

Photo Date: 29 April 2019



# Bald Head Island, N.C. Beach Monitoring Program

## Monitoring Report No. 17 (May 2018 to May 2019)

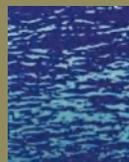
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July 2019



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**BALD HEAD ISLAND, N.C.**  
**Beach Monitoring Program**  
**Report No. 17**  
**(May 2018 – May 2019)**

**EXECUTIVE SUMMARY**

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The most recent Wilmington Harbor Inner Ocean Bar maintenance dredging of Bald Head Shoal Channel Reach 2, and the Smith Island Channel segment was initiated in the summer months of May/June 2018. Approximately 1.15 Mcy of sand excavated during that operation were placed at Oak Island pursuant to the terms of the Wilmington Harbor Sand Management Plan (WHSMP). Subsequent to federal beach disposal on Oak Island, Bald Head Island will be the recipient of the next two *future* beach disposal operations in accordance with the continued implementation of a present day WHSMP. Prior to that time (with the next disposal *estimated* to be spring of 2021) the need to offset annual erosional losses at South Beach on Bald Head Island, as well as to maintain the updrift fillet of the terminal groin constructed in 2015, necessitated that the Village design and permit a 1 Mcy *interim* beach fill project. The latter was constructed between 13 January 2019 and 22 March 2019. The project borrow site was Jay Bird Shoals. Work was performed by Marinex Construction, Inc. The final fill volume was 1.1 Mcy due to the addition of a Post-Florence FEMA Claim for documented storm related losses from the *engineered beach* in September 2018 (Olsen 2018). The final resultant renourishment contract amount was \$11,767,000.

As part of the assessment for the 2019 beach renourishment project to be constructed at South Beach by the Village, it was determined that numerous sand tube groins had reached the end of their effective life and that replacement was warranted. Permits allowed for both an extension of time beyond April 1<sup>st</sup> for *both removal and replacement* of all remaining thirteen (13) sand tube groins (and underlayments). Subsequent to the solicitation of competitive bids, the geotube replacement project was awarded to McPherson Marine Services, LLC. The total Contract amount was \$1,204,179.00. This was exclusive of the cost of tubes. The cost of the custom geotextile tubes, a poly-urea coating and delivery was approximately \$320,000 (*i.e.* 13 tube groins with new underlayments). The work was initiated on/about 13 February and Substantially Completed by 22 March 2019. A *Post-Construction Report*, formulated to document the 2018-2019 project, details all elements of work performed by both contractors (Olsen 2019).

By about 2013, the results of a comprehensive annual beach monitoring program initiated in 2000 by the Village of Bald Head Island yielded the conclusion that sand placement alone could *not* successfully offset navigation channel impacts to the west end of South Beach which have been typically manifest in chronic rates of erosion and a consistent northerly

recession of the shorefront. Accordingly, the Village was ultimately forced to “change the existing dynamic” by constructing a single terminal groin designed to complement the placement of beach fill at the persistent South Beach erosional “hot spot”. The project was permitted to be constructed in two phases – with Phase 2 being optional. Simplistically, the structure was designed to serve as a “template” for fill material placed eastward thereof on South Beach. The Phase 1 1,300 ft. long terminal groin (completed in Nov. 2015), was designed however as a “leaky” structure (*i.e.* semi-permeable) so as to provide for some level of continued sand transport to West Beach and portions of the Point (located both westward and northward of the groin stem). Through May 2019, terminal groin project performance – based upon monitoring – has been both as intended – and as predicted.

Between November 2000 and April 2015, Bald Head Island had received about 7.0 Mcy, mol of sand from the initial widening/deepening and four (4) subsequent maintenance dredging operations for the Wilmington Harbor Navigation Project entrance channel. Including 2019, the Village has placed another 3.2Mcy along the West Beach and South Beach shorelines. Accordingly, in the net Bald Head Island has experienced a total estimated sand placement volume of approximately 10.2 Mcy since 2000 at those two locations – with South Beach receiving some 90% or more of the total.

Conversely, the *gross* volumetric sediment *loss* over the November 2000 to May 2019 (post-fill) monitoring timeframe is conservatively computed at -7.191 Mcy, or approximately -388,700 cy per year – on “average”. This “loss” addresses the continuous section of Bald Head Island shorefront extending from the marina entrance to the Cape Fear spit. The assignment of an *average annual* long-term rate of sand loss at Bald Head Island however, has *not* necessarily been a meaningful indicator of navigation project impact. Such an average rate is often temporally biased by periods of beach fill equilibration, groinfield “effectiveness,” major storm events (such as Hurricane Florence), the occurrence of episodic destabilization dredging events in close proximity to the island, as well as other physiographic phenomena temporally affecting annualized quantities of alongshore sediment transport – from Bald Head Island. In addition, the island’s littoral system continues to adjust to the quasi-stabilizing effect of the terminal groin in existence only since 2015. Along South Beach per se, there has been historically a “nodal point” some 7,000 ft. eastward of the terminal groin (approx. STA 116+00). At or close to the nodal point, the directionality of *net littoral transport* on an annual basis changes from West (toward the groin) to East (toward Cape Fear). *Note* – depending on wave climatology, the condition and exposure of the sand tube groinfield, as well as other factors, the effective location of the nodal point can vary slightly along South Beach from year to year. Currently, within the 22,755 shoreline influenced by sand placed since 2000, some 2.992 Mcy remain in the littoral system (measured above elevation -16 ft. NGVD 29). This includes the 1.1 Mcy beach fill recently constructed in early 2019.

Although not directly impacted by long-term navigation channel improvements and maintenance of the Cape Fear River entrance, the Village Council elected to initiate monitoring of the East Beach shorefront at Bald Head Island in November 2008. Since that time, it is observed that East Beach can undergo strong seasonal variations of beach width and profile volume to a large degree dependent upon storm frequency and intensity, as well as the ever-changing configuration of the Cape Fear spit. The most recent May 2019 survey data show a net shoreline accretion of approximately 149,900 cy (above elevation -16 ft NGVD) throughout the 6,000 ft East Beach shoreline lying northward of Cape Fear over the last 12 months. Between November 2008 and May 2019, the total change has been +439,100 cy. Most of this volume is associated with accretion of the Cape Fear spit facing Onslow Bay.

Unfortunately, recent configurations of the Cape Fear spit deemed beneficial to East Beach have resulted in a high rate of erosion and duneline recession along the easternmost section of South Beach – directly seaward of the Shoals Club facility. For example, between 2000 and 2019, the average MHWL erosion rate at this general location has been about -14 ft/yr.

In 2019, the Village was required by Permit to perform the 9<sup>th</sup> year of monitoring for the Jay Bird Shoals borrow site utilized to construct the non-federal 1.85 Mcy beach fill sponsored by the Village in 09/10. The computed change within the monitored survey area (excavated and unexcavated) was a *net* gain of approximately 93,000 cy over the 108 month monitoring period following initial project construction. As noted previously however, the Village built a 1.1 Mcy fill project in 2018/19 utilizing the Jay Bird Shoal borrow site immediately prior to the March survey.

After the extension of the two marina entrance channel jetties in 2015, reduced shoaling within the navigation channel resulted in a corresponding reduced volume of disposal sand being placed along the Row Boat Row shoreline. Although the Village had planned to continue to proactively bypass sand from the south jetty fillet (at the distal end of West Beach) to the Row Boat Row shorefront, it became clear that the existing four (4) low level timber groins would not be capable of providing an acceptable level of shoreline stabilization at that location – i.e. with a significant reduction in episodic sand placement.

Hence, near the end of the 2017 monitoring period, the Village initiated construction of two (2) shore parallel detached rock breakwaters located north of the marina entrance seaward of the Row Boat Row shoreline. The placement of breakwaters between existing groins northward of the marina entrance was intended to combine the attributes of each of the two types of stabilization structure so as to reduce the rate of sediment transport from the eroding shoreline caused principally by ferry/barge generated waves. The subject expanded

shore stabilization project (detached breakwaters *and* existing groinfield) was designed to have a sand fill prior to construction. The source of the fill was the existing Bald Head Creek borrow area. A previously permitted Bald Head Creek borrow area was dredged in early 2017 by Marcol Dredging. Some 26,000 cy were placed at Row Boat Row prior to breakwater implementation. Since that time several channel maintenance/sand bypass operations have occurred – with placement along the Row Boat Row shorefront.

