U.S. Army Corps of Engineers
Charleston District

APPENDIX O

CHARLESTON HARBOR POST 45

Charleston, South Carolina

Cumulative Impacts Analysis

03 October 2014

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1.0 AUTHORITY AND APPROACH

The National Environmental Policy Act (NEPA), as implemented by Council on Environmental Quality (CEQ) regulations (40 CFR §§ 1500 -1508) requires federal agencies, including the U.S. Army Corps of Engineers (USACE), to consider cumulative impacts in rendering a decision on a federal action under its jurisdiction. Hence, this appendix to the Charleston Harbor Post 45 Feasibility Report and Environmental Impact Statement (FR/EIS) discusses potential impacts resulting from other facilities, operations, and activities that in combination with potential impacts from the Proposed Action may contribute to cumulative impacts in the proposed project impact zone. 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. Cumulative effects include, but are broader than, the direct and indirect effects described in other sections of the EIS. According to 40 CFR 1508.8, “direct effects” are caused by the action and occur at the same time and place, while “indirect effects” are caused by the action and are later in time or farther removed in distance, but are still reasonably foreseeable. Indirect effects may include growth inducing effects and other effects related to induced changes in the pattern of land use, population density or growth rate, and related effects on air and water and other natural systems, including ecosystems. A cumulative impact analysis assesses the total impact of the direct and indirect effects of the proposed action in combination and interaction with the effects of all other activities impacting the same resources.

An inherent part of the cumulative effects analysis is the uncertainty surrounding actions that have not yet been fully developed. The regulations provide for the inclusion of uncertainties in the FR/EIS analysis, and state that “when an agency is evaluating reasonably foreseeable significant adverse effects on the human environment in an FR/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).

The geographic area used for the scope of this analysis (the project impact zone) varies for each affected resource. Air quality is generally evaluated on a county by county basis by United States Environmental Protection Agency (USEPA), so cumulative effects on air quality are based on impacts to the counties sharing the harbor: Charleston, Dorchester, and Berkeley (as these units represent the spatial scale at which effects are determined). Water quality, however, may be affected in the harbor, upstream of the harbor (including the Wando, Ashley, and Cooper Rivers), downstream through the entrance channel, and at/near the proposed material disposal area. Wetland habitats to be considered for cumulative impacts are generally located in riparian areas that are directly connected to the harbor and affected rivers and up to a certain elevation (see wetland impact appendix for additional details), but not necessarily throughout the nearby counties. Hardbottom marine habitats are assessed across the county’s offshore waters. Sediment dynamics are evaluated through the tributaries and into the harbor, while shorelines evaluated are located in the harbor and on the coast. Aesthetics are considered relative to the harbor and surrounding lands.

The temporal scope of this evaluation spans the initial dredging of the harbor to anticipated future actions within the projected 50-year life of the proposed action in the geographic areas identified above for the various evaluated resources.

Finally, for the purpose of evaluating the effects of past and potential future actions, this evaluation focuses on (1) actions that would impact the geographic areas (noted above) that would be impacted by the proposed Federal action, (2) actions that affect the resources that are affected by the proposed action, and (3) the actions that would be induced by the proposed action. In accordance with the intent of the USACE planning modernization initiative, the analysis focuses on the specific resources and impact areas of concern and excludes analysis related to areas and resources that would not be meaningfully impacted by the proposed action or induced actions. Also, in accordance with CEQ guidance, "agencies are not required to list or analyze the effects of individual past actions unless such information is necessary to describe the cumulative effect of all past actions combined. Generally, agencies can conduct an adequate cumulative effects analysis by focusing on the current aggregate effects of past actions without delving into the historical details of individual past actions" (*Guidance on the Consideration of Past Actions in Cumulative Effects Analysis*, CEQ 2005). Aggregate past actions are noted where relevant in Section 4.0. Furthermore, the analysis of impacts must focus on specific resources or impact areas of concern. Focusing the analysis only on resources where there is a likelihood of reasonably foreseeable impacts supports the intent of the NEPA process, which is "to reduce paperwork and the accumulation of extraneous background data; and to emphasize real environmental issues and alternatives" [40 CFR Part 1500.2(b)].

However, actions undertaken by federal, state, and local agencies are particularly highlighted below in Section 2.0 because their results have typically affected the widest geographic portion of the project area, have been ongoing for decades and are likely to continue throughout the life of the project, and have impacted many of those resources affected by the proposed action (e.g., water quality, wetlands, etc.). While USACE Charleston District and South Carolina Ports Authority (SCSPA) have been responsible for most dredging in the harbor, USACE and Santee Cooper (also known as the South Carolina Public Service Authority) have been or are involved with permitting and/or managing the large reservoirs upstream of the harbor. Information in Section 2.0 does not comprise the only actions to affect resources cumulatively in the project area, but they have had (and will continue to have) the greatest effect on the Charleston Harbor ecosystem and a working knowledge of these actions provides an important context for understanding the scope and scale of cumulative effects. Section 3.0 lists resources that will not likely be cumulatively affected by the Proposed Action, and Section 4.0 details those that may be cumulatively affected, regardless of action (i.e., single or aggregate).

2.0 SELECTED PAST, PRESENT, AND FUTURE ACTIONS

2.1 Past Actions

2.1.1 Water Management

2.1.1.1 Introduction

Stakeholders have requested that USACE examine the influence of the reservoir system upstream of Charleston Harbor during assessment of cumulative impacts for the proposed project. For the purposes of this assessment, the construction of the dams and canals (and the resulting flow configuration) comprises "past actions" that are among factors influencing the existing condition of the project area. Releases of water from reservoirs affect not only water quantity, depths, and flows downstream, but also the quality of water including salinity and dissolved oxygen levels. Therefore, the discussion below includes consideration of the water management system (past modifications, currently proposed actions, and likely future actions) in conjunction with the federal navigation project.

2.1.1.2 Watershed Configuration

Ashley River. The Ashley River is a blackwater/tidal river rising from the Wassamassaw and Great Cypress Swamps in western Berkeley County and flowing into the western part of Charleston Harbor. Areas of the river are bordered by historic plantations; a large portion of the Ashley River Basin is now occupied by residential or commercial development (USACE 1996). It consolidates its main channel about 5-miles west of Summerville, widening into a tidal estuary just south of Fort Dorchester. The river then flows for approximately 17 miles along the historical banks of the City of North Charleston before reaching peninsular Charleston. The much wider Ashley joins the Cooper River off the Battery in Charleston (at the tip of the peninsula, off White Point Garden) to form Charleston Harbor before discharging into the Atlantic Ocean.

Wando River. The Wando River is a tidewater river in the coastal area of South Carolina. It begins in the town of Awendaw and empties into the Cooper River at Charleston Harbor. The Wando River originates in the coastal plain and flows into the eastern part of Charleston Harbor. Portions of the lower Wando River are bordered by marsh which changes to woodland in upper reaches of the river. Development along the Wando River has been encouraged with completion of Interstate Highway 526 and the Ravenel Bridge. At present, residences and subdivisions are present along stretches of the river as are a shipyard and the State Port Authority's Wando River Terminal (USACE 1996).

Santee River. The Santee River is formed by the confluence of the Congaree and Wateree rivers (about seven miles upstream from Lake Marion) and generally flows southeast into Lake Marion, which is impounded by the Santee Dam (see Figure 1). The Santee's flows from the lake are either diverted to Lake Moultrie via the 7.5-mile-long Diversion Canal or pass through Santee Dam via the spillway or the Santee Hydroelectric Station. Waters from the spillway or hydroelectric station flow downstream east (north of Lake Moultrie) in a 37-mile-long bypass reach until joined by the USACE Rediversion Canal (see below) from Lake Moultrie, and the river continues to its divergence into the North and South Santee rivers (approximately 12 miles from the coast), which flow into the Atlantic Ocean approximately 45 miles northeast of Charleston. The Santee River Basin encompasses 1,279 square miles and comprises 11 watersheds (including the Rediversion Canal).

Cooper River. Formerly a tidal estuary prior to construction of the Santee Cooper Power and Navigation Project (i.e., the creation of two reservoirs on the Cooper and Santee Rivers for hydroelectric power generation and navigation purposes), the Cooper River is now a major freshwater river that flows southeasterly for about 50 miles to Charleston Harbor. The Cooper River starts with flows released from Lake Moultrie (via Pinopolis Dam) that join Wadboo Creek. The East Branch Cooper River flows into it approximately 18 miles from the tailrace of Pinopolis Dam at the juncture called the "Tee." Upstream of the Tee, the river is a meandering natural channel bordered by extensive tidal marshes and old rice fields in varying states of disrepair. This area contains large amounts of poorly defined overbank storage and unmeasurable flows through broken levees between the main channel and rice fields. The East Branch of Cooper River is a tidal slough throughout its eight-mile reach. On the Cooper River, from the Tee to Goose Creek, industries are located along the west bank at the river and extensive *Spartina altemiflora* salt marshes dominate the east bank. Downstream of the Goose Creek confluence, the main channel of the Cooper River has been dredged by USACE for navigation purposes. Industries dominate the west bank of the river and the east bank contains numerous dredge-material disposal areas. The Cooper River is tidally affected throughout its entire reach (Conrads et al 2002), and its basin covers 843 square miles, including Lake Moultrie.

The Rediversion Canal is an 11.5-mile canal connecting outflow from Lake Moultrie to the Santee River. The Rediversion Canal was constructed by USACE in 1985 as a mechanism to reduce shoaling in Charleston Harbor. In addition to the canal, USACE constructed an 84 MW hydroelectric generating station in the canal at St. Stephen, approximately half the distance from the lake to the Santee River. The SCPSA (South Carolina Public Service Authority, i.e., "Santee Cooper") operates the St. Stephen station cooperatively with the Jefferies station as part of the "River Rediversion Agreement," though this development is not part of the licensed Santee Cooper Project. About 70% of the outflow from Lake Moultrie currently passes through this canal to the lower Santee River (SCPSA 2004a).

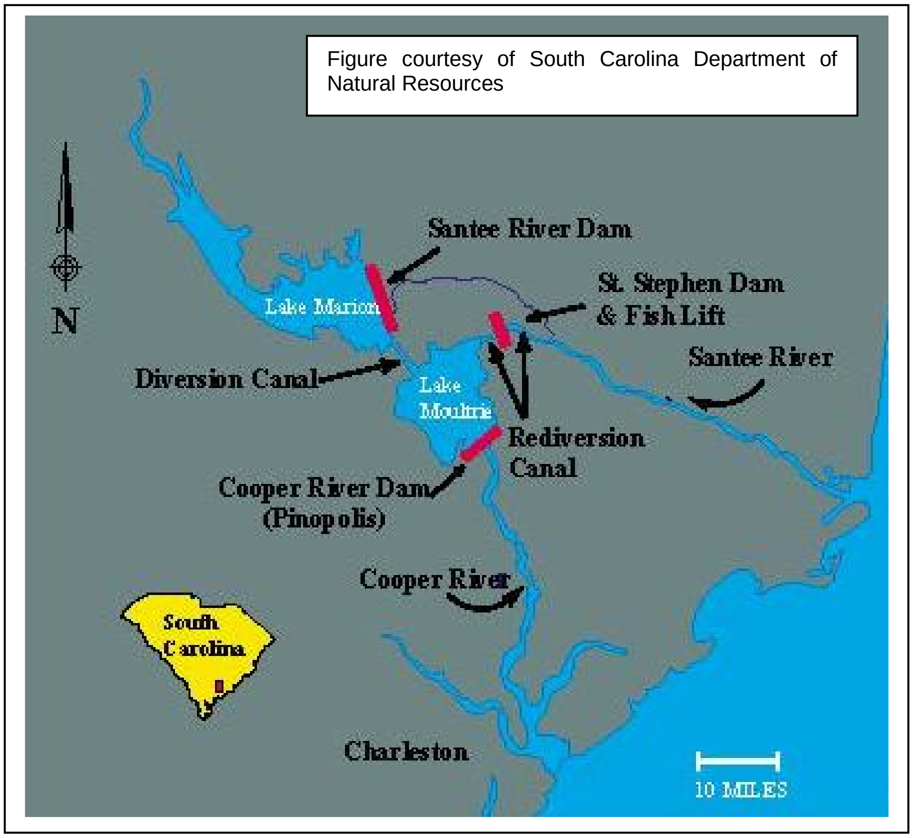

Figure 1 Santee Cooper Water Management Features

2.1.1.3 Discharges and Flows

Santee-to-Cooper Diversion. Charleston Harbor and the Cooper River have both been subject to significant alterations. Prior to 1941, Charleston Harbor was well-mixed, tidally dominated estuarine system with a freshwater discharge via the Cooper River of only <u>2 m^3/s</u> (71 cubic feet per second, or "cfs") (Kjerfve 1976). In 1941, however, SCPSA diverted 88% of the Santee River's flow to the Cooper River (via Lake Moultrie) in order to harness hydroelectric power (Kjerfve 1976; Rutz 1987; Kjerfve and Magill 1990). As a consequence, the Cooper River discharge (based on annual average) increased to <u>442 m^3/s</u> (15,610 cfs).

In 1954, the Bushy Park Industrial Complex was established along the east bank of the Back River and the west bank of the Cooper River. Given the abundant freshwater directed toward Charleston from the Santee-to-Cooper diversion, a freshwater reservoir was constructed by damming the Back River at the lower end near the confluence with the Cooper River. This supplied water to the park's industrial users. Durham Canal was constructed as a conduit between the upper end of the reservoir and the freshwater part of the Cooper River (SCWRC 1979).

Cooper-to-Santee Rediversion. The results of diversion brought not only increased water discharge to Charleston Harbor but also increased suspended material loads. This resulted in severe shoaling in the harbor. Maintenance dredging costs for the harbor's navigation channels therefore increased to $5 million annually by 1975 (Kjerfve 1976). Consequently, USACE developed and executed plans to re-divert a portion of the Cooper River (i.e., from Lake Moultrie through an 11.5-mile canal) flow back to the Santee River to alleviate the shoaling problem. In addition to the canal, a hydroelectric plant was built at St. Stephen on the rediversion canal to help offset lost power generation from the Jefferies Hydroelectric Plant. The approximate difference in the water levels between the rediversion canal and St. Stephen tailrace is 46 feet (Kjerfve 1976).

