning hotspot: Ravenel Bridge: From April through September, dredging will not occur within Hog Island Reach within a distance of 1000 ft on either side of the Bridge.
	Endangered Species	USACE will abide by the Terms and Conditions of the Biological Opinion issued for the new work construction and the most up-to-date Regional Biological Opinion.
	Water Quality	USACE will abide by the conditions within the 401 water quality certification issued by the SC Department of Health and Environmental Control.
	Fish and Wildlife Habitat	USACE will abide by the conservation recommendations outlined in the US Fish and Wildlife Coordination Act Report and the Essential Fish Habitat conservation recommendations provided by NMFS, where practicable and justified.
	Public Outreach	USACE will commit to a public outreach strategy by holding a public meeting and inviting interested persons to attend to learn about the construction of the project. USACE will also maintain a website with geospatial information concerning the location and status of construction.
	Coastal Zone Management	USACE will abide by the conditions outlined in the SCDHEC-OCRM coastal zone consistency determination
Pre-, during, and Post-construction	Monitoring	USACE will perform pre-, during, and post-construction monitoring as detailed in Appendix P of the Main Report.
Post - Construction	Adaptive Management	USACE will commit to coordinating adaptive management and corrective actions related to project impacts and monitoring results with resource agencies.

7.0 PUBLIC/AGENCY PARTICIPATION AND COMMENTING

The study coordination effort involved keeping the public, state, and federal agencies informed of study progress and obtaining feedback. The study involved close coordination between the Corps of Engineers and the sponsor. The Corps of Engineers conducted the study, consolidated information from other agencies, formulated plans, and coordinated study findings at various points during the study. The Project Delivery Team encouraged participation of environmental resource agencies during the formulation of data gathering plans for sediment analysis, environmental resource evaluations and related numerical modeling. The harbor and docking pilots, U.S. Coast Guard, maritime interests, the sponsor, and the public provided recommendations and reviews of potential measures to resolve navigation concerns in small group and public meetings. In addition to reviews by the public and other local, state, and federal agencies, USACE requires quality control and agency technical reviews during the study process. Consistent with the Water Resources Development Act 2007, the project underwent independent external peer review (IEPR) concurrent with the public review.

7.1 Authority

Public involvement during this study is being conducting in compliance with the following federal laws and regulations:

- National Environmental Policy Act (NEPA) of 1969, as amended (Pub. L. 91-190, 42 U.S.C. 4321-4347, January 1, 1970, as amended by Pub. L. 94-52, July 3, 1975, Pub. L. 94-83, August 9, 1975, and Pub. L. 97-258, § 4(b), Sept. 13, 1982);
- U.S. Clean Water Act, Section 404(a);
- Council on Environmental Quality Regulations for Implementing the Procedural Provisions of NEPA, Sec. 1501.7 Scoping and Sec. 1506.6 Public Involvement;
- 30 CFR Part 230 and Engineering Regulation (ER) 200-2-2;
- ER 1105-2-100.

federal agencies are required under NEPA to undertake an assessment of the environmental effects of their proposed actions prior to making decisions. Two major purposes of the environmental review process are better informed decisions and citizen involvement in weighing the effects of those decisions. There are three federal agencies that have particular responsibilities for NEPA. Primary responsibility is vested in the Council on Environmental Quality (CEQ), established by Congress as outlined in NEPA. The U.S. Environmental Protection Agency (USEPA) Office of Federal Activities reviews environmental impact statements (EISs) and some environmental assessments (EAs) issued by federal agencies. Another government entity that may become involved in NEPA is the U.S. Institute for Environmental Conflict Resolution, which was established by the Environmental Policy and Conflict Resolution Act of 1998 to assist in resolving conflict over environmental issues that involve federal agencies.

In 1978, CEQ issued binding regulations directing agencies on the fundamental requirements necessary to fulfill their NEPA obligations. The CEQ regulations set forth minimum requirements for agencies. The CEQ regulations also called for agencies to create their own implementing procedures that supplement the minimum requirements based on each agency's specific mandates, obligations, and missions. In accordance with these regulations, the USACE put in place ER 2002-2 (30 CFR Part 230) specific to NEPA compliance, as well as ER 1105-2-100 to provide, among other things, specific internal guidance on a number of environmental compliance issues including NEPA.

