Wilmington Harbor, North Carolina
Navigation Improvement Project

Integrated
Section 203 Study
&
Environmental Report

APPENDIX N
MITIGATION, MONITORING, AND ADAPTIVE MANAGEMENT PLAN

February 2020

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List of Acronyms

AFSA	Anadromous Fish Spawning Area
CDF	Confined Disposal Facility
CFR	Code of Federal Register
CFRW	Cape Fear River Watch
CY	Cubic Yards
DCA	Dial Cordy and Associates Inc.
DEIS	Draft EIS
EFH	Essential Fish Habitat
EIS	Environmental Impact Statement
ER	Engineering Regulation
FL	Functional Loss
FT	Feet
FWOP	Future Without Project
FWP	Future With Project
HEP	Habitat Evaluation Procedures
HSI	Habitat Suitability Index
LCFR	Lower Cape Fear River
MOTSU	Military Ocean Terminal at Sunny Point
NC	North Carolina
NCSPA	North Carolina State Ports Authority
NCWRC	North Carolina Wildlife Resource Commission
NECFR	Northeast Cape Fear River
NEPA	National Environmental Policy Act
NOAA	National Oceanic and Atmospheric Administration
PED	Pre-Construction Engineering and Design
PNA	Primary Nursery Area
PRM	Permittee-responsible Mitigation
PSI	Pounds Per Square Inch
RCW	Red-cockaded Woodpecker
RFG	Relative Functional Gain
SLR	Sea Level Rise
TEU	Twenty-foot Equivalent Units
TNC	The Nature Conservancy
TSP	Tentatively Selected Plan
TWG	Technical Working Group
UMAM	Unified Mitigation Assessment Method
USACE	United States Army Corps of Engineers
USC	United States Code
USFWS	United States Fish and Wildlife Service
WRDA	Water Resources Development Act
WRRDA	Water Resources Reform and Development Act

1 INTRODUCTION AND PLAN FRAMEWORK

Based upon the mitigation process and requirements established by Section 906 of the Water Resources Development Act (WRDA) of 1986 [33 United States Code (USC) 2283], as amended by Section 2036 of WRDA 2007 and Section 1040 of the Water Resources Reform and Development Act (WRRDA) of 2014, the Council on Environmental Quality's National Environmental Policy Act (NEPA) regulations [40 Code of Federal Regulations (CFR) Sections 1502.14(f), 1502.16(h), and 1508.20], and Section C-3 of Engineer Regulation (ER) 1105-2-100; the United States Army of Engineers (USACE) will ensure that project related adverse effects on ecological resources are avoided or minimized to the extent practicable, and that remaining, unavoidable impacts are compensated to the extent justified. For adverse ecological effects which cannot be avoided or minimized, options will include compensatory mitigation in the form of restoration, establishment, enhancement, and/or preservation. Any proposed mitigation should be practicable and ensure that the project will not have more than negligible adverse impacts on ecological resources.

Mitigation planning is a critical element of the overall planning process, which began early in feasibility study development. The mitigation, monitoring, and adaptive management plan developed in this report is a preliminary plan that presents a set of mitigation and monitoring measures that would sufficiently provide compensatory mitigation for the environmental impacts of the navigation improvements included in the TSP. The preliminary mitigation, monitoring, and adaptive management plan is technically feasible, can be implemented at a reasonable cost, and has been developed with technical input from local agency subject matter experts.

Over the past year numerous meetings have been held with the Wetland and Fish and Fish Habitat Technical Working Groups (TWG) to work through the impact assessment process, develop functional assessments for tidal wetland and fish habitat impacts, and to assess mitigation options. The USACE initiated development of the Interagency Review Team (IRT) in December 2019 and will continue coordination through the NEPA process. Continuing technical coordination with the TWGs will support completion of the Draft Environmental Impact Statement (DEIS), which will include the final mitigation, monitoring, and adaptive management plan. The preliminary draft plan identified herein provides the elements of a plan that will continue to be modified and or refined during completion of the DEIS.

Mitigation and monitoring costs are included in total project costs and were developed to ensure that costs for the preliminary plan sufficiently approximate final plan costs. Estimated costs for mitigation elements described in the Mitigation, Monitoring and Adaptive Management Plan were developed adhering to the USACE planning guidance principles for cost estimating. Real estate costs were developed through consultation with landowners and with the aid of USFWS for a proposed conservation easement. Construction costs for mitigation measures described in the plan were prepared using standard engineering and construction cost estimating protocols at a feasibility study level of design. Estimates for wetland plant installation were obtained through consultation with local wetland plant nurseries. Monitoring costs were developed using comparable budgets associated with other recent deep draft navigation projects (e.g. Charleston Post 45 deepening project) and based on past budgeting for the Wilmington Harbor deepening project initiated in 2000 for project monitoring. While the overall budget is robust and not expected to change substantially, recognize that aspects of the mitigation plan are subject to change during development of the DEIS and agency coordination process.

This section provides a summary of the preliminary draft plan, including a review of avoidance and minimization measures considered during the design process for ecological resources, mitigation measures for those resources which may be significantly impacted, functional assessments to determine mitigation requirements, and selected mitigation measures based on agency review and engagement. In addition, conceptual monitoring protocols for assessing project effects, mitigation success and adaptive management measures are provided. During early 2020 additional technical meetings will be held with local subject experts and agencies to develop specific monitoring protocols for project effects.

- Indirect effects of salinity shifts on tidal palustrine freshwater forested (swamp forest) and herbaceous wetlands;
- Direct effects of conversion of shallow water benthic habitat, including Primary Nursery Areas (PNAs) and non-PNA, to deeper benthic habitat;
- Indirect changes in fish habitat suitability due to salinity changes for selected managed and protected fish species;
- Erosional effects on three managed bird islands in the Lower Cape Fear River (LCFR) including Battery Island, Ferry Slip, and South Pelican Island; and
- Effects of vessel wakes on selected shoreline reaches of the river from the mouth of the Cape Fear to below the Military Ocean Terminal at Sunny Point (MOTSU).

Finally, the report also includes conceptual monitoring plan elements for both mitigation measures and long-term project effects (ten years), as well as adaptive management measures. A detailed final mitigation plan will be completed during the NEPA coordination process.

1.1 Avoidance and Minimization Measures

The first step in mitigation planning involves efforts to avoid and/or minimize impacts. Because the alternative action plans included similar levels of channel widening and incremental levels of channel deepening, there were few opportunities to formulate approaches to avoiding and or minimizing effects on ecological resources. Impact assessment methods and results of the analysis for wetlands, fish, and fish habitat effects were reviewed with interagency TWGs during the development of the study report. These meetings centered on the primary environmental concerns of the project (dissolved oxygen, salinity increase, wetlands, fish habitat, and endangered fish species) as identified during early public and agency involvement. Further refinements to avoidance and minimization measures may occur during development of the DEIS. The following measures were taken to avoid and minimize project related effects.

1.1.1 Evaluation during pre-construction engineering and design of minimizing slope of channel where widening is proposed

During the Pre-Construction Engineering and Design (PED) phase, detailed ship simulation results will be used to optimize the widening measures to the size necessary to safely maneuver vessels. For purposes of the effects analysis in the feasibility phase, these channel widening measures have been assumed to be at maximum size. The optimization of those measures could reduce environmental effects on fish habitat, salinity intrusion, wetlands, and shallow subtidal habitat; as well as the projected increase in channel shoaling. Any substantial changes or reductions in significant effects will be reviewed during the PED phase of the project

1.1.2 Excluding the addition of passing lanes within the river portion of the project

Initial design considerations included assessing the addition of passing lanes in the wider reaches of the channel within the river; however, further analysis discounted this measure due to the extent of dredging required, potential increases in salt water intrusion upriver, and potential conversion of shallower more productive subtidal habitat to deeper less productive soft bottom habitat. Avoiding widening for passing lanes also reduced potential significant effects on fish habitat and brackish and freshwater wetlands.

1.1.3 Widening within the inlet on the west side to minimize erosional effects to the east

To minimize erosional effects of widening the inlet entrance channel on the Bald Head Island shoreline, channel widening is proposed only on the west side of the channel. Baldhead Shoal Reach 1 is proposed to be widened up to 200 ft on the west side to allow vessels to better align themselves entering the turn at the Smith Island and Baldhead-Caswell Reaches. These latter two reaches would then be widened on the east side, where there is naturally deep water already existing, to provide an acceptable radius of curvature to allow the design vessel to safely make this turn.

1.1.4 Minimize the loss of sand from the estuarine system through beneficial use of dredged material in the lower river

The loss of sediment from the river-estuary through placement offshore in the ODMDS is not beneficial to the overall estuarine sediment processes and potentially reduces material available for tidal marshes to capture and deposit, thus naturally keeping up with sea level rise. Restoring existing bird islands and potentially building new ones serves to keep sediment in the system; can yield ecological benefits, such as observed for South Pelican and Ferry Slip islands; and, if sited and designed appropriately, can serve as least cost options to disposal offshore. Engagement with the interagency Beneficial Use TWG demonstrated the desire on the part of both state and federal agencies to maximize use of dredged material, as shown in the beneficial use plan (Main Report Appendix R: Dredged Material Management). Further refinement during PED can serve to demonstrate the ecological and cost benefits of these measures.

1.1.5 Reducing rock blasting effects by further geotechnical analysis during PED

Past geotechnical investigations and recent geophysical surveys (Appendix B: Geotechnical) involving rock strength analysis indicates that rock over 4,000 psi would require blasting, while rock under this strength can be removed without blasting using either a cutterhead dredge or a rock bucket clamshell dredge. As a result of improved dredging technologies and the fact that the USACE did not require blasting for the -42-foot project, further geotechnical analysis will be performed during PED to reduce the footprint of rock over 4,000 psi, therefore minimizing potential effects resulting from noise impacts to marine mammals and fish that blasting may cause.

1.1.6 Cultural resource impact avoidance or minimization

Most of the anomalies identified during the surveys performed for this study consisted of modern debris and did not represent significant historic or cultural items; however, due to the sheer number of anomalies detected and mapped, it is recommended that an archaeologist be on board to monitor for cultural resources when dredging occurs in these areas. If any additional resources are discovered during construction, the dredge will be shut down and coordination will be conducted to comply with the National Historic Preservation Act.

2 TIDAL FRESHWATER WETLANDS

2.1 Guidance and Framework

Present USACE policy, under Section 2036(a) of WRDA 2007, requires that mitigation plans comply with applicable mitigation guidance and policies of the regulatory programs administered by the Secretary of the Army. The USACE and the United States Environmental Protection Agency published regulations (33 CFR Parts 332, and amending 33 CFR Part 325 and 40 CFR Part 230) entitled, "Compensatory Mitigation for Losses of Aquatic Resources," ("Mitigation Rule") on 10 April 2008. The purpose of these regulations is to improve the quality and success of compensatory mitigation plans authorized by Department of the Army regulatory permits. Subsequent guidance (CECW-PC Memorandum, Implementation Guidance for Section 2036 (a) of the Water Resources Development Act of 2007 (WRDA 07) - Mitigation for Fish and Wildlife and Wetlands Losses, 31 August 2009), published by the USACE, determined that civil works guidance for mitigation planning is consistent with the policies and standards of the USACE Regulatory wetlands mitigation program.

In accordance with civil works guidance and the Mitigation Rule, the USACE is responsible for determining what is ecologically preferable from one project to the next. The Mitigation Rule emphasizes the selection of compensatory mitigation sites on a watershed basis. Equivalent standards are also provided under the rule for all three types of compensatory mitigation: mitigation banks, in-lieu fee programs, and permittee-responsible mitigation plans. The preferential hierarchy for types of wetland mitigation includes restoration, enhancement, establishment, and preservation. Under civil works guidance and the Mitigation Rule, restoration should be the first method considered.

It is important to acknowledge that this study considered the effects resulting from the proposed project's maximum dimensions. As discussed above, during the PED phase of the project, ship simulation will be used to potentially reduce effects associated with wideners and overall widening of the channel due to increases in depth. Therefore, since all mitigation alternatives are evaluated based on an assumption of maximum impacts, it is the intent that additional avoidance and minimization may be realized during PED.

2.2 Wetland Impact Summary

Based upon the comprehensive analysis of the predicted spatial changes in salinity associated with dredging for the TSP, wetlands affected are summarized in Table 1 and covered fully in the Main Report Appendix F: Wetlands Impact Assessment. These predicted changes are based upon a comparison of FWOP and Future with Project (FWP) conditions. The FWOP conditions were based upon a dry year and low SLR scenario for the mainstem of the river, and a typical year and low SLR for the tidal creeks.

Table 1
Freshwater Tidal Wetlands Potentially Affected under the TSP

Water Body	Isopleth Shift	Model Scenario	Wetland Class (acres)		Total Freshwater Wetlands
			Tidal Swamp Forest	Tidal Freshwater Marsh	
Cape Fear Mainstem	Oligohaline-Freshwater	Dry Year RSLR1	29.9	16.2	**46.1**
Cape Fear Mainstem	Mesohaline-Oligohaline	Dry Year RSLR1	0.0	0.0	**0.0**
Northeast Cape Fear	Oligohaline-Freshwater	Dry Year RSLR1	75.8	16.7	**92.5**
Northeast Cape Fear	Mesohaline-Oligohaline	Dry Year RSLR1	0.0	0.0	**0.0**
Smith Creek	Oligohaline-Freshwater	Typical Year RSLR1	27.4	0.0	**27.4**
Sturgeon Creek	Oligohaline-Freshwater	Typical Year RSLR1	19.4	55.2	**74.6**
Jackeys Creek	Oligohaline-Freshwater	Typical Year RSLR1	58.0	0.0	**58.0**
Barnards Creek	Mesohaline-Oligohaline	Typical Year RSLR1	0.0	0.0	**0.0**
Town Creek	Oligohaline-Freshwater	Typical Year RSLR1	13.9	0.0	**13.9**
Town Creek	Mesohaline-Oligohaline	Typical Year RSLR1	0.0	0.0	**0.0**
Lilliput Creek	Oligohaline-Freshwater	Typical Year RSLR1	17.4	9.7	**27.1**
Lilliput Creek	Mesohaline-Oligohaline	Typical Year RSLR1	0.0	0.9	**0.9**
Total (acres)			**241.8**	**98.7**	**340.5**

The tidal freshwater wetlands that were identified as potentially affected by oligohaline-freshwater isopleth shifts under the TSP include 241.8 acres of tidal freshwater swamp forest and 98.7 acres of tidal freshwater marsh. Although in many cases the projected oligohaline-freshwater isopleth shifts cover substantial distances, the projected surface salinity changes within the isopleth shift zones are limited to very small increases of ≤0.3 parts per thousand. Although tidal freshwater swamp forest communities are capable of tolerating or recovering from occasional pulses of saline water, they are generally not able to tolerate regular flooding by saline waters. Tidal freshwater marshes, as defined by the baseline classification, are slightly more tolerant of very low oligohaline salinities; however, the restriction of freshwater marshes to relatively short reaches of the estuary in the immediate vicinity of the oligohaline-freshwater boundary indicates that overall salinity tolerance is very limited. Thus, tidal swamp forest and tidal freshwater marsh communities are potentially vulnerable to relatively small increases in salinity. Given the very small projected increases in salinity, the exact nature and extent of effects are difficult to predict. It is anticipated that the projected salinity increases may have some effects on community composition, and that shifts in freshwater community composition towards the brackish marsh spectrum could reduce community diversity. However, it is considered unlikely that the projected increases would result in large-scale swamp forest to marsh conversions.

2.3 Mitigation Options for Indirect Effects on Tidal Wetlands

This section provides a review of available options for mitigating unavoidable indirect effects to tidal wetlands. Many options were identified and assessed prior to completion of the wetland effects analysis and reflected opportunities throughout the salinity range in the river-estuary, including for saltmarsh, brackish marsh, and tidal freshwater marsh/swamp forest mitigation. Following completion of the wetland assessment and coordination with the Wetland TWG, options in the lower estuary and tributaries including Upper Town Creek were eliminated from further consideration and inclusion in this plan. Only feasible options available for mitigating effects on tidal swamp forest and freshwater marsh were further evaluated.

Mitigation options reviewed included potential tidal forested wetland preservation parcels within the Cape Fear River, including the Black River, where restoration and/or enhancement of wetland functional values could also be included (Figure 1). In addition, an additional goal was to work with other stakeholders in the basin to leverage the benefits of cooperative efforts towards regional acquisition goals.

2.3.1 Tidal Wetland Forest Mitigation Options

To assess alternative sites to serve as mitigation, early coordination was conducted with The Nature Conservancy (TNC), Coastal Land Trust, United States Fish and Wildlife Service (USFWS), North Carolina Wildlife Resource Commission (NCWRC), and local stakeholder and landowners within the Cape Fear River watershed. Many of the properties initially identified had been targeted by TNC for preservation due to their natural characteristics, the high quality of riverine swamp forest present, and vulnerability to timber production and adjacent upland development. A total of 14 tracts were screened during the planning process based on those with low, medium, and high conservation priority. Criteria for early screening the tracts included the acreage of tidal swamp forest and total acreage (>1,000 acres), TNC conservation priority rating, the location of the tract in relationship to the upstream limit of salinity change, the extent of tidal floodplain available, the location of property in relation to other state managed lands, the presence of adjacent high quality uplands with natural heritage element occurrences, and the availability of restoration or enhancement opportunities. Those without significant tidal swamp wetland community types were excluded. Tracts which, when pooled and owned by the same forest were dropped from further analysis, as were most located totally below the upstream limit of the potential salinity change. Once the wetland impact assessment and modeling were completed, it was then determined that a minimum of 3,420 acres of tidal forest and other owner or added to other parcels, where practicable, that were less than 3,420 acres were then culled from the final list. Following the screening analysis only two privately-owned parcels remained for further analysis.

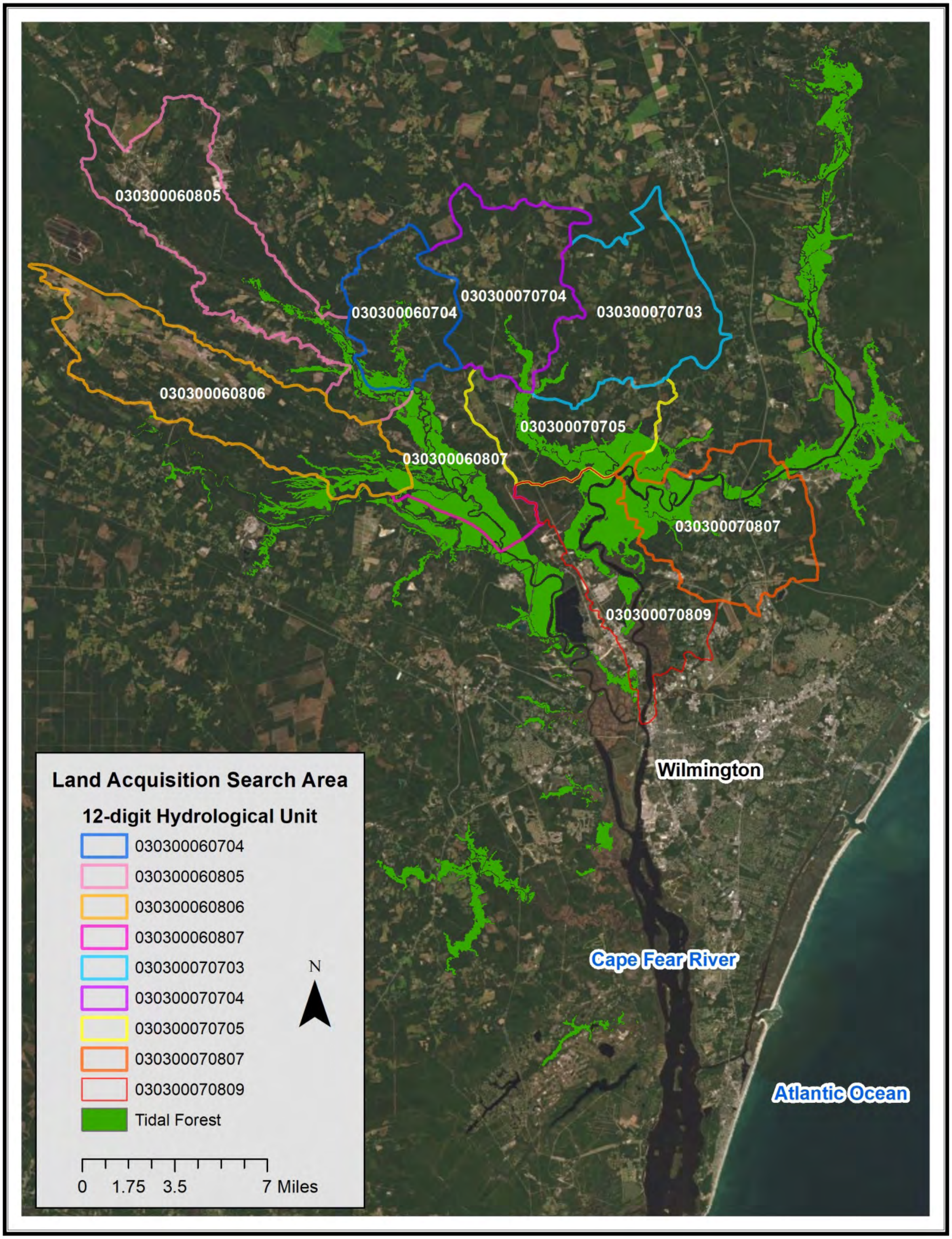


Figure 1
Tidal Wetland Forest Preservation Land Acquisition Search Area

The Black River and Northeast Cape Fear River wetland mitigation properties (Figure 2) were assessed as mitigation options through coordination with TNC, Coastal Land Trust, and other entities. Based on the wetland effects analysis presented earlier in this plan, these mitigation options are acceptable for mitigating impacts to freshwater marsh and tidal swamp forest. The preferred preservation approach is PRM through acquisition of tidal wetlands or headwater stream wetlands. While a conservation easement may suffice if the property offers higher resource protection value than others, fee simple purchase is the preferred transaction. In addition, where practicable, restoration and/or enhancement measures were also assessed for both tracts.

