Feasibility Study

Protection of NC 12

Town of Kitty Hawk
Dare County

Division 1
FS-0701A

Feasibility Studies Unit
Program Development Branch
N.C. Department of Transportation

Documentation Prepared by Ko & Associates, P.C.

Mark E. Reep, P.E.
Project Manager
Ko & Associates, P.C.

Derrick W. Lewis, P.E.
Feasibility Studies Unit Head
Feasibility Studies Unit, NCDOT

Nicole M. Hackler, P.E.
Feasibility Studies Engineer
Feasibility Studies Unit, NCDOT

7/20/07
Date

FS-0701A

Protection of NC 12

Town of Kitty Hawk, Dare County

Division 1

I. General Description

This feasibility study (FS-0701A) addresses improvements to a 3.8-mile segment of NC 12 (Virginia Dare Trail) between Wilkinson Street and US 158, in the Town of Kitty Hawk in Dare County (see Figure 1 for location). The proposed improvements include the construction of a protective berm to protect NC 12 from overwash, erosion, and flooding damage during storms. Since 2002, NCDOT has focused road and dune repairs on a 1,300-foot portion of NC 12 from north of Kitty Hawk Road to north of Starfish Lane. NCDOT placed sandbags underneath the road shoulder, constructed a protective berm on the beach side of the road, and added localized beach fill to rebuild the dunes in this area. This feasibility study responds to a December 2006 request from the Town of Kitty Hawk to expand and maintain a berm damaged during a November 2006 storm.

With Project FS-0701A, NCDOT evaluated incrementally extending the berm protection along the east side of NC 12 from Wilkinson Street to Ocean Boulevard near US 158. A 10-foot wide protective berm would be constructed approximately 6 to 8 feet higher than roadway elevation. Approximate 4:1 construction slopes (a 4-foot horizontal width to 1-foot vertical rise) would be used on both the roadway side and beach side of the berm. The berm construction limits will likely extend approximately 100 feet from the existing pavement edge.

This study is the initial step in the planning and design process for this project and is not the product of exhaustive environmental or design investigations. The purpose of this study is to describe the proposed project, including costs, and to identify potential problems that may require consideration in the planning and design phases.

II. Background and Need for Project

For thousands of years, the barrier islands have experienced dynamic changes as the islands have formed, eroded, and reformed. Geological research conducted by East Carolina University indicates the Kitty Hawk area is located above a former Roanoke River channel that filled with sediment more than 3,000 years ago. Prior to 1780 AD, the sea level rose approximately 0.25 feet per century. Since 1780, the sea level has risen sharply at a rate of approximately 1.5 feet per century. Since the 1840's, the barrier islands have lost from 750 to 2,500 feet of beach, corresponding to a rate of 5 to 6.7 feet per year (Riggs, 2007). In Kitty Hawk, the shoreline east of NC 12 has decreased from approximately 1,000 feet in 1932 to less than 200 feet today. According to a shoreline

change study conducted in 1998, erosion rates in Kitty Hawk are among the highest in the Outer Banks (NC Division of Coastal Management, 1998). These indicate the average erosion rates ranged from 2 to 4 feet per year in Kitty Hawk. The highest erosion rates occur between Starfish Lane and Balchen Street.

Existing beachfront houses and the roadway prevent portions of the beach from being stabilized or replenished by overwash events. This is due to clearing and removing the overwash material from the roadway and beneath houses. As a result, the wave energy is rapidly eroding and narrowing the beach. If current conditions are allowed to continue, future storms could lead to large-scale damages and result in negative economic consequences for Kitty Hawk.

Since 2002, NCDOT has performed emergency road clearing and repair work in response to storm damage from hurricanes and northeasters. The Department has spent approximately $3.2 million during this time in the Kitty Hawk area, primarily between Kitty Hawk Road and Starfish Lane, a distance of approximately 1,300 feet. The improvements have included sandbag installation, berm construction, placement of beach fill, and dune repairs. These are summarized in Table 1.

Table 1: NC 12 Construction and Maintenance Activities in Kitty Hawk (2002 to 2007)

Date	Description	Cost
January 2002	Installation of 800 feet of sandbag protection on the east side and construction of a protective berm	$375,000
March 2003	Installation of an additional 550 feet of sandbags	$125,000
May 2003	Increase in height and width of existing sandbags and construction of a berm	$350,000
Fall 2003	Repairs to the roadway and dunes along the entire Kitty Hawk portion of NC 12 due to damage from Hurricane Isabel	$900,000
Spring 2005	Placement of 90,000 cubic yards of sand on the beach	$1,200,000
Spring 2006	Reconstruction of the berm	$100,000
January 2007	Reconstruction of the berm due to damage from a November 2006 northeaster	$125,000

Current problems with the road are concentrated in areas where homes are between the beach and road. Water is channeled under the homes, along driveways, and directed into the highway. In April 2003, storm overwash penetrated the dunes and undermined the pavement, requiring substantial roadway repairs. During the November 2006 northeaster, water overtopped NC 12 and the overwash was trapped between NC 12 and US 158. Water levels were as high as 3 feet above the ground. Some overwash of the road

continues in this area, but the road pavement has not been compromised since the construction improvements have been in place. The primary areas of dune loss and overwash are in selected locations between Byrd Street and Historic Street (see Figure 2):

- Sibbern Street to South of White Avenue
- South of Hurdle Street to Kitty Hawk Road
- Kitty Hawk Road to Historic Street
- Balchen Street to Eckner Street
- Fonck and Byrd Street Beach Accesses

Since 2003, a panel of coastal engineering and erosion experts has consulted with NCDOT on the extent of NC 12 repairs needed in Kitty Hawk. The group acknowledges that the NC 12 sandbag installation and berm repairs will last only a few years. Ultimately, longer-term solutions of much larger magnitude are needed to more effectively protect the roadway, beach, and economic viability of the community. Such long-term solutions may ultimately include large scale beach nourishment and/ or the relocation of NC 12.

The purpose of this project is to maintain mobility, safety, and access to the beach, residences, and businesses along NC 12. This feasibility study addresses immediate, short-term, and intermediate solutions for road protection and beach stabilization until large-scale improvements can be implemented.

III. Route Function, Traffic Volumes, and Programmed Road Improvements

NC 12 is a two-lane, 28-foot roadway that contains 10-foot travel lanes and 4-foot paved shoulders within a 60-foot right of way width. The posted speed limit is 35 miles per hour (mph). Locally known as the Beach Road, NC 12 is classified as a minor arterial and is the primary beachfront access road. It provides additional capacity for evacuation and offers an alternative route for local traffic and emergency vehicles when US 158 is impassible. US 158 is classified as a Principal Arterial and the designated hurricane evacuation route in Kitty Hawk. Existing land uses along NC 12 include mostly single family residences, with some condominiums, trailer parks, restaurants and hotels.