After the rediversion project was fully implemented in August 1985, the flows to the Cooper River were reduced to a level that would alleviate sedimentation in the harbor while ensuring adequate freshwater for the Bushy Park Reservoir through Durham Canal (SCWRC 1979). The weekly average discharge target was set at <u>130 m^3/s</u> (i.e., 4,500 cfs) (Kjerfve and Magill 1990), although instantaneous discharges may vary from 0 to 28,000 cfs, the latter of which is the hydraulic capacity of the facility.

Shoaling in Charleston Harbor remained a concern even a decade after rediversion. In 1995, the South Carolina Public Services Commission (SCPSC) concurred that the weekly average flow for the Jefferies Hydroelectric Station was "sufficiently small enough to substantially reduce shoaling in Charleston Harbor, but also sufficiently large enough to preclude salinity intrusion in the Bushy Park Industrial Complex located down river near Goose Creek, South Carolina" (SCPSA 2004a).

Discharges from Jefferies Station have little effect on water levels. In fact, even with the not insubstantial 4,500 cfs flows, tidal effects (which range from 4 to 6 feet as indicated in SCPSA 2004a and USACE 2006) are still the primary determinant of Cooper River levels. The Cooper River is actually tidally influenced up to the tailrace of the Pinopolis Dam discharge. As a result, a typical tailwater rating curve does not apply. At the base of dam, tailwater elevation is tidally affected by 2 to 4 feet, but can vary from about 1 to 8 feet NGVD within the range of project discharges (SCPSA 2004a). Water levels downstream of Jefferies Station experience only small, temporary effects resulting from dam releases (Normandeau 2002). Typically, dam releases result in less than 12 inches of rise in water level, and that much only during low-tide conditions (that rise is smaller than the range of natural tidal variation).

As of 1990, SCPSA (with concurrence from USACE) voluntarily increased the minimum flow at St. Stephen to 5,600 cfs during the fish-passage season (SCPSA 2004a), i.e., generally March to mid-May. Flows from St. Stephen merge with the 500 cfs minimum flow released from the Santee Station about 37 miles downstream of Santee Dam and proceed another 50 miles to the Atlantic Ocean.

Santee Spillway. The Santee Spillway Hydroelectric Station at Lake Marion maintains a minimum flow of 500 cfs in the Santee River, from downstream of Santee Dam to the Rediversion Canal. Tailwater elevation at the Santee Spillway typically remains at about 27.0 feet NGVD. Although a minimum flow of 500 cfs is mandated, SCPSA routinely discharges a continuous flow of 600 cfs to ensure compliance with the 500-cfs license requirement. All normal inflow exceeding the minimum flow at Santee Station is passed to Lake Moultrie via the Diversion Canal. When inflow to the project exceeds the generating capacity of all three generating stations during high flow conditions, the excess flow is passed through the Santee Spillway Tainter gates (a type of flood gate using a radial arm for opening and closing) (SCPSA 2004a). Both the Jefferies and the USACE St. Stephen station are operated as semi-peaking facilities.

2.1.1.4 Regulatory Issues

On March 15, 2004, SCPSA, filed an application with the Federal Energy Regulatory Commission **(**FERC) for a new license under Part I of the Federal Power Act (FPA), to continue operating its existing 130-megawatt (MV) Santee Cooper Hydroelectric Project (FERC Project No. 199), located on the Santee and Cooper rivers in Berkeley, Calhoun, Claredon, Orangeburg, and Sumter counties, South Carolina. FERC, under authority of the FPA, may issue licenses for up to 50 years for the construction, operation, and maintenance of non-federal hydroelectric projects. The current license was issued on May 9, 1979, and expired on March 31, 2006. In the interim, FERC issued an annual license, which will continue (renewed on an annual basis) until FERC has made a decision on a new license. (See section 2.2.1.1 below for discussion of present/on-going actions.)

2.1.2 Navigation

2.1.2.1 Charleston Harbor

Charleston Harbor has been federally maintained for over 160 years. The River and Harbor Act of 1852 initially authorized navigation improvements to Charleston Harbor (Table 1). The subsequent River and Harbor Act of 1878 authorized the deepening of a channel through the ocean bar to a depth of 21 feet MLW, as well as the construction of a pair of rubble jetties (completed in 1895). In 1898 and 1904, additional dredging occurred in the harbor to secure channel depths of 26 and 30 feet deep, respectively. In October 1940, a 35-foot project was authorized, which provided for a channel from the North Charleston Terminal area out to the 35-foot ocean contour (USACE 2010b).

The October 1974 Interim Feasibility Report, as supplemented by the 1980 *Phase I Advanced Engineering and Design Study of Charleston Harbor*, recommended implementing a 38-foot-deep channel in Shipyard River and 38-foot depths in both the upper and lower turning basins, as well as construction and maintenance of a 40-foot deep navigational channel 26.97 miles in length from the North Charleston Terminal on the Cooper River to the 42-foot ocean contour. A January 1984 report for Charleston Harbor Wando River Extension recommended: (1) federal maintenance of the Wando River navigational channel (completed by the South Carolina State Ports Authority in 1981) and (2) deepening of the Wando River channel from 35 feet to 40 feet (completed by USACE in 1996) (USACE 2010b).

The 1996 Feasibility Study and Environmental Assessment for Charleston Harbor recommended an authorized project depth of 45 feet (47 feet for the entrance channel) plus 2 feet of allowable overdepth and 2 feet of advanced maintenance (total projected dredging depth of 51 feet). The harbor was deepened to that project depth between 1999 and 2004 (USACE 2010a).

Table 1 Major Past Federal Actions at Charleston Harbor Excluding Maintenance

Year	Project	Authorization	Type of Action
1852	Original Dredging	Rivers and Harbors Act (RHA) of 1852	Deepening
1878	Deepen and jetties	RHA of 1878	Deepen to 21 feet MLW out to Ocean Bar;
1899	Deepening	RHA of 1899	Harbor deepening to 26 feet
1904	Deepening	RHA of 1902	Harbor deepening to 30 feet
1940	Deepening and Extending	RHA of 1940	Deepen to 35 feet from ocean contour to North Charleston Terminal
1974 & 1980	Deepening and Extending	Water Resources Development Act (WRDA) of 1986	Channel realignment and Harbor and Shipyard River, entrance channel to 40 feet from North Charleston Terminal out to the 42-foot ocean contour (27 miles), 38-foot deep channel in Shipyard River and upper and lower turning basins.
1996	Deepening	WRDA of 1996	Adoption of Wando River for USACE maintenance; deepen from 35 to 40 feet
1999-2004	Deepening	WRDA of 1996	Harbor to 45 feet (49 entrance channel extending to the 47-foot ocean contour) including +2 feet (allowable overdepth) +2 feet advanced maintenance

The existing Federal navigational channel extends a distance of 26.97 miles from the North Charleston Terminal on the Cooper River to the 47-foot ocean contour. An additional 2.08 mile channel extends up the Wando River to the Wando Welch Terminal (operated by the South Carolina State Ports Authority. The existing Federal channel varies in width from 400 feet (in Town Creek and Wando River) to 1000 feet wide in the entrance channel (Fort Sumter Range).

USACE conducted dredging of the anchorage basin in Charleston Harbor in the fall of 2013. The anchorage basin is a 157-acre span along the shipping channel inland of Fort Sumter. Over 400,000 cubic yards of material was removed and placed in upland disposal areas on Morris Island near Cummings Point (B. Peterson 2013).

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 (USACE 2010b). This was maintenance-dredged (from the harbor to the Coleman Boulevard Bridge) by USACE in January and February 2014.

Typically, maintenance of the harbor occurs on a 12-18 month frequency interval. The anticipated average annual maintenance dredging needs from the federal channels (in the future-without-Post 45-dredging condition) are approximately 2,200,000 cubic yards (USACE 2009b). Dredging in the inner harbor is typically done by cutterhead pipeline dredges with disposal in the upland confined disposal areas. Some areas of the lower harbor reaches are dredged by clamshell dredges, which load sediments into barges that deliver material to the ODMDS (Ocean Dredged Material Disposal Site). Hopper dredges are used to maintain the entrance channel, with material taken to the ODMDS (see Engineering Appendix of the FR/EIS for further discussion).

2.1.2.2 Ocean Dredged Material Disposal Site

The Charleston ODMDS is one of the most active, frequently used sites in the South Atlantic Bight. Since 1987, approximately 40,407,780 million cubic yards of dredged material have been discharged at the Charleston ODMDS.

The general site has been in use since 1896 for disposal activities. The original management plan for ocean dredged materials disposal associated with the Charleston Harbor complex (1987) called for two sites. The permanently designated ODMDS was approximately 2.8 x 1.1 nautical miles in size (See Figure 1 of USACE 2005). This site was designated to receive all dredged material emanating from maintenance dredging activities in the harbor and entrance channels. Surrounding the permanent ODMDS was a larger ODMDS. This site encompassed an area of approximately 5.3 x 2.3 nautical miles (see Figure 1 of USACE 2005, label indicates "larger ODMDS"), and was designated for one-time use, only, for placement of material obtained during the Charleston Harbor Deepening Project. This larger ODMDS was designated for a seven-year period of use (1987-1994) for placement of material obtained during the Charleston Harbor Deepening Project.

Due to the discovery of nearby live-bottom habitat in 1989-1990, a line was immediately put in place by the EPA that was located on the eastern edge of the smaller ODMDS, in an effort to protect these valuable resources (USACE 2005 Figure 1, labeled "EPA line"). The 1991 rule in the Federal Register stated that "All dredged material, except entrance channel material, shall be limited to that part of the site east of the line…unless the materials can be shown by sufficient testing to contain 10% or less of fine material (grain size of less than 0.074 mm) by weight and shown to be suitable for ocean disposal."

Video mapping of the seafloor was conducted during this same time period (1990) by the EPA in the vicinity of the ODMDSs in an effort to precisely map the location and extent of live bottom within and beyond the boundaries of both the smaller and larger ODMDSs. Based on the results of the video survey, the interagency Site Management and Monitoring Plan (SMMP) Team (EPA, SCDNR, USACE, and SCSPA) jointly decided in 1993 that the area actively used for disposal should be moved to a new location within the larger ODMDS to avoid future disposal of materials on sensitive live bottom habitat. This location was four square miles in size, and agreed upon by all agencies (USACE 2005 Figure 1, four square mile Disposal Zone). The creation of this four square mile Disposal Zone within the larger ODMDS is discussed in the *Charleston ODMDS Site Management Plan* (USACE 1993). Based on the SMMP, USACE began building an L-shaped berm on the western side of the four square mile Disposal Zone using material from the 42-ft deepening project.

In 1995, the smaller ODMDS was officially de-designated in the Federal Register due to the presence of live bottom habitat in the area. The language describing the larger ODMDS was modified such that the site could be used for all disposal materials permitted for offshore disposal, which meant that the site was no longer limited for the disposal of deepening materials. In addition, the time limit restricting the use of the larger disposal area to a seven-year period was removed, and the site was permitted for "continued use."

In 2002, the four square mile Disposal Zone was defined as the only area in which disposal can continue and the boundary that restricts the disposal of fine-grained material was removed.

2.1.2.3 Confined Upland Disposal Sites

For the 1996 widening and deepening project, dredged material was considered for disposal at upland contained disposal areas within economical pumping distance, where there was sufficient capacity for disposal, or for when material was not suitable for ocean disposal. Upland areas that were considered included the Clouter Creek Disposal Area, Daniel Island Disposal Area, Morris Island Disposal Area, the Naval Weapons Station Disposal Area, and Drum Island Disposal Area (USACE 1996). For the recent evaluation of additional advance dredging, a hydraulic pipeline dredge was used for maintenance dredging in the Upper Harbor of the Cooper River (from near Shipyard River upstream); that material was placed in the Clouter Creek diked upland disposal area (USACE 2009b). The February 2014 examination of USACE GIS data ("historic dredging areas" layer) indicated that during the last decade, the majority of material has been deposited at the Clouter Creek site and the ODMDS, but some has been deposited at Drum Island site, Yellow House Creek site, and Morris Island; Daniel Island has not recently been used by USACE.

2.1.2.4 Port-Associated Facilities

Charleston Harbor's modern (i.e., following Reconstruction) port facilities were predicated on the establishment of the Port Utilities Commission in the 1920's. At that time, most of the peninsula's commercial waterfront assets were owned by the Charleston Terminal Company (originally the East Shore Terminal Company, which was in turn co-owned by two rail companies). In 1922, the city purchased the company. Two decades later, the South Carolina Ports Authority was established by the state legislature. Since its inception, the SCSPA constructed five facilities at Charleston Harbor. The establishment of facilities included both filling riparian areas as well as dredging to accommodate berths. The terminals are the following (please see FR/EIS for mapped locations):

- North Charleston Terminal (NCT)
  Became operational in 1945
  Current Project Depth = -45'
  Current Total Allowable/Permit Depth = -51'
  Post-Panamax container cranes
  Berth Space = 2,500 linear feet

- Wando Welch Terminal (WWT)
  Dedicated in 1982
  Current Project Depth = -45'
  Current Total Allowable/Permit Depth = -52'
  Four container berths; Berth space = 1,144 linear feet
  399 acres of additional container storage space
  Super Post-Panamax and Post-Panamax container cranes
  Opened 1982

- Columbus Street Terminal (CST):
  Acquired by SCSPA from City of Charleston in 1947
  Current Project Depth = -45'
  Current Total Allowable/Permit Depth = -51'
  Berth Space = 3,800 linear feet
  Post-Panamax and Suez-class container cranes
  Container, breakbulk, bulk, rolling stock, heavy-lift, and project cargo

- Union Pier Terminal (UPT):
  Current Project Depth = -35'
  Current Total Allowable/Permit Depth = -45'
  Cruise terminal built 1971
  Berth Space = 2,470 linear feet

- Veterans Terminal (VT):
  Current Project Depth = -35'
  Current Total Allowable/Permit Depth = -42'
  Bulk, break-bulk, RO-RO, and project cargo
  Berth Space = 4,921 linear feet
  110 Acres

At NCT, the wharf structure was modified in 2008 to accommodate a total dredge depth of 60 feet. Maintenance dredging is performed in the berthing areas of the SCSPA terminals as well as at docks and piers. The above actions necessarily included land clearing and filling riparian zones for construction, as well as dredging of berths.

