

**HOLDEN BEACH EAST END
SHORE PROTECTION PROJECT
ENVIRONMENTAL IMPACT STATEMENT
FINAL**



February 2018

Prepared for:

**US Army Corps of Engineers, Wilmington District
Wilmington, NC**

and

Town of Holden Beach

Prepared by:

**Dial Cordy and Associates Inc.
(Third Party Contractor)
Wilmington, NC**

EXECUTIVE SUMMARY

ES.1 Introduction

The Town of Holden Beach (Town) is seeking Department of the Army (DA) authorization to construct an approximately 1,000 ft long terminal groin and to implement a beach nourishment regime consisting of the placement of approximately 120,000 to 180,000 cubic yards of sand on the East End of Holden Beach which would be extracted from the preferred Lockwoods Folly Atlantic Intracoastal Waterway Inlet Crossing (LFI)/Bend-Widener borrow site every four years, with the addition of potential supplemental sand acquisition from the inland Lockwoods Folly Inlet (LFI) navigation channel and Central Reach offshore borrow site. The project area is located along the East End of the eight mile long barrier island of Holden Beach which is located west of the Cape Fear River and has an east-west orientation, facing Long Bay and the open Atlantic Ocean to the south, and separated from mainland Brunswick County to the north by tidal marshes and the Atlantic Intracoastal Waterway (AIWW).

The proposed project is under consideration for a Department of the Army authorization pursuant to Section 404 of the Clean Water Act and Section 10 of the Rivers and Harbors Act. The National Environmental Policy Act (NEPA) requires the preparation of an Environmental Impact Statement (EIS) for major Federal actions that may significantly affect the human environment. This Environmental Impact Statement is being prepared as the proposed project (applicant's preferred alternative) is being considered for DA authorization pursuant to the Clean Water Act and Rivers and Harbors Act, which constitutes a major Federal action pursuant to NEPA. This EIS evaluates the potential impacts on the human environment that may result from implementing the applicant's preferred alternative or any other reasonable alternatives.

ES.2 Purpose and Need

The Town of Holden Beach (Town) is seeking federal and state permits to allow the construction of a 30-year shoreline protection project that would serve to mitigate chronic erosion experienced along the eastern portion on the Town's oceanfront shoreline so as to protect and secure public infrastructure, roads, homes, businesses, beaches, recreational assets, and protective dunes.

While the majority of the Holden Beach oceanfront shoreline has experienced long-term net erosion over the last 70 years, erosion has been most severe along the island's easternmost 2-mile reach bordering LFI. Average long-term erosion rates along the East End reach are among the highest in the state, ranging from -3 to -8 feet (ft)/year. Chronic erosion has contributed to dune breaching and flooding along the East End, most recently during Hurricane Hanna in 2008. Since 1993, East End erosion has resulted in the loss of approximately 27 oceanfront properties (including houses and infrastructure). Periodic nourishments by both the Town and the USACE have provided temporary shore protection benefits along the East End; however, the rapid loss of placed sand to erosion necessitates repeated, costly nourishment events

approximately every two years. To date, the Town's East End shore protection strategy has been one of reliance on frequent USACE beneficial use of dredged material projects that are funded primarily by the USACE; however, the long-term status of federal funding is precarious. Thus, a long-term, cost-effective, independent Town shore protection program is needed to combat chronic East End erosion.

ES.3 Alternatives

The Town's Preferred Alternative (Alternative 6 – Intermediate Terminal Groin with Beach Nourishment) would assume responsibility for East End shore protection through the construction of an ~1,000-ft-long intermediate terminal groin at the eastern end of the oceanfront beach between Stations 00+00 and 10+00 and the implementation of an independent 30-year beach nourishment plan. The main stem of the intermediate terminal groin would include a 700-ft-long segment extending seaward from the toe of the primary dune and a ~300-ft anchor segment extending landward from the toe of the primary dune. The groin would also include a 120-ft-long shore parallel T-Head segment centered on the seaward terminus of the main stem. The anchor segment is designed to prevent flanking of the groin in the event of shoreline migration landward of the primary dune. The anchor segment would be entirely buried at the completion of groin construction, and the majority of the anchor segment is designed to remain buried based on historical shoreline analyses back to 1938. The intermediate groin is designed to be a relatively low profile structure, both to allow sand over-passing and to minimize impacts to beach recreation and aesthetics. In addition to the 300-ft anchor segment, a portion of the adjoining 700-ft segment across the upper dry beach would also be completely buried, thus maintaining recreational beach access across the groin. The relatively low profile of the groin would allow some sand over-passing even under eroded conditions at the end of the four-year nourishment cycle.