According to estimates by the NCDOT Transportation Planning Branch, current (2006) average annual traffic on NC 12 is estimated to be 9,300 vehicles per day (vpd) south of the project area in Kill Devil Hills. By the year 2030, traffic is expected to reach 16,500 vpd. Trucks are estimated to represent 5% of the NC 12 traffic. Current traffic on US 158 is estimated to be 44,200 vpd, and 2030 year traffic is expected to reach 79,600 vpd. Trucks represent 7% of the US 158 traffic. Table 2 summarizes the traffic volumes and roadway classifications for these two routes.

Table 2: Traffic Volumes and Roadway Classifications

Roadway	Current Traffic (2006) (vehicles/ day)	Future Traffic (2030) (vehicles/ day)	Truck Percentage	Functional Classification	Strategic Use
NC 12	9,300	16,500	5%	Minor Arterial	None
US 158	44,200	79,600	7%	Principal Arterial	Hurricane Evacuation Route

Three programmed projects in the *2007-2013 State Transportation Improvement Program* (TIP) are in the Kitty Hawk area, but only one of these has immediate influence on the current feasibility study. This project, U-2917, proposes to relocate NC 12 one block west of the existing location from Wilkinson Street to US 158 parallel to this feasibility study area (see Figure 3). Additionally, TIP Project R-3419 proposes to widen a 14.6-mile portion of US 158 to seven lanes from US 64-264-NC 12 (Whalebone) to Putter Lane (Kitty Hawk), and TIP Project R-4457 proposes to convert the US 158-NC 12 intersection in Kitty Hawk to an interchange.

IV. Description of Alternatives

This study evaluates incremental phases for constructing immediate and intermediate berm protection measures for NC 12. The project was divided into 24 sections, A through Y, for cost evaluation purposes. These segments were then combined to form four phases for the most cost effective approach to construction (see Figure 2 for further information). This phasing considers a gradual approach for closing the gaps between dunes by acquiring properties along NC 12 and constructing a protective berm.

The proposed 10-foot wide protective berm would be constructed approximately 6 to 8 feet higher than roadway elevation. Approximate 4:1 construction slopes (a 4-foot horizontal width to 1-foot vertical rise) would be used on both the roadway side and beach side of the berm. Approximately 85 feet of additional right of way or easement is anticipated to contain the proposed berm.

Beach fill projects require detailed sampling of potential sand sources to ensure that suitable material is placed on the beach (NC Division of Coastal Management, 2007). For past NC 12 construction work, NCDOT hauled sand from a mainland borrow site approximately 12 miles north of Kitty Hawk. If there is not enough sand available from a mainland site, an off-shore sand source may need to be used. In its Final Feasibility Report and EIS on Hurricane Protection and Beach Erosion Control, the US Army Corps of Engineers identified two off-shore borrow sites for possible beach fill. Dredging was

also considered; however, this would require lengthy permitting and sand suitability studies. In addition, dredging activities would be limited to short seasons during spring or summer since the Kitty Hawk beaches have no harbor of refuge for construction-related vessels during fall and winter months, when northeasters are common. However, restrictions during the sea turtle nesting season from May to November further narrow the window of opportunity for dredging and would likely have an effect on cost and constructability. In this study, the construction costs were estimated for three possible methods of obtaining borrow material:

- Truck hauling of sand from a mainland borrow site
- Pipeline dredging from a nearby off-shore borrow site
- Hopper dredging from a more distant off-shore borrow site

The costs also account for building the project in small or large sections to help identify the most cost effective project phasing.

The proposed phases are described below and shown on Figure 2. Each phase is divided in two parts. Part A includes acquisition of vacant parcels and construction of a protective berm in vacant areas. Part B includes acquisition of occupied parcels and construction of the remaining protective berm for that phase. The segment descriptions, lengths, and costs are summarized in Tables A1 and A2 in the Appendix. Tables 3, 4, and A3 through A6 provide an overview of the costs and relocation requirements for each phase. Tables 4, A7, A8, and A9 also show the cost effectiveness for constructing longer portions of the project at one time. The unit costs for construction mobilization decrease as the project length increases.

- Phase 1 - White Avenue to Historic Street
- Phase 2 - Wilkinson Street to White Avenue
- Phase 3 - Historic Street to Eckner Street
- Phase 4 - Eckner Street to Ocean Boulevard

Phase 1 -White Avenue to Historic Street – 1.1 Miles

Phase 1 is the most immediate area of need requested by the Town of Kitty Hawk. This phase can be implemented in two parts to extend the previously constructed 1,300-foot berm to a total length of 1.1 miles along Sections H through M. In Phase 1A, approximately 65 vacant parcels would be acquired and the protective berm would be constructed across these parcels. In Phase 1B, the remaining 16 occupied parcels would be acquired and the protective berm would be completed between White Avenue and Historic Street.

The estimated right of way cost for Phase 1A is $10,000,000. The most cost effective method for obtaining borrow material is by trucking the sand from a mainland site. The construction cost for Phase 1A using mainland borrow material is estimated to be $2,500,000 resulting in a total cost of $12,500,000. Phase 1B will require 16 residential relocations, and the estimated right of way cost is $11,000,000. The construction cost for

Phase 1B using mainland borrow material is estimated to be $600,000 resulting in a total cost of $11,600,000. The total Phase 1 cost with right of way using mainland borrow material is $24,000,000.

If mainland borrow sources are not sufficient, pipeline dredging or hopper dredging may be considered using an off-shore borrow site. The total Phase 1 cost with right of way using pipeline dredging is estimated to be $33,300,000, and the total cost with right of way using hopper dredging is estimated to be $43,400,000.

Phase 2 - Wilkinson Street to White Avenue – 0.9 Mile

Phase 2 is considered an intermediate need and would improve a 0.9-mile portion of NC 12 along Sections A through G. Added to Phase 1, this phase would result in a more effective 2-mile total length from Wilkinson Street to Historic Street. In Phase 2A, approximately 34 vacant parcels would be acquired and the protective berm would be constructed across these parcels. In Phase 2B, the remaining 21 occupied parcels would be acquired and the protective berm would be completed between Wilkinson Street and White Avenue.

The estimated right of way cost for Phase 2A is $5,300,000. The construction cost for Phase 2A using mainland borrow material is estimated to be $1,500,000 resulting in a total cost of $6,800,000. Phase 2B will require 21 residential relocations, and the estimated right of way cost is $14,400,000. The Phase 2B construction cost using mainland borrow material is estimated to be $1,000,000 resulting in a total cost of $15,400,000.