Attributes for both properties are listed in Table 2. Through purchase, conservation and conveyance of title to a willing non-governmental organization or the North Carolina Wildlife Resources Commission (NCWRC), either of these two tracts could be protected in perpetuity and would serve to benefit the watershed by increasing the extent of contiguous preserved tidal wetlands and to some degree the adjacent transitional habitats and uplands.

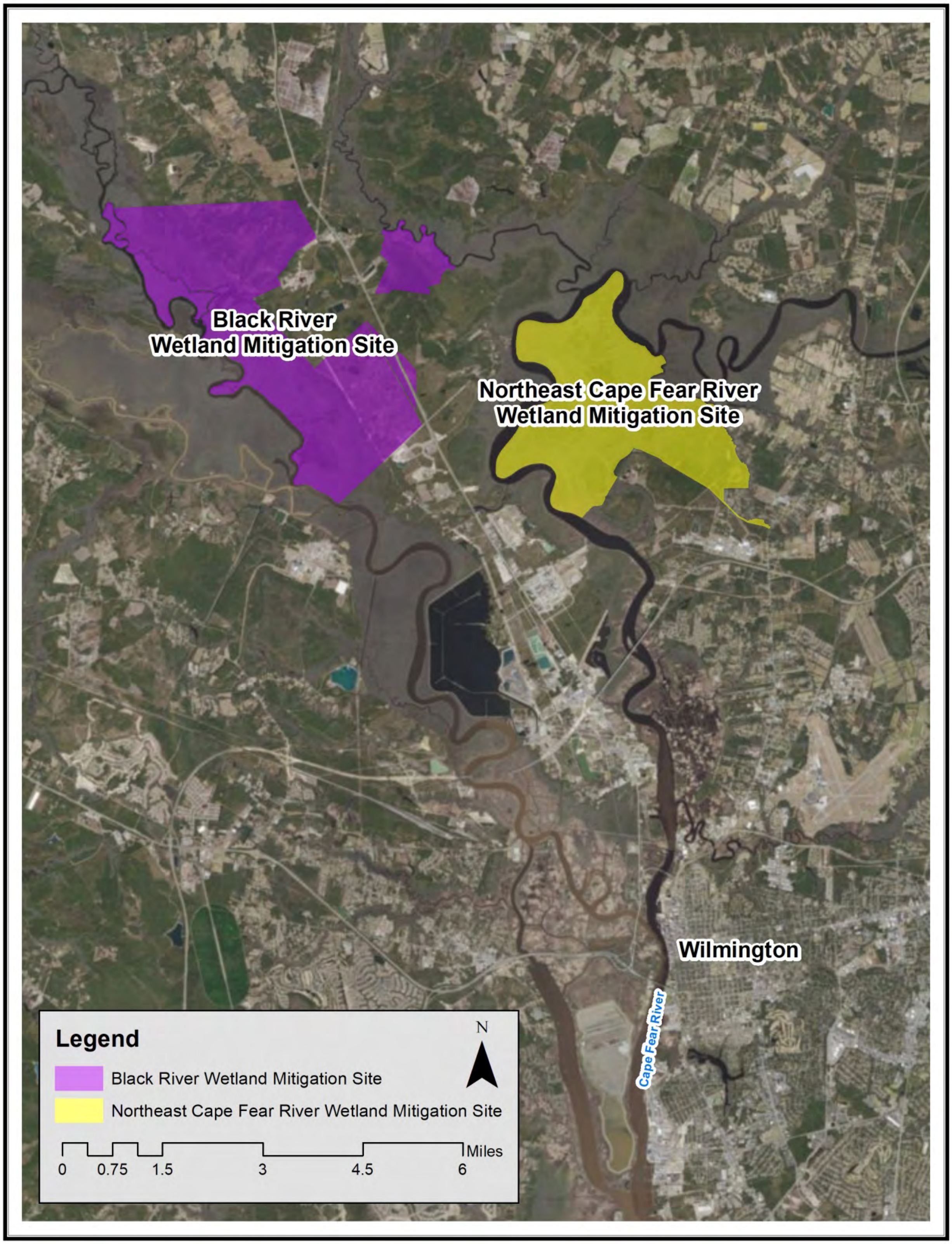


Figure 2
Wetland Mitigation Properties Selected Following Screening Analysis

Table 2
Resource Information for the Northeast Cape Fear River and Black River Wetland Mitigation Sites

	Northeast Cape Fear River Wetland Mitigation Site	Black River Wetland Mitigation Site
Total Area (ac)	3,900	4,485
Tidal Swamp Area (ac)	900	2,350
Non-tidal Wetland Area (ac)	1,925	1,335
Uplands Area (ac)	1,075	800
Conservation Priority	Medium	High
Restoration and Enhancement Potential	Low	High
Preservation Type	Fee Simple	Fee Simple/Easement
Collaborative Interest by Stakeholders	Medium	High

2.3.1.1 Northeast Cape Fear River Wetland Mitigation Site Summary

The Northeast Cape Fear River Wetland Mitigation Site is contiguous with an 8.5-mile reach of the Northeast Cape Fear River (NECFR) that extends from Fishing Creek up to Prince George Creek (Figure 2) The approximately (~)3,900-acre potential mitigation site encompasses ~900 acres of river-contiguous tidal cypress-gum swamp on the NECFR floodplain, ~1,750 acres of non-tidal pond pine woodland and non-riverine swamp forest on expansive interior terraces, ~175 acres of tidal freshwater marsh intermixed with salinity impacted cypress-gum swamp, and ~1,075 acres of uplands consisting of managed loblolly pine stands and natural longleaf pine-scrub oak communities (Figure 3). Hydrological conditions on the site are largely unaltered. Tidal flow from the river onto the floodplain is unimpeded and there are no ditches or other hydrological modifications that are indicative of any past efforts to manipulate water levels within the site. Wetland vegetation and hydrology on the site are minimally impacted by a network of unimproved access roads and a 100-foot-wide power line right-of-way that runs east-west across the northern portion of the site.

The 8.5-mile NECFR reach along the site is a state-designated PNA and a state-designated Anadromous Fish Spawning Area (AFSA). As a state-designated PNA, the river also comprises Essential Fish Habitat (EFH) for federally managed estuarine-dependent species; including penaeid shrimp, red drum, and summer flounder. The NECFR along the site is also designated critical habitat for the Carolina Distinct Population Segment of the federally endangered Atlantic sturgeon. The NECFR provides habitat for the Atlantic sturgeon as well as the federally endangered shortnose sturgeon and other anadromous species such as striped bass and American shad. The entire mitigation site, with the exception of ~500 acres of loblolly pine plantation, is encompassed by the state-designated Northeast Cape Fear River Floodplain Natural Area, which is assigned the highest North Carolina Natural Heritage Program ranking of exceptional based on the quality of individual and collective biodiversity elements. The site also adjoins the state-owned Cape Fear River Wetlands Game Land, which encompasses tidal cypress-gum swamps and non-riverine wetlands along both sides of the NECFR immediately above the site. No

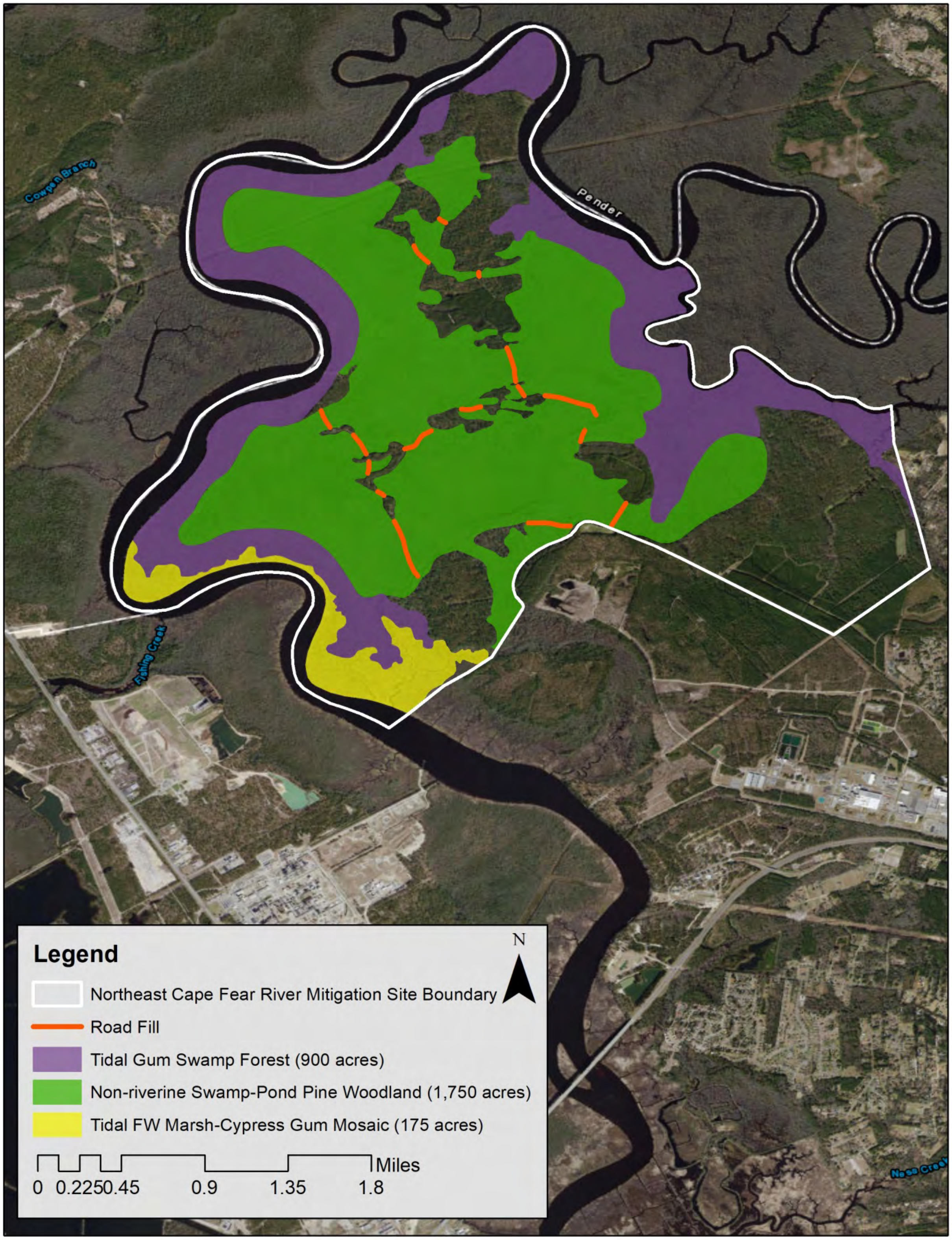


Figure 3
Northeast Cape Fear River Wetland Mitigation Site Habitats and Present Conditions

specific threats to wetlands on the site were identified. Timber harvest is a potential threat, but no logging has occurred in the wetlands for at least the last 50 years.

Current and future salinity conditions were a major consideration in evaluating the suitability of potential mitigation sites. The currently active swamp forest to tidal marsh conversion zone on the NECFR extends ~2.0 river miles into the lower mitigation area, and modeling results show salinity-driven wetland impacts extending an additional 0.7 mile upriver due to effects of the TSP (Figure 4). Consequently, ~350 acres of river-contiguous tidal wetlands within the lower portion of the site are unsuitable as mitigation due to current or projected salinity effects. The proximity of the active salinity effects zone is a major risk factor, as any exceedance of the projected upstream extent of salinity intrusion would render additional wetland acreage within the site unsuitable as mitigation. Due to the long-term continuing effects of SLR and salinity intrusion, the ability of the mitigation site to sustain tidal freshwater wetland functions beyond the 50-year project life is potentially limited.

Wetland preservation would be the principal mitigation mechanism employed on this tract. Protection of the ~3,900-acre potential mitigation site would provide an estimated 2,825 acres of wetland preservation; including ~900 acres of river-contiguous tidal cypress-gum swamp, ~1,750 acres of non-tidal pond pine woodland and non-riverine swamp, and ~175 acres of tidal freshwater marsh intermixed with salinity impacted cypress-gum swamp (Figure 3). The estimated 2,825 acres of wetland preservation would provide mitigation for the 341 acres of affected tidal wetlands at a ratio of 8.1 to 1.0. The overall 8.3 to 1.0 ratio represents tidal cypress-gum swamp preservation at a ratio of 2.6 to 1.0, mixed tidal freshwater marsh/cypress-gum swamp preservation at a ratio of 0.5 to 1.0, and non-tidal pocosin/non-riverine swamp preservation at a ratio of 5.1 to 1.0. Exclusion of the ~350 acres of existing and projected salinity impacted tidal wetlands reduces the overall preservation ratio to 7.3 to 1.0. Approximately 10,000 linear feet (ft) of narrow (~20-foot-wide) access roads on the interior wet terraces could potentially be restored to non-tidal swamp forest and pocosin wetlands. Restoration would involve road fill removal and grading to reestablish original pre-impact elevations followed by the planting of wetland tree species that are constituents of the existing on-site wetland communities. A total of ~4.5 acres of wetlands could be restored within the road corridors

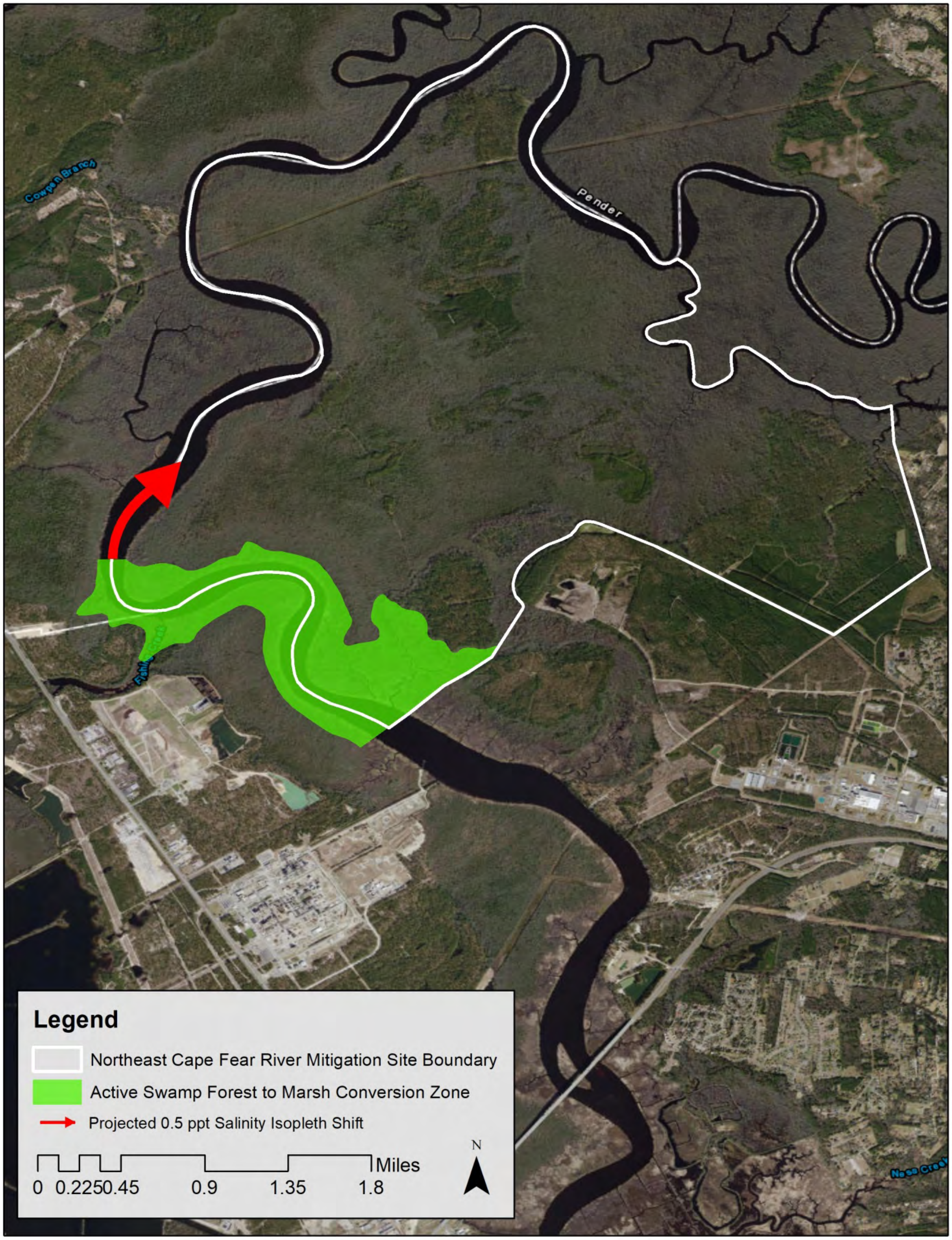


Figure 4
Site Suitability Analysis for Northeast Cape Fear River Wetland Mitigation Site

2.3.1.2 Black River Wetland Mitigation Site Summary

The Black River Wetland Mitigation Site is contiguous with the lowermost nine-mile reach of the Black River immediately above its confluence with the Cape Fear River. The ~4,485-acre mitigation site encompasses ~2,350 acres of river-contiguous tidal cypress-gum swamp on the east-side tidal floodplain of the Black River, ~1,335 acres of non-tidal pocosin wetland communities, and ~800 acres of xeric sandhill scrub uplands (Figure 5). The tidal cypress-gum swamps have a moderately dense to dense canopy of bald cypress (*Taxodium distichum*), pond cypress (*T. ascendens*), water tupelo (*Nyssa aquatica*), swamp tupelo (*N. biflora*), green ash (*Fraxinus pennsylvanica*), and red maple (*Acer rubrum*). Typical understory shrubs include titi (*Cyrilla racemiflora*), wax myrtle (*Morella cerifera*), and cane (*Arundinaria gigantea*); and the generally sparse herbaceous layer includes species such as lizard tail (*Saururus cernuus*), arrow-arum (*Peltandra virginica*), and pickerel-weed (*Pontedaria cordata*). Pocosin wetland communities of the pond pine woodland type comprise a broad, nearly continuous zone along the outer margin of the floodplain. The pond pine woodland community has an open canopy of scattered pond pine (*Pinus serotina*) and loblolly bay (*Gordonia lasianthus*), and a very dense shrub understory of typical pocosin shrubs such as gallberry (*Ilex coriacea*), fetterbush (*Lyonia lucida*), titi, red bay (*Persea palustris*), and sweetbay (*Magnolia virginiana*). On the northern portion of the site, the contiguous pond pine woodland community grades northeastward into a mosaic of xeric sandhill scrub uplands and linear streamhead pocosin wetlands. The xeric sandhill scrub community has an open canopy of longleaf pine (*Pinus palustris*), an understory of scattered turkey oak (*Quercus laevis*), and a very sparse wiregrass (*Aristida stricta*) herbaceous layer. The composition of the streamhead pocosins is similar to that of the pond pine woodland pocosin community, with an open canopy of pond pine and a very dense understory of typical pocosin shrubs. The mosaic of xeric sandhill scrub uplands and streamhead pocosins are positioned on the gentle western slope of a lengthy sand ridge that spans both sides of US Highway 421. The streamheads drain southwestward directly to the Black River floodplain.