7.2 Scoping and Public Meetings

As stated by the CEQ, there shall be an early and open process for determining the scope of issues to be addressed and for identifying the significant issues related to a proposed action. This process is called scoping. The CEQ identifies the public that should be involved in the scoping process as affected federal, state, and local agencies, any affected Indian tribe, the proponent of the action, and other interested persons (including those who might not be in accord with the action on environmental grounds).

In compliance with ER-200-2-2 and CEQ Regulation 1501.7, a Notice of Intent (NOI) was published in the Federal Register (Vol. 76, No. 156, August 12, 2011) to advertise the intent of the USACE to prepare an Environmental Impact Statement. NEPA scoping was an important part in the development of study objectives, identification of constraints and in determining the significant concerns of the public and agencies. In accordance with the NEPA, an information letter was sent to resource agencies, tribes and special interest groups on August 11, 2011. Additionally, NEPA scoping meeting information was mailed to interested parties in November, 2011. A scoping meeting with the resource agencies was held on October 4, 2011. The NEPA Scoping meeting was held on December 13, 2011, at Mark Clark Hall, the Citadel, in Charleston, South Carolina. The purpose of the meeting was to solicit for views and comments regarding environmental and cultural resources, study objectives, and other important features/concerns in the study area. The following list identifies the main issues have generated comments and concerns from stakeholders, and are discussed thoroughly within the EIS:

A. ***NEPA process related:*** It was stated that the USACE should avoid an overly restrictive statement of purpose in the EIS that limits the alternatives analysis.

B. ***Economics:*** The general public and agencies want to understand how the project would use updated economic data, including growth trends to evaluate alternatives.

C. ***Salinity Impacts:*** How the proposed deepening may affect salinity levels within the Charleston Harbor has generated substantial concern and comments. Specifically, this concern relates to impacts to wetland communities, intrusion to the Bushy Park reservoir, and groundwater.

D. ***Sea level rise:*** Many citizens, stakeholder, and agencies were concerned about the impact of sea level rise cumulatively evaluated with the impacts of the project.

E. ***Dissolved oxygen:*** Many citizens, stakeholder, and agencies were concerned about the impact of the proposed project on the exiting dissolved oxygen concerns in Charleston Harbor. References were made to the existing Total Maximum Daily Load (TMDL) that regulates the amount of oxygen demanding substances can be discharged into the Harbor without contravening the water quality standard.

F. ***Sediment quality and disposal:*** Must thoroughly review impacts related to sediment toxics and dredged material disposal.

G. ***Fish and wildlife habitat:*** Many comments were related to ensuring that the project won't significantly impact threatened and endangered species as well as other fish and wildlife resources, including bird habitat.

H. ***Shoreline Erosion:*** The general public and agencies are concerned with existing erosion problems facing many areas in Charleston Harbor and how the proposed deepening may affect this issue. Some of these stakeholders have also requested that USACE place dredged material along certain shorelines to reduce the effects of erosion. These areas include Crab Bank, Morris Island, Shutes Folly, Ft. Sumter, etc.

I. ***Air quality:*** The general public and agencies want to understand how the project would influence air quality in the region, including priority pollutants, toxics and greenhouse gases. Also of concern was the potential concentration of pollutants in certain areas and impacts to environmental justice communities.

J. ***Cultural resources:*** The general public and agencies were concerned about impacts to cultural and historic resources, both in-water and land-side.