A small-scale borrow site was developed with Bald Head Creek in 2012. Since that time, the borrow site has been excavated for purposes of constructing small-scale fill projects at Row Boat Row or West Beach on three separate occasions. Historically, much of the borrow site’s physical “recovery” has been due to marina channel and sand bypass operations. In the seven years since the initial dredging project (2012-2019) the area within the limits of the permitted borrow site has experienced a net gain of +75,300 cy.

In the spring of 2017, the Village submitted permit applications accompanied by indepth geotechnical studies and environmental analyses necessary to develop a long term (and large scale) borrow site located within Frying Pan Shoals. The purpose of such a borrow site was to both ensure compliance with Permit conditions necessitating the maintenance of the updrift fillet associated with the 2015 terminal groin project and to provide a long-term source of beach quality material sufficient to meet future South Beach renourishment requirements. It was originally anticipated that the borrow site would be needed for limited sand placement along South Beach in 2018/19. That conclusion resulted from the scheduled hiatus in the disposal of channel maintenance sand on Bald Head Island by the Wilmington District, USACOE. Pursuant to the existing tenets of the Wilmington Harbor Sand Management Plan, all beach quality channel maintenance material excavated in the summer of 2018 was placed at Oak Island.

In June 2017 however, the National Marine Fisheries Service (NMFS) issued concerns related to the near term use of a Frying Pan Shoals (FPS) borrow site *without first exploring and exhausting other viable sand-source alternatives*. Realistically, the only alternate borrow area available for near term sand placement at Bald Head Island (BHI) was sand remaining in the previously permitted JBS borrow site. Accordingly, in consideration of the NMFS request the Village agreed to withdraw their Application and to prioritize the use of the previously authorized borrow site permitted at Jay Bird Shoals (JBS) (including both the partially recovered area dredged in 2009/10 and a remaining undredged portion of the borrow site. For purposes of doing so, the Village was instructed to seek modifications to the existing terminal groin permits which had included proposals for renourishment of the shoreline bordering the terminal groin via the use of alternate sand sources – one of which included Jay Bird Shoals. With the documented depletion of the Jay Bird Shoals borrow site resulting from the 2018/19

renourishment project, the Village intends to reinitiate the permitting of a long term borrow site located within Frying Pan Shoals in 2019.

An important secondary precept of the spring of 2019 beach fill project constructed by the Village was to allow for the replacement of a sand tube groinfield which had become damaged over time. During renourishment, the groin field in its entirety was covered by beach fill. This allowed a second contractor to excavate and replace all 13 sand tube groins “in the dry”.

The original Permits for construction of the terminal groin at Bald Head Island stipulated that if the permittee elected to dredge more than 250,000 cy from the Jay Bird Shoals borrow site after 2015, limited additional monitoring of the eastern end of Oak Island must be performed. At the scheduled time of the last routine island wide survey at Bald Head Island (*i.e.* November 2018), the Village initiated the requisite monitoring at Oak Island (Caswell Beach). The first report of findings for Oak Island will follow a scheduled November 2019 monitoring survey. That will allow for a full year of change representing both pre-and post-dredging conditions within the Jay Bird Shoals borrow site. Those findings will be addressed by a stand-alone report.

**BALD HEAD ISLAND, N.C.**  
**Beach Monitoring Program**  
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**(May 2018 – May 2019)**

**TABLE OF CONTENTS**

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1.0	INTRODUCTION .....	1
1.1	Overview .....	1
1.2	Physical Setting .....	2
1.3	Monitoring Period Wave Climate (May 2018 to May 2019) .....	5
1.4	Wilmington Harbor Federal Navigation Channel & Sand Management Plan .	11
1.5	Historical Erosion Control Activities (1991 to 2019) .....	12
1.5.1	Channel Maintenance Beach Disposal & Beach Restorations - Chronology .....	12
1.5.2	Erosion Control Structures (1996 to 2019) - Chronology .....	12
2.0	BEACH RENOURISHMENT PROJECT IMPLEMENTATION (2018/2019) .....	14
2.1	Pre-Construction Activities - Timeline .....	14
2.2	Project Permits and Terms .....	14
2.3	Marine Cultural Resource Protection.....	14
2.4	Project Borrow Source Development .....	15
2.5	Beach Fill Design .....	18
2.6	Bidding & Project Cost to Construct .....	21
2.7	Construction Equipment and General Technique – Dredging & Beach Fill ...	21
3.0	SAND TUBE GROINFIELD REPLACEMENT (2019) .....	23
3.1	Groinfeld History (Pre-2019) .....	23
3.2	2019 Contract Concurrent with the Beach Renourishment Project .....	23
4.0	PHYSICAL MONTORING PROGRAM .....	26
4.1	Monitoring Baseline & Beach Profiles .....	26
4.2	Bald Head Creek Borrow Site Surveys.....	30
4.3	Jay Bid Shoal Borrow Site Surveys.....	31
4.4	Orthorectified Aerial Photography .....	31
5.0	MONITORING (SURVEY) RESULTS .....	33
5.1	Methodology .....	33
5.2	Year 18: Monitoring Program (May 2018 – Sept. 2018 – May 2019) .....	34
5.3	West Beach, “The Point” and South Beach: Discussion .....	34
5.3.1	Survey Period: May 2018 to September 2018 .....	34

5.3.2	Survey Period: September 2018 to May 2019 .....	45
5.3.3	Year 18 Monitoring Results: May 2018 to May 2019 .....	46
5.3.4	Long-Term Beach Changes: November 2000 to May 2019 .....	47
5.3.5	MHWL Shoreline Position .....	51
5.3.6	Chronology of “The Point” .....	53
5.4	East Beach Shoreline Conditions .....	55
5.5	Row Boat Row Conditions .....	61
6.0	BORROW SITE MONITORING (SURVEY) RESULTS .....	63
6.1	Bald Head Creek .....	63
6.2	Jay Bird Shoals .....	67
7.0	ONGOING PLANNED OR PROPOSED ACTIVITIES .....	73
8.0	SUMMARY AND CONCLUSIONS .....	74
9.0	REFERENCES .....	79

**LIST OF APPENDICES**

<b>APPENDIX A:</b>	Plotted Beach Profiles (November 2000 to May 2019)
<b>APPENDIX B:</b>	Aerial Photography (April 2019)
<b>APPENDIX C:</b>	Aerial Photography (October 2018)
<b>APPENDIX D:</b>	Aerial Photography (April 2018)
<b>APPENDIX E:</b>	Photo Chronology of “The Point”
<b>APPENDIX F:</b>	September 2018 and May 2019 Monitoring Survey Drawings

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**1.0 INTRODUCTION**

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**1.1 Overview**

This engineering report presents measured physical changes along the South Beach, West Beach, East Beach and Row Boat Row shorelines of Bald Head Island (BHI) based principally upon both historical and updated monitoring surveys performed annually on behalf of the Village of Bald Head Island (Village). It likewise addresses actions taken by the Village or others which have or could affect shoreline conditions. More, specifically, this report addresses:

- (1) A summary of Bald Head Island's physical setting including a discussion of the Federal Navigation Channel and the status of the Wilmington Harbor Sand Management Plan.
- (2) An overview of Hurricane Florence which impacted Bald Head Island and the State in September 2018. It resulted in a subsequent FEMA Claim (Olsen 2018).
- (3) Recent volume and shoreline position changes measured between monitoring surveys of May 2018, September 2018 and May 2019 along the West Beach, "the Point" and South Beach shorelines, as well as *long-term changes* since November 2000. Updates of East Beach and the Cape Fear Spit conditions are likewise provided, as well as near term changes for the Row Boat Row shoreline which receives episodic sand placement associated with routine marina entrance channel sand bypass operations.
- (4) Measured changes in the Bald Head Creek borrow site last dredged in 2017 as the sand source for small scale West Beach and Row Boat Row beach fills.
- (5) A discussion of the 1.1 Mcy 2018/19 Beach Restoration Project constructed along a portion of S. Beach and the dredging of the Jay Bird Shoals borrow site.
- (6) A discussion of the concurrent 2018/19 Sand Tube Groinfield Repair Project.