Hydrological Conditions and Site Impairments

Tides are diurnal in the Black River with a mean tidal range of ~2.0 ft in the river mouth at the southern end of the mitigation site. Hydrological conditions on the site are largely unaltered. Tidal flow from the river onto the floodplain is unimpeded and there are no ditches or other hydrological modifications that are indicative of any past efforts to manipulate water levels within the site. Timber harvest operations over the last 20 years have resulted in localized hydrological modifications through forest road construction and the use of shovel-logging timber harvest systems. Clear cuts conducted in 2000, 2010, and 2016 have removed ~1,000 acres of mature swamp forest from the southern, central, and northern portions of the tidal floodplain (Figure 5). Each of the three clear cut operations employed the construction of a permanent forest access road from the uplands across a portion of the tidal floodplain. The roads are generally river-perpendicular, and thus are not impeding tidal flow from the river or upland drainage across the floodplain. However, the roads are restricting lateral flow across the floodplain, especially in the case of the two lower access roads that extend nearly to the river. Borrow ditches that line the roads have no outlet to the river or its tributaries, but are contributing to localized hydrological effects. Shovel-logging employs an expansive network of log mat skidder trails to harvest and remove timber from extremely wet sites such as the Black River tidal floodplain. The log mats are removed as the cuts are completed, leaving behind a network of shallow ditch-like linear depressions. As in the case of the forest road borrow

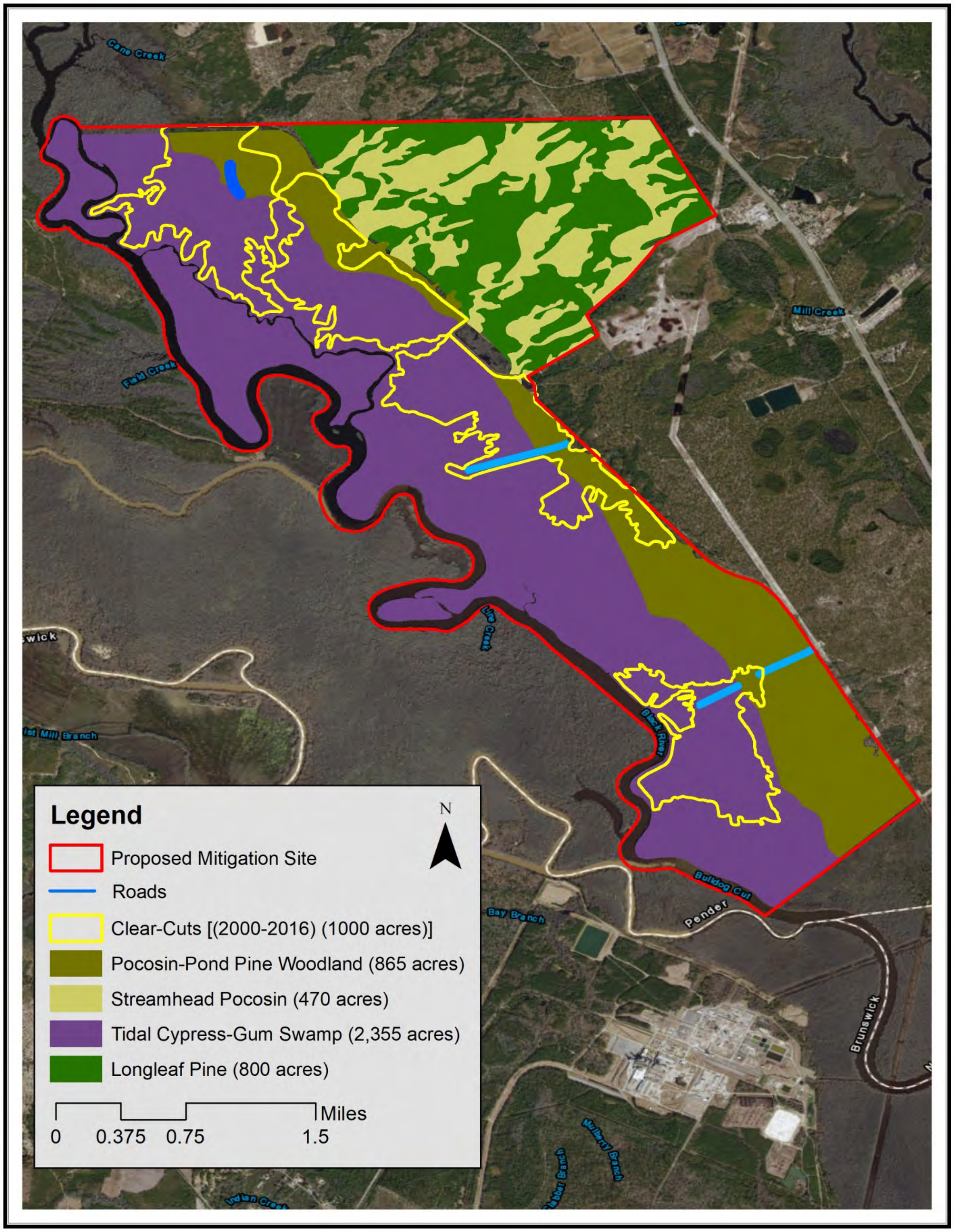


Figure 5
Black River Wetland Mitigation Site Habitats and Present Conditions

ditches, the skidder trails on the site do not have an outlet to the river, but have altered the hydrology of the site on a localized scale. The skidder trail network from the earliest (ca. 2000) clear cut remains readily apparent on current aerial imagery and can be mistaken for a system of drainage ditches. Portions of two small streams that originate from streamhead pocosins on the northeastern portion of the site are impounded within a 20-acre waterfowl pond along the outer margin of the floodplain. The impoundment is formed by a 3,000-linear-foot berm that connects to upland xeric sandhill scrub areas that adjoin the floodplain. The three clear cut areas are in various stages of succession and are regenerating naturally. The remaining mature cypress-gum swamps and pond pine woodland pocosins represent high quality examples of their respective community types. Analysis of aerial imagery indicates that the majority of the streamhead pocosin communities on the northeastern portion of the site, while not appearing to be hydrologically altered, are currently managed as loblolly pine (*Pinus taeda*) plantations. Additional field investigation is needed to fully evaluate the condition of the streamhead pocosin wetlands.

Landscape Relationships and Ecological Significance

The lower Black River along the mitigation site is a state-designated PNA and a state-designated AFSA. As a state-designated PNA, the river also comprises EFH for federally managed estuarine-dependent species; including penaeid shrimp, red drum, and summer flounder. The Cape Fear River along the southern boundary of the mitigation site is designated critical habitat for the Carolina Distinct Population Segment of the federally endangered Atlantic sturgeon. The Cape Fear River and the Black River provide habitat for the Atlantic sturgeon as well as the federally endangered shortnose sturgeon and other anadromous species such as striped bass and American shad. This mitigation site is divided between two state-designated Natural Areas that are assigned the highest North Carolina Natural Heritage Program ranking of exceptional based on the quality of individual and collective biodiversity elements (Figure 6). The tidal floodplain and its associated cypress-gum swamps are part of the Lower Black River Swamp Natural Area and the pocosin and xeric sandhill scrub communities that comprise the remainder of the site are part of the 421 Sandhills Natural Area. The xeric sandhill scrub and pocosin communities within the mitigation site provide nesting and foraging habitat for an extant population of the federally endangered red-cockaded woodpecker (RCW) (*Picoides borealis*). The 421 Sandhills RCW population encompasses 23 active clusters between the Black River floodplain and US HWY 421, including three active clusters on the northeastern portion of the mitigation site (Figure 7). The 0.5-mile foraging partitions that are associated with the 23 clusters encompass essentially all of the pocosin communities within the mitigation site.

The mitigation site also adjoins two tracts that comprise part of the state-owned Cape Fear River Wetlands Game Land. The adjoining Game Land tracts encompass tidal cypress-gum swamps on the west-side tidal floodplain of the Black River opposite the southern and northern portions of the mitigation site. The larger of the two tracts extends southwest from the Black River across Roan Island to the Cape Fear River.

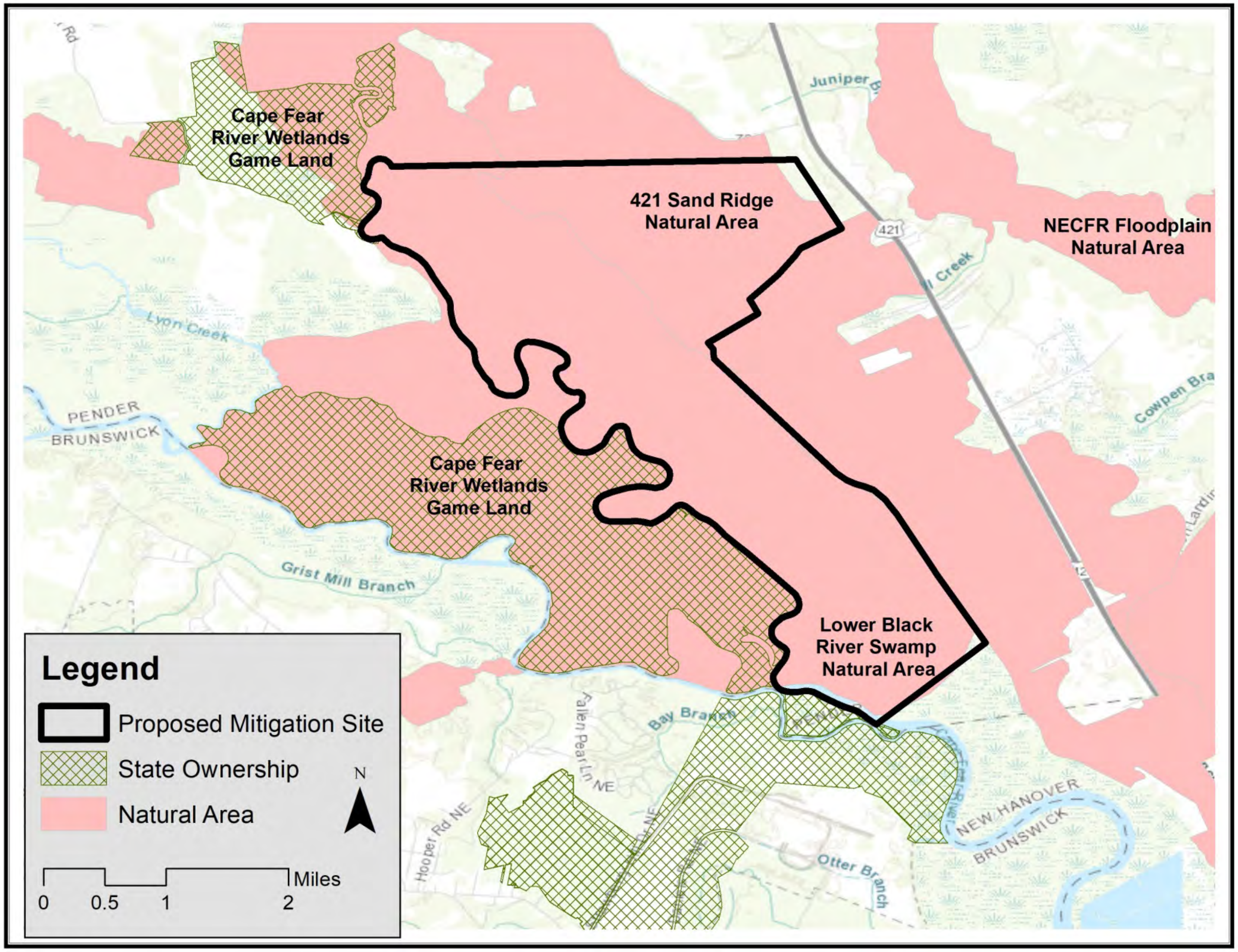


Figure 6
Managed and Natural Areas in Vicinity of Black River Wetland Mitigation Site

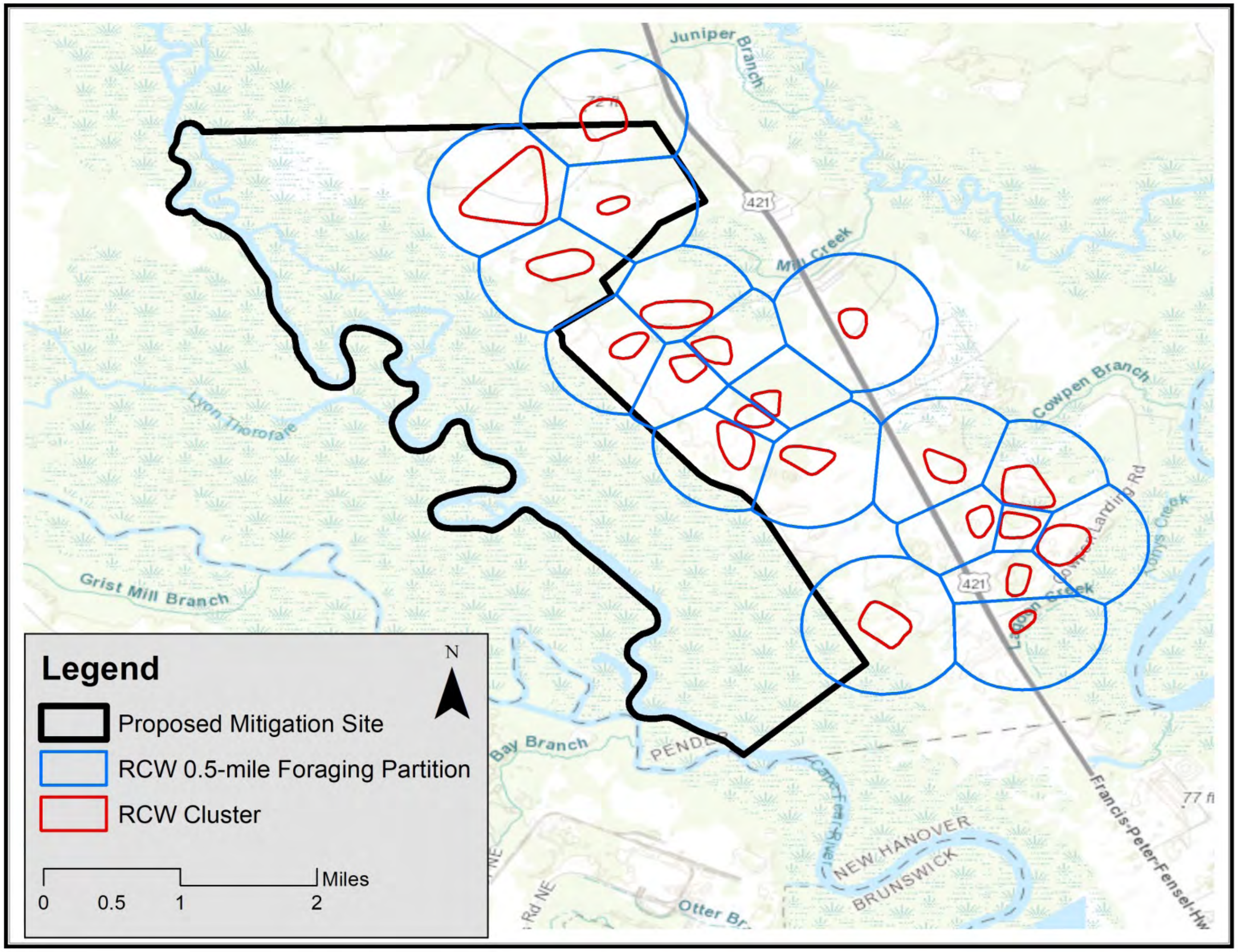


Figure 7
Red-cockaded Woodpecker Clusters on the Black River Wetland Mitigation Site

Current and Future Threats

Timber harvest is the principal current and future threat to the cypress-gum swamps and pond pine woodland pocosins in the mitigation area. In addition to functional losses that are associated with the removal of mature forests, the use of shovel-logging and the construction of permanent forest roads across the tidal floodplain are significant stressors impacting hydrology, soils, and vegetation. As described above, the expansive log mat skidder trail networks that are used to harvest timber from the tidal floodplain leave behind corresponding networks of shallow linear depressions that significantly impact hydrology on a localized scale. Each clear cut operation is accompanied by the construction of a permanent borrow-ditch forest access road that directly impacts wetlands and further restricts lateral flow across the floodplain. New clear cut timber harvests are imminent if the site is not protected. As described above, the most recent of the clear cuts that have removed ~1,000 acres of mature tidal cypress-gum forest from the site was conducted in 2016. The owner of the site is actively pursuing additional contracts to clear cut additional areas of tidal swamp forest on the site. Through discussions with the land manager in December 2019, field biologists with Dial Cordy and Associates Inc. (DCA) were informed of an additional timber harvest contract that had recently fallen through. The streamhead pocosin wetland communities on the northeastern portion of the site are threatened by their continued management as loblolly pine plantations. The ecological integrity of the streamhead pocosins is impacted by the presence of dense offsite loblolly pine stands, and these communities are subject to mechanical disturbance from timber harvest and timber stand management activities.

Current and future salinity conditions at the site were a major consideration in evaluating the suitability of the site for mitigation. This property was selected as a potential mitigation site based in part on its location approximately six miles above the area of model-projected salinity effects on the mainstem Cape Fear River. At this location, the mitigation site is expected to sustain tidal freshwater forested wetland functions through the 50-year life of the project and beyond. Giese et al. (1985) estimated that salinity intrusion ≥0.2 ppt in the Cape Fear River as far upstream as the mouth of the Black River would require the simultaneous occurrence of an exceptionally high tide and an exceptionally low inflow rate. Under flow conditions representing the minimum Jordan Lake release rate and a 100-yr low flow rate between Lillington and the Cape Fear River mouth, the upper limit of salinity intrusion in the Cape Fear River was projected to occur six miles below the Black River in the vicinity of Indian Creek. Measured salinities during the 10-year Wilmington Harbor 96 Act monitoring study also suggest that regulated discharge in the Cape Fear River affords the Black River some protection against salinity intrusion (Leonard et al. 2011). Monitoring never detected saline water as far upriver as Station P9 at the mouth of the Black River, despite the occurrence of extreme drought conditions and the driest year on record during the study period. In sharp contrast, the unregulated NECFR experienced extreme upriver salinity intrusion during the most severe period of drought-induced low flow, with pulses of high salinity water causing temporary damage to tidal swamp forests at the uppermost stations.

Mitigation Summary

Purchase of ~4,485 acres of the subject properties in perpetuity would provide an estimated 3,685 acres of wetland preservation; including ~2,350 acres of tidal cypress-gum swamp, ~865 acres of pocosin pond pine woodland wetlands, and ~470 acres of streamhead pocosin wetlands (Figure 8). Protection of the site would also conserve ~800 acres of natural longleaf pine xeric sandhill scrub uplands that provide nesting and foraging habitat for the endangered red-cockaded woodpecker. The estimated 3,600 acres of wetland preservation would provide mitigation for the 341 acres of affected tidal wetlands at a ratio of 10.8 to 1.0. Acquisition is proposed to include the fee simple purchase of the swamp forest wetlands and adjacent pocosin wetlands (3,220 acres) and purchase of a conservation easement on the streamhead pocosin and long leaf pine uplands (1,270 acres). The overall 10.8 to 1.0 ratio represents tidal cypress-gum swamp wetland preservation at a ratio of 6.9 to 1.0 and pocosin wetland preservation at a ratio of 3.9 to 1.0. A total of ~25 acres of wetlands could be restored within three road/ditch corridors; including ~14 acres of tidal cypress-gum swamp and ~11 acres of pond pine woodland pocosin. Removal of the roads would provide additional hydrological enhancement within the existing adjoining wetlands through the restoration of natural lateral flow across the floodplain.

2.3.2 Selected Alternative for Wetland Mitigation

Based upon the mitigation requirements for civil works planning, the preservation of land and eventual conveyance to a non-profit organization or the NCWRC is an environmentally-preferred mitigation alternative. Sufficient mitigation bank credits for the wetland type effected or in-lieu fee program credits are presently not available. While this may change over the next few years, with several mitigation banks being considered, this at present does not represent a viable option.

Wetland creation options were assessed as a type of mitigation option available for meeting compensatory requirements associated with this project. Accomplishing this type of mitigation typically involves excavating uplands to the elevation of the adjacent wetlands and planting the area with native wetland vegetation. Potential upland areas of adequate size located in the targeted region for selecting mitigation sites were limited or not available for purchase. In addition, creating large areas of tidal swamp forest is very expensive and the degree of risk to achieve success very high. For these reasons, no effective options were available to consider wetland creation as a viable choice to compensate for functional wetland losses associated with the TSP.

While restoration is most commonly preferred over preservation for mitigation, available opportunities for in-kind tidal swamp restoration are limited in scale, and can only partially fulfill the mitigation needed. Due to the type of wetland being restored (e.g. tidal swamp) and difficulty associated with achieving restoration success, the risk and long-term cost of monitoring and management are greater. Restoration measures considered on the two parcels included removal of timber roads and ditches through forested wetlands. Enhancement opportunities are available on both tracts, including planting of cypress or other hardwood species within prior cut-over areas.

Preservation of land and future conveyance to the NCWRC as the principal mitigation element for wetland effects associated with a shift in salinity is the preferred plan. Preservation of high quality tidal swamp forests provides significant benefits within the watershed and ensures the perpetual ability of these wetlands to provide important physical, chemical, and biological

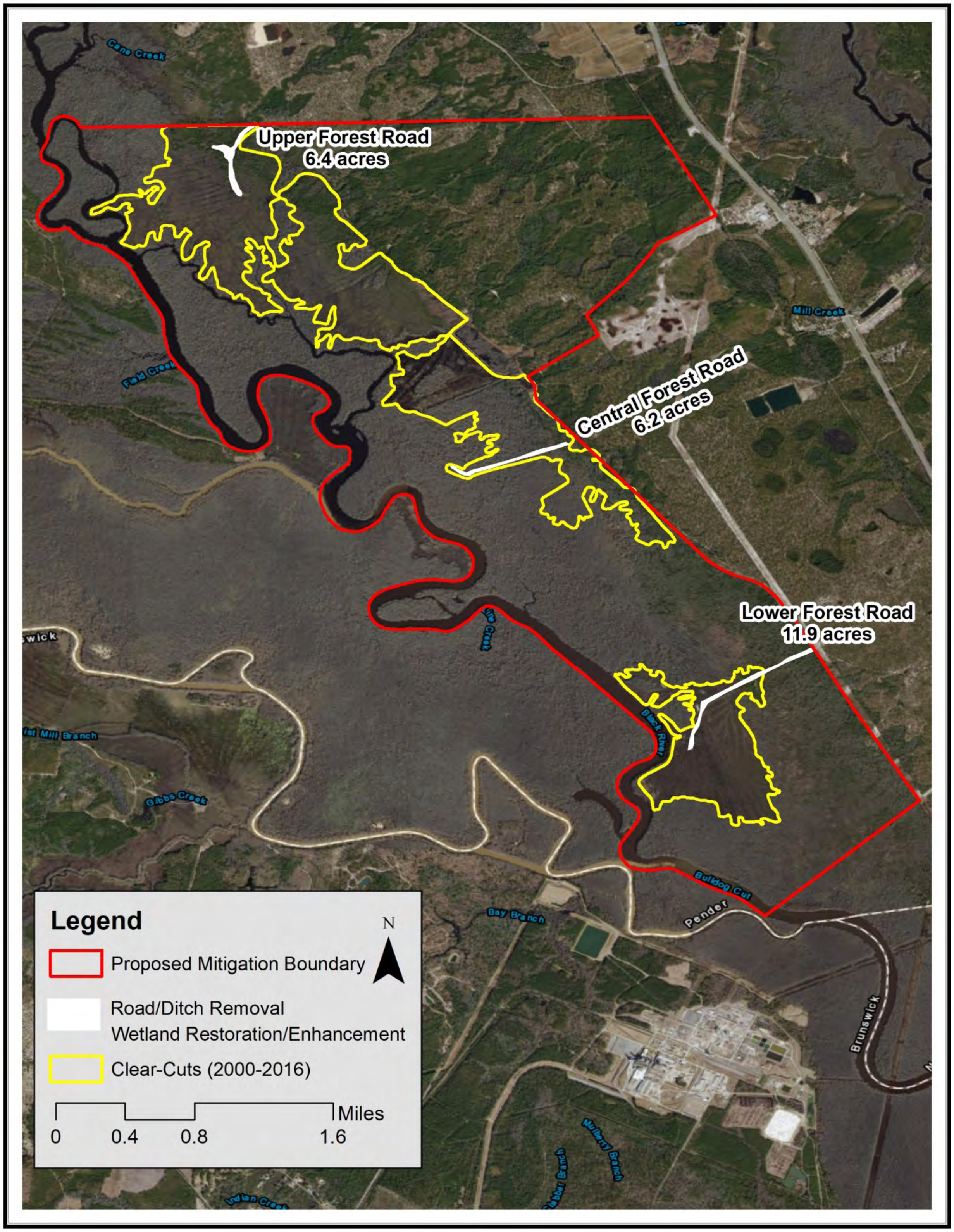


Figure 8
Black River Wetland Mitigation Site Conceptual Mitigation Plan

benefits to the LCFR Basin. While it is likely that silvicultural activities will continue to occur on the planted pine portions of adjacent tracts of land and eventually developed; preserving upland buffers adjacent to the swamp forest serves to provide a critical buffer for minimizing future soil erosion, water quality degradation, and serves to protect the intrinsic functional values of the swamp forest. Due to the high degree of focus by the TNC, Coastal Land Trust, NCWRC, National Fish and Wildlife Foundation, National Oceanic and Atmospheric Administration (NOAA), Cape Fear River Partnership, Cape Fear River Watch (CFRW), and mitigation bankers within the lower Cape Fear watershed; the proposed acquisition will make a significant contribution to the sustainability of the watershed. As proposed, preservation as the selected type of mitigation serves as a low risk and practicable option. Future changes in land-use and increases in residential/industrial development within these two areas of the watershed place these resources at risk of being adversely modified and benefits substantially reduced. The proposed mitigation would protect and sustain these at-risk riparian resources for perpetuity. The inclusion of adjacent uplands as buffers would also help protect and sustain the aquatic resources and, through removal from future development, aid in reducing stressors on the watershed for the long-term.

