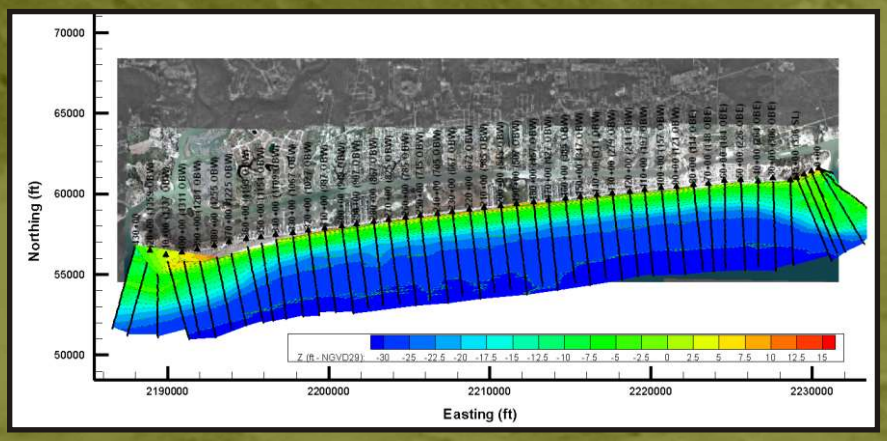
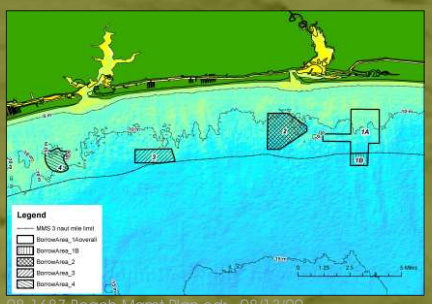
APPENDIX F

HOLDEN BEACH MASTER PLAN

Beach Management Planning
and
Borrow Area Investigation

Prepared For:
Town of Holden Beach, North Carolina





08-1687 Beach Mgmt Plan.cdr 08/13/09

August 2009

ATM
APPLIED TECHNOLOGY & MANAGEMENT

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1.0 INTRODUCTION

This study recommends future beach management planning for the Town of Holden Beach based on all available sand investigations proximal to Holden Beach. Existing permits (CAMA PN#14-02, USACE #200500935, DWQ #20011836) are scheduled to expire on December 31, 2009, the Town will be required to develop and apply for a new beach nourishment permit for any major beach nourishment work. Based on conversations with regulatory personnel, additional modifications of the existing permitting vehicle will be allowed; however in a limited capacity for emergency erosional events only.

While the Town's previous shoreline management initiatives have been successful, most of the island's beachfront is still eroding and will continue to do so. Implementation of the beach management planning proposed herein will help the Town sustain a healthy shoreline which is more stable, provides storm protection, supports recreational use and enhances property values.

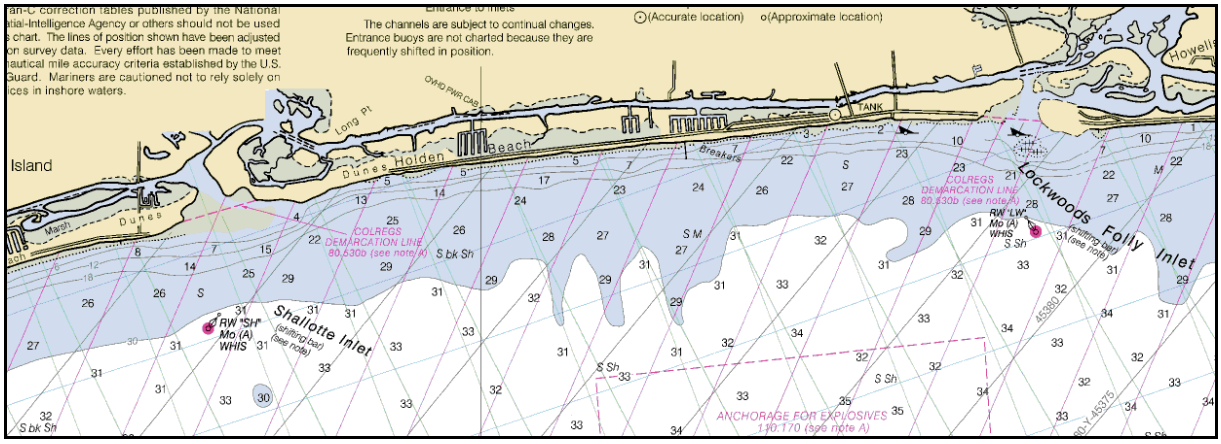

Photo 1-1. Project Location Map of Holden Beach, NC (NOAA Chart 11536)

The Town's updated beach management plan considers the changes which have occurred to the Holden Beach shoreline over the last decade as well as changes in policy that have been adopted by USACE and NCDENR during the course of the existing permit. These changes will impact borrow area sediment compatibility and monitoring requirements. In the past, a new permit typically required the development of either an Environmental Assessment (EA) or an Environmental Impact Statement (EIS). An EA is the preferred option because it involves significantly less work and time

compared to an EIS. However, regulatory personnel have recently begun attempting to streamline typical beach nourishment permitting, and this has been a major issue for the NC Beach and Inlet Management Plan (BIMP) development team. This study takes these recent and proposed policy changes into account and strives to develop the most cost effective beach maintenance plan for the Town of Holden Beach.

2.0 PROJECT HISTORY

The Town of Holden Beach has been proactive in monitoring and maintaining their shoreline, particularly those sections nearest to Lockwood Folly Inlet where erosion rates are the highest. Since 2002, the Town has conducted six relatively small beach nourishment projects utilizing upland borrow sources. The first project was constructed in spring 2002 to extend the USACE Section 933 Project which was part of the Wilmington Harbor Deepening (February 2002). Most recently the Town placed 190,000 cy along ~10,000 linear feet of shoreline in spring 2009.

Table 2-1. Summary of Holden Beach Nourishment Projects since 2001

Date	Primary Sponsor	Beach Stations Nourished	Approximate Volume of Material Placed (cy)	Nourishment Material Source
12/01 – 2/02	USACE	87+00 – 192+00	525,000	Wilmington Harbor Deepening Project
3/7/02 – 4/30/02	Town of Holden Beach (Phase I)	66+00 - 90+00, 175+00 – 217+00	141,800	Oyster Harbor upland site
3/02-4/02	USACE	20+00 – 30+00[1]	32,000	AIWW Maintenance Dredging
Winter 2002-2003	Town of Holden Beach	90+00 – 175+00	30,000	Boyd Street Disposal Area
9/04 – 11/04	USACE	15+00 – 40+00	113,230	Lockwood's Folly Inlet AIWW
12/03 – 4/04	Town of Holden Beach (Phase II)	46+00 – 68+00 and 215+00 – 238+00	123,000	Smith borrow site
5/5/06 – 5/24/06	USACE	15+00 – 40+00	62,853	Lockwood's Folly Inlet AIWW
Spring 2006	Town of Holden Beach	Eastern Reach	42,000	Smith borrow site
Spring 2006	Town of Holden Beach	Western Reach	3,200	Smith borrow site
1/08 – 3/08	Town of Holden Beach	60+00 – 95+00, 245+00 – 270+00	201,000	Smith borrow site
12/08-2/09	USACE	20+00 – 55+00	100,000	Lockwood's Folly Inlet AIWW
3/09-4/09	Town of Holden Beach	55+00 - 110+00, 210+00 - 255+00	190,000	Smith borrow site
		Approximate Total Volume since 2001	1,564,083	

Notes: 1) Lockwood's Folly Inlet Hazard Area

The Town-sponsored projects have *cumulatively* placed 730,900 cy of sandy material on the beach, most of which has been east of station 110+00. Figure 2-1 presents a figure with stationing and approximate placement locations. This represents an annualized rate of 104,400 cubic yards per year (cy/yr) [see Table 2-1 for details].

Besides the Wilmington Harbor deepening, Lockwoods Folly Inlet and certain sections of the Atlantic Intracoastal Waterway (AIWW) have provided sediment for USACE projects. Lockwoods Folly Inlet is a federally authorized navigation channel maintained by the USACE. Channel dredging is accomplished via pipeline, split-hull, or sidecast methods. Based on available information, it is estimated that approximately 40,000 cy/yr of Lockwoods Folly inlet dredged material is placed on the east end of Holden Beach. The remainder is either placed on Long Beach or sidecast.

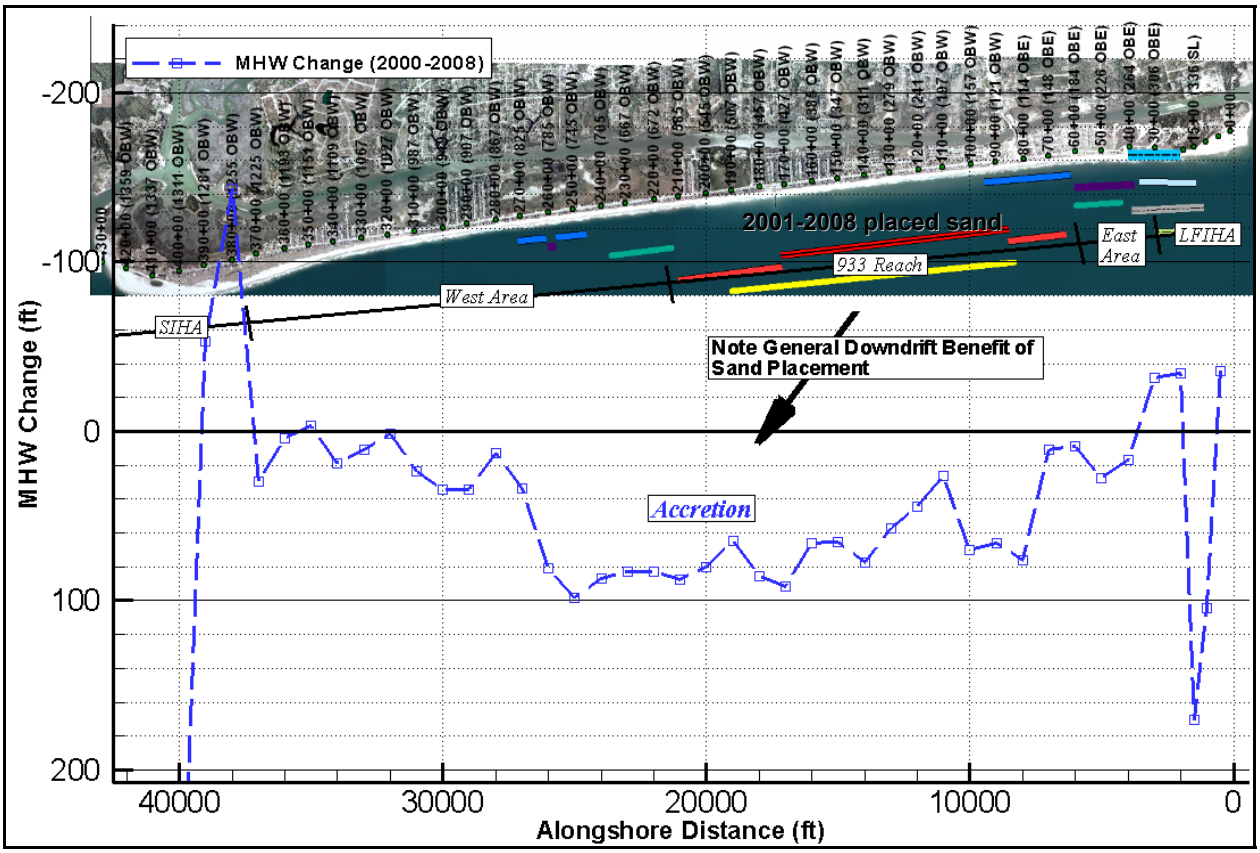

Photo 2-1: Holden Beach MHW change from 2000 to 2008. Note general western drift. For more detail on nourishment events, see Figure 2-1 on the following page.

In total, federal projects since 2001 have placed ~ 833,000 cy on Holden Beach. The total quantity placed since 2001 is ~1.56M cy, or an annualized average of ~195,000 cy/yr. Photo 2-1 presents the placement locations in relation to shoreline growth since 2001. Note the general downdrift benefits from placement on the eastern sections of shoreline.

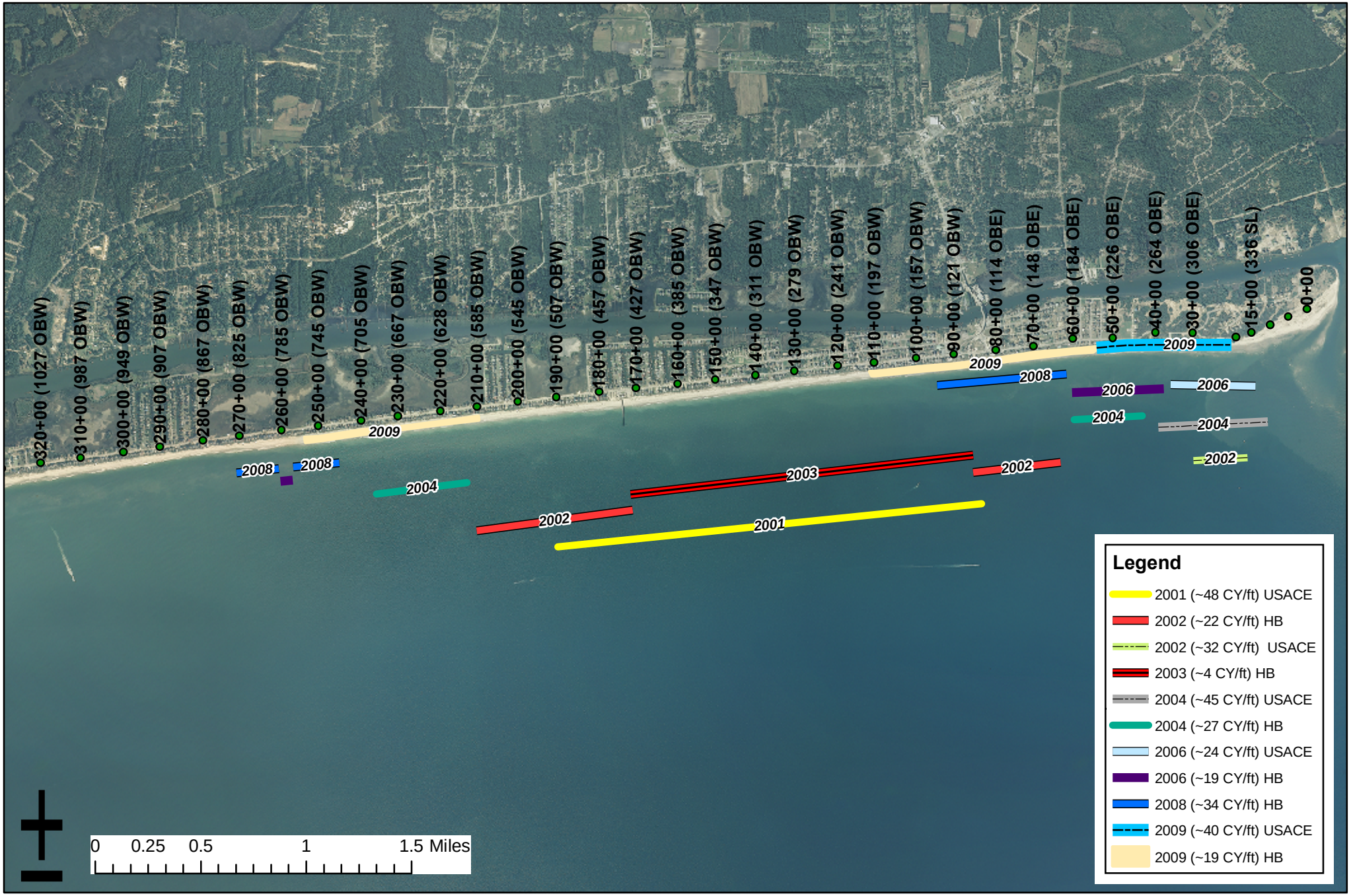

Figure 2-1:
Holden Beach Nourishment Activity Since 2001
(HB=Holden Beach)

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3.0 PROJECT NEED

The primary cause of shoreline retreat along Holden Beach is due to long-term erosion through natural processes of littoral sediment transport, storm related recession and rise in sea level. Tidal currents, wave focusing and storage of sediment in the ebb and flood shoals of surrounding inlets (Shallotte and Lockwoods Folly) have also considerably affected the shoreline history of Holden Beach. Along the eastern end of the island, erosion has been prominent due to the continual shifting and reorientation of the main ebb and flood channel(s) of Lockwoods Folly Inlet. The result has been a starvation of sand along the eastern portion of the island which has caused an "erosional wave" propagating west. Net transport has been estimated to be ~ 228,000 cy/yr to the west (Thompson, 1999).

As described in Section 2 above, the Town has been proactive in monitoring and maintaining their shoreline since 2001. Figures 3-1 and 3-2 present a comparison of the 2008 and 1993 shorelines where the benefits of the Town's management activities can be seen. The Town has funded six truck haul beach nourishment projects ranging in volume from 30,000 to ~200,000 cy, placing unit volumes of 3.5 cy/ft to 35 cy/ft. The recent projects have allowed the Town to keep pace with erosion in many areas (except for the eastern end). However, the process of placing additional sand must continue into the future to ensure the recreational and storm damage protection benefits of a wider sandy beach.

For some time now there has been a growing demand from the residents of Holden Beach, as well as in neighboring Supply, NC, for the Town to abandon truck haul projects and pursue alternate and/or offshore borrow sites. The Town has not been fully satisfied with upland borrow sources for the following reasons:

- Sediment quality from upland sources:
    - Grain size: smaller mean grain size and larger percent fines affects project performance and life cycle
    - Sediment Color: orange/red sediment content negatively impacts shoreline aesthetics and potential negative environmental impacts
- Slow production rates limit the scale of the nourishment projects

- Limitations on seaward placement/extent of fill
- Small scale projects typically not as cost effective or an efficient use of fill material
- Repeated small scale projects may exacerbate environmental impacts
- Frequent upland projects negatively impact traffic, roads, and tourism

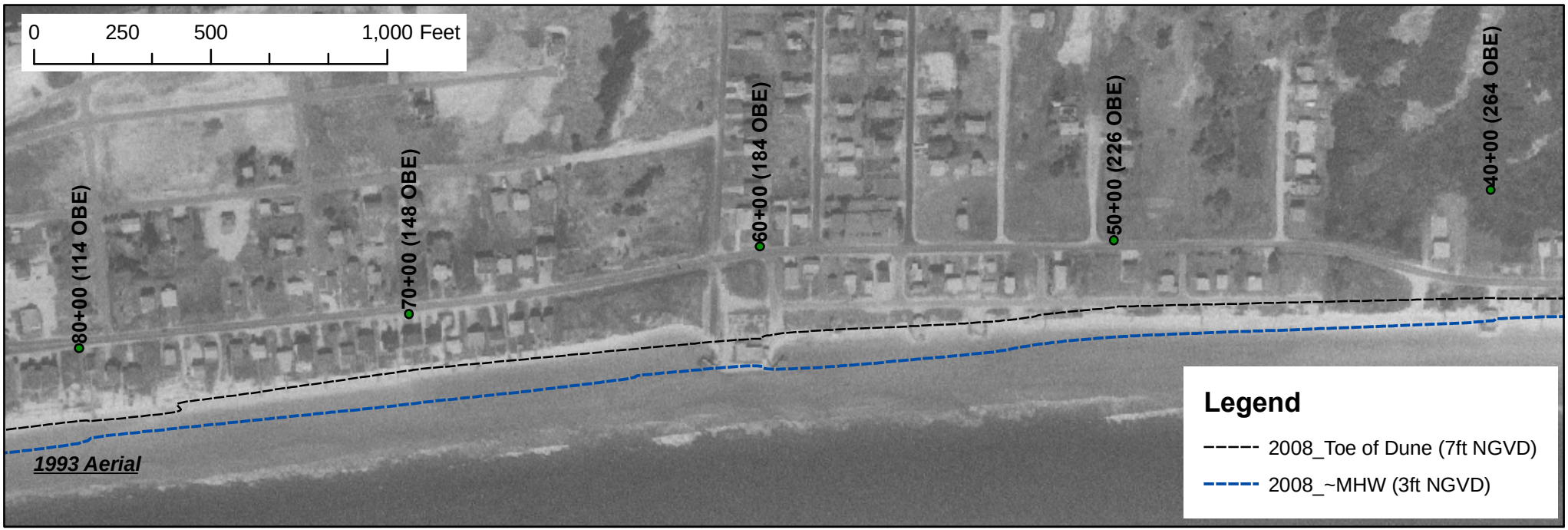

Figure 3-1
1993 and 2008 Aerial Comparison - East End

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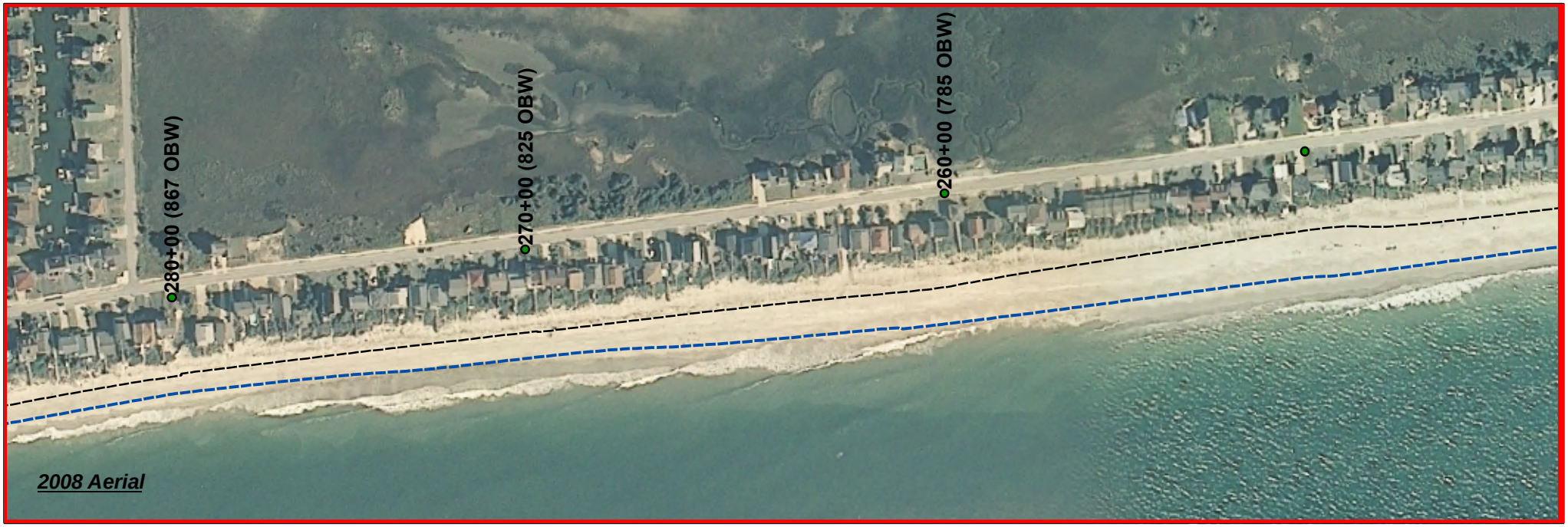

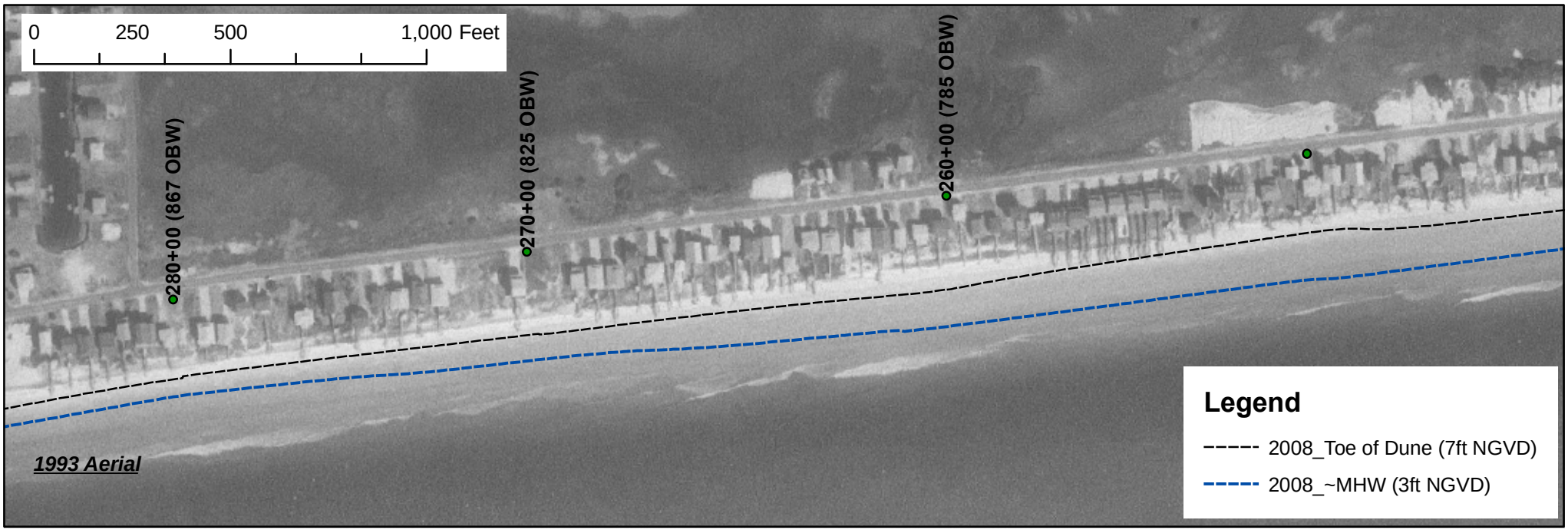

Figure 3-2
1993 and 2008 Aerial Comparison - West End

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4.0 EXISTING PERMIT

Since 2002, Holden Beach has performed beach nourishment activities under CAMA Permit No. 14-02, NCDWQ Permit No. 20011836, and USACE Permits No. 200101101 No. 200500935. The Town most recently modified its existing permits in early 2009 in order to allow a FEMA sponsored nourishment to mitigate for Tropical Storm Hanna damages (See Photo 4-1). The existing permits expire on December 31, 2009.

An additional modification request to extend this permit expiration date has been recommended by both CAMA and USACE regulatory staff. This would allow Holden Beach to have an active permit for emergency use associated with storm events. Volumes associated with these emergency activities are typically less than 100,000 cy (although the 2009 FEMA permit mod was 190,000 cy). Note that once an emergency nourishment is required, additional modifications to the permit pertaining to volume, placement, and possibly borrow sources would be necessary. The Turkey Trap Road and Smith Borrow sites are currently authorized sand sources in the existing permits.

Photo 4-1: 2009 Holden Beach Nourishment Reaches

5.0 CORPS PLANS

The USACE has developed a nourishment schedule where, currently, it is anticipated that Holden Beach will receive approximately 250,000 cy per year in sediment (USACE-CHL, 2008) (See table 5-1). Sediment sources currently consist of Lockwood Folly Inlet and either Jaybird Shoals or Frying Pan shoals.

Table 5-1. USACE Alternatives Analysis (Alt 8 is preferred alternative)

	Holden Beach		Lockwood Folly			
Alts	48 yr total (cy)	Annual (cy/yr)	48 yr total (yr)	Annual (cy/yr)	Notes	Results
Alt 0	-	-	-	-	No action	Severe Erosion
Alt 1	18,624,000	388,000	28,256,000	588,667	49.7 mcy total from LF, Shallotte, Tubbs	downdrift erosion of LF, LF depleted
Alt 2	18,624,000	388,000	24,296,000	506,167	49.7 mcy total, 8.7 mcy from SMP	ebb shoals depleted
Alt 3	8,000,000	166,667	6,000,000	125,000	20.7 mcy total, 8.7 mcy from SMP	ebb shoals recover almost fully
Alt 4	9,000,000	187,500	6,000,000	125,000	same total as 3, but diff placements	
Alt 5	21,831,017	454,813	24,296,000	506,167	similar to Alt 2	ebb shoals depleted
Alt 6	12,207,017	254,313	6,000,000	125,000	same as Alt 4, except initial 3.2 mcy fill	
Alt 7	9,000,000	187,500	7,500,000	156,250	more economical placement (LF goes to HB)	LF and Shallotte dredged 3mcy more because Holden doesn't get 1st SMP nourishment
Alt 8	12,207,017	254,313	7,500,000	156,250	more economical placement (LF goes to HB)	LF must be dredged on a 4-yr cycle (same with Alt7)
Alt 9	6,000,000	125,000	6,000,000	125,000	same as Alt 7-8, except 3mcy less sand	not as ideal
Alt 10	9,207,017	191,813	7,500,000	156,250	same as Alt 7-8, except 3mcy less sand	not as ideal

Notes: Alts 1, 2, & 5 place significantly more sand. All other alts referred to as 'sand-limited options'.
SMP=sand management plan (Jay Bird or Frying Pan Shoal)

It is estimated that 250,000 cy/yr annualized will satisfy Holden Beach sediment deficit requirements; however, USACE beach nourishments are unfortunately susceptible to future budget constraints and variations that can significantly delay or even cancel project execution.

Therefore, despite the outcome of the USACE General Reevaluation Report (GRR) and other USACE and State nourishment studies, it is recommended that the Town continue with its own beach management plan and coordinate closely with federal and state activities. Data collection to support the GRR project permitting began this summer (2009) however; it is estimated that beach placement activities are still several years out.

As seen from Table 5-1, Holden Beach is planned to receive ~254,000 cy of material per year with ~156,000 cy coming from Lockwood Folly. Lockwood Folly is scheduled to be dredged every 4 years; therefore nourishments of approximately 625,000 cy are planned to occur. This represents a significant amount of sand in relation to previous projects and is likely sufficient to maintain the Holden Beach shoreline under typical wave conditions. Conversely, excavating 625,000 cy from Lockwood Folly ebb shoals may be difficult to permit and impacts to nearby shorelines could potentially be significant. Note that Lockwood Folly dredging is not solely devoted to Holden Beach nourishment under all alternatives.

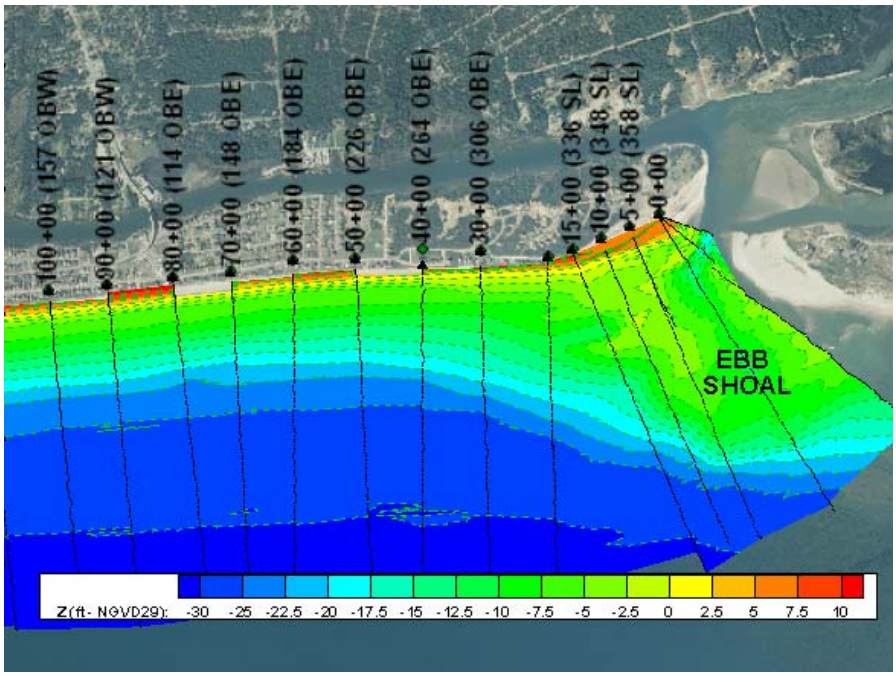

Photo 5-1: Lockwood Folly ebb shoal region. Color contours represent October 2008 beach survey.