Another public meeting was held on April 30, 2013, at Mark Clark Hall, the Citadel to discuss the proposed project, show the studies and analyses that had been completed at that time, and again solicit the public for comments. This meeting was held in order to provide a project mid-point opportunity for comment, and was in addition to the NEPA-required meetings. Written comments from federal, state, and local governmental agencies, various private and non-profit organizations, and individuals are included in NEPA Scoping and Coordination Appendix Q. Both of the meetings followed a similar format consisting of a brief presentation/remarks, followed by an informal poster session which provided stakeholders with opportunity to further discuss the study with the experts. The meetings were organized around three basic themes: Environmental, Engineering, and Economics. In addition, there were informative displays related to project schedule, process, and plan formulation processes. The meetings were advertized through the local media (newspaper and in some cases television), mailings, e-mailing, and on the study website.

The Draft IFR/EIS was released for public review on October 10, 2014. A Notice of Availability (NOA) was published in the Federal Register on the same day (Federal Register 79:197 / Friday, October 10, 2014). The report was released for a 45 day public review period and no requests for extension were received. The public meeting for the release of the Draft IFR/EIS was held on October 24, 2014 at the Citadel Alumni Center. The meeting was held in order to present the findings of the study and the recommended plan to interested members of the public.

The NOA of the Final Integrated Feasibility Report and Environmental Impact Statement (IFR/EIS) will be published in the Federal Register to initiate the 30 day public review/comment period.

Study presentations, reports, minutes to meetings, and other documents can be found at the following study website: http://www.sac.usace.army.mil/Missions/CivilWorks/CharlestonHarborPost45.aspx.

A mailing list of recipients can be found in Appendix Q. Although not an exhaustive list, some areas of public interest and/or concern are presented below:

- Dredged material placement
- Beneficial use of dredged material / regional sediment management
- Effects on national and regional economics
- Water quality of the system
- Compliance with NEPA
- Shoreline erosion
- Documentation of existing resources
- Quality and quantity of mitigation
- Modeling inputs and methods
- Impacts to endangered species
- Climate change and sea level rise

- Determination of economic benefits
- Sediment chemistry
- Determination of impacts to various resources
- Impacts to aquifers and groundwater

Details on the comments received during the public review of the Draft IFR/EIS, along with USACE responses are included in the NEPA Scoping and Coordination Appendix (Appendix Q).

7.3 Agency Coordination



Federal, state and local agencies were invited to attend meetings and provide comments throughout the scoping and public involvement process included the USACE, U.S. Coast Guard (USCG), U.S. Environmental Protection Agency (USEPA), U.S. Fish and Wildlife Service (USFWS), U.S. Geological Survey, U.S. Forest Service, US. Department of Agriculture, the South Atlantic Fishery Management Council, National Park Service, and National Marine Fisheries Service (NMFS). State agencies included the SC Department of Natural Resources, SC Department of Health and Environmental Control (SCDHEC), SCDHEC-Office of Ocean and Coastal Resource Management, SC Department of Archives and History, Berkeley Charleston Dorchester Council of Governments, and the South Carolina Sea Grant Consortium.

At the beginning of the NEPA study process, resource agencies were asked to participate on an Interagency Coordination Team (ICT) and to sign an ICT Charter that established a commitment to work together in a timely manner. While the charter was never signed due to several agencies expressing concerns over it, the ICT framework was still utilized throughout the study process. Throughout the study, the team had extensive coordination considering the accelerated schedule associated with this project. The following list presents the main points of official coordination with resource agencies, and do not document the many phone calls, small meetings, and emails between District staff and resource agency personnel during the feasibility phase.

1) Oct 4, 2011: Interagency Coordination Team kickoff meeting/scoping meeting
2) November 22, 2011: Sediment testing ICT meeting
3) December 11, 2011: Environmental Fluid Dynamics Code (EFDC) ICT meeting
4) December 2011 – January 2012: multiple commenting mechanisms for EFDC data collection plan
5) July 25, 2012: CAR kickoff meeting