## 1.2 Physical Setting

Bald Head Island is located in Brunswick County, North Carolina at approximately 33°51' N, 78°00' W (**Figure 1.1**). It is roughly 25 miles south of the City of Wilmington and 32 miles east of the South Carolina/North Carolina state line. It is the southernmost of the coastal barrier islands which form the Smith Island complex at the mouth of the Cape Fear River. The southeastern tip of the island is Cape Fear (also referred to as Cape Fear Point) from which Frying Pan Shoals extend seaward over 20 miles to the southeast.

The island's east and south shorelines, "East Beach" and "South Beach", front the Atlantic shoreline. The west shoreline, or "West Beach", fronts the Cape Fear River. The north side of the island is bounded by the Bald Head Creek estuary, Middle Island and Bluff Island. The Cape Fear River entrance, over one mile in width, separates Bald Head Island from Oak Island (or Caswell Beach).

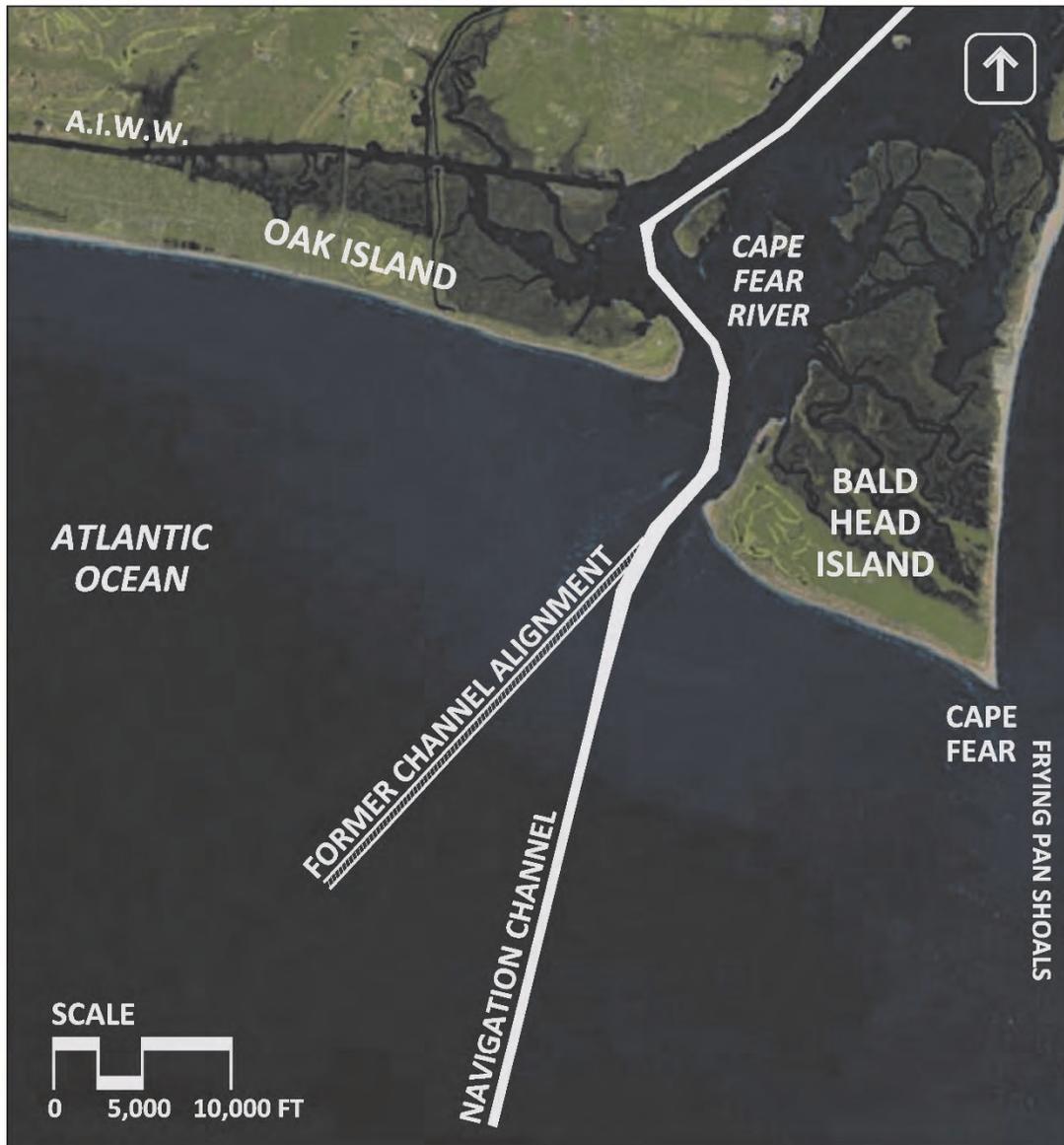
The astronomical tides in the vicinity of Bald Head Island are semi-diurnal and have average mean and spring ranges of approximately 4.3 ft and 5.0 ft, respectively. Tidal datums for Bald Head Island are listed in **Table 1.1** and the predicted astronomical tides during the May 2018 to May 2019 monitoring period are plotted as **Figure 1.2**.

**Table 1.1:** Tidal datums for Bald Head Island, North Carolina<sup>1</sup>.

<b>Datum</b>	<b>Elevation (ft-NGVD29<sup>2</sup>)</b>
Mean Higher High Water (MHHW)	+2.82
Mean High Water (MHW)	+2.51
NAVD 1988	+1.10
Mean Tide Level (MTL)	+0.35
NGVD 1929	0.00
Mean Low Water (MLW)	-1.81
Mean Lower Low Water (MLLW)	-1.98