The projected beach nourishment regime would involve the placement of ~120,000 – 180,000 cy of sand on the East End beach extracted from the preferred Lockwoods Folly AIWW Inlet Crossing (LFI)/Bend-Widener borrow site every four years, with the addition of potential supplemental sand acquisition from the inland LFI navigation channel and Central Reach offshore borrow site. The beach fill profile design include a +9 ft North American Vertical Datum (NAVD) high dune with a 50-ft-wide crest, a +7 ft NAVD high, ~200-ft-wide berm, and a 90- to 200-ft-wide transition with a 15 percent slope.

ES.4 Summary of Environmental Consequences

This Final Environmental Impact Statement (EIS) meets requirements under the Federal Environmental Assessment and Review Process in determining how to best meet the needs of the people and the environment. This EIS includes an evaluation of resources and considerations involved in responding to the chronic erosion on the eastern portion of Holden Beach so as to preserve the integrity of its infrastructure, provide protection to existing development, and ensure the continued use of the oceanfront beach along the easternmost portion of its oceanfront shoreline. Significant resources which occur in the permit area include

socioeconomic resources, marine resources, terrestrial resources, threatened and endangered species, recreation and aesthetic resources, and cultural resources.

ES.5 Major Conclusions

Chronic erosion has been a major threat to the homes, infrastructure, and natural resources along the eastern portion of Holden Beach. Immediate and long-term action is needed to alleviate this threat. The Town is seeking federal and state permits to allow for the construction of a terminal groin with supplemental fill west of the structure obtained from the LFIX. These actions would serve to mitigate the chronic erosion on the eastern portion of the island so as to preserve the integrity of its infrastructure, provide protection to existing development, and ensure the continued use of the oceanfront beach. Federal consultations with National Marine Fisheries Service and US Fish and Wildlife Service has been completed. Responses to comments provided during the Draft EIS scoping process has been incorporated into this Final EIS where applicable.

ES.6 Areas of Controversy

As part of the Public Scoping and Public Notice process, the USACE received several comment letters regarding the Proposed Action and the environmental review process. Comment letters received during the scoping process are provided in Appendix A. Table 1.1 below summarizes from whom comments were received through scoping, the comments, and identifies the specific section in the EIS where the comment is addressed. The comments are organized by general category. Note that the summary table is not intended to be a comprehensive description, but rather a synopsis of the nature of the comments received during scoping. Refer to comment letters in Appendix A for specific comments received during scoping. While all comments have been considered in the development of this EIS, not every issue on this list was evaluated in detail.

Additional issues and comments raised by the PRT during project development meetings, held on 6 September 2012 and 30 May 2013, are summarized in Table 1.2 below.

It is expected that state and federal agencies along with the public will provide comments to this Final EIS which will result in a comprehensive analysis of alternatives including proposed inlet management initiatives. On-going coordination with the North Carolina Division of Coastal Management will continue with the submittal of the CAMA Major Permit application.

Table 1.1. Summary of scoping comments provided during the Public Scoping and Public Notice process.

| No. | Nature of Comment (Summary) | Agency/ Entity | Category | Inclusion in EIS |
|-----|--|----------------|------------------------|------------------|
| 1 | Damage to downstream beaches (including Sunset Beach and Ocean Isle Beach) and to immediate west of groin | Public | Physical | 5.4 |
| 2 | Costly beach renourishment projects and homeowner lawsuits against Town of Holden Beach | Public | Economic | 3.1 |
| 3 | Uphold ban on groins; should not be a tax payer expense | Public | State Regulation | 1.7 |
| 4 | Reduced tax base and tourism revenue from home and beach access loss; increased dredging at Lockwood Folly | Public | Economic | 4.7 |
| 5 | Impacts to Oak Island estuaries that serve as marine nursery areas | Public | Fisheries | 4.5 |
| 6 | Impacts on designated critical habitat for threatened and endangered Piping Plovers | Public | Species Protection | 4.5 |
| 7 | Concern for who will be financially liable for Oak Island restoration and property owner compensation | Public | Financial | 1.7 |
| 8 | Include comparative Quantitative Modeling of inlet dynamics and beach erosion/accretion | Public | Physical | 5.4 |
| 9 | Investigate non-structural alternatives for erosion control | NCCF | State Regulation | 3.1 |
| 10 | Identify/map/evaluate "404" wetlands, "critical habitat" and imminently threatened structures | NCCF | State Regulation | 4.2 |
| 11 | Plans for construction/maintenance of groin and management of inlet/estuarine/ocean shorelines | NCCF | State Regulation | 3.1 |
| 12 | Identify how property owners and local gov. on both sides of inlet affected by all project alternatives | NCCF | State Regulation | 5.4 |
| 13 | Identify funding sources needed for all stages of project (in absence of state or local funds); Applicant provided cost estimates and assurances of ability to cover all costs | NCCF | Financial/Economic | 3.1 |
| 14 | Detailed info and modeling on storm impacts and sea level rise on and from groin to structures, property, environment, habitat, tidal flow, fisheries, etc. | NCCF | Physical/Environmental | 5.3 |
| 15 | Cost-benefit analyses related to storm events and economic impact to fisheries/tourism; determine long-term management costs | NCCF | Financial/Economic | 5.4 |
| 16 | Incorporation of State Beach and Inlet MP into EIS | NCCF | State Regulation | 1.7 |
| 17 | Determine how project will comply w/Endangered Species Act (groin impacts to piping plover/sea turtles) | NCCF | Species Protection | 5.4 |