The total Phase 2 cost with right of way using mainland borrow material is $22,100,000. The total cost with right of way using pipeline dredging from an off-shore borrow site is estimated to be $29,600,000, and the total cost with right of way using hopper dredging is estimated to be $37,900,000.

Phase 3 (Historic Street to Eckner Street) – 0.9 Mile

Phase 3 is considered an intermediate need and would improve a 0.9-mile portion of NC 12 along Sections N through S. Added to Phases 1 and 2, this phase would protect a 2.9-mile length of NC 12 from Wilkinson Street to Eckner Street.

In Phase 3A, approximately 22 vacant parcels would be acquired and the protective berm would be constructed across these parcels. In Phase 3B, the remaining 46 occupied parcels would be acquired and the protective berm would be completed between Historic Street and Eckner Street.

The estimated right of way cost for Phase 3A is $3,500,000. The construction cost for Phase 3A using mainland borrow material is estimated to be $800,000 resulting in a total cost of $4,300,000. Phase 3B will require 46 residential relocations, and the estimated

right of way cost is $31,800,000. The Phase 3B construction cost using mainland borrow material is estimated to be $1,700,000 resulting in a total cost of $33,500,000.

The total Phase 3 cost with right of way using mainland borrow material is $37,700,000. The total cost with right of way using pipeline dredging from an off-shore borrow site is estimated to be $45,400,000, and the total cost with right of way using hopper dredging is estimated to be $53,900,000.

Phase 4 (Eckner Street to Ocean Boulevard) – 0.9 Mile

Phase 4 is also considered an intermediate need and would improve a 0.9-mile portion of NC 12 along Sections T through Y. When combined with Phases 1, 2, and 3, this would protect the entire threatened 3.8-mile length of NC 12 from Wilkinson Street to Ocean Boulevard.

In Phase 4A, approximately 22 vacant parcels would be acquired and the protective berm would be constructed across these parcels. In Phase 4B, the remaining 48 occupied parcels would be acquired and the protective berm would be completed between Eckner Street and Ocean Boulevard.

The estimated right of way cost for Phase 4A is $3,400,000. The construction cost for Phase 4A using mainland borrow material is estimated to be $700,000 resulting in a total cost of $4,100,000. Phase 4B will require 48 residential relocations, and the estimated right of way cost is $33,800,000. The Phase 4B construction cost using mainland borrow material is estimated to be $1,800,000 resulting in a total cost of $35,600,000.

The total Phase 4 cost with right of way using mainland borrow material is $39,600,000. The total cost with right of way using pipeline dredging from an off-shore borrow site is estimated to be $47,400,000, and the total cost with right of way using hopper dredging is estimated to be $56,000,000.

Table 3: Phase Construction Summary

Constructed Phases	Relocations	Right of Way Costs	Construction Costs	Total Costs
			Truck Hauling Mainland Borrow Source	
Phase 1A (65 Vacant Parcels)	0	$10,000,000	$2,500,000	$12,500,000
Phase 1B (16 Occupied Parcels)	16	$11,000,000	$ 600,000	$11,600,000
Phase 1 Total (White Ave. – Historic St.)	**16**	**$21,000,000**	**$3,000,000**	**$24,000,000**
Phase 2A (34 Vacant Parcels)	0	$ 5,300,000	$1,500,000	$ 6,800,000
Phase 2B (21 Occupied Parcels)	21	$14,400,000	$1,000,000	$15,400,000
Phase 2 Total (Wilkinson St. - White Ave.)	**21**	**$19,700,000**	**$2,400,000**	**$22,100,000**
Phase 3A (22 Vacant Parcels)	0	$ 3,500,000	$ 800,000	$ 4,300,000
Phase 3B (46 Occupied Parcels)	46	$31,800,000	$ 1,700,000	$33,500,000
Phase 3 Total (Historic St. – Eckner St.)	**46**	**$35,300,000**	**$2,400,000**	**$37,700,000**
Phase 4A (22 Vacant Parcels)	0	$ 3,400,000	$ 700,000	$ 4,100,000
Phase 4B (48 Occupied Parcels)	48	$33,800,000	$1,800,000	$35,600,000
Phase 4 Total (Eckner St. – Ocean Blvd.)	**48**	**$37,200,000**	**$2,400,000**	**$39,600,000**

NOTE: There are only residential relocations involved with this project. No business relocations are expected.

Table 4: Total Cost Summary

Constructed Phases	Total Costs (Right of Way and Construction)		
	Truck Hauling Mainland Borrow Source	Pipeline Dredging Offshore Borrow Source	Hopper Dredging Offshore Borrow Source
Phase 1 (White Ave. to Historic St.)	$ 24,000,000	$ 33,300,000	$ 43,400,000
Phase 2 (Wilkinson St. to White Ave.)	$ 22,100,000	$ 29,600,000	$ 37,900,000
Phase 3 Total (Historic St. – Eckner St.)	$ 37,700,000	$ 45,400,000	$ 53,900,000
Phase 4 Total (Eckner St. – Ocean Blvd.)	$ 39,600,000	$ 47,400,000	$ 56,000,000
Phase 1 and 2	$ 45,700,000	$ 56,800,000	$ 69,200,000
Phase 1, 2, 3, and 4	$121,300,000	$122,700,000	$124,900,000

V. Other Alternatives Considered

Other design concepts that were considered during this study include:

- Realignment of NC 12
- Beach nourishment
- Sandbag installation
- No-build

Most of these were not investigated in detail because they were not considered to be cost effective for this project; however, brief overviews of the other alternatives considered are given below.

Realignment of NC 12

NCDOT is reevaluating the feasibility of relocating NC 12 one block west as part of TIP Project No. U-2917. This proposal was examined in a 1994 feasibility study, was reevaluated in 2003, and costs are currently being updated. Short of substantial beach nourishment by others, the relocation of NC 12 is considered to be a viable long-term solution. The Town of Kitty Hawk does not endorse the relocation of NC 12 due to the disruptions to small businesses and beach cottages that form the foundation of the town's economy and character.

Beach Nourishment

Beach nourishment in Kitty Hawk has been evaluated by the US Army Corps of Engineers in a Feasibility Study and Final EIS on Hurricane Protection and Beach Erosion Control (US Army Corps of Engineers, 2003). In this study, the Corps of Engineers recommended constructing a 50-foot berm and dune along the shoreline from near First Street in Kill Devil Hills to Kitty Hawk Road, a length of 4.1 miles. The northern 1.4-mile portion of the nourishment project is located within the limits of Phases 1 and 2 of this NC 12 protection study. This Corps of Engineers' study also recommended nourishing a 10.1-mile portion of Nags Head shoreline (see study area limits in Figure 4). In April 2007, Nags Head voters rejected a referendum to raise taxes for the project, but Town and County officials are seeking other funding sources. The Kitty Hawk portion would be considered in a later phase of the Corps of Engineers recommended project.