The Black River Wetland Mitigation Site is best suited to provide the compensatory mitigation requirements in accordance with applicable wetland policies and regulations and in accordance with risk and uncertainty analysis. Given that a portion of the Northeast Cape Fear River Wetland Mitigation Site is within the area of the river where salinity shifts may occur, the viability of the property is reduced. With a stated goal of maximizing the preservation of swamp forest, the Black River property has over two times the acreage of swamp forest compared to the NECFR property. Finally, restoration and enhancement opportunities and the conservation priority ranking are higher for the Black River property.

2.3.3 Compliance with the Mitigation Rule

2.3.3.1 Goals and Objectives

The purpose of this tract is to provide mitigation that will offset the effects of projected salinity increases on 341 acres of tidal freshwater wetlands under the TSP. Mitigation sufficient to offset these effects will be provided through PRM wetland preservation and restoration. The proposed mitigation treatments are summarized below in Table 3 and shown in Figure 8.

Table 3
Black River Wetland Mitigation Site Summary

Wetland Type	Preservation (acres)	Restoration (acres)		
		Lower Forest Road	Central Forest Road	Upper Forest Road
Tidal Cypress-Gum Swamp	2,350	6.1	6.2	1.4
Pocosin - Pond Pine Woodland	865	5.8		5.0
Streamhead Pocosin	470			
Long leaf pine upland buffer	800			
Total	**4,485**	**11.9**	**6.2**	**6.4**

Wetland Preservation

Wetland preservation would be the principal mitigation mechanism employed on this tract. Protection of the ~4,485-acre mitigation site would provide an estimated 3,685 acres of wetland preservation; including ~2,350 acres of tidal cypress-gum swamp, ~865 acres of pocosin pond pine woodland wetlands, and ~470 acres of streamhead pocosin wetlands. Protection of the site would also conserve ~800 acres of natural longleaf pine xeric sandhill scrub uplands that provide nesting and foraging habitat for the endangered RCW. Property is proposed to be protected through fee simple purchase of 3,220 acres of wetlands and through a conservation easement for the streamhead pocosin wetlands and adjoining 800 acres of long leaf pine uplands. Contingent on the confirmation of wetland acreages through the completion of a Section 404 wetland jurisdictional determination, the estimated 3,600 acres of wetland preservation would provide mitigation for the 341 acres of affected tidal wetlands at a ratio of 10.8 to 1.0. The overall 10.8 to 1.0 ratio represents tidal cypress-gum swamp wetland preservation at a ratio of 6.9 to 1.0 and pocosin wetland preservation at a ratio of 3.9 to 1.0.

Forest Road Removal - Wetland Restoration and Enhancement

The three forest access roads and their associated borrow ditches (Figure 8) will be restored to tidal cypress-gum swamp and pond pine woodland pocosin wetlands through the removal of upland road fill and the return of the material to the roadside borrow ditches to reestablish the original pre-impact grade of the road/ditch corridors. Upon reestablishment of the natural grade, the corridors will be planted with bald cypress and/or pond cypress along with other wetland tree species that are constituents of the existing on-site wetland communities. A total of ~25 acres of wetlands will be restored within the three road/ditch corridors; including ~14 acres of tidal cypress-gum swamp and ~11 acres of pond pine woodland pocosin. Removal of the roads will provide additional hydrological enhancement within the existing adjoining wetlands through the restoration of natural lateral flow across the floodplain.

2.3.3.2 Site Protection

To mitigate for the potential vegetative conversion of 340.5 acres of freshwater wetlands, the USACE would propose that the NCSPA acquires (fee simple and or conservation easement) land considered high priority acquisition by the USFWS and TNC. Once under public control, it is anticipated the land would be provided to either NCWRC or a non-profit organization to manage, as an addition to adjacent state-owned lands. The land would be subject to the same protections and use requirements common to other conservation land use agreements between state and federal agencies.

2.3.3.3 Baseline Conditions

Following additional coordination with the IRT and TWGs, site visits will be scheduled to develop the final mitigation measures. Once concurrence is obtained, a baseline survey will be performed of the subject property in coordination with the landowners.

2.3.3.4 Determination of Mitigation Credits

Mitigation planning was performed with the incorporation of risk and uncertainty into the mitigation planning process. The most important risk factor identified in the mitigation planning process was identified as the uncertainty associated with salinity modeling and salinity model results. This uncertainty is based on knowledge uncertainty, the imperfectness of modeling and data inputs, and the inherent variability of natural systems such as wetlands. The salinity model results indicate virtually no impact to salinity that can be distinguished from projected future impacts due to SLR. The uncertainty associated with this result directly affects the design objective, which is to appropriately mitigate for tidal forest and freshwater marsh impacts. The unacceptable level of uncertainty associated with the salinity model's no-impact result caused the Wetland TWG to remove the "no mitigation" option from further consideration.

Mitigation plan design was used to reduce the risks associated with knowledge uncertainty and inherent variability. Although mitigation planning for this project is constrained by existing land uses and ownership, multiple mitigation options to manage the risk associated with the uncertainty of the salinity model results were assessed. An array of alternative treatments and measures, including passive measures such as property acquisition for ecosystem preservation and active restoration and enhancement measures have been identified for development of alternative mitigation plans.

The alternative mitigation treatments and measures will be evaluated for completeness, effectiveness, efficiency and acceptability according to the Planning Guidance Notebook (USACE 2000). A final recommended plan will be selected during development of the EIS in coordination with the USACE, the local sponsor, and stakeholders. A draft plan has been developed to indicate that appropriate mitigation can be developed for this project and to ensure that sufficient mitigation cost is included in the project's total cost.

The mitigation needed to compensate for wetland impacts, based on risk and uncertainty and to be in compliance with the USACE mitigation policies, includes preservation of tidal forested wetlands in accordance with the USACE accepted ratios for preservation, restoration, and enhancement. Should restoration and/or enhancement measures be selected as part of the final plan, this ratio can be lower than the required 10:1 ratio. Therefore, if only preservation is selected, a minimum of 3,410 acres would be required to mitigate for the impacts of the salinity shift on 340.5 acres of tidal forest and freshwater marsh. In addition, due to the use of risk and uncertainty and modeling results, no functional assessment modeling is deemed practicable.

2.3.3.5 Mitigation Work Plan

The conceptual mitigation plan for the Black River wetland mitigation property is shown in Figure 8 and Table 3, and includes purchase and preservation of 3,690 total acres, which includes 2,350 acres of tidal forested wetland along nine miles of the Black River, 1,335 acres of stream head pocosin and pocosin pond pine wetlands, and 800 acres of longleaf pine uplands; which buffer the adjacent wetlands. The USFWS and NCWRC will work towards managing not only the lands purchased, but will also work with stakeholders to acquire the remaining uplands on the tract where active RCW clusters are present. In addition to preservation, 25 acres of forested wetland will be restored through the removal of three timber access roads and the filling of roadside ditches (Figures 8). Following grading of the site to wetland elevations, the site will be planted with hardwood swamp bare root tree seedlings at a density of 600 stems per acre. Species planted would include bald cypress, black gum, and green ash. Due to the seed source present and likely recruitment from the adjacent wetlands, no groundcover or shrub species will be planted. Following approval by the IRT of the proposed wetland mitigation, a final mitigation plan, in accordance with USACE mitigation rules policy will be prepared.

Work plan items for PED would include a land survey and plat of the property; a full biological survey of the site, including active use by federal and state listed species; a wetland jurisdictional survey, and a topographic survey of the present timber access roads and ditches. During PED, full plans and specifications for the wetland restoration measure will be prepared and reviewed with the IRT. Other conditions for purchase would be coordinated in accordance with the forthcoming real estate requirements specified in Main Report Appendix E: Real Estate.

2.3.3.6 Maintenance Plan

Maintenance requirements would be limited to normal property maintenance by the public entity that the properties are conveyed to following purchase. The eventual conveyance deed to the state (NCWRC) would indicate the project name and that the purpose of the property transfer is for compensatory mitigation associated with effects associated with the said project. In the event that the lands are not placed under state ownership, restrictive deed covenants will be enacted to ensure the lands are held as mitigation lands in perpetuity to meet the project requirements. For those lands protected through a conservation easement, appropriate conditions and management requirements would be prepared and coordinated with the USFWS to ensure provisions for management of the existing RCW cavity trees and foraging habitat. Since restoration is presently being proposed, which includes removal of the three timber access roads/ditches, annual site visits (7 years) for the purpose of monitoring restoration success will be required. The only annual maintenance item for this would be selective removal of invasive species from the three areas restored.

2.3.3.7 Performance Standards

The potential conversion of tidal swamp forest to freshwater and brackish marsh associated with salinity shifts upriver as a result of implementing proposed TSP would be mitigated for through the acquisition/preservation and restoration of tidal swamp forest located adjacent to waters of the United States. Ecological performance standards to be met for the restoration measures would include: 1) achieving a viable hardwood species stem count of 200 trees per acre annually for seven years, and 2) achieving 85 percent (%) groundcover from natural recruitment of indigenous hardwood species after two to seven years. Annual monitoring and maintenance will be performed to ensure standards are being met with annual reports prepared and submitted to document site conditions, compliance with performance standards, maintenance, and additional planting performed,

2.3.3.8 Monitoring Requirements

While not typically required for preservation lands conveyed to the state (NCWRC), site visits will be conducted one, three, and five years following construction to verify that swamp forest functions are still being met. Selected restoration and/or enhancement treatments and measures will require annual monitoring for seven years to assess success. Monitoring will include both hydrologic and vegetative data collection; with a goal of achieving 85% success for planted species five years after construction is completed. These will be timed to be conducted concurrently with project hydrologic monitoring and long-term monitoring of potentially affected tidal wetlands. A detailed monitoring plan tied to achieving desired success criteria will be prepared during the NEPA process and incorporated into the final mitigation plan.

2.3.3.9 Long-term Management Plan

Since preservation of existing habitat is the preferred mitigation for compensation of the majority of the shift in wetland types attributable to the indirect effects of salinity changes, a long-term management plan is not required or needed. While restoration measures will be implemented, achieving these goals should not require long-term management. Covenants and restrictions conveyed with the title transfer of the land to the state (NCWRC) should suffice to ensure the ecological functions attributable to tidal wetlands and adjoining pocosin wetlands are maintained for perpetuity. As long as the conditions developed for any conservation easement that may be proposed are satisfactory to the owner and the USFWS, there should not be any long-term management concerns.

2.3.3.10 Adaptive Management

Since the parcels will ultimately be transferred to state ownership, there should be no true concerns related to achieving the desired results and performance standards or restoration measures defined above. Given the likelihood of success for the proposed restoration measures, adaptive management measures are not needed.

3 FISH AND FISH HABITAT RESOURCES

This section includes a description of impacts, mitigation options, functional assessments (mitigation requirements), and the selected draft mitigation plans for direct impacts to shallow water habitat (PNA and non-PNA) and indirect effects of salinity on fish habitat suitability for selected fish species. Direct impacts on shallow water habitat functional loss and mitigation proposed were assessed using the Unified Mitigation Assessment Method (UMAM). This method was established to fulfill the mandate of subsection 373.414(18), F.S., which requires the establishment of a uniform mitigation assessment method to determine the amount of mitigation needed to offset adverse impacts to wetlands and other surface waters. Indirect effects on fish habitat suitability were quantitatively assessed using the USFWS Habitat Suitability Index (HSI) for selected managed and/or protected fish species. Mitigation requirements were assessed using the USWFS Habitat Evaluation Procedures (HEP). Direct and indirect effects of construction of the TSP on fish and fish habitat were evaluated in the main report and Appendix J: Fish Habitat Assessment. Further refinement may occur during development of the DEIS.

Over the past year, workshops have been held with the Fish and Fish Habitat TWG to review methods used to assess direct and indirect effects of the TSP, results of the effects analysis, mitigation requirements, functional assessments, and mitigation options (see Main Report Appendix Q: Public and Agency Involvement Correspondence for summaries of meetings). The sites tentatively selected for mitigation have been accepted by most TWG members.

3.1 Mitigation for Direct Impacts to Shallow Water Unvegetated Habitat

This section includes a review of direct impacts on unvegetated shallow water habitat, results of a functional assessment for determining mitigation requirements, and a summary of the proposed mitigative treatments and measures. Mitigation requirements will be based on civil works mitigation policy as well as results of HEP analysis reviewed by the Fish and Fish Habitat TWG. The USACE is committed to providing mitigation consistent with their mitigation policies for significant resource impacts that are documented and agreed upon by the IRT.

3.1.1 Direct Impacts to Shallow Water Unvegetated Habitat

Direct effects of the alternative plans on shallow water unvegetated habitat (PNA and non-PNA) within the CFR is discussed within the Main Report. Impacts include a total of 4.14 acres of PNA <6 ft, 1.73 acres of PNA 6 to 12 ft, 1.70 acres of non-PNA <6 ft, 5.8 acres of non-PNA 6 to 12 ft, and a total of 27 acres of foraging habitat >12 ft.

3.1.2 Mitigation Options for Direct Impacts to Shallow Water Estuarine Habitat

Given the location of most of the proposed impacts to shallow water PNA (near Eagle Island), and the requirements to restore or enhance like aquatic habitat, mitigation options available for consideration were very limited. The only alternatives considered were acquiring uplands and converting the property to subtidal aquatic habitat, excavating closed USACE dredged disposal sites, the purchase and restoration of multiple properties that are presently dominated by Phragmites wetlands and restoration of Alligator Creek on Eagle Island. None of first three alternatives were deemed cost-effective or as ecologically desirable as restoration of Alligator Creek. As to use of closed disposal areas, this would require considerable evaluation by the USACE, given that present policies do not allow for changes in use or ownership. Only consideration of Alligator Creek as mitigation was advanced for further analysis and consideration by the TWG and IRT. Further analysis during development of the DEIS will be performed to finalize the site selection and restoration actions proposed.

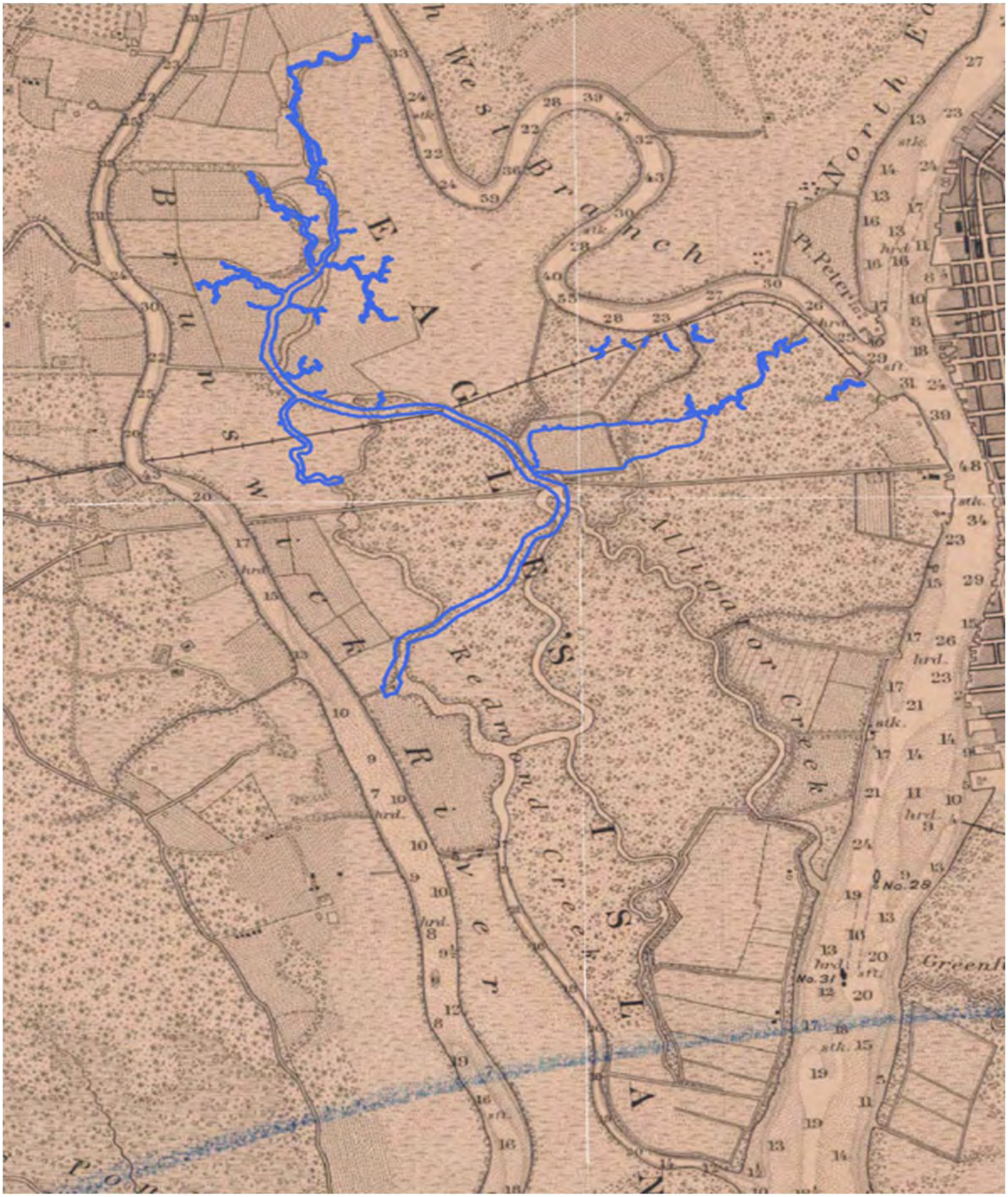
3.1.2.1 Alligator Creek Restoration and Enhancement

Prior to the construction of the Eagles Island Confined Disposal Facility (CDF) by the USACE, several tidal creeks that traversed the lower half of the island (Figures 9 and 10). Many of these creeks are now gone, but the portion of Alligator Creek that runs northwest to southeast is outside of the containment dike that surrounds the CDF. This creek has closed up over the decades since the access road to Eagles Island blocked tidal flow to the creek in the early 1940s.

This restoration and enhancement action was first proposed by the USACE as a mitigation option for proposed dredging upriver, as part of a General Reevaluation Report/EIS, which, as proposed would have restored about 25 acres of intertidal and subtidal habitat along the historic location of 10,000 linear ft of tidal creek.

Figure 11 illustrates the location of the historic creek alignment overlaid on a recent aerial photograph and parcel boundaries. Most of the interior habitat is considered jurisdictional wetland and is dominated by *Phragmites australis*. With tidal connections to Redmond Creek to the northwest and the Cape Fear River to the southeast, there would be sufficient tidal head difference. Restoration of the creek would have similar meanders as the old creek based on historical aerial photography. This restoration would also allow regular tidal flushing to the interior marshes that has not occurred since the 1950s. The northern end of Alligator Creek is presently proposed for restoration as part of the Kerr -McGee settlement program approved by state and federal stakeholders (Figure 11). Coordination with the stakeholders for this action is ongoing to ensure consistency in modeling and channel design.

Conceptually, restoration would restore approximately 7,000 linear feet of tidal creek (12.1 acres) at a width of 75 ft, and depth of three feet below Mean Low Low Water. In addition, construction would include placement of a bridge at the access road and shoreline stabilization at the channel access on the river (Figure 12). Figures 13 and 14 illustrate the conceptual master plan prepared for the overall restoration of Alligator Creek. Enhancement of 16.1 acres of coastal tidal marsh would be constructed through excavation of Phragmites as a 50-foot buffer along each side of the restored channel. Following excavation, native tidal marsh species would be planted along the channel edge shelf. To enhance fisheries habitat, an additional 6.8 acres of tidal pools and creeks would be excavated from the Phragmites marsh. Construction would entail removal of vegetation and excavation of old spoil material to establish the original creek channel, tidal pools, creeks, and tidal marsh. More detailed analysis is needed to confirm elevations on site and to accurately estimate the volume of material to excavate to achieve good tidal flushing through the restored channel. It is anticipated that excavated spoil material would be pumped and/or hauled by truck to the Eagles Island CDF.