6.0 COUNTY ACTIVITIES

Lockwood Folly Aquatic Restoration NOAA grant was submitted in July 2009 and is primarily sponsored by Brunswick County. Permitting has not begun and presumably will not until a decision to fund the grant occurs. The project was originally planned for this winter (2009/2010 dredge window) however permitting can be lengthy and this project may not occur until the following winter. Approximately 90,000 cy of material is to be placed at approximately 30 cy/ft (similar to recent Town project widths). See Photo 6-1 for the preliminary fill template, which overlaps with the Town's latest project in 2009.

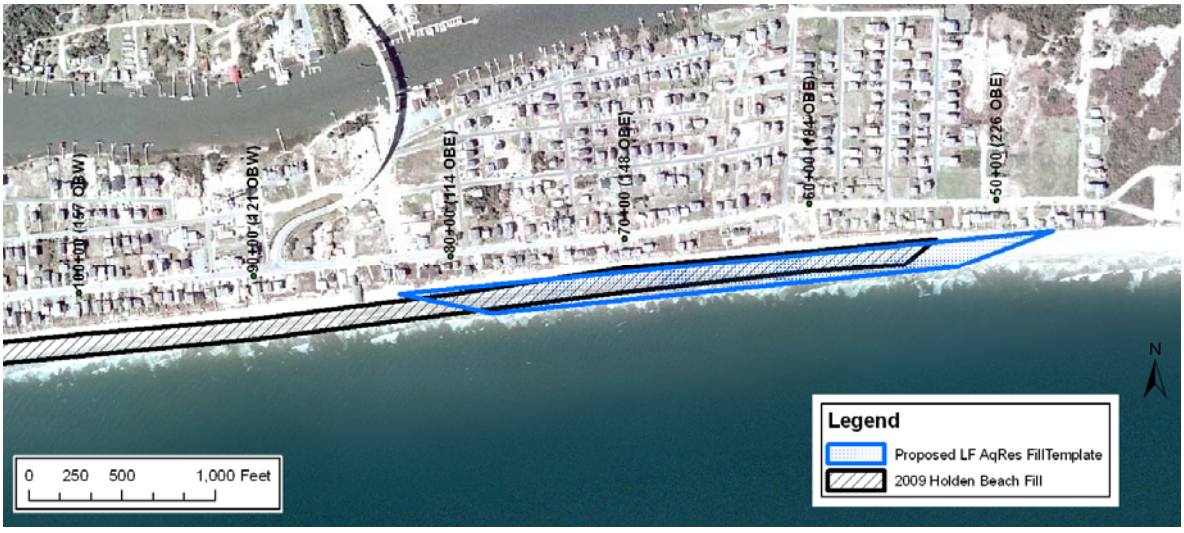

Photo 6-1. Currently proposed fill template using sand from the LF Aquatic Restoration Study. Note overlap with 2009 HB project.

7.0 NEW PERMIT

7.1 BEACH NOURISHMENT VOLUMES AND PLACEMENT

One of the primary goals of this study is to have no net reduction in sand volume from Holden Beach. Additional needs to increase storm protection, increase recreational beach area or address hot spots may also be required.

As of October 2008 (i.e., the last island-wide survey), the eastern half of Holden Beach (Station 30+00 to Station 200+00), excluding the inlet hazard area, remained at a 140,000 cy deficit relative to the post USACE 933 Project survey (June 2002), despite the Town adding nearly 500,000 cy of sediment in periodic small scale nourishment projects during that timeframe.

The October 2008 survey was performed one month after Tropical Storm Hanna, which was calculated to have eroded approximately 190,000 cy of material from Station 30+00 to 272+00, which represents all sections of beach where Town-sponsored nourishment has occurred.

In general terms, the USACE 933 project advanced the shoreline while all activities since then have been effective at maintaining the shoreline. Therefore based on recent nourishment activities, a range of 125,000 to 250,000 cy/yr is estimated to be needed, under normal wave activity. As previously mentioned, the USACE has recently proposed approximately 250,000 cy/yr, given on-time scheduling and adequate funding.

In terms of Holden Beach permitting volumes and placement, the new permit is recommended to include Stations 30+00 to 300+00, which represents the majority of the shoreline (approximately 5.3 miles) with an average placed volume of 50 cy/ft (similar to the USACE 933 project). This equates to a volume of 1.4 million cubic yards, which would be broken down into manageable phases of work, similar to the original 2001 permitting effort. Note that some research has recommend fill volumes greater than 70 cy/ft because these were found to provide a greater than 70% retention of fill after one year based on review of several projects (Stauble and Hoel, 1986).

Also note that some of the localized erosion rates are beyond the ability to address with fill placement alone. Typically loses greater than 10 ft/year cannot be effectively addressed with fill alone, which is the case adjacent to Lockwood Folly Inlet. In a recent N.C. Coastal Resources Commission (CRC) meeting in February, Dr. William Cleary identified both Lockwood Folly and Shallotte Inlets as good candidates for terminal groins.

7.2 UPDATED PERMITTING REGULATIONS

The new permitting effort for a major beach nourishment activity will likely require an environmental assessment (EA) or environmental impact statement (EIS), depending on the borrow site and the volumes proposed. Holden Beach developed an EA for the 2001 permitting and has since been working off this document via CAMA permit modifications. Because of the significant differences in time and cost in EA versus EIS development, permitting coordination has already begun in order to optimize this process. Nonetheless, several new NCDENR policy changes will affect all nourishment permitting and these include new sediment criteria and a new static vegetation line policy

7.2.1 NEW SEDIMENT CRITERIA

New sediment criteria will increase monitoring efforts and costs; although it would not represent a large increase compared to the current data collection and monitoring programs (as established by the Holden Beach 2001 permitting effort). One significant change is that sand sample collection and analysis is required out to a 20 ft depth, which necessitates a boat as well as increased laboratory analysis. Current sand sample collection only occurs at MLW, MSL, MHW, and at the toe-of-dune. Percent fines, percent shell, and grain size criteria have been increased slightly, however previous Holden Beach nourishment sediment would have satisfied these criteria.

7.2.2 STATIC VEGETATION LINE

Holden Beach has no static vegetation line. The USACE 933 project in 2001 intentionally placed just under 50 cy/ft to avoid the static vegetation line trigger. All subsequent USACE and Holden Beach fills were also small enough to avoid this trigger (i.e., less than 200,000 cy). A recent change to NCDENR policy has eliminated the 50 cy/ft criteria and have increased the volume trigger to beach fills greater than 300,000 cy (i.e., ‘large project’). Therefore the next beach fill that is greater than 300,000 cy, either

by the USACE or by the Town, will trigger the establishment of a static vegetation line. Holden Beach setbacks are presented in Photo 7-1. Note that western end of the island is the minimum 60-ft and not completely shown

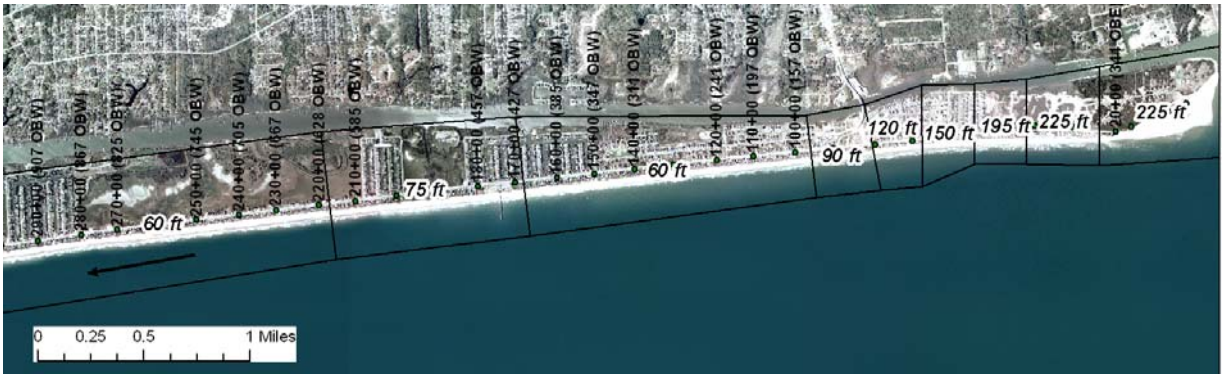

Photo 7-1. 2004 CAMA Setback Zones on Holden Beach.

It is important to note that new rules allow for communities to petition the CRC for a static line exception after 5 years have elapsed since nourishment project construction. The petitioner must develop a 30- year nourishment plan that; (1) identifies the appropriate sand resources for the life of the plan, and (2) identifies realistic monetary resources for the plan. If the static line exception is granted, the oceanfront properties along the community can revert to using the existing vegetation line criteria (which is on a lot-by-lot basis).

This updated policy essentially encourages long-term beach maintenance activities that provide storm mitigation while also allowing for the replacement of older, non-conforming structures with newer, conforming structures.

The future USACE GRR beach fill placements, to occur over the next 50 years, are currently planned as the static vegetation line exception vehicle for several communities, including Carolina Beach and Wrightsville Beach (NCDENR's Jeff Warren, personal communication). Therefore several precedents will likely be established prior to Holden Beach static vegetation line issues. Of course any project-established static vegetation line will be in effect for 5 years at a minimum, before the exception is granted.

In summary, USACE Holden Beach activities are recommended to be used for static line exception in order to reduce costs to Holden Beach. Note that this study has identified up to 25 years worth of sand and more discussion on potential available volumes are discussed in the following Section. Also, the Town does have the necessary funding in place (i.e. the BPART fund); however additional sediment criteria related testing would be immediately required for all 25 years worth of sand.

8.0 POTENTIAL BORROW SITES

Several borrow sources were considered for this study and these generally include: upland, inlet/AIWW dredged disposal areas, offshore, and Lockwood Folly Inlet. All borrow sites were evaluated for sediment quality and quantity as well as permitting and logistical requirements. Figure 8-1 presents a location map showing investigated upland and inlet borrow areas.

8.1 UPLAND BORROW SITES

Given the more stringent constraints on borrow source compatibility (introduced in 2008 and 2009), it is anticipated that permitting the use of upland borrow areas will be more difficult; however, natural resources permitting and post-project monitoring are typically less rigorous when compared to offshore or inlet borrow sources. Many of the reviewing agencies involved in beach nourishment permitting, such as the USFWS and NMFS, are more focused on ocean resources; therefore, upland permitting can be more expedient. Additionally, truck haul projects do not involve the expensive mobilization/demobilization costs associated with dredges and can occur much more quickly.

Of course, sand color, smaller volumes, grain size, and placement methods (i.e. trucking) are potential downsides to this alternative. Additionally, the N.C. Department of Transportation requires permitting and has the ability to shut down operations or require roadway mitigation. Nonetheless, upland borrow sites can be extremely valuable for unplanned/emergency mitigation efforts, such as the 2009 Holden Beach project.

As such, the Town became aware of several new potential upland borrow areas during the 2009 nourishment bid process and further investigation of these sites was performed.

8.1.1 TURKEY TRAP ROAD (PERMITTED)

The Turkey Trap Road Borrow Site is located near the intersection of Turkey Trap Road and Stanbury Road, and is an approximate 3.6 mile drive to the beach strand. The majority of the 38 acre site is medium to densely covered with trees and other vegetation. In early 2005 ATM contracted with Engineering Consulting Services, Inc.

(ECS) to collect 10 soil borings from within the site. The borings were driven to a depth of approximately 35-40 ft below grade. From these 10 borings, 40 composite samples were created and analyzed by ECS according to standard grain size analysis methods.

The soil borings revealed clay lenses throughout the borrow site, varying in thickness between 2 ft and 8 ft, with the larger thicknesses found in the southwest area. Towards the northeast end, clay lenses were less substantial and mean sediment grain sizes generally increased. The sediment is described as light grey, fine to medium sand toward the northeast portion of the borrow site and brownish grey, fine to medium sand and clayey sand toward the southwest. The composite median and mean grain sizes for the borrow site are 0.23 mm and 0.28 mm respectively and the average percent fines (percent of material passing the #200 sieve) is 9.4%.

The Turkey Trap Road Borrow soil is stratified and will require significant sidecasting and sorting of material to extract the best quality for the beach. Additionally, the presence of wetlands will complicate the excavation process. At best, the Turkey Trap Rd Borrow site is only expected to yield ~ 460,000 cy of material. Note that this yield is substantially less than the original 800,000 cy estimate because of increased wetland buffers. Figure 8-2 shows the Turkey Trap Road borrow area (also known as the Kirby Walter site in previous permitting documents). The site has the necessary permits (i.e., NCDENR, USACE, Brunswick County) however an NCDOT driveway permit is still needed and preliminary discussions have indicated that NCDOT may require some roadway upgrades. These upgrades have been estimated at $375,000 by Criser Troutman Tanner Engineering; which will add significantly to the cost of using this borrow area.

8.1.2 SMITH BORROW SITE (PERMITTED)

The Smith site has been tested previously and used in previous years for beach nourishment. The material quality varies depending on location within the property, but has in general been found to be acceptable. The Smith site is an approximate 4.0 mile haul distance from the beach strand. The volume remaining within the Smith site that is of beach quality is currently unknown as additional borings would be required prior to further use of this site. There are some limitations to the Smith site, due to the Owner's development plans that dictate which areas are possible for excavation (and may not

correspond to the best quality sands). The site has also been for sale for residential development and therefore may not be available for future use. For planning purposes, this site cannot be relied upon as a future source, however potentially 200,000 cy of beach compatible material could be obtained under best-case-scenario conditions. Figure 8-3 presents the Smith borrow area.

8.1.3 TRIPP UPLAND SITE

Limited boring information as well as test pit observations indicates that the Tripp site contains potentially a large quantity of light colored beach quality sand. The Tripp site is an approximate 64 acre parcel located off Makatoka Rd in Supply, NC. The site is located west of HWY 17N and is approximately a 13 mile drive from the beach strand. Additional borings are recommended and would likely be required for permitting. Figure 8-4 presents the Tripp site. In comparison to the existing permitted borrow sites; borings indicate that this represents the best upland material in terms of color and grain size. A large pond has been excavated at this site previously and is approximately 55 ft deep, therefore a relatively large amount of material may be available. The site also has an existing mining permit (similar to the existing permitted borrow areas).

Photo 8-1: Tripp Site Test Pit

According to the existing mining permit, approximately 8 acres of land has been designated wetland while the existing lake is also approximately 8 acres. Some areas of clay were also identified during test pit excavation. For estimated sand volumes, it was assumed that 25 acres was available (based on borings, test pits, existing wetland delineation, and USDA soil maps). Assuming a 30 foot cut-depth, this equates to 1.2 million cy available. Section 8.5 summarizes potential volumes available for all alternatives. Also note that the Tripp site is also under consideration for sale and a potential buyer contacted ATM about its use as a borrow area.

8.1.4 OTHER UPLAND SITES

Several other sites were proposed by contractors during the 2009 bidding process; however none were estimated to contain sufficient volumes of beach compatible material without excessive sidecasting and separation of unsuitable material. Color and percent fines were also generally marginal. Future publicized announcements for potential borrow areas are recommended if additional upland sand resources are required.

8.1.5 MONKS ISLAND

Monks Island is a currently inactive dredge spoil site located adjacent to the Atlantic Intracoastal Waterway, on the western end of Holden Beach. The island is long and narrow with roughly uniform topography. The western half of the island has been divided into 5 residential lots which are currently for sale. The eastern end is available for mining. The potential borrow area consists of about 10 acres of land up to an elevation of +20 ft NGVD (~mean sea level). Based on a site visit by ATM and Holden Beach personnel, the material contained within the existing dikes consists of fine to medium grained sand and may be suitable for placement on the beach. However, currently there are no available borings to quantify sediment quality and quantity.

Photo 8-2. Monks Island CDF

Also note that the USACE has recently surveyed this borrow area (new stakes were in place during the July 2009 site visit) and is evaluating it for further disposal. The USACE is also evaluating the possibility of building up the confining berm (which is currently about 30 feet above mean sea level) to increase capacity. According to USACE staff, the site consists of a layered mixture of beach compatible/non-compatible material and is constructed on a wetland base. Therefore its use as a borrow area for beach nourishment is questionable, however it cannot be ruled out. Figure 8-5 presents an image of this location.

8.1.6 SHEEP ISLAND

Sheep Island is a currently inactive dredge spoil site located adjacent to the Atlantic Intracoastal Waterway north of Long Beach (see Figure 8-6). Sheep Island is long and narrow; central portions of the island lie at elevations near or a few feet above sea level while topography peaks at either end where dikes have been constructed by the USACE to contain dredge spoil.

At the western end of the island, the spoil area covers approximately 4 acres and fill reaches a height of +20 ft NGVD. At the eastern end the spoil area covers approximately 28 acres and the fill reaches a height of +20 ft NGVD. Based on an ATM site visit in July 2009, the material contained within the dikes consists of fine to medium

grain sand and may be suitable for placement on the beach. However, currently there are no available borings to quantify sediment quality and quantity.

Photo 8-3: Sheep Island confined disposal facility (CDF)

Similar to Monks Island, Sheep Island was formed by sidecasting and pipelining dredged material onto wetlands decades ago (a practice which is no longer allowed). Therefore the base of Sheep Island consists of cohesive muddy sediment (i.e. wetland soil), while the material within the CDF consists of a layered mixture of compatible and non-compatible material.

As a result, its use as a borrow area for beach nourishment is questionable. Figure 8-6 presents an image of this location.

Also note that the USACE is also preparing this site for non-compatible dredged material disposal this winter (2009/2010) (see Photo 8-4).

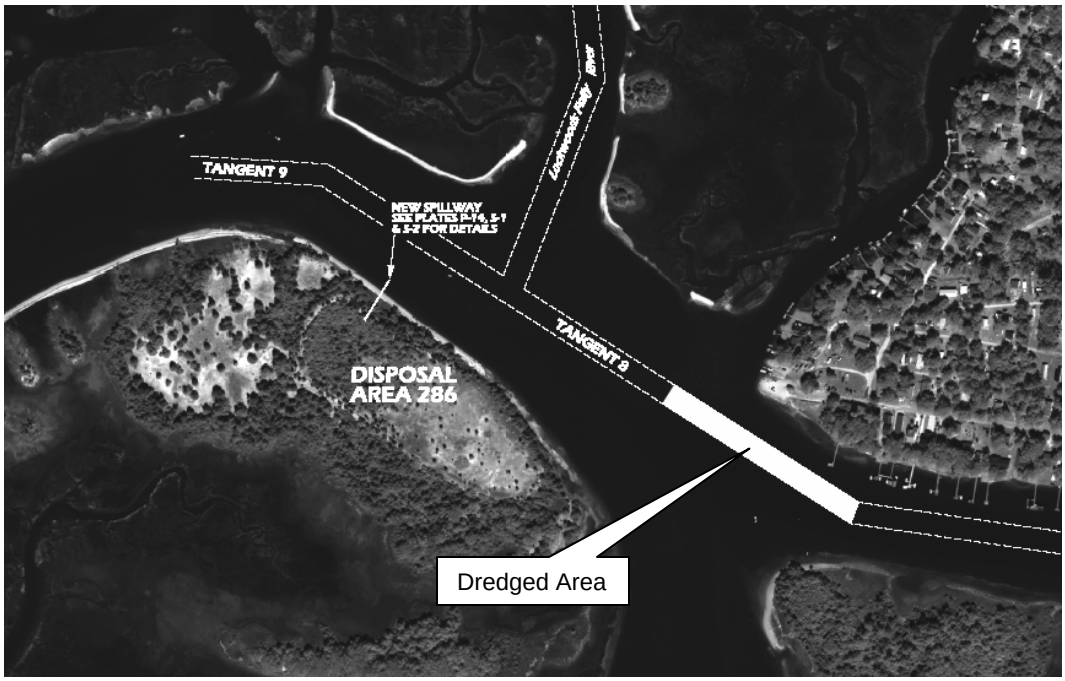

Photo 8-4: Sheep Island confined disposal facility (CDF) planned use for 40,000 cy of non-compatible beach material in 2009/2010.

According to USACE AIWW dredging plans, 40,000 cy of material will be disposed on Sheep Island this winter. Note that borings of the proposed dredge footprint show material quality just outside of acceptable limits (fines in the 10-15% range, when less than ~10% is required). Therefore this sand is suitable for dune reconstruction and could be suitable for beach placement with some processing.

8.2 LOCKWOODS FOLLY INLET

While inlets on the US east coast generally provide good quality sand (which comes from adjacent beaches over time), inlet borrow source permitting can be very costly and time consuming, typically requiring an EIS and extended agency review. Therefore, use of inlet ebb shoals must be approached with caution and fully evaluated. In contrast to permitting inlets as borrow areas, dredging for navigational purposes and placing dredged sand on nearby shorelines as a 'beneficial use' of dredged material is typically much less complex.

Lockwoods Folly Inlet contains a federally authorized navigation channel and the USACE performs routine maintenance dredging for navigation using pipeline (i.e.,

cutterhead), split-hull hopper and side-cast dredges. Unlike Shallotte Inlet, there is no defined dredge template and dredging activities are restricted to “deep water”. This restriction limits the ability for the USACE to perform advanced dredging; consequently, dredging within Lockwoods Folly Inlet itself generally occurs 2 - 3 times per year. Several shipwrecks also exist at this inlet that must be avoided. The shoaling rate has been estimated between 125,000 cy/yr (OCTI, 2008) and 140,000 cy/yr (Machemehl, et al., 1977). An additional concern of the “following deep water” dredging practice is that the channel is currently very close to the Holden Beach shoreline, which can exacerbate erosion. A more centrally located channel would provide more shoreline stability.

Borings collected within the inlet and inlet crossing indicate beach quality sediment layer thicknesses between 3 and 7 ft. The conceptual Lockwoods Folly Borrow Area covers approximately 22 acres (see Figure 8-7); assuming an average layer thickness of 3 ft it is estimated that this borrow area may yield up to 130,000 cy on an annual basis. Note that this would confine dredging to the navigation channel only and would occur under existing navigation-related permitting, which is a favorable option from a permitting perspective.

In addition to ocean-side inlet areas, the AIWW portion of Lockwood Folly Inlet has proven to be a valuable source of beach compatible material. Lockwood Folly Inlet was dredged in January 2009 by the USACE and approximately 100,000 cy of sand was placed on Holden Beach. The USACE is planning a similar project for the upcoming winter 2009/2010 dredging window; where 150,000 cy of material will be dredged from the AIWW and placed on the eastern reach of Holden Beach. Figure 8-8 presents both USACE projects. Note that 150,000 cy of dredged material in the channel equates to approximately 120,000 cy of material on the beach (due to dredging losses, in-situ water content, etc.).

The recent beneficial use of this dredged material by the USACE for beach placement is an effective inlet management plan and this is planned to occur in the future. If the USACE discontinues this practice, then it is recommended that Holden Beach become involved in Lockwood Folly Inlet management. Initial studies (USACE-CHL, 2008) have proposed to dredge approximately 625,000 cy of sandy material from the ebb shoal

(i.e. ocean-side) every 4 years; which may be difficult to permit and may result in impacts to nearby shorelines.

8.3 SHALLOTTE INLET

Shallotte Inlet maintenance dredging material has typically gone to Ocean Isle, which represents the downdrift shoreline. Shallotte inlet has a deeper authorized dredge depth to -15 feet NGVD and has a wider channel; therefore more material is generally available. Figure 8-9 presents this inlet. The Shallotte Inlet dredged area represents approximately 113 acres. In 2001, approximately 1.8 million cy was dredged from this inlet for beach nourishment. According to the 2008 USACE-CHL study, the preferred alternative includes dredging approximately 625,000 cy every 4 years from Shallotte, which is identical to proposed Lockwood Folly Inlet management.

8.4 OFFSHORE

Offshore borrow areas represent an attractive alternative because larger volumes can be placed at higher production rates with less equipment on the beach. Additionally, offshore borrow areas tend to have relatively large volumes of compatible sand which can sustain multiple nourishment cycles. However, USACE, USGS, and UNCW exploration offshore of Holden Beach (and most of northern Long Bay) has revealed little to no feasible sand sources for renourishment. Most of the offshore region has been characterized as hardbottom with a thin veneer of sand, with the exception of the extensive shoals at Cape Fear and Jay Bird Shoals. However, many of these research projects have been on a regional scale, and ATM coordinated with applicable agencies in order to develop a literature and data review specific to the needs of Holden Beach.

Over the past two decades the USACE, Wilmington District (SAW), has funded numerous geotechnical investigations in the offshore, inlets, Atlantic Intracoastal Waterway (AIWW) and historic dredge spoil sites of Brunswick County, NC. The coverage has primarily focused on the inlets (Tubbs, Shallotte, and Lockwoods Folly), offshore of the inlets, offshore of Ocean Isle Beach, offshore of Oak Island, Yellow Banks dredge spoil site, Jaybird Shoals, Lockwoods Folly River, and the Eastern Channel of Lockwoods Folly Inlet. Vibracore spacing varies dramatically between localities, ranging from 100 to more than 2,000 ft. The following is a list of known vibracore and boring datasets:

Table 8-1 Known Vibracore and Boring Datasets

Borrow Area	Year	No. Test Locations	Sampling Region
Brunswick County Beaches	1971	Not Provided	Offshore
Brunswick County Beaches	1971	Not Provided	Onshore
Ocean Isle	1994	65	Offshore
Tubbs Inlet	1994	17	Inlet
Brunswick County Beaches	1998	16	Offshore
Lockwoods Folly Inlet	1998	11	Inlet
Yellow Banks	1998	11	Upland Spoil Site
Jaybird Shoals	1998	21	Offshore
Shallotte Inlet	1998	13	Inlet
Yellow Banks	2001	27	Upland Spoil Site
Eastern Channel	2002	15	Lockwoods Folly Inlet
Lockwoods Folly Inlet	2002	28	Inlet
Lockwoods Folly River	2002	10	River
Brunswick County Beaches	2002	20	Offshore
Brunswick County Beaches	2003	92	Offshore
Cleary Borrow Area	2004	23	Offshore
TED	2004	6	Offshore
Ocean Isle	2005	13	Offshore

Subsurface investigations have also been performed. Under contract with the SAW, C&C Technologies performed geophysical sub-bottom profiling and mapping offshore of Ocean Isle in 1999 and of Holden Beach and Oak Island in 2003. The 1999 study focused on the 1.0 to 3.5 mile range offshore of Ocean Isle, while the 2003 study focused on the 2.5 to 6.0 mile range offshore of Holden Beach and Oak Island. It is noted that beyond the 3 nautical mile limit (~3.5 statute miles), borrowing of soils falls under the additional jurisdiction of the Minerals Management Service (MMS).

The offshore mapping by C&C Technologies consisted of single beam soundings to identify areas that may contain significant surface sediment layers and to delineate such areas as potential sediment sources. Various surface bottom types were mapped: Top of Rock, Reworked Sands and Channels. The investigators identified a large region offshore of Lockwoods Folly Inlet and Oak Island, containing lenses of reworked sands overlain on relic flood plain channels, as a “suggested sediment borrow area” (See Figure 8-10). The authors estimated upwards of 90 million cy of sediments existing in these historic offshore channels overlain by roughly 60 million cy of “reworked sediments”, which are largely remnants of retreating beaches, barrier islands and spits.

In viewing vibracore results for this area, the material generally contains higher fines (>12%) and therefore is not beach compatible according to sediment criteria.

Based on review of all the available offshore vibracores (as well as seismic and sidescan data), ATM has delineated several potential regions of interest (see Figure 8-11). Within these, several areas are recommended for further investigation and are discussed below. There are only a few areas that have lenses of beach quality sediment that exceed 4-5 ft thickness. However, there are areas offshore that could be potential borrow sources if the proper equipment is used.

Little River Borrow Area

An example of such a project is the recent North Myrtle Beach nourishment project, where offshore sediments were dredged from relatively thin veneers averaging approximately 2 feet in depth, using a hopper dredge, to construct a successful 700,000 cy project in 2007/2008. The Little River Borrow Area is presented in Figures 8-12 and 8-13. Recent borrow site investigations (USACE, 2007) show that the Little River borrow area contains at least 11.2 million cubic yards of quality borrow material and has been used several times since being permitted in 1993. The site extends from approximately 1.5 to 4 miles offshore and contains approximately 6,400 acres of ocean bottom. Vibracore data was studied from this site in analyzing sediment data offshore of Holden Beach.

Note that offshore borrow area studies typically begin with seismic sub-bottom profiling and sidescan sonar deployment in order to establish areas where vibracoring should occur. However just because seismic and sidescan studies do not reveal significant sources of sand does not mean that there is no sand. This is the case for the Little River borrow area and this is generally the case for offshore of Holden Beach. Figure 8-13 shows unfavorable sand thickness based on USGS seismic and sidescan data (USGS, 2005), however sand is available and this borrow are has been successfully used two times since it was originally permitted in the early 1990's. In general, vibracores represent the most reliable data.

Holden Beach Offshore Borrow Areas

Five primary offshore sites were established based on vibracore, seismic, and sidescan data and are pictured in Figure 8-11 (borrow areas 1A, 1B, 2, 3, & 4). A brief description of each site is found below. A hopper dredge would most likely be used for the offshore borrow areas proposed. Hopper dredges are typically used for offshore areas and excavate sediment directly onboard, then travel to a nearshore transfer station to pump material to the beach.

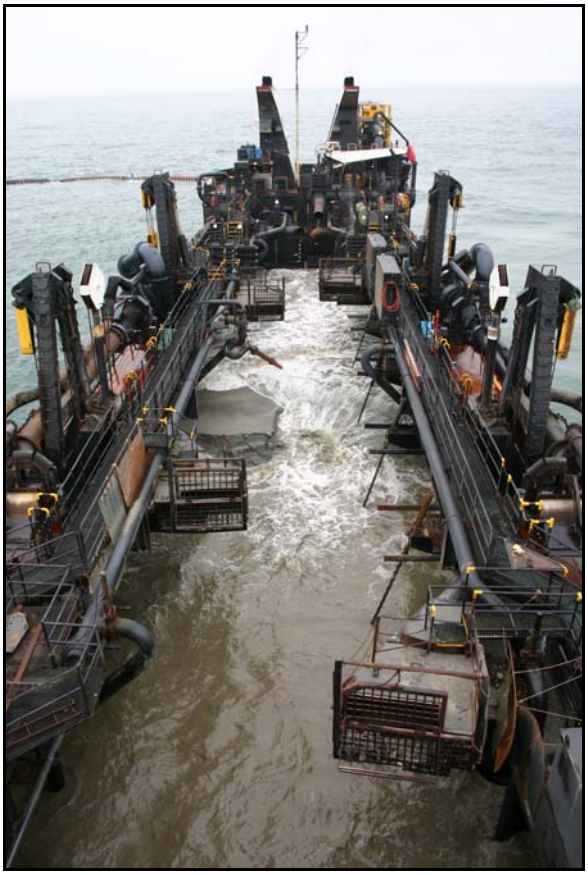

Photo 8.4-1: Hopper dredge with transfer pipeline in the distance.