Table 1.1. (concluded).

| No. | Nature of Comment (Summary) | Agency/ Entity | Category | Inclusion in EIS |
|------------|---|-----------------------|-------------------------|-------------------------|
| 18 | Provide proof that terminal groin will reduce frequency of required beach re-nourishment | NCCF | Physical | 5.4 |
| 19 | Need for Essential Fish Habitat (EFH) assessment in surf zone including impacts to state-managed fish species | NMFS | Habitat | Individual Document |
| 20 | Recommend EIS characterization of larval/juvenile fish use of surf zones and nearshore areas and migration in Lockwood Folly and Shallotte inlets | NMFS | Fisheries | 5.4 |
| 21 | Recommend EIS characterization of ebb and flood tidal flow complexes, longshore sediment transport, and beach sediment erosion, accretion, and granulometry | NMFS | Physical Modeling | 5.4 |
| 22 | Long and short term monitoring and modeling of shoreline erosion/accretion on west end of Oak Island | Town of Oak Island | Physical | 6.3 |
| 23 | Modeling of terminal groin impact on ebb channel alignment and deep vs. shallow draft inlets | Town of Oak Island | Physical | 5.4 |
| 24 | Verify how use of offshore "borrow" site (beach nourishment source) will impact Brunswick County Coastal Storm Damage Reduction Project, Oak Island shoreline, and Lockwood Folly Inlet | Town of Oak Island | Physical/Economic | 5.4 |
| 25 | Determine potential for recharge and subsequent use of borrow site including sand source and time to recharge | Town of Oak Island | Physical/Economic | 5.4 |
| 26 | Request field investigation, analysis and modeling of HB groin impact to larval fish transport dynamics in and near Lockwood Folly inlet | DMF | Fisheries | 5.4 |
| 27 | Request field investigation of larval and juvenile fish distribution in inlet and proposed groin locations | DMF | Fisheries | 5.4 |
| 28 | Request monitoring of benthic macroinvertebrates in areas impacted by proposed groins | DMF | Environmental | 4.2 |
| 29 | EIS to include discussions/research relating to all essential and protected fish habitats and larval fish transport in groin areas and inlets | DMF | Habitat/Fisheries | 4.4 |
| 30 | EIS to include characterizations of fish and invertebrate composition/abundance in inlet and adjacent surf zone | DMF | Fisheries/Environmental | 4.4 |
| 31 | EIS to include potential impacts to and monitoring plans for benthos in surf/swash zones and nearshore areas | DMF | Environmental | 5.4 |
| 32 | EIS to include potential impacts of proposed groin to wetlands, fish habitat, and commercial/rec fishing | DMF | Habitat/Fisheries | 5.4 |
| 33 | EIS to include potential impacts from dredging and from beach and nearshore placement and how these impacts can be minimized | DMF | Physical | 6.1 |
| 34 | EIS to include discussions on potential impacts on regional sand budgets | DMF | Economic | 5.3 |

Table 1.2. Summary of issues raised during the Project Review Team meetings.

| Nature of Comment (Summary) | Agency | Resolution | Meeting Date |
|--|-----------------------|--|---------------------|
| Physical monitoring thresholds and responsibility of determination of exceedance | NCDCM | Adaptive Monitoring Plan | 6 September 2012 |
| Monitoring of coastal resources should include biological resources | NCWRC | Present Mitigation Measures in Chapter 6 | 6 September 2012 |
| Current structures/houses identified as imminently threatened | FWS/USACE | Structure loss analyzed in Chapter 5 | 6 September 2012 |
| Sediment compatibility analysis of AIWW Crossing at Lockwood Folly Inlet | USACE | Vibracores collected; data included in Chapter 3 | 6 September 2012 |
| Sustainability of 400-foot bend widener as primary source of material for proposed project | NCDCM | Historical analysis of borrow area usage | 6 September 2012 |
| Differences between No Action Alternative and Abandon/Relocate | FWS | Description provided in Chapter 3 | 6 September 2012 |
| Modeling results of the various groin alternatives | USACE/NCDCM | Review of modeling results in Chapter 5 | 6 September 2012 |
| Maintenance costs of terminal groin | NCDCM | Terminal groin construction discussed in Chapter 3 | 6 September 2012 |
| Basis of Study Area boundary | Dr. Bill Cleary | Study area boundary captures all resources | 6 September 2012 |
| Distribution of the Draft Engineering Report | USACE | Engineering Report provided as Appendix F | 30 May 2013 |
| Lockwood Folly Inlet channel variability | Dr. Bill Cleary | Review of model in Chapter 5 | 30 May 2013 |
| Gross shoal changes | Dr. Bill Cleary | Modeling used to analyze transport trends | 30 May 2013 |
| Timing of modeling runs | NC Coastal Federation | Model runs for each alternative spanned 4 years | 30 May 2013 |
| T-head component of proposed groin design | NCDCM | Amended legislation provides for T-head component | 30 May 2013 |
| Effects on Oak Island during model runs of each alternative | USACE | Analyzed in model and discussed in Chapter 5 | 30 May 2013 |
| Discussion of 50-year USACE project | NCDCM | Reviewed in Alternatives Analysis in Chapter 3 | 30 May 2013 |
| Recreational Impacts | Dunescape POA | Analyzed in Chapter 5 | 30 May 2013 |