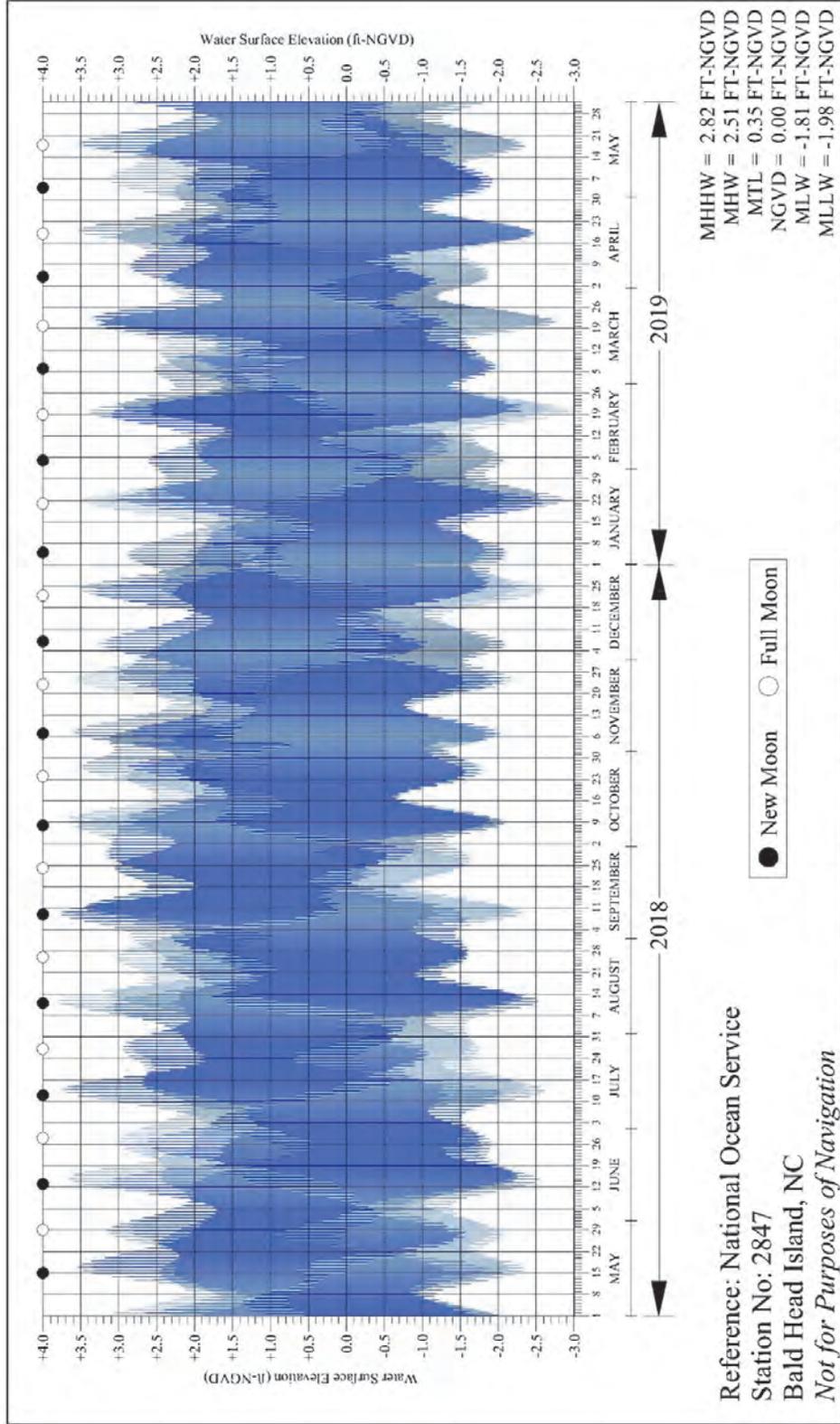
<sup>1</sup> Approximations based upon extrapolation from Southport, N.C.

<sup>2</sup> NGVD 1929: National Geodetic Vertical Datum of 1929 (1929 Mean Seas Level). Horizontal coordinates are referenced to the North Carolina State Plane Coordinate System, North American Datum of 1983.



**Figure 1.1:** Location of Bald Head Island, N.C. and Federal Navigation Channel.

# May 2018 through May 2019 Predicted Astronomical Tides Bald Head Island, North Carolina

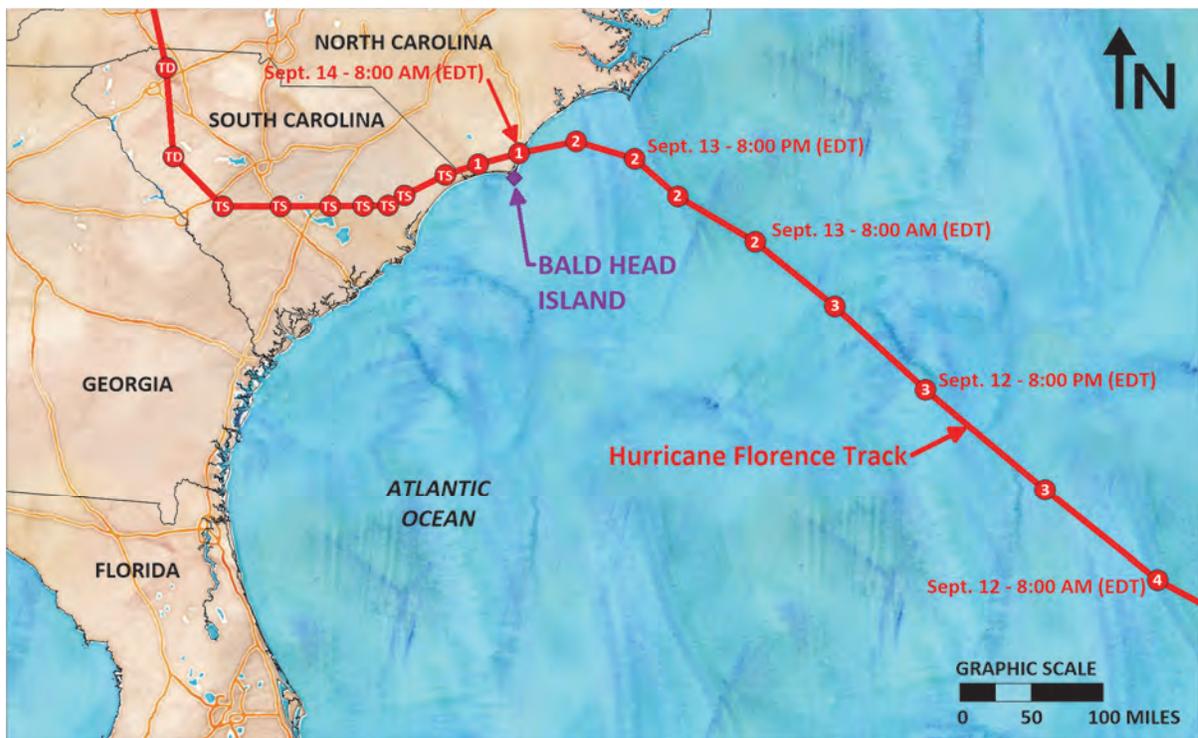


**Figure 1.2:** May 2018 through May 2019 predicted astronomical tides, Bald Head Island, North Carolina.

### 1.3 Monitoring Period Wave Climate (May 2018 to May 2019)

During the 12-month monitoring period, Bald Head Island experienced the effects of Hurricane Florence (September 2018). **Figure 1.3** plots the track of Hurricane Florence as the storm approached the east coast of the United States.

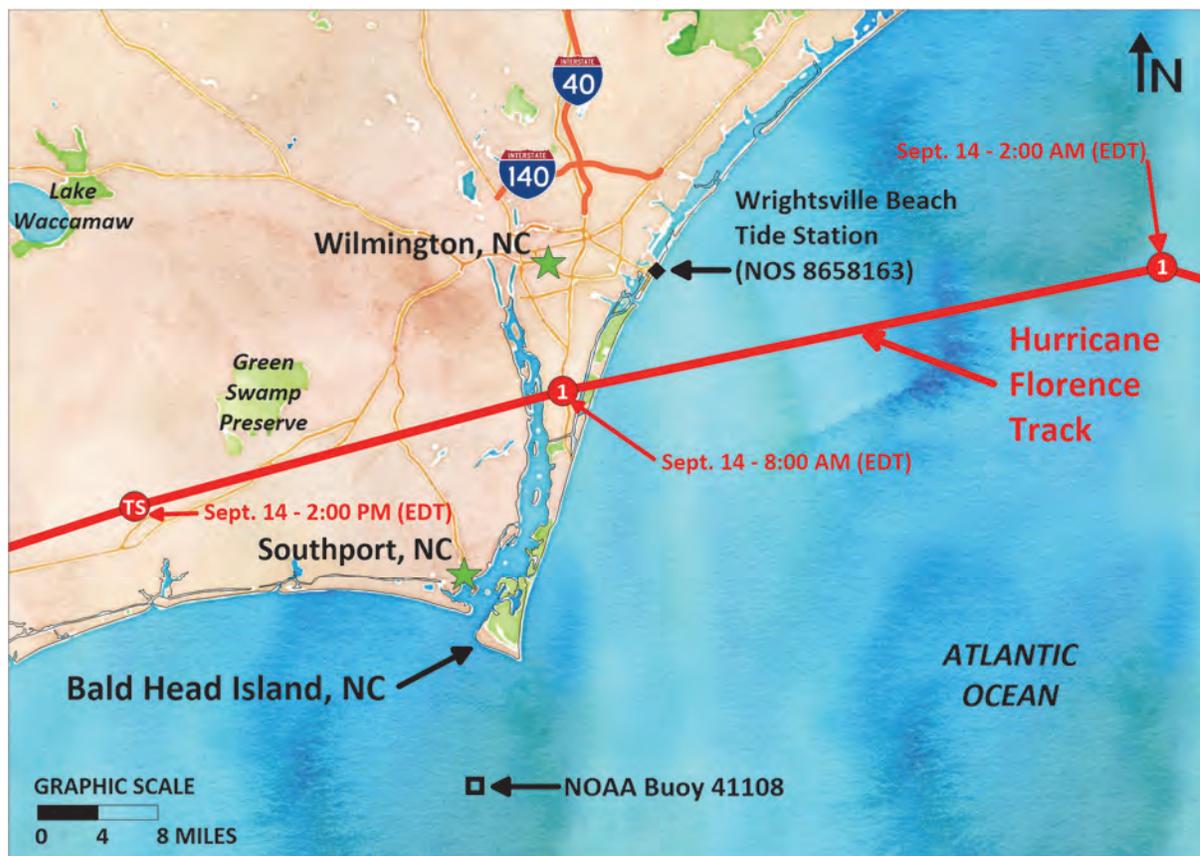
Hurricane Florence formed as a tropical depression off of the west coast of Africa on August 30, 2018. The storm moved west and northwest across the Atlantic Ocean, reaching tropical storm strength on September 1. By September 5, Florence had reached Category 4 strength. The strength of Florence fluctuated between tropical storm and Category 4 hurricane as it approached the east coast of the United States. Florence made landfall on the morning of September 14, just south of Wrightsville Beach, North Carolina as a Category 1 hurricane with 90 mph sustained winds. At the closest, the center of then Category 1 Hurricane Florence passed about 18 miles northeast of Bald Head Island, bringing sustained winds of 54 mph and gusts of 67 mph to the monitored shoreline (NOAA 2019).