6) December 5, 2012: ICT study progress report (ICT update)
7) February 19, 2013: ICT distribution of cultural resources and hardbottom resources report
8) February 25, 2013: EFDC calibration meeting
9) April 29, 2013: Beneficial use of dredged material ICT meeting
10) May 23, 2013: ICT study progress report (ICT update)
11) June 12, 2013: ICT distribution of minutes from DHEC/USACE meeting on DO and TMDL analysis
12) July 26, 2013: ICT distribution of wetlands characterization report
13) August 6, 2013: ICT distribution of sediment contaminants report
14) September 20, 2013: ICT study progress report (ICT update)
15) September 20, 2013: ICT distribution of diving report on 3 potential cultural resource anomalies
16) November 20, 2013: ICT meeting on hardbottom habitat and wetland impact methodology
17) December 11, 2013: ICT meeting on dissolved oxygen impacts and Habitat Suitability Index results
18) February 13, 2014: Hardbottom habitat impact determination meeting
19) February 27, 2014: Meeting with USACE/BCDCOG/SCDHEC to discuss dissolved oxygen modeling and the TMDL
20) March 3, 7, 8, 2014: Meetings with USACE/BCDCOG/SCDHEC/TMDL dischargers (industry) to discuss obtaining real discharge data for TMDL analysis
21) March 12, 2014: ICT provided information on options for wetland mitigation calculation. USACE requested feedback on options and the tentative selection of UMAM.
22) April 16-17, 2014: ICT meeting on wetlands mitigation determination using UMAM – field work on the Cooper River
23) April 23, 2014: ICT distribution of UMAM scoring for Cooper River wetlands
24) April – May 2014: Comments and concurrence on UMAM scoring received from SCDHEC, SCDNR, and USEPA.
25) April 24, 2014: Meeting with SCDHEC/USEPA/USACE to gain support for new analysis of cumulative impacts to DO from Post 45 and dischargers
26) June 6, 2014: ICT distribution of hardbottom habitat impact assessment, HEA findings, mitigation concept, and monitoring/adaptive management plan
27) June – July 2014: Informal consultation with NMFS and USFWS on Draft Biological Assessment findings

28) June – July 2014: Informal coordination with NOAA on Essential Fish Habitat assessment and dissolved oxygen data requests.
29) July 9, 2014: Meeting with SCDHEC to discuss dissolved oxygen and TMDL modeling results.
30) Ongoing throughout project: Coordination with USFWS for the Coordination Act Report development.
31) November 2014 – February 2015: extensive coordination with wetland ICT concerning wetland impacts and mitigation strategy
32) December 8, 2014: Received Coastal Zone Consistency determination from SCDHEC-OCRM, with conditions
33) January 28-29, 2015: USACE initiated a 2 day meeting/field work with the wetland ICT to address concerns with wetland impact determination and UMAM scores for the preservation of the identified mitigation parcel.
34) March 2, 2015: Meeting between USACE, SCDAH, and NPS to discuss concerns related to ship wakes and significant historic resources in Charleston Harbor
35) March 3, 2015: Meeting between USACE and EPA to discuss significant concerns with the Draft IFR/EIS.
36) March 16, 2015: Received 401 Water Quality Certification from SCDHEC, with conditions
37) April 17, 2015: Received Section 106 of the NHPA concurrence from SCDAH with the District's no adverse affect determination, contingent upon the implementation of the proposed Programmatic Agreement between USACE, SCDAH, and NPS.
38) April 22, 2015: Received NMFS Biological Opinion

Comments received from agencies during the public review of the draft, along with USACE responses are included in the NEPA Scoping and Coordination Appendix (Appendix Q).

7.4 Environmental Operating Principles

The USACE Environmental Operating Principles (EOPs) have been taken into consideration throughout the study process, and will continue to be part of construction and operation of the proposed Charleston Harbor Post 45 Project. Below are the USACE EOPs:

- Foster sustainability as a way of life throughout the organization.
- Proactively consider environmental consequences of all USACE activities and act accordingly.
- Create mutually supporting economic and environmentally sustainable solutions.
- Continue to meet our corporate responsibility and accountability under the law for activities undertaken by the USACE, which may impact human and natural environments.
- Consider the environment in employing a risk management and systems approach throughout the life cycles of projects and programs.

- Leverage scientific, economic and social knowledge to understand the environmental context and effects of USACE actions in a collaborative manner.
- Employ an open, transparent process that respects views of individuals and groups interested in USACE activities.