2.2 Present Actions

2.2.1 Water Management

2.2.1.1 Existing Facilities and Operation

The jurisdictional, SCPSA-owned part of the Santee Cooper Project comprises several facilities and associated lands and waters along the Santee and Cooper Rivers. This includes Lake Marion and Lake Moultrie, the largest and third largest lakes in South Carolina. The project structures consist of Santee Dam (also known as Wilson Dam) on the Santee River, Pinopolis Dam on the

Cooper River, the Diversion Canal, the Santee Spillway Hydroelectric Station, and the Jefferies (formerly known as Pinopolis) Hydroelectric Station.

Santee Dam impounds Lake Marion on the Santee River. The Santee Spillway Hydroelectric Station is located just downstream of the abutment of the Santee spillway to the south dam. The station contains a single, vertical-shaft, turbine generator with a capacity of 1.92-MW, a rated head of 46 feet and a maximum hydraulic capacity of 660 cfs. The station is used to maintain a minimum flow of 500 cfs in the Santee River. Most of the water impounded by Santee Dam exits Lake Marion through the 5-mile-long Diversion Canal to Lake Moultrie.

Pinopolis Dam impounds Lake Moultrie. The Jefferies Hydroelectric Station there has an integral intake structure and contains one 8-MW unit and four 27-MW units, with a total maximum hydraulic capacity of 28,000 cfs. The Jefferies Hydroelectric Station was designed to accommodate an additional 27-MW generating unit to allow for potential expansion of generation capacity. The station is operated in a semi-peaking mode in accordance with agreements between SCPSA and the USACE Cooper River Rediversion Project. Discharge through Jefferies Station typically is restricted to an average weekly flow of 4,500 cfs, although additional discharges may be made to mitigate high salinity levels in the downstream Bushy Park Industrial Complex (http://www.bushyparkindustrialcomplex.com/). Some flow is also used for the operation of the Pinopolis lock, which facilitates navigation and upstream fish passage.

The non-jurisdictional (relative to FERC authority) USACE Cooper River Rediversion Project includes a rediversion canal that returns water from Lake Moultrie back to the Santee River, an 84-MW hydroelectric station, and a fish lift to allow fish to pass upstream beyond the St. Stephen Hydroelectric Station. SCPSA operates the St. Stephen Station in a semi-peaking mode, but the federally-owned facility is not a part of the Santee Cooper Project. The St. Stephen Station uses the remainder of the discharge from Lake Moultrie not utilized by the Jefferies Hydroelectric Station and the Pinopolis Lock.

2.2.1.2 Regulatory Issues

FERC, under authority of the FPA, may issue licenses for up to 50 years for the construction, operation, and maintenance of non-federal hydroelectric projects. The current license was issued on May 9, 1979, and expired on March 31, 2006. In the interim, FERC issues Santee Cooper annual licenses, a process likely to continue until FERC permits an extended operating license.

Current operational requirements include a continuous minimum flow of 500 cfs from Santee Spillway Hydroelectric Station, and an average weekly flow of 4,500 cfs from the Jefferies station. The Jefferies station is operated in accordance with the Cooper River Rediversion Agreement between SCPSA and the USACE (Contract No. DACW60-77-C-005, and supplemental agreements). This agreement specifies that flow requirements at the Santee and Jefferies stations are met first, and any remaining flows are discharged through the federally-owned St. Stephen Station. While St. Stephen is federally owned, it is operated by SCPSA via contract agreement with the USACE.

2.2.1.3 Operations

SCPSA is not proposing any changes in project structures but proposes minor changes in operations as part of the licensing application. SCPSA proposes to implement several environmental protection and enhancement measures, but will continue providing a weekly average flow of 4,500 cfs from Jefferies station to minimize shoaling in Charleston Harbor and prevent saline waters from reaching Bushy Park Industrial Complex (FERC 2007). Discharges from the USACE St. Stephen Station are proposed to continue to provide continuous minimum flows of 5,600 cfs from March 1 through April of each year to maintain fish passage (if inflows allow). The USACE is not partner to the FERC licensing process and is not proposing any changes to the elements of the St. Stephen facility, which it owns.

2.2.2 Navigation

2.2.2.1 Post 45 Navigation Improvements

A Water Resources Development Act (WRDA) Section 905(b) reconnaissance report (USACE 2010b) was prepared in 2010 investigating the need for additional deepening of Charleston Harbor. Based upon the 905(b) report, there was federal interest in proceeding to the feasibility phase of the study to further analyze and evaluate improvements to Charleston Harbor. The Tentatively Selected Plan (TSP), which is the locally preferred plan (LPP), contains the following navigation improvements:

1. Deepen the existing entrance channel from a 47-foot project depth to a 54-foot depth over the existing 800-foot bottom width while maintaining the existing stepped or winged 1000-foot width.

2. Extend the entrance channel seaward from the existing location to the 54-foot project depth contour.

3. Deepen the inner harbor from an existing depth of 45 feet to 52 feet to the container facility on the Wando River and the new container facility on the Cooper River and 48 feet for the reaches above that terminal to the container facility in North Charleston over varying expanded bottom widths ranging from 400 to 1800 feet (at the North Charleston Terminal turning basin.

4. Enlarge the existing turning basins at the Wando Welch and new SCSPA terminals to accommodate Post Panamax generation 2 and 3 container ships.

5. Enlarge the North Charleston Terminal turning basin to accommodate Post Panamax generation 2 container ships.

6. Place dredged material at the existing upland confined disposal facilities at Clouter Creek, Daniel Island, or Ocean Dredged Material Disposal Site for the upper harbor reaches and at the Ocean Dredged Material Disposal Site for material from the lower harbor.

7. Dredge SCSPA berths along accessed by Federal channels (see below).

2.2.2.2 Port-Associated Facilities

<u>2.2.2.2.1</u> <u>Port</u> <u>Berths</u>

Maintenance dredging is periodically performed in the berthing areas of the SCSPA terminals as well as docks and piers. Due to the Proposed Action, SCSPA is proposing to deepen berths at the North Charleston Terminal (NCT) and Wando Welch Terminal (WWT), where depths are currently 45 feet (total allowed/permitted are 51 and 52 feet, respectively). New depths have not yet been proposed, and depend to a large degree on the depths to which the Cooper and Wando

Rivers will be dredged during Post 45. At WWT, the wharf structure will be improved during 2014-2016. An analysis is currently underway to determine the cost differential between modifying the structure to accommodate depths from 55 to 60 feet (Personal communication, P. Moore, SCSPA, email February 2014). While SCSPA is responsible for funding these improvements, the work will be performed concurrently with the Proposed Action and contracted by USACE.

2.2.2.2.2 New Container Terminal at Charleston Naval Complex

Among other navigation-related construction in the area is the Container Terminal at the Charleston Naval Complex (CNC) positioned between the Cooper River and Shipyard Creek in North Charleston, across from Daniel Island. The 2006 FR/EIS for this project contained a cumulative impact assessment, which also discusses cumulative impacts of dredging (USACE 2006). That SCSPA facility will comprise the following, according to the project contractor, Parsons Brinckerhoff (2014):

1. Clearing and grubbing of 135 acres;
2. Excavation of a 20-acre storm water detention pond; installation of 4,167 miles of wick drains;
3. Vibro-compaction of 2 million cubic yards of tideland fill material;
4. Delivery and placement of 5 million cubic yards of fill/surcharge;
5. Construction of a 5,000-foot-long pipe pile and sheet pile containment structure;
6. Construction of a 10.3-acre wharf structure (3,000 feet long and 150 feet wide)
7. Dredging over 4 million cubic yards of material to create three berths and turning basin (adjacent to the wharf) across 86.7 acres; and
8. Placing 583,000 cubic yards of buttress and armor rock.
9. Construction of a 6,000-foot, two-lane roadway with 6,300 linear feet of ductile iron water main and 6,700 linear feet of sewer force main.

The above will therefore consist of development across approximately 288 acres for support cargo marshaling, processing, and handling facilities (Parsons Brinckerhoff 2014). Upland disposal of dredged material is proposed in existing dredged disposal sites located on the south end of Daniel Island.

2.2.2.3 Maintenance of Federal Channels

Maintenance dredging is ongoing in Charleston Harbor. Recent dredging permits for berths allow for some additional dredging (6-7 feet in order to compensate for the 5 to 6 foot tidal variance in the harbor) for advanced maintenance.

2.2.2.4 Ocean Dredged Material Disposal Site Modification

As a result of the Charleston Harbor Deepening Study ("Post 45" study) and the anticipated sediment disposal needs, USACE and EPA are currently evaluating the need and sighting considerations for a modified ODMDS under Section 102 of the Marine Protection Resources and Sanctuaries Act (MPRSA). The project is running concurrently with the Post 45 Study and a final rulemaking is anticipated in 2015.

2.2.2.5 Downdrift Beach Renourishment

USACE Charleston District is currently implementing a beach renourishment project to help provide protection against storm damage to Folly Beach. Approximately 1.5 million cubic yards of sand will be placed along the coast to renourish 5.34 miles of beach. The beach renourishment is being conducted as part of a 50-year agreement with the City of Folly Beach, and is the first periodic renourishment since 2005. This action is noted here due to its relevance to the Section 111 study findings by USACE (1987) that indicated an effect of navigation channel jetties on downdrift communities.

2.3 Future/ Anticipated Actions

2.3.1 Water Management

While the Jefferies Hydroelectric Station was designed to accommodate an additional 27-MW generating unit to allow for potential expansion of generation capacity, SCPSA has no current plans to expand. SCPSA summer generating capability is approximately 6,100 MW. Of that amount, hydroelectric power generation is approximately 550-MW or 9%. The Santee Cooper Project contributes 128-MW or just over 2% of the total generating capability of SCPSA (Santee Cooper 2012).

The average annual increase in South Carolina electricity consumption during 1980-2010 was 2.4%. Future needed capacity will be met by natural gas fired generators and nuclear reactors currently under construction (DoE 2012) (Columbia Regional Business Report 2012).

In addition to the power and developmental purposes for which licenses are issued (e.g., flood control, irrigation, water supply), FERC must give equal considerations to the purposes of energy conservation; the protection, mitigation of damage to, and enhancement of fish and wildlife (including related spawning grounds and habitat); the protection of recreational opportunities; and preservation of other aspects of environmental quality.

USACE's water management objectives for the future include continuing current practices without changes to the operations of the rediversion/diversion canals. Continuation of Supplemental Agreement No. 6 between SCPSA and USACE included a provision for discharging through the Jefferies Hydroelectric Station to mitigate high-salinity levels at the Bushy Park Industrial Complex (background chloride concentrations in the Cooper River inflow varies monthly between 14 and 51 ppm, the average is 26 ppm, according to Teeter, 1992). Under contract to USACE, USGS will continue to operate salinity gages in the Cooper River that trigger alarms for two levels of salinity and a schedule of water releases for each salinity alarm level (SCPSA, 2004a).

2.3.2 Navigation and Port Facilities

The most likely subsequent, navigation-related actions to be implemented following the project implementation are (1) dredging (either for maintenance of permitted depths or for increased depths) of berths (including non-SCSPA berths) associated with federal channels and (2) eventually, the regular maintenance of federal channels themselves. For non-entrance-channel reaches, O&M dredging has historically occurred at a 12- to 18-month interval.

O&M dredging is periodically required at all five SCSPA berths; this will continue in the future. These include Wando Welch Terminal, North Charleston Terminal, Columbus Street Terminal, Union Pier, and Veterans Terminal. Of these, perhaps three may be dredged more deeply in the future if the Post 45 project is constructed. It is anticipated that, of the other approximately 45 berths in the harbor, it would be practical to dredge only one or two more deeply. Future anticipated actions concurrent with the above include the further use of the ODMDS and/or confined upland disposal sites.

In addition to federal and SCSPA actions, other port-related actions may be undertaken by private entities. The Regulatory Division of USACE (Charleston District) has received the following applications, which are representative of commerce-related projects in the Charleston Harbor area:

- Application #SAC-2013-00202-2IR for new and maintenance dredging comprising 42 acres in Shipyard Creek and construction of a wharf, 14 timber-cluster dolphins, retaining wall, and toe wall. The 42 acres comprise 21.2 acres of previously dredged bottom, 7.7 acres of not-previously dredged creek bed (bounded by the project toe-of-slope), and an additional 13.1 acres of not-previously dredged creek bed (required to accommodate the necessary 3:1 side-slopes for both previously and non-previously dredged bottom). Approximately 0.38 acre of tidal wetlands will be filled. The application process is underway, and no estimate of likelihood of construction or timeline is currently available.

- Application #SAC-2005-5475-2G (fka 2005-2W-286) to modify an existing terminal by installing a new shipping conveyor system , transfer towers and a ship loader, extending a dock, relocating two mooring dolphins; and increasing the dredged area (by 0.87 acre) adjacent to the proposed dock extension in Shipyard Creek. The proposed depth for the expanded area is the same as the permitted depth of the remainder of the berthing areas, i.e., -45' MLW plus allowable 2' overdepth. It is estimated that up to 40,000 cubic yards of material will need to be dredged in order to achieve the proposed depth. The expansion would occur east towards the confluence of Shipyard Creek and the Cooper River. Dredged material would be disposed (via pipeline) to either the Clouter Island or Drum Island Confined Disposal Facility. Finally, installation of the conveyor system will result in shading 0.51 acre of Waters of the U.S.

- Application #SAC-2013-00960 to construct an Intermodal Container Transfer Facility (ICTF) at the former Charleston Naval Complex (CNC). The proposed ICTF will provide access to Class I railroads (CSX Transportation and Norfolk Southern Railway) that serve the Port of Charleston and various local businesses and industries. The proposed project includes the construction and operation of a 90-acre intermodal facility where containerized freight will be transferred between trucks and rail cars. This portion of the project will include storage and processing railroad tracks, wide-span gantry cranes, container stacking areas, administrative and maintenance buildings, automated gate systems, and vehicle driving lanes. The current design has nearly 20,000 track feet of processing tracks and 30,000 track feet of classification tracks. In addition, approximately 42-acres of road and rail improvements will be required to operate the proposed ICTF.