Because this nourishment project is extensive in size, scope, cost, and environmental complexity, it is considered beyond the scope of this NC 12 protection study.

Sandbag installation

Sandbag installation was considered to protect the pavement from being undermined by erosion during overwash events. The sandbag placement would be in layers approximately 8 feet deep by 15 feet wide beneath the shoulder. The cost for placing sandbags ranges from $890 to $1,000 per linear foot and is approximately 1.6 times higher than the protective berm construction cost. Due to the extensive permitting requirements, costs, and potential impact to utilities, sandbag installation is only considered appropriate for repairing undermined pavement in emergency situations.

No-build

Currently, beachfront houses and NC 12 prevent portions of the beach from being stabilized or replenished by overwash events. If no action is taken, future storms could lead to large-scale damages that would negatively affect mobility, safety, access, and local economic conditions.

VI. Community Issues

- The Phase 1 improvements would relocate 16 residences and acquire right of way and easements from 81 beachfront properties. The Phase 2 improvements would relocate 21 residences and acquire right of way and easements from 55 beachfront properties. Town officials are concerned about preserving the residential and business infrastructure to protect the Town's economic vitality. It will be important to involve the local officials and community during the planning and design phases of these protective berm measures.
- Prior to construction of the protective berm in 2005, the Town faced local controversy when it acquired beachfront properties using eminent domain. In its

December 2006 request for the NC 12 protection, the Town strongly encouraged NCDOT to acquire right of way on a voluntary basis rather than using eminent domain.

- There are no potential environmental justice indicators in the project area.
- In conjunction with this project, the Town may consider more restrictive land clearing requirements at beachfront residences. With less excavation around these homes, there would be fewer gaps in the dunes and better protection from storm damage.

VII. Natural Environment Issues

A detailed environmental study was not conducted for this feasibility study, however an environmental screening did find the following items which may need further evaluation in later planning and design stages:

- *Protected Species* –The Feasibility Study and Final EIS on Hurricane Protection and Beach Erosion Control determined that the following federally protected species could be affected by beach construction: Green Sea Turtle, Loggerhead Sea Turtle, Kemp's Ridley Sea Turtle, Leatherback Sea Turtle, Piping Plover, and Seabeach Amaranth. Protected species surveys are likely needed during the detailed planning and design stages of the project.
- *Permits* – The project is located within a coastal development zone and is subject to the requirements of the Coastal Area Management Act (CAMA). A CAMA permit will be required in coordination with the NC Division of Coastal Management. Typically, a CAMA major permit satisfies the other permit requirements associated with Sections 401 and 404 of the Clean Water Act.
- *Sand Borrow Sites* – Detailed sand suitability studies and environmental screenings will need to be performed at any mainland or off-shore borrow sites to ensure that the material is suitable for placement on the beach.

VIII. Conclusions

The improvements contained in this report are not considered a long-term solution but an interim measure to protect NC 12 until a more permanent solution can be provided. Long-term solutions may ultimately include large scale beach nourishment and/ or the relocation of NC 12. The improvements investigated in this report consist of phased construction of a protective berm. The proposed 10-foot wide protective berm would be constructed approximately 6 to 8 feet higher than roadway elevation.

Phase 1 is the most immediate area of need requested by the Town of Kitty Hawk. In Phase 1A, approximately 80 percent of the parcels are vacant and would be acquired for the protective berm construction. In Phase 1B, the remaining 20 percent of parcels that are occupied would be acquired for the protective berm to be completed between White Avenue and Historic Street, a length of 1.1 miles.

Phase 2, when combined with Phase 1, would result in a more effective 2-mile total length from Wilkinson Street to Historic Street. In Phase 2A, approximately 60 percent of parcels are vacant and would be acquired for the protective berm construction. In Phase 2B, the remaining 40 percent of parcels that are occupied would be acquired for the protective berm to be completed between Wilkinson Street and White Avenue.

Phases 1 and 2 (from Wilkinson Street to Historic Street) are the least developed, less expensive, and require the fewest number of parcels and relocations. These two phases cover approximately 60 percent of the dune loss and overwash locations. The combination of Phases 1 and 2 would require 37 residential relocations and result in a total cost of $45,700,000 using a mainland borrow site. The total cost using pipeline dredging is estimated to be $56,800,000, and the total cost using hopper dredging is estimated to be $69,200,000.

By combining Phases 1, 2, and 3 (from Wilkinson Street to Eckner Street), 99 percent of the dune loss and overwash locations would be protected. However, Phase 3 is the second most expensive option since it requires the acquisition of a large number of occupied parcels. Phase 4 is the most expensive option because it requires the acquisition of the largest number of occupied parcels. If the entire project is constructed in a single contract, Phases 1, 2, 3, and 4 would require 131 residential relocations and result in a total cost of $121,300,000 using a mainland borrow site. The total cost using pipeline dredging is estimated to be $122,700,000, and the total cost using hopper dredging is estimated to be $124,900,000.

In conjunction with this project, the Town may consider more restrictive land clearing requirements at beachfront residences. With less excavation around these homes, there would be fewer gaps in the dunes and better protection from storm damage.

IX. BIBLIOGRAPHY

NC Division of Coastal Management, Long-Term Average Annual Shoreline Change Study & Setback Factors - North of Kill Devil Hills to South of Duck, Raleigh, NC, 1998