In coordination with the agencies and other stakeholders, the USACE proactively considered the environmental consequences of the proposed deepening project. Avoidance and minimization measures were evaluated, and mitigation will be provided to offset unavoidable adverse impacts to natural resources (i.e., wetlands and submerged aquatic vegetation). In accordance with the mandate of this designation and the EOPs, the USACE has proposed a project that supports economic and environmentally sustainable solutions.

7.5 USACE Campaign Plan

USACE Vision: A great engineering force of highly disciplined people working with our partners through disciplined thought and action to deliver innovative and sustainable solutions to the Nation's engineering challenges.

USACE Mission: Provide public engineering services in peace and war to strengthen our Nation's security, energize the economy, and reduce risks from disasters.

Commander's Intent: The USACE will be one disciplined team, in thought, word, and action. We will meet our commitments, with and through our partners, by saying what we will do and doing what we will say. Through execution of the Campaign Plan, the USACE will become a GREAT organization as evidenced by the following in all mission areas: delivering superior performance; setting the standard for the profession; making a positive impact on the Nation and other nations; and being built to last by having a strong "bench" of educated, trained, competent, experienced, and certified professionals.

The FR/EIS for this project is consistent with these themes. The vertical USACE project team jointly applied the latest policy and planning guidance and worked closely with federal, State and local stakeholders and professionals familiar with the problems, opportunities and resources of Charleston Harbor to fully and fairly evaluate the feasibility of deepening the port in an expeditious fashion to achieve the common goals of providing safe, effective, and efficient navigation while protecting the environment. Extensive reviews requiring the timely cooperation of internal and external team members were performed to ensure quality and consistency.

8.0 LIST OF PREPARERS

The project delivery team for the Post 45 study was extensive. It comprised team members from every District in the USACE South Atlantic Division (Wilmington, Charleston, Savannah, Jacksonville, and Mobile). The team members listed below provided substantial text to the Integrated Feasibility Report/Environmental Impact Statement. Primary authors are marked with an asterisk.

Name (First Last)	Affiliation
Colt Bowles	Plan Formulator, Planning and Environmental Branch, Charleston District, USACE
Sara Brown	Hydraulic Engineer, Charleston District, USACE
George Ebai	Economist, Planning and Environmental Branch, Charleston District, USACE
Belinda Estabrook	Real Estate, Planning and Purchase Section, Savannah District, USACE
Jason Evert	Biologist, Dial Cordy and Associates
Kelly Kaltenbach	Geologist, Geotechnical and Dam Safety Section, Wilmington District, USACE
Mark Messersmith*	Biologist, Planning and Environmental Branch, Charleston District, USACE
Patrice Morey	Planning Division, Jacksonville District, USACE
Todd Nettles	Economist, Chief, Deep Draft Navigation Planning Center of Expertise, Mobile District, USACE
Dick Powell*	Plan Formulator, Planning Division, Jacksonville District USACE
Bret Walters*	Chief, Planning and Environmental Branch, Charleston District, USACE
Brian Williams	Project Manager and Chief of Programs and Civil Project Management, Charleston District, USACE

The USACE was assisted in the preparation for its review of several Appendices by Dial Cordy and Associates and Gulf Engineering Consultants (DCA/GEC), A Joint Venture. Specifically:

- Appendix H - Essential Fish Habitat Assessment (Jason Evert, DCA)
- Appendix I - Hardbottom Impacts and HEA (Jason Evert and Bill Precht, DCA)
- Appendix L - Wetlands Impact Assessment (Jason Evert and Mike Rice, DCA)
- Appendix O - Cumulative Impacts Assessment (Eddy Carter and Lauren Averill, GEC and Jason Evert, DCA)
- Appendix P - Mitigation, Monitoring and Adaptive Management (Jason Evert, Steve Dial and Bill Precht, DCA)

9.0 RECOMMENDATIONS

I concur with the findings presented in this report. The Recommended Plan (RP) developed is technically sound, economically justified, and socially and environmentally acceptable.