Proposed Conceptual Offshore Site 1A

Offshore Site 1A consists of approximately 1,669 acres located just southeast of Lockwoods Folly Inlet between 1.25 and 3 miles offshore. Borings indicate beach quality sediment layer thicknesses of 1.5-4 ft. Assuming an average layer thickness of 1.5 ft, it is estimated that this borrow area may yield up to 4M cy. Figure 8-14 presents estimated sand thickness from vibracore borings for borrow area sites 1A and 1B.

Proposed Conceptual Offshore Site 1B

Offshore Site 1B consists of approximately 268 acres located just southeast of Lockwoods Folly Inlet between 3 and 4 miles offshore. Borings indicate beach quality sediment layer thicknesses of 1.5-4 ft. Assuming an average layer thickness of 1.5 ft, it is estimated that this borrow area may yield up to 648,000 cubic yards of sediment. Note this site is located beyond the 3-mile limit and would require additional permit approval from the Minerals Management Service.

Proposed Conceptual Offshore Site 2

Offshore Site 2 consists of approximately 1,100 acres south of Lockwoods Folly Inlet between 1.5 and 3 miles offshore. Borings indicate beach quality sediment layer thicknesses of 1.5-3.5 ft. Assuming an average layer thickness of 1.5 ft, it is estimated that this borrow area may yield up to 2.7M cy. Figure 8-15 presents beach compatible sand thickness from vibracore data for this site.

Proposed Conceptual Offshore Site 3

Offshore Site 3 consists of approximately 646 acres and is located directly south of Holden Beach and is between 2.5 and 3.5 miles offshore. Available borings indicate sediment layer thicknesses of 1-4.5 ft. Assuming an average layer thickness of 1.5 ft, it is estimated that this borrow area may yield up to 1.6M cy. Figure 8-16 presents vibracore results for borrow area 3. Sand channels and other results from the 1999 and 2003 seismic studies are also presented. Sand channels may or may not indicate beach quality sand (i.e., <10% fines, median grain size similar to native beach, etc.); however they do generally warrant further investigation.

Proposed Conceptual Offshore Site 4

Offshore Site 4 consists of approximately 527 acres and is located southwest of Shallotte Inlet between 2 and 3 miles offshore. Available borings indicate sediment layer thicknesses of 1.5-4.5 ft. The volume yield of this borrow area is currently estimated at 1.3M cy. Figure 8-17 presents vibracore results for borrow area 4. Seismic tracklines from 1999 are also presented, however no sand channels were identified in this area (C&C, 1999).

8.5 BORROW AREA VOLUMES

A summary table of all potential borrow area volumes is presented in Table 8-2. Note that the 'estimated yield' represents a realistic volume; however each estimate is based on varying amounts of information and subject to change. Over 11 million cubic yards of material has been estimated from the identified borrow areas. Assuming that Holden Beach requires 250,000 cy/yr to maintain a healthy and stable beach, this volume amounts to approximately 46 years worth of *potential* sediment available.

Table 8-2: Potential Borrow Area Volumes

Borrow Area	Acreage	Est. Avg. Thickness (ft)	Estimated Yield (cy)
Turkey Trap Road Borrow Area	10	0-30	200,000
Smith Borrow Area	Unknown	Unknown	0
Proposed Tripp Borrow Area	25	10-55	403,000
Sheep Island Borrow Area	28	10-20	452,000
Monk Island Borrow Area	10	10-20	161,000
Lockwoods Folly Inlet Borrow Area	22	3	106,000
Offshore Borrow Area 1A	1,669	1.5-4	4,039,000
Offshore Borrow Area 1B	268	1.5-4	649,000
Offshore Borrow Area 2	1,103	1.5-3.5	2,669,000
Offshore Borrow Area 3	646	1.5-4	1,563,000
Offshore Borrow Area 4	527	1.5-3	1,275,000
		Total	11,517,000

Sites Recommended for Further Investigation

Four sites have been located which are recommended for immediate future investigation. These sites are preferred areas within the proposed borrow areas mentioned above and are presented in Figure 8-18.

The preferred area within borrow area 1A is similar to the borrow area recommended by Dr. Cleary following 1999 offshore investigations and is presented in Figure 8-19. Note that Dr. Cleary's suggested borrow area was established prior to some of the vibracore results presented in Figure 8-19 and the area is not as promising based on the latest data.

Borrow area 1A vibracore spacing is approximately 2,000 ft while regulatory agencies require spacing of no more than 1,000 ft (or 1 core for every 23 acres). This area is

offshore of Oak Island, however the proposed shallow cut-depth (2-3 ft) and the distance from shore is anticipated to result in negligible shoreline impacts; although some coordination and wave modeling may be necessary.

The preferred areas within borrow areas 2 and 3 are directly offshore of Holden Beach, however; less information is available for these sites and these sites would therefore require the most vibracoring. Future use of these sites is highly dependent on the results of these vibracores.

The preferred area within borrow area 4 represents the most reliable source of sediment and this general area was identified by the USACE following the 2003 studies. Vibracore spacing is 1,000 ft, therefore no additional vibracores are required (according to NCDENR standards). This area is offshore of Ocean Isle; however given the shallow cut-depth and the distance offshore, it is anticipated that dredging this site will result in negligible shoreline impacts.

In order to satisfy permitting requirements, some additional seismic, sidescan and magnetometer research will be needed for all of the preferred areas for further investigation. Previous seismic and sidescan studies were exploratory in nature and did not perform transect spacing as required for permitting.

Table 8-3: Recommended Offshore Sites – Potential Borrow Area Volumes

Borrow Area	Acreage	Est. Avg. Thickness (ft)	Estimated Yield (cy)
Subset Borrow Area 1A	660	1.5-4	1,597,000
Subset Borrow Area 2	350	1.5-3.5	847,000
Subset Borrow Area 3	240	1.5-4	581,000
Subset Borrow Area 4	265	1.5-3	641,000
		Total	3,666,000

Table 8-3 presents estimated volumes from the offshore borrow sites that are recommended for further investigation. As previously mentioned, a nourishment of approximately 500,000 cy to 600,000 cy (similar to the USACE 933 project) is recommended; therefore each of these sites are estimated to be available for at least one and possibly two nourishment events.

Figure 8-1
Upland and Inlet Conceptual Borrow Areas (BAs)

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Figure 8-2
Turkey Trap Road Permitted Borrow Area

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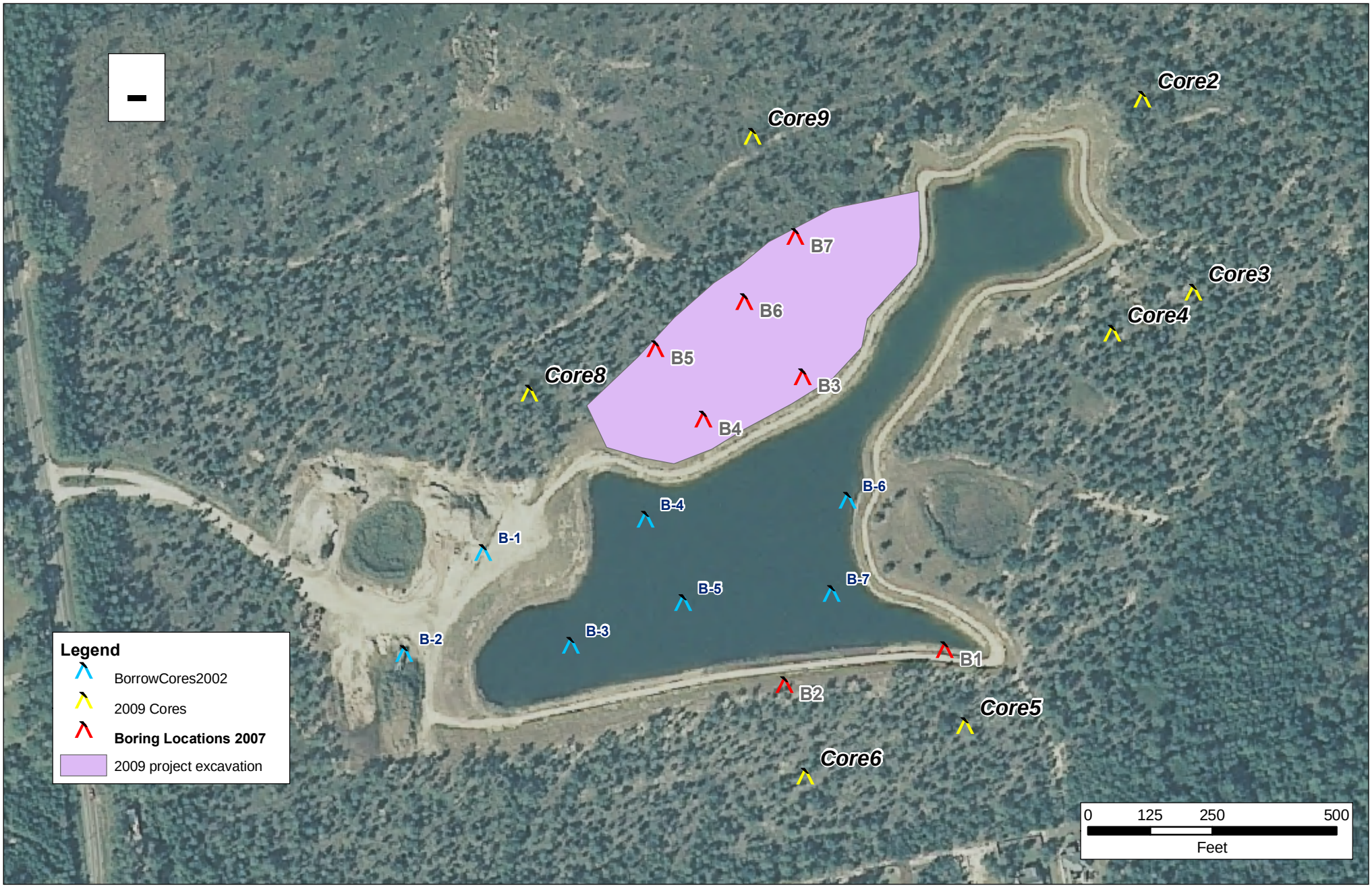

Figure 8-3
Smith Borrow Site showing 2009 excavation

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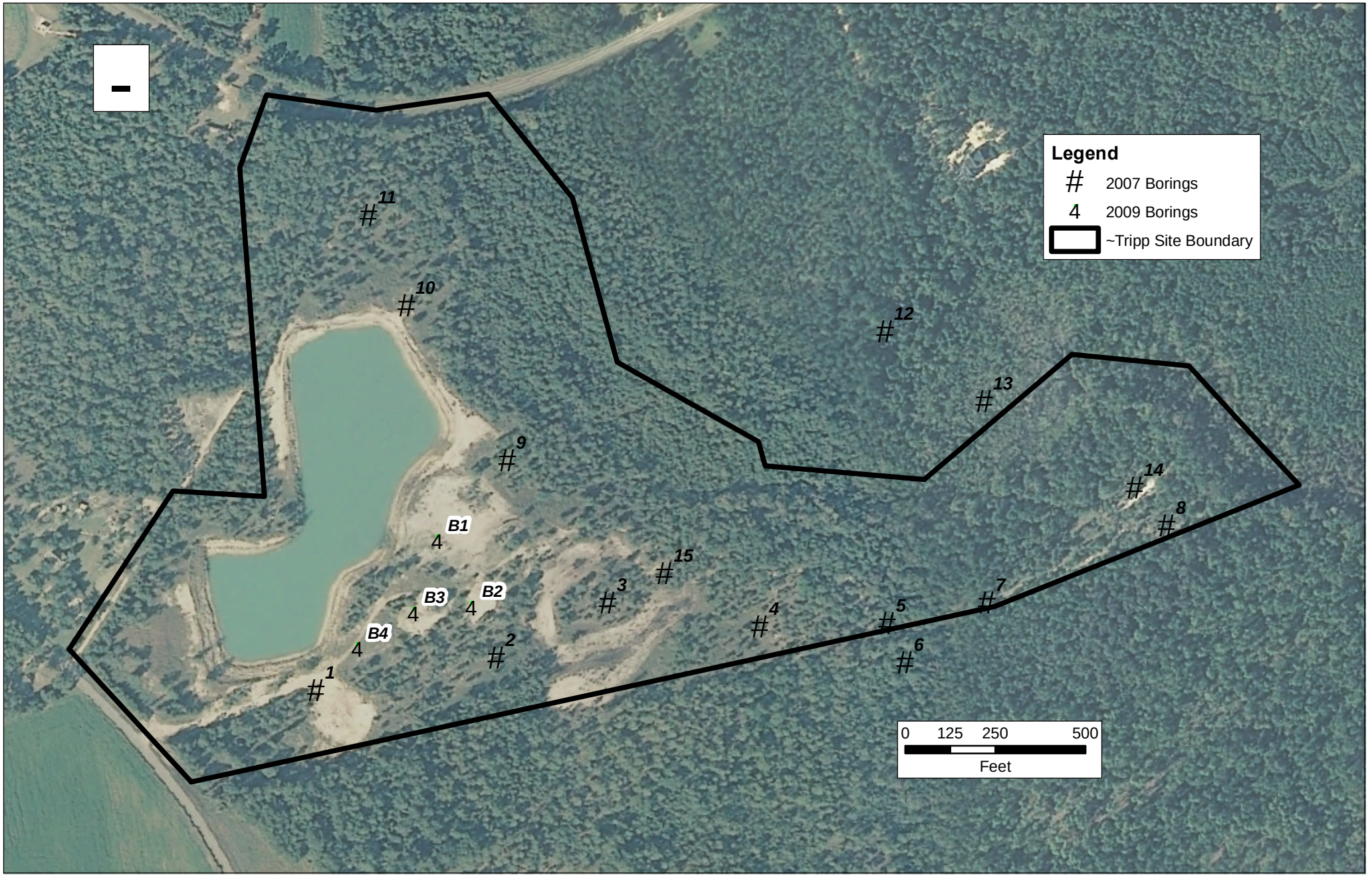

Figure 8-4
Tripp Site Boundary and Boring Locations.
Note that adjacent properties may also be available.

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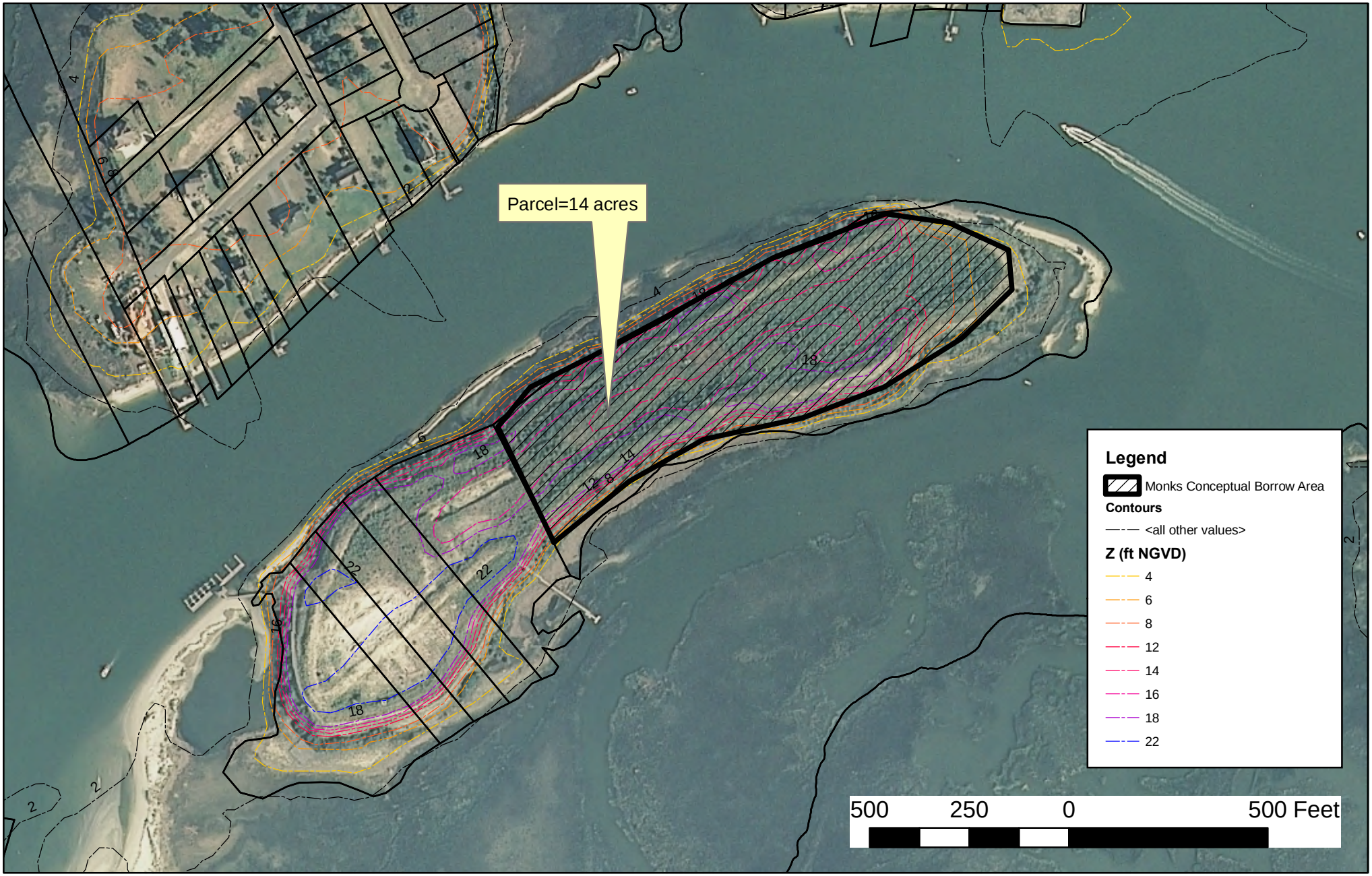

Figure 8-5
Monks Island conceptual borrow area

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Figure 8-6:
Sheep Island Conceptual Borrow Areas

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APPLIED TECHNOLOGY & MANAGEMENT

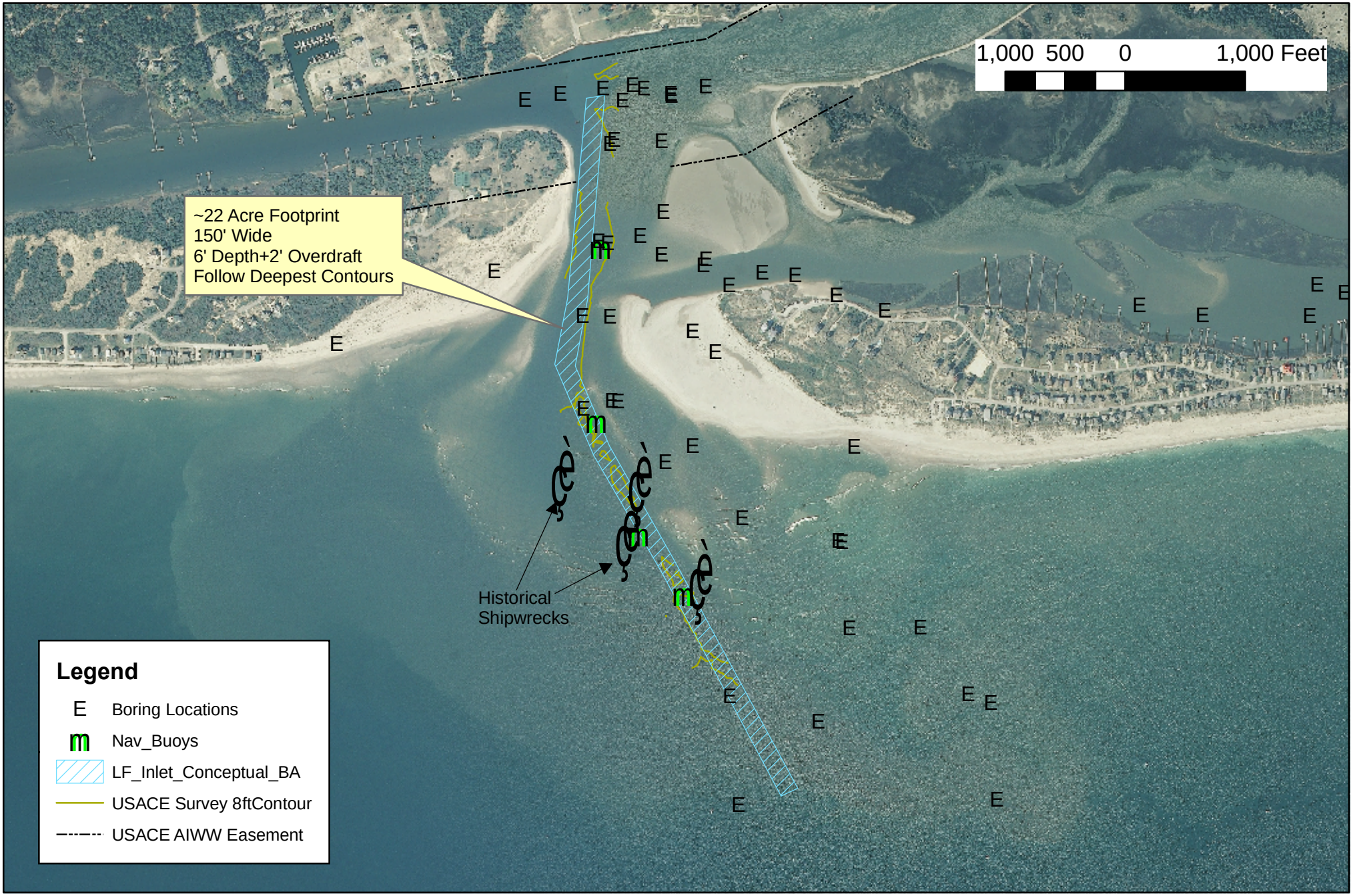

Figure 8-7:
Lockwood Folly Inlet conceptual borrow area

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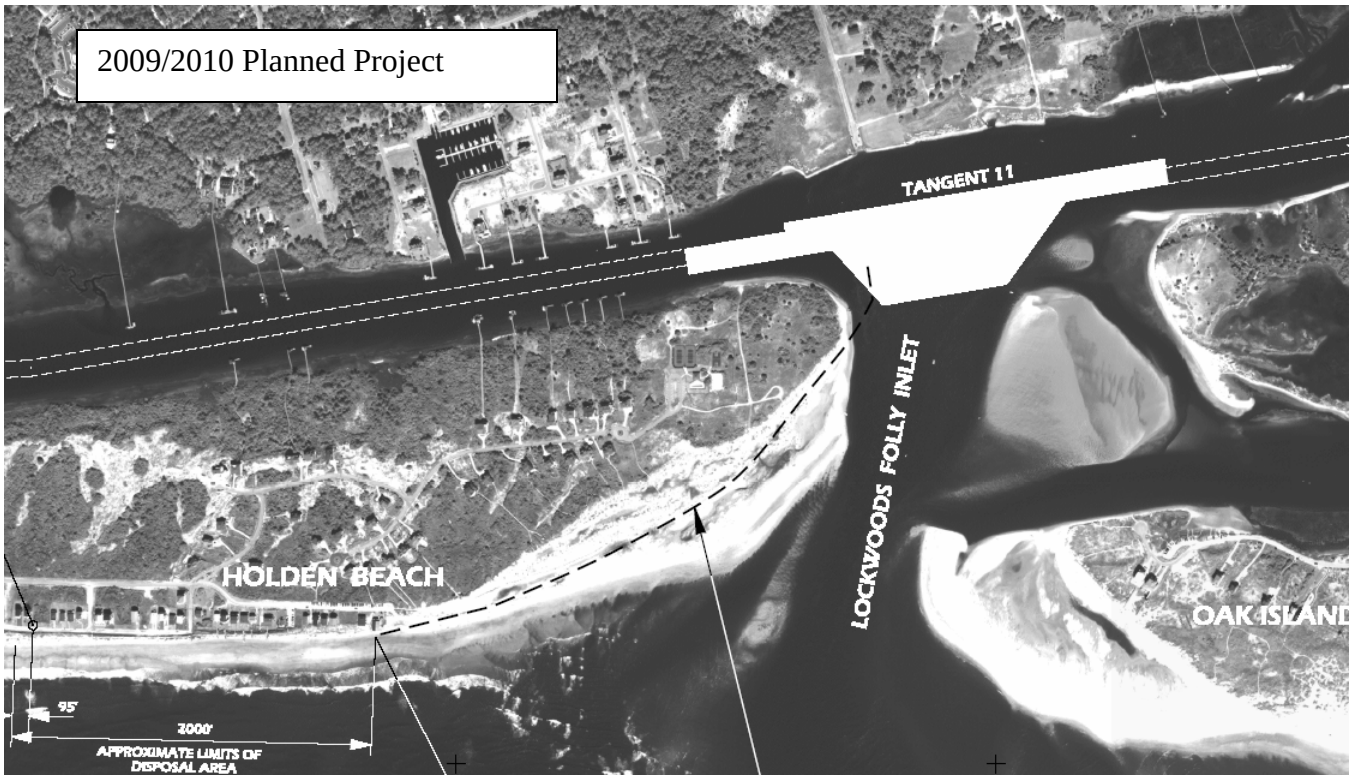

Figure 8-8:
Lockwood Folly AIWW dredging plans. Note that 2008/2009 beach placement extended over approximately 3,500 feet. It is recommended that the planned placement also extends farther west.

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Figure 8-9:
Shallotte Inlet historical borrow area

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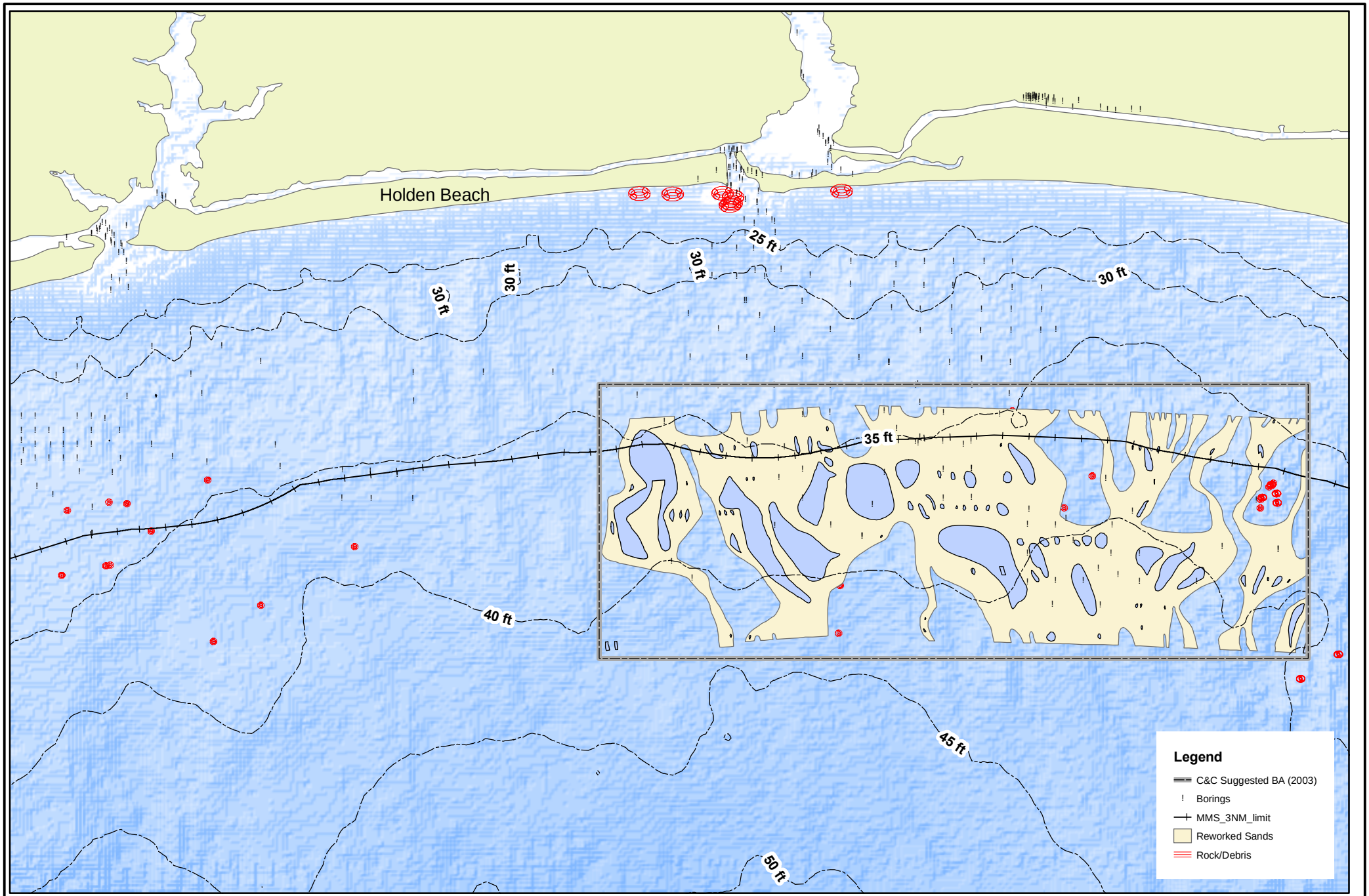

Figure 8-10:
C&C Suggested Borrow Area (2003)