TABLE OF CONTENTS

| | Page |
|---|------|
| EXECUTIVE SUMMARY | II |
| LIST OF TABLES..... | X |
| LIST OF FIGURES | XI |
| LIST OF PHOTOS | XII |
| LIST OF ACRONYMS..... | XIII |
| 1.0 INTRODUCTION..... | 1-1 |
| 1.1 Project Overview | 1-1 |
| 1.2 Overview of the NEPA EIS Process..... | 1-3 |
| 1.3 Agency Coordination and Involvement | 1-4 |
| 1.4 Applicable Federal Laws and Executive Orders..... | 1-7 |
| 1.5 Applicable State Laws and Regulations..... | 1-10 |
| 2.0 PURPOSE AND NEED | 2-1 |
| 2.1 Project Purpose | 2-1 |
| 2.2 Background..... | 2-1 |
| 2.3 Need for the Proposed Action..... | 2-7 |
| 3.0 PROJECT ALTERNATIVES | 3-1 |
| 3.1 Alternatives..... | 3-1 |
| 3.1.1 Alternative 1: No Action..... | 3-1 |
| 3.1.2 Alternative 2: Abandon and Retreat..... | 3-7 |
| 3.1.3 Alternative 3: Beach Nourishment | 3-8 |
| 3.1.4 Alternative 4: Inlet Management and Beach Nourishment | 3-13 |
| 3.1.5 Alternative 5: Short Terminal Groin and Beach Nourishment..... | 3-15 |
| 3.1.6 Alternative 6: Intermediate Terminal Groin and Beach Nourishment (Applicant's Preferred Alternative) | 3-21 |
| 3.2 Alternatives Considered but Eliminated from Further Evaluation..... | 3-24 |
| 4.0 AFFECTED ENVIRONMENT | 4-1 |
| 4.1 General Environmental Setting..... | 4-1 |
| 4.2 Physical Environment | 4-4 |
| 4.2.1 Geomorphology, Geology, and Sediments..... | 4-4 |
| 4.2.2 Sediment Transport | 4-5 |
| 4.2.3 Hydrodynamics and Water Quality..... | 4-7 |
| 4.2.4 Flooding and Flood Zones | 4-7 |
| 4.3 Biological Resources | 4-8 |
| 4.3.1 Marine Habitats and Communities | 4-10 |
| 4.3.2 Beach and Dune Communities | 4-14 |
| 4.3.3 Inlet and Estuarine Communities | 4-17 |
| 4.3.4 Endangered, Threatened, and Rare Species and Species of Concern | 4-24 |
| 4.4 Cultural Resources | 4-54 |
| 4.5 Public Interest Factors..... | 4-54 |
| 4.5.1 Socioeconomic Resources..... | 4-54 |
| 4.5.2 Land Use | 4-62 |
| 4.5.3 Infrastructure..... | 4-63 |
| 4.5.4 Scenic Resources..... | 4-64 |
| 4.5.5 Light..... | 4-65 |
| 4.5.6 Water Quality | 4-65 |
| 4.5.7 Air Quality | 4-66 |
| 4.5.8 Noise | 4-66 |

| | | |
|-------|---|-------|
| 4.5.9 | Hazards and Water Safety..... | 4-67 |
| 5.0 | ENVIRONMENTAL CONSEQUENCES | 5-1 |
| 5.1 | Impact Analysis Methodology | 5-1 |
| 5.1.1 | Direct and Indirect Impact Analysis..... | 5-1 |
| 5.1.2 | Cumulative Impact Analysis..... | 5-4 |
| 5.2 | Model-Projected Effects of the Alternatives on Shoreline Change..... | 5-8 |
| 5.3 | Alternative Economic Comparison | 5-24 |
| 5.4 | Projected Environmental Impacts of the Alternatives | 5-26 |
| 5.4.1 | Alternative 1: No Action | 5-26 |
| 5.4.2 | Alternative 2: Abandon and Retreat..... | 5-55 |
| 5.4.3 | Alternative 3: Beach Nourishment | 5-72 |
| 5.4.4 | Alternative 4: Outer Inlet Channel Management and Beach Nourishment..... | 5-97 |
| 5.4.5 | Alternative 5: Short Terminal Groin and Beach Nourishment..... | 5-126 |
| 5.4.6 | Alternative 6: Intermediate Terminal Groin and Beach Nourishment..... | 5-151 |
| 5.5 | Summary of Alternative Effects..... | 5-170 |
| 6.0 | AVOIDANCE, MINIMIZATION AND MITIGATIVE MEASURES..... | 6-1 |
| 6.1 | Terminal Groin Measures..... | 6-1 |
| 6.1.1 | Terminal Groin Design Features..... | 6-1 |
| 6.1.2 | Inlet Management Plan..... | 6-2 |
| 6.2 | Dredging Measures..... | 6-4 |
| 6.3 | Beach Fill Placement Measures..... | 6-4 |
| 6.4 | Conservation Measures | 6-6 |
| 7.0 | REFERENCES..... | 7-1 |