**Figure 1.3:** Hurricane Florence (2018) track as the storm approached the coast of the United States. Track retrieved from the National Hurricane Center (NHC 2019).

**Figure 1.4** plots the track of Hurricane Florence in the vicinity of Bald Head Island. The figure also displays the location of NOAA Buoy 41108, located roughly 9 miles south of Bald Head Island in approximately 42 feet of water. The center of Hurricane Florence passed within about 28 miles of the buoy. The buoy was deployed in March 1988 and has been collecting data nearly continuously for 31+ years except for an approximate 5 year period between April 1992 and May 1997. The data collected by the buoy includes significant wave height (average of the highest one-third of all waves in a 20-minute sampling period), wave period, wave direction, wind speed and other standard meteorological data.

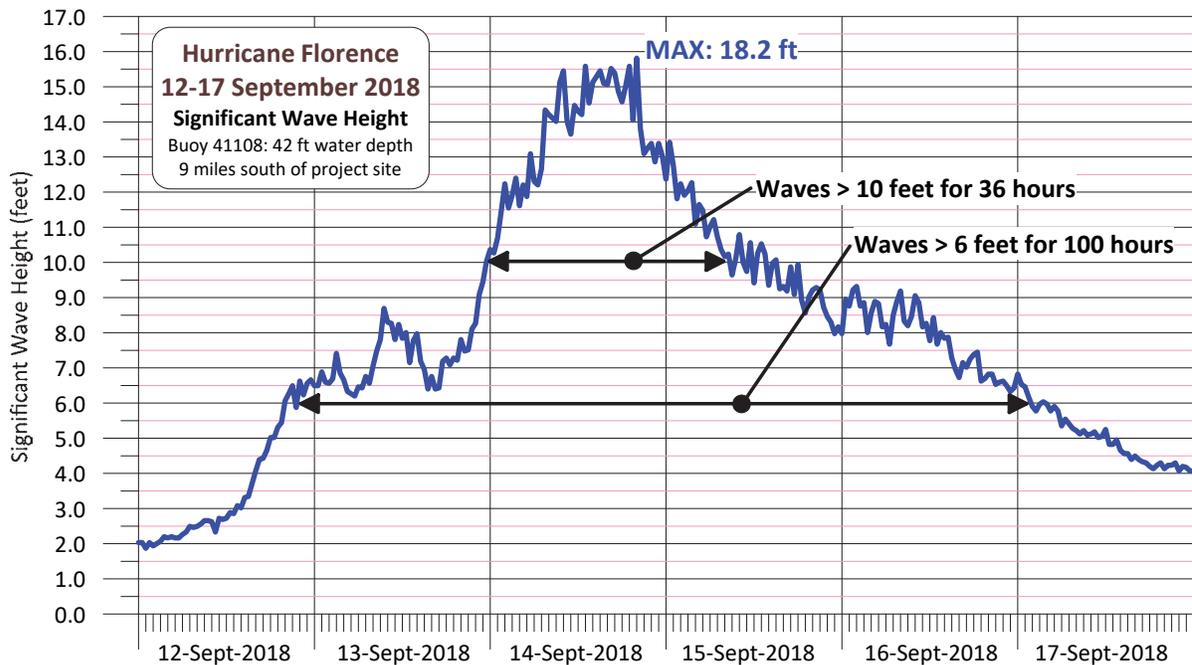
Additionally, Figure 1.4 shows the location of the Wrightsville Beach, NC tide station (NOS 8658163), owned and maintained by NOAA’s National Ocean Service (NOS) Water Level Observation Network. The tide station is located at the offshore end of the Johnny Mercers Fishing Pier, approximately 28 miles northeast of the monitored area. In addition to water levels, the station typically collects readings of wind speed, gust speed, atmospheric pressure, and other meteorological data. However, the station did not collect meteorological data during Hurricanes Florence. Hurricane Florence made landfall approximately 10 miles southwest of the station.



**Figure 1.4:** Track of Hurricane Florence in the vicinity of Bald Head Island showing the location of NOAA Buoy 41108 and the Wrightsville Beach tide station (NOS 8658163). Track retrieved from the National Hurricane Center (NHC 2019).

**Figure 1.5** depicts the time series measured at the buoy during the passage of Hurricane Florence. While the buoy is located offshore in unprotected waters, the wave conditions measured can generally be related to nearshore conditions along the monitored area. Additionally, some fraction of the waves measured at the buoy are directed offshore. All wave statistics mentioned in this section will be from measurements at Buoy 41108.

During Hurricane Florence, significant wave heights peaked at 15.81 feet on the evening of September 14<sup>th</sup>, as the storm’s center was approximately 40 miles northeast of the wave buoy. The dominant wave period peaked at about 9 seconds during this time. It is noted that these measurements reflect the significant wave height, or the average of the highest 1/3<sup>rd</sup> of waves passing the buoy during a 20 minute sampling period. There are waves that passed during the storm that were larger in height – some waves may have been as much as twice as high. Large waves persisted along the coast for a significant duration of time with significant wave heights greater than 10 feet lasting for more than 36 hours and waves greater than 6 feet for 100 hours. For comparison, during Hurricane Matthew (October 2016), wave heights greater than 10 feet lasting for about 22 hours and waves greater than 6 feet for 36 hours.



**Figure 1.5:** Time series of significant wave heights measured at NOAA Buoy 41108 as Hurricane Florence moved by Bald Head Island, NC. The buoy is located approximately 9 miles south of Bald Head Island in 42 feet of water.

**Figure 1.6** displays a time series of significant wave heights measured at NOAA Buoy 41108 from May 2018 through May 2019. The average significant wave height<sup>3</sup> at NOAA Buoy 41108 during the Year 18 monitoring period (May 25, 2018 to May 22, 2019<sup>4</sup>) was 3.28 feet with a maximum wave height of 15.81 ft measured during Hurricane Florence. The Year 17 average value is approximately 2 percent higher than the full record average significant wave height of 3.21 feet (March 1988 through May 2019) and 3 percent lower than the Year 16 average wave height (3.43 feet). Note that the Year 18 period included the effects of Hurricanes Florence and while the *average* wave height over the course of Year 18 was slightly lower than Year 17, the maximum wave height experienced that year (15.81 ft) was significantly higher compared to Year 16 (11.61 ft).