APPLIED TECHNOLOGY & MANAGEMENT

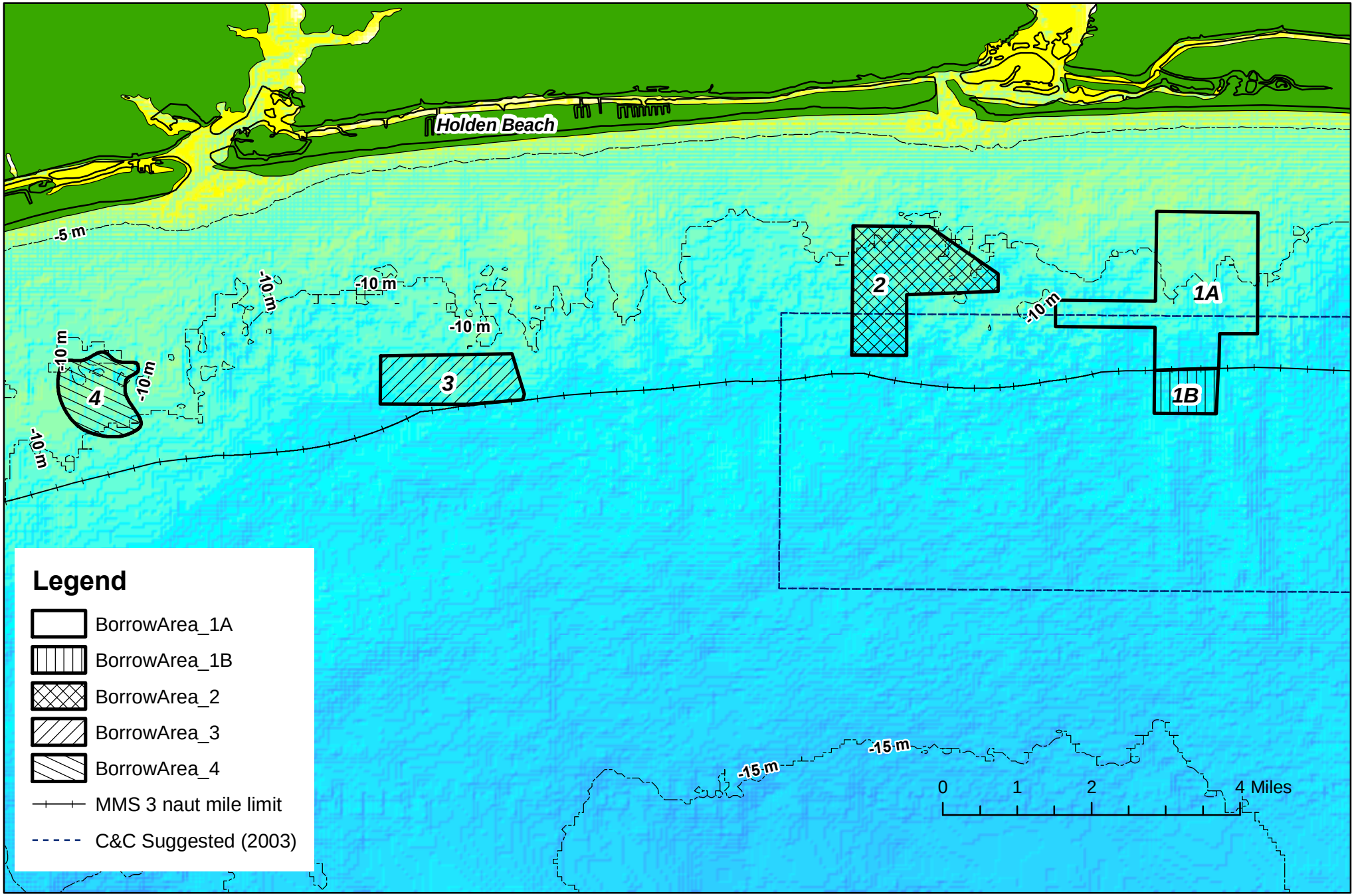

Figure 8-11:
Conceptual Borrow Areas for Holden Beach

APPLIED TECHNOLOGY & MANAGEMENT

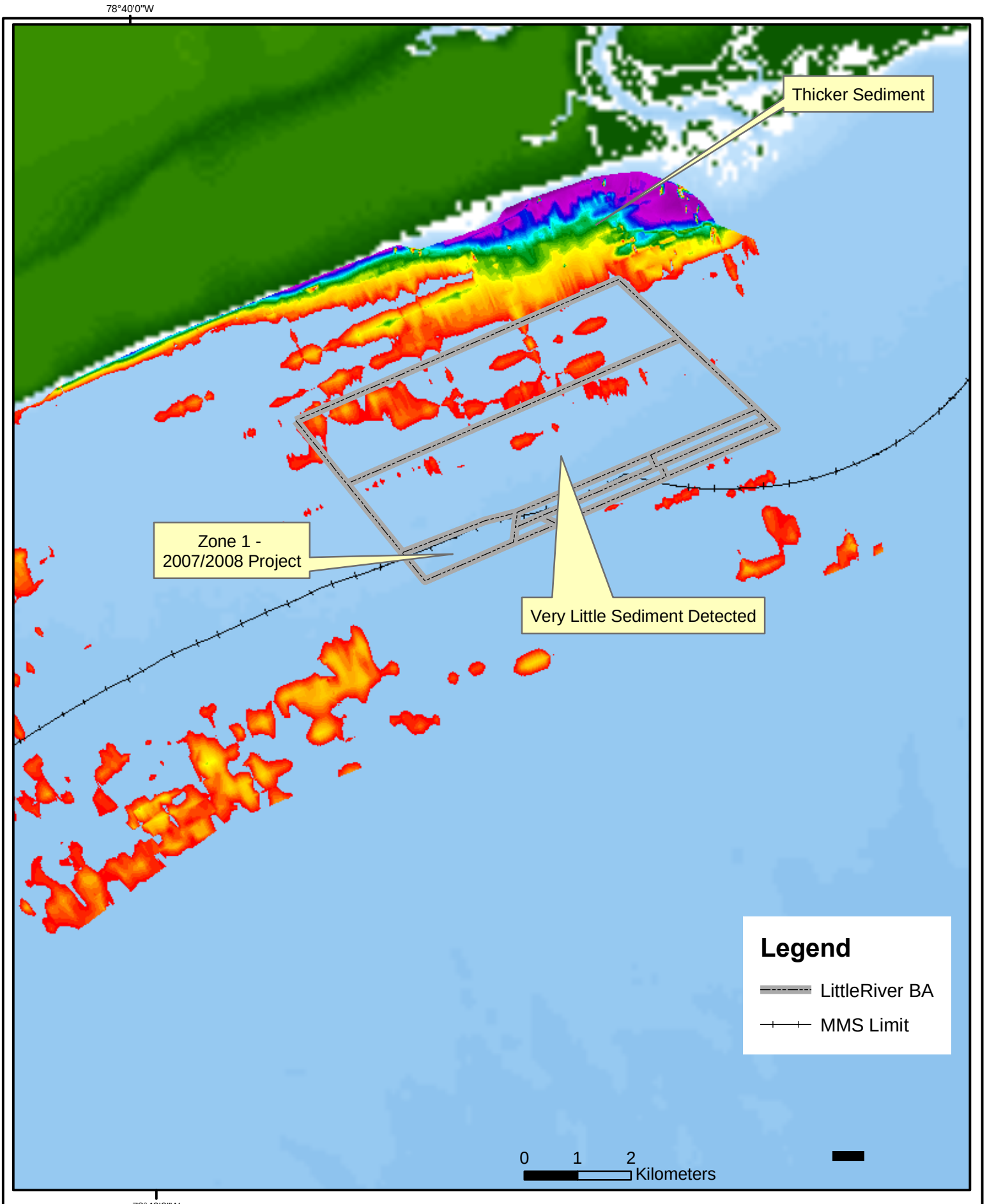

FIGURE 8-12:
Little River Borrow Area
Available Sand according to Seismic Studies

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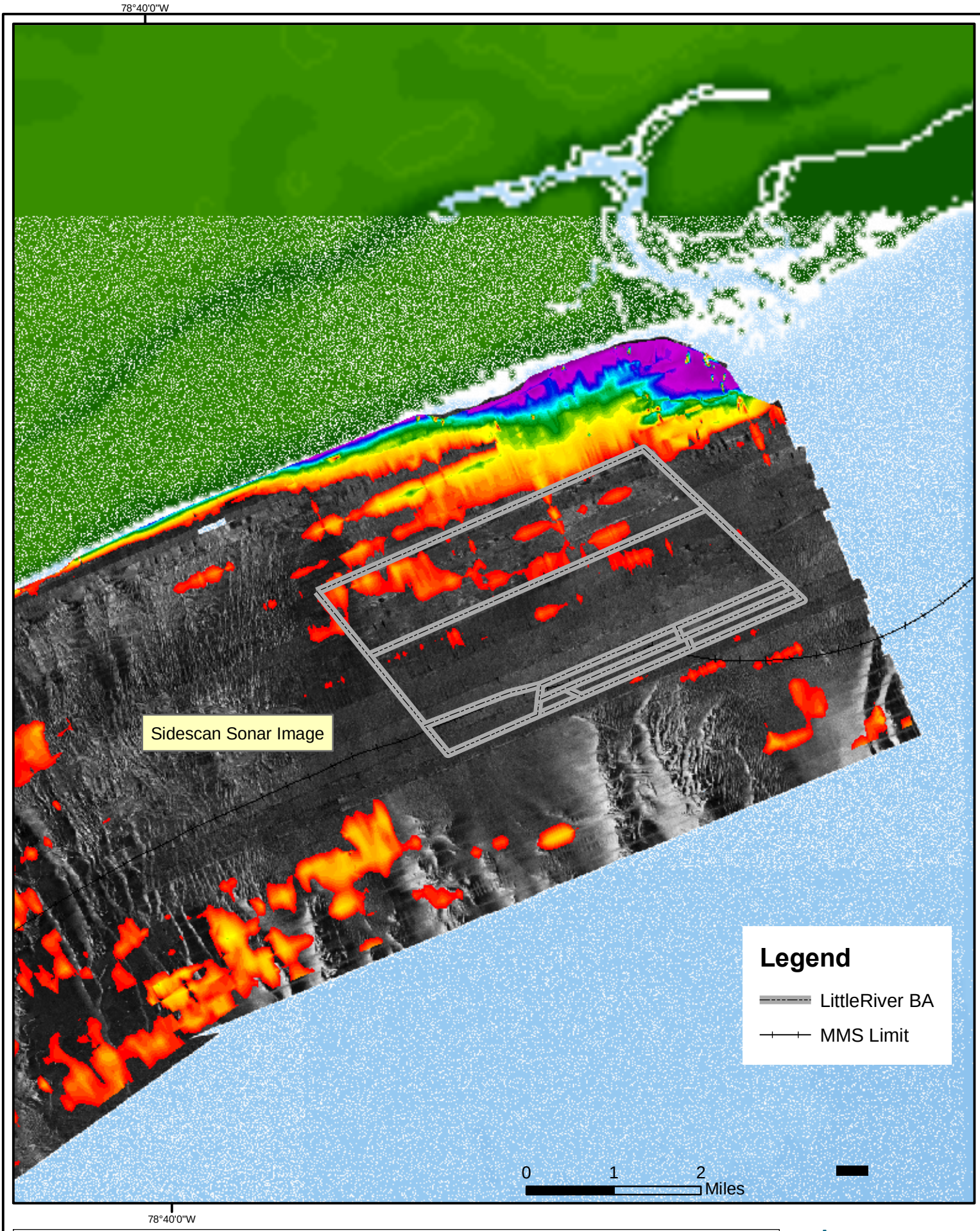

Figure 8-13:
Little River Borrow Area Sidescan
Seafloor is characterized as mixture of hardbottom and sand

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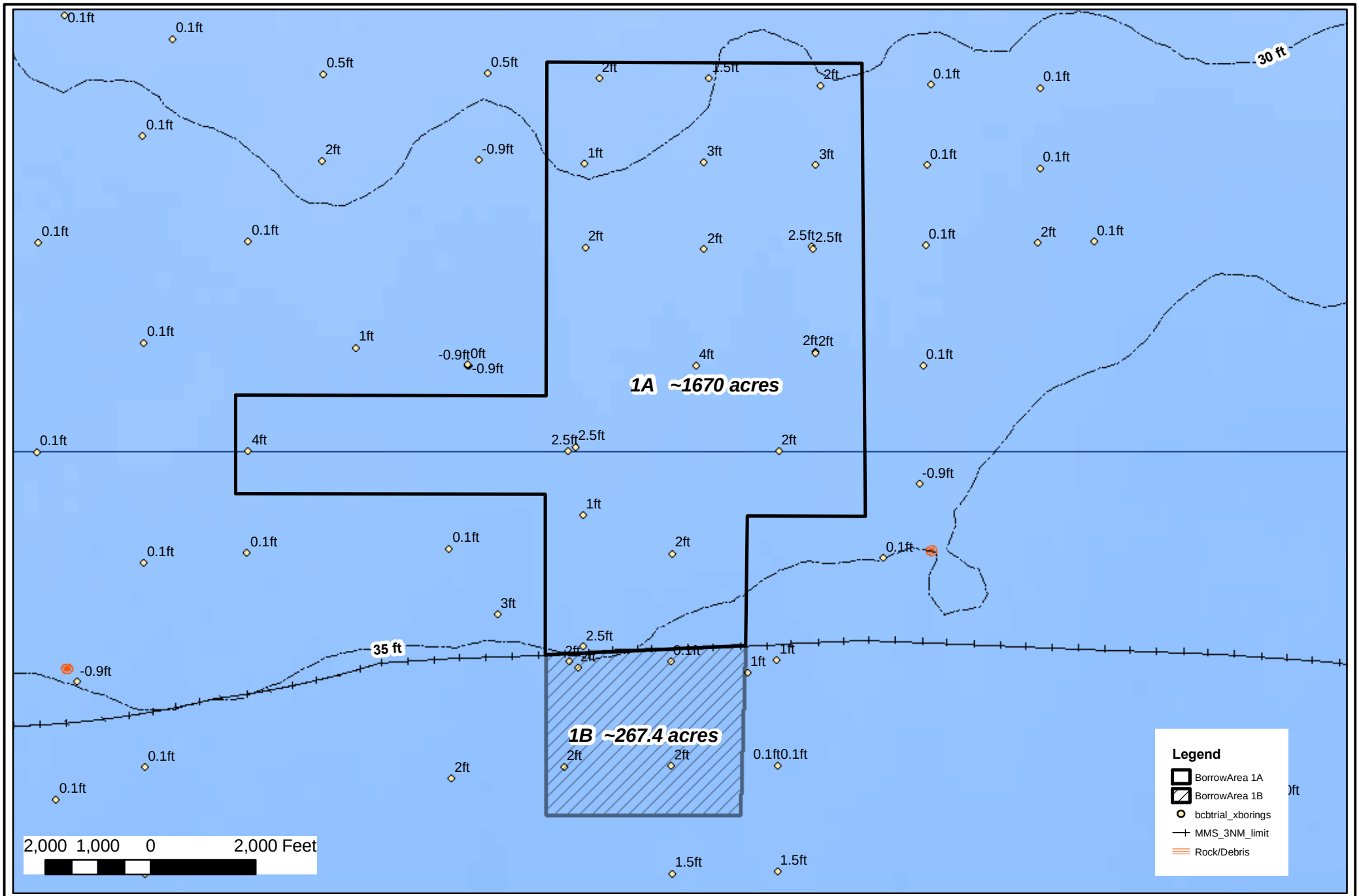

Figure 8-14:
Proposed Borrow Areas 1A and 1B
Vibracore results showing beach compatible sand thickness

APPLIED TECHNOLOGY & MANAGEMENT

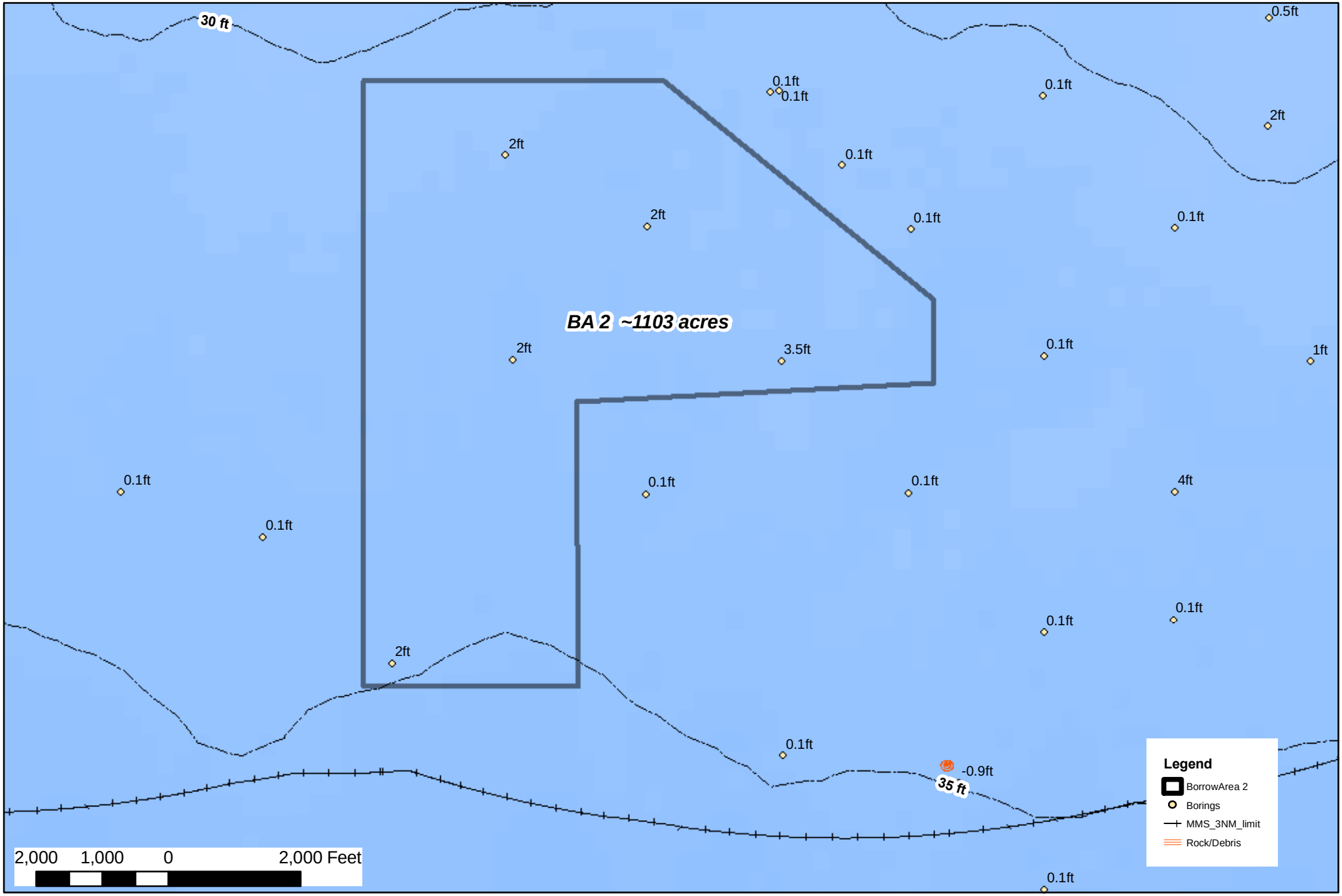

Figure 8-15:
Proposed Borrow Area 2
Vibracore Results presenting Beach Compatible Sand Thickness

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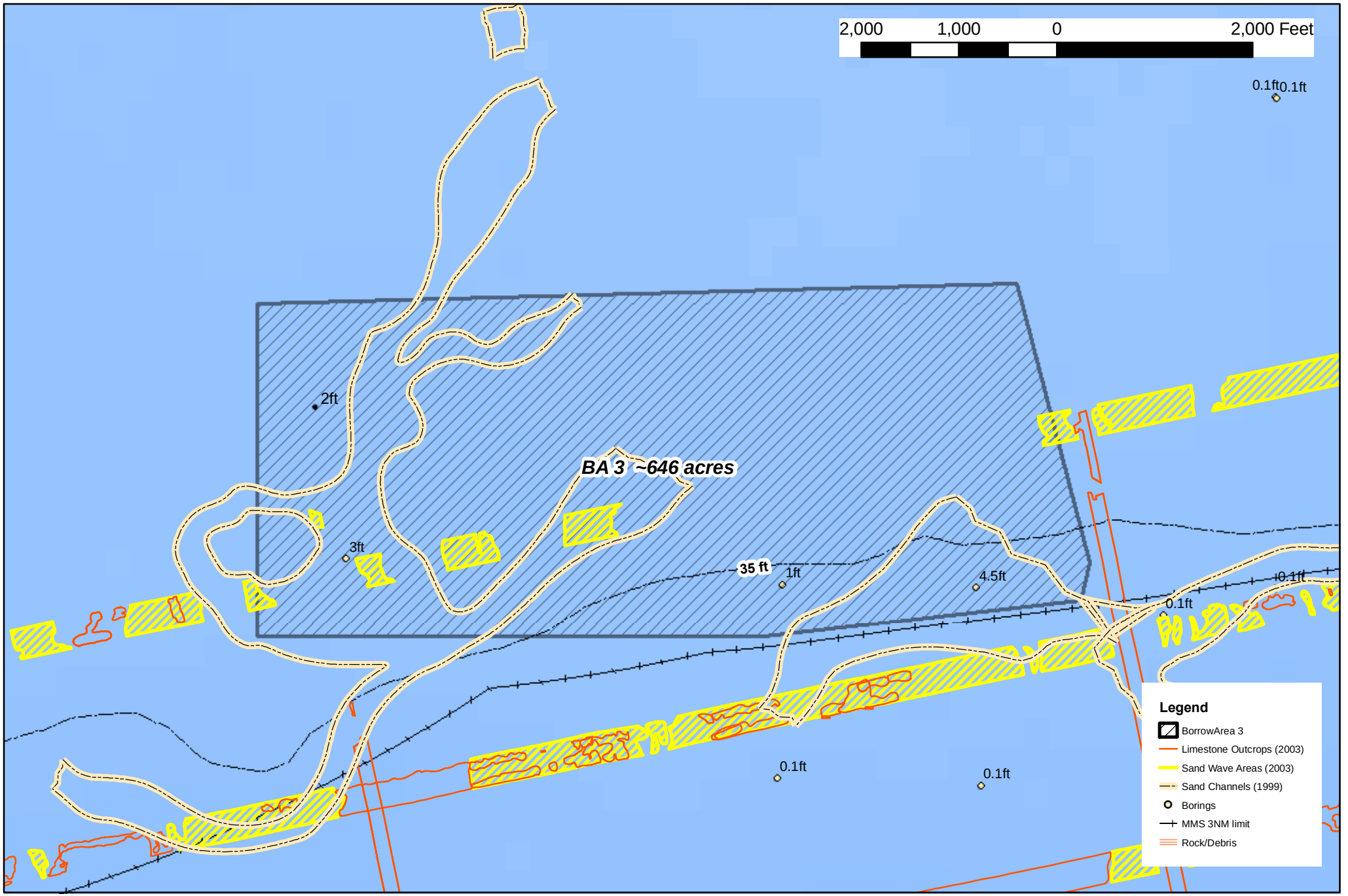

Figure 8-16:
Proposed Borrow Area 3 Vibracore Thickness
Sand Channels and Limestone Outcrops (from Seismic Study) also plotted

ATM
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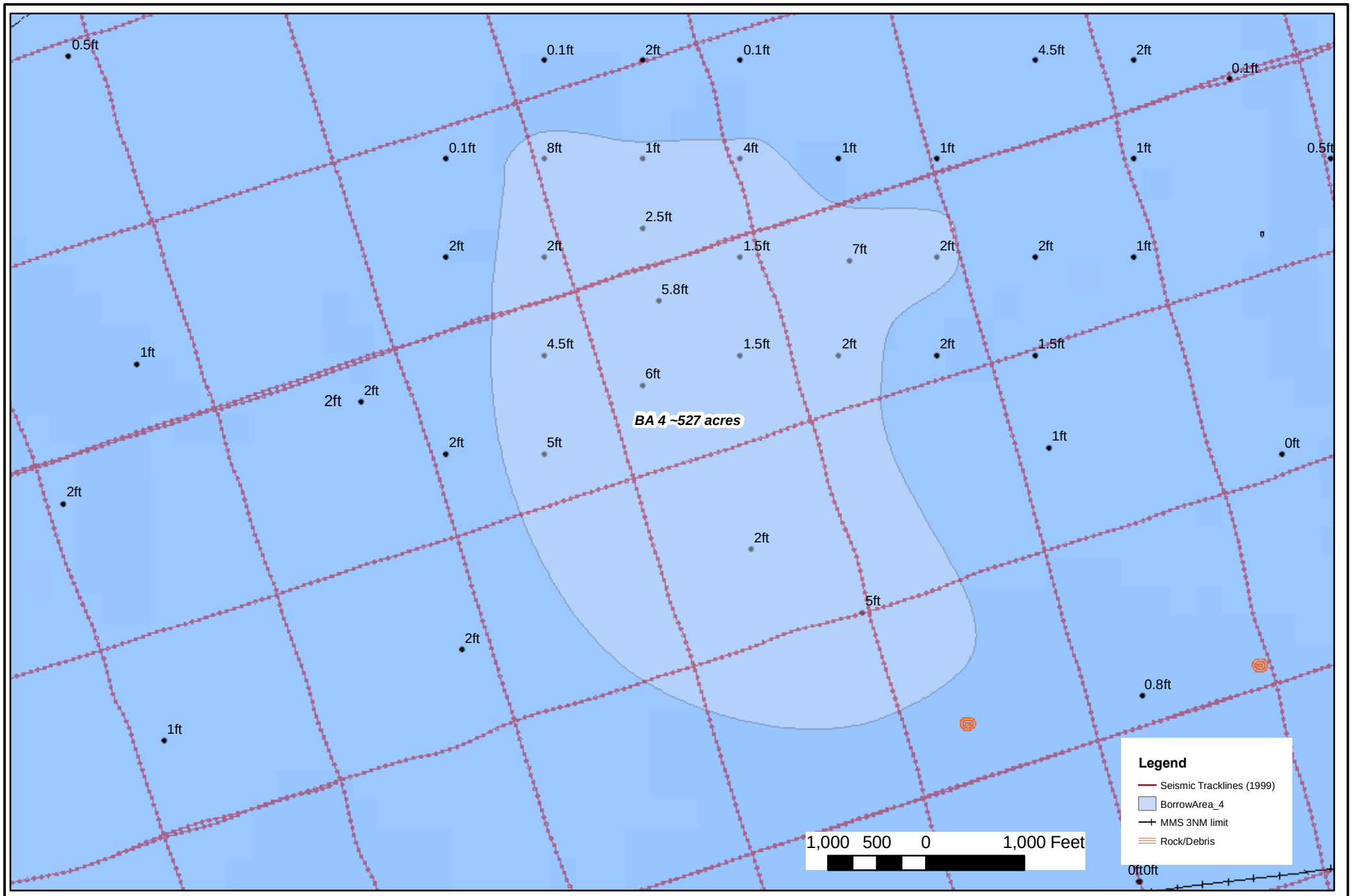

Figure 8-17:
Proposed Borrow Area 4 Vibracore Sand Thickness
1999 Seismic tracklines also plotted (no sand channels were identified)

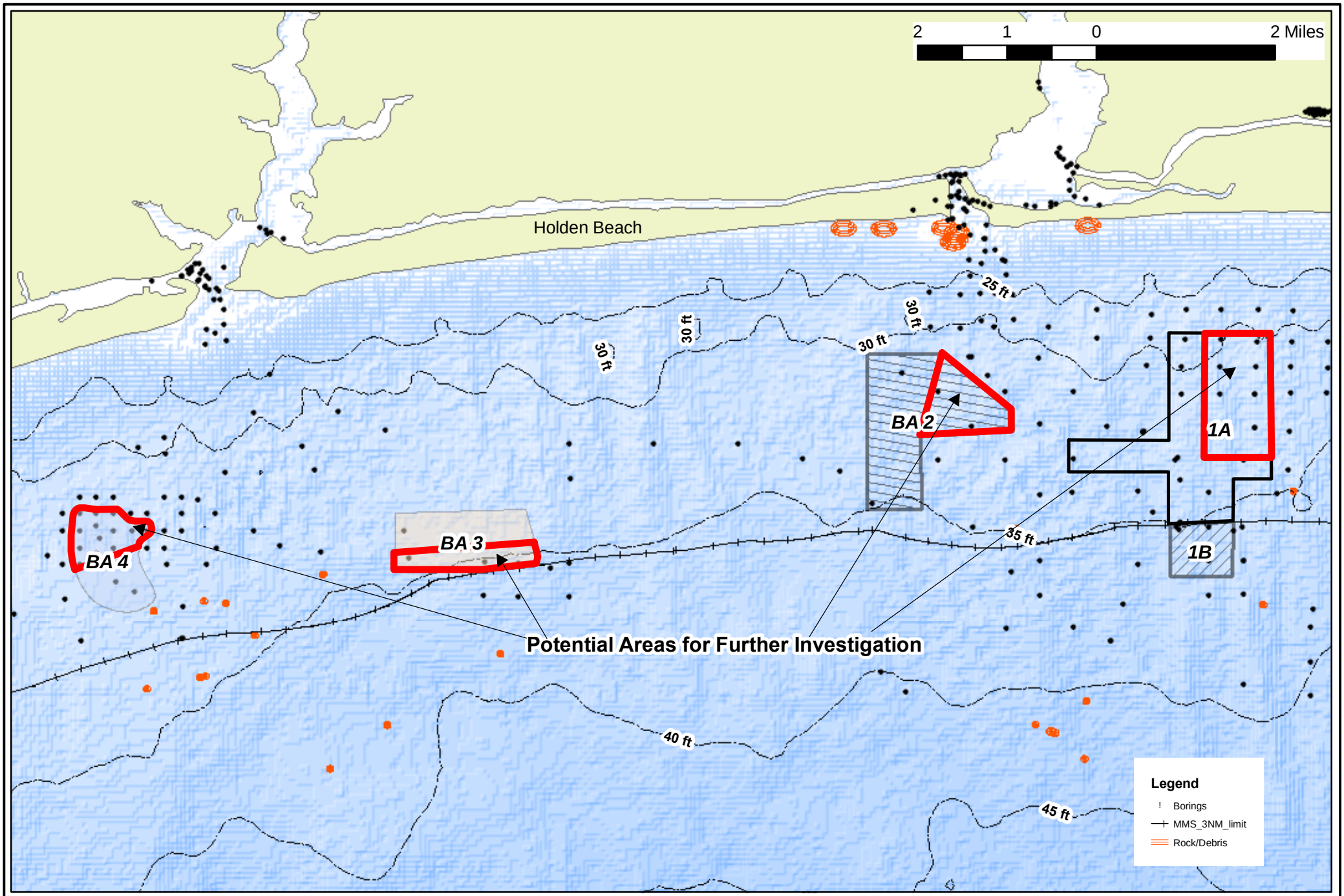

Figure 8-18:
Recommended Areas for Further Investigation

APPLIED TECHNOLOGY & MANAGEMENT

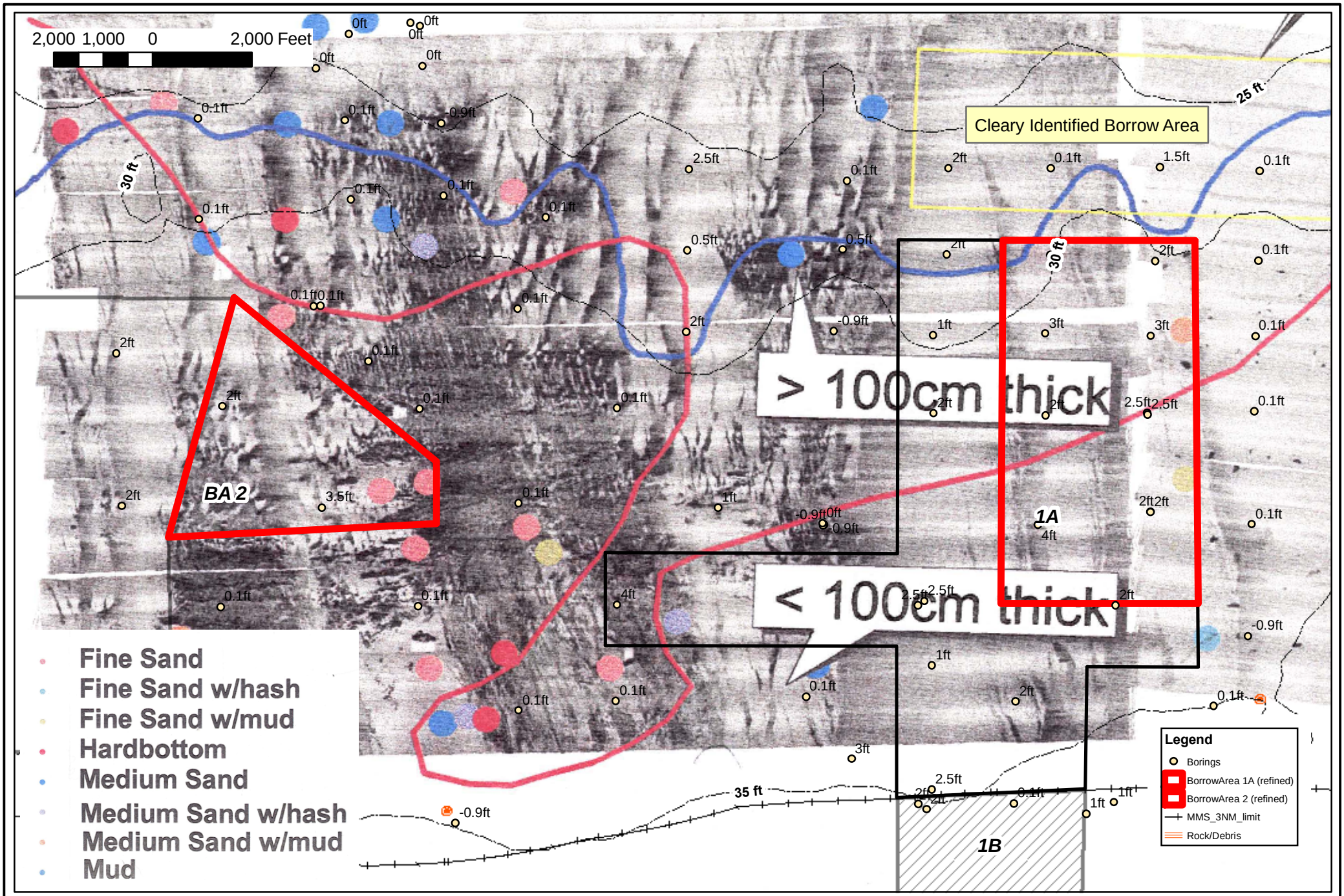

Figure 8-19
Borrow Areas 1A and 2 in relation to Cleary sidescan and
Cleary identified borrow area (provided by USACE,1999).