The facility will impact approximately 6.1 acres of tidal salt marsh and other waters of the United States associated with Noisette Creek and Shipyard Creek.

3.0 RESOURCES NOT LIKELY TO BE CUMULATIVELY AFFECTED

Based on currently available information, there are some resources that are not anticipated to experience measurable cumulative effects, although they may involve either direct or indirect effects (some of them *de minimus*) due to the proposed project. In such cases, such effects are addressed elsewhere in this FR/EIS. The resources listed below are not anticipated to be adversely affected in concert with past or future actions or ongoing present actions.

3.1 Land Use

The proposed project does not include or require land use changes. However, some land use changes are likely to occur indirectly due to logistical needs/opportunities following deepening. The port may elect to handle cargo more efficiently through alteration of shoreside terminals following deepening of the harbor and channels. Such changes may result in other redevelopment of existing infrastructure, facilities, and nearby industries. However, because the amount of cargo amount being transferred through the port is not anticipated to increase beyond the levels predicted under the future-without-project (FWOP) condition, the land use/cover of infrastructure is not anticipated to change significantly as a result of deepening. It is expected that execution of elements of the port's master plan will result in changes to infrastructure with or without the proposed federal project; deeper-draft vessels will call at certain port facilities (at conducive tides) regardless of the proposed project. Many required equipment upgrades have already occurred.

3.2 Terrestrial Natural Resources

No impacts to upland terrestrial habitats (wetlands are discussed below in Section 4.0) are anticipated for the proposed project.

3.3 Threatened or Endangered Species

Effects to species protected under the Endangered Species Act of 1973 are not likely to be significant if the proposed project is constructed, and therefore no contributions to cumulative effects are anticipated. Detailed discussions for all protected species are provided in the Post 45 Biological Assessment (included in the appendices of the FR/EIS).

3.4 Other Fish and Wildlife

The proposed project's impacts to fish and wildlife species at the population level are minimal and the project is not expected to contribute to cumulative effects. Effects to various resources were separately considered below:

- Direct impacts due to construction are anticipated to be minimal. Motile species can avoid the dredge equipment. However, there will be some entrainment of slow-moving benthic individuals as well as larvae and eggs suspended in the water column. Seasonal "windows" for dredging will be observed in order to ensure the availability of critical spawning and foraging periods.

- o Indirect effects to fish due to impacts to hardbottom resources will occur. However, substrates will re-colonize and mitigation will ultimately increase the overall acreage of these habitats in the project area that are available for use by fishes and invertebrates (and foraging sea turtles as well).

- o There may be some minor alterations in the vegetative species composition of riparian wetlands (due to slight shifts in river salinity in the Cooper River, less so in the Ashley River.

- o Likewise, slight alterations in salinity in open waters of the estuary and farther upstream are not anticipated to significantly affect the amount of habitat suitable for six representative fish species, including shortnose and Atlantic sturgeon, studied by USACE (see Fishery Habitat Assessment including HSI model data output and SCDNR data in the appendices of the FR/EIS).

- o Finally, the beneficial placement of dredged material, whether at the ODMDS (for use as hardbottom habitat and sediment containment) or at selected locations (such as Crab Bank) could result in net benefits to fish and wildlife populations, respectively. A thorough monitoring plan at any and all dredged material disposal sites, whether considered “beneficial” or not (and upland or offshore) will ensure that no cumulative impacts to fish and wildlife occur.

3.5 Anadromous Fishes

Previous impacts in the project area affecting anadromous fishes included the construction of dams on the Cooper and Santee Rivers. These were essentially barriers to upstream migrations of fish to native spawning grounds (in addition to the redirection of much of the flow from the Cooper Basin to the Santee Basin). Fish passage has been somewhat mitigated by the installation of a fish lift and bypass (at St. Stephen) and navigation/”fish” locks that permit passage of many fish species. If the proposed project is constructed, neither changes in operation of the dams, locks, fish lifts, nor discharge is expected. Anticipated habitat suitabilities for four anadromous species (including two sturgeon species) for the future with-project condition were modeled in the Fisheries Assessment (see appendices to the FR/EIS). Little or no adverse affect to these (and other) species is expected due to the proposed project. Therefore, cumulative impacts are not likely to occur.

3.6 Essential Fish Habitat: Estuarine Water Column

The estuarine water column is considered an Essential Fish Habitats (EFH). Effects of the Proposed Action on certain parameters integral to the water column are discussed in Sections 3.7 and 4.1 below. The latter section details that the Proposed Action may result in slight shifts in water column salinity and dissolved oxygen (DO). Whether these slight changes materially affected the water column to the degree that managed fish species would be impacted was a concern to USACE and resource agencies and required separate investigations. With regard to EFH, where DO and salinity were important factors in habitat suitability for several fish species, significant effects were not observed in predictive models for future conditions under the proposed plan (see Fishery Habitat Study, an appendix of the FR/EIS). In addition, potential effects of project impacts to EFH (including estuarine water column) on several other species (managed under the Magnuson-Stevens Fishery Conservation and Management Act) were examined in the Post 45 Essential Fish Habitat Assessment (an appendix to the FR/EIS). No significant adverse effects on fishes attributable to DO or salinity changes were apparent. Therefore, no contribution to cumulative effects on water column EFH is anticipated due to the implementation of the proposed action.

3.7 Water Quality

3.7.1 Turbidity

Water quality impacts due to turbidity from construction activities in the harbor and channels would be temporary due to implementation of construction best management plans (BMPs) including dredge shut-down protocols, and therefore there would be no cumulative impacts due to project construction. Water quality impacts due to turbidity from dredged material deposition at the Charleston (ODMDS) would also be temporary, but to ensure protection of nearby sensitive marine benthic habitats (notably, hardbottoms), a rigorous and detailed monitoring plan will be implemented. This will require coordination with EPA, SCDNR, and SCDHEC. Turbidity from the effluent from dewatering of material at confined upland disposal sites could be a concern for regulatory agencies, but USACE will comply with water quality certification requirements issued by SCDHEC.

3.7.2 Hazardous and Toxic Substances

USACE has collected samples and conducted physical/chemical, toxicological, and bioaccumulation evaluations on sediment samples for the purpose of determining where and how sediment dredged during potential deepening can be disposed. Laboratory results indicated that dredged material meets requirements for disposal of sediments offshore at the Charleston ODMDS. Results of the testing will be documented in an MPRSA Section 103 evaluation for approval by the EPA.

3.7.3 Concurrent Effect of Sea Level Change

Sea Level Change (SLC) is not a “resource” per se, but a concurrent environmental consideration that, in combination with project effects, should be assessed. SLC during the life of the project (50 years) is taken into account as part of the future-without-project condition. SLC affects water depths and flow velocities in the estuary and upstream to the projected/modeled tidal boundary. Habitats that vary according to water depth and velocity are expected to change depending on SLC. The historical rate of SLC is derived from nearest NOAA tide gauge in Charleston Harbor. The Responses to Climate Change Program, through the USACE Institute of Water Resources (IWR), developed an on-line Sea Level Change Calculator that estimates the amount of predicted sea level change from 1992 forward (based on EC 1165-2-212 and NRC curves and equations). Using the IWR on-line Sea Level Rise Calculator and spreadsheet the trend at Charleston is estimated to be 2.74 mm/yr. In essence, the effects of SLC alone (even in the absence of the proposed project; deeper navigation channels do not alter the rate of SLC) will have the effect of pushing brackish waters farther upstream than where they are currently positioned. When the effect of the proposed project is additionally considered, saline waters are pushed even farther upstream. Cumulative effects on water salinity and dissolved oxygen (a variable also affected by SLC) are discussed below in Section 4.0, but USACE anticipates that there will be no significant cumulative effect on fishes (as noted above) even though they are sensitive to DO levels and are distributed according to salinity.

3.8 Ground Water

Conclusions found in the geotechnical appendix of the FR/EIS, indicate that seepage of saltwater into the freshwater aquifer below the Cooper MARL is not likely. The SCDNR was consulted in 1994-1995 by Charleston District USACE to explore what the potential groundwater impacts would be relating to the Charleston Harbor -45 Deepening Project. The SCDWR Hydrology Department provided a memorandum for the record stating there would be no adverse impact to the Floridan aquifer if the channel were deepened to -45 feet MLSW. The reason for this decision was the substantial thickness of the Cooper Group that overlies the aquifer. The thickness of this stratum is stated in the document to be 200 to 260 feet thick beneath the project site. Furthermore, this strata and the Floridan Aquifer System dips and thickens seaward to the southeast, which further isolates it from the relative shallow dredging. Similarly, based on the geologic setting, depth and thickness of the local stratigraphy, there would still be no impact anticipated to the Floridan aquifer as a result of deepening the Charleston Harbor to -50 feet MLLW. In addition, there would also be little or no impact anticipated to the shallow, surficial aquifer system. Much of this aquifer system already lies within the depth prism of the present project; no problems relating to the 1995 harbor deepening have been reported. Because these aquifers are not confined, are thin and discontinuous, and are prone to drought-related fluctuation, they are not considered consistent sources of water. Finally, many of the shallow wells in close proximity to Charleston Harbor have already been designated unusable or abandoned due to saltwater intrusion. See the geotechnical appendix of the FR/EIS for details.

3.9 Sediments (Hazardous Content)

The project would not result in any release of any hazardous, toxic, or radioactive waste and the project would not result in any foreseeable future actions that would result in a cumulative effect from sediments. Sediment testing indicated that contaminant levels in material to be dredged are suitably low for upland disposal.

3.10 Coastal Barrier Resources

No coastal barrier resources (including Morris Island, which is in a Coastal Barrier Resources Act, or “CBRA” zone) would be affected directly or indirectly by the Proposed Action, although the entrance channel jetties (initially installed in 1895) continue to affect downdrift areas. The Charleston Harbor jetties are necessary to provide safe harbor entrances, but they protrude far enough out into the nearshore sediment transport zone that they can restrict sediment from being transported along the coast, where it would otherwise contribute to beach formation. When the jetties were completed in 1896, the Charleston Lighthouse on Morris Island (also referred to as the Morris Island Lighthouse) stood some 2,700 feet inland. With the jetties altering the natural sand transport, the shoreline began eroding rapidly and by 1940 had eroded back the 2,700 feet to the lighthouse. The lighthouse today stands approximately 2,000 feet offshore. Total shoreline retreat was 4,700 feet in 90 years, i.e., over 50 feet per year. The trajectory of sand was just the opposite on Sullivan’s Island and Isle of Palms, South Carolina, located north (updrift) of the jetties. There, the beach has widened over the years (Western Carolina University 2005).

USACE Charleston District currently cost-shares with the City of Folly Beach (on Folly Island, southwest of Morris Island) a beach renourishment project to help provide protection against storm damage to Folly Beach. Approximately 1.5 million cubic yards of sand was placed along the coast to renourish 5.34 miles of beach in the most recent periodic nourishment. This project in part resulted from needs resulting from the installation of jetties.

Detailed coastal sediment transport modeling associated with the Proposed Action will be completed during Preconstruction Engineering and Design (PED) phase of the project to determine if there is any risk of contributing to downdrift material deficits.

3.11 Harbor Shoreline Dynamics and Adjacent Properties/ Real Estate

Shoreline sustainability is necessary for both recreational and commercial interests within the harbor, and for the economic interests and ecological stability of the region. Shorelines are affected by the construction of coastal structures and harbor maintenance, both of which can reduce the sediment budget thereby lessening natural land accretion. The primary cause of shoreline erosion is waves generated by wind and vessel wakes. Given that, it's reasonable to consider whether the Proposed Action may indirectly affect the shorelines of properties in the vicinity of the project footprint.

Photography Study. Shoreline changes in the harbor along and adjacent to the federally authorized navigation channels was determined by USACE from 1994 to 2011 using aerial imagery from SCDNR and NRCS. The Wando River was studied from the convergence with the Cooper River upstream to the I-526 overpass. The Ashley River was studied from the convergence with Charleston Harbor to the James Island Connector (State Road 30) overpass. The Cooper River was studied from Charleston Harbor jetties at the mouth of Charleston Harbor up to a point slightly north of Bushy Park. Particular areas of concern within the study area are the northern portions of James Island adjacent to Fort Johnson, Fort Sumter, Sullivan's Island adjacent to Fort Moultrie, Crab Bank, and Castle Pinckney. Folly Beach and Morris Island are also considered. Table 2 lists some areas of concern and their distances from the navigation channel.

Table 2 Shoreline Distance from Federal Navigation Channel

Shoreline	Distance from Federal Navigation Channels (feet)
Fort Sumter	2900
Sullivan's island	1300
Castle Pinkney	1000 to 1500
Crab Bank	2200 to 2900

For the photographic study, "The end-point rate [EPR] is calculated by dividing the distance of shoreline movement by the time interval elapsed between the oldest and most recent shoreline" (Himmelstoss, E.A. 2009). The first and last shoreline intervals were run to see the EPR for the whole study time period. The areas that showed growth over the study interval were the seaward face of Sullivan's Island just inward of the Charleston Harbor Jetties, the seaward face of James Island south of Fort Sumter, and the small inlet behind Fort Johnson (-1.4 to 14 m/yr). Areas of shoreline loss over the study period were the north edge of James Island just west of Fort Sumter (-8.0 to 1.5 m/yr) and sparse areas of upper Yellowhouse Creek.

Harbor Wave Study. An erosion assessment (see Engineering Appendix of the FR/EIS) was performed by USACE to analyze ship wakes and wind-generated waves. The same four critical areas discussed in the table above are the areas of concern analyzed for wave erosion near the harbor entrance where erosion has historically been a concern. Two types of waves were considered: wind-generated and wake-generated. Wind-generated waves are solely dependent on weather and tide conditions and are therefore not expected influenced by the proposed project; whereas vessel-generated waves are expected to be effected by the project. Moreover, it is important to determine which of the two types of waves is dominant in shaping the harbor's shorelines.

A given wind can create a variety of wave heights according to the fetch distance available for it to travel over. These wind waves do not decay until the wind stops, changes direction, or travels out of the wind zone and can create a variety of wave heights for a location depending on the wind duration, which vary greatly in the Charleston Harbor. Wind speed distribution was analyzed between January 2010 and December 2011 and determined that the highest number of harbor winds come from the southwest, whereas the largest number of high intensity winds come from the north-northeast.