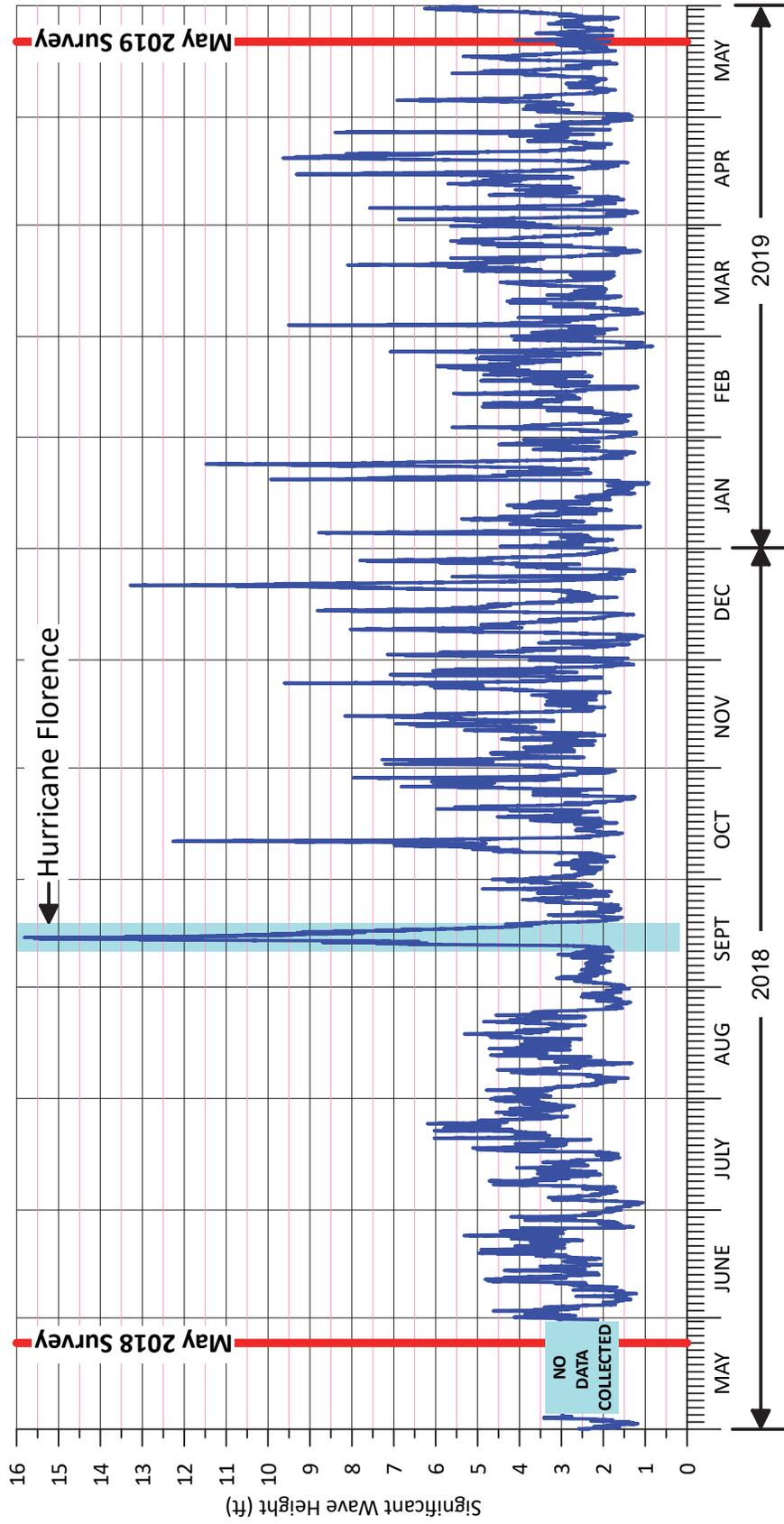
During the Year 18 monitoring period, roughly 6.7 percent of the recorded wave heights were above 6 feet, compared to 5.8 percent for the full record average. That is, there were roughly 15 percent more wave events recorded above 6 feet during the Year 17 monitoring period than would be expected during a typical similar period of time. Similarly, during the Year 17 monitoring period, the occurrence of waves above 10 feet was higher than the full record average (0.8 percent for Year 17 compared to 0.2 percent for the long-term average).

**Figure 1.7** displays the time series of water levels measured at the Wrightsville Beach, NC tide gage as Hurricane Florence passed. The maximum water level recorded during Hurricane Florence was approximately +6.61 ft-NGVD. This occurred about 1 hour before the days predicted high tide (+3.08 ft-NGVD). The corresponding storm surge (i.e. level above predicted tides) at this time was +3.76 ft. The maximum storm surge of +4.03 ft occurred approximately 30 minutes before the maximum water level (less than 1.5 hours from high tide). At this time, the predicted water level was +2.44 ft-NGVD yielding a measured water level of +6.47 ft-NGVD.

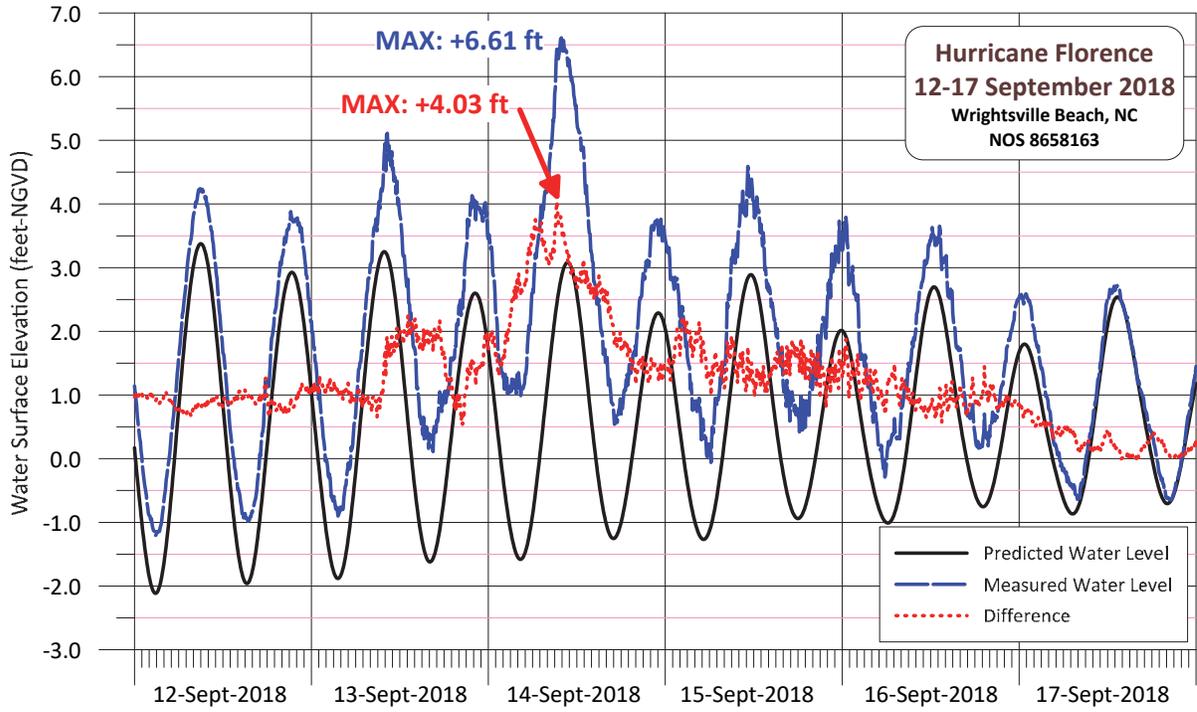
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<sup>3</sup> These measurements reflect the significant wave height, or the average of the highest 1/3<sup>rd</sup> of waves passing the buoy during a 20 minute sampling period.

<sup>4</sup> The May 2018 beach profile survey was completed May 25, 2018 and the May 2019 beach profile survey completed on May 22, 2019.