9.0 COSTS

A basic presentation of costs associated with all proposed alternatives is discussed in this section. Pre-project data collection, permitting, project construction and post-project monitoring costs represent the primary areas where costs figure prominently. Beach nourishments utilizing offshore sources require a significant up-front cost, although these costs are typically similar to smaller project costs on an annualized basis because of longer nourishment intervals. Note that the costs presented below are based on recent experience and similar projects however are conceptual only. A more detailed cost analysis can be provided after selection of a preferred alternative(s).

Data Collection

In terms of borrow site investigations required for permitting; the type of data collection and site investigation is dependent upon the preferred borrow area(s). Offshore and inlet borrow areas typically require bathymetry, seismic profiling, magnetometer and sidescan studies as well as vibracoring. Upland borrow areas typically require borings and wetland delineations. New sediment criteria require vibracore/boring spacing every 1,000 feet (or 1 core every 23 acres). Offshore borrow areas are typically much larger than upland borrow areas, in terms of acreage, therefore more vibracores are needed. Both water and land-based borrow areas will require laboratory sediment analysis.

Based on recent offshore borrow area costs for similar borrow areas (which included bathymetry, seismic, sidescan, and limited vibracores), the costs of investigating one of the recommended borrow areas are estimated at $40,000 -$60,000. This cost is highly dependent upon the number of vibracores needed. Upland borrow area investigations should be similar in cost to Smith and Turkey Trap Road investigations, ranging from $10,000-$20,000 (depending on wetlands, etc.).

Permitting

As previously mentioned, the level of permitting is dependent upon the selected borrow area(s). Upland and offshore borrow areas have typically only required EA development; while inlet or nearshore borrow areas have typically required EIS documents. EIS document development requires significantly more time and effort. The

USACE is currently utilizing the inner portions of Lockwood Folly for navigation/nourishment and plans to utilize the ebb shoal of Lockwood Folly for the GRR project. As a result, the Town can most likely avoid the EIS permitting that is likely associated with the proposed ebb shoal borrow area and allow the USACE to lead this effort. If USACE plans change, then the Town may have to reevaluate the feasibility of this alternative.

Project Construction

Mobilization/Demobilization costs of offshore dredges require larger scale nourishment projects. For planning purposes, offshore dredge mobilization costs can be conservatively estimated at $2,000,000. Any use of an offshore site needs to be justified on a cost basis relative to other alternatives. Therefore a 500,000 cy to 600,000 cy project would be needed in order to achieve a cost in the $10/cy to $12/cy range.

Previous upland fill placements have been under $9/cy; however several major limitations may occur with the Turkey Trap Road and Tripp sites. The NCDOT has requested upgrades to all secondary roads totaling approximately $375,000 for the Turkey Trap Road site. The Tripp site represents an approximate 13 mile drive, which is three times farther than the Smith or Turkey Trap sites. This increases truck travel time which slows production. In order to maintain similar levels of production as previous projects, more trucks would be needed, most likely increasing costs.

Monitoring

Post-project monitoring costs will likely be greatest for inlet and nearshore borrow areas. Offshore borrow areas can also require a significant level of monitoring if extensive hardbottom is nearby. Note that a 500-meter buffer for hardbottom is normally required. Upland borrow area monitoring typically requires the least amount of effort.

"206 Project" Funding Mechanism

The Town's BPART fund has been instrumental in providing timely funding for beach nourishment projects. The recent FEMA project, where initial funds were required by the Town for later reimbursement by FEMA is a good example of this. Additionally, USACE projects typically require a 65/35 fund sharing agreement, with the State, the County,

and the Town covering the 35% “local sponsor” cost. Of course Town-sponsored nourishments are entirely covered by the BPART fund.

Depending on USACE project scheduling and funding, another option for the Town is a “206 Project” alternative. Section 206 of the 1992 Water Resources Development Act gives all local sponsors the opportunity to construct their own federally-authorized beach nourishment projects and still receive federal funding for both engineering and project construction. Essentially, the local sponsors, most likely led by the Town, would fund the entire permitting and construction of a large nourishment project and would receive reimbursement for the 65% federal share.

There is some additional coordination with the USACE required; similar to the FEMA reimbursable project that the Town performed earlier this year. Also note that congressional authorization is also required for reimbursement. The 206 project option is common in Florida, where communities frustrated with USACE project delays have developed programs with the necessary financial backing to place sand on the beach in a more expedient and timely manner.

10.0 SUMMARY & PATH FORWARD

10.1 SUMMARY

Holden Beach remains proactive in its beach management and plans to continue its sand placement activities by identifying multiple potential borrow areas for long-term planning purposes. Upland-based fills have proven effective over the last 9 years, however these projects are relatively small, typically less than 200,000 cy, and the community desires to explore offshore and inlet opportunities. In terms of logistics, inlet or offshore projects offer the advantages of (1) improved borrow material quality – color and grain size; (2) enabling dredges to more effectively transport and place the sand on the beach; and (3) allowing for larger, more effective and efficient beach nourishment projects.

The general goal of this beach management plan is to maintain a healthy, wide beach. At a minimum, the goal is no net reduction in sand volume; however it is recommended that a larger nourishment occur to "get ahead" of the background erosion and increase the current beach widths. The backbone of all nourishment activities since 2001 was the Federal 933 project associated with the Wilmington Harbor deepening. The Town's smaller-project approach has proven effective and is most likely viable in the future; however this is dependent on USACE fill activities which are subject to delays and funding shortages. As such, the Town wants to look longer term, in the 10-30 year horizon to identify potential sources and to "be ready" when long-term and storm-induced nourishment needs arise. If offshore sediment is used, then future nourishment volumes similar to the 933 project, which placed ~525,000 cy of sand are needed.

To summarize the basic borrow areas available:

Upland sources –

- Good for small projects (< 200,000 cy) and to supplement other larger fill projects
- Good for dune rebuilding and creation
- Sand color and quality not as good typically as in-water sources
- Slow production rates and shorter life-cycles (every 1-2 years)
- Truck and DOT/road issues

- Turkey Trap Road site and Smith site are currently permitted

Dredge Spoil Islands along the AIWW (i.e. CDFs) –

- Consist of layered material that would require separation of beach compatible and non-beach compatible material
- Reuse of this material would increase CDF disposal capacity and allow continued disposal operations
- Islands have become valuable for natural resources, recreation, and in some cases, development

Offshore sources-

- Good for larger projects, typically more economic with larger volumes (due to mobilization fees).
- Generally “sand-starved” offshore region; however North Myrtle Beach/Little River borrow area project has successfully performed shallow-cut hopper excavation
- Typically better quality sand due to its “pre washed” nature

Lockwoods Folly Inlet –

- Currently not fully utilized because of sidecasting operation and only following “deep-water” permit criteria
- USACE AIWW related navigation dredging has placed approximately 300,000 cy of material on the beach since 2002 (~ 45,000 cy/yr)
- USACE regional analysis supports placement of 156,000 cy/yr (625k cy every 4 years) from LWF ebb shoals on Holden Beach
- Remains a key to long-term management
- channel alignment and shoaling patterns have been documented to cause problems to adjacent shorelines

Note that at the extreme east end Holden, beach erosion rates have been historically larger than practical to treat with fill alone (primarily associated with inlet effects). A terminal structure would help to stabilize this area; however the level of effort in permitting and monitoring is currently unknown. In conversations with regulatory personnel, several communities are currently preparing terminal structure documentation

in order to begin permitting as soon as possible if regulatory changes occur. Therefore a precedent will most likely be set before the Town deliberates this option. In any case, a feasibility level study should be performed prior to permitting to establish benefits and costs as well as evaluate alternatives. The feasibility study would form the basis of any permitting effort.

10.2 PATH FORWARD

The suggested path forward has been developed based on ATM and Holden Beach conversations with NCDENR and USACE regulatory staff, as well as with USACE beach nourishment and navigation personnel.

1. Continue with Post-Project and Annual Monitoring - Post-project monitoring is required by permit conditions and consists of biological sampling, sand sampling and surveying of pre-established project and control reaches. Annual island-wide assessments of beach conditions are the basis of the Town's ongoing beach monitoring program and include all tasks sufficient to satisfy FEMA guidelines for receiving federal funds to restore beaches recognized during federally declared disasters. Annual island-wide monitoring and post-project monitoring can often be performed simultaneously to minimize costs and both events are scheduled to occur in October, 2009.

2. Extend Existing Permit- The existing permits expire on December 31, 2009 and both CAMA and USACE regulatory agencies have recommended requesting extensions. This will primarily serve as a safeguard to allow the Town to respond to future emergency erosional events in a timely manner. The Town has at least one permitted upland site (i.e., Turkey Trap Road) and it is recommended that the Town continue to have an upland site reserved for smaller nourishment projects (including dune construction). Note that once a future emergency event occurs, additional modifications related to volume and placement will be necessary.

3. Begin New Permitting Program – This program will include a suite of projects/responses/triggers and include several borrow areas from the upland and offshore. Beach nourishment permitting typically includes identifying more volume than needed and in many cases more than one borrow area. This study has summarized all known current options and is presented to the Town for review. The recommended offshore borrow area is Borrow Area 4, while the Tripp upland borrow site is also recommended for smaller projects. The Turkey Trap Road site should also continue to be included.

4. Scoping Meeting with Regulatory Agencies – As soon as preferred borrow areas are selected; the Town and ATM will present its preferred suite of alternatives for a pre-application meeting. This will be followed by necessary data collection and permit application.

During this process, the Town and ATM will continue to engage the USACE with respect to proposed nourishment plans. Lockwood Folly navigation dredging and beach maintenance is a key component in this process. The USACE has been dredging Lockwood Folly for navigation and placing material on the beach in amounts ranging from 30,000 cy to 120,000 cy. The Town and ATM have been actively engaging USACE personnel in order expand these activities to reach the ~150,000 cy/yr goal.

The Town can maximize flexibility in beach nourishment activities by completing permitting as soon as possible. This allows for increased leverage in negotiating with dredgers as well as for planning around major USACE fill placement activities. If USACE fill activities proceed on schedule and with adequate funding, then large-scale nourishments by the Town may not be necessary. However complete reliance upon USACE plans can be risky and the Town's historical beach management activities over the last decade have been essential in maintaining storm protection and recreational beach width.

As mentioned in Section 9, an available funding option for placing sand on the beach while also retaining the 65% federal cost sharing is the "206 Project" alternative. The Section 206 of the 1992 Water Resources Development Act gives all local sponsors the opportunity to construct their own federally-authorized beach nourishment projects and

still receive federal funding for both engineering and project construction. The 206 Project option is common in Florida, where communities have been frustrated with USACE project delays. Essentially, the local sponsors, most likely led by the Town, would fund the entire permitting and construction of a large nourishment project and would receive reimbursement for the 65% federal share.

11.0 REFERENCES

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APPENDIX G

HOLDEN BEACH WORK PLAN

The Town of Holden Beach

Incorporated 1969

110 Rothschild Street
Holden Beach, North Carolina 28462

Phone: 910.842.6488
Fax: 910.842.9315

Mr. Mickey Sugg
Project Manager
US Army Corps of Engineers
69 Darlington Avenue
Wilmington NC 28403-1343

RE: Initiation of NEPA permitting process for Holden Beach Terminal Groin Project

Dear Mr. Sugg,

The Town of Holden Beach would like to continue the permitting process for a terminal groin and beach fill project. Pursuant to our inter-agency scoping meeting on October 12, 2011, you have requested a Work Plan in order to establish a project description and general outline of the tasks to be performed under the National Environmental Policy Act (NEPA) permitting process. By copy of this letter, we would like to initiate the NEPA permitting process for the proposed project.

Please find the attached Work Plan which outlines the general project description (i.e. groin and nourishment) as well as tasks to be conducted during Environmental Impact Statement (EIS) document development. Thank you for your time and we look forward to working with you. Please contact me or our designated coastal engineering firm, Applied Technology and Management, for more information.

Sincerely,

David Hewett
Holden Beach Town Manager

Work Plan for the Proposed Terminal Groin on the East End of Holden Beach

Lockwoods Folly Inlet, North Carolina

November 2, 2011

Prepared for: USACE

Submitted by: The Town of Holden Beach, NC

TABLE OF CONTENTS

1.0 INTRODUCTION

This document represents the Work Plan requested by Mr. Mickey Sugg of the US Army Corps of Engineers (USACE) to begin the National Environmental Policy Act (NEPA) permitting process for a terminal groin on the east end of Holden Beach, adjacent to Lockwoods Folly Inlet (see Figure 1-1 for location map). The Work Plan described herein includes the general tasks to be conducted during the NEPA and Environmental Impact Statement (EIS) development process.

The Town of Holden Beach (also referred to herein as the Town) is positioned to the west of Lockwoods Folly Inlet while Oak Island is positioned to the east. Both Holden Beach and Oak Island are located within Brunswick County.

The proposed terminal groin is one component of the Town of Holden Beach's ongoing comprehensive beach management program, further described in the Holden Beach 2009 Beach Management Plan. A terminal groin structure on the eastern end of Holden Beach is an alternative that is being considered as the preferred method to reduce the high erosion losses that have historically occurred at the east end of Holden Beach, in addition to proactive sand management of Lockwoods Folly Inlet.

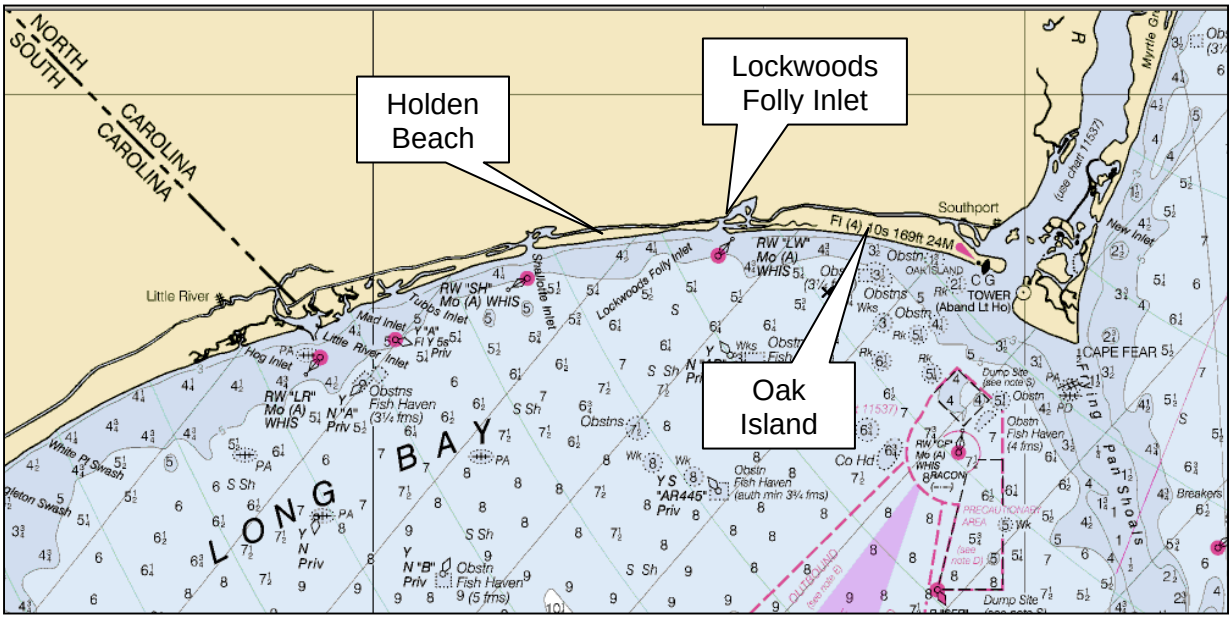
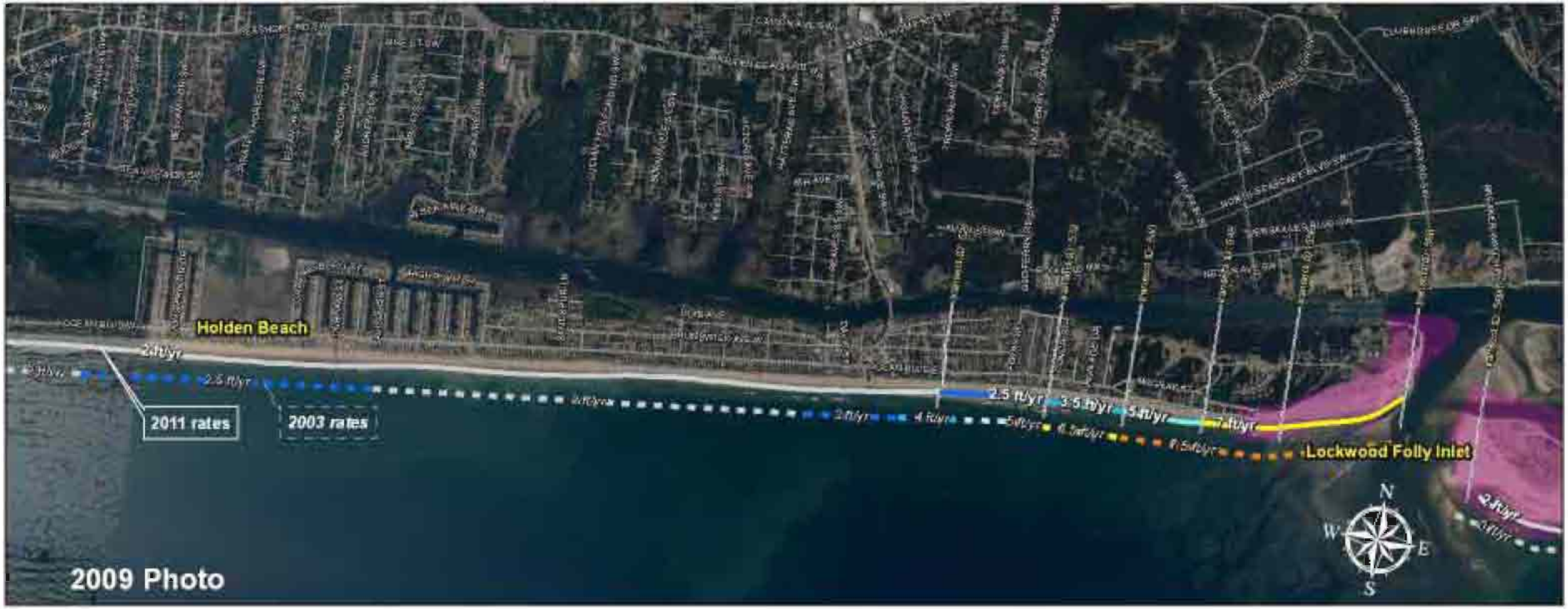


Figure 1-1. Project Location Map of Holden Beach and Lockwoods Folly Inlet, NC (NOAA Chart 11520)

Figures 1-2 and 1-3 present 2011 NC Division of Coastal Management (DCM) long-term erosion rate maps for the east end of Holden Beach and the west end of Oak Island. Note long-term erosion rates through 2011 are slightly less than 2003 rates for eastern Holden Beach, at least partially due to recent nourishment activities.



2011 Long-Term Average Annual Erosion Rate Update

at Holden Beach, North Carolina

Legend

2011 Setback Factors (feet/year)	2003 Setback Factors (feet/year)
2.0	0.0 - 2.0
2.1 - 3.0	2.1 - 3.0
3.1 - 4.0	3.1 - 4.0
4.1 - 5.0	4.1 - 5.0
5.1 - 6.0	5.1 - 6.0
6.1 - 7.0	6.1 - 7.0
7.1 - 8.0	7.1 - 8.0
> 8.0	> 8.0
Erosion Rate Factor Transition Boundary	Inlet Hazard Area
Beach Fill Project > 300,000 cubic yards	Photo: 2009 USDA NAIP

Map Scale: 1:20,000

0 1,500 3,000 6,000 Feet

0 0.25 0.5 1 Miles

Horizontal Datum: NC State Plane NAD 83 Feet

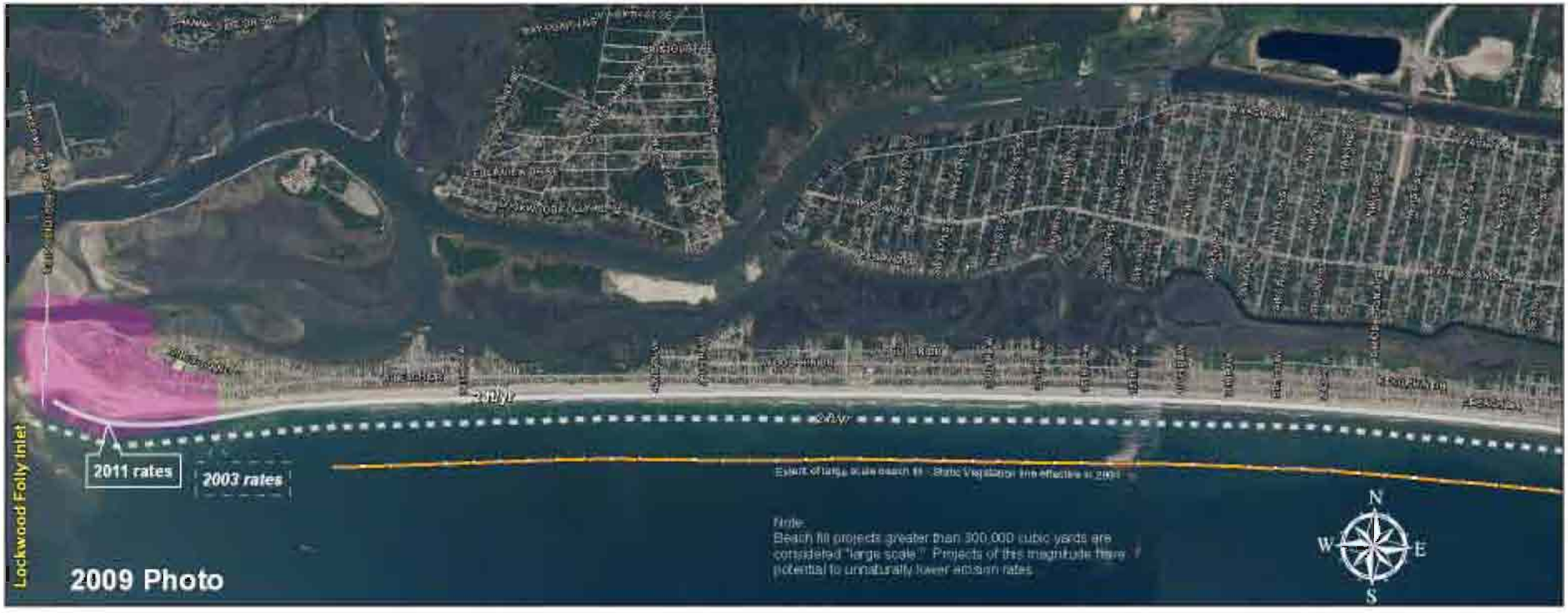
Setback Factors on this map represents long-term average annual erosion rates measured in feet per year. Shoreline segments that are accreting or have erosion rates less than two feet per year receive a setback factor value equal to two.

The information presented here is not predictive, nor does it reflect short-term erosion potential. This map may not be suitable for property specific determination of erosion rate factors near rate transition boundaries due to its small scale. For site specific determinations contact your CAMA Local Permit Official, or regional Division of Coastal Management field office.

400 Commerce Avenue
Morehead City, North Carolina 28557
1-888-4RCOAST

http://www.nccoastalmanagement.net

FIGURE 1-2: 2011 Long-Term Average Annual Erosion Rates Eastern Holden Beach

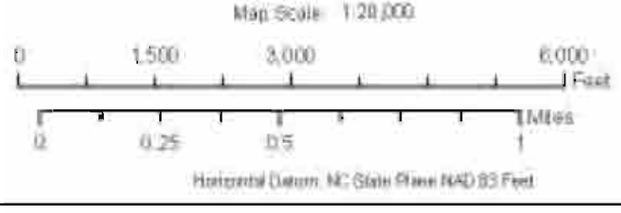


2011 Long-Term Average Annual Erosion Rate Update

at Oak Island, North Carolina

Legend

2011 Setback Factors (feet/year)	2003 Setback Factors (feet/year)
2.0	0.0 - 2.0
2.1 - 3.0	2.1 - 3.0
3.1 - 4.0	3.1 - 4.0
4.1 - 5.0	4.1 - 5.0
5.1 - 6.0	5.1 - 6.0
6.1 - 7.0	6.1 - 7.0
7.1 - 8.0	7.1 - 8.0
> 8.0	> 8.0
Erosion Rate Factor Transition Boundary	Inlet Hazard Area
Beach Fill Project > 300,000 cubic yards	Photo: 2009 USDA NAIP



Setback Factors on this map represents long-term average annual erosion rates measured in feet per year. Shoreline segments that are accreting or have erosion rates less than two feet per year receive a setback factor value equal to two.

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FIGURE 1-3: 2011 Long-Term Average Annual Erosion Rates Western Oak Island

2.0 PURPOSE AND NEED

The Town of Holden Beach proposes to construct a terminal groin on the shoreline adjacent to Lockwoods Folly Inlet that would complement the existing nourishment activities on the east end of Holden Beach. A beach nourishment component is also proposed and will occur concurrently with groin construction. *In general, the east end shoreline reach experiences localized erosion rates that are beyond the ability to effectively address with beach fill placement alone.*

The purpose of the proposed project is erosion control and beach/dune restoration which will protect residential structures and Town infrastructure on the east end of Holden Beach. In addition to homes and infrastructure, an additional purpose of the project is to maintain adequate recreational beach area as well as maintaining the public parking and public beach access on the eastern end of the island.

Figure 2-1: Holden Beach East End dune restoration activities following Hurricane Hanna dune erosion and breaching.

The east end of Holden Beach has and is experiencing consistent, relatively severe erosional conditions. The beach as well as the dune system have experienced chronic and episodic

erosion and have been rebuilt several times during the past decades. Likewise, dune breaching and flooding has also occurred, most recently during Hurricane Hanna in 2008 (see Figure 2-1). Note that periodic nourishments by both the Town and USACE have relieved this erosion; however, the periodic fill placement only provides a short-term benefit, and a more long-term solution is required.

The Town of Holden Beach desires to implement a long-term beach and dune stabilization strategy to protect the beach, dune system, and the public/private infrastructure by constructing a terminal groin at the eastern end of Holden Beach. In order to facilitate bypassing to downdrift areas, sand will also be placed adjacent to the groin. Final locations and placement quantities of sand will be determined during the project design process.

The proposed terminal groin installation is based on the following objectives:

- Stabilize the shoreline and maintain a healthy dry upper beach (berm) and dune;
- Increase opportunities for recreation, beach access, and enhancing available environmental habitats (i.e., potential to stabilize or increase inlet area shoreline sea turtle nesting, shorebird, and benthic community activity);
- Reduce future beach nourishment project frequency and required beach maintenance (dune rebuilding and revegetating, sand fending and walkover repair/replacement); and
- Optimize the groin benefits with reduction of both annual maintenance costs and future beach nourishment costs.

3.0 INDEPENDENT BEACH MANAGEMENT ACTIVITIES

In addition to seeking a permit for a terminal groin project, several other permitting projects are ongoing or planned by either the Town or the USACE. *Note that the proposed terminal groin project will include an east end nourishment*.

3.1 EXISTING TOWN BEACH NOURISHMENT PERMIT

Since 2002, Holden Beach has performed beach nourishment activities under CAMA Permit No. 14-02, NCDWQ Permit No. 20011836, and USACE Permits No. 200101101 and No. 200500935. The Town most recently modified its existing permits in early 2009 to allow a FEMA-sponsored nourishment to mitigate for Hurricane Hanna damages.

Given the above, the Town currently has active permits to place ~65,000 cy of beach compatible material utilizing the Smith and Turkey Trap upland borrow areas. Fill placement limits cover the majority of the Town's oceanfront shoreline. The DCM and USACE permits are valid until November 2013 and December 2014, respectively, and provide Holden Beach an active permit for emergency use following storm events. Volumes associated with such emergency activities are typically less than 100,000 cy (although the 2009 FEMA permit modification was 190,000 cy). Note that once an emergency nourishment is required, additional modifications to the permit pertaining to volume, placement, and possibly borrow sources may be necessary, depending on need at the time of the request. The Turkey Trap Road and Smith borrow sites are currently authorized sand sources in the existing permits (see Section 6.5 for more information on borrow areas).

3.2 ISLAND-WIDE NOURISHMENT UTILIZING OFFSHORE BORROW AREA

The Town is currently developing the necessary data/materials to submit a beach nourishment application using an offshore borrow area. The fill template for this project is centrally located on the island and separate from the terminal groin project.