| | |
|------------|---|
| Appendix A | Scoping Documents |
| Appendix B | Draft EIS Comment and Responses |
| Appendix C | USFWS July 2016 Biological Opinion |
| Appendix D | SB 151 Legislation |
| Appendix E | Inlet Management Plan |
| Appendix F | Holden Beach Master Plan |
| Appendix G | Holden Beach Work Plan |
| Appendix H | ATM Engineering Analysis |
| Appendix I | Holden Beach Permit Sheets |
| Appendix J | Holden Beach Resolution |
| Appendix K | Lockwoods Folly Inlet Historical Aerial Imagery |
| Appendix L | Annotated Bibliography of Nearshore and Estuarine Fisheries |
| Appendix M | Bird Nesting Data (1972-2014) |
| Appendix N | Sea Turtle Nesting Locations (2005-2014) |
| Appendix O | Understanding Cost and Benefits |
| Appendix P | Central Reach Project Permits |
| Appendix Q | Environmental Consequences Impact Summary |
| Appendix R | Eastern Channel Shorebird Monitoring Plan |

LIST OF TABLES

| | Page |
|---|-------|
| Table 1.1. Project Review Team | 1-5 |
| Table 2.1. Town of Holden Beach nourishment summary 2001-2017. | 2-6 |
| Table 3.1. Project alternatives..... | 3-1 |
| Table 3.2. Summary of borrow area alternatives with NCDPCM sediment compatibility criteria..... | 3-11 |
| Table 4.1. Biotic communities in the Permit Area. | 4-8 |
| Table 4.2. Federally listed species. | 4-25 |
| Table 4.3. State-listed species. | 4-53 |
| Table 4.4. Demographic summary. | 4-56 |
| Table 4.5. Housing characteristics. | 4-57 |
| Table 4.6. Economic impact of beach recreation..... | 4-58 |
| Table 4.7. Value of taxable real property FY 2011/2012..... | 4-58 |
| Table 4.8. Land use summary..... | 4-63 |
| Table 5.1. Project alternatives..... | 5-1 |
| Table 5.2. Holden Beach and Oak Island shore protection projects. | 5-6 |
| Table 5.3. Year 4 model-projected net habitat change (acres). | 5-12 |
| Table 5.4. Model-projected East End relative beach widths (0 ft NAVD88). | 5-18 |
| Table 5.5. Comparison of alternative economic factors. | 5-25 |
| Table 5.6. Maximum percentage of daily (24-hr) inlet flow volume entrained during dredging. | 5-36 |
| Table 5.7. Alternative 1 scope of costs and benefits..... | 5-55 |
| Table 5.8. Alternative 2 model-simulated tidal prism volumes (100 mcf). | 5-58 |
| Table 5.9. Alternative 2 scope of costs and benefits..... | 5-71 |
| Table 5.10. Alternative 3 - relative tidal prism volumes (percentage of corresponding Alternative 2 volumes). | 5-78 |
| Table 5.11. Alternative 3 scope of costs and benefits..... | 5-96 |
| Table 5.12. LFI Model-projected ebb shoal sediment volume change (cubic yards). | 5-98 |
| Table 5.13. Alternative 4 relative tidal prism volumes (percentage of corresponding Alternative 2 volumes). | 5-104 |
| Table 5.14. Alternative 4 scope of costs and benefits..... | 5-125 |
| Table 5.15. Alternative 5 relative tidal prism volumes (percentage of corresponding Alternative 2 volumes). | 5-132 |
| Table 5.16. Alternative 5 scope of costs and benefits..... | 5-151 |
| Table 5.17. Alternative 6 relative tidal prism volumes (percentage of corresponding Alternative 2 volumes). | 5-155 |
| Table 5.18. Alternative 6 scope of costs and benefits..... | 5-169 |