Source: USACE

Figure 9
1893 Aerial Photograph of Eagles Island and Alligator Creek

Source: Draft Wilmington Harbor General Reevaluation Report/EIS 2009

Figure 10
1938 Aerial Photograph of Eagles Island

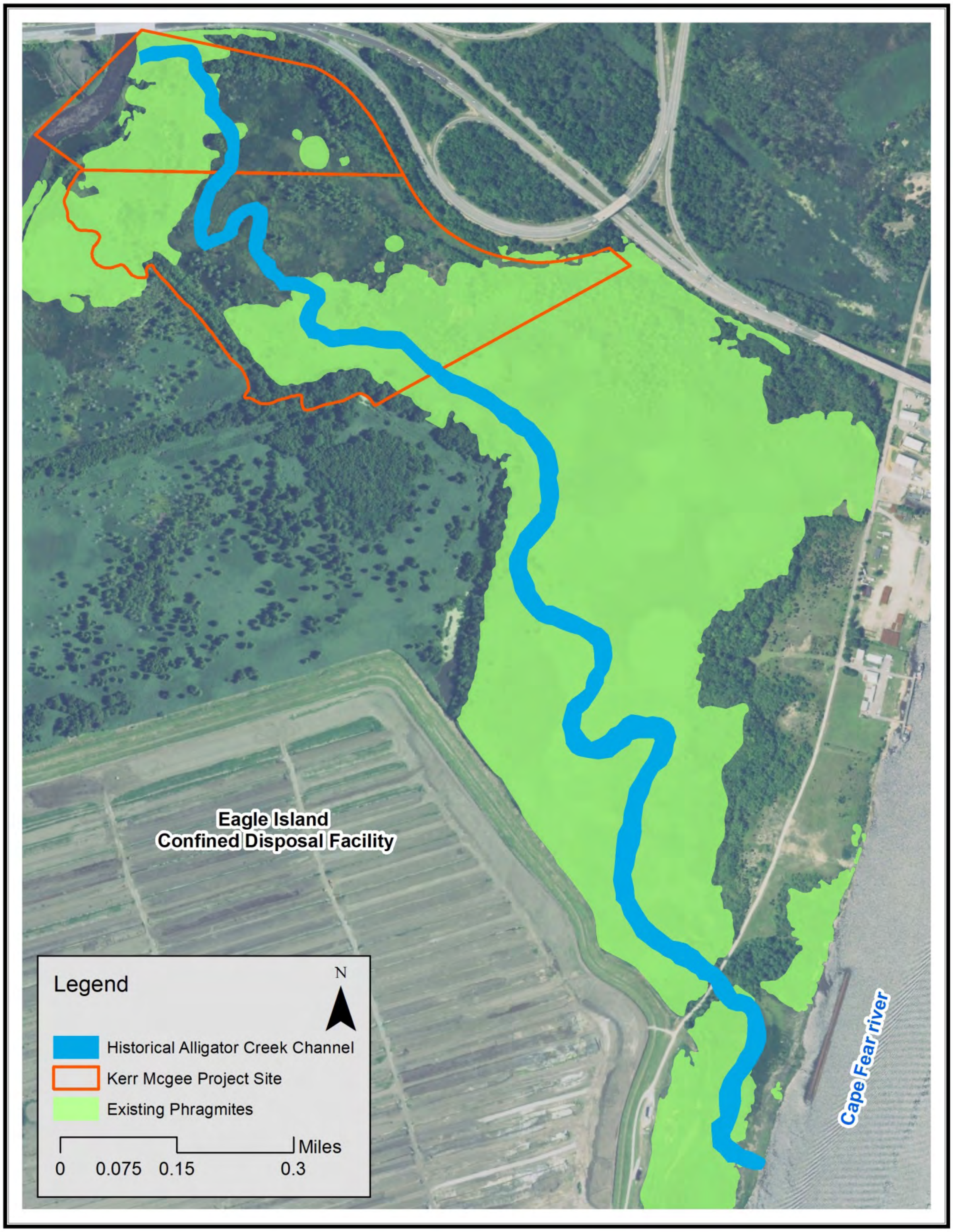


Figure 11
Alligator Creek Existing Conditions

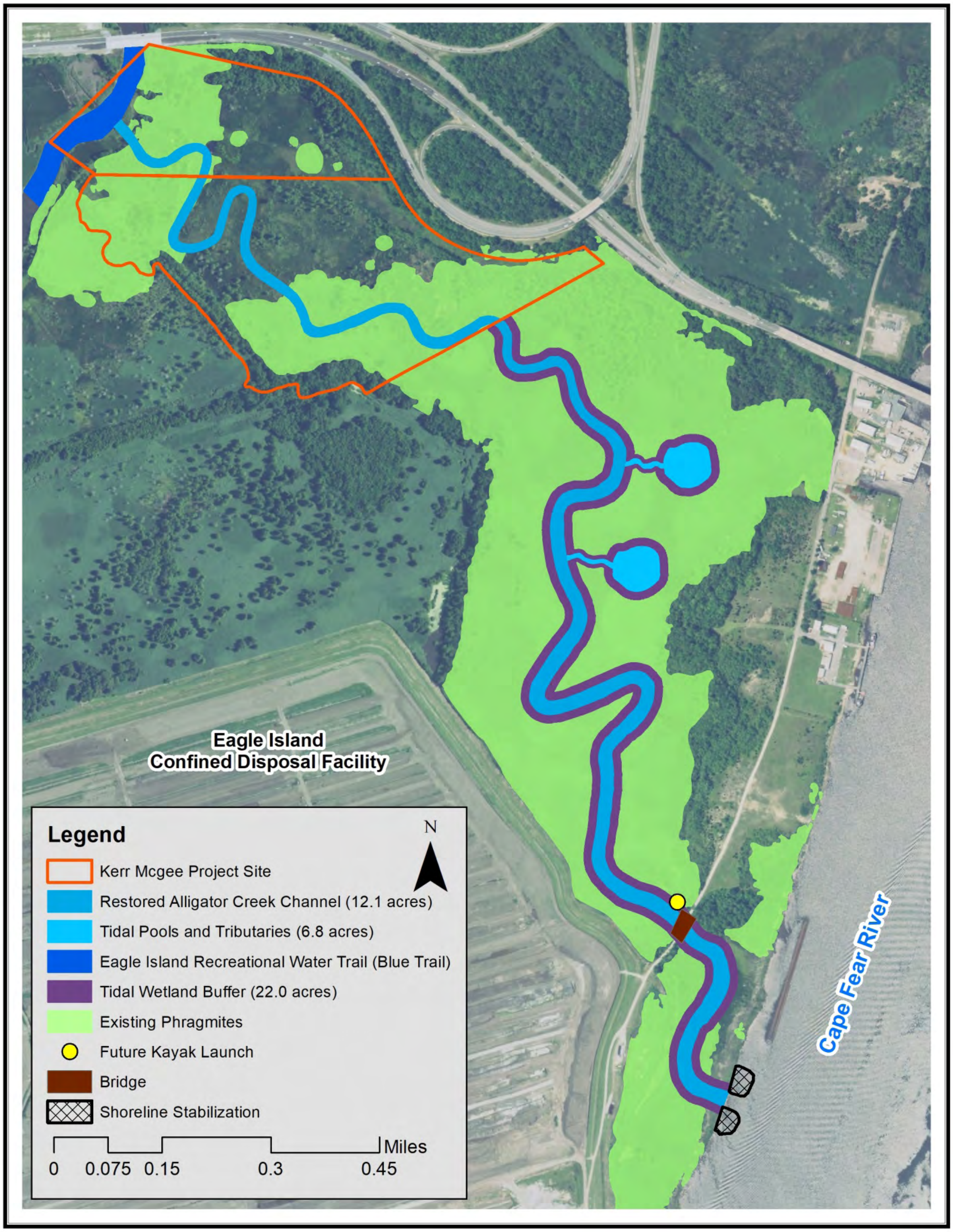


Figure 12
Alligator Creek Restoration Mitigation Plan

Figure 13
Alligator Creek Conceptual Master Plan

Figure 14
3d Rendering of Alligator Creek Conceptual Plan

The restored channel will connect Redmond Creek to the Cape Fear River shoreline at the northeast corner of the Eagle Island CDF. At present most of the historic channel is now monospecific Phragmites marsh on top of old fill material. Of the total area of the creek corridor, 99% is presently dominated by Phragmites, based on a comparison of recent wetland mapping for the Cape Fear River watershed with the proposed corridor (Appendix E: Wetland Assessment, Figure 12).

Restoration of the historic Alligator Creek will provide habitat for a myriad of both freshwater and estuarine dependent invertebrates and fish fauna, foraging habitat for juvenile fish, and other nektonic species, and enhance water quality from both the Brunswick River and Cape Fear River, through tidal exchanges. This restored creek channel will quickly be used by anadromous fish species including stripers and sturgeon for foraging during their annual runs up river and annually by stripers living in this region of the river year round.

The presence of areas of Phragmites that are proposed for enhancement can be attributed to the underlying fill material and associated reductions in tidal inundation and soil salinity and sulfide relative to the surrounding natural marshes. Hydrological restoration via fill removal and the lowering of elevations to those of the adjacent natural marshes will increase soil salinities and sulfide concentrations; thereby, rendering the sites unsuitable for Phragmites recolonization and/or shifting the competitive advantage to native species. The ability of Phragmites to invade salt and brackish marshes is constrained by salinity, sulfide, and prolonged tidal inundation (Chambers et al. 2003). Phragmites establishment in tidal salt and brackish marshes is typically associated with tidal restriction and reductions in soil salinity and sulfide concentrations. Dredged material deposition in tidal marshes produces microtidal (i.e., tidally restricted) areas with reduced soil salinities that are susceptible to Phragmites invasion (Fell et al. 2002). Excavation has been used successfully to restore Phragmites-dominated dredge spoil sites to natural marshes in Connecticut and New Hampshire (Moore et al. 2009). In these cases, the use of excavation to simultaneously remove Phragmites and restore tidal hydrology increased salinity and sulfide concentrations and restored both native plant communities and associated faunal species.

Ecological Lift and Functional Replacement

Hydrological restoration by fill removal and the lowering of elevations to those of the adjacent natural brackish marshes would restore juvenile nekton access to areas that are currently tidally restricted; thereby, restoring or enhancing the functions of the areas as estuarine nursery habitats. The restoration of native vegetation and tidal hydrology would restore or enhance the foraging and refuge habitat functions of these wetlands for estuarine dependent juveniles. Additional ecological uplift would occur through the provision of enhanced foraging habitat for colonial nesting wading birds. The Cape Fear River estuary supports the largest nesting assemblage of colonial wading birds in the state, including up to 15,000 nesting pairs of white ibis annually. The tidal marshes of the Cape Fear River estuary are important foraging habitats for breeding and non-breeding wading birds. Hydrological restoration via fill removal would increase tidal floodwater volumetric capacity and residency time, thereby enhancing water quality functions in terms of pollutant, sediment, and nutrient removal.

3.1.3 Selected Alternative for Mitigation

For this preliminary draft plan, Alligator Creek has been selected as the draft preferred plan and has gained preliminary acceptance by the Wetland TWG. Given Alligator Creek's prior location, the ability to restore the complete historic aquatic habitat which has been dominated by Phragmites habitat and spoil material for over 60 years, the significant benefits to demersal and migratory estuarine fish species, and collaborative efforts with the stakeholders restoring the north end of the creek; use of the site to mitigate functional losses to shallow water PNA and non-PNA habitat is the preferred choice.

3.1.4 Determination of Credits Required

To evaluate direct impacts to fisheries habitat resulting from construction of the TSP, the UMAM was used. The UMAM was developed in Florida in response to a request by the Florida State legislature to evaluate mitigation options to offset adverse effects to wetlands and wetland functions. According to the UMAM training manual, “The UMAM is designed to assess any type of impact and mitigation, including the preservation, enhancement, restoration, and creation of wetlands, as well as the evaluation and use of mitigation banks….” Moreover, the UMAM is a flexible tool that is appropriate for evaluating impacts to surface waters and benthic and sessile communities. For this reason, it was determined to be the most applicable method for evaluating the direct effects to fisheries habitat associated with the Wilmington Harbor Navigation Improvements Project. Recommended by the USACE Ecosystem Planning Center of Expertise, the UMAM was successfully applied to calculate mitigation needs for the Jacksonville Harbor project and the Charleston Harbor Post 45 Study.

The UMAM offers a standardized approach for assessing the ecological functions at an impact site and proposed mitigation site using functional indicators that fall into three components: location and landscape support, water environment, and community structure. Each component is scored on a scale from 0 to 10 (10 = optimal) and component scores are summed and divided by 30 to produce a normalized index between 0.0 and 1.0. Impact sites are evaluated FWOP and FWP conditions, and the difference in index scores between conditions results in an impact delta. Impact deltas are multiplied by the acres of impact to quantify functional loss (FL).

Mitigation sites are evaluated under FWOP and FWP conditions and utilize the same functional indicators and method described for impact assessment; however, the mitigation delta is adjusted using a preservation factor, time lag and/or risk. The preservation factor was not applicable to this project because proposed mitigation involves restoration instead.

Time lag refers to the period between when functions are lost at an impact site and replaced by mitigation. Time lag in years is related to a t-factor as established in UMAM guidelines and ranges from 1 (immediate recovery of functions) to 3.91 (>55 years to recover functions).

Risk accounts for the uncertainty regarding the success of mitigation and is scored on a scale from 1(no risk) to 3(high risk) on quarter-point increments.

Relative Functional Gains (RFG) are calculated using the following mitigation determination formula: RFG = Mitigation Delta/(t-factor x Risk), and the acres of mitigation needed to offset impacts is determined by dividing the FL by the RFG.

When more than one impact assessment area or mitigation assessment area exists, total FL and total RFG is determined by summing the FL and RFG for each assessment area.

3.1.4.1 Methodology

Prior to implementing the UMAM, the location and extent of impacts were determined using ArcGIS 10.6 software (Table 4). Shapefiles representing the proposed dredging footprint and the state designated PNA were acquired, and geoprocessing tools were applied to identify the impact sites. Using USACE bathymetry data, impacts were classified into habitat classes (PNA <6 ft, PNA between 6 and 12 ft, and foraging habitat >2 feet), and ecological functions associated with each class were identified. For example, areas <12 ft provide nursery functions, but deeper habitat serves as foraging habitat.

After identifying the location and habitat classes found within impact sites, each site was evaluated using functional indicators. Potential indicators were provided to the Fish and Fish Habitat TWG for feedback prior to the assessment and all comments were considered during the analysis. Ultimately, an internal review of indicators and scoring criteria was conducted to produce preliminary results. Six impact sites located from the NCSPA Anchorage Basin to the mouth of the Cape Fear River were identified and evaluated, and functional loss was calculated for each site and summed to determine the overall functional loss (Figures 15-20).

Table 4
Impact Summary for UMAM Assessment

	Impact Site #1	Impact Site #2	Impact Site #3	Impact Site #4	Impact Site #5	Impact Site #6	Foraging >12 feet
PNA <6 ft		4.14 acres					
Non-PNA <6 ft			0.3 acre	1.0 acre		0.4 acre	
PNA 6 to 12 ft	0.1 acre	1.63 acre					
Non-PNA 6 to 12 ft			1.5 acres	3.4 acres	0.3 acre	0.6 acre	
Foraging >12 ft							27.0 acres

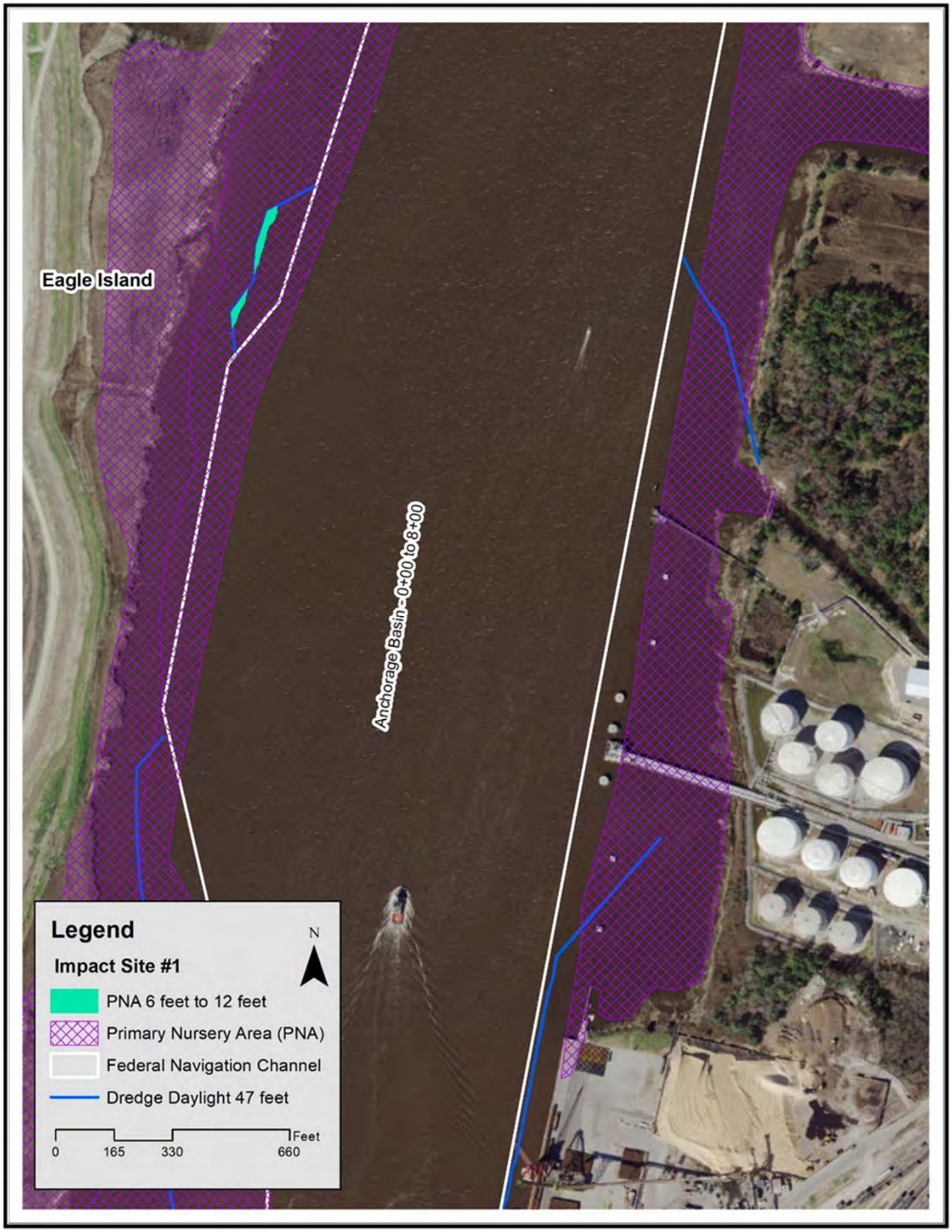


Figure 15
Location of Impact Site #1 near the Anchorage Basin at the Port of Wilmington

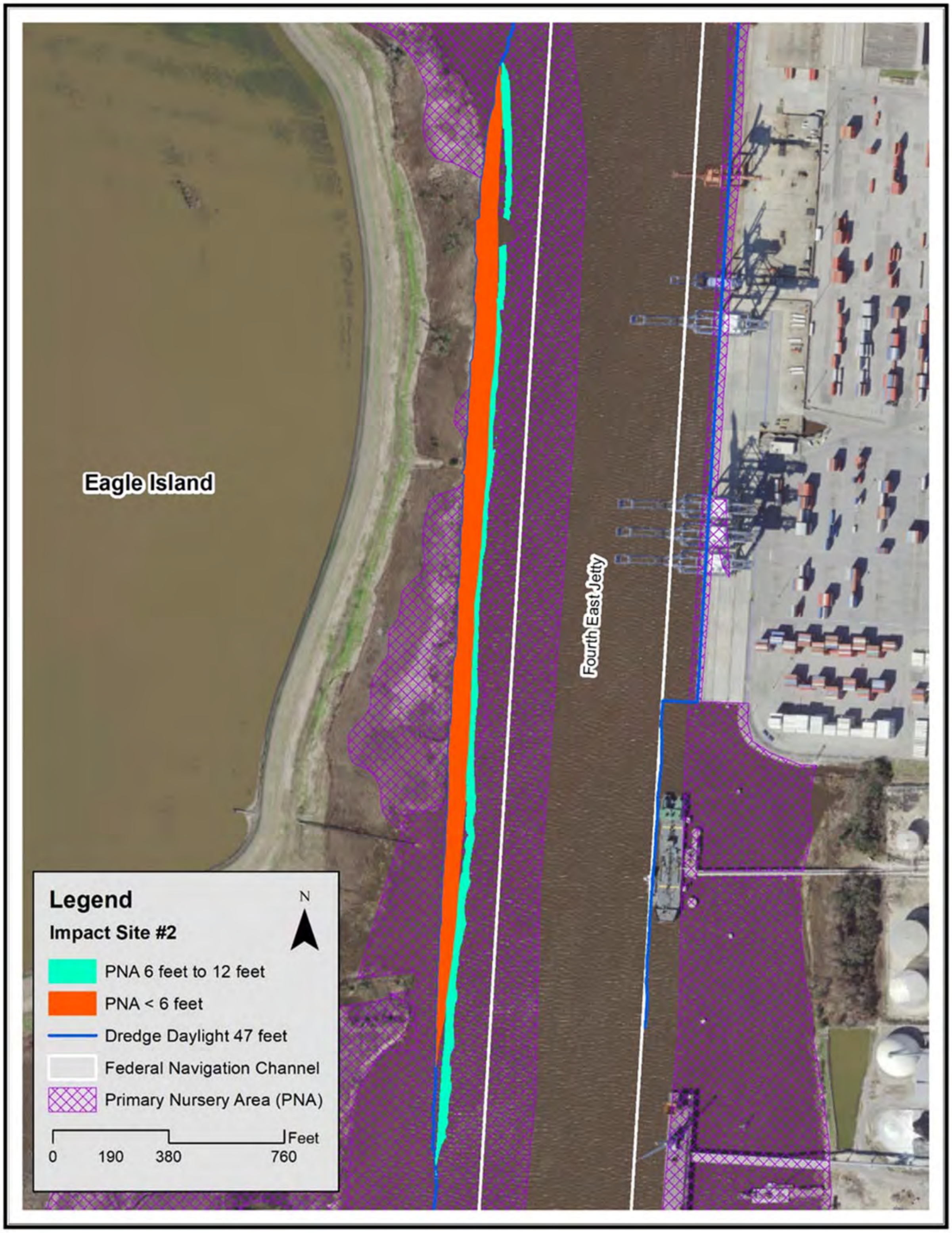


Figure 16
Location of Impact Site #2 Adjacent to Eagle Island near the Fourth East Jetty Reach of the Federal Navigation Channel