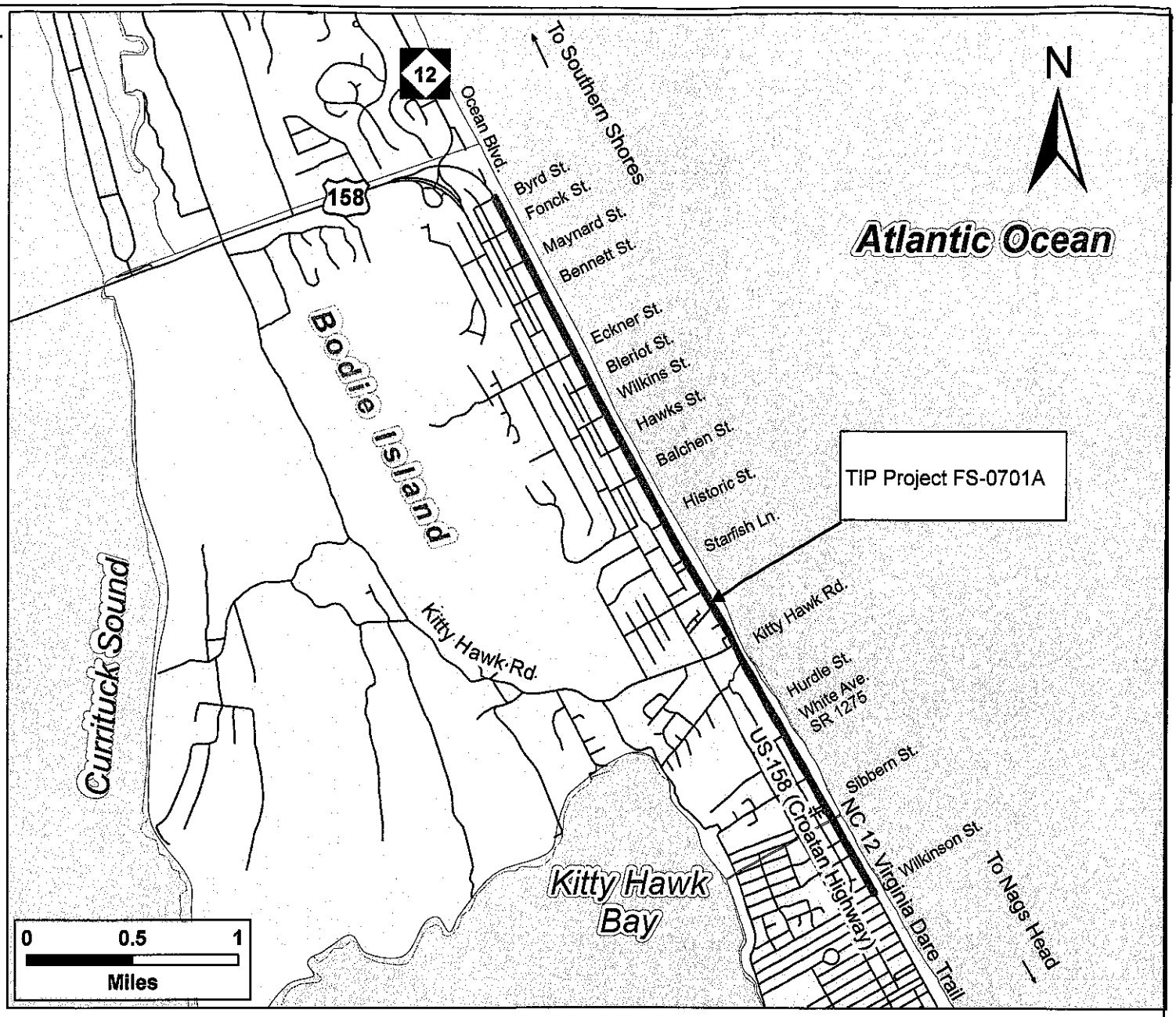
NC Division of Coastal Management, Technical standards for beach fill projects, available from http://www.nccoastalmanagement.net/Rules/07H%20.0312%20-final.pdf, March 13, 2007

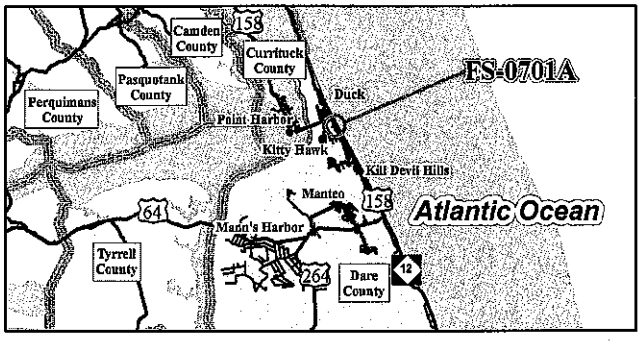
NC General Assembly, Limitations on Erosion Control Structures, available from http://www.ncga.state.nc.us/EnactedLegislation/Statutes/HTML/BySection/Chapter_113A/GS_113A-115.1.html, March 13, 2007

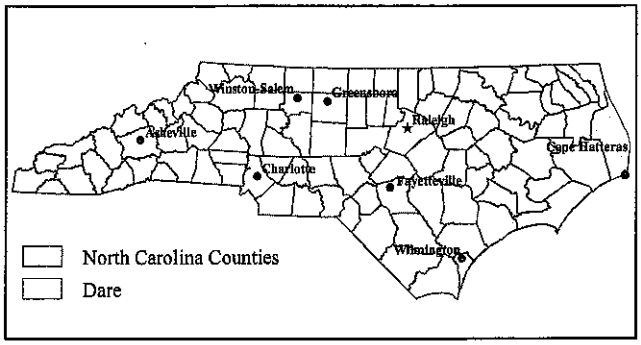
Riggs, Dr. Stanley R., Distinguished Professor of Geology, East Carolina University, personal communications, March 29 and April 11, 2007.

US Army Corps of Engineers, Final Feasibility Report and Environmental Impact Statement on Hurricane Protection and Beach Erosion Control – Dare County Beaches (Bodie Island Portion), Wilmington, NC, 2003