Waves generated by vessels travel outward from the sides of the vessels and will contact shorelines if there is not long enough distance for the waves to dissipate. The size of these waves are affected by the size of the vessel, shape of the hull, direction of the tidal current, speed of travel and shape of the channel. Changing the cross-section of the Charleston Harbor by deepening it from 45 ft MLLW increases the blockage factor as well as the under keel clearance, thereby reducing the vessel-generated waves, and increases vessel maneuverability in the waterway.

The projected increase in number of *Post-Panamax* vessels is expected to provide a significant decrease in the overall number of Panamax and other smaller commercial vessels. Given that the latter are known to travel at increased velocities and generate larger waves, a net decrease in waves is anticipated; this is a potential environmental benefit of the proposed action. Assessment calculations support the hypothesis that increased vessel sizes transiting in a deepened harbor throughout the day would be less impactful than vessels of increased size transiting in the current harbor over the limited window of high tide.

The maximum average wave height created by vessels (in the future-with-project condition) is predicted to be shorter (than that in the existing condition) because vessel generated waves are directly affected by the depth of water they over which they are traveling. In the future with-project condition, vessels travel more slowly with additional water under-keel. Comparatively, wind-wave height is generated due to surface forces, independent of water depth. The wave study concluded that wind-generated waves reach each foot of the areas of concern 1,000 to 10,000 times as often as vessel generated waves. Therefore, the proposed project will not increase the amount of wave energy that could add to the erosive forces along these shorelines. Moreover, no additional influence on cumulative effects due to the proposed action is anticipated.

Shoreline Enhancement. Adjacent properties may benefit from material dredged from the harbor during the Proposed Action. The photographic study noted above may help guide those efforts. The study showed that the existing bird-nesting island called "Crab Bank," which was originally created as an inner-harbor dredge spoil area by USACE, has been condensing and migrating towards the northeast (towards the Mt. Pleasant side of Charleston Harbor). The island appeared to be becoming more wave-washed during periods of high tides as it migrated. Mitigating this potential effect for the proposed project is a concern for USACE, SCDNR, and USFWS, as well as local stakeholders. Beneficial use of the project's dredged material to enhance Crab Bank is a potential solution to this issue. Similar issues may arise for Fort Sumter, Castle Pinckney, and the south shore of Sullivan's Island that borders the north shore of the inlet. At Fort Sumter (south side of the inlet), the channel-facing side of Fort Sumter has been armored with rip-rap and throughout the photographic study interval (1994-2011) it appeared to remain stable. The tidal marsh/sand flat area to be leeward side of the island appears to be slowly accreting material. Shute's Folly Island, on which Castle Pinckney resides, has been slowly contracting on all sides.

The small, tidal, sand island off the northern point appears to be migrating towards the main northern shoreline of the Shute's Folly. The rip-rap armoring on the face of Castle Pinckney (on the south shore of the island) appears to be holding and preventing any further erosion. The effects noted above to these areas are localized, and can be mitigated through management measures.

Given the above, the Proposed Action will not adversely affect shorelines of adjacent properties and hence will not contribute to related cumulative effects. Furthermore, the project may have a net positive effect on shoreline maintenance and restoration in certain areas of the harbor. Some of these measures are discussed below.

3.12 Dredged Material

Management of dredged material for the Proposed Action will likely have a beneficial effect on the environment, and therefore will not contribute to cumulative, adverse effects associated with dredged material. Recent navigation projects have since demonstrated that dredged material can be a resource rather than a "waste product" (USACE 2010). Potential opportunities for beneficial use of dredged material initially included shorebird and/or colonial waterfowl habitat creation, marsh creation, beach renourishment, and marine hardbottom creation. Sites/options considered during the NEPA scoping process, which involved agencies and the general public, included the following:

- Crab Bank
- Sandbar complex between east end of southern jetty and Cummings Point
- Morris Island Lighthouse
- Castle Pinckney
- Feeder berms for barrier islands
- Offshore fish habitat berms
- Augmenting ODMDS berms
- Fort Sumter

After a meeting with the ICT and after external and internal prioritization the following options will be carried forward to the Pre-Construction Engineering and Design (PED) phase:

- ODMDS berm creation
- Hardbottom habitat creation
- Crab Bank enhancement
- Shute's Folly enhancement
- Nearshore placement off Morris Island

Charleston District will evaluate all possible beneficial uses of dredged material and coordinate this evaluation with SCDHEC, SCDNR, USFWS, and NMFS. Dredged material used for beneficial purposes will not contribute to adverse cumulative impacts. Any material not used for beneficial purposes and deposited at permitted upland facilities or the ODMDS will also not contribute to adverse cumulative effects because, as noted in above Sections 3.6.1 and 3.8, neither sediment chemistry nor temporary turbidity at the ODMDS or due to return flow discharge from the use of existing upland facilities will result in appreciable adverse effects.

3.13 Air Quality

Any impacts to air quality resulting from construction activities would be temporary. The total increases in temporary air pollutants would be relatively minor to the existing point- and mobile-source emissions in the tri-county area. Following construction, the shift in vessel traffic will likely result in fewer ships (albeit larger ones) making calls to the port, which, in combination with more efficient fuels may decrease air pollution resulting from vessels. Charleston, Berkeley, and Dorchester Counties are designated attainment areas. No foreseeable future actions leading to an increase in emissions would directly result from navigation features of the project, at least for the life of the project (50 years). (See additional details in the Air Quality section of the FR/EIS.) It should be noted, however, that the installation of the proposed Navy Base Intermodal Facility (see above) may result in increased emissions. This facility would potentially be constructed with or without the Post 45 project.

3.14 Noise

Noise impacts would be temporary, occurring with construction activities. Following construction, due to the projected decrease in vessels calling at the port, USACE anticipates no increase in noise at the port due to the project. (Additional details are provided in the noise appendix and Section of the FR/EIS.)

3.15 Aesthetics

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…"

Although the definition of aesthetics is fluid with the concepts of beauty and human values, 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. 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. The degree to which any adverse feature affects aesthetics is frequently based on scale, position, and proximity relative to the viewer.

Dredge vessels and equipment used during construction may temporarily affect aesthetics in Charleston Harbor, just as scaffolding and cranes temporarily obscure architectural features in an urban setting. However, dredge equipment does not differ from that used during maintenance events that occur periodically in the harbor. Shore-based equipment will be staged in only industrial and commercial areas that will not impede the aesthetics of the Charleston area; those sites will be determined during the Pre-construction Engineering and Design phase of the project.

Charleston is a historic seaport, and has been associated with vessels of increasing size for hundreds of years. Regardless of the implementation of the proposed project, larger vessels will call at the port. One potential effect on local aesthetics could be that larger vessels are anticipated to 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. Also, deepening is expected to result in *fewer* ships calling at Charleston Harbor berths because of the increased efficiency of larger vessels (as predicted by economic analyses). Moreover, the number of times that obviously larger vessels will call at the port is relatively small, and their presence in the harbor is temporary. Therefore, the proposed project is not likely to have cumulative effects on aesthetics.

3.16 Cultural and Historic Resources

A buried anomaly was found in the lower harbor outside of the navigation channel. Coordination with SC Department of Archives and History and SC Institute for Anthropology and Archaeology resulted in an agreement to have an archaeologist onboard the dredge when operating in the vicinity of the anomaly. Remote sensing surveys will be conducted in all areas proposed for widening to ensure that incidental damage to any such resources will be avoided. It is anticipated that no cultural or historic resources would be affected by the project. Therefore, no cumulative effect to these resources would result from construction of, or operation of, the Proposed Action. (Cultural and historic investigation data are detailed in the FR/EIS.) Architectural cultural and historic resources may also be considered aesthetic resources (see section above).

3.17 Native American Resources

The project would have no effect and would not influence any foreseeable future actions that could adversely affect Native American tribes.

3.18 Environmental Justice

Traffic, noise, and air pollution are among primary concerns for residents in and near industrial/commercial areas, such as the port and areas servicing port activities. As noted above, the total amount of cargo is not anticipated to significantly increase during the life of the project, and therefore, no appreciable changes in traffic, noise, and air pollution are anticipated. Due to increased efficiencies in (vessel and truck) fuel and decreases in the total number of port calls, improvements may actually occur in these factors. Minority and low-income populations constitute an overall small percentage of the communities bordering the portions of the harbor to be improved under the proposed project. Therefore USACE does not anticipate disproportionately high and adverse effects to minority and low-income populations in those communities, and the project would not influence any foreseeable future actions that could adversely affect low-income populations. For details, see full environmental justice section in the FR/EIS (Section 5.4.23.

3.19 Recreation

No effects to recreation would occur during construction or following construction. Therefore, there would be no adverse cumulative effect to recreation resulting from this project

4.0 POTENTIAL CUMULATIVE EFFECTS ON RESOURCES

4.1 Water Quality

4.1.1 Dissolved Oxygen

4.1.1.1 Dynamic Processes

Dissolved oxygen (DO) is critical for marine and aquatic life. Factors affecting DO (usually measured in milligrams per liter, or "mg/L") include consumption by biodegrading material (biological oxygen demand, or BOD), rate of water column primary production, water temperature, water velocity, turnover (vertical mixing), and depth. Enlargement of navigation channels can result in DO decreases due to hydraulic changes affecting these factors. For example, as channel depth increases, benthic DO decreases due to increased BOD and decreased primary productivity. Also, as the channel prism (cross-section) enlarges, velocity decreases, and additional brackish water is moved to the upper portions of the estuary. Because the percent saturation (i.e., solubility) of DO in water decreases (at approximately 0.2 mg/L oxygen per 5 ppt increase) with increases in salinity, these formerly fresh water habitats experience slight decreases in DO. Finally, as the channel prism enlarges, the average velocity decreases, reducing the mixing of oxygen throughout the water column. If dissolved oxygen concentrations decrease to unacceptable levels, it could have deleterious effects on fish and other aquatic organisms. Lower dissolved oxygen concentrations also reduce the ability of the estuary to handle the point- and non-point source (PS and NPS, respectively) loads of certain pollutants entering the estuary.

A partially mixed system has a stratified water column, with DO being lower near the bottom where decomposition rates are high and primary production is low, and denser saltwater (which sinks in the water column) decreases oxygen solubility. Many coastal waters in South Carolina have DO levels below the established SCDHEC DO criteria. Wastewater dischargers and other anthropogenic influences may contribute to low DO as well. Natural factors such as organic loading and reduced oxygen levels in waters draining wetlands and marshes, and subsequent mixing lower in estuaries can create naturally low DO conditions. The waters in and around Charleston Harbor are considered to be both naturally low in DO (for the above reasons) and further impacted by wastewater dischargers and stormwater runoff.

4.1.1.2 Historic Conditions and Impacts

The Charleston Harbor area has been impacted by various projects throughout its long history. The most apparent marine impacts result from navigation, water resource and energy development, and agricultural projects. Obviously, there are no "pre-impact," late 18^{th} century, observational DO data for the Cooper River estuary available to compare to current DO levels and provide a definitive, conclusive determination of cumulative impacts. However, given all the past major actions (creation and abandonment of riparian agricultural marshes; jetty construction and intermittent harbor dredging/expansions; construction of reservoirs and operation of water management facilities; and non-point-source impacts), DO in the Cooper River and estuary is probably much more variable than it was in the 18^{th} century. In addition, consecutive perturbations to the system likely have had effects on a wider geographic scale throughout the estuary than the initial, early actions did.

In lieu of a quantitative historical assessment, which would be impossible, a qualitative assessment of past actions and their most likely effect may be informative. It is likely that there have been several periods when DO in the estuary had different character (average concentration, amount of temporal variability, and spatial variability), and each perturbation (or suite of actions/events) either increased or decreased DO. These periods could arbitrarily be labeled (1) *agriculture* (pre-1878); (2) *early navigation* (1878 to approximately 1942); (3) *diversion and mid-century dredging* (approximately 1942 to 1985); and (4) *rediversion and recent dredging* (1985 to the present) (Table 3). Although DO levels in the below paragraphs are broadly noted as being "higher" or "lower," it should be noted that these assessments are coarse and relative to the broadest geographic scale in the project area. Vertical variability within the vertical water column is also noted in broadest terms.

Agriculture Period (Pre-1878). The agriculture period was characterized by tidal freshwater marshes located along the upper reaches of the Cooper River, many of which were hydraulically manipulated impoundments and used as rice fields. Water quality in estuarine impoundments would (and still does) vary: the salinity of the water could have varied from near 0 ppt to as much as 30 ppt, depending on amount of rainfall and water exchanges with the Cooper River. Dissolved oxygen also likely varied greatly. When temperatures and salinities were high, water would have contained less DO than when the water was cold with low salinity. Apart from high temperatures, decaying plant material would have contributed to low DO levels in these marshes/impoundments. Waters with high BOD would have been released to the Cooper River on occasion (depending on berm porosity, maintenance, and flooding intervals). Once the high-BOD water joined the main stem of the river, DO may have been locally suppressed, and perhaps remnant, elevated BOD persisted several hours later when the waters reached the lower estuary at Charleston. It is reasonable to expect that BOD in the estuary cycled in conjunction with the growing seasons.

Prior to 1895, depths in the Charleston Harbor entrance channel ranged from 10-13 feet, but were considerably deeper in the harbor proper. At this point in time, combined discharges from the Ashley, Cooper, and Wando rivers measured only 350 cfs. The estuary as a whole was well mixed due to dominance of tidal processes, and the circulation was primarily tidally driven. Construction of jetties and dredging of the entrance channel to 21 feet opened the harbor for navigation in 1895, but that channel deepening had little effect on physical regimes in the estuary, which remained well-mixed. Given the influences of BOD from upstream, but substantial mixing in the harbor, DO could have transitioned from lower levels in the river and upper estuary to higher levels downstream.

Early Navigation (1878-1942). During the early navigation period, Charleston Harbor was still characterized as a well-mixed estuary; wave action and circulation patterns continued to supply the lower estuary waters with oxygen. However, conditions upstream likely changed. Following the Civil War, many former agricultural impoundments fell into disrepair, and the seasonal pulse of high BOD waters draining to the estuary may have subsided to some degree. However, the impoundments still supported emergent vegetation, and continued to function as cells that contributed low-DO water to the Cooper River.