I recommend that the existing deep-draft navigation project at Charleston Harbor be modified to provide for implementation of a federal project for deeper draft commercial vessels in accordance with the locally preferred plan selected herein, with such further modifications thereto as in the discretion of the Chief of Engineers, may be advisable. Mitigation is principally required for approximately 323.7 acres of indirect impacts to freshwater wetlands projected to occur through a shift from fresh/brackish marsh to brackish/salt march as a result of salinity changes due to the deepening and widening. Mitigation is also provided for hardbottom impacts. Aids to navigation would be provided at 100% federal cost. For the purpose of calculating the Section 902 limit, the estimated first cost of the project is $493,300,000 including an estimated federal share of $224,300,000 and an estimated non-federal share of $269,000,000. The average annual costs are $28,000,000. Average annual benefits are $108,900,000 with a benefit to cost ratio of 3.89.

The RP conforms to the essential elements of the U.S. Water Resources Council's Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies and complies with other Administration and legislative policies and guidelines on project development. If the project were to receive funds for federal implementation, it would be implemented subject to the cost sharing, financing, and other applicable requirements of federal law and policy for navigation projects including WRDA 1986, as amended; and would be implemented with such modifications, as the Chief of Engineers deems advisable within his discretionary authority. Aids to navigation are to be funded by the U.S. Coast Guard. Federal implementation is contingent upon the non-federal sponsor agreeing to comply with applicable federal laws and policies. Prior to implementation, the non-federal sponsor shall agree to:

a. Provide, during the periods of design and construction, funds necessary to make its total contribution for commercial navigation equal to:

(1) 50 percent of the cost of design and construction of the general navigation features (GNFs) and mitigation (including mitigation LERR) attributable to dredging to a depth in excess of -45 feet MLLW but not in excess of -50 feet MLLW, plus

(2) 100 percent of the costs of GNFs and mitigation (including mitigation LERR) attributable to dredging to a depth over -50 feet MLLW;

b. Provide all lands, easements, rights-of-way, relocations, and disposal areas (LERRs), including those necessary for the borrowing of material and the disposal of dredged or excavated material, and perform or assure the performance of all relocations, including utility relocations, all as determined by the federal government to be necessary for the construction or operation and maintenance of the GNFs. Provide and maintain during the authorized life of the project the mitigation lands (approximately 665.6 acres) determined required for mitigation due to wetland impacts for the project.

c. Pay with interest, over a period not to exceed 30 years following completion of the period of construction of the GNFs, an additional amount equal to 10 percent of the total cost of construction of the GNFs less the amount of credit afforded by the Government for the value of the LERR is provided by the sponsor for the GNFs. If the amount of credit afforded by the Government for the value of LERR, and relocations, including utility relocations, provided by the sponsor equals or exceeds 10 percent of the total cost of construction of the GNFs, the sponsor shall not be required to make any contribution under this paragraph, nor shall it be entitled to any refund for the value of LERR and relocations, including utility relocations, in excess of 10 percent of the total cost of construction of the GNFs.

d. Provide, operate, and maintain, at no cost to the Government, the local service facilities in a manner compatible with the project's authorized purposes and in accordance with applicable federal and state laws and regulations and any specific directions prescribed by the federal government.

e. Provide 100 percent of the excess cost of operation and maintenance of the project over that cost which the federal government determines would be incurred for operation and maintenance of a depth in excess of the NED plan.

f. Accomplish all removals determined necessary by the federal government other than those removals specifically assigned to the federal government;

g. Give the federal government a right to enter, at reasonable times and in a reasonable manner, upon property that the Sponsor owns or controls for access to the project for the purpose of completing, inspecting, operating and maintaining the GNFs.

h. Hold and save the United States free from all damages arising from the construction or operation and maintenance of the project, any betterments, and the local service facilities, except for damages due to the fault or negligence of the United States or its contractors.