There are essentially two reaches of beach that are historically nourished on Holden Beach:

1) Island-Wide (baseline Station 40+00 west to Station 270+00)
2) East End (Station 40+00 east to Lockwoods Folly Inlet)

Figure 3-1 presents these two reaches with Holden Beach and USACE beach fill placements since 2001. This document will refer to the "east end" as defined above. Also note that ATM observations indicate that the net transport between ~Stations 0+00 and ~40+00 (see Figure 3-

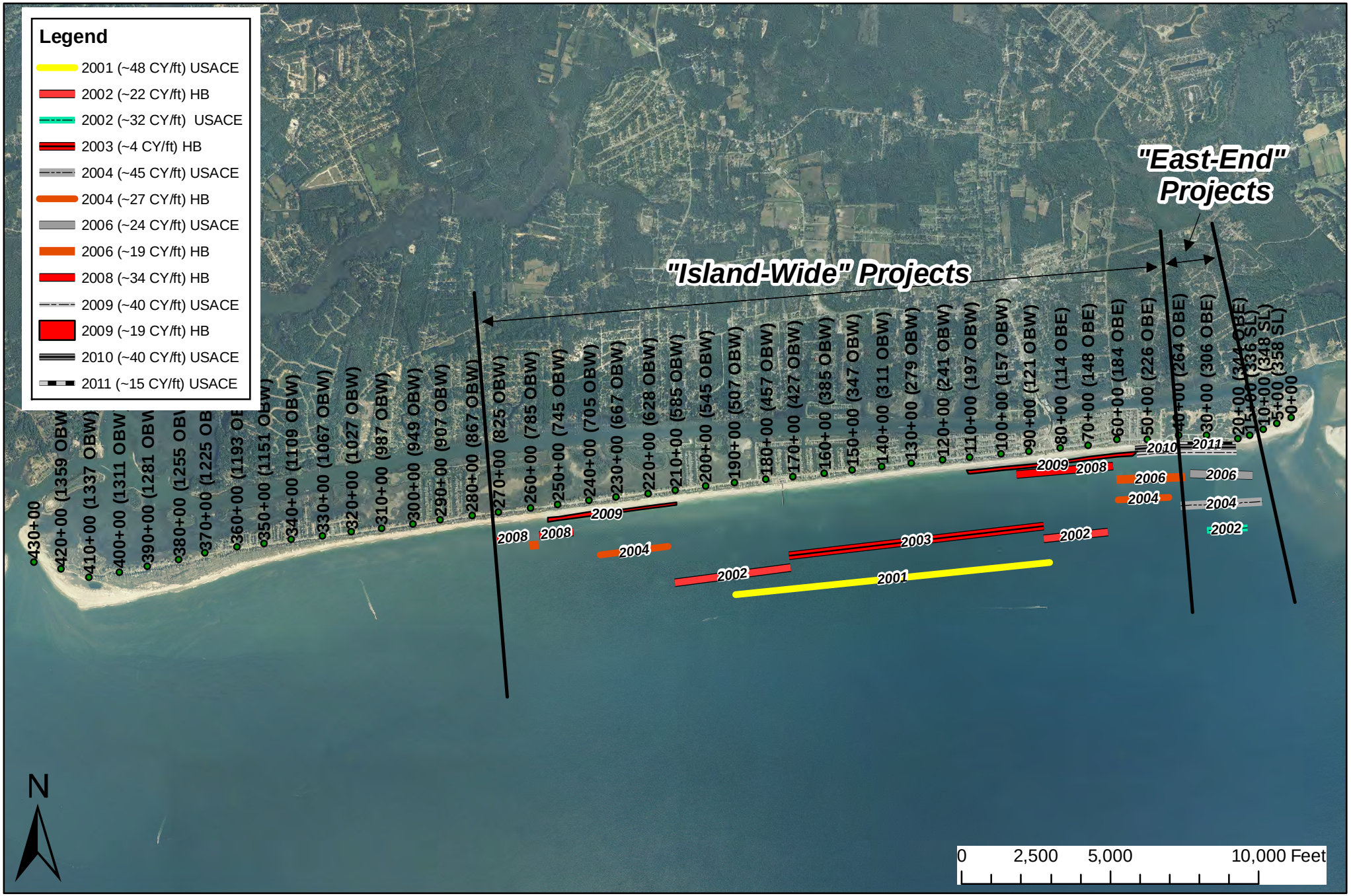


Figure 3-1:
Holden Beach Nourishment Activity Since 2001. Note only USACE projects occur on "East-End"
(HB=Holden Beach)

APPLIED TECHNOLOGY & MANAGEMENT

1 for stationing) is toward the east, due to the strong influence of the Lockwoods Folly Inlet processes (ATM, 2001).

Historically, the Town has not placed material on the east end beach and has relied on USACE shallow draft waterway maintenance dredging projects for east end sand placement. Note that the Town's nourishment projects are completely funded by the Town, from permitting through design, construction, and monitoring. The "USACE" east end beneficial nourishments from AIWW dredging, as described in this document, are primarily funded by the Corps, while the Town is typically responsible for 25 to 35% of the costs. The USACE is also in charge of permitting, design, construction and monitoring for the "USACE" projects described in this document. The 2001 beach nourishment along the central portion of Holden Beach ("Section 933 Project") was sponsored by the USACE, with cost sharing by the Town, as part of mitigation for deepening of the Wilmington Harbor.

Town fill placement is typically done in coordination with USACE east end fill placement. For example, in 2009 the Town began its "island-wide" fill placement where the USACE east end fill placement stopped (See Figure 3-1). Since 2002, the Town has not placed sand farther east than Station 40+00 (see Table 3-1) as a berm/beach nourishment. It is noted that the Town has performed limited *dune restoration efforts* on the east end in response to storm events.

Table 3-1: Town of Holden Beach Nourishment Summary over last decade (USACE fill placement is not included in this table).

Date	Baseline Stations Nourished	Approximate Volume of Material Placed (cubic yards)	Material Source
3/02 – 4/02	66+00 - 90+00, 175+00 – 217+00	141,700	Oyster Harbor upland site
Winter 2002-2003	90+00 – 175+00	30,000	Boyd Street Disposal Area
12/03 – 4/04	46+00 – 68+00 and 215+00 – 238+00	123,000	Smith borrow site
Early 2006	40+00-60+00	42,000	Smith borrow site
Early 2006	260+00 – 262+00	3,200	Smith borrow site
1/08 – 3/08	60+00 – 95+00 and 245+00 – 270+00	201,000	Smith borrow site
03/09 – 4/09	55+00 – 110+00 and 210+00 – 255+00	190,000	Smith borrow site

Regulatory agencies have historically established Station ~30+00 as the eastern-most limit of fill placement for Town projects. Natural resource agencies have promoted this to maintain a buffer for the shorebird habitat adjacent to Lockwoods Folly Inlet.

One of the primary goals of the Town's beach management strategy is to have no net reduction in sand volume from Holden Beach. Additional needs to increase storm protection to upland infrastructure, increase recreational beach area, and/or address hot spots may also be required.

For the proposed “island-wide” Holden Beach nourishment project utilizing an offshore borrow source, the forthcoming permit application is anticipated to include Stations 40+00 to 300+00, which represents the majority of the ocean shoreline (approximately 5.0 miles) with an average placed volume of 50 cy/ft (similar to the USACE Section 933 project). This equates to a volume of 1.3 million cubic yards, which would be broken down into manageable phases of work, similar to the original 2001 permits.

From a timing perspective, the Town must remain flexible in placement of beach fill material due to the ongoing consideration of a USACE “50-yr” nourishment project (see Section 3.3). The USACE 50-yr nourishment project is also essentially “island-wide”.

The ongoing USACE AIWW dredging and beach fill placement (e.g., beneficial use of dredged material) is an ‘east end’ project, similar to the proposed groin and nourishment project (see Section 5.3.3). While some coordination is needed to avoid possible overlap or logistical issues, “east end” projects are generally separate and unique from “island-wide” projects based on timing, purpose, and project sponsor(s).

3.3 USACE 50 YEAR PROJECT

The USACE Brunswick County Beaches (BCB) project includes the nourishment of Caswell Beach, Oak Island, and Holden Beach over a 50-year cycle. The USACE recently released an updated Review *Plan for the Integrated General Reevaluation Report and Environmental Impact Statement for Brunswick County Beaches, North Carolina* (USACE, 2011).

The 2011 Review Plan study area focus is Oak Island and Holden Beach. The two islands are separated by Lockwoods Folly Inlet. Other waterbodies in the study area include the Cape Fear River to the east, Shallotte Inlet to the west, and the Atlantic Intracoastal Waterway (AIWW) to the north. The study area also includes offshore borrow areas lying 1 to 8 miles from the shoreline and borrow areas in Jaybird Shoals, Frying Pan Shoals, Lockwoods Folly Inlet, and Shallotte Inlet.

The proposed nourishment footprint for Holden Beach will be an “island-wide” nourishment, similar in scope to the USACE’s 2001/2002 Section 933 project. The Oak Island nourishment is also planned to be island wide.

The current timeline for the BCB project estimates the Final EIS/NEPA Public Review (MSC Commanders Public Notice) in January 2014 (USACE, 2011). No dates for project construction (i.e. beach nourishment) are provided. Recent experience suggests that USACE nourishment projects are very susceptible to funding limitations, thus the fate of the BCB project is uncertain and not likely to advance to construction in the short-term.

4.0 PROJECT SITE HISTORY

The east end of Holden Beach has historically experienced severe erosional conditions. Many residences and infrastructure on the east end have been lost to erosion, where delineated parcels out in the water are all that remain (see Figure 4-1).

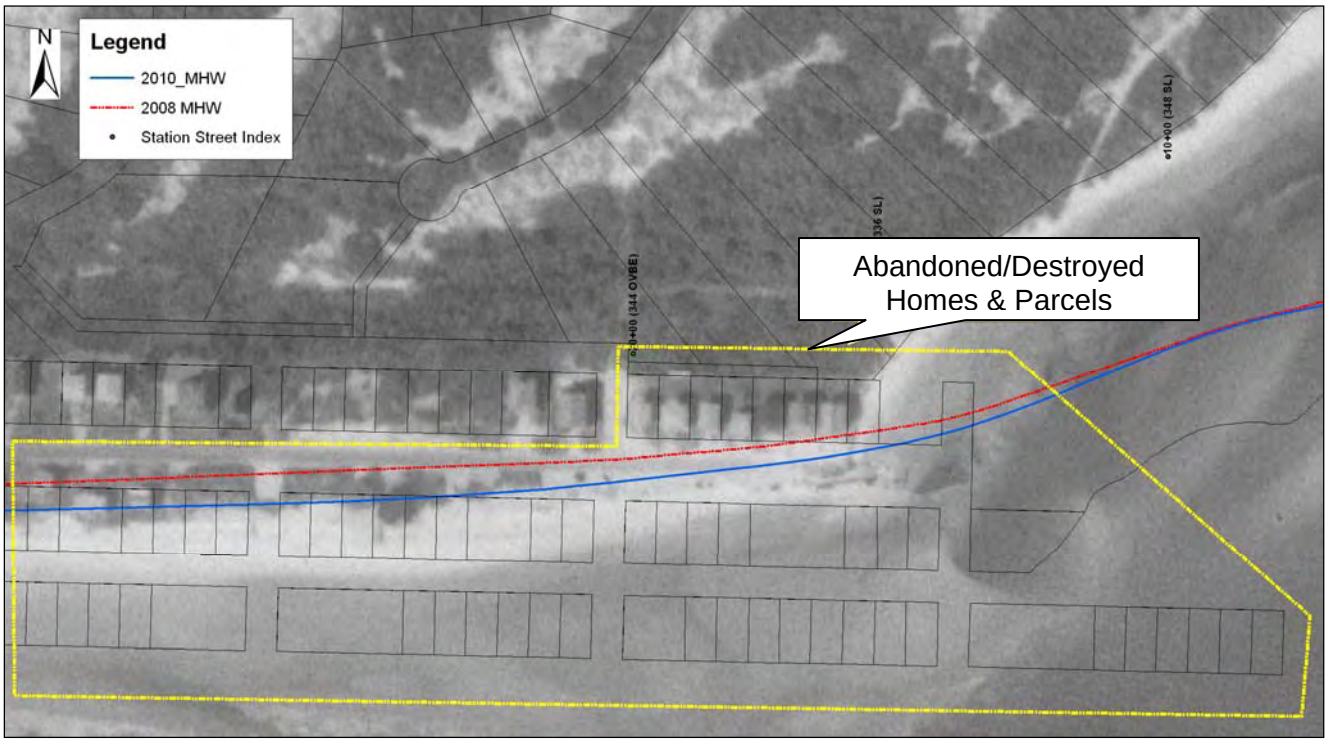


Figure 4-1: 1993 aerial and parcel lines depicting abandoned/destroyed parcels on East End of Holden Beach.

A temporary terminal groin field was constructed in the 1970s along the east end of Holden Beach. The project consisted of 15 sand-filled nylon tubes that were found to be beneficial in stabilizing dredged material from Lockwoods Folly Inlet (Machemehl, 1975). Figure 4-2 present a layout of the 15 groins on the east end of Holden Beach, and Figure 4-3 presents photos of the groins (from Machemehl, 1975). While the groin field was successful and economical, the temporary nature of the nylon material and the lack of ongoing nourishment activities limited its long-term effectiveness.

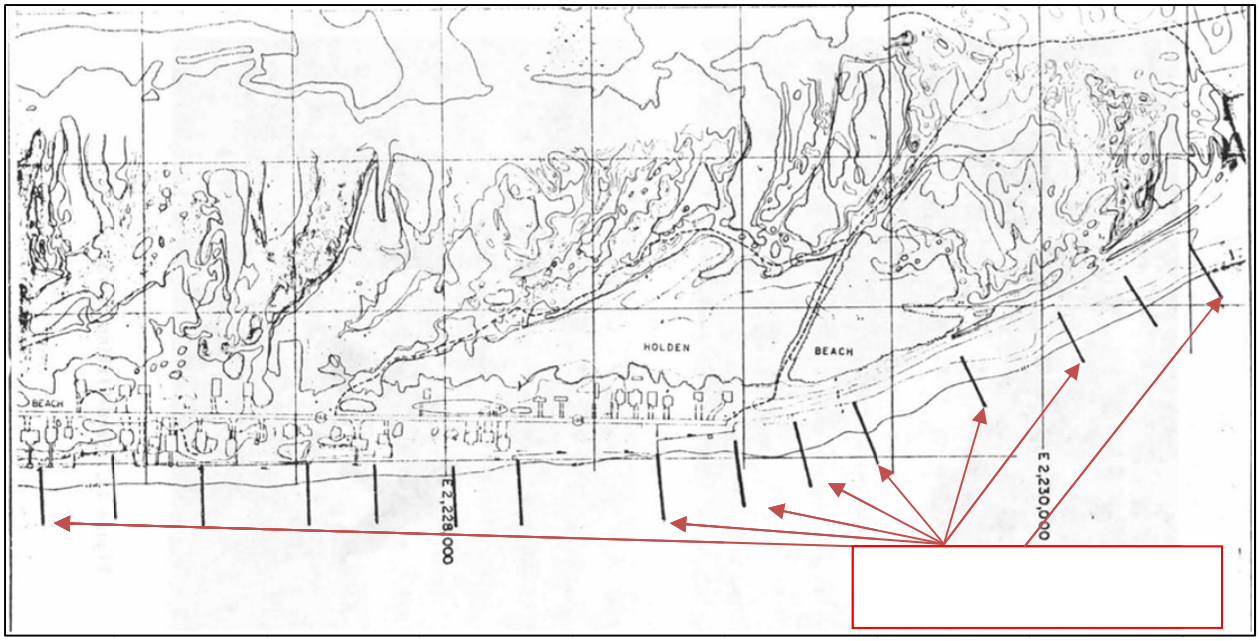
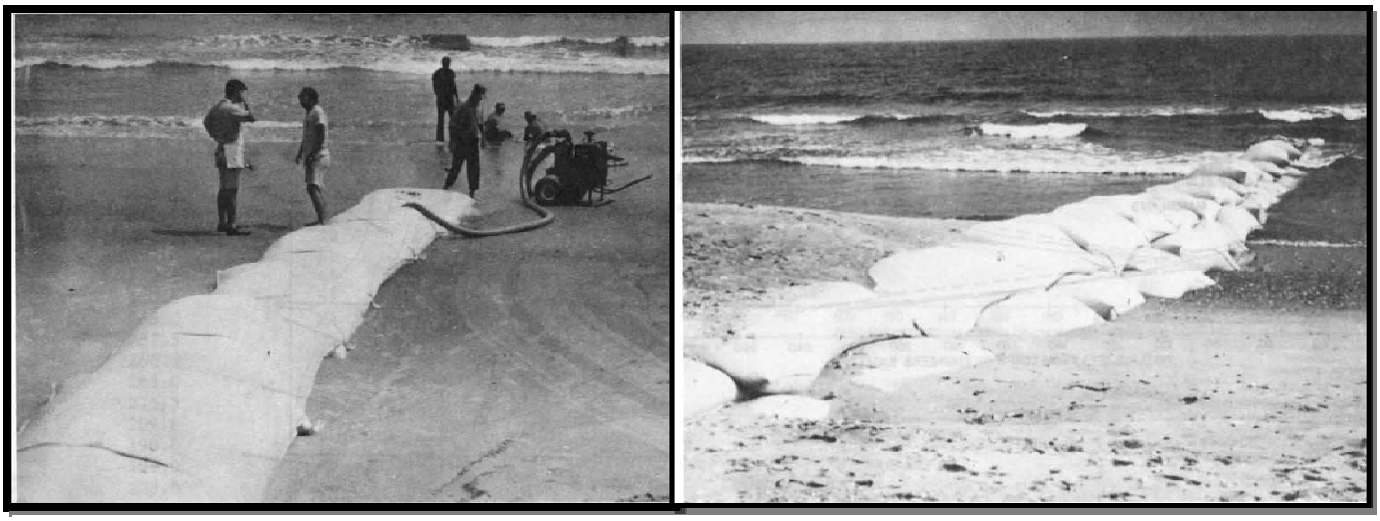


Figure 4-2: 1970's groin layout on east end of Holden Beach (source: Machemehl, 1975)



The USACE 1973 General Design Memorandum (GDM) for Yaupon and Long Beach also evaluated the use of terminal structures at Lockwoods Folly Inlet. Figure 4-4 presents a conceptual terminal groin system; although they are described as 'jetties' in the GDM (USACE, 1973). Sand management (i.e., mechanical back-passing and by-passing) was also included for this alternative.

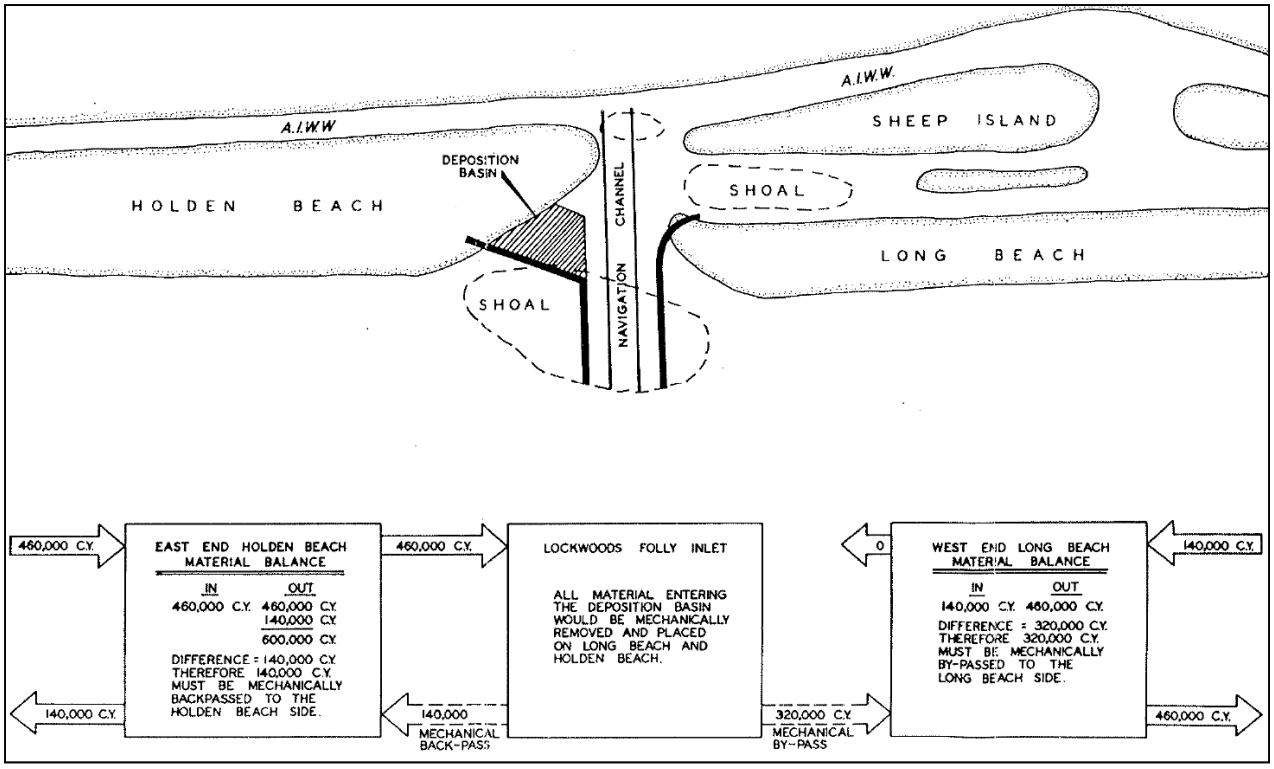


Figure 4-4: Conceptual jetties alternative relative to sediment budget (USACE, 1973)

As previously mentioned, the east end area experiences localized erosion rates that are beyond the ability to effectively address with beach fill placement alone (again, recognizing the importance of inlet management to control the erosion along both sides of the inlet). In a February 2009 N.C. Coastal Resources Commission (CRC) meeting, Dr. Bill Cleary identified Lockwoods Folly Inlet as a good candidate for terminal groins. Additionally, the recent NC Terminal Groin Study (Moffatt & Nichol, 2010) included Lockwoods Folly Inlet as one of the 12 inlets studied statewide from an economics perspective.

5.0 EXISTING CONDITIONS

The primary cause of shoreline retreat along Holden Beach is due to long-term erosion through natural processes of littoral sediment transport, sea level rise, and storm related recession. Tidal currents, wave focusing and storage of sediment in the ebb and flood shoals of surrounding inlets (Shallotte and Lockwoods Folly) have also considerably affected the shoreline history of Holden Beach. Along the eastern end of the island, erosion has been prominent due to the continual shifting and reorientation of the main ebb and flood channel(s) of Lockwoods Folly Inlet. Figure 5-1 presents a typical schematic of these ebb and flood channel features.

Sediment transport along the shorelines adjacent to Lockwoods Folly Inlet has a net direction into the inlet, due to refraction of waves by the ebb shoal and inlet induced flood tidal currents. As a result, much of the sand on the inlet shorelines of Holden Beach and Long Beach (Oak Island) travels into Lockwoods Folly Inlet (especially during flood tides). During ebb tides, flow is more concentrated and jets out in a more centrally located flow, moving sediment near the main channel out onto the outer ebb shoal.

Figure 5-1: Conceptual regional and local net sediment transport schematic at Lockwoods Folly Inlet (2004 aerial).

In addition to inlet-related transport, the eastern end of Holden Beach is influenced by regional sediment transport. Regional net sediment transport is generally from north to south for the entire East Coast. Of course in the case of Holden Beach, sediment transport is not north to south, but east to west (i.e., downcoast). This is based on site observations and previous studies by the USACE (Thompson et al, 1999; USACE-CHL, 2008; OCTI, 2008). It is noted that some older references (USACE, 1973 and Machemehl, 1977) suggest that net transport along the eastern end of Holden Beach is more strongly toward the east. ATM observations indicate that the net transport between ~Stations 0+00 and 45+00 (see Figure 5-2 for stationing) is toward the east, due to the strong influence of the Lockwoods Folly Inlet processes (ATM, 2001). This varies based on shoal and channel configuration and wave climate.

On a regional level, sand transport occurs via "bypassing" of sand along the ebb shoal of the inlet (see Figure 5-1). The shoal system typically begins at the shoreline curvature inflection point on Long Beach and extends across Lockwoods Folly Inlet out to ~2,000 feet offshore, before arcing back to Holden Beach.

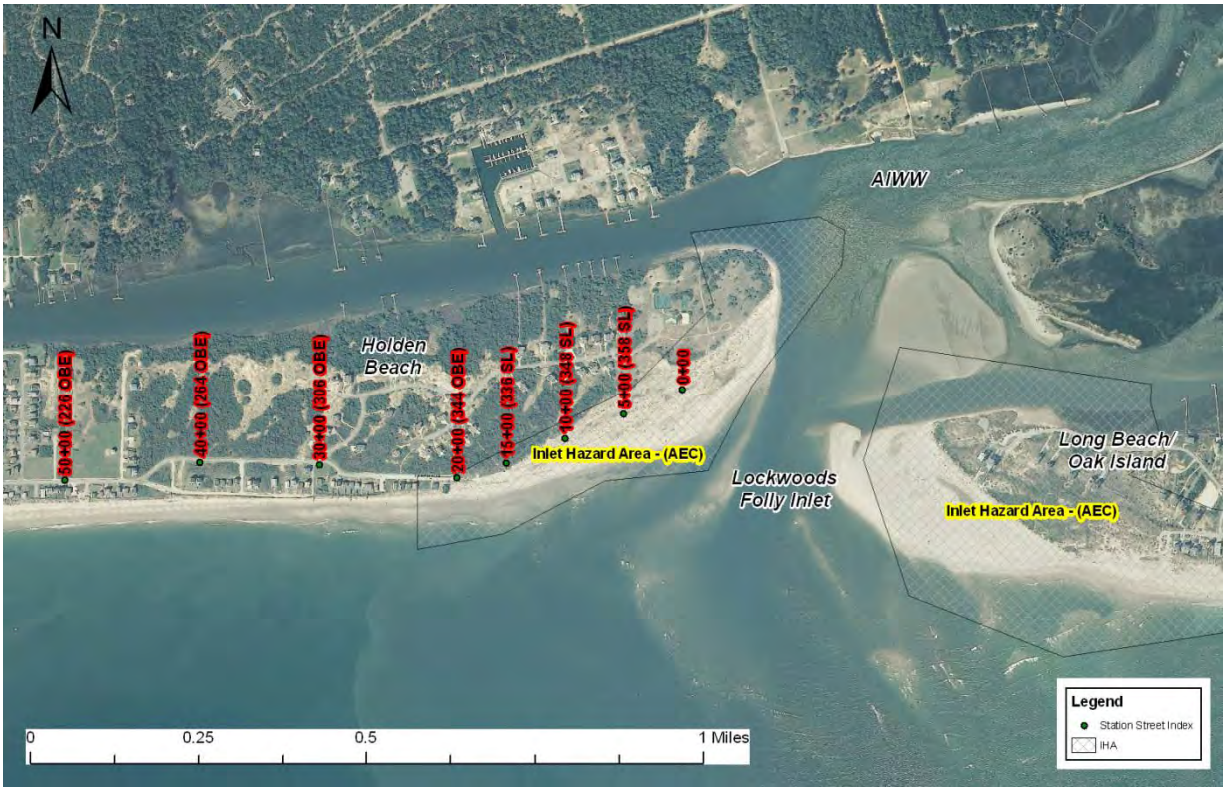


Figure 5-2: Current Inlet Hazard Areas for Lockwoods Folly Inlet. Holden Beach stationing is also pictured.

The overall east-west position of Lockwoods Folly Inlet has remained relatively stable for several centuries (Cleary, 2008). However, the position and orientation of the main ebb channel (large red arrow in Figure 5-1) relative to Holden and Long Beach significantly affects erosion

and accretion patterns at the east end of Holden Beach (and west end of Long Beach). Ebb shoal breaching (and associated sand bypassing across the outer ebb shoal bar(s)) and realignment events can be estimated using aerial photos and bathymetry (see Figure 5-3).

The western Oak Island shoreline, while affected by Lockwoods Folly Inlet, has been historically more stable than the east end of Holden Beach (Cleary, 2008). A similar pattern occurs at nearby Shallotte Inlet, where the west end of Holden Beach experiences typically less severe erosion cycles than the east end of Ocean Isle.

During a majority of the time over the past 70 years, the main ebb channel of the inlet has been aligned toward the southeast and Long Beach (see Figure 5-3, upper image). This has resulted in severe erosion along the east end of Holden Beach (some of the highest erosion rates in southeastern NC per OCTI, 2008) and resulted in the loss of properties along the beachfront. During times when the main ebb channel of the inlet is oriented closer to Holden Beach or perpendicular to the shoreline (as occurred in ~ 2001-2004, see Figure 5-3, lower image), some relief to the erosion occurs.

A critical consideration in stabilizing the east end of Holden Beach (and west end of Long Beach) is thus actively managing the inlet so that the channel is centered and oriented north-south to “equalize” the erosion stress on each side of the inlet and minimize sand losses from the beach. This is partially accomplished by the current periodic dredging of the inlet shallow draft channel areas by the USCAE, with placement of the sand on the adjacent beaches. *It is anticipated that a terminal groin, in conjunction with an ongoing inlet dredging/nearshore placement program, is the most effective solution to stabilizing the shoreline proximate to the inlet.*

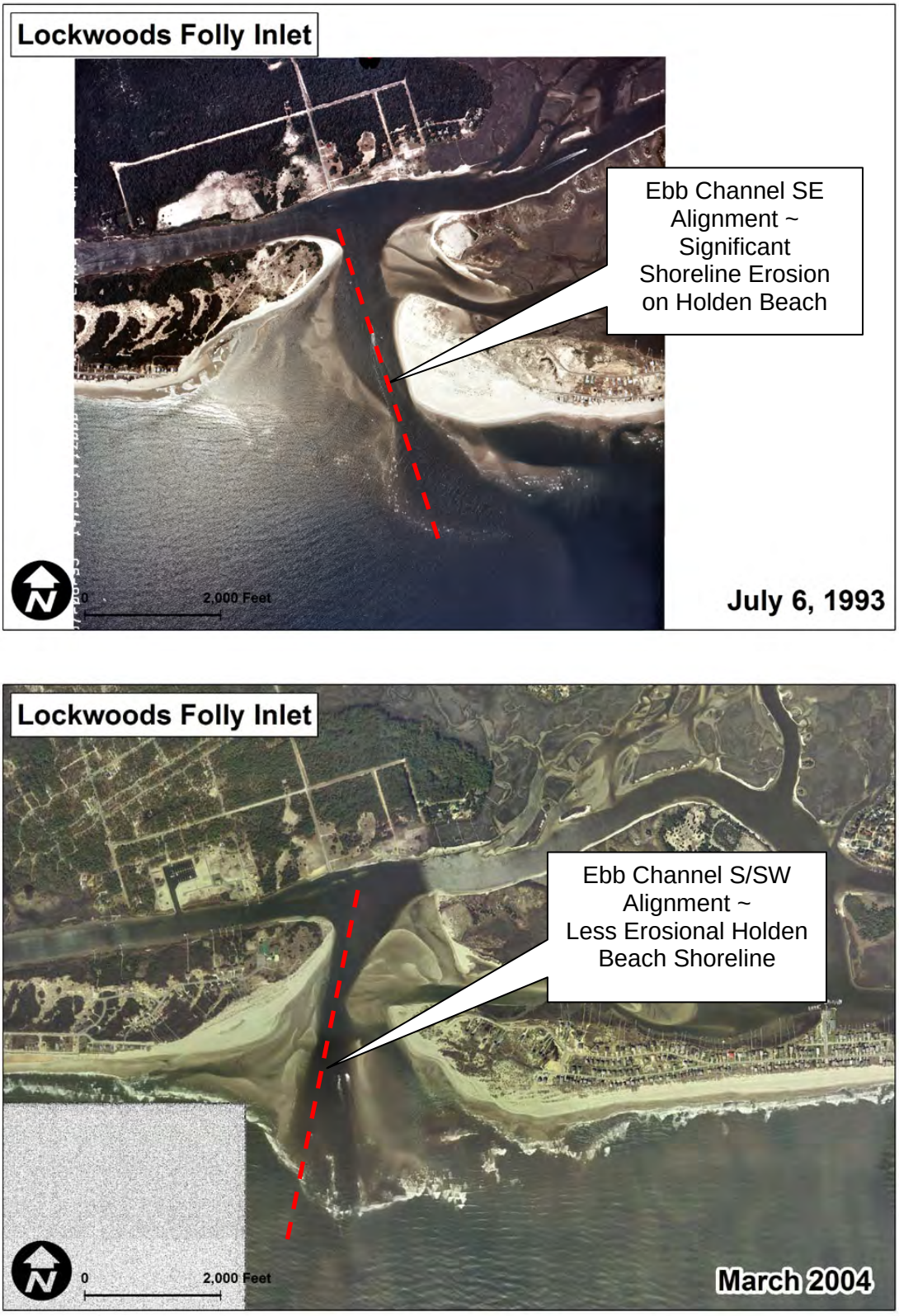


Figure 5-3: USACE aerial photos showing erosion and accretion patterns related to position/orientation of inlet main ebb channel (aerials source: Cleary, 2008)

5.1 GROSS VERSUS NET SEDIMENT TRANSPORT

Terminal groins, as with all groins and jetties, typically hold sand on the updrift side (forming a 'fillet') while potentially detrimentally affecting downdrift beaches under extremely erosional conditions. In a regional net transport sense, Holden Beach is downdrift of the proposed eastern end terminal groin. However, locally, the inlet throat itself is downdrift of any groin placed along the inlet margin. Therefore, terminal groin design must consider the potential impacts, mainly to Holden Beach itself as well as Lockwoods Folly Inlet. Note that nourishment is proposed to be included with any groin installation. This minimizes potential for negative downdrift impacts. Additionally, combining beach fill and groin structures is typically more effective than nourishment-only in 'hot-spot' erosional areas.