Diversion and Mid-century Dredging (1942 to 1985). Following the completion of the Santee Cooper Hydroelectric Project in 1942, large flows of freshwater (averaging 15,600 cfs) were diverted from the Santee River into the Tailrace Canal at Pinopolis Dam and on into what was formerly the head of the Cooper River near Moncks Corner. The source of that water was Lakes Moultrie and Marion, which were impounded to serve the hydroelectric plant. Typically, water released from reservoirs is low in dissolved oxygen, and this may have been the case during this period. However, faster-moving waters are better able to absorb oxygen. Therefore, any waters high in BOD may have been recharged by the time they reached the lower estuary.

Prior to rediversion, with high river flow and strong stratification, mixing between the surface and bottom layers was restricted and the major source of DO for the bottom layer was offshore oceanic waters. Consequently, the concentration of DO in the bottom layer was dependent on factors affecting bottom flow.

Rediversion and Recent Dredging (1985 to present). In the mid-1980s most of the flow from the reservoirs was rediverted back into the Santee River to alleviate excess shoaling in Charleston Harbor. Following rediversion, flows average about 4,500 cfs (the weekly flow target designed to minimize shoaling in Charleston Harbor while maintaining the freshwater supply in the West Branch Cooper and Back River Reservoir). Results of an extensive sampling effort (pre- and post-rediversion) found DO concentrations exhibited no differences between the harbor basin, and Cooper and Wando rivers, nor between pre- and post-rediversion periods (Van Dolah, 1990). Also, at high river flow (post-rediversion), the DO percent saturation was reported to be fairly constant throughout the estuary. At low river flow (pre-rediversion), surface aeration was reported to be the major source of DO throughout the estuary, and the DO concentration in the estuary was generally lower during low river flow (, and dropped in the upstream direction.

Although rediversion appears to not have had significant effects on DO, dredging in recent decades has affected hydraulics and likely water quality characteristics, including DO, in the estuary (Van Dolah, 1990).

Table 3 **Estimated Historic and Spatial Dissolved Oxygen Scenarios for Cooper River and Charleston Harbor**

Period	Approximate Years	Relative Cooper River DO Levels	Relative Harbor DO Levels
Agriculture	Pre-1878	Lower than before Agriculture period	Moderate due to tidal mixing
Early Navigation	1878 to 1942	Not significantly different than Agricultural period	Not significantly different than Agricultural period
Diversion and Mid-century Dredging	1942 to 1985	Much higher than Early Navigation period due to increased flows; high-velocity currents mix water	Lowered, as harbor transitioned to partially-mixed, and gravitational circulation
Rediversion and Recent Dredging	1985 to present	Lower than during Diversion period, but higher than during Agricultural	Potentially lower than during previous period due to lower Cooper River flows combined with continued partial mixing

4.1.1.3 Existing Conditions and Proposed Project

Reservoirs. Water quality issues experienced by Lakes Marion and Moultrie are common in backwater systems that drain watersheds receiving large anthropogenic nutrient inputs (SCDHEC, 1999), and are often characterized by naturally low pH and DO concentrations. Both SCPSA and SCDHEC monitor water quality in the project impoundments and upstream and downstream reaches of the Santee and Cooper rivers. Overall, aquatic life and recreational uses are fully supported in Lake Moultrie and in the main channel of Lake Marion. Therefore for those areas, DO appears to be sufficient. Low DO concentrations in certain coves of Lake Marion result in some impaired uses.

Cooper River. Since rediversion, the 18-mile meandering natural channel of the Cooper continued to be bordered by extensive tidal marshes and old rice fields in varying states of disrepair. This area still contains large amounts of poorly defined overbank storage and unmeasurable flows through broken levees between the main channel and the rice fields. Controversy has existed for years about the relative roles that PS and NPS oxygen-consuming constituent loads (evaluated by measured DO levels) have on the river's water quality. Conrads et al. (2002) used field data collected from 1993-1995 in a statistical and modeling analysis of DO in the Cooper River. Findings indicated that rainfall runoff decreased DO and that ebb tidal flow from nearby rice fields caused a large decrease in DO, likely caused by organic loading. The sensitivity of DOD ("dissolved-oxygen deficit") to a 1-inch rainfall was estimated to -0.25 mg/L, and the overall sensitivity to tidally forced organic loading was 2.0 mg/L or more.

According to Conrads et al. (2002), the variability of DO in the Cooper River is a result of many factors including the following:

- quality of water from Lake Moultrie and Charleston Harbor
- the loading of oxygen-consuming matter from tidally influenced marshes, abandoned rice fields, and other non-point sources
- effluent from permitted point-sources, and
- the local physical characteristics of streamflow, tidal range, salinity and temperature.

Both recreational and aquatic life uses are fully supported in the Cooper River. However, decreasing DO concentrations and pH levels have been historically identified as concerns (Mead and Hunt 2001; SCPSA 2004a; SCPSA 2004b). The standard for DO is a daily average not less than 5.0 mg/l, with instantaneous readings not less than 4.0 mg/l.

Charleston Harbor and Proposed Project. Section 303(d) of the Clean Water Act (CWA) and EPA's Water Quality Planning and Management Regulations (40 CFR Part 130) require states to develop total maximum daily loads (TMDLs) for water bodies that are included on the §303(d) list of impaired waters. A TMDL is the maximum amount of pollutant a water body can assimilate while meeting water quality standards for the pollutant of concern. All TMDLs include a wasteload allocation (WLA) for all National Pollutant Discharge Elimination System (NPDES) – permitted discharges, a load allocation (LA) for all nonpoint sources, and an explicit and/or implicit margin of safety (MOS).

The 2013 dissolved oxygen (DO) TMDL revises and combines 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 is a new 3-Dimensional Environmental Fluid Dynamics Code model (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/).

Many of the waters in the Charleston Harbor area are known to experience naturally low DO levels that do not attain established numeric criteria. Inclusion of these sites not supporting the aquatic life use has been based on the reasonable potential that anti-degradation requirements under South Carolina Regulation 61-68 (S.C. R.61-68), Section D.4.a, are not maintained due to impacts from point sources or other activities causing more than 0.1 mg/L DO depression.

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 significant effect on the TMDL waste load allocation (WLA). Although the methodology used by DHEC is 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.

After modeling the DO impacts resulting from the time-varying discharges, the impacts were combined with the impacts resulting from the Post 45 project (previously modeled by the USACE Charleston District) in order to estimate the cumulative effects on DO. Post 45 impacts were based the 52-48 Alternative, which represents the maximum deepening and widening alternative under consideration for the FR/EIS. 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. 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. As a result, 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 3.6 above, and Section 5.4.14 and Appendix K of the FR/EIS), USACE anticipates that long-term impacts from reductions in DO will 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.

4.1.1.4 Likely Future Impacts

The EFDC model was used to evaluate the potential environmental impacts to the Cooper River associated with the SCSPA proposed port expansion (currently under construction) at the Charleston Naval Complex (CNC). The model results were used to qualitatively evaluate potential impacts to DO in the river near the project site, which is considered impaired (not meeting water quality standard). Based on the hydrodynamic and salinity model results, it is expected that the project would likely result in very small, localized decreases in DO near the project site, particularly at the river bottom. Among sources of likely future actions that may affect DO is maintenance dredging of channels and berths. Maintenance of the navigation channel is performed on essentially an annual basis. Dredges, typically hydraulic cutterhead dredges in the inner harbor, are used to remove sediments that have settled within the authorized channel dimensions. Sediments removed from the river are placed in upland confined disposal facilities. This operation re-suspends a small volume of sediments into the water column. The re-suspension of these sediments can cause dissolved oxygen levels to drop. Monitoring indicates that the effects of this resuspension on dissolved oxygen levels are small, temporary, and localized.

The temporary, local effects noted above would also occur during O&M dredging, where berths are deepened, and also where portions of channels are dredged, such as in Shipyard Creek for work associated with USACE permit applications #SAC-2013-00202-2IR and #SAC-2005-5475-2G reference above in Section 2.3.2. Shipyard Creek itself merits some additional discussion due to proposed work in that subwatershed. Surface water quality monitoring station MD-243 (sampled from 1999 through 2007) is located in Shipyard Creek between Marker #6 and the McAlloy Dock. SCDHEC noted (in http://www.scdhec.gov/HomeAndEnvironment/Docs/50201-050.pdf) that, "Aquatic life uses are fully supported. Significant decreasing trends in five-day biochemical oxygen demand, turbidity, total phosphorus and total nitrogen concentration, and a significant increasing trend in dissolved oxygen concentration suggest improving conditions for these parameters." The average DO for the sample period (43 samples total) was 7.0 mg/L, which is a level conducive to marine life. Given (1) the historical characterization of Shipyard Creek's waters as fully supporting designated uses, as well as (2) dredging BMPs requiring water quality monitoring and shut-down protocols, (3) permit conditions for on-site water treatment for these projects, and (4) the relatively small proportion of contribution of discharges of Shipyard Creek to Watershed 03050201 (the combined, Cooper, Ashley, and Wando Rivers and Harbor TMDL unit), it is not likely that these projects, taken into account with the Proposed Action, will contribute to long-term, cumulative effects on water quality with respect to DO. In addition, regulatory measures and or future technological advances will minimize the chance of exceeding established water quality (including DO) standards.

4.1.1.5 Findings

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, as discussed above, 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. Mitigation for DO impacts should not be required to offset project impacts in order to comply with South Carolina's anti-degradation rule.

4.1.2 Salinity

4.1.2.1 Historic Conditions and Impacts

Prior to 1941, Charleston Harbor was a well-mixed tidally dominated estuarine system with an average freshwater discharge via the Cooper River of only 2 m^3/s. During this period, salinities in much of the middle and lower Cooper River were likely similar to those that currently exist in the Wando River (i.e., greater than 18 ppt).

In 1941 however, the SCPSA diverted 88% of the Santee River's flow to the Cooper River in order to harness hydroelectric power. As a consequence, the Cooper River discharge increased to 442 m^3/s causing: (1) a shift of longitudinal salinity distribution downstream, (2) a change from well-mixed to partially-mixed conditions in the estuary, (3) an exchange of tidally dominated circulation for gravitational circulation, and (4) an increase in sediment input and subsequent shoaling in Charleston Harbor (Kjerfve 1976; Kjefve and Greer 1978; Patterson 1983; Kjerfve and Magill 1990). Given #1 above, salinities for much of the middle and lower Cooper were likely vastly decreased to perhaps 1-5 ppt.

Because of severe shoaling from the vastly increased discharge, maintenance dredging of the harbor navigation channel became very expensive. Consequently, USACE developed and executed plans to redivert a portion of the Cooper River flow back to the Santee River to alleviate the shoaling problem. Rediversion was fully implemented by August 1985. Since then, Cooper River flow has been maintained at a weekly average discharge of 130 m^3/s (4500 cfs). This rate is necessary to prevent salinity intrusion into the upper reaches of the Cooper River where industrial complexes requiring freshwater are located along Back River Reservoir.

Decades ago, stakeholders identified salinity as a concern related to water management for both industrial and residential purposes. The Lakes Marion and Moultrie, constructed as part of the Santee Cooper Project in the 1930s and 1940s, play a vital role in providing a continuous flow of freshwater into the Cooper River. These flows, along with the salinity alert system operated by the USACE and USGS, have allowed salinity levels to be managed to maintain freshwater in the Back River Reservoir since rediversion.

The salinity alert system was implemented when the Cooper River Rediversion Project was completed in 1985. It comprises a system of tide gages and water quality monitoring stations that provide advance warning of a salinity threat (at two predetermined levels) to the reservoir. Provisions have been included in the contract ("Supplemental Agreement No. 6") between the USACE and SCPSA, which permit emergency flow releases (i.e., a contingency schedule, SCPSA 2004a) through the Jefferies Hydroelectric Station (at Pinopolis Dam) to mitigate high salinity levels at the tidally affected Bushy Park Industrial Complex located 28 miles downstream. Prototype tests were conducted before and after rediversion project completion to determine the maximum of fresh water (weekly average discharge) that could be released from Lake Moultrie into Cooper River without causing stratification and the resultant sediment trapping density currents in Charleston Harbor. Pre-project model tests indicated that 3,000 cfs weekly average was the maximum freshwater inflow, which would maintain a well-mixed harbor water column. However, prototype tests proved that stratification would also be prevented with average inflow up to 4,500 cfs. The tests also indicated that salinity intrusion protection of Bushy Park Reservoir could be more efficiently accomplished with the nonstructural monitoring system with 4,500 cfs inflow as opposed to 3,000 cfs. The weekly average flow requirement in the contractual agreement between the USACE and SCPSA is presently identified as 4,500 cfs.

The lowered (from post-diversion discharge of $\underline{442\ m^3/s}$ or 15,610 cfs to $\underline{130\ m^3/s}$ or 4500 cfs), but reliable, freshwater discharge into the Cooper River has increased the effects of tidal forcing in its estuary, resulting in more intense vertical mixing and an upstream shift of longitudinal salinity distribution (Bradley, Kjerfve, and Morris 1990). The mean monthly harbor surface salinity changed from 30.1 ppt to 16.8 ppt as a result of the diversion, but has since increased to an average of 22.0 ppt since rediversion (Kjerfve and Magill 1990). Lower and middle Cooper River salinities also increased due to the lower flows coming downstream from the reservoirs.

4.1.2.2 Proposed Project

USACE water quality model results indicated the potential movement of brackish water farther up the Cooper and Ashley Rivers as a result of deepening the channel to the greatest depth under consideration (52/48 feet). Based on modeled low-flow conditions, the 0.5 ppt boundary (on which Cowardin based habitat delineation between the freshwater zone and the area transitioning to brackish water) is estimated to move approximately 1.2 miles upstream in the Ashley River. That boundary is anticipated to move approximately one mile upstream in the Cooper River. In the Wando River, which is already mostly polyhaline the majority of its length, salinities may become somewhat higher for approximately 20 river-miles, exceeding 18 ppt. Potential effects on wetlands and marine/aquatic species are discussed below.

Salinity effects were evaluated using the EDFC model for typical and low-flow conditions. Potential project impacts to freshwater and brackish wetlands will be largely a function of the change in average annual surface salinity concentration. The project alternatives cause increases in salinity in all three rivers, but the largest increases occur in the Wando River.