FIGURES





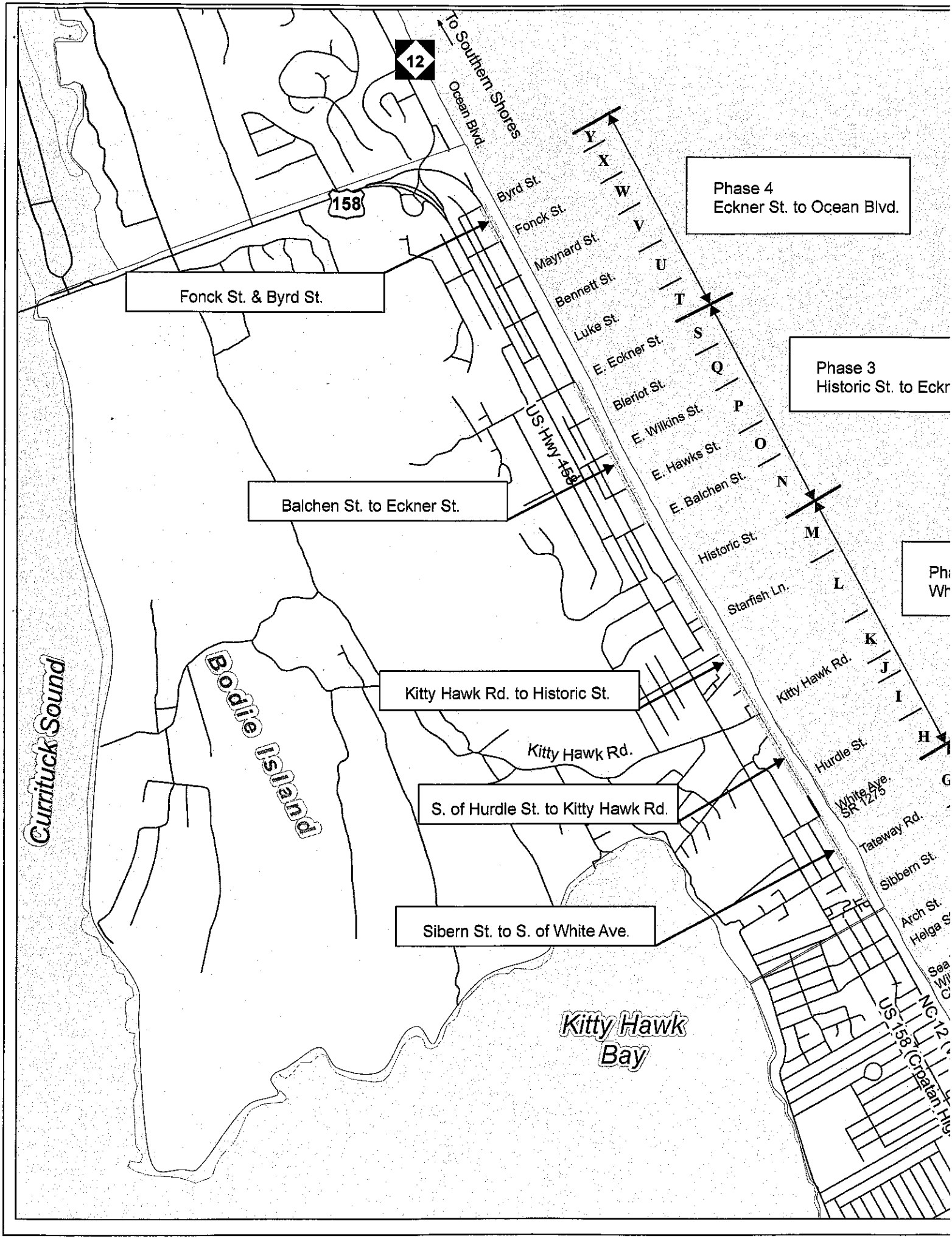


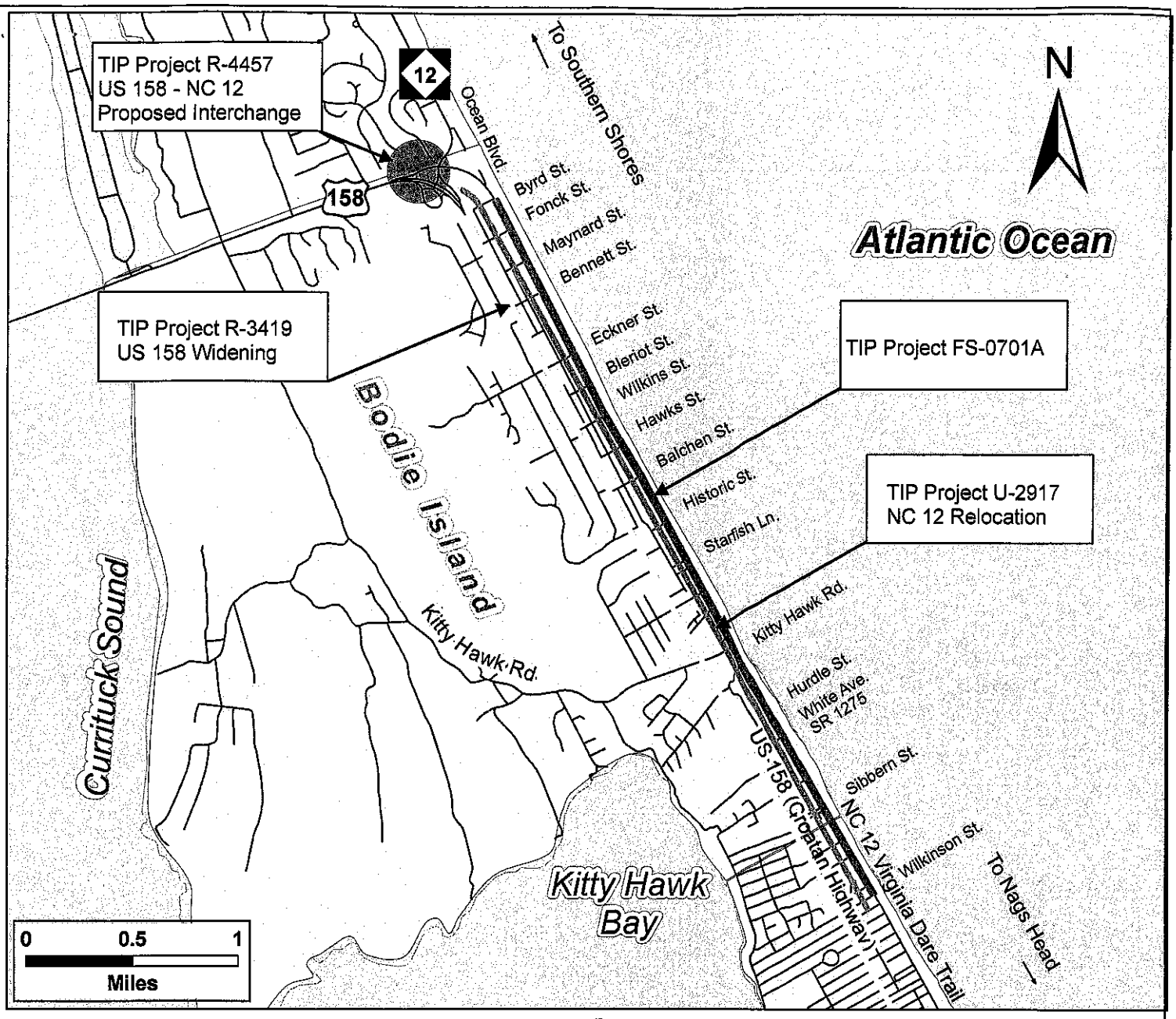
STATE OF NORTH CAROLINA
DEPARTMENT OF TRANSPORTATION