i. Keep, and maintain books, records, documents, and other evidence pertaining to costs and expenses incurred pursuant to the project, for a minimum of 3 years after completion of the accounting for which such books, records, documents, and other evidence are required, to the extent and in such detail as will properly reflect total cost of the project, and in accordance with the standards for financial management systems set forth in the Uniform Administrative Requirements for Grants and Cooperative Agreements to State and local governments at 32 CFR, Section 33.20.

j. Perform, or ensure performance of, any investigations for hazardous substances that are determined necessary to identify the existence and extent of any hazardous substances regulated under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), 42 USC 9601–9675, that may exist in, on, or under LERR that the federal government determines to be necessary for the construction or operation and maintenance of the GNFs. However, for lands, easements, or rights-of-way that the Government determines to be subject to the navigation servitude, only the Government shall perform such investigations unless the federal government provides the sponsor with prior specific written direction, in which case the sponsor shall perform such investigations in accordance with such written direction.

k. Assume complete financial responsibility, as between the federal government and the sponsor, for all necessary cleanup and response costs of any hazardous substances regulated under CERCLA that are located in, on, or under LERR that the federal government determines to be necessary for the construction or operation and maintenance of the project.

l. Agree, as between the federal Government and the non-Federal Sponsor, that the non-Federal Sponsor shall be considered the operator of the local service facilities for the purpose of CERCLA liability.

m. To the maximum extent practicable, perform its obligations in a manner that will not cause liability to arise under CERCLA.

n. Comply with Section 221 of Public Law 91-611, Flood Control Act of 1970, as amended, (42 U.S.C. 1962d-5b) and Section 101(e) of the WRDA 86, Public Law 99-662, as amended, (33 U.S.C. 2211(e)) which provide that the Secretary of the Army shall not commence the construction of any water resources project or separable element thereof, until the sponsor has entered into a written agreement to furnish its required cooperation for the project or separable element.

o. Comply with the applicable provisions of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, Public Law 91-646, as amended, (42 U.S.C. 4601-4655) and the Uniform Regulations contained in 49 CFR Part 24, in acquiring lands, easements, and rights-of-way necessary for construction, operation, and maintenance of the project including those necessary for relocations, the borrowing of material, or the disposal of dredged or excavated material; and inform all affected persons of applicable benefits, policies, and procedures in connection with said act.

p. Comply with all applicable federal and state laws and regulations, including, but not limited to: Section 601 of the Civil Rights Act of 1964, Public Law 88-352 (42 U.S.C. 2000d), and Department of Defense Directive 5500.11 issued pursuant thereto; Army Regulation 600-7, entitled "Nondiscrimination on the Basis of Handicap in Programs and Activities Assisted or Conducted by the Department of the Army"; and all applicable federal labor standards requirements including, but not limited to, 40 U.S.C. 3141-3148 and 40 U.S.C. 3701-3708 (revising, codifying and enacting without substantive change the provisions of the Davis-Bacon Act (formerly 40 U.S.C. 276a et seq.), the Contract Work Hours and Safety Standards Act (formerly 40 U.S.C. 327 et seq.), and the Copeland Anti-Kickback Act (formerly 40 U.S.C. 276c)).

q. Provide the non-federal share of that portion of the costs of mitigation and data recovery activities associated with historic preservation, that are in excess of 1 percent of the total amount authorized to be appropriated for the project.

r. Not use funds from other federal programs, including any non-federal contribution required as a matching share therefore, to meet any of the sponsor's obligations for the project unless the federal agency providing the federal portion of such funds verifies in writing that such funds are authorized to be used to carry out the project.

The recommendation contained herein reflects the information available at this time and current departmental policies governing formulation of individual projects. It does not reflect program and budgeting priorities inherent in the formulation of a national civil works construction program or the perspective of higher review levels within the executive branch. Consequently, the recommendation may be modified before it is transmitted to the Congress as a proposal for authorization and implementation funding. However, prior to transmittal to the Congress, the State of South Carolina, the South Carolina State Ports Authority (the non-Federal Sponsor), interested federal agencies, and other parties will be advised of any significant modifications and will be afforded an opportunity to comment further.

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John T. Litz
Lt. Colonel, U. S. Army
District Commander

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