**Figure 1.6:** Significant wave heights recorded by NOAA Buoy 41108 during the 2018-19 monitoring period (Wilmington Harbor, NC).



**Figure 1.7:** Time series of water levels measured at the Wrightsville Beach NOAA tide gage (NOS 8658163) located along the open Atlantic Coast, as Hurricane Florence passed.

#### **1.4 Wilmington Harbor Federal Navigation Channel and Sand Management Plan**

A detailed discussion of the history of the navigation channel and the Wilmington Harbor Sand Management Plan is provided in Monitoring Report No. 15 (Olsen 2017).

The Wilmington Harbor Federal Navigation Project extends up the Cape Fear River from a point seven statute miles seaward of the Bald Head Island Marina, upstream 30.4 miles to a location just north of the City of Wilmington, N.C. The Wilmington District, U.S. Army Corps of Engineers (USACE) is responsible for maintaining the project at its congressionally authorized depths and widths.

The Wilmington Harbor Sand Management Plan (USACOE 2000) was formulated as a specific action element of the deepening project for Wilmington Harbor. For the most part, the Plan was in direct response to the stated concerns of the Village of Bald Head Island regarding the historical harbor maintenance impacts and potential new impacts of the deepening project to both the regional sediment budget and Bald Head Island. The Plan's stated purpose was to reverse the practice of placing beach quality sand in the off-shore disposal area by calling for placement of this sand onto adjacent beaches. Over a theoretical six-year biennial maintenance cycle, the initial Wilmington Harbor Sand Management Plan (WHSMP) stipulated that approximately 1.0 Mcy of sand was to be placed on the beaches of Bald Head Island in years two and four (*after* initial construction) and on Oak Island/Caswell Beach during year six. The six-year disposal cycle was proposed for the life of the project but, accordingly to its terms, could be altered based upon documentation of impacts to adjacent beaches, changes in conditions and other relevant factors. The first six-year (3 maintenance event) cycle was completed in April 2009. In early 2011, the Wilmington District issued a draft report-of-findings both summarizing approximately 10-years of monitoring and readdressing the tenets of the original (2000) Sand Management Plan based upon their interpretation of monitoring results, related analyses and other salient factors or considerations. Subsequently the District solicited public comments from the two (2) principal stakeholders – the Village of Bald Head Island and Caswell Beach.

It has been OAI's continuing opinion that the division of sand between the two (2) abutting shorefronts of Oak Island and Bald Head Island should be based upon the cumulative quantities of sediment lost from each shoreline over the prior dredging cycle(s) as documented by survey, as well as identifiable impacts which exceed the November 2000 (pre-project) benchmark survey. Alternatively, it should be based upon the ratio of documented littoral transport rates for each island toward the Cape Fear River.

## 1.5 Historical Erosion Control Activities (1991 to 2019)

### 1.5.1 Channel Maintenance Beach Disposal and Beach Restorations – Chronology

Beach fill placement activities constructed at Bald Head Island since 1991 are summarized in **Table 1.2**. Not including 2018/19, a detailed discussion of the history of channel maintenance beach disposal and beach restoration activities is provided in Monitoring Report No. 15 (Olsen 2017).

**Table 1.2:** Beach disposal or sand placement activities at Bald Head Island since 1991.

Year	Volume	Sponsor	Location
1991	0.35 ± Mcy	VBHI	(Sta. 24+00 to 138+00)
1996	0.65 ± Mcy	VBHI	(Sta. 24+00 to 142+00)
1997	0.45 ± Mcy	VBHI	(Sta. 24+00 to 128+00)
2001	1.849 ± Mcy	USACE*	South Beach (Sta. 41+60 to 205+50)
2005	1.217 ± Mcy	USACE*	South Beach (Sta. 46+00 to 126+00)
2006	47,800 cy	VBHI	West Beach (Sta. 16+00 to 34+00)
2007	0.9785 ± Mcy	USACE*	South Beach (Sta. 46+00 to 174+00)
2009/10	1.850 ± Mcy	VBHI	West Beach (Sta. 8+00 to 32+00) South Beach (Sta. 40+00 to 190+00)
2012	137,990 cy	FEMA/VBHI	West Beach & Western South Beach
2013	1.566 ± Mcy	USACE*	South Beach (Sta. 44+00 to 150+00)
	92,500 cy		West Beach (Sta. 8+00 to 27+00)
2015	1.33 ± Mcy	USACE*	South Beach (Sta. 41+50 to 154+00)
2016/17	50,000 cy	VBHI	West Beach and Row Boat Row
2018/19	1.1 Mcy	VBHI	South Beach (Sta. 49+00 to Sta. 146+00)

\* Disposal pursuant to the WHSMP

### 1.5.2 Erosion Control Structures (1996 to 2019) - Chronology

Erosion control structures constructed at Bald Head Island since 1996 are summarized in **Table 1.3**. A detailed discussion of the (pre-2019) history of erosion control structures is provided in Monitoring Report No. 15 (Olsen 2017).

**Table 1.3:** History of erosion control structures at Bald Head Island since 1994.

<b>Year</b>	<b>Location</b>	<b>Description</b>
1994	Western South Beach	Sand bag revetment located along 645 feet of the back-beach berm
1996 (March)	Western South Beach	Sixteen (16) soft groins (geotube-type structures) were constructed of geotextile material and sand fill
2003/2004	Western South Beach	Rehabilitation of 1994 constructed sand bag revetment. Revetment lengthened by approximately 200 feet and base width increased to 40 ft and crest elevation raised to +12 ft-NGVD).
2005 (January to March)	Western South Beach	Replacement of 1996 constructed sand tube groin field. Minor changes in groin location were made in an effort to improve performance. Similarly, experimental “tapered” tubes were deployed in an attempt to better accommodate beach profile recession over time.
2009	Western South Beach	Complete rehabilitation of the sand tube groin field. Some adjustment of groin lengths, and the westward relocation of groin no. 16 were made in an attempt to refine the project design.
2011	Western South Beach	300 ft sand bag revetment was constructed on the downdrift (western side) of the last sand tube groin in order to protect several endangered residential structures.
2013	Western South Beach	In the spring of 2013, the westernmost five (5) sand tube groins were replaced in their entirety. This work was co-funded by FEMA as part of a post-Irene damage mitigation effort. The project P.W. was BHGJS04 in accordance with FEMA declaration 4019 DR NC.
2015	Western South Beach	In the spring of 2015, construction was initiated on a single 1,300 ft. long rock terminal groin designed to complement future placement of beach fill at South Beach. At that time, the westernmost three (3) geotube groins were removed in their entirety. A detailed description of the project is provided in Monitoring Report No. 15 (Olsen 2017).
2015	Bald Head Marina	The two marina entrance channel structures seaward of Row-Boat-Row originally constructed by Bald Head Island, Ltd., were modified through the addition of rock extensions.
2017	Row Boat Row	Two (2) detached breakwaters were constructed just north of the Marina Entrance. Construction details are provided in Monitoring Report No. 16 (Olsen, 2018).
2019	Western South Beach	All remaining 13 sand tube groins were removed and replaced.

## **2.0 BEACH RENOURISHMENT PROJECT IMPLEMENTATION (2018/2019)**

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### **2.1 Pre-Construction Activities – Timeline**

In order to construct a scheduled renourishment project during the winter of 2018/19, the Village was required to perform new or updated investigations, design analyses and permit-related activities well in advance of the initiation of work. Accordingly, the most important work elements preceding the actual award of a contract for the subject beach restoration project to a qualified dredging firm in late 2018 included the following items:

#### PHASES OF WORK

- Beach and Borrow Surveys
- Borrow Site Redevelopment
- Marine Archaeological Survey (Update of borrow site anomalies)
- Engineering Design/Analyses
- Permitting
- Design Documents
- Sandtube Groin Field Replacement Design
- Groin Field Permitting
- Bid Advertisement – Beach Restoration
- Bid Advertisement – Groinfield Replacement (2<sup>nd</sup> Contractor)

### **2.2 Project Permits and Terms**

By permit, the types of open coast dredging and beach fill placement activities involved are limited in the State of North Carolina to a construction window of 15 November through 31 March. Concerns in this regard were associated with the fact that sand tube groin field replacement had to occur within the same regulatory timeframe for work on the beach. To facilitate the removal and replacement process for the thirteen (13) structures, the beach fill berm within the affected limits of the field needed to have been partially constructed. Special provisions were required to allow tube replacement activities to occur under the dredge contractor's shore pipe. The overall project therefore necessitated two (2) contractors working and coordinating at the same time, in the same general areas of S. Beach.