Gross transport includes sand transport that moves both east to west and west to east, depending on wind and wave direction, currents, etc. Net transport sums up all gross transport and is typically used when describing sediment transport. Net transport has been estimated to be ~ 228,000 cy/yr to the west (Thompson, 1999). Gross transport is also important, especially for the east end of Holden Beach, where sand moving from west to east moves into Lockwoods Folly and is lost from the beach system into the shoals and channel. OCTI (2008) estimates gross transport to be ~650,000 cy/yr at Lockwoods Folly Inlet (~400,000 cy/yr to the west, ~150,000 cy/yr to the east; resulting in a net transport of ~250,000 to the west).

Sediment budget estimates for Lockwoods Folly Inlet (USACE, 1973; Machemehl, 1977; OCTI, 2008) indicate a "sink" of sand (material lost from the adjacent beaches and deposited into the inlet shoals) ranging from 125,000-240,000 cy/year (generated from both Holden and Long Beach shorelines). The proposed terminal groin would likely reduce the amount of sand lost to this "sink" effect. This would in turn reduce annual maintenance dredging costs.

5.2 NATURAL RESOURCES

The estuarine/back bay region of Lockwoods Folly Inlet includes the Atlantic Intracoastal Waterway (AIWW) as well as Lockwoods Folly River (see Figure 5-4). The Lockwoods Folly River is a relatively small tidal river with very low freshwater inflows (USACE, 1992).

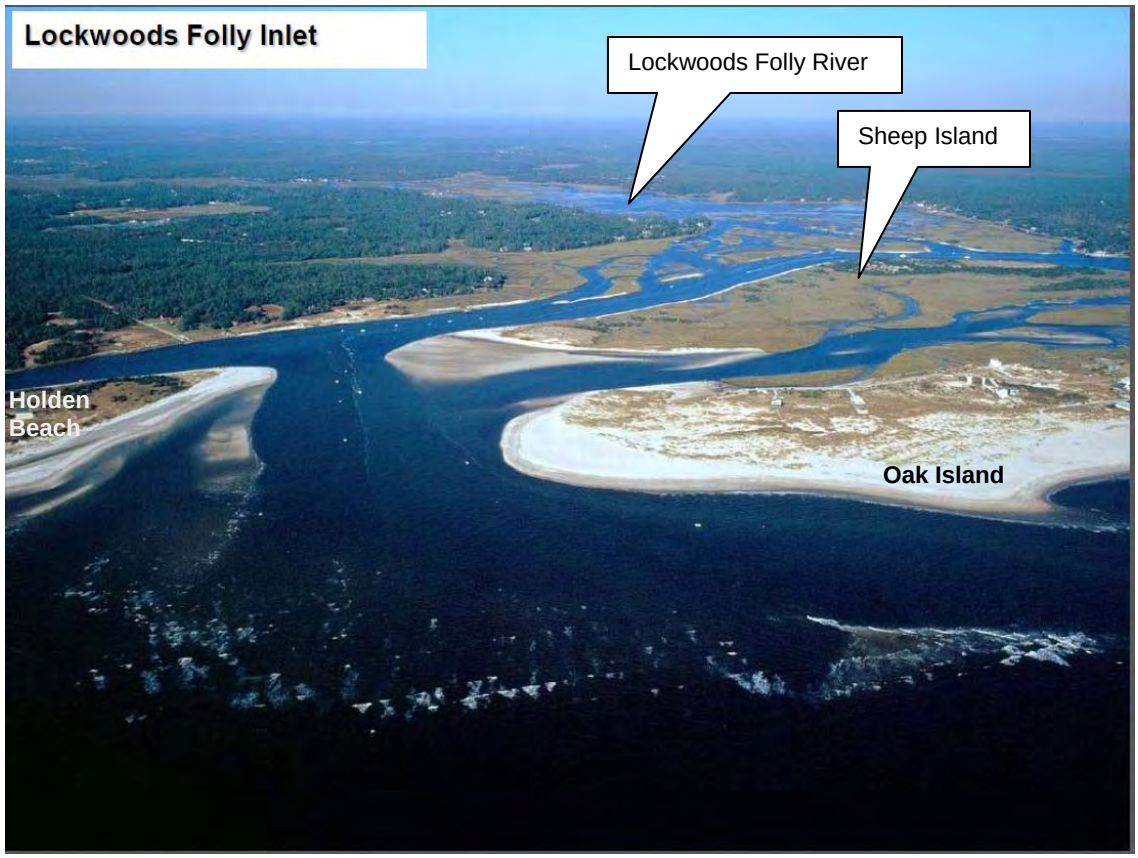


Figure 5-4: Lockwoods Folly Inlet (source: USACE Shallow Draft Users Meeting Presentation).

In 2009, Brunswick County submitted a Water Resources Development Grant Application to dredge shoals from the Lockwoods Folly River to enhance flushing (see Figure 5-5). According to the grant application: "*Sediment deposition is believed to be responsible for alteration of the hydrology and the aquatic habitat of tidal creeks at the southern extent of the Lockwoods Folly River.*" Figure 5-5 below presents a land classification schematic of the area.

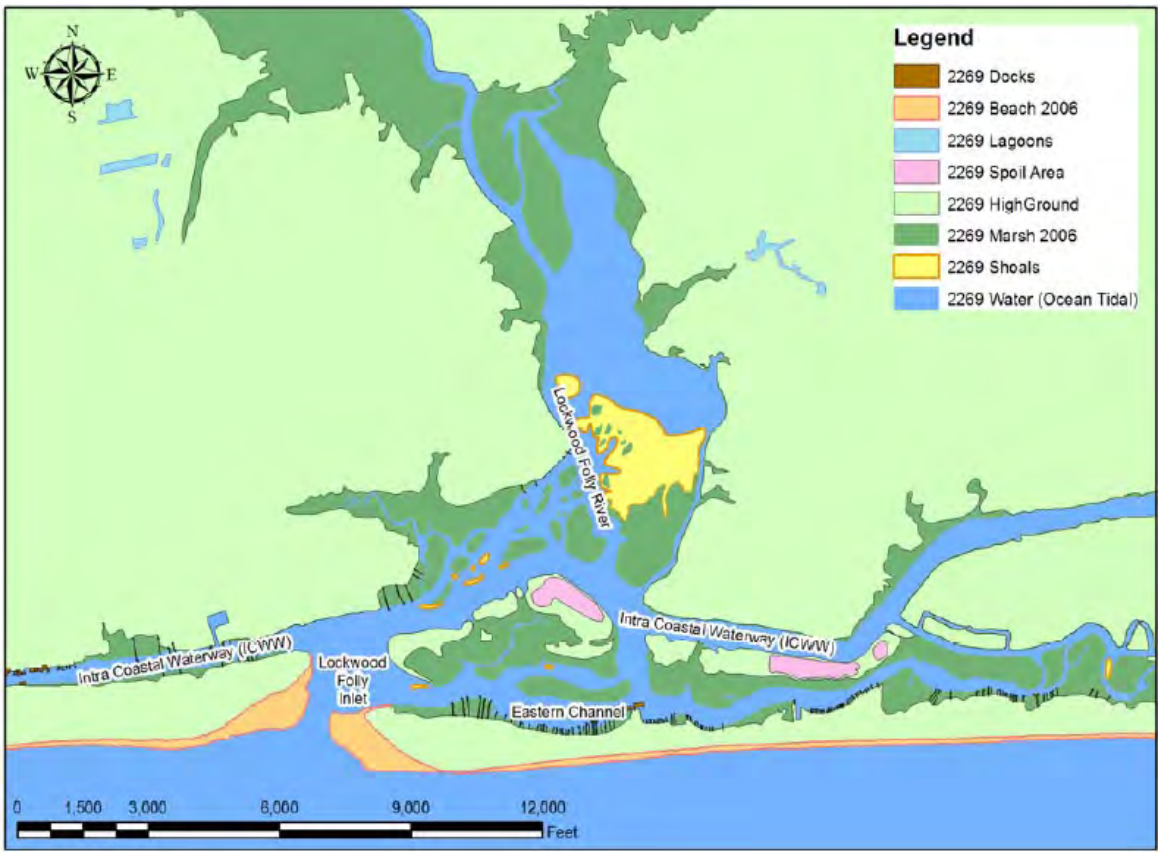


Figure 5-5: Lockwoods Folly River area land classifications (source: Brunswick County, 2009)

In addition to the above project, the USACE has also studied the Lockwoods Folly Inlet area for its ongoing 50-year Brunswick County Beaches nourishment program. Figure 5-6 below is from a USACE presentation related to environmental resources at the inlet. Additionally, several general essential fish habitat (EFH) concerns were identified and these include:

(1) Loss of benthic foraging habitat for finfish and shrimp.
    (a) Shrimping grounds around the shoals
(2) Finfish
    (a) Sandy shoal features are important juvenile finfish foraging habitat
    (b) Larval Fish transport

Figure 5-6: Natural resources as identified during the USACE Brunswick County Beaches Project Permitting (source: USACE presentation at January 2009 Brunswick County Beaches PDT meeting)

5.3 ECONOMICS

The oceanfront beaches and adjacent properties on the east end of Holden Beach comprise a major social and economic resource for the Town of Holden Beach. Additionally, tourism has been Brunswick County's number one industry for decades (South Brunswick Magazine, http://www.thesbm.com/brunswicktda). In general, erosion of the east end of Holden Beach can result in a reduced tax base due to the loss of homes as well as reduced tourism due to restricted beach access and recreation. As indicated previously, annual maintenance dredging of the shallow draft project at Lockwoods Folly Inlet, as well as annual dredging of the Lockwoods Folly AIWW crossing are also anticipated to be reduced as a result of the proposed terminal groin project.

5.3.1 RECREATION

Public access to the eastern end of Holden Beach and Lockwoods Folly Inlet are a critical economic component to the Town. Popular activities include, but are not limited to, surf fishing, swimming, surfing, walking, shell hunting, sunbathing, bird watching, and boating. Currently, there are periods of significant loss of dry beach due to erosion, which limits many beach

activities to low-tide periods. The proposed groin and nourishment project would make the beach more accessible during the year, particularly during times of high tide. Cost-effective maintenance of a navigable shallow draft channel from the ocean to the AIWW is also a benefit to recreational sport fishing interests, who have the opportunity to utilize the Lockwoods Folly Inlet channel to seek safe refuge in the event of storms.

5.3.2 INFRASTRUCTURE

In addition to residential homes, principal elements of the town's infrastructure include the streets, utility lines, and public access parking areas owned and maintained by the Town. FEMA has helped cover damages that occurred during hurricanes; however the Town has to fund any repairs due to northeasters or other erosional events not declared a federal emergency.

The recently published Terminal Groin Report (Moffatt & Nichol, 2010) developed two different economic categories for a general assessment of terminal groin feasibility:

1) 30 Year Risk Area (YRA)
2) Imminent Risk Property (IRP)

The 30 year risk areas (YRAs) were defined by lines on aerial photo maps provided by the North Carolina Division of Coastal Management. The maps are based on aerial photos from 2003-2009. Any land existing seaward of the lines is assumed to be at risk in the next 30 years. These lines were agreed upon by the Science Panel for use in this assessment since they represent the best currently available data (see Moffatt & Nichol, 2010 for more information).

Imminent Risk Property (IRP) and infrastructure are located immediately adjacent to erosion control sandbags locations or between two nearby sandbag locations (Moffatt & Nichol, 2010).

The Terminal Groin Study included the following economic values:

- Residential property
- Commercial property
- Government property
- Road infrastructure
- Waterline infrastructure
- Sewer infrastructure
- Property tax base and revenues
- Recreation and environmental value

The NEPA permitting process for the proposed terminal groin project will build upon the economic analysis established in the Terminal Groin Study.

5.3.3 DREDGING

Lockwoods Folly Inlet contains a federally authorized shallow draft navigation channel where the USACE performs routine maintenance dredging for navigation using pipeline (i.e., cutterhead), split-hull hopper, and side-cast dredges. Due to different USACE funding sources, there are two basic routine maintenance activities that occur at Lockwoods Folly Inlet:

1) Outer Bar side-cast dredging
2) Lockwoods Folly Inlet AIWW crossing cutter-head dredging and beach fill placement

Figure 5-7 presents these two project footprints. In terms of outer bar dredging, there is no defined dredge template for Lockwoods Folly Inlet and dredging activities are restricted to follow "deep water". This restriction limits the ability for the USACE to perform advanced dredging; consequently, dredging within Lockwoods Folly Inlet itself generally occurs 2 - 3 times per year. Several shipwrecks also exist at this inlet that must be avoided.

In addition to ocean-side inlet areas, the AIWW portion of Lockwoods Folly Inlet has proven to be a valuable source of beach compatible material. Lockwoods Folly Inlet AIWW crossing is dredged annually and beach fill is usually placed on the eastern end of Holden Beach. The primary purpose of this project is for AIWW maintenance, therefore the project footprint is necessarily limited to the AIWW and a bend widener. Table 5-1 below presents the history of this project over the last decade. A project is currently contracted for winter 2011/2012 (per email communication from Roger Bullock, USACE Navigation Branch).

Table 5-1: Recent Lockwoods Folly Inlet AIWW Crossing fill placement on the eastern end of Holden Beach

Date	Beach Stations Nourished	Approximate Volume of Material Placed (cubic yards)
3/02 - 4/02	20+00 – 30+00	32,000
9/04 – 11/04	15+00 – 40+00	113,230
May 2006	15+00 – 40+00	62,853
Winter 2008/2009	20+00 – 40+00	100,000
April 2010	20+00 – 55+00	140,000
February 2011	20+00 – 40+00	32,000
Winter 2011/2012	20+00 – 40+00	30,000 estimated*

*Note – estimate from USACE Navigation Branch

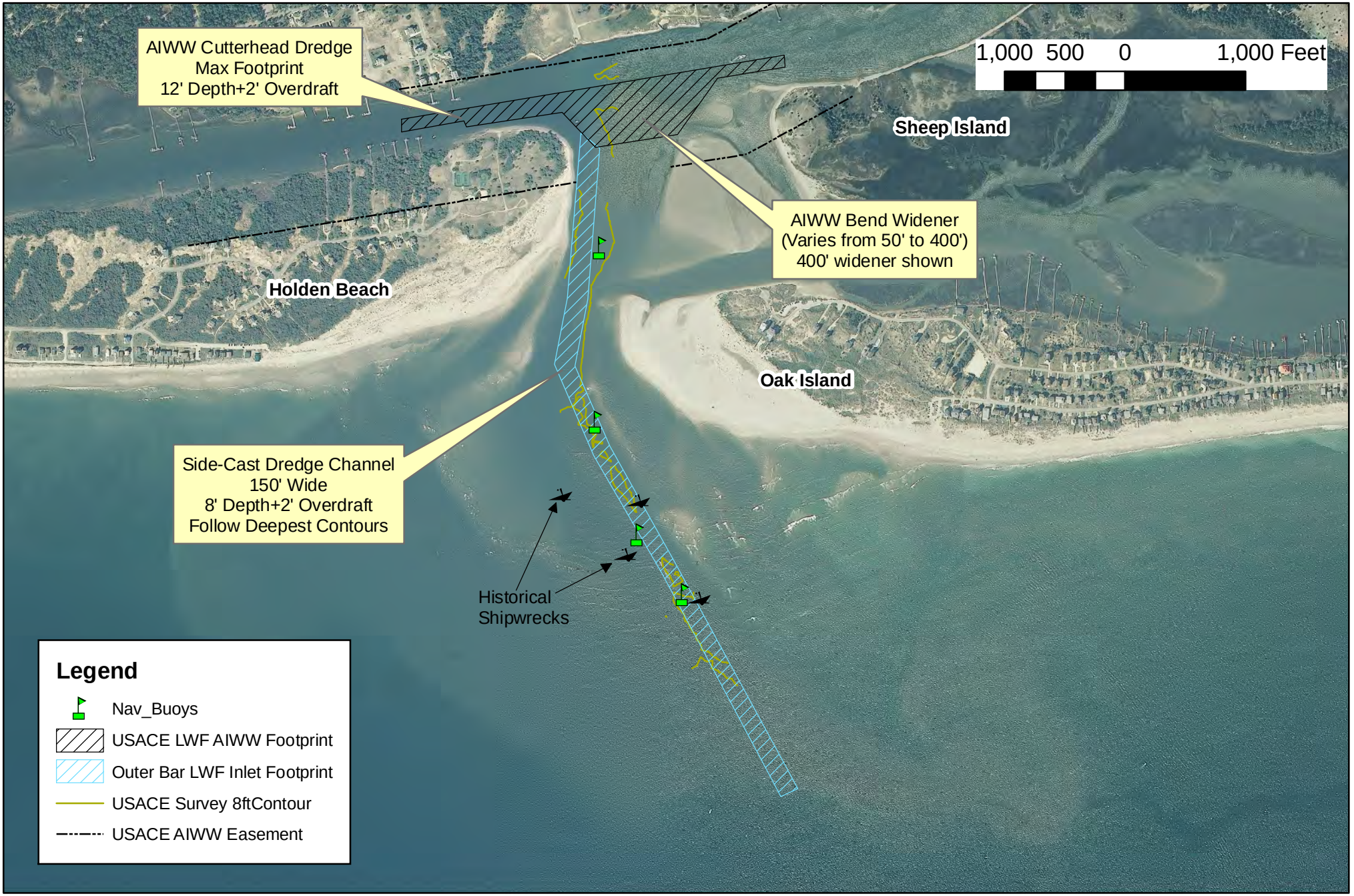


Figure 5-7:
Lockwood Folly Inlet USACE Dredging Activities
Two primary USACE activities occur -
1) Outer bar side-cast dredging and 2) AIWW cutterhead dredging and beach fill placment

APPLIED TECHNOLOGY & MANAGEMENT

The shoaling rate for Lockwoods Folly Inlet has been estimated between 125,000 cy/yr (OCTI, 2008) and 140,000 cy/yr (Machemehl, et al., 1977). From a terminal groin and beach nourishment perspective, it would be beneficial if the current AIWW dredge footprint were expanded to capture more of the material that is trapped in Lockwoods Folly Inlet.

The beneficial use of this dredged material by the USACE for beach placement is a critical component of an effective inlet management plan and this is planned to occur in the future. If the USACE discontinues this practice due to funding shortages, then Holden Beach plans to establish a Memorandum of Agreement to continue this placement (and has been in contact with the USACE about this).

It is anticipated that a terminal groin will incrementally reduce the amount of AIWW dredging and therefore reduce costs associated with this effort. Reduced shoaling of the AIWW is beneficial to recreational and commercial navigation. The Varnamtown shrimping fleet on the Lockwoods Folly River and recreational sportfishermen from the area marinas use this reach of the AIWW frequently. While the proposed terminal groin project is anticipated to enhance navigation for inner portions of the Lockwoods Folly Inlet and the AIWW; the proposed groin will not cut off the outer ebb shoal (as a jetty would) and not eliminate the need for maintenance dredging.

6.0 AVAILABLE ALTERNATIVES

An important component of the Work Plan is to identify available alternatives for the proposed project. Available alternatives, as identified by the NC Division of Coastal Management (DCM), to consider include:

1. No action/abandonment
2. Buyout/relocation
3. Beach nourishment without inlet relocation
4. Beach nourishment with inlet relocation
5. Sand borrow site analysis/selection

In order to evaluate each alternative, an economic analysis will also be incorporated.

6.1 NO ACTION

The No-Action alternative refers to performing no beach or inlet management activities. This alternative would allow erosion to continue and would result in the loss of additional property. Properties would likely be condemned and require removal where homes and infrastructure are impacted. This would result in tax revenue losses accumulated to Brunswick County and the Town of Holden Beach in addition to the substantial loss of property value to the individual property owners. The No Action alternative would also likely limit beach recreation and tourism due to reduced access and minimal available dry beach at higher tides.

6.2 THREATENED STRUCTURE RELOCATION

The threatened structure relocation or buyout program is an alternative that can be practical under certain circumstances. The recent relocation of the "Serendipity" house in Rodanthe is an example of a recent relocation.

In terms of buyout programs, the Heinz (2000) report found that:

> *A previous attempt to encourage removal and relocation of threatened structures—the Upton-Jones Program, which existed from 1987 to 1994–was suspended because of limited usage and unintended outcomes. A relocation program, if pursued, would have to be carefully designed to avoid the shortcomings of the Upton-Jones Program.*

Additionally, a recent study of the beaches in the state of Delaware by Parsons and Powell weighs the cost of beach retreat against the cost of beach nourishment over the next 50 years. The study concluded that the cost of retreating from eroding coasts will be approximately four times the cost of renourishing the state's beaches (Parsons and Powell, 2001).

In order to review this alternative for the east end of Holden Beach, relocation and buyouts will be assessed on a site specific basis. Some losses will occur under this alternative and these losses typically include the costs of property lost, costs of property that must be purchased to relocate a structure, and the costs of relocation. Most homes on the east end of Holden Beach are single-family residential properties. Commercial and multi-family properties typically cannot

be moved, and the loss of the property is not recoverable. Costs associated with relocation/buyout are typically estimated over 10 to 30 year time span, in order to gauge long-term effects. Note that limited lots are available on Holden Beach and relocated structures would no longer be located on the oceanfront.

6.3 BEACH NOURISHMENT WITHOUT INLET RELOCATION

The beach nourishment without inlet relocation alternative has been the status quo for the last decade. While beach erosion has been reduced under this alternative (in comparison with the 1990s where many homes and properties were lost), additional alternatives (such as the proposed terminal groin project) may prove to be more practicable. Storm related erosion as well as long-term erosion continues to make the east end of Holden Beach vulnerable under this alternative. Terminal groins (as well as groins in general) are typically employed in areas where beach erosion rates have been historically larger than practical to treat with fill alone. Figure 6-1 below presents a photo of a recent USACE AIWW dredge and beach nourishment project on the east end of Holden Beach.

Figure 6-1: April 2010 photograph of the USACE Lockwoods Folly Inlet AIWW Nourishment project. Note Town-funded dune planting in the foreground.

6.4 BEACH NOURISHMENT WITH INLET RELOCATION

The beach nourishment with inlet relocation alternative will also be considered during the NEPA permitting process. However, it is noted that the Lockwoods Folly Inlet has in general been positionally stable for the last century (Cleary, 2008). While inlet relocation has been successful for the Mason Inlet relocation project in 2001 as well as other inlets that are highly migratory, inlet relocation at Lockwoods Folly Inlet is not anticipated to be a cost-effective or necessary

solution for inlet management. Inlet main ebb channel orientation has a direct effect on erosion/accretion trends on the adjacent shorelines (see Sections 4 and 5). . The current inlet location is favorably positioned (Cleary, 2008), however erosion continues to threaten the eastern end of Holden Beach, while the western end of Oak Island has a low (2 ft/yr) DCM long-term erosion rate (see Figure 1-3). A portion of the inlet management plan may include recommendations for additional measures to maintain a favorable orientation/alignment the inlet's main ebb channel.

6.5 SAND BORROW SITE ANALYSIS/SELECTION

The Town of Holden Beach, as a part of its ongoing beach management program, has developed a list of potential borrow areas and preliminarily screened them. The 2009 Holden Beach Management Plan considered several borrow sources and these generally include: upland, inlet/AIWW dredged disposal areas, offshore, and Lockwood Folly Inlet. All borrow sites were evaluated for sediment quality and quantity as well as permitting and logistical requirements.

Upland and inlet/AIWW dredged disposal areas will be the primary focus for this analysis. Sand borrow site analysis will incorporate the latest DCM sediment criteria for beach compatibility. As previously mentioned, the ideal borrow source is the Lockwoods Folly Inlet AIWW project that is conducted by the USACE on an annual basis (see Section 5.3.3). Material from this activity is placed on the eastern end of Holden Beach and this activity is expected to continue. Other alternatives will also be identified by the Town in order to continue this basic operation. Borrow areas types in this analysis include:

Upland sources –

- Suitable for small projects (< 200,000 cy) and to supplement other larger fill projects
- Good for dune rebuilding and creation
- Sand color and grain size typically not as good as in-water sources
- Slow production rates and shorter life-cycles (every 1-3 years)
- Truck traffic and DOT/road maintenance issues
- Turkey Trap Road site and Smith site are currently permitted

Dredge Spoil Islands along the AIWW (i.e. CDFs) –

- Consist of layered material that would require separation of beach compatible and non-beach compatible material
- Reuse of this material would increase CDF disposal capacity and allow continued disposal operations

- Islands have become valuable for natural resources, recreation, and in some cases, development

Lockwoods Folly (LWF) Inlet –

- Currently not fully utilized/optimized because of side-casting operation and only following "deep-water" permit criteria
- USACE AIWW related navigation dredging has placed approximately 300,000 cy of material on the beach since 2002 (~ 45,000 cy/yr)
- USACE regional analysis supports placement of 156,000 cy/yr (625,000 cy every 4 years) from LWF ebb shoals on Holden Beach
- Critical to long-term beach and inlet management
- Channel alignment /orientation and shoaling patterns have been documented to cause problems to adjacent shorelines

Figure 6-2 presents a general location map of the borrow areas to be included in this analysis. Additional discussion on borrow area sources is provided below.

USACE Lockwoods Folly Inlet AIWW dredging

Ideally, the annual USACE navigation related nourishment of Lockwoods Folly Inlet AIWW Crossing can be used to fulfill the nourishment component of a terminal groin project at Holden Beach. This should help facilitate permitting because the annual USACE Lockwoods Folly Inlet AIWW Crossing dredging/nourishment project is already permitted. Additionally, the ongoing nature of the inlet dredging would also continue to provide benefits to the groin effectiveness and most likely satisfy any ongoing nourishment requirements for the groin. Of course, the Lockwoods Folly Inlet AIWW Crossing nourishment volumes may also be decreased with the installation of a terminal groin. Figure 6-3 presents the typical placement footprint of the USACE Lockwoods Folly Inlet AIWW dredged area. The USACE AIWW projects typically place between approximately 30,000 and 125,000 cy of beach compatible material annually (see Section 5.3.3 for more information).

Figure 6-2
Potential and Historic Upland Potential Borrow Areas (BAs)
and Confined Disposal Facilities (CDFs) for dredged material

APPLIED TECHNOLOGY & MANAGEMENT

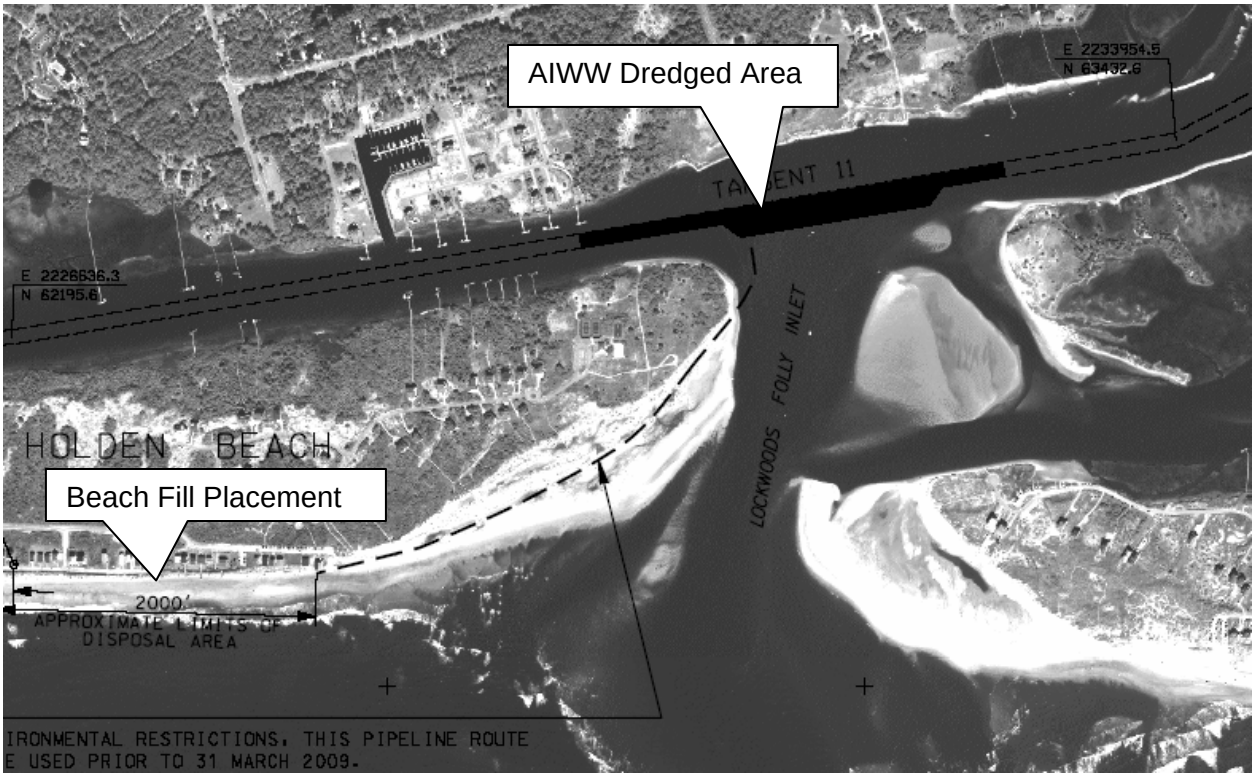


Figure 6-3: Annual USACE Lockwoods Folly Inlet AIWW dredging and beach placement schematic. Placement typically occurs between Holden Beach Station 20+00 and Station 40+00.

In order for the Town of Holden Beach to permit a terminal groin, it is anticipated that the Town will need to develop a nourishment plan separate from the ongoing USACE east end nourishment in the event that the USACE AIWW dredging project does not continue. As a result, the Town will include its own borrow area plan for the proposed terminal groin project. The Town has already coordinated with the USACE Navigation Branch and the NCDENR Division of Water Resources (DWR) about establishing a Memorandum of Agreement whereby the Town would fund any AIWW dredging (and beneficial nourishment) if USACE future funding is insufficient.