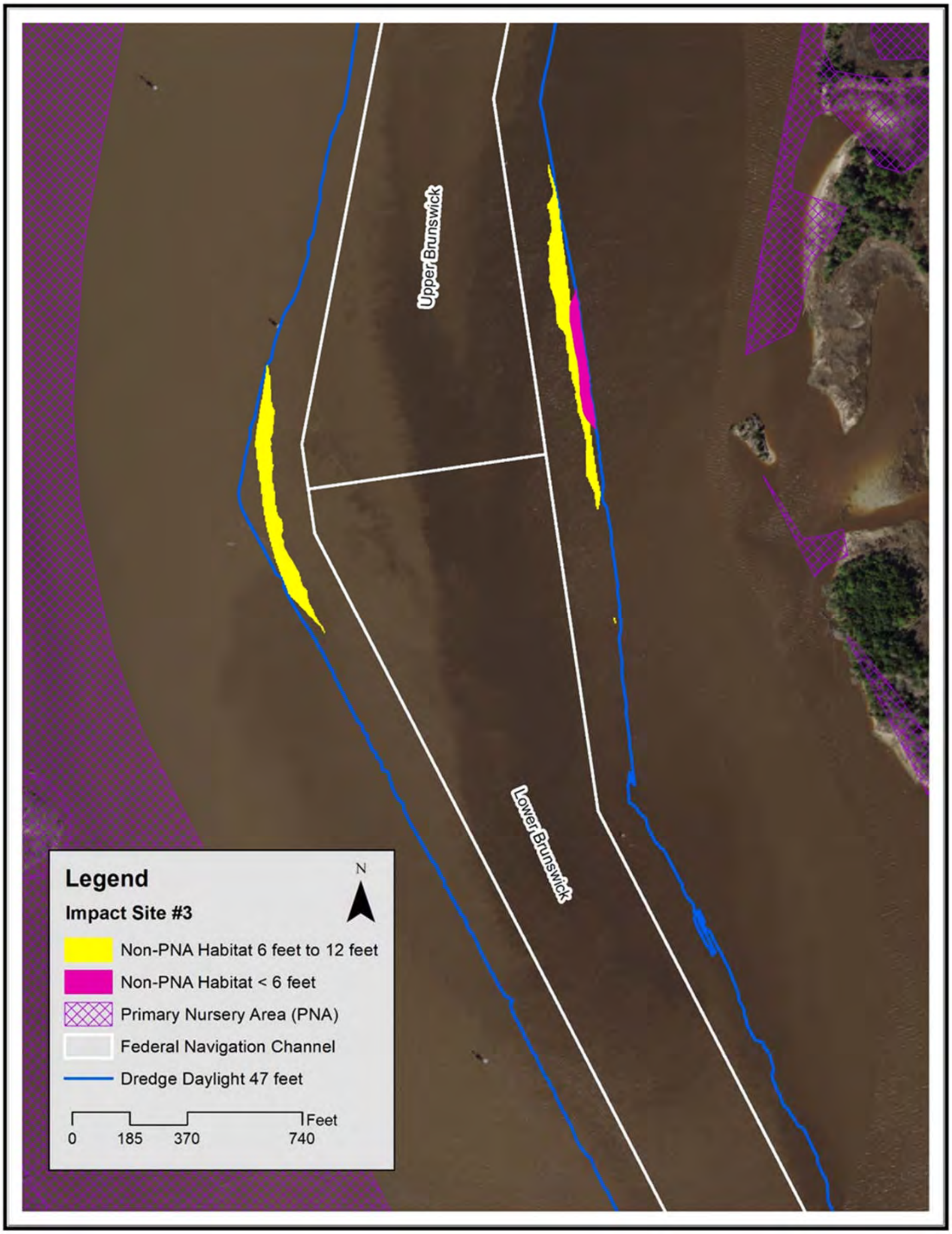


Figure 17
Location of Impact Site #3 Downstream from Impact Sites #1 and #2

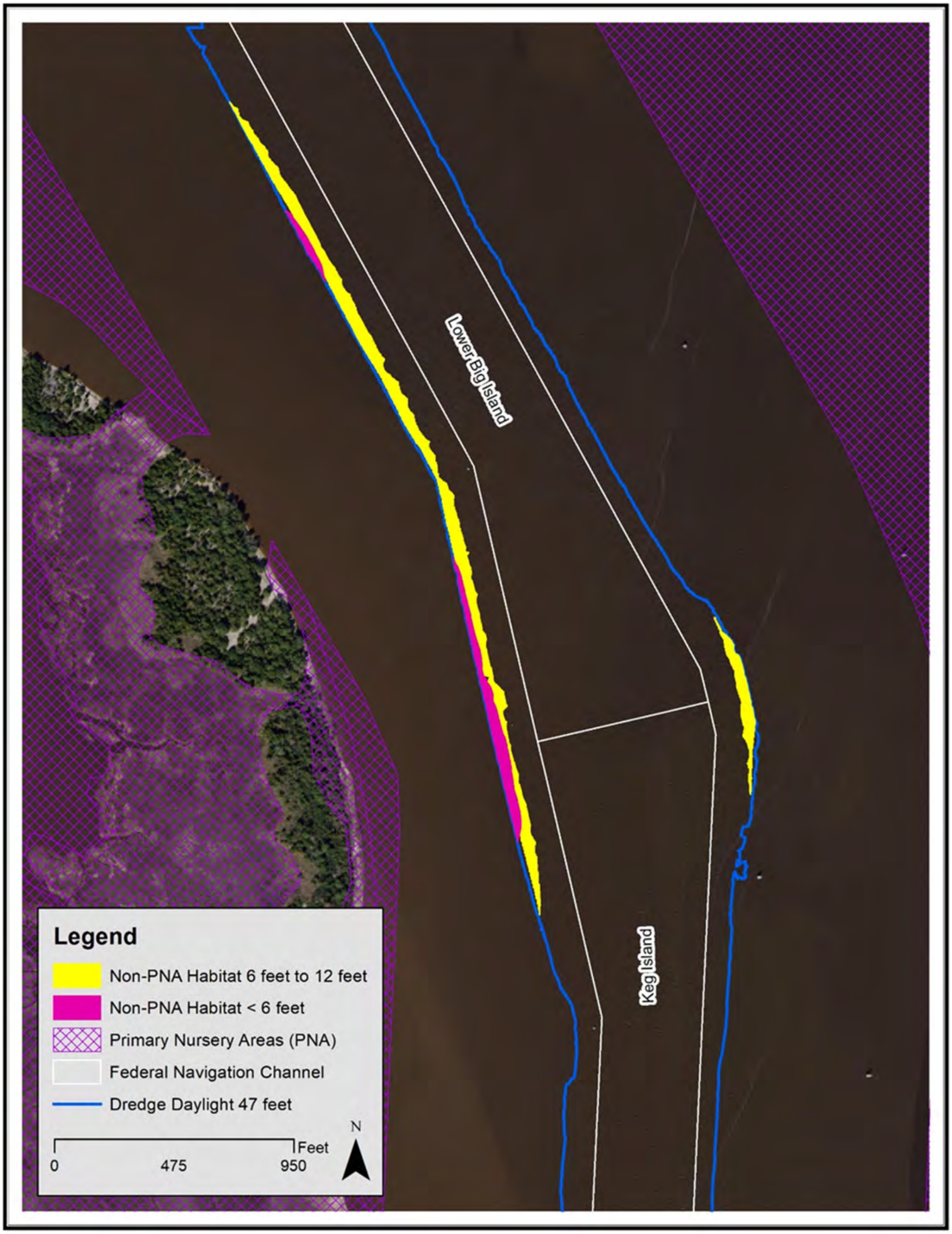


Figure 18
Location of Impact Site #4 near Keg Island in the Cape Fear River Adjacent to the Federal Navigation Channel

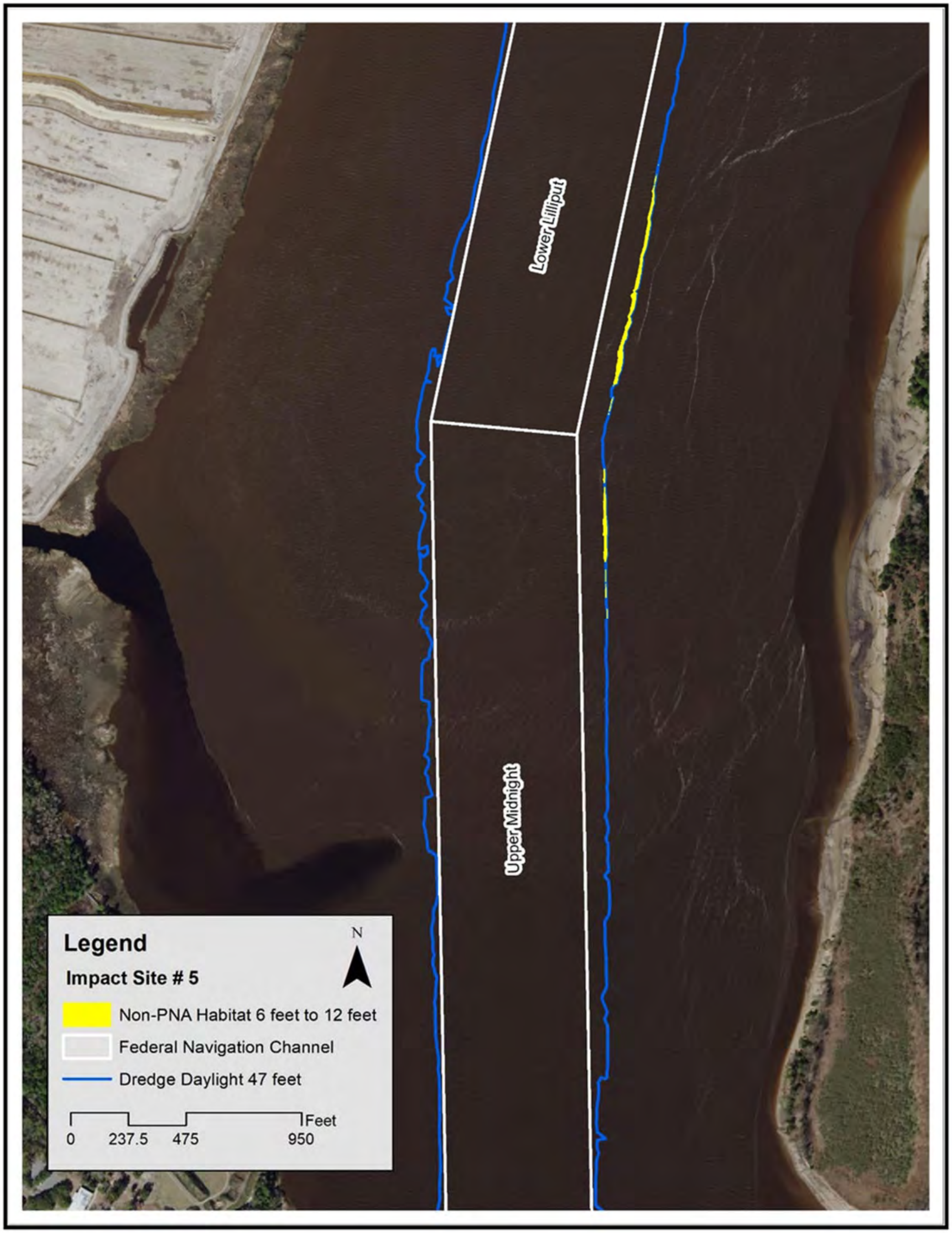


Figure 19
Location of Impact Site #5 near the Upper Midnight Reach of the Federal Navigation Channel

Figure 20
Location of Impact Site #6 in the Mouth of the Cape Fear River Entrance Channel

Proposed mitigation (Alligator Creek Restoration) was evaluated using the same criteria, but a time lag of five years and a risk factor of 1.25 were included to calculate the RFG. Finally, the total FL was divided by the RFG to determine the acres of mitigation needed to offset the project impacts.

3.1.4.2 Results and Discussion

Preliminary results were based on hydrodynamic modeling, aerial imagery interpretation, and local expert knowledge. It is anticipated, however, that during development of the DEIS the IRT may participate in UMAM training and conduct site visits to further refine scoring. Table 4 provides a summary of impacts for each habitat category. Table 5 provides a scoring summary the UMAM results, which indicate that 40 acres of habitat (PNA/Foraging) would be directly impacted by new dredging within the inner harbor and would require 18.9 acres of mitigation to offset lost functions. A review of the impact areas and locations shown in Figures 15 through 20 is provided below.

Areas ≤12 feet

Proximity to port activities and the heavily industrialized Cape Fear River near Wilmington, North Carolina (NC) reduced scores at impact sites #1 and #2 under the existing condition. Impact site #1 is 0.1 acre of PNA (6 to 12 ft). The site is located adjacent to Eagle Island and near the NCSPA anchorage basin (Figure 15). Impact site #2 is 5.8 acres and contains PNA <6 ft and PNA between 6 and 12 ft. This site is located adjacent to Eagle Island and directly across from the Fourth East Jetty channel reach (Figure 16). Impact site #3 is 1.8 acres of non-PNA habitat <6 ft and between 6 and 12 ft. This site is located further downstream from impact site #2 and is adjacent to the existing federal navigation channel (Upper and Lower Brunswick Reaches), approximately 500 ft from the nearest PNA (Figure 17). Impact site #4 is 4.4 acres of non-PNA habitat adjacent to the federal navigation channel near the Big Island and Keg Island reaches. This site is approximately 500 ft from the nearest PNA (Figure 18). Impact site #5 is 0.3 acre of non-PNA habitat between 6 and 12 ft. It is located near the lower Lilliput channel reach, but not near a PNA (Figure 19). Impact site #6 is located in the mouth of the Cape Fear River and is comprised of 0.6 acre of non-PNA habitat <6 ft and 6 to 12 ft (Figure 20). The nearest PNA to this site is located behind Baldhead Island.

Areas > 12 Feet

Areas >12 ft impacted by proposed dredging of the TSP totaled 27 acres and were classified as foraging habitat. These areas differ from shallow PNA habitat because they do not offer the same nursery functions; such as, primary and secondary productivity, refuge from predators and proximity to emergent vegetation. Moreover, deep soft bottom habitat acts as a biogeochemical sink, sequestering nutrients, chemicals, and microbes and allows for deposition and the resuspension of toxic substances (North Carolina Department of Environmental Quality 2016).

To calculate the amount of acreage needed to offset the functional impacts to fisheries habitat resulting from the proposed navigation improvements, the total FL was divided by the RFG, resulting in 18.9 acres needed for mitigation (Table 5). It is important to note that the UMAM evaluates functional losses and gains based on the quality of the existing habitat at the impact sites and the quality of habitat at the proposed mitigation site. Since habitat quality at the mitigation site is expected to be near optimal upon completion of the restoration effort and

Table 5
Scoring Summary for UMAM Assessment

	Existing Condition	With Project	Impacted Acreage	Impact Delta	Functional Loss
Impact Site #1			0.1	0.4	0.04
Location and Landscape Component (C1)	4	4			
Water Environment Component (C2)	6	0			
Community Structure Component (C3)	7	0			
Total	17	4			
Total/30	0.6	0.1			
Impact Site #2			5.8	0.4	2.3
Location and Landscape Component (C1)	4	4			
Water Environment Component (C2)	5	0			
Community Structure Component (C3)	5	0			
Total	14	4			
Total/30	0.5	0.1			
Impact Site #3			1.8	0.2	0.36
Location and Landscape Component (C1)	7	7			
Water Environment Component (C2)	7	4			
Community Structure Component (C3)	7	4			
Total	21	15			
Total/30	0.7	0.5			
Impact Site #4			4.4	0.2	0.88
Location and Landscape Component (C1)	9	9			
Water Environment Component (C2)	7	4			
Community Structure Component (C3)	7	4			
Total	23	17			
Total/30	0.8	0.6			
Impact Site #5			0.3	0.3	0.09
Location and Landscape Component (C1)	8	8			
Water Environment Component (C2)	8	4			
Community Structure Component (C3)	8	4			
Total	24	16			
Total/30	0.8	0.5			

Table 5 (concluded)

	Existing Condition	With Project	Impacted Acreage	Impact Delta	Functional Loss
Impact Site #6			0.6	0.3	0.16
Location and Landscape Component (C1)	9	9			
Water Environment Component (C2)	9	5			
Community Structure Component (C3)	9	5			
Total	27	19			
Total/30	0.9	0.6			
Impact Site #7 (Deep Water > 12ft)			0.3	27	8.1
Location and Landscape Component (C1)	9	9			
Water Environment Component (C2)	9	4			
Community Structure Component (C3)	9	4			
Total	27	17			
Total/30	0.3	0.6			
Total Functional Loss					11.95

	Existing Condition	With Mitigation	Mitigation Delta	Time Lag (T-Factor)	Risk	Relative Functional Gains
Mitigation Site (Alligator Creek)			0.9	1.14	1.25	0.6
Location and Landscape Component (C1)	0	9				
Water Environment Component (C2)	0	9				
Community Structure Component (C3)	0	9				
Total	0	27				
Total/30	0	0.9				
Acres of Mitigation	18.9					

habitat quality at the impact sites is lower, less acreage is needed to offset the functional loss (Table 5.)

Mitigation

Proposed mitigation includes restoration of 18.9 acres of restored stream channel, tributaries, and shallow tidal pools in the location of historic Alligator Creek. The restored stream channel would be 75 ft wide and would be flanked by 50 ft of created tidal marsh on each side. The stream channel restoration would reestablish 12.1 acres of shallow PNA. In addition, two tributaries and shallow tidal pools totaling 6.8 acres would be connected to the stream channel. The mitigation site is located on Eagle Island at the location of historic Alligator Creek and is currently dominated by the invasive common reed *Phragmites australis*. Therefore, under the FWOP conditions, the proposed mitigation site was given a score of 0 for all components (no nursery functions present). Under the FWP condition; however, the proposed mitigation assessment area received near optimal (9) scores for all components. In conclusion, the proposed mitigation will restore 18.9 acres of PNA, and create wetland 16.1 acres of tidal wetland.

3.2 Mitigation for Indirect Effects on Fish and Fish Habitat Resources

While other options were evaluated for mitigation, only restoring anadromous fish passages to historic spawning grounds above Lock and Dams #2 and #3 were considered viable compensation for consideration by the Fish and Fish Habitat TWG. Additional options or sites were considered, but eliminated from further consideration based on the results of the HSI Fish Suitability Assessment and consultation with the TWG. This section includes as summary of the fish habitat suitability analysis, HEP compensation analysis of the preferred mitigation plan, and a description of the proposed mitigation plan.

3.2.1 Indirect Effects on Fish Habitat Suitability

To quantify potential indirect impacts to fish habitat suitability resulting from the alternative plans, a fish HSI analysis was completed (Main Report Appendix J: Fish Habitat Assessment). Six species were selected for the assessment, including Atlantic sturgeon (*Acipenser oxyrinchus oxyrinchus*), Atlantic menhaden (*Brevoortia tyrannus*), white shrimp (*Litopenaeus setiferus*), southern flounder (*Paralichthys lethostigma*), red drum (*Sciaenops ocellatus*), and striped bass (*Morone saxatilis*). The assessment utilized a coupled modeling approach, combining a three-dimensional hydrodynamic and water quality model with USFWS HSI models. These models use a numerical index to score areas on a 0.0-1.0 scale and provide a way to quantify habitat value through species-habitat relationships. Changes in habitat value were quantified using the USFWS HEP and reported as losses or gains in Habitat Units (HUs). Habitat units were determined by multiplying the HSI score for a given area by the total available acreage (USFWS 1980). Examining the difference in HUs between the FWOP and the TSP revealed losses of 123.08 and 226.12 HUs for Atlantic sturgeon and striped bass, respectively. These functional losses occurred near Wilmington, NC, and were classified as indirect impacts to Atlantic sturgeon and striped bass foraging habitat.

3.2.2 Determination of Credits Required

To identify gains that benefit the target species (Atlantic sturgeon and striped bass) and offset the impacts, a HEP Compensation Analysis was performed (USFWS 1980). The compensation goal is to offset the HU losses (349.2) with an equal or greater number of HU gains. The compensation area comprises the Cape Fear River mainstem from the USACE Lock and Dam #2 to the historic spawning grounds at Smiley Falls near Lillington, NC (Figure 21). The proposed mitigation includes the removal of Lock and Dam #2 as well as the construction of a fish passage at the USACE William O'Huske Dam (Lock and Dam #3) near Fayetteville, NC. Alternatively, an analysis was performed to evaluate changes in HUs gained if a fish passage was implemented at Lock and Dam #2 instead of dam removal. Removing and/or modifying these barriers restores

Figure 21
Location of Lock and Dams #1,# 2, and #3 in the Cape Fear River Watershed

access to historic spawning grounds for Atlantic sturgeon, striped bass, and American shad; however, proceeding with removal or fish passage construction at Lock and Dam #2 without modifying Lock and Dam #3 does not provide the HUs necessary to reach the compensation goal. Likewise, implementing a fish passage at Lock and Dam #3 does not provide the same benefits to the target species if Lock and Dam #2 is not removed or modified to support access to upstream habitat.

To calculate the HUs gained from implementing the proposed mitigation, the compensation area was classified into three habitat classes: migratory/foraging habitat, artificial spawning habitat (fish passage), and natural spawning habitat (Smiley Falls). Habitat Suitability Index scores were assigned to each class, and HUs gained were determined by multiplying the HSI scores by available acreage (Tables 6 and 7 and Figure 22). Natural spawning habitat was given the highest HSI score (1.00) followed by artificial spawning habitat (0.50) and migratory/foraging habitat (0.25).