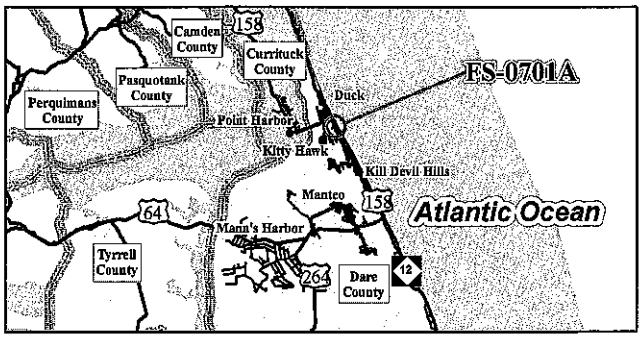
Project Vicinity Map
FS-0701A

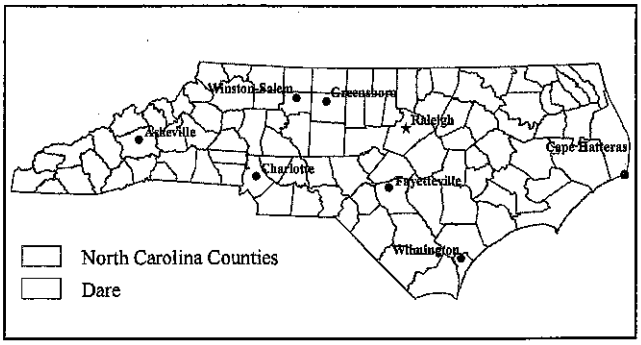
Improvements to NC 12
Kitty Hawk, Dare County

Figure 1


To Southern Shores
12
Ocean Blvd.
158
Byrd St.
Fonck St.
Maynard St.
Bennett St.
Luke St.
E. Eckner St.
Bleriot St.
E. Wilkins St.
E. Hawks St.
E. Balchen St.
Historic St.
Starfish Ln.
Kitty Hawk Rd.
Hurdle St.
White Ave.
SR 1275
Tateway Rd.
Sibbern St.
Arch St.
Helga St.
Y
X
W
V
U
T
S
Q
P
O
N
M
L
K
J
I
H
G
Phase 4
Eckner St. to Ocean Blvd.
Phase 3
Historic St. to Eckr
Fonck St. & Byrd St.
US Hwy 158
Balchen St. to Eckner St.
Kitty Hawk Rd. to Historic St.
Kitty Hawk Rd.
S. of Hurdle St. to Kitty Hawk Rd.
Sibern St. to S. of White Ave.
Currituck Sound
Bodie Island
Kitty Hawk Bay
US 158 (Croatan Hwy.
NC 12





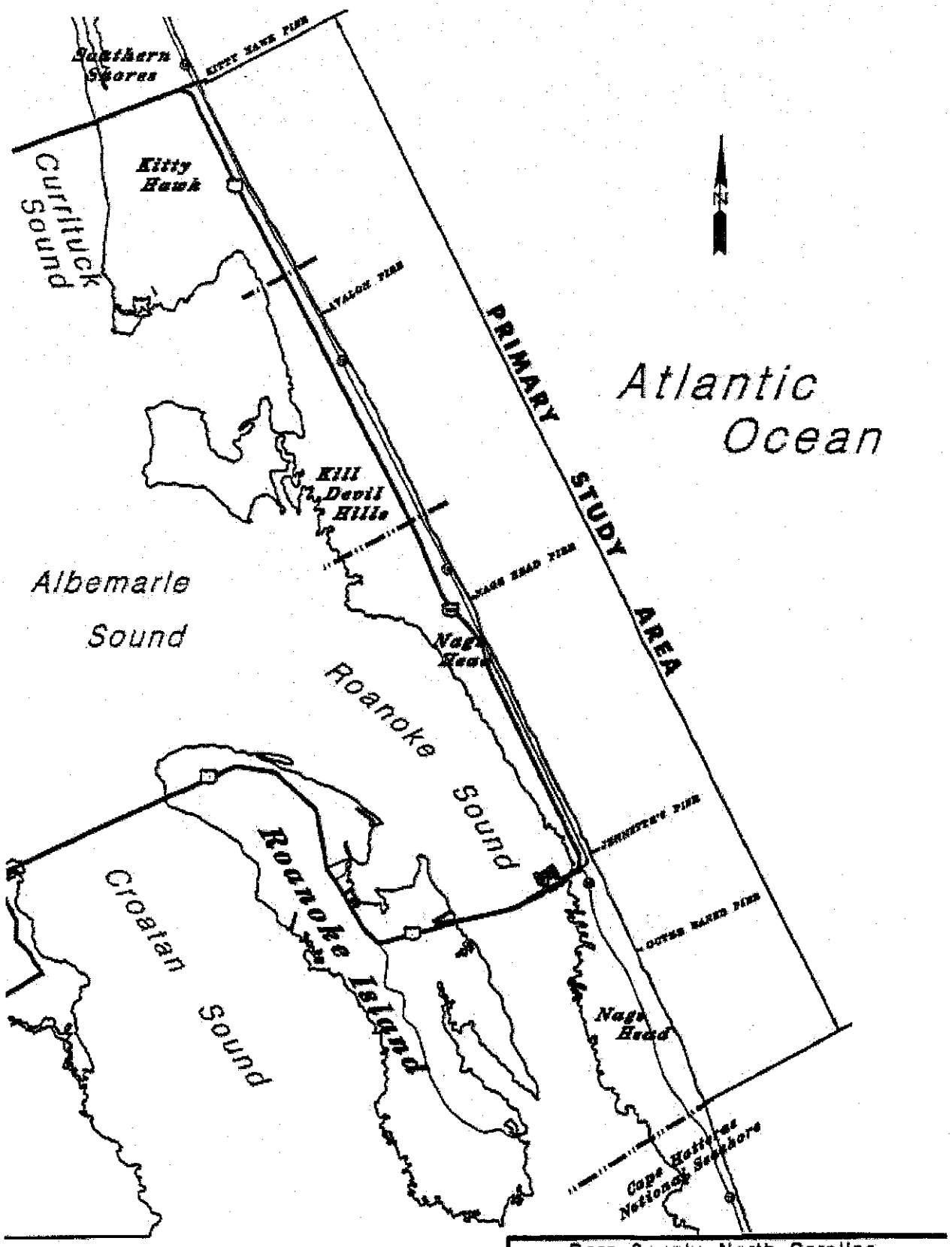


STATE OF NORTH CAROLINA
DEPARTMENT OF TRANSPORTATION

Other Transportation Projects in the Vicinity of FS-0701A

Improvements to NC 12 Kitty Hawk, Dare County

Figure 3



Dare County, North Carolina
Dare County Beaches

Hurricane Protection and Beach Erosion Control Study Area

Figure 4

APPENDIX

Table A1 - Sections

Phase 1 (White Avenue to Historic Street)			
		Distance	
Section	Limits	Feet	Miles
H	White Avenue to a point 1,060 feet North of White Avenue	1,060	0.20
I	A point 1,060 feet North of White Avenue to a point 2,060 feet North of White Avenue	1,000	0.19
J	A point 2,060 feet North of White Avenue to Kitty Hawk Road	510	0.10
K	Kitty Hawk Road to a point 1,000 feet North of Kitty Hawk Roac	1,000	0.19
L	A point 1,000 feet North of Kitty Hawk Road to Starfish Lane	1,240	0.23
M	Starfish Lane to Historic Street	1,250	0.24
	Total	**6,060**	**1.1**