USACE Lockwoods Folly Inlet Outer Channel Dredging

As described in Section 5.3.3, side-caster dredges are used by the USACE to maintain the outer navigation channel at Lockwoods Folly Inlet. However, the new USACE shallow draft split-hull hopper dredge (the Murden) is slated to slowly replace the sidecaster dredge (personal communication, Bob Keistler, USACE Navigation Branch, 2011). This would allow for nearshore placement of beach compatible material that is currently sidecast. This option will continue to be explored with the USACE as the transition from side-casting to hopper dredging the outer channel occurs. The Town, Oak Island, Brunswick County, and NCDENR DWR have

recently entered into an agreement with the USACE to provide $450,000 to continue dredging of the navigation channel for the 2012 federal fiscal year (i.e., Oct 1, 2011 to Sept 30, 2012).

Upland Borrow Areas

The Town's use of upland borrow areas has proven valuable for recent nourishment projects and the Town plans to continue the use of upland borrow areas in the future. Fill projects utilizing upland borrow areas can be extremely valuable for unplanned/emergency mitigation efforts, such as the 2009 Holden Beach project in response to Hurricane Hanna. Additionally, truck haul projects do not involve the expensive mobilization/demobilization costs associated with offshore dredges and can occur much more quickly.

Potential negative aspects of upland borrow areas in the region include variations in sand color, practical volume limitations, and placement methods (i.e. trucking). Additionally, the N.C. Department of Transportation requires permitting and has the ability to shut down operations or require roadway mitigation.

Three potential upland borrow areas are described below.

6.5.1 TURKEY TRAP ROAD (PERMITTED)

The Turkey Trap Road Borrow Site is located near the intersection of Turkey Trap Road and Stanbury Road, and is an approximate 3.6 mile drive to the beach strand. The site is owned by the Town and covers 38 acres. In early 2005 ATM contracted with Engineering Consulting Services, Inc. (ECS) to collect 10 soil borings from within the site. The borings were driven to a depth of approximately 35-40 ft below grade. From these 10 borings, 40 composite samples were analyzed by ECS according to standard methods.

The Turkey Trap Rd Borrow site is expected to yield ~ 460,000 cy of material. Note that the Turkey Trap Road borrow area is also known as the Kirby Walter site in previous permitting documents. The site has the necessary permits from NCDENR, USACE, Brunswick County, and NCDOT (driveway permit).

6.5.2 SMITH BORROW SITE (PERMITTED)

The Smith site has been tested previously (borings were taken in 2002, 2007 and 2009) and used in previous years for the Town's beach nourishment (see Section 8.2). The material quality varies depending on location within the property, but has in general been found to be suitable. The Smith site is an approximate 4.0 mile haul distance from the beach strand. There are some limitations to the Smith site, due to the owner's development plans that dictate which areas are possible for excavation. The site has also been for sale for residential development and therefore may not be available for future use. For planning purposes, this site can only be relied upon as a short-term source, however potentially 200,000 cy of beach compatible

material could be obtained, and possibly more. Figure 6-4 presents a photo of the Smith Site during nourishment operations in 2009.

Figure 6-4: Smith Upland Borrow Area during 2009 Holden Beach Nourishment Project

6.5.3 TRIPP UPLAND SITE

Limited boring information as well as test pit observations indicates that the Tripp site contains potentially a large quantity of light colored beach quality sand. The Tripp site is an approximate 64 acre parcel located off Makatoka Rd in Supply, NC. The site is located west of HWY 17N and is approximately a 13 mile drive from the beach strand. Figure 6-5 presents a photo of a test pit at the Tripp site. In comparison to the existing permitted borrow sites; borings indicate that this site represents the best upland material in terms of color. A large pond has been excavated at this site previously and is approximately 55 ft deep, therefore a relatively large amount of material may be available. The site also has an existing mining permit (similar to the existing permitted borrow areas).

Figure 6-5: Tripp Site Test Pit

6.5.4 MONKS ISLAND

Monks Island is a currently inactive dredge spoil site located adjacent to the Atlantic Intracoastal Waterway, on the western end of Holden Beach. The island is long and narrow with roughly uniform topography. The western half of the island has been divided into 5 residential lots which are currently for sale. The eastern end is available for mining. The potential borrow area consists of about 10 acres of land up to an elevation of +20 ft NGVD (~mean sea level). Based on a site visit by ATM and Holden Beach personnel, the material contained within the existing dikes consists of fine to medium grained sand and may be suitable for placement on the beach. However, currently there are no available borings to quantify sediment quality and quantity.

Figure 6-6: Monks Island CDF

In 2010, the USACE raised the Monks Island perimeter dike/berm to increase capacity. According to USACE staff, the site consists of a layered mixture of beach compatible/non-compatible material and is constructed on a wetland base. Therefore, its potential use as a borrow area for beach nourishment is questionable, however it cannot be ruled out with current data. Figure 6-2 presents an image of this location.

6.5.5 SHEEP ISLAND

Sheep Island is a currently inactive dredge spoil site located adjacent to the AIWW north of Oak Island. Sheep Island is long and narrow; central portions of the island lie at elevations near or a few feet above sea level while topography peaks at either end where dikes have been constructed by the USACE to contain dredge spoil (see Figure 6-7 for site photo).

At the western end of the island, the spoil area covers approximately 4 acres and fill reaches a height of +20 ft NGVD. At the eastern end the spoil area covers approximately 28 acres and the fill reaches a height of +20 ft NGVD. Based on an ATM site visit in July 2009, the material contained within the dikes consists of fine to medium grain sand and may be suitable for placement on the beach. However, currently there are no available borings to quantify sediment quality and quantity.

Figure 6-7: Sheep Island confined disposal facility (CDF)

Similar to Monks Island, Sheep Island was formed by side-casting and pipelining dredged material onto wetlands decades ago (a practice which is no longer allowed). Therefore the base of Sheep Island consists of cohesive muddy sediment (i.e. wetland soil), while the material within the CDF consists of a layered mixture of compatible and non-compatible material.
As a result, its potential use as a borrow area for beach nourishment is questionable and would require additional geotechnical data collection.

6.6 TERMINAL GROIN AND BEACH NOURISHMENT

The beach nourishment and terminal groin alternative is the pending preferred alternative and is discussed in more detail in the next section.

7.0 PENDING PREFERRED ALTERNATIVE -TERMINAL GROIN & NOURISHMENT

The pending preferred alternative to the chronic erosion on the eastern end of Holden Beach features the construction of a terminal groin in conjunction with a beach nourishment and inlet management program. The two primary components of the project are described in greater detail in the following sections. Note that the designs presented below are conceptual in nature and will be finalized during the NEPA permitting process.

7.1 TERMINAL GROIN COMPONENT

Preliminary conceptual terminal groin alternative layouts have been developed based on shoreline movement and historic conditions on the east end of Holden Beach. The general design goals include: protection of public access; improvement of recreational beach area; enhancement of upper beach/dune habitat; stabilization of the east end of the beach (which represents the highest erosion rates on the island) from short-term and long-term fluctuations; and to reduce beach and AIWW dredging maintenance costs.

In general, the length of the terminal groin is dictated by the size of the inlet, the configuration of the end of the island, and the length of shoreline the groin is designed to stabilize. Two conceptual layouts were developed and are presented in Figures 7-1 and 7-2. It is noted that these groin alternatives are necessarily conceptual only and subject to further detailed evaluation, but present the general area where a terminal groin would be considered.

Groin Alternative 1 - This conceptual layout consists of a large terminal groin structure approximately 1,600 feet in length and is located immediately adjacent to Lockwoods Folly Inlet. This long structure is anticipated to create a large sand fillet and is positioned to close off the nearshore flood channel(s) that carries sand into the inlet throat and AIWW area, and straighten the shoreline to the west of it (see conceptual sand fillet on Figure 7-1). The groin is presented as a rubble-mound (i.e., rock) structure that also features a 'spur' which extends out perpendicularly near the base of the groin. A similar feature occurs on the Ft. Macon terminal groin as well as other terminal groins. This spur feature helps in maintaining a buffer between the groin and the Lockwoods Folly Inlet Channel. Otherwise, the channel may migrate directly adjacent to the terminal groin (see Kieslich, 1981). The groin profile will also be similar in profile to that of the Ft. Macon groin (i.e., crest height ~7 ft MLW, crest width ~10 ft, 2:1 side slopes).

For this groin alternative, additional analysis to estimate the potential impacts of trapping a large volume of sand from reaching the inlet (and its effect on the inlet sediment budget) must be completed. This analysis would be part of the inlet management plan required for terminal groin permitting.

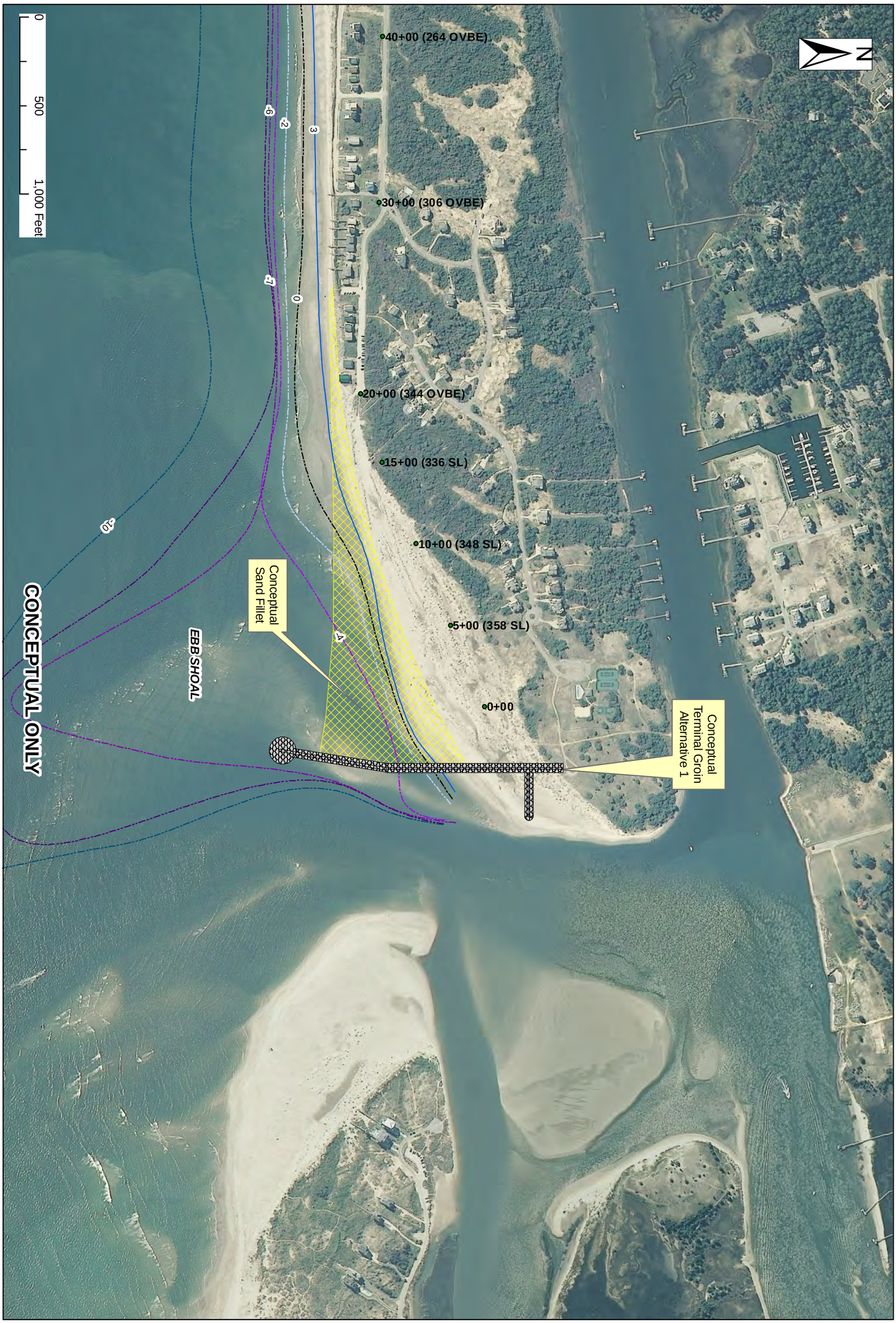


FIGURE 7-1:
Conceptual Terminal Groin Alternative 1
East End, Holden Beach
2010 Depth Contours in feet NGVD (MHW=3 ft, MLW=-2 ft); 2008 Aerial

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APPLIED TECHNOLOGY & MANAGEMENT

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FIGURE 7-2:
Conceptual Terminal Groin Alternative 2
East End, Holden Beach
2010 Depth Contours in feet NGVD (MHW=3 ft, MLW=-2 ft); 2008 Aerial

Groin Alternative 2 - This conceptual layout consists of a terminal groin typically 400-600 feet in length and is located to the east of existing shorefront properties (~Station 15+00). The shorefront properties along the shoreline from Stations 20+00 to 45+00 remain the most vulnerable from an erosion/storm damage perspective. The dune in this area was breached during Hurricane Hanna landfall in 2008 and remains a vulnerability in the upper beach and dune system. A groin is anticipated to enhance the upper beach, which would help maintain and stabilize the dune system. The groin is conceptually presented as a rubble-mound (i.e., rock) structure with an asymmetric T-Head. The T-Head feature is included to enhance fillet formation of the beach fronting the eastern shoreline area, since a shorter groin in this location would be expected to have less of a stabilizing effect on the shoreline to the west than Alternative 1. T-Heads may also help to minimize formation of potential rip currents. Construction of this smaller groin would be expected to have a smaller impact on the sediment budget of the inlet than Alternative 1, but may result in some additional erosion along the inlet margin (~Station 0+00 to 10+00), and thus more detailed analysis is required to determine the proper dimensions and location to maximize effectiveness while minimizing adjacent impacts. A box is shown on Figure 7-2 to depict the general area where a smaller groin may be considered.

Figure 7-3 below presents a conceptual profile of the Alternative 2 terminal groin at Station 20+00. The groin crest is ~7 ft NGVD and the profile generally follows the slope of the shoreline (MHW=+3 ft NGVD, MLW=-2 ft NGVD). The groin will be low-profile to allow some sand bypassing. Note that the May 2011 Station 20+00 in Figure 7-3 captures a USACE LWF Inlet nourishment project. The proposed fill template would be similar to these ongoing projects.

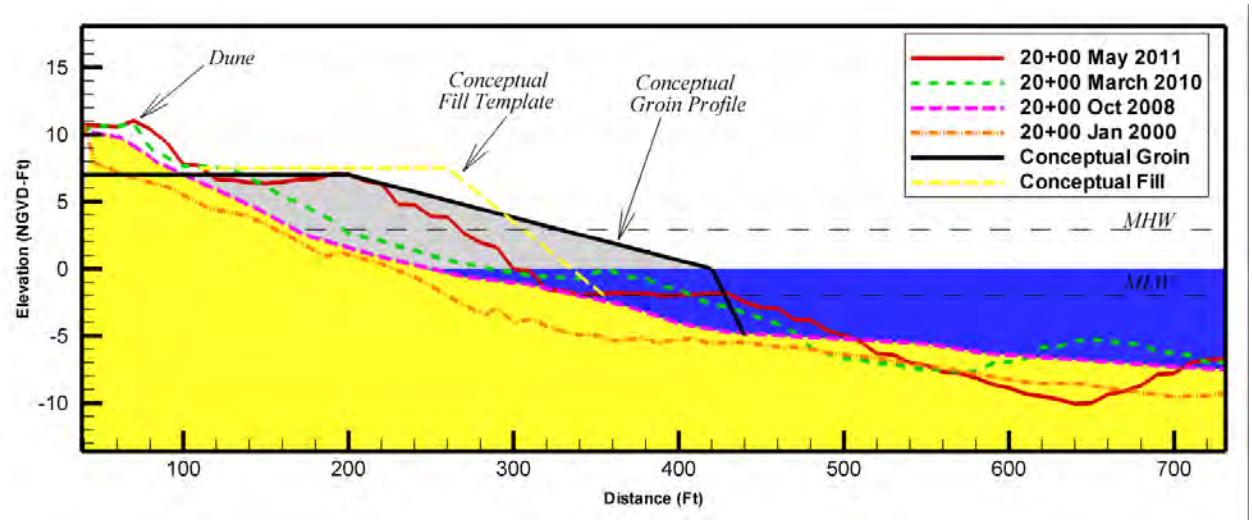

Figure 7-3: Conceptual groin profile for alternative 2. Several Station 20+00 transects are plotted for reference. Note that the USACE recently placed material for the May 2011 transect.

7.2 BEACH FILL COMPONENT

SAND SOURCES

As with any groin or terminal groin permitting project, beach fill must also occur to minimize any potential downdrift impacts and to enhance the project area in general. The terminal groin will also in turn slow erosional losses of any placed fill material.

There are four primary potential sources of beach fill material that are available for the proposed terminal groin project:

1. USACE Lockwoods Folly Inlet AIWW dredging
2. USACE Lockwoods Folly Inlet outer channel dredging
3. Upland Borrow Areas
4. Upland Dredged Disposal Areas

These alternative sand sources are described in Section 5.5. Note that Holden Beach currently has an active permit for beach nourishment using an upland borrow area and is also currently developing a permit application for an offshore borrow area that is *independent of terminal groin permitting*.

BEACH FILL FOOTPRINT

As seen in the conceptual groin figures, a 'fillet' of sand is expected. In order to proactively create this 'fillet' feature, beach nourishment is required with groin construction. The beach fill essentially artificially creates this fillet feature and some overfill is also recommended to allow immediate bypassing of sand around the groin. The beach fill footprint is directly related to the size and configuration of the terminal groin. Because the terminal groin alternatives are conceptual, with a range in sizes provided, the beach fill footprints are also necessarily conceptual and a general range is provided.

The sand fillet volume of the proposed groin was calculated based on an area of sand accreting along the shoreline west of the proposed terminal groin. Minimum nourishment volumes can computed by determining the cross-sectional area differences between the groin profile and the latest surveyed beach profile and then multiplying by the alongshore reach length. This is basically assuming that the updrift beach will match the groin profile. In order to arrive at a volume, total minimum beach nourishment equates to the minimum cy/ft multiplied by the alongshore reach length divided by 2 (for a triangular fillet).

In this way, a nourishment volume can be established for an individual groin. Note that this fill volume is rather small and it would not be cost effective to mob/demob a large ocean-going dredge for this amount. Note that fillet volume will change based on the latest shoreline position; with more volume needed for a more eroded condition.

Alternatively, timing groin construction with the annual USACE AIWW inlet crossing maintenance and/or shallow draft split-hull hopper inlet navigation dredging would likely provide adequate volumes (estimated fill at approximately 20 cy/ft) to prefill the groin fillet.

Recent nourishment projects by the Town have placed volumes from ~15 cy/ft to ~25 cy/ft utilizing upland borrow sources (see Figure 7-4). Additionally, recent USACE AIWW beach fills have ranged between ~20 and ~40 cy/ft. Fill templates for recent projects typically feature an upper beach berm with crest elevation of +7 ft NGVD. The constructed berm crest width typically ranges from100 to 300 ft. A transitional slope of 1V:10H is typically constructed from the seaward berm crest to the pre-project beach. Figure 7-3 in the previous section displays a conceptual fill at Station 20+00 that ranges between 30 to 40 cy/ft (depending on the shoreline used).

Figure 7-4: 2009 Holden Beach Nourishment Project during Construction (West Reach is shown). Typical upland placement that will be employed for the proposed terminal groin project.

Benefits of nourishment and groin projects are often based on estimates of storm damage reduction for a prospective alternative (i.e., the level of damages prevented by implementation of an alternative). Figures 7-5 and 7-6 present conceptual beach fill footprints for the proposed project.

The Alternative 1 groin features a conceptual fill footprint of approximately 27 acres. Assuming 40 cy/ft unit fill placement, approximately 160,000 cy of material will be required.

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FIGURE 7-5:
Conceptual Terminal Groin Alternative 1with Beach Fill Footprint
East End, Holden Beach
2010 Depth Contours in feet NGVD (MHW=3 ft, MLW=-2 ft); 2008 Aerial

FIGURE 7-6:
Conceptual Terminal Groin Alternative 2 with Beach Fill Footprint
East End, Holden Beach
2010 Depth Contours in feet NGVD (MHW=3 ft, MLW=-2 ft); 2008 Aerial

The shorter Alternative 2 groin features a conceptual fill footprint of approximately 14 acres. Assuming a 30 cy/ft unit fill placement, approximately 80,000 cy of material will be required. Following initial project construction, on-going monitoring would determine future re-nourishment requirements.

Benefits

The implementation of the terminal groin in conjunction with beach nourishment is anticipated to widen the beach on a longer term basis. Studies in Florida (Dean, 1988) and North Carolina (Rogers,2001) have shown that wider berm widths will cause waves to dissipate farther offshore and away from structures, thus reducing the breaking wave forces (and damages) on structures (see Figure 7-7).

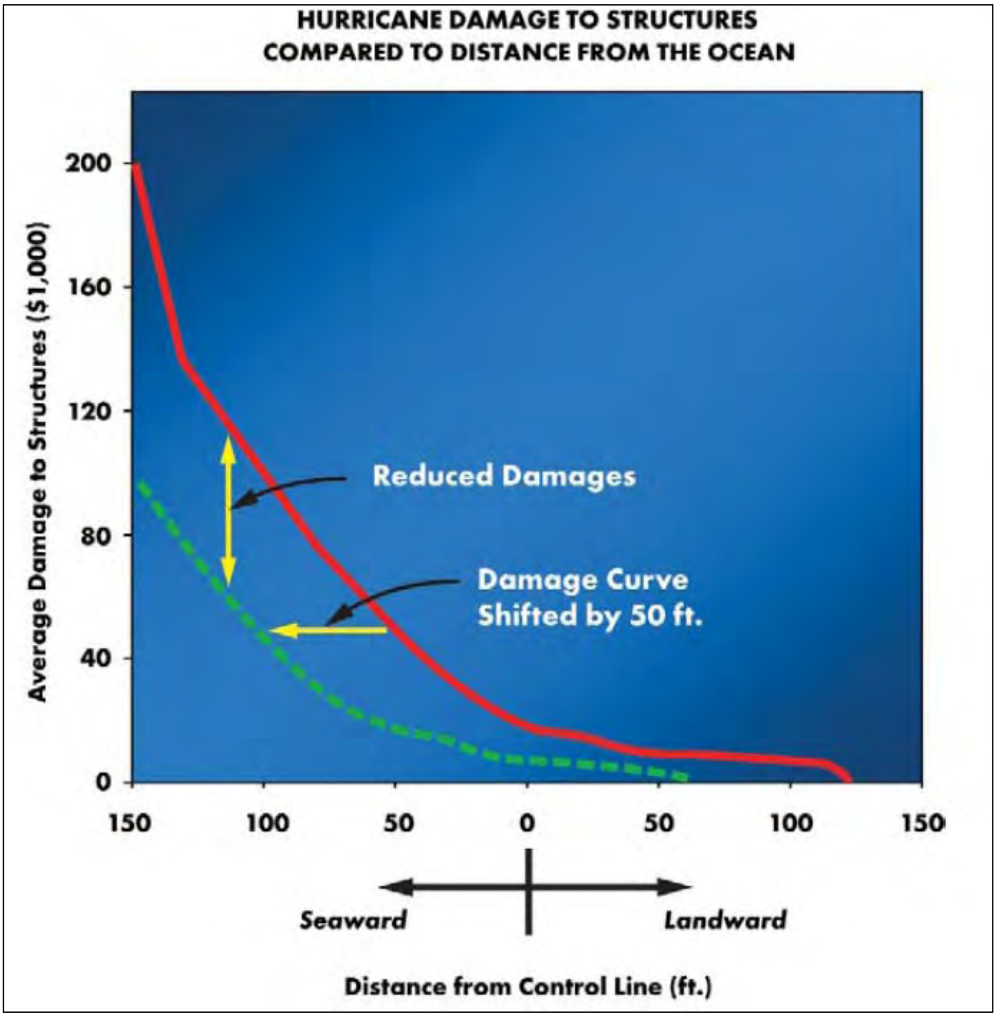

Figure7-7: Storm damage reduction adopted by Old Dominion after Dean, 1988. Damages were estimated from inspection of 540 structures damaged during Hurricane Eloise (1975).

7.3 CONSTRUCTION METHODS

The proposed terminal groin construction and beach nourishment will conceptually use land-based equipment (e.g. bulldozers, dumptrucks, excavators) to the extent possible. In general, excavators will load dump trucks at the borrow area, trucks will travel to the site and offload the beach-compatible sand, then a bulldozer will shape the sand into the design beach template. Alternately, a shallow draft cutterhead dredge may also be used, if the sand source is from Lockwoods Folly Inlet, the AIWW, or a nearby AIWW CDF. Sand would then be delivered via pipeline to the project site.

Construction materials for the groins (i.e., rock, geotextiles, and potentially marine mattresses for the foundation) will be delivered to the project site via trucks. In general, shorter groins would likely be constructed from land; however a longer groin may require construction of a trestle (similar to Amelia Island, FL terminal groin project) or the use of standard barges. In some cases, a jack-up barge may be required in the nearshore area to reduce impacts of waves and currents on construction operations. A small crane will place the rock and foundation materials. A track hoe or other excavator will also be required to excavate down to the base of the groin for foundation placement. Any sand temporarily displaced will be stockpiled and then used as backfill.

8.0 EXISTING AND PROPOSED DATA NEEDS AND STUDIES

Proposed terminal groin DCM regulations currently require:

(1) Alternatives Analysis (including home/building relocation)
(2) An Environmental Impact Statement (EIS) that has been developed by an independent third party
(3) An engineering design bearing the seal of a registered professional engineer
(4) Proof of notification of adjacent property owners and local governments on both sides of the inlet
(5) An inlet management and monitoring (including mitigation triggers) plan
(6) Identification of the financial resources necessary for potential future mitigation.

A significant amount of information currently exists on the Lockwoods Folly Inlet area. In addition to the reports and data included in the reference list, physical and biological reporting and monitoring data from all recent beach nourishment events, ranging from the USACE 2001 Wilmington Harbor Deepening nourishment project (Section 933 project) up to the Town's 2009 nourishment project can be used to develop baseline conditions and future monitoring programs.

An inlet management plan including consideration of the terminal groin project will be developed based on existing reports and data. From this study, a sediment budget will be developed based on the terminal groin and nourishment effects and a course of action (defining renourishment triggers, etc.) will be established based on ongoing and future monitoring. At this time, no numerical modeling is proposed. In general, the applicant does find numerical modeling to be a useful tool and the use of a suitable model can be explored in the future.

Available Studies

The Lockwoods Folly Inlet and the adjacent shorelines of Holden Beach and Oak Island have been studied from a shoreline change and sediment transport perspective since the 1970's, when the USACE evaluated shore protection for Brunswick County beaches and Machemehl placed 15 geotextile groins on the east end of Holden Beach. Since then, research and monitoring has continued. Please see the references in Section 10 for a listing of studies relevant to the permitting of a terminal groin on the east end of Holden Beach.

8.1 PROJECT TIMING

The Town of Holden Beach desires to have the ability to commence with project construction as soon as possible. From a timing perspective, project construction is anticipated to occur in the winter of 2013/2014 (i.e., approximately two years from now). This timing is obviously dependent on several other beach management activities as described in Section 3.

9.0 SUMMARY

The Town of Holden Beach has been actively and independently performing beach management activities on its shoreline for decades. More recently, the Town began performing several significant nourishment projects in order to augment and further the benefits of the USACE Wilmington Harbor Deepening 933 nourishment project in 2001/2002. The Town's projects are completely funded, permitted, designed, constructed, and monitored by Holden Beach.

From a beach nourishment and erosion perspective, the Town and the USACE have identified two general erosion control project reaches: 1) Island-Wide and 2) East-End. The "island-wide "reach ranges from Station ~40+00 to Station ~270+00 (~4.3 miles). The USACE 933 project and all Town nourishment projects over the last 10 years have occurred within the island-wide reach. These island-wide projects have been devoted to offsetting island-wide erosion and have been relatively successful in this endeavor.

The "east end" shoreline reach ranges from Lockwoods Folly Inlet to Station ~40+00 (~0.8 miles); where the island's highest erosion rates occur. The annual USACE Lockwoods Folly Inlet AIWW Crossing dredging and fill placement projects have a primary goal of offsetting inlet-related erosion on the east end of Holden Beach. The east end projects concentrate on a smaller shoreline area however this reach continues to be the most vulnerable to erosion and dune breaching (which occurred as recently as 2008 during Hurricane Hanna). Lockwoods Folly Inlet has been relatively stable historically with respect to its central channel location; however, the adjacent shorelines are characterized by some of the largest inlet-induced erosion rates in southeastern North Carolina (Cleary, 1999).

The Town would like to begin the NEPA permitting process for a terminal groin and nourishment project for the East-End of Holden Beach and the Work Plan described herein outlines and describes the proposed project (project site, purpose and need, existing studies, alternatives, etc.).

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ATTACHMENT A - Town of Holden Beach Resolution for Terminal Groin Permitting

RESOLUTION 11-12
TERMINAL GROIN PERMIT APPLICATION

WHEREAS, the Town of Holden Beach, North Carolina is a barrier island bounded by the Atlantic Intracoastal Waterway to the north, the Atlantic Ocean to the South, the Shallotte Inlet to the West and the Lockwood Folly Inlet to the East; and,

WHEREAS, the Town of Holden Beach CAMA Land Use Plan supported the reconsideration of the previous state prohibition on erosion control structures particularly in inlet hazard areas; and,

WHEREAS, the Town of Holden Beach has supported by action and resolutions; all adopted unanimously, legislative efforts over the past several years to allow terminal groins in locations adjacent to NC inlets according to specific criteria and as determined by sound engineering practice; and,

WHEREAS, Senate Bill 110 "An Act To Authorize the Permitting And Construction Of Up To Four Terminal Groins Under Certain Conditions" has been enacted by the General Assembly; and,

WHEREAS, the Division of Coastal Management has presented the Terminal Groin Permit Process to the Coastal Resources Commission at their 25 August 2011 meeting; and,

WHEREAS, the Town of Holden Beach has a Beach Management Plan that identifies a terminal groin structure at the island's east end adjacent to the Lockwood Folly inlet as a solution that would help to stabilize the area; and,

WHEREAS, the Town of Holden believes it is in the best interest of its citizens, property owners, visitors, neighbors, mariners, commercial and recreational fisherman to stabilize the east end of Holden Beach adjacent to the Lockwood Folly Inlet; and,

WHEREAS, the Town of Holden Beach would like to move forward with obtaining the permits required to construct a Terminal Groin on the east end of Holden Beach.

NOW THEREFORE BE IT RESOLVED that the Board of Commissioners of the Town of Holden Beach NC does hereby direct the Holden Beach Town Manager to make application to the North Carolina Division of Coastal Management/Coastal Resources Commission for a permit to construct a Terminal Groin on the east end of Holden Beach adjacent to the Lockwood Folly Inlet.

This the 13th day of September, 2011.

J. Alan Holden, Mayor

ATTEST:

Heather Finnell, Town Clerk

TOWN OF HOLDEN BEACH SEAL ESTABLISHED FEBRUARY 14, 1969 HOLDEN BEACH, NC