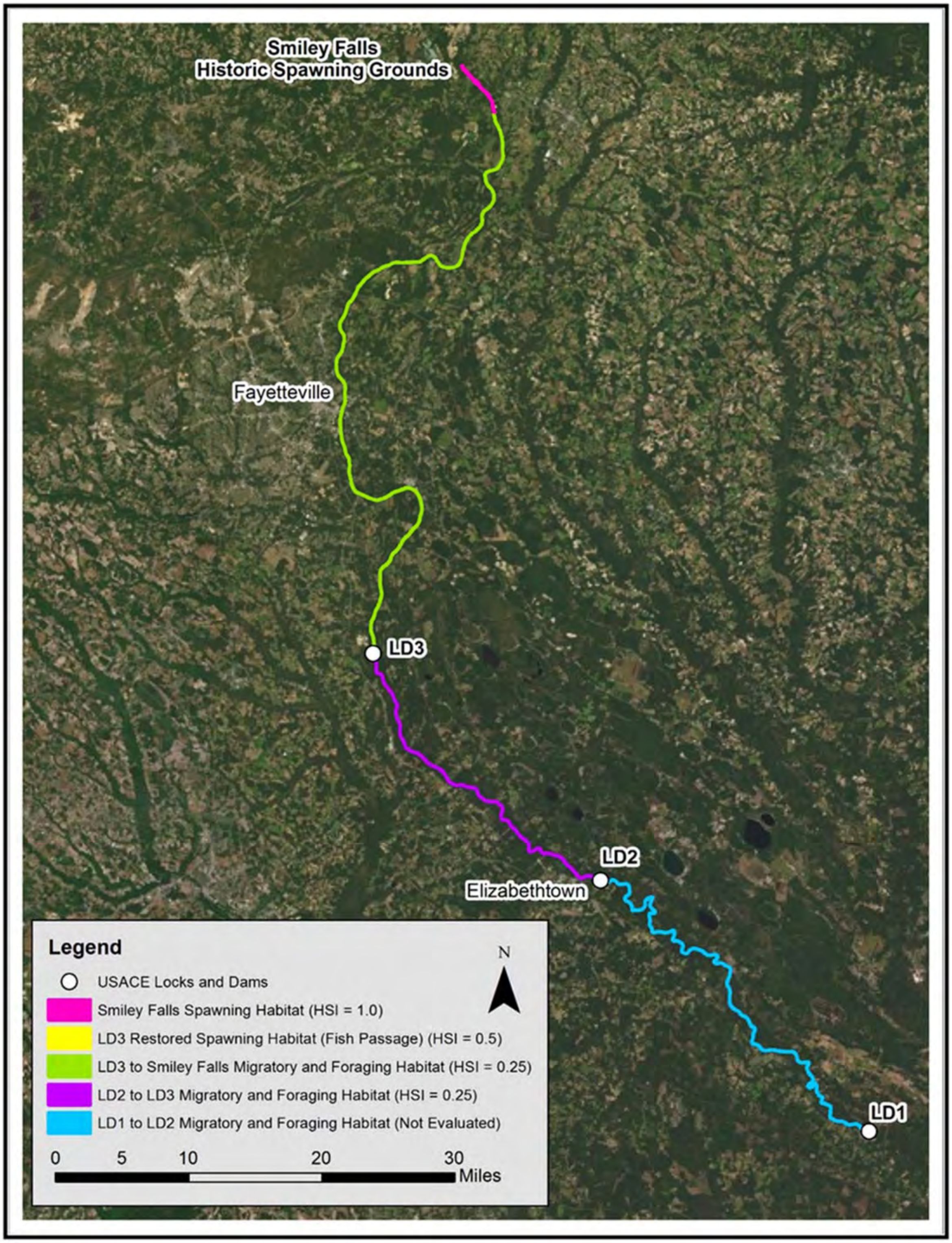
Results for two treatment scenarios are described below, the difference being removal of Lock and Dam #2 for the first scenario and a fish passage at Lock and Dam #2 for the second.

Table 6
HEP Compensation Analysis for Treatment Scenario 1

Scenario 1 Assessment Areas	HSI	Acreage	HUs Gained
Lock and Dam #2 to Lock and Dam #3 (Migratory/Foraging Habitat)	0.25	997.94	249.49
Lock and Dam #3 Fish Passage (Artificial Spawning Habitat)	0.50	11.48	5.74
Lock and Dam #3 to Smiley Falls (Migratory/Foraging Habitat)	0.25	2072.00	518.00
Smiley Falls (Natural Spawning Habitat)	1.00	247.07	247.07
Total			**1020.30**

Table 7
HEP Compensation Analysis for Treatment Scenario 2

Scenario 2 Assessment Areas	HSI	Acreage	HUs Gained
Lock and Dam #2 Fish Passage (Artificial Spawning Habitat)	0.50	14.13	7.07
Lock and Dam #3 Fish Passage (Artificial Spawning Habitat)	0.25	997.94	249.49
Lock and Dam #3 to Smiley Falls (Migratory/Foraging Habitat)	0.50	11.48	5.74
Smiley Falls (Natural Spawning Habitat)	0.25	2,072.00	518.00
Lock and Dam #3 Fish Passage (Artificial Spawning Habitat)	1.00	247.07	247.07
Total			**1027.37**



Note: LD = Lock and Dam, HSI = Habitat Suitability Index

Figure 22
Lock and Dams #2 and #3 HEP Analysis Habitat Classes

3.2.2.1 Scenario 1 (Removal of Lock and Dam #2 and Fish Passage at L Lock and Dam #3)

Removing Lock and Dam #2 would allow target species to access 997.94 acres of upstream migratory/foraging habitat between Lock and Dam #2 and Lock and Dam #3, resulting in 249.49 HUs gained. However, an additional 99.71 HUs would be needed to offset losses associated with the TSP (349.20). A fish passage at Lock and Dam #3 would create novel spawning habitat below the dam and reconnect the target species with natural spawning grounds at Smiley Falls. This scenario results in an additional 770.81 HUs gained and satisfies the compensation goal (Table 6).

3.2.2.2 Scenario 2 (Fish Passages at Lock and Dam #2 and Lock and Dam #3)

Implementing a fish passage at Lock and Dam #2 would create novel spawning habitat below the dam and offer another option should removal be deemed inappropriate. Regardless, it would be necessary to modify Lock and Dam #3 to reach the compensation goal (349.20) because constructing a fish passage at Lock and Dam #2 would only result in 256.56 HUs gained (Table 7).

In conclusion, either scenario above will achieve the required compensation goal and offset losses to foraging habitat associated with the TSP; however, Scenario 2 provides 7.07 additional HUs by creating artificial spawning habitat below Lock and Dam #2. Under both scenarios, overcompensation is provided, and the additional HUs gained can mitigate for unquantifiable impacts to the target species as described in the Biological Assessment (Appendix F), including entrainment and vessel strikes, blasting and associated activities, sediment suspension and turbidity, and artificial nighttime lighting. Moreover, dredging activities are expected to occur for approximately three to four years and overcompensation can address concerns related to prolonged project activities.

3.2.3 Mitigation Options for Indirect Effects on Fish Habitat Suitability

As stated above, the only technically acceptable alternative for providing mitigation for unavoidable effects on fish habitat suitability is restoration of fish passages 2 and 3 on the Cape Fear River.

3.2.3.1 Restoration of Fish Passages for Lock and Dams #2 and #3

Restoring access to historic migratory fish habitat in the Cape Fear River Basin above all three lock and dams serves as a comprehensive watershed based strategy to improve the resilience of anadromous fish populations in the river system (Figure 21). The Cape Fear River Action Plan, developed by the Cape Fear River Partnership, identified the action of constructing fish passage structures at Lock and Dams #2 and #3 on the Cape Fear River as a high priority and critical for the recovery of endangered and federally-managed species and the Cape Fear ecosystem. Construction of the rock rapids fish passages would provide for greater free flowing access to historic spawning grounds utilized by federally listed and federally-managed fish species, without compromising congressionally authorized purposes of navigation or affecting water supply users with intakes upstream of each the dams, such as the Lower Cape Fear Public Utility Authority and Fayetteville Public Works Commission

Actions taken to date and proposed within the next year by the USACE and other stakeholders have and will include the following activities:

- The USACE constructed the fish passage at Lock and Dam #1 in 2012 as mitigation for 2000-2002 harbor deepening project (Figure 23).
- The CFRW, in partnership with DCA and the Southeast Aquatic Resources Partnership, enhanced 0.5 acres of anadromous spawning habitat below Lock and Dam #2.
- Bladen County received funding from state agencies and the National Fish and Wildlife Foundation (Duke Energy Settlement) and initiates planning, engineering design, and permitting for fish passage structures for Lock and Dams #2 and #3.
- The CFRW received funding from Coastal Recreational Fishing License Fund grant for planning, design, and permitting of modification to Lock and Dam #1 fish passage (2017).
- The USACE is completing filling of the scour hole below Lock and Dam #2 (2018-2019).
- The USACE initiated Disposition Study for Lock and Dams on the Cape Fear River with a draft document due February 2020.

The CFRW obtained state funding and with more funding coming, proposes to implement construction of modification to Lock and Dam #1 rock weir fish passage structure in 2020. Prior to the advent of dam construction, the Cape Fear Watershed generally provided a largely unimpeded river network. Anadromous species could cross the coastal plains to spawn in the riffles and rapids along the steeper gradient fall line where the coastal plains of NC meet the Piedmont region. These rapids provided critical spawning habitat for American shad, Atlantic and shortnose sturgeon, striped bass, and other species sustaining populations - not only in the Cape Fear River, but in coastal waters of the Atlantic Ocean.

Dam construction fragmented the Cape Fear Watershed and blocked these historic migrations. The role of the Lower Cape Fear dams in the decline of anadromous species of the Cape Fear River have been well documented as shown in the below table (Table 8). American shad, Atlantic sturgeon, shortnose sturgeon, striped bass, and river herring are all known to have been significantly more abundant upstream of dams prior to their construction.

Figure 23
Existing Rock Arch Rapids Fish Ramp at Lock and Dam #1

Table 8
Changes in Population Size for Anadromous Species in the Cape Fear River

Species	Population potential	Current population estimates
Atlantic Sturgeon	8700 (based on historic landings, Earll 1887)	<300 (ASSRT 2007)
Shortnose sturgeon	31,000 (based on Kynard 1997)	<100 (based on Moser and Ross 1995)
American shad	447,000 (based on historic habitat, St. Pierre 1997)	Not available
River herring	2,300,000 (based on historic habitat and historic landings, Chestnut and Davis 1995)	Not available
Striped bass	100,000 (based on historic landings from Chesnut and Davis 1975) and personal communication with C. Collier, NCDME, and J. Hightower, NCSU/USGS	10,000 (based on NCDM tagging data and personal communication with C. Collier, NCSMF)

Source: Cape Fear River Action Plan for Migratory Fish 2013

Lock and Dams #2 and #3 continue to impede free flowing spawning runs to Smiley Falls, a historical spawning habitat. Restoring greater fish passage beyond these two barriers is critical to rebuilding resilient migratory fish populations and functional coastal ecosystems in the Cape Fear River and a top priority of the Cape Fear River Partnership and NOAA. Constructing fish passages at Lock and Dams #2 and #3 will increase the availability of spawning habitat to a greater number of anadromous fish species and ensure resilient populations during extreme weather events. By increasing the proportion of a watershed that is available to migrating fish, we increase the likelihood that they will successfully reproduce in the less affected areas of the watershed; thereby, increasing population resilience as the impacts of climate change become more pronounced. Converting these dams to fishways and connecting an additional 84 free-flowing river miles of mainstem habitat and 995 tributary miles to the Atlantic Ocean will provide coastal plain river ecosystems in general, and the anadromous fish species of the Cape Fear River basin in particular, with greater resilience to extreme weather events. Since the conversion of Lock and Dam #1 to rock arch rapids in 2012, American shad reproduction appears to have increased upstream of the dam and an Atlantic sturgeon has been observed below Lock and Dam #2. Proposed modifications to the Lock and Dam #1 fish passage should serve to benefit striped bass and Atlantic sturgeon and will be completed in 2020.

The planning and design effort for the nature-like fishways at Lock and Dams #2 and #3 were based on evaluating the performance of the completed fishway at Lock and Dam #1 and modifying the design to reflect updated guidelines by NOAA and the United States Geological Survey in natural fishway design, as well as the physical conditions and operational considerations at these two locations (Turek et. al. 2016).

3.2.3.2 Fish Passage Design

Fish passage structures have been built at dam sites for over 200 years as a means of remediating dam related fragmentation effects on migratory fish. Early fish passes often had designs based on understandings of anadromous gamefish species such as salmon that were known to be strong swimmers or capable jumpers. They were built of concrete or other man-made materials and had little resemblance to natural river features. A variety of fish pass designs have been developed that include baffle fishways, vertical slot fishways, siphons, fish lifts or elevators, and others. These artificial structures had variable success in passing target species but typically were not effective in passing the full spectrum of migrating fishes. Many of the river species that depend on migration are not exceptionally fast swimmers and do not jump, but are well adapted to moving through natural riffles and rapids.

Nature-like fish passage, as the name implies, endeavors to match the geometry and materials of natural river features. Practical designs for nature-like fish passage have been developed for applications in North America (Gaboury et. al. 1994, Aadland 2010) and Europe (Parasiewicz et al. 1998, FAO 2002). Further design guidance for nature-like fishways along the Atlantic Coast have been provided by Turek et. al. (2016). By emulating morphology, hydraulics, and substrates, nature-like fishways ideally create a seamless transition from the river with morphological characteristics that native fishes routinely encounter. Nature-like fishway design criteria are developed to accommodate the slowest swimming representatives of the native fish community. American shad and other anadromous species of the Cape Fear River are of interest due to documented declines in abundance following dam construction on coastal rivers.

Core design rationale includes:

- Nature-like fishways should pass the full suite of native fish species in the respective watershed.
- Fishways should be passable over the range of seasonal flow conditions normally occurring in the associated watershed.
- To the degree possible, fishways should be geomorphically like reaches of the natural river channel. Limitations of real estate and available funds tend to require that fishways are steeper than the average slope of the main river channel. However, many low gradient rivers, including the Cape Fear, have segments of steeper rapids. In the Cape Fear River, these riffles and rapids are critical habitat for many species.

Construction would be similar to the rock rapids in a diversion channel except the rapids are constructed along the entire downstream face of the dam. The slope of the rapids would be generally at five percent or flatter and rock placement would be designed so that bypass would appear as a natural rapid to the migrating fish. Large rocks (generally 3-4 ft in diameter) are placed in parallel veins about 20 ft apart, which results in veins about every foot drop in elevation. The surface rocks would be sized such that they would not be moved by water velocity or debris such as downed trees. The rocks would be placed so that they slow the water velocity and provide “flow shadows” which allows the fish to rest. Generally, the rocks in the veins are contiguous, but occasionally there are gaps in the veins to allow the fish to pass in low flow conditions. However, most of the time during the spring migration period, the rocks are submerged, and rapids just appear to be an area of rough water. The center of the rapids is about one foot lower than the sides, so during low flow, the water is concentrated in the middle so that the fish can still pass. Another advantage of the lower center is that the flow is concentrated toward the middle of the stream which helps preclude erosion of the adjacent shorelines.

3.2.3.3 Current Status

Bladen County, with support from the Cape Fear River Partnership, various federal and state stakeholders and Bladen County’s consultants, has undertaken the planning and preliminary design of fish passages at Lock and Dams #2 and #3 based on the effort completed by the USACE Wilmington District for Lock and Dam #1. The construction of the rock arch rapid fish way at Lock and Dam #1 and the success of passing species such as American shad on the LCFR after fish passage construction at Lock and Dam #1 has accelerated the planning and design of similar structures at Lock and Dams #2 and #3.

The planning stage for development of fish passages at Lock and Dams #2 and #3 started in fall 2016 with collection of data including conducting field investigations (bathymetric and topographic surveys). During this period, a basis of design for the fish passage structure was developed, which included the core design rationale for selection of natural-like fish passage structure at Lock and Dams #2 and #3 in addition to the fundamental design criteria for the structures.

Preliminary hydrologic analyses were performed to assess and identify the range of discharges in the Cape Fear River for the design of the fish passages. Alternative concepts were developed at each lock and dam based on physical and environmental conditions, constructability and regulatory considerations, construction cost, and projected passing efficiencies of target species. Five to six alternatives were developed for each lock and dam. Refinements to each alternative fishway were performed using the results of preliminary hydraulic analyses to determine the flow paths, weir heights, and pool configurations that produced velocities suitable for fish to swim upstream.

An alternative analysis is underway to identify the preferred alternative at each lock and dam based on set of selection criteria and the need to maintain the mandated authorization of these federally installations that are managed by the USACE. A preliminary preferred fish passage structure has been selected for Lock and Dam #3, but additional evaluation of a preferred fish passage at Lock and Dam #2 is still underway in light of the Section 216 disposition study undertaken by the USACE Wilmington District to deauthorize all three lock and dams on the Cape Fear River.

More detailed hydrologic and hydraulic analyses are underway to refine the design of the preferred alternative for Lock and Dam #3 in preparation for submitting environmental and Section 408 applications to the USACE for review and approval of construction in fall 2020.

4 MITIGATION FOR EROSION OF BIRD ISLANDS IN THE LOWER CAPE FEAR RIVER

This section includes a summary of the past and present use of three islands in the LCFR by coastal waterbirds (Figure 24), a review of potential threats imposed by erosive losses of the islands on these bird populations, and a mitigation plan for improving bird habitat and prolonging the lifespan of the islands. While some modeling and analysis of the effects of vessel wakes has been performed for specific locations along the shoreline from Southport to Brunswick Town and Battery Island, no modeling has been performed for Ferry Slip and South Pelican**.** During the development of the DEIS, additional modeling analysis will be performed on these islands to determine the extent of effect of ship generated waves on erosive processes. These results will determine the extent of effects and mitigation needed to compensate for the loss of island habitat.

Figure 24
Location of Ferry Slip Island, South Pelican Island, and Battery Island

4.1 Background

The Lower Cape Fear River (LCFR) provides habitat for approximately 25% of nesting coastal waterbirds in North Carolina. These bird populations utilize a number of islands and marsh complexes on an annual basis. However, all of these areas are subjected to SLR and wave energy within the Cape Fear River, which are exacerbated by vessel wakes. Preliminary modelling indicates that there may be increased erosion due to the project vessel wakes from larger vessels. Potential increases in erosion due to vessel wakes from larger vessels, when combined with current stressors and projected levels of SLR, could serve to shorten the lifespan of these islands and decrease their utility to the avian populations that utilize them for nesting and roosting activities. As such, naturalistic protection of these island shorelines and the addition of new material will be required in order to protect and sustain these islands over the coming decades.

4.1.1 South Pelican Island and Ferry Slip Island

South Pelican Island and Ferry Slip Island are artificial, dredged-sand islands that were created in the early 1970s (Personal communication, L. Addision, Audubon NC March 2019). Each island is currently permitted for seven acres above mean high water, but both are currently much smaller. Both islands have served as important bird habitat for over two decades. These islands are periodically nourished and require sand replenishment approximately every four to seven years in order to maintain their utility to the avian community. Recent trends, including the effects of SLR, have resulted in the majority of the clean, beach-quality material being diverted to local beaches instead; which has resulted in the decrease in usable area due to lack of timely nourishment. The lack of available, high quality material combined with erosion, vegetative encroachment, and human disturbance has the potential to cause undue impacts to the avian populations that utilize these islands for nesting. South Pelican Island and Ferry Slip Island currently encompass roughly circular areas of approximately six acres and four acres, respectively, and both islands last received sand in 2004. Threats from the project include increased wave energy resulting from boat wakes and the deepened and widened channel. This pair of islands constitutes the most important nesting area for royal and sandwich terns, and supports the largest colony of brown pelicans in the southeast region of NC (National Audubon Society 2010a and 2010b). They currently support a number of other nesting birds including the snowy egret, cattle egret, tricolored heron, white ibis, American oystercatcher, willet, clapper rail, gull-billed tern, and laughing gull. They also serve as a roosting habitat for Arctic-nesting shorebirds.

4.1.2 Battery Island

Battery Island is a natural island that first received dredged material in the first half of the 1900s. It currently encompasses an area of 120 acres and includes upland forest and *Spartina* marsh habitats. It supports a number of nesting birds including the great egret, snowy egret, cattle egret, tricolored heron, little blue heron, black-crowned night heron, glossy ibis, white ibis, American oystercatcher, willet, clapper rail, seaside sparrow, and other march-nesting passerines. It also serves as a roosting habitat for Arctic-nesting shorebirds, seaside sparrow, saltmarsh sparrow, and Nelson’s sparrow. It supports one of the largest concentrations of wading birds in NC and is considered to be a globally significant rookery for white ibis. Threats from the project include increased wave energy resulting from boat wakes and the deepened and widened channel. The edge of the island is comprised of a narrow sandy or shell berm on the north, west, and south sides; but this has been eroding over time and is accelerating due to the island's exposure to heavy boat traffic and wave activity. Efforts to protect and strengthen the shoreline have been undertaken (most recently, the placement of geotubing by the USFWS on the southwest shoreline in 2002-2003), but these have been ineffective due to lack of maintenance funding. Areas on the western and eastern shorelines have decreased by approximately 30 meters since the early 2000s and mature cedar trees (approximately 30-40 years old) began falling into the LCFR in 2015. The retreating shoreline has also resulted in increased saltwater encroachment, which has negatively impacted the native tree populations; which, in turn, negatively affects the bird species that utilize these trees for nesting.

4.2 Conceptual Mitigation Plan

For Ferry Slip and South Pelican Islands, approximately 250,000 cubic yards (cy) would be placed on each island, which would expand them to approximately 15 acres each. This would increase the longevity and promote use by current and future avian communities. Since "beach quality" sand (less than 10% fines) is required for this mitigation, it is assumed that the material for both islands would originate from the Horseshoe Shoal Reach. Depending upon future geotechnical investigations, material from the Reeves Point and/or Snows Marsh Reaches may be deemed suitable and could decrease the proposed cost. The amount of dredged material that would be available for use may vary in quality and location within the project area. The quality of sediment is characterized primarily by grain size and suitability as described below (Main Report Appendix B: Geotechnical).