Phase 2 (Wilkinson Street to White Avenue)			
		Distance	
Section	Limits	Feet	Miles
A	Wilkinson Street to Sea Village Street in Kitty Hawk	290	0.05
B	Sea Village Street to Helga Street	830	0.16
C	Helga Street to Arch Street	450	0.09
D	Arch Street to a point 600 feet North of White Avenue	600	0.11
E	A point 600 feet North of White Avenue to Sibbern Street	300	0.06
F	Sibbern Street to Tateway Road	900	0.17
G	Tateway Road to White Avenue	1,210	0.23
	Total	**4,580**	**0.9**

Phase 3 (Historic Street to Eckner Street)			
		Distance	
Section	Limits	Feet	Miles
N	Historic Street to East Balchen Street	1,310	0.25
O	East Balchen Street to Hawks Street	850	0.16
P	Hawks Street to Wilkins Street	870	0.16
Q	Wilkins Street to Bleriot Street	860	0.16
S	Bleriot Street to Eckner Street	840	0.16
	Total	**4,730**	**0.9**

Phase 4 (Eckner Street to Ocean Boulevard)			
		Distance	
Section	Limits	Feet	Miles
T	Eckner Street to Luke Street	810	0.15
U	Luke Street to Bennett Street	900	0.17
V	Bennett Street to Maynard Street	870	0.16
W	Maynard Street to Fonck Street	850	0.16
X	Fonck Street to Byrd Street	850	0.16
Y	Byrd Street to Ocean Boulevard	410	0.08
	Total	**4,690**	**0.9**

Table A2 - Construction and Righ

	Section	Distance (ft.)	Construction Costs		
			Sandbags	Protective Berms	Total
Phase 1	H	1,060	$950,000	$575,000	$1,525,000
	I	1,000	$900,000	$550,000	$1,450,000
	J	510	$475,000	$275,000	$750,000
	K	1,000	$900,000	$550,000	$1,450,000
	L	1,240	$2,500	$675,000	$677,500
	M	1,250	$1,150,000	$675,000	$1,825,000
Phase 2	A	290	$275,000	$175,000	$450,000
	B	830	$750,000	$450,000	$1,200,000
	C	450	$425,000	$250,000	$675,000
	D	600	$550,000	$325,000	$875,000
	E	300	$300,000	$175,000	$475,000
	F	900	$800,000	$500,000	$1,300,000
	G	1,210	$1,100,000	$650,000	$1,750,000
Phase 3	N	1,310	$1,250,000	$700,000	$1,950,000
	O	850	$800,000	$475,000	$1,275,000
	P	870	$800,000	$475,000	$1,275,000
	Q	860	$800,000	$475,000	$1,275,000
	S	840	$800,000	$450,000	$1,250,000
Phase 4	T	810	$750,000	$450,000	$1,200,000
	U	900	$850,000	$500,000	$1,350,000
	V	870	$825,000	$475,000	$1,300,000
	W	850	$800,000	$475,000	$1,275,000
	X	850	$800,000	$475,000	$1,275,000
	Y	410	$400,000	$225,000	$625,000
		Totals	$17,452,500	$11,000,000	$28,453,000

TABLE A7 - PROTECTIVE BERM CONSTRUCTION COST AND FACTOR

CONSTRUCTION	LENGTH (MILES)	TRUCK HAULING MAINLAND BORROW SOURCE		
		CONSTRUCTION	COST FACTOR	CONSTI
Small Quantity Construction (1,000 foot sections)	0.19	$10,800,000	0.982	$51,6
Large Quantity Construction (entire project)	3.80	$8,100,000	0.736	$9,5

Note: Construction cost factors for small and large quantity construction were calculated by the Project Services Unit, NCDOT

TABLE A8 - ADDITIONAL PROTECTIVE BERM CONSTRUCTION ALTERNATIVES - CO

CONSTRUCTED PHASES	LENGTH (MILES)	TRUCK HAULING MAINLAND BORROW SOURCE		
		CONSTRUCTION	COST FACTOR	CONST
Phase 1 (White Avenue to Historic Street)	1.10	$3,000,000	0.920	$12,
Phase 2 (Wilkinson Street to White Avenue)	0.90	$2,400,000	0.934	$9,9
Phase 3 (Historic Street to Eckner Street)	0.90	$2,400,000	0.934	$10,
Phase 4 (Eckner Street to Ocean Boulevard)	0.90	$2,400,000	0.934	$10,
Phase 1 and 2	2.00	$5,000,000	0.859	$16,
Phase 1 and 3	2.00	$5,000,000	0.859	$16,
Phase 1, 2, and 3	2.90	$6,700,000	0.798	$15,
Phase 3 and 4	1.80	$4,500,000	0.872	$15,
Phase 1, 3, and 4	2.90	$6,800,000	0.798	$15,
Phase 1, 2, 3, and 4	3.80	$8,100,000	0.736	$9,5

Note: Intermediate cost factors were calculated by interpolating between the factors given in Table A3 for each borrow method / source.

TABLE A9 - SUMMARY OF ADDITIONAL PHASE CONSTRUCTIO

CONSTRUCTED PHASES	RELOCATIONS	RIGHT OF WAY COSTS	CONSTRU	
			TRUCK HAULING MAINLAND BORROW SOURCE	PIPELINE OFFSHOI SO
Phase 1 (White Avenue to Historic Street)	16	$21,000,000	$3,000,000	$12,
Phase 2 (Wilkinson Street to White Avenue)	21	$19,700,000	$2,400,000	$9,9
Phase 3 (Historic Street to Eckner Street)	46	$35,300,000	$2,400,000	$10,
Phase 4 (Eckner Street to Ocean Boulevard)	48	$37,200,000	$2,400,000	$10,
Phase 1 and 2	37	$40,700,000	$5,000,000	$16,
Phase 1 and 3	62	$56,300,000	$5,000,000	$16,
Phase 1, 2, and 3	83	$76,000,000	$6,700,000	$15,
Phase 3 and 4	94	$72,500,000	$4,500,000	$15
Phase 1, 3, and 4	110	$93,500,000	$6,800,000	$15
Phase 1, 2, 3, and 4	131	$113,200,000	$8,100,000	$9,