LIST OF FIGURES

| | Page |
|--|------|
| Figure 1.1. Study Area Map | 1-7 |
| Figure 2.1. Layout of 1970s Sandbag Groin Field on East End of Holden Beach..... | 2-2 |
| Figure 2.2. East End Sandbag Groin Field Construction 1970s..... | 2-2 |
| Figure 2.3. Holden Beach Fill Placements since 2001..... | 2-5 |
| Figure 2.4. NCDRCM Long-Term Shoreline Erosion Rates for the East End of Holden Beach (2003 vs 2011) | 2-8 |
| Figure 2.5. Holden Beach East End Shoreline Change and Property Loss 1993-2008..... | 2-9 |
| Figure 2.6. Permitted Sandbag Revetments on the East End of Holden Beach..... | 2-10 |
| Figure 3.1. USACE LFIX AIWW Dredging and Beach Placement Schematic..... | 3-3 |
| Figure 3.2. LFIX Federal Navigation Project (includes bend widener and AIWW). | 3-4 |
| Figure 3.3. 2017 Hydrographic Survey of the LFIX and AIWW Crossing | 3-5 |
| Figure 3.4. Alternative 3 – Conceptual East End Beach Fill Footprint..... | 3-9 |
| Figure 3.5. Alternative 3 – Conceptual East End Beach Fill Profile (Dune ~50 ft wide, Berm ~200 ft wide | 3-10 |
| Figure 3.6. Alternative 3 – Preferred and Potential Borrow Sites | 3-12 |
| Figure 3.7. Alternative 4 – Conceptual Beach Fill and Outer Inlet Channel Footprint | 3-14 |
| Figure 3.8. Alternative 5 – Conceptual Beach Fill and Short Terminal Groin Footprint | 3-16 |
| Figure 3.9. Alternative 5 – Short Groin Cross Section and Profile | 3-19 |
| Figure 3.10. Typical Groin Profile and Cross Section | 3-20 |
| Figure 3.11. Alternative 6 – Beach Fill and Intermediate Terminal Groin Footprints | 3-22 |
| Figure 3.12. Alternative 6 – Intermediate Groin Cross Section and Profile | 3-23 |
| Figure 3.13. Lockwoods Folly River Habitat Restoration Project, Phase I – Eastern Channel..... | 3-25 |
| Figure 4.1. Study Area | 4-2 |
| Figure 4.2. Conceptual Regional and Local Net Sediment Transport Schematic at LFI (2004 aerial)..... | 4-6 |
| Figure 4.3. Study Area Flood Zones..... | 4-9 |
| Figure 4.4. Hardbottom Habitat in the Vicinity of the Study Area | 4-13 |
| Figure 4.5. Potential Submerged Aquatic Vegetation in the Vicinity of the Study Area | 4-21 |
| Figure 4.6. Intertidal and Subtidal Habitat in the Vicinity of the Study Area | 4-23 |
| Figure 4.7. North Atlantic Right Whale Southeastern Calving Critical Habitat..... | 4-27 |
| Figure 4.8. Shorebird Critical Habitat, Sightings, and Nests in the Vicinity of the Study Area | 4-33 |
| Figure 4.9. Loggerhead Turtle Nesting in the Vicinity of the Study Area (2005 - 2014)..... | 4-41 |
| Figure 4.10. Loggerhead Turtle Nesting in the Vicinity of the Study Area (2005 - 2014)..... | 4-42 |
| Figure 4.11. Loggerhead Turtle Critical Habitat in the Vicinity of the Study Area | 4-43 |
| Figure 4.12. Seabeach Amaranth in the Study Area in 2014 | 4-52 |
| Figure 4.13. Shipwrecks Located in LFI | 4-55 |
| Figure 5.1. Alternative 2 – Model-Projected YR4 Shoreline Change | 5-10 |
| Figure 5.2. Holden Beach – Model-Projected YR4 MHW Lines for all Alternatives | 5-11 |
| Figure 5.3. Holden Beach – Model-Projected YR4 MLW Lines for all Alternatives | 5-13 |
| Figure 5.4. Alternative 1 and 3 – Model-Projected YR4 Shoreline Change..... | 5-14 |
| Figure 5.5. Alternative 4 – Model-Projected YR4 Shoreline Change | 5-15 |
| Figure 5.6. Alternative 5 – Model-Projected YR4 Shoreline Change | 5-16 |
| Figure 5.7. Alternative 6 – Model-Projected YR4 Shoreline Change | 5-17 |
| Figure 5.8. Alternatives 1, 3, 4, 5, and 6..... | 5-18 |