- Category A (Best) – Potentially suitable for engineering structural fill or beach nourishment. Fines content typically <10%, d50 of at least 0.25 millimeters and low calcium carbonate content.
- Category B (Intermediate) – Potentially suitable for non-engineered fill. Fines content approximately 10-20% and may include thin lenses of fine-grained deposits.
- Category C (Poor) – Potentially suitable for low-quality fills (e.g. habitat restoration and development, offshore berms, parks and recreation, etc.). Fines content approximately 20-25%
- Category D (Poor) – Disposal Area (upland or offshore)

Categories C and D are considered to be poor or unsuitable for fills and beach nourishment due to their high percent fines content. Although a significant amount of historical data has been collected on the type of dredged material that is available, further analysis would be required to thoroughly evaluate the amount, quality, and location of sediments in the project area. Overall, there is a large quantity of Category A and B material spanning from the start of the entrance channel offshore and extending up through the mouth of the Cape Fear River. The proximity of this good and intermediate quality material to the proposed mitigation sites in the southern area of the project area would be an advantage in reducing the costs of transport and disposal. Further analysis will be required to assess the cost-effectiveness of the remaining material north of the three islands.

Both Ferry Slip Island and South Pelican Island are currently permitted for an area of seven acres each. It is proposed that the permitted size for each island be increased to 15 acres to accommodate the project's expected volume of dredged material, which would otherwise be disposed in the Offshore Dredged Material Disposal Site (Figures 25 and 26). It is recommended that the island footprints be reshaped to include more curvature, as this would increase linear shoreline available to birds. Incorporating more variation in elevation and slope might also attract additional avian species that have lost traditional beach habitat. The increase in each island's permitted footprint would require approval from all federal and state agencies, but is more easily done as part of a federally authorized project. Modeling of the coastal processes and geotechnical analysis would be required to assess the most effective way of placing sediment on these islands to maximize lifespan and minimize erosion over time factoring in the increased wave action and flow resulting from the deepened and widened channel.

For Battery Island, proposed mitigation measures include the placement of dredged material along the southern and western shorelines of Battery Island to restore the previously-existing berm and protect the existing trees from saltwater intrusion. Approximately 250,000 cy of material dredged from nearby reaches would be used to re-nourish the beach along the south and west sides of Battery Island (Figure 27). Width and height should be commensurate with the berm that was lost, which was approximately one meter above Mean High Water and approximately 10-20 meters in width (Personal communication. L. Addison, Audubon NC March 2019).

To ensure the long-term viability of each island and the benefits provided to shorebirds, establishing physical targets (*e.g.* minimum allowable size and elevation) that would trigger dredging or other restoration projects with an appropriate funding source would ensure that these islands do not degrade beyond their functional utility for nesting birds in the LCFR ecosystem. Development of a management plan for the islands within the framework of the mitigation program for the TSP will be assessed during development of the DEIS and through agency coordination.

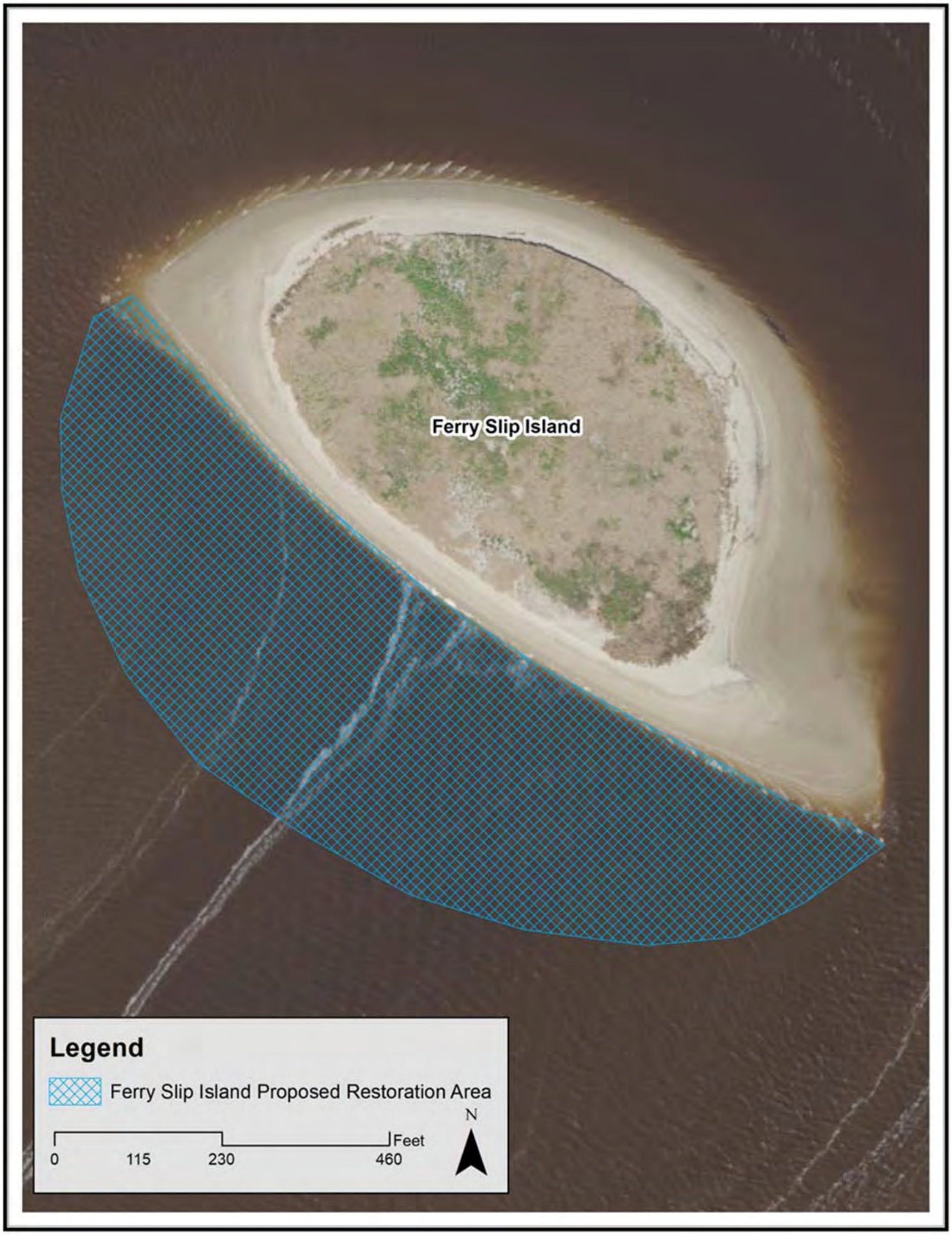


Figure 25
Ferry Slip Island Conceptual Restoration Plan

Figure 26
South Pelican Conceptual Restoration Plan

Figure 27
Battery Island West Shoreline Conceptual Enhancement Plan

5 MITIGATION FOR VESSEL WAKE EFFECTS ON SHORELINES IN THE LOWER CAPE FEAR RIVER

This section includes a review of vessel wake modeling on selected areas along the shoreline of the LCFR, and proposed mitigation measures to attenuate wave action and project shoreline resources and properties. At the request of stakeholders, more modeling and orders of other areas will be performed during the development of the DEIS. This plan is conceptual and will be revised during the NEPA process.

5.1 Vessel Wake Modeling Summary

An evaluation was made of the effect of ship generated waves as a result of the deepened and widened channel and the new 12,400 Twenty-foot Equivalent (TEU) container ship design vessel. To evaluate the primary ship generated wave, the XBeach model was used and three areas of concern were identified where an increase in vessel wakes due to the project may negatively impact the shoreline. These include Orton Point, Brunswick Town/MOTSU, and a northern section of Southport, as shown on Figures 28 through 31 (the yellow to red areas show increases in bed shear stress, a proxy for erosion potential, between the design 12,400 TEU vessel and the existing 8,000 TEU vessel). More details on the modeling effort can be found in the Main Report Appendix A: Engineering.

5.2 Shoreline Vessel Wake Attenuation Mitigation Measures

5.2.1 Orton Point

Much of this shoreline is already protected by a rock revetment and no mitigation efforts are proposed in these locations. However, there are two sections of shoreline (650 ft and 1,500 ft) with a marsh platform in front which are currently unprotected and may be impacted (Figure 32) A rock sill (Figures 32 and 33) is proposed in these areas to provide protection from increased vessel wakes to the existing marsh. The rock sill would extend up to Elevation +3.0 North American Vertical Datum. A rock revetment along the shoreline was considered in these areas, but it was not deemed feasible as its construction would be detrimental to the existing marsh platform in front and would not provide protection to these marshes from ship wake induced erosion.

5.2.2 Brunswick Town/MOTSU

Various sections of this shoreline are already protected by a rock revetment and the proprietary pile supported “Reefmaker” system (Figure 34) with additional sections currently in the bidding process. In areas where an unprotected marsh platform still exists and may be impacted, a rock sill is proposed to provide protection from increased vessel wakes (Figure 32). The rock sill would extend up to Elevation +3.0 North American Vertical Datum and extend along approximately 2,600 ft of shoreline. Similarly to Orton Point, a rock revetment along the shoreline was considered in these areas, but was not deemed feasible as its construction would be detrimental to the existing marsh platform in front and would not provide protection to these marshes from ship wake induced erosion.

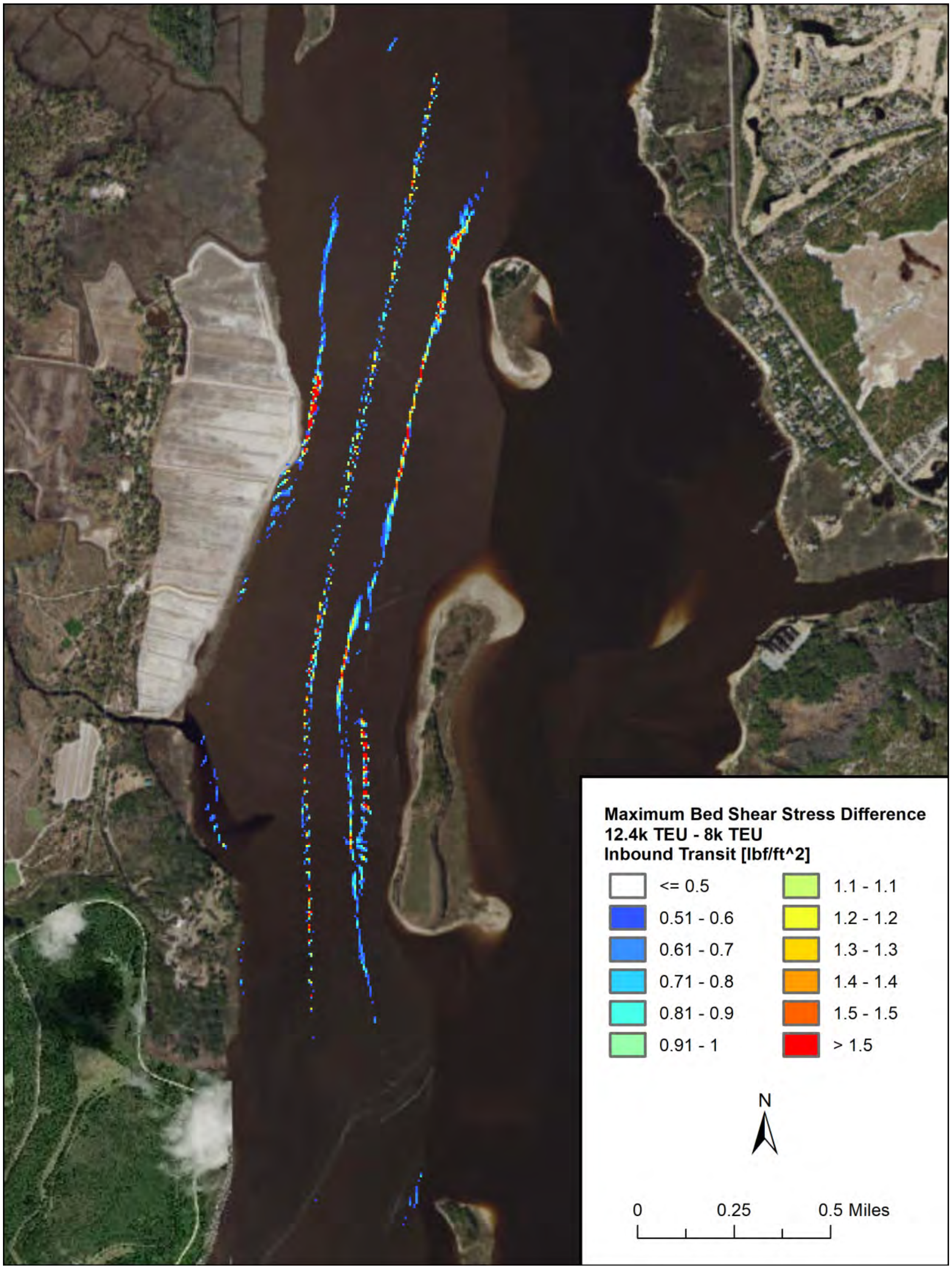


Figure 28
Vessel Wake Analysis for Orton Point Inbound

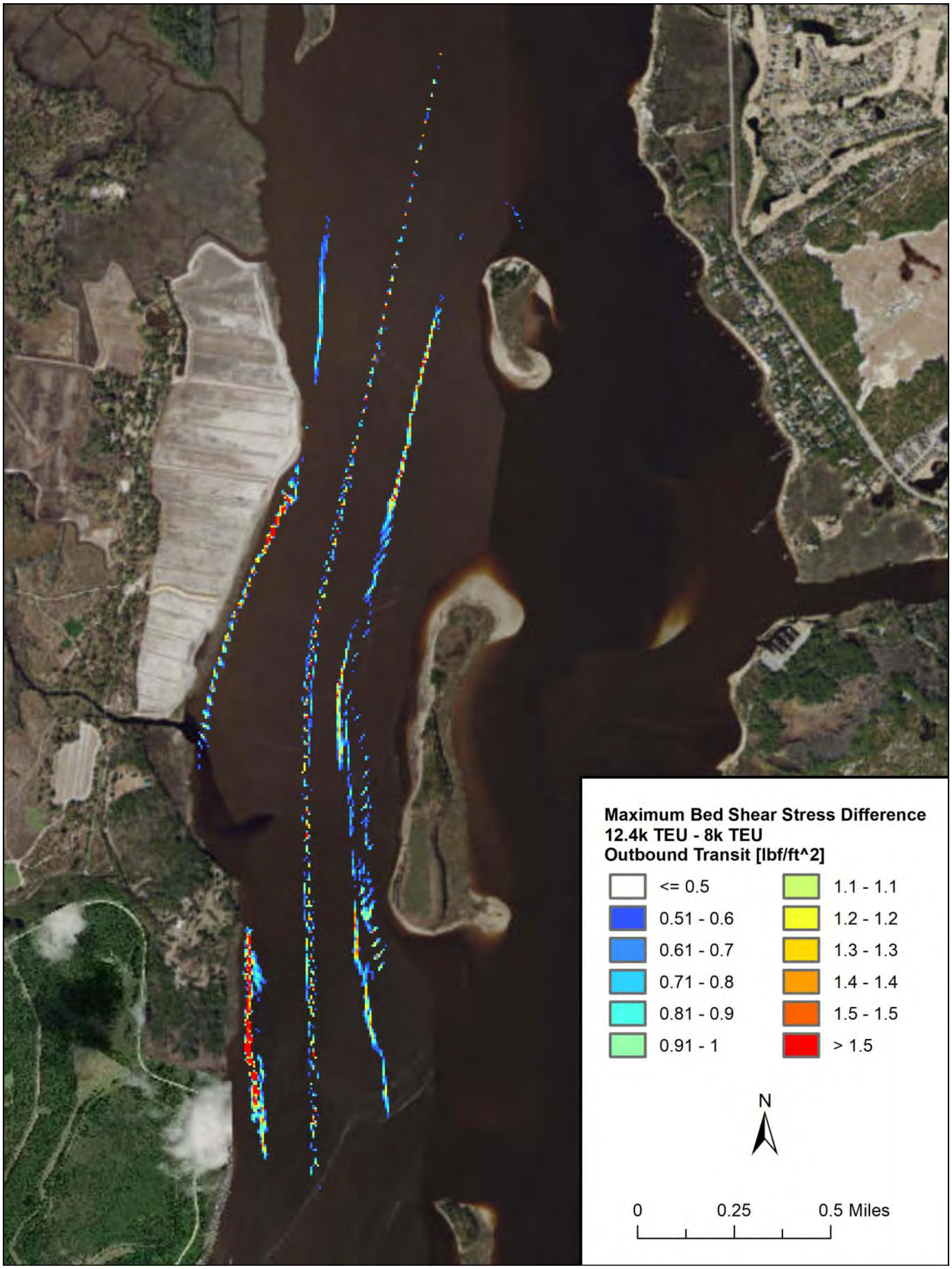


Figure 29
Vessel Wake Analysis for Orton Point Outbound

Figure 30
Vessel Wake Analysis for Southport Inbound

Figure 31
Vessel Wake Analysis for Southport Outbound

Figure 32
Conceptual Mitigation Plan for Orton Point and Brunswick Town Area

Figure 33
Example of Rock Sill Used for Shoreline Protection

Figure 34
Example of Reef Maker Wave Attenuation Structure

In an area extending about 700 ft along the shoreline where the bottom profile is rather steep and the remnants of a historically significant wharf exists, a rock sill is not a viable approach as it would require a significant amount of material and its cost would be comparable to that of a pile supported system, although in some areas the bottom profile may drop off too quickly for a rock sill to even be constructed in a stable position. Hence, the proprietary "Reefmaker" system (or similar system) is proposed for this area.

5.2.3 Southport

About 1,700 ft of shoreline at the north end may be negatively impacted by the proposed project (Figure 35). The marsh in the area has been heavily eroded or no longer exists, and the shoreline consists of rock revetments and bulkheads in various conditions. Additionally, private piers extend out into the river at this location. A "living shoreline" (Figures 33 and 35) is proposed in this area. It would consist of a rock sill similar to those proposed in the other locations above. However, the beneficial use of material dredged from the adjacent Lower Swash Reach would then be placed behind the sill and planted.

Figure 35
Conceptual Mitigation Plan for Upper Southport Area

5.2.4 Additional Shoreline Potentially Impacted By Vessel Wakes

During development of the DEIS, additional areas may be analyzed, as identified by concerned stakeholders to determine if they may be negatively impacted by ship generated waves as a result of the deepened and widened channel and the new 12,400 TEU container ship design vessel. If such impacted areas are found, similar mitigative measures as those discussed previously would be considered such as rock sills, pile supported "reef" systems, living shorelines and /or placement of dredged material for habitat creation.

6 MONITORING PROGRAM AND ADAPTIVE MANAGEMENT MEASURES

A comprehensive monitoring program, corrective action plan, and adaptive management measures will be developed thorough formal coordination with the IRT recently assembled by the USACE for development of the DEIS, as well as through the Wetland and Fish and Fish Habitat TWGs, which have been meeting for over a year. Anticipated components of the monitoring program and schedule are included in Table 9. Development of the monitoring program will include collaborative efforts with the University of North Carolina at Wilmington Center for Marine Science, and federal and state agencies with specific knowledge and experience within the river. Due to the knowledge gained from the ten years of post-construction monitoring by University of North Carolina at Wilmington for the last Wilmington Harbor deepening project in 2000, their guidance will be beneficial. An estimated budget for the monitoring efforts defined below was prepared based in part on review of monitoring protocols for recently approved deep draft navigation projects along the southeast coast, and by establishing a reasonable level of effort for project related monitoring and mitigation- based monitoring.

Table 9
Monitoring and Adaptive Management Program Components and Schedule

Tidal Wetlands - Conceptual framework - Preconstruction - multispectral imagery of tidal wetlands (1 year) - Post-construction - multispectral imagery of tidal wetlands (Years 1, 3, and 7) - Mitigation site trend analysis using multispectral imagery (Years 1, 3, and 7) - Mitigation plan baseline and post- restoration monitoring (7 years) - Corrective action plan and adaptive management measures
Fish and Fish Habitat - Conceptual framework - Preconstruction baseline benthic and fish resource monitoring (1 year) - Construction concurrent pre-treatment monitoring (1-3 years) - Post-construction benthic and fish resource monitoring (Years 1,3,5, and 7) - Mitigation plan(s) baseline and post-construction monitoring (7 years) - As-built surveys of all constructed mitigation measures (1 year) - Corrective action plan and adaptive management measures

Table 12 concluded

Water Column Modelling Post-Construction Calibration Monitoring - Conceptual framework - Preconstruction calibration and data collection platform constructed - Construction concurrent data collection (3-4 years) - Post-construction data collection (6-7 years) - Post- construction model calibration and report (1 year) - Corrective action and adaptive management measure
Shoreline Change Monitoring - Conceptual framework - Preconstruction shoreline survey and mapping (1 year) - Post- construction surveys and mapping (Years 1,5, and 7) - Mitigation plan(s) baseline and post-construction monitoring (7 years) - As-built surveys of all constructed mitigation measures (1 year) - Corrective action plan and adaptive management measures
Lower Cape Fear Bird Islands Erosion Monitoring - Conceptual framework - Preconstruction shoreline survey and mapping (1 year) - Post- construction surveys and mapping (Years 1,5, and 7) - Mitigation plan(s) baseline and post-construction monitoring (7 years) - As-built surveys of all constructed mitigation measures - Corrective action plan and adaptive management measures
Threatened and Endangered Species Monitoring - Construction dredge monitoring using PSOs - Construction - blast monitoring per Biological Opinion and monitoring plan - Construction - sea turtle and nest monitoring for beach placement - Construction – Atlantic sturgeon monitoring during dredging - Mitigation baseline and post-construction monitoring for lock and dam fish passages
Beneficial Use of Dredged Material Project(s) Monitoring - Conceptual framework - Preconstruction surveys for island treatment sites and beach disposal areas - Post- construction beach disposal areas surveys - Post-construction island treatment monitoring - As-built surveys for island treatment sites - Corrective action plan and adaptive management measures

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