During typical flow conditions, the maximum predicted changes in average annual surface salinity are approximately 1.5 to 1.9 ppt in the Wando River for 50-48 Alternative and 52-48 Alternative, respectively. During low flow conditions, the project effects on salinity change in the Wando River are similar to the effects during typical flow conditions. For low-flow conditions, the maximum predicted changes in average annual surface salinity are approximately 1.4 and 1.9 ppt in the Wando River for the 50-48 Alternative and 52-48 Alternative, respectively.

In the upper Cooper River, where potential changes to wetland vegetation are a concern, Alternative 50-48 causes the 5 ppt annual average surface salinity to shift approximately 800 feet upstream during typical flow conditions. The 5 ppt annual average surface salinity indicates the approximate transition from brackish to saltwater marsh vegetation. The 50-48 Alternative causes the 0.5 ppt annual average surface salinity to shift approximately 1,100 feet upstream. The 0.5 ppt annual average surface salinity indicates the approximate transition from fresh to brackish marsh vegetation. Alternative 52-48 will cause the 5 and 0.5 ppt average annual surface salinity concentrations to shift approximately 1,300 and 1,700 feet upriver, respectively.

USACE expects to maintain the agreement between the USACE and SCPSA indicating the 4,500 cfs weekly average discharge. The salinity alert system as described above will continue to protect freshwater resources upstream. USACE does not anticipate the need for emergency releases of water (i.e., discharges greater than the 4,500 cfs weekly average) from the reservoir (to decrease salinity concentrations) with increased frequency in the presence of the proposed project (compared to the historical frequency). The Engineering Appendix of the study provides additional details regarding the salinity alert system.

4.1.2.3 Likely Future Impacts

Neither changes in the operation of discharges from upstream reservoirs nor additional needs for dredging navigation channels deeper (than currently proposed) is under consideration. As these appear to be the most important factors in governing estuary salinities, no future alterations of salinity are foreseeable but for those attributable to SLC or natural causes.

Models were used to project the future, more-upstream positions of certain key salinity thresholds (for habitat classification purposes, according to Cowardin et al., 1979) for the Wando, Ashley, and Cooper Rivers in the absence of the Proposed Action. Results are found in the Table 4 below.

Table 4 **Liner distance in change of position of salinity thresholds between exiting and future-without-project condition based on models**

River	Salinity threshold (ppt)	Distance (river-feet) of upstream change in position
Cooper	0.5	7,039
Cooper	5.0	8,248
Cooper	18.0	513
Ashley	0.5	2,935
Ashley	5.0	2,572
Ashley	18.0	3,583
Wando	0.5	n/a
Wando	5.0	n/a
Wando	18.0	3,071

4.1.2.4 Findings

The Proposed Action will slightly increase salinities in the harbor and tributary rivers, which contributes to cumulative effects on salinity if the baseline considered for comparison is system conditions post-1942. However, if the baseline considered for comparison is system conditions prior to 1942, the Proposed Action is actually somewhat restorative in nature, as the system was formerly a tidal, brackish bay.

4.2 Essential Fish Habitat: Wetlands

4.2.1 Historic Conditions and Impacts

As was the case for the examination of historic DO and salinity levels in the harbor and its tributaries, a quantitative determination of historical wetland impacts for the focal watershed(s) would prove difficult at best. This is due not only to the length of time that the project setting has been under the influence of land development, water management, and navigation improvements, but also to the geographic scale of the impact area. However, a qualitative assessment with some general conclusions may be possible. Given that impacts for the proposed project are indirect and based on only slight changes in wetland pore water salinity, attention to the description regarding historic water column salinity changes (above) is informative.

Prior to 1941,and indeed, prior to European colonization, Charleston Harbor was a well-mixed, tidally dominated estuarine system with an average freshwater discharge via the Cooper River of only 2 m^3/s. During this period, due to low freshwater inputs, salinities in much of the middle and lower Cooper River were likely similar to those that currently exist in the Wando River (i.e., greater than 18 ppt). As such, it is also likely that riparian and tidally influenced wetlands were also more substantially associated with brackish marsh vegetation species.

The first systemic, direct impacts to riparian wetlands of the Cooper River basin occurred as colonial settlers commenced agricultural practices in and around Charleston. While rice production in South Carolina originally began in uplands, it moved to freshwater swamps in the early 1700's and eventually to tidally influenced areas by the end of that century. To facilitate rice production in tidal waters, embankments with water control structures, known as "trunks" and "spillways," were used to impound waters thereby allowing for management of water levels for rice production. Water quality in estuarine impoundments would (and still does) vary: the salinity of the water could have varied from near 0 ppt to as much as 30 ppt, depending on amount of rainfall and water exchanges with the Cooper River. These direct impacts affected hundreds of acres of wetlands.

During the period noted above, and until approximately the 1830s, urban development of the Charleston peninsula was extensive and resulted in some channelization of small tributaries to the Ashley and Cooper Rivers and filling of riparian, tidal wetlands. Yarrow (2009) noted that, "in Charleston on the peninsula section of town, a significant area is filled-in salt marsh. Much of this was done in the 1700s. In addition, many of the 'upland' areas of the city were former wetlands that have been paved." Historic maps from the end of this period show extensive riparian wetlands still present on other lands surrounding the harbor, albeit many areas just uphill from marshes were being converted to agricultural lands.

Rice production continued until the Civil War devastated most of the plantations where rice was grown. That, coupled with the elimination of slave-labor, halted rice production. Many of these fields lay uncared for until the early part of the 20th century. By the early 1900's, management of the rice fields and plantations transitioned from rice cultivation to waterfowl attraction (for hunting).

When SCPSA (note: *not* SCSPA) diverted 88% of the Santee River's flow in 1941, increasing the Cooper River's discharge to 442 m^3/s, there was a significant shift in the longitudinal salinity distribution downstream. Salinities in riparian wetlands along the middle and lower Cooper may have decreased to perhaps 1-5 ppt, and the mean monthly harbor surface salinity changed from 30.1 ppt to 16.8 ppt as a result of the diversion. These indirect impacts may have affected thousands of acres of wetlands, and could have stimulated the succession of woody swamps in tidal freshwater wetlands that were formerly brackish marshes associated with the middle and upper Cooper River.

In the mid-1980s, most of the flow from the reservoirs was rediverted back into the Santee River; resulting flows averaged about 130 m^3/s (4,500 cfs). This in turn affected a partial reversal in the salinity gradient precipitated by the initial diversion. The mean monthly harbor surface salinity changed from 16.8 ppt to 22.0 ppt since rediversion. Lower and middle Cooper River salinities also increased due to the lower flows coming downstream from the reservoirs. Similar salinity changes would have rippled through the pore water of riparian wetlands and creeks draining to the Cooper River, reversing some of former vegetation changes. Indirect impacts of the rediversion may have included conversion of hundreds of acres of freshwater wetlands to brackish wetlands in the Cooper River basin. In recent decades (perhaps in the last 40 years), with increased dredging of the channel, the limits of brackish waters has likely climbed even farther back upstream. This may have resulted in yet more brackish-marsh acreage increases, even possibly upstream into some of areas that have not been brackish since pre-colonization.

Since European colonization, direct impacts on riparian wetlands have continued. “In South Carolina, an estimated 6.4 million acres of wetlands in 1780 have been reduced to 4.6 million acres… Floodplains were drained for agriculture, and streams were dammed to provide power for grist mills, saw mills and hydroelectric plants” (Yarrow 2009). Residential and commercial development was also a major cause of wetland impacts. Of course, wetlands in the vicinity of the project area are a subset of South Carolina’s 1.8-million-acre wetlands loss noted above, and lost riparian wetlands along the Ashley and Cooper Rivers comprise another subset. Notwithstanding, the proportion of wetlands directly affected in the Charleston area must be significant, as the metropolitan area has grown to comprise over 42,000 acres, resulting from development on uplands and wetlands, and the agricultural lands of the Ashley and Cooper River basins comprising over double that area (again, across both uplands, existing wetlands, and former wetlands).

Although the historic acreage of direct impacts to wetlands cannot be precisely determined, clearly thousands of acres wetlands have been directly affected/filled in the Charleston area over the past three centuries, and a large proportion of that acreage has been located in the riparian corridors extending from the harbor up the Ashley and Cooper rivers. A recent query of Clean Water Act (CWA) Section 404 permit applications received by the Charleston District USACE lends evidence that even following significant economic challenges of the last decade, wetland impacts will continue to be proposed to further the agricultural, industrial, commercial, and residential needs of the area; hundreds of applications were received from 1999 to date.

4.2.2 Present Conditions and Actions

Preserves. Today, many of these historic rice fields discussed above, in conjunction with other tidal impoundments, are maintained and managed as habitat for waterfowl, shore birds, and other wildlife (including protected species) and serve as ecological preserves. There are approximately 100 plantations with the tidal impoundments in the coastal areas of Charleston, Berkeley, Dorchester, Georgetown, Horry, Beaufort and Jasper counties (Jeffries 2012).

Proposed Action. Dredging operations would not *directly* affect existing wetlands. However, indirect effects are predicted; specifically, slight changes in the vegetation assemblages due to marginal increases in salinity of the Cooper and Ashley Rivers. Modeling efforts indicated that if the maximum alternative dredge depth is constructed (52/48’), approximately 7.2 and 3.3 acres of forested wetlands and non-forested marshes, respectively, in the Ashley River Basin would be affected, and approximately 193.5 and 55 acres of forested wetlands and non-forested marshes, respectively, in the Cooper River Basin would be affected (see many additional important details in the *Wetland Impact Assessment* appendix to the FR/EIS). In affected areas, some plant species intolerant of salinities ranging from 0.5 ppt to 5.0 ppt may decrease in coverage while others with tolerance would increase. Population densities and diversity of fish and wildlife are not anticipated to be adversely affected, as the areas will remain vegetated and provide expected wetland functions (bank stability, water storage, nutrient cycling, refuge and forage, etc.).

USACE proposes to mitigate for the lost functions of the affected wetlands, such that there is no net loss of functional value of freshwater forested and tidal herbaceous wetlands. Mitigation and monitoring of both impact and mitigation sites would be performed is the proposed project if constructed. Adaptive plans would be engaged should the actual acreage of impact be incidentally larger than anticipated.

4.2.3 Future Actions

There are many CWA 404 applications currently under review by USACE Charleston District that involve wetland impact throughout its jurisdiction (e.g., see Section 2.3.2). Certain of them involve impacts in riparian situations, while others are inland. Also, some wetlands proposed for being directly impacted are nontidal freshwater (forested and unforested), some are tidal freshwater (forested and unforested), and some are in brackish marshes. Given the estimated impacts to wetlands due to the Proposed Action, the type of wetlands of greatest concern would be tidal freshwater wetlands that are located in upstream reaches of the Ashley and Cooper Rivers. To date, other than preservation actions, USACE has not determined other impacts that would contribute to cumulative effects in that geographic area (upper and middle reaches of riparian wetlands of the Cooper and Ashley Rivers) with that habitat classification. Future actions that may be proposed and implemented for such areas would be more likely to have direct impacts from the discharge of dredged or fill material, rather than the shift in vegetative structure expected to result from the Proposed Action. However, such future actions will be subject to regulatory permitting and mitigation requirements, thereby limiting the cumulative effects. Compensatory mitigation for the Proposed Action that includes preservation of significant tracts of wetlands will further limit the potential for future cumulative effects. Future actions that contribute to altering the bathymetry (depth) of the Rivers (e.g., channel deepening projects) could contribute to cumulative impacts to tidal freshwater wetlands as a result of denser, more saline water moving further up the rivers.

4.2.4 Findings

Cumulative effects on wetlands in the wider project area (the impact area being a subset of this area, as noted above) are principally attributed to centuries of filling, draining, and ditching tidal marshes. Other anthropogenic effects on wetlands are myriad and include decades of water quality degradation. The Proposed Action will slightly increase the relative cover of vegetation tolerant of more brackish pore water, and decrease that which is sensitive to brackish pore water. This is an indirect effect, as wetlands will retain the vast majority of their functions (detailed in the Wetland Impact Assessment in the FR/EIS appendices). Therefore, although wetland functions of the future-with-project condition will be offset by mitigation actions, there may still be some cumulative loss of freshwater, tidal wetlands in the upper and middle Cooper River if the baseline considered for comparison is system conditions post-1942 (year that Santee Diversion was completed). However, if the baseline considered for comparison is system conditions prior to 1942, the Proposed Action actually is somewhat beneficial, as some historic brackish-tolerant vegetation will be recruited in its former range. In the case of this project, cumulative effects relative to the Proposed Action will be offset via implementation of a compensatory mitigation project(s).

4.3 Essential Fish Habitat: Hardbottom Communities

Past Effects and Resulting Conditions. Hardbottom communities off of Charleston County currently comprise 311,262 acres of known habitat and 53,918 acres of probable habitat (Figure 2). There is a substantial concentration of these habitats offshore of Charleston Harbor and to the south of the entrance channel. In addition to those natural communities, dozens of artificial reefs have been created in the county’s waters. There is no estimate available for the number of acres of hardbottom previously impacted by the federal project. It is known, however, that previous dredging events have both impacted hardbottom as well as removed the sand overburden from other locations exposing hardbottoms for colonization by various benthic organisms.