| | |
|---|-------|
| Figure 5.9. Oak Island – Model-Projected YR4 MLW Lines..... | 5-22 |
| Figure 5.10. Oak Island – Model-Projected YR4 MHW Lines for all Alternatives | 5-23 |
| Figure 5.11. Alternative 2 – Model-Projected YR4 Habitat Changes | 5-60 |
| Figure 5.12. Alternative 2 – Projected Properties at Risk and Infrastructure Impacts at YR4 End..... | 5-69 |
| Figure 5.13. Alternative 3 – Model-Projected YR4 Habitat Changes | 5-83 |
| Figure 5.14. Alternative 3 – Projected Properties at Risk and Infrastructure Impacts at YR4 End..... | 5-95 |
| Figure 5.15. Alternative 4 – Model-Projected YR4 Habitat Changes | 5-110 |
| Figure 5.16. Alternative 4 – Projected Properties at Risk and Infrastructure Impacts at YR4 End..... | 5-124 |
| Figure 5.17. Alternative 5 - Typical Flood Tide Current Vector Diagram | 5-133 |
| Figure 5.18. Alternative 5 - Typical Ebb Tide Current Vector Diagram | 5-134 |
| Figure 5.19. Alternative 5 - Relative Particle Concentration..... | 5-135 |
| Figure 5.20. Alternative 5 – Model-Projected YR4 Habitat Changes | 5-138 |
| Figure 5.21. Alternative 5 – Projected Properties at Risk and Infrastructure Impacts at YR4 End..... | 5-149 |
| Figure 5.22. Alternative 6 - Typical Flood Tide Current Vector Diagram..... | 5-156 |
| Figure 5.23. Alternative 6 – Typical Ebb Tide Current Vector Diagram..... | 5-157 |
| Figure 5.24. Alternative 6 - Relative Particle Concentration..... | 5-158 |
| Figure 5.25. Alternative 6 – Model-Projected YR4 Habitat Change | 5-160 |
| Figure 5.26. Alternative 6 – Projected Properties at Risk and Infrastructure Impacts at YR4 End..... | 5-167 |
| Figure 6.1. Bird Monitoring Plan for the Lockwoods Folly River Habitat Restoration Project, Phase I – Eastern Channel..... | 6-9 |

LIST OF PHOTOS

| | Page |
|--|------|
| Photo 2.1. View to east of 2014 USACE LFIX East End placement project..... | 2-3 |
| Photo 2.2. View to east of 2014 USACE LFIX East End placement and dune restoration project. | 2-3 |
| Photo 2.3. 2014 USACE LFIX maintenance dredging | 2-4 |
| Photo 3.1. View of temporary containment berm during the 2014 beneficial use project on the East End..... | 3-6 |
| Photo 3.2. Equipment utilized during the 2014 beneficial use project on the East End | 3-6 |
| Photo 3.3. View of sidecast dredge, the Merritt, working within the outer bar channel of LFI..... | 3-8 |
| Photo 3.4. Garden City, SC, sheet-pile groin after construction during low tide | 3-17 |
| Photo 3.5. Hunting Island, SC, groin at low tide. | 3-17 |
| Photo 4.1. View of tidal marsh along Eastern Channel, Oak Island, NC..... | 4-3 |
| Photo 4.2. View to the north of Eastern Channel and LFI flood shoal system..... | 4-3 |
| Photo 4.3. Colonial waterbirds resting on the Oak Island western spit. | 4-16 |
| Photo 4.4. Exposed boilers of the Bendigo (left foreground) and the USACE dredge boat, Currituck, Site 0001LFI..... | 4-56 |

LIST OF ACRONYMS

| | |
|------------|--|
| ° | Degree |
| µPa | Micropascal |
| AADT | Average Annual Daily Traffic |
| AC | Acres |
| AEC | Areas of Environmental Concern |
| AIWW | Atlantic Intracoastal Waterway |
| AL | Alabama |
| ASSRT | Atlantic Sturgeon Status Review Team |
| ATM | Applied Technology and Management, Inc. |
| BA | Biological Assessment |
| BCB | Brunswick County Beaches |
| BFE | Base Flood Elevation |
| BPART | Beach, Parks, Access and Recreation/Tourism Fund |
| C | Centigrade |
| C2 | Category 2 |
| CAMA | Coastal Area Management Act |
| CARO-COOPS | Carolinas Coastal Ocean Observing and Prediction System |
| CEQ | Council of Environmental Quality |
| CETAP | Cetacean and Turtle Assessment Program |
| CFR | Code of Federal Regulations |
| CIRP | Coastal Inlets Research Program |
| CM | Centimeter |
| CMP | Coastal Migratory Pelagics |
| CMS | Coastal Modeling System |
| COLREGS | International Regulations for Preventing Collisions at Sea |
| CRC | Coastal Resources Commission |
| CSDR | Coastal Storm Damage Reduction Project |
| CT | Connecticut |
| CWA | Clean Water Act |
| CY | Cubic Yards |
| CY/YR | Cubic Yards per Year |
| CZMA | Coastal Zone Management Act |
| dB | Decibels |
| DEIS | Draft Environmental Impact Statement |
| DON | Department of Navy |
| DPS | Distinct Population Segments |
| DWR | North Carolina Division of Water Resources |
| EA | Environmental Assessment |
| EFH | Essential Fish Habitat |
| EIS | Environmental Impact Statement |
| EM | Engineering Manual |
| EPA | Environmental Protection Agency |
| ESA | Endangered Species Act |
| F | Fahrenheit |
| FEIS | Final Environmental Impact Statement |
| FEMA | Federal Emergency Management Agency |

| | |
|--------|--|
| FHWG | Fisheries Hydroacoustic Working Group |
| FIRM | Flood Insurance Rate Maps |
| FL | Florida |
| FR | Federal Register |
| FSC | Federal Species of Concern |
| FT | Feet |
| FWCC | Florida Fish and Wildlife Conservation Commission |
| GA | Georgia |
| GIS | Geographic Information System |
| GMI | Geo-Marine Inc. |
| GPS | Global Positioning System |
| GS | General Statute |
| HP | Horsepower |
| HQW | High Quality Waters |
| HZ | Hertz |
| IMP | Inlet Management Plan |
| IWC | International Whaling Commission |
| KHZ | Kilohertz |
| KM | Kilometers |
| KW | Kilowatt |
| LA | Louisiana |
| LFI | Lockwoods Folly Inlet |
| LFIX | Lockwoods Folly Inlet Crossing |
| M | Meters |
| MA | Massachusetts |
| MCY | Million Cubic Yard |
| mg/L | Milligrams/Liter |
| MGPD | Million Gallons Per Day |
| MHW | Mean High Water |
| MLW | Mean Low Water |
| MLLW | Mean Lower Low Water |
| MM | Millimeters |
| MMPA | Marine Mammal Protection Act |
| MOA | Memorandum of Agreement |
| MS | Mississippi |
| MSFCMA | Magnuson-Stevens Fishery Conservation and Management Act |
| MSL | Mean Sea Level |
| N | North |
| NAI | Normandeau Associates, Inc. |
| NAVD | North American Vertical Datum |
| NC | North Carolina |
| NCAC | North Carolina Administrative Code |
| NCDAQ | North Carolina Division of Air Quality |
| NCDCM | North Carolina Division of Coastal Management |
| NCDENR | North Carolina Department of Environment and Natural Resources |
| NCDMF | North Carolina Division of Marine Fisheries |
| NCDOT | North Carolina Department of Transportation |
| NCDWQ | North Carolina Division of Water Quality |
| NCEPA | North Carolina Environmental Policy Act |
| NCFMP | North Carolina Flood Mapping Program |

| | |
|-----------|--|
| NCNHP | North Carolina Natural Heritage Program |
| NCWRC | North Carolina Wildlife Resource Commission |
| NEPA | National Environmental Policy Act |
| NFIP | National Flood Insurance Program |
| NHPA | National Historic Preservation Act |
| NIMA | National Insurance and Mitigation Administration |
| NJ | New Jersey |
| NMFS | National Marine Fisheries Service |
| NOAA | National Oceanic and Atmospheric Administration |
| NOI | Notice of Intent |
| NPS | Nonpoint Source |
| NRC | National Research Council |
| NRHP | National Register of Historic Places |
| NTU | Nephelometric Turbidity Units |
| NY | New York |
| ORW | Outstanding Resource Waters |
| OSA | Office of State Archaeology |
| OSHA | Occupational Safety and Health Administration |
| PN | Public Notice |
| PNA | Primary Nursing Area |
| PPT | Parts Per Thousand |
| PRT | Project Review Team |
| RI | Rhode Island |
| RMS | Root-Mean-Square |
| SAFMC | South Atlantic Fisheries Management Council |
| SAV | Submerged Aquatic Vegetation |
| SC | South Carolina |
| SEAMAP-SA | Southeast Area Monitoring and Assessment Program |
| SEPA | State Environmental Policy Act |
| SHPO | State Historic Preservation Office |
| SMP | Sand Management Plan |
| SPL | Sound Pressure Level |
| SR | State Road |
| SST | Sea Surface Temperature |
| SSSRT | Shortnose Sturgeon Status Review Team |
| TAC | Technical Advisory Committee |
| TEWG | Turtle Expert Working Group |
| TSS | Total Suspended Solids |
| TX | Texas |
| US | United States |
| USACE | United States Army Corps of Engineers |
| USCG | United States Coast Guard |
| USEPA | United States Environmental Protection Agency |
| USFWS | United States Fish and Wildlife Service |
| VA | Virginia |
| W | West |
| WRDA | Water Resources Development Act |



**U.S. Army Corps
of Engineers®**
Wilmington District

**FINAL
ENVIRONMENTAL IMPACT STATEMENT**

HOLDEN BEACH EAST END SHORE PROTECTION PROJECT

Brunswick County

U.S. Army Corps of Engineers

Wilmington District

A handwritten signature in black ink, appearing to read 'R. J. Clark', written over a horizontal line.

Robert J. Clark

Colonel, U.S. Army

District Commander

U.S. Army Corps of Engineers

Wilmington District

7 MAR 18

Date