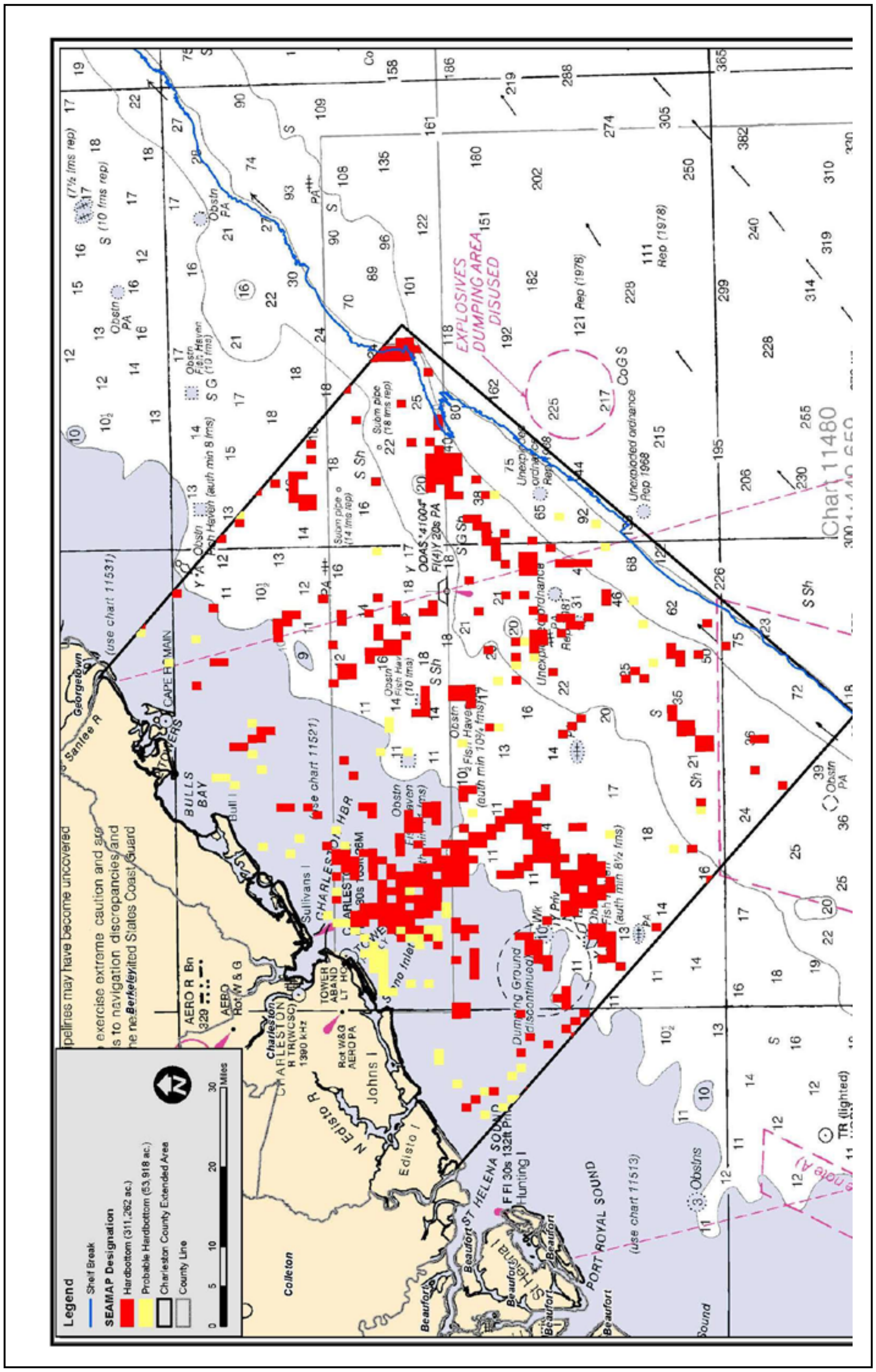

Figure 2 Hardbottom Habitat of Charleston County

Proposed Action. Construction of the Proposed Action would directly impact up to 28.6 acres of hardbottom, and expose an undeterminable amount of hardbottom for potential colonization and periodic maintenance dredging. Regardless of whether the expanded area is deepened, entrance channel maintenance is anticipated to occur at intervals of 18 months or more. If the proposed project is not constructed, hardbottom habitats in the vicinity of the project may be regularly affected by the proximity of vessel hulls and propellers to benthic habitats.

Likely Future Actions. At this time, USACE is not aware of any plans to adversely affect hardbottoms for any other project in the tri-county area. Since hardbottom is mostly found in the offshore environment, typically actions (requiring Section 404 or Section 10 permits) would not affect these resources.

Findings. 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 (see hardbottom habitat and HEA report appendices to the mitigation appendix), in addition to the proposed compensatory mitigation project. Since the majority of the exposed hardbottom would be offshore from regular maintenance dredging shoals, they will provide some stable habitat over the life of the project. Additionally, the structural complexity of the bottom features (a result of dredging) will provide more variability with the project. Therefore, the contribution of the Proposed Action to cumulative effects on hardbottoms will be minimal.

4.4 Other Essential Fish Habitats

The estuarine water column, wetlands, and hardbottoms are EFH and are addressed in Sections 3.6, 4.2, and 4.3, respectively. The only other EFH for which there is a possibility of cumulative impacts is shallow sub-tidal habitat. Approximately 2.84 acres of shallow sub-tidal habitat comprising two areas: one across from the Wando Welch Terminal on the Wando River, and one in the Cooper River across from the new terminal at the former Naval base) will be directly impacted by the Proposed Action.

4.5 Sediments

4.5.1 Dynamics

Processes. Erosion in marine and aquatic environments is the detachment of soil particles from surfaces (i.e., stream/river beds and banks, beaches, etc.) by water, moving as rain, waves, subsurface currents, or streams. Erosion from wind and rain also drives soil particles from land surfaces (particularly cleared lands) into receiving waters from runoff or constructed stormwater systems. Impervious surfaces in urbanized areas increase runoff velocities, and increase erosive forces in streams. Particles eroded from river banks and beds are transported downstream in suspension or as bedload (along the bottom of the stream). Sedimentation occurs when the eroded particles are deposited onto surfaces at the bottom of slower-moving river reaches, lakes, or estuaries.

Sediment input has dramatically increased due to human development in coastal areas. The intensity of urbanization along some estuaries is sufficiently high, such that associated sedimentation accounts for most of the input. Furthermore, alterations to estuarine circulation patterns (i.e., from significant deepening) can dramatically increase sedimentation (decreased velocities can result in precipitation of suspended materials). For these reasons, sedimentation rates in estuaries (including Charleston Harbor) are typically high, and reflect poor land conservation practices and altered inlet hydraulics (Schubel 1977).

History. Much of the sedimentation in Charleston Harbor was due to the major water diversion (1942-1985) associated with the completion of the Santee Cooper Project, which resulted in approximately 88% of the freshwater flow from the Santee River being directed into the Cooper River (Van Dolah and Davis 1990). This change increased freshwater flow to the harbor from 2 m^3/s to approximately 442 m^3/s. The increased freshwater flow changed the circulation pattern from a well-mixed estuary to a two-layered pattern. Post-diversion flows comprised enormous volumes of sediment, approximately four times the previous amount (Schnubel 1977). Prior to 1942, freshwater input to the harbor was small. In the pre-diversion period, fine-grained sediment moved through the estuary to the coastal zone, and little dredging was required. After diversion, fine particles of sediment that had previously been carried through the estuary were now trapped in the harbor by the net upstream flow of the lower water layer (Schubel 1977). In summary, sedimentation resulted from the combination of altered estuarine circulation and enormous of sediments being transported to the estuary.

To alleviate shoaling and reduce dredging expenses, rediversion (in 1985), redirected approximately 70% of the originally diverted flow from the Cooper River back to the Santee River (Van Dolah and Davis 1990). This significantly reduced harbor sedimentation, and partially restored estuarine hydraulic cycles. Levels if sedimentation following rediversion resembles those in recent years.

Existing Conditions. Multiple sources of the sediments cause shoaling in the harbor (see Section 4.5.2 below). These are sediments discharged from Pinopolis Dam; biogenic sources in the estuary (e.g., diatom phytoplankton, marsh vegetation); stormwater runoff from the surrounding watershed; shoreline erosion; ocean sediments; and other unknown sources. Table 5 summarizes estimates of these sources based on Teeter (1989), Patterson (1983), and USACE Post 45 models.

Sediment core data in Charleston Harbor indicate that the sediment bed varies in its composition, with the fraction of sand ranging between 5 and 88%, and the fraction of fine grained material (silts and clays) ranging between 12 and 95%. The fine-grained material in the estuary creates deposits of low-density unconsolidated mud. As described by Teeter (1989), this material has bulk densities between 1.22 and 1.05 grams per cubic centimeter (g/cm^3) and "consistencies between that of mayonnaise and pea soup."

Table 5 Charleston Harbor System Sediment Source Estimates

Source	Average Rate (million cy/yr)	Percentage Of Total
Inflow at Pinopolis Dam	0.24	11%
Plant Production (marshes & diatom plankton)	0.37	17%
Storm Water Runoff	0.11	5%
Shoreline Erosion	0.03	1%
Ocean and Other Sources	1.44	66%

Recent, long-term average maintenance dredging of the inner harbor federal shipping channel (FSC) (exclusive of the entrance channel) is about 1.6 million cubic yards per year (USACE data for 2004 through 2012). In addition to the FSC maintenance dredging, SCSPA dredges approximately 340,000 cubic yards per year from its terminals in the harbor, and private facilities dredge approximately 230,000 cubic yards per year. The total inner harbor dredging is summarized in Table 6. Figure 3 illustrates the most problematic areas of shoaling in the harbor.

Table 6 Average Maintenance Dredging Rates

Dredging Location	**Average Rate (million cy/hr)**	**Percentage Of Total**
Federal Shipping Channel	1.62	74%
SCSPA Terminals	0.34	16%
Private Facilities	0.23	11%
Total Dredging Volume	2.19	-

Proposed Project. Increased sedimentation within the navigational channel as a result of deepening the channels for the proposed project is anticipated. To characterize the sedimentation patterns in the Charleston Harbor and estimate the effects of Post 45 on sedimentation patterns, the BCDCOG model was calibrated such that it can be used to predict the project-related effects of various channel modification alternatives based on the existing hydrodynamic patterns and sedimentation rates in the lower Cooper River and Charleston Harbor. Results of the alternatives modeling were used to predict shoaling rates and hence to estimate changes in navigation channel maintenance dredging quantities. USACE Charleston District selected the Environmental Fluid Dynamics Code (EFDC) to meet these needs.

The suspended sediment concentration for the freshwater inflow at the upstream boundary and the suspended sediment concentration for the offshore open boundary were the same values as those used in a previous sedimentation model study conducted by the USACE Engineer Research and Development Center (ERDC, formerly "WES," or Waterways Experiment Station) that was used to assess sedimentation at the Columbus Street terminal (Teeter et al. 2000).

The initial values for the sediment characteristics, bed erosion and bed deposition coefficients were determined based on the values used in the ERDC model study. The calibration involved the adjustment of the deposition and erosion coefficients to achieve reasonable agreement in comparisons between simulated and measured total suspended (TSS) data. The model calibration consisted of qualitative comparisons to measured TSS data to ensure that the model was accurately suspending and transporting sediments. The model confirmation used comparison of the simulated bottom elevation change (i.e., simulated deposition and erosion) to long-term measured dredging rates.

Findings. 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 the 50-48 Alternative and the 52-48 Alternative. 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, the 50-48 Alternative and the 52-48 Alternative are 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. It is anticipated that future O&M events will remove a large proportion of this material, but only if it settles in Federal channels and basins.

Figure 3 Charleston Harbor High-Shoaling Areas

4.5.2 Sources

Teeter (1989) estimates that the inflow of sediment from the discharge at Pinopolis Dam is about 240,000 cubic yards per year. This is based on a study by the USGS (Patterson 1983) and adjusted for the post-rediversion average flow rate of 4,500 cfs. This represents only about 11% of the total sediment entering the CHS.

Biological activity can contribute both organic and inorganic sediment to the harbor. This material includes decaying plants and animals, and skeletal remains of diatoms and other plankton. Patterson (1983) estimates that erosion and biological activity in tidal marshes, combined with diatom production could account for 17% of sediment sources in the estuary, and Teeter (1989) used the same assumption. This estimate is highly uncertain. Teeter *et al*. (2000) analyzed shoaling material at the Columbus Street Terminal. The organic fraction in these samples averages around 10%, which supports the conclusion that biological activity is a significant source of sediments. Although marsh areas may export some organic matter, marsh areas are also a sediment sink because low current velocity conditions in the marsh areas create a depositional environment for sediments. Therefore, the net effect of the marsh areas on the sediment budget is unknown. For this analysis, it is assumed that biological activity accounts for approximately 17% of sediment sources, the same estimate as that used by Teeter (1989).

Stormwater runoff contains suspended sediments and was estimated by Patterson (1983) to contribute 150,000 cubic yards per year to the harbor sediments. For this analysis, the storm water runoff sediment was estimated on the basis of 2001 land use types in the watershed, event mean concentrations (EMCs) for land use types given by Harbor and Baker (2007), and stormwater flows predicted by the LSPC model. This yields an estimate of 110,000 cubic yards per year (5% of the total sources), which is similar in magnitude to the estimate made by Patterson (1983).

On the basis of analysis of National Ocean Survey data between 1933 and 1963 to determine changes in bottom elevation, Patterson (1983) estimated that shoreline erosion contributes 20,000 to 40,000 cubic yards per year.

The ocean is a source of fine sand and fine grain sediments that are carried into the harbor on flooding tides. Potential sources of fine-grained material from the ocean include sediment from the continental shelf and fluvial sediment discharge updrift from the CHS (Patterson 1983). Coastal storm events likely to greatly increase this source as waves action increases suspended sediments along the coast and frontal passages cause subtidal variations in the water levels. The ocean source is unqualified, and it is combined with other unknown sources in Table 5. According to Teeter (1989), the unknown component could largely be composed of ocean sources.

Much of the material that shoals in the federal channel (see Figure 3) comprises fine grained sediments already in the harbor. Teeter (1989) estimates that there is a large reservoir of unconsolidated mud on the floor of the estuary that is on the order of 20 to 30 million cubic yards in volume. These sediments are continuously resuspended by tidal currents and storm events and settle in lower energy areas. Unconsolidated mud also moves as a density current along the bottom and is generally not moved with the net estuarine circulation.

5.0 CONCLUSIONS

Potential cumulative effects on many resources (due to the proposed action) were considered. 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 (an EFH), 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 some potential to contribute to adverse cumulative effects, to any degree are listed below, where details regarding that finding are also noted:

- **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. Therefore, whether the project is likely to contribute to cumulative effects on water salinity is not conclusive depends on which baseline is used for analysis.

- **Essential Fish Habitat: Wetlands**. Some riparian 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 action may contribute to cumulative effects to freshwater palustrine forested 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 the 50-48 Alternative and the 52-48 Alternative. 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, the 50-48 Alternative and the 52-48 Alternative are 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. It is anticipated that future O&M events will remove a large proportion of this material, but only if it settles in Federal channels and basins.

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.

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