### **2.3 Marine Cultural Resource Protection**

In the initial development of the project offshore borrow source, verification of *potential* archaeological items of significance (to be avoided by the dredge) is a standard part of the overall permitting process. To that end, Tidewater Atlantic Research, Inc. (TAR) was retained to perform an Archaeological Remote Sensory Survey on Jay Bird Shoal (Tidewater, April 2007). All work performed complied with the criteria of the National Historic Preservation Act (PL 89-665), NEPA, etc.

Initial field work for the 2010 project was conducted on 18 and 19 March 2007. Remote sensory data generated by the Jay Bird Shoals survey identified a total of 49 magnetic anomalies, none of which however had an acoustic signal. Two exclusion zone buffers were identified for the 2010 project. In late 2017, an “Anomaly Reassessment Investigation” was performed by TAR. (Tidewater 2017). As a result, the design documents for the reuse of the original Jay Bird Shoals borrow site were able to designate buffers around the anomalies of concern which were reduced in size. That “refined” approach was both accepted and codified by the State Historic Preservation Officer, as well as by the State and Federal permits eventually issued for the project.

## **2.4 Project Borrow Source Development**

The pay volume of sand required for a 09/10 renourishment project was slightly more than 1.59 Mcy. The “pay” volume for the 2018/19 project was 1.1 Mcy (including a FEMA Claim for slightly less than 100,000 cy). The gross volume dredged is typically estimated to exceed the pay volume by 10%, mol.

The Village had identified a viable borrow source of beach-compatible sand for fill placement at Bald Head Island which is detailed in a Sand Search investigation performed by Olsen Associates, Inc (2007). The 225-acre site evaluated near the seaward end of Jay Bird Shoals was located approximately 0.8 miles offshore of Bald Head Island and 1.6 miles offshore of Oak Island. The final area designated as the project borrow site was approximately 158 acres.

Seabed elevations ranged between -5 ft to -16 ft NGVD within the proposed borrow limits (**Figure 2.1**).

By design, the borrow area for both the Village funded 2009/10 and the 2018/19 beach fill projects was sited on the distal (seaward) end of a highly dynamic linear shoal feature bordering the western perimeter of the original navigation project entrance channel. As such it is part of the overall Jay Bird Shoal complex westward of Bald Head Island, which forms much of the present-day Cape Fear River ebb tidal platform. The latter large-scale morphological unit has been significantly altered in spatial extent, volume, ambient depths, etc. from its natural configuration due to the construction and long-term maintenance of the Cape Fear River Entrance Navigation Channel beginning in the late 1800s.



Of specific interest in the development of the overall Jay Bird Shoals borrow site were the following characteristics:

- reasonable accessibility to Bald head Island and maximum distance from Oak Island so as to minimize conflict with future similar work by others;
- documentation of a lack of adverse impact to littoral processes along adjoining barrier island shorelines due to wave transformation at the modified shoal formations;
- documented strata of high quality beach compatible sediment suitable for meeting both recently adopted State Standards and post-placement performance criteria acceptable to the Engineer;
- lack of significant benthic or other resources to be temporarily impacted by excavation;
- desirable constructability characteristics for purposes of sand excavation and beach fill construction by an ocean certified cutter suction dredge,
- an acceptable level of potential cultural resource avoidance necessary for dredge operational feasibility; and
- siting of the borrow area in a dynamic depositional area for purposes of encouraging post-construction substrate recovery, or minimization of substrate composition modification, over time (in contrast to a site selected either upon or within a transgressive type shoal feature).

Suitable beach quality sediments within the Jay Bird Shoals borrow site were designed to be excavated by cutter suction dredge and transported by submerged pipeline to the western end of Bald Head Island. From the pipe landing point, the material could be distributed by shore pipe to either the West Beach or South Beach shorelines. Within the borrow site, two (2) groups of magnetic anomalies and a federal tide gage structure had been identified and needed to be avoided by the dredge contractor via specified exclusion areas. The design depth of the borrow area varied between -20 and -22 ft NGVD (mol.). The proposed footprint of the final permitted area to be excavated was approximately 158 acres and was located at the distal (*i.e.*, seaward) end of Jay Bird Shoals. Existing depths in the proposed borrow area ranged between -5 ft and -16 ft NGVD. All material to be excavated met recently adopted Technical Standards for Beach Fill Project as published in the North Carolina Administrative Code (15A NCAC 07H.0312). The details of the sediment and Vibrocore data from the most recent site geotechnical exploration are provided in the Sand Search Investigation Report (Olsen 2007a). Similarly, the results of numerical modeling intended to evaluate potential impacts of the borrow site to the local wave climatology are presented in Olsen Associates, Inc., December 2007 Report. Subsequent to the 2009/10 project, portions of the excavated borrow site reshored with high quality sediment – thereby allowing for “re-excavation” of a portion of the original site in 2018/19.

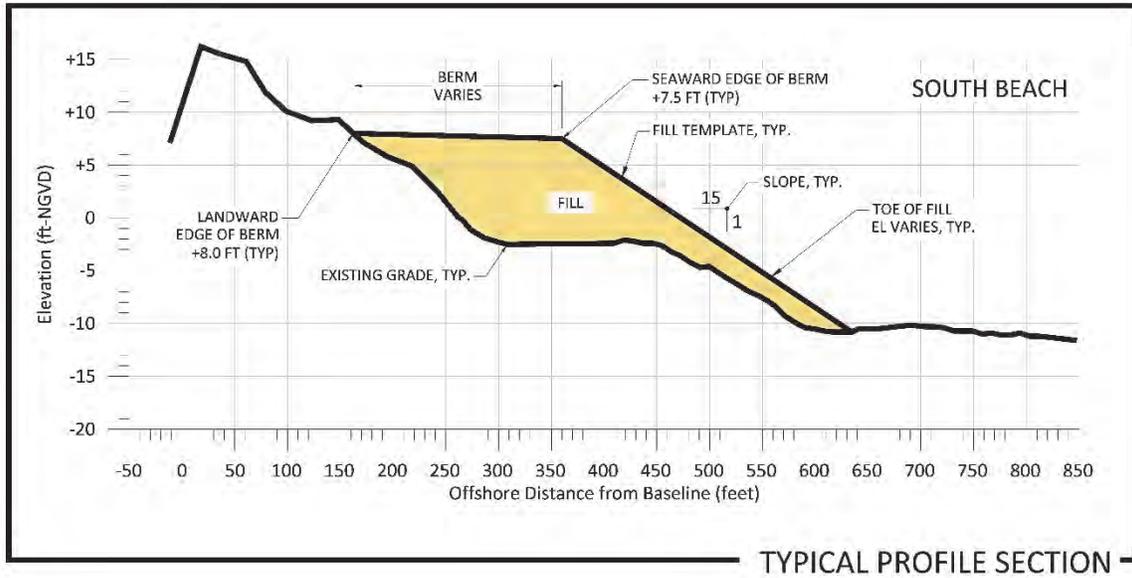
## 2.5 Beach Fill Design

**Figure 2.2** depicts the typical characteristics associated with the design beach fill template for the South Beach project discussed herein. On South Beach, the specified fill densities for the 2018/19 renourishment project varied between 50 cy/ft and 200+ cy/ft. The latter exceedingly high fill volume placement occurred at the centroid of the fill near a nodal point in littoral transport. **Figure 2.3** graphically portrays the actual cumulative alongshore placement progress for the South Beach fill segment, on a daily basis as recorded by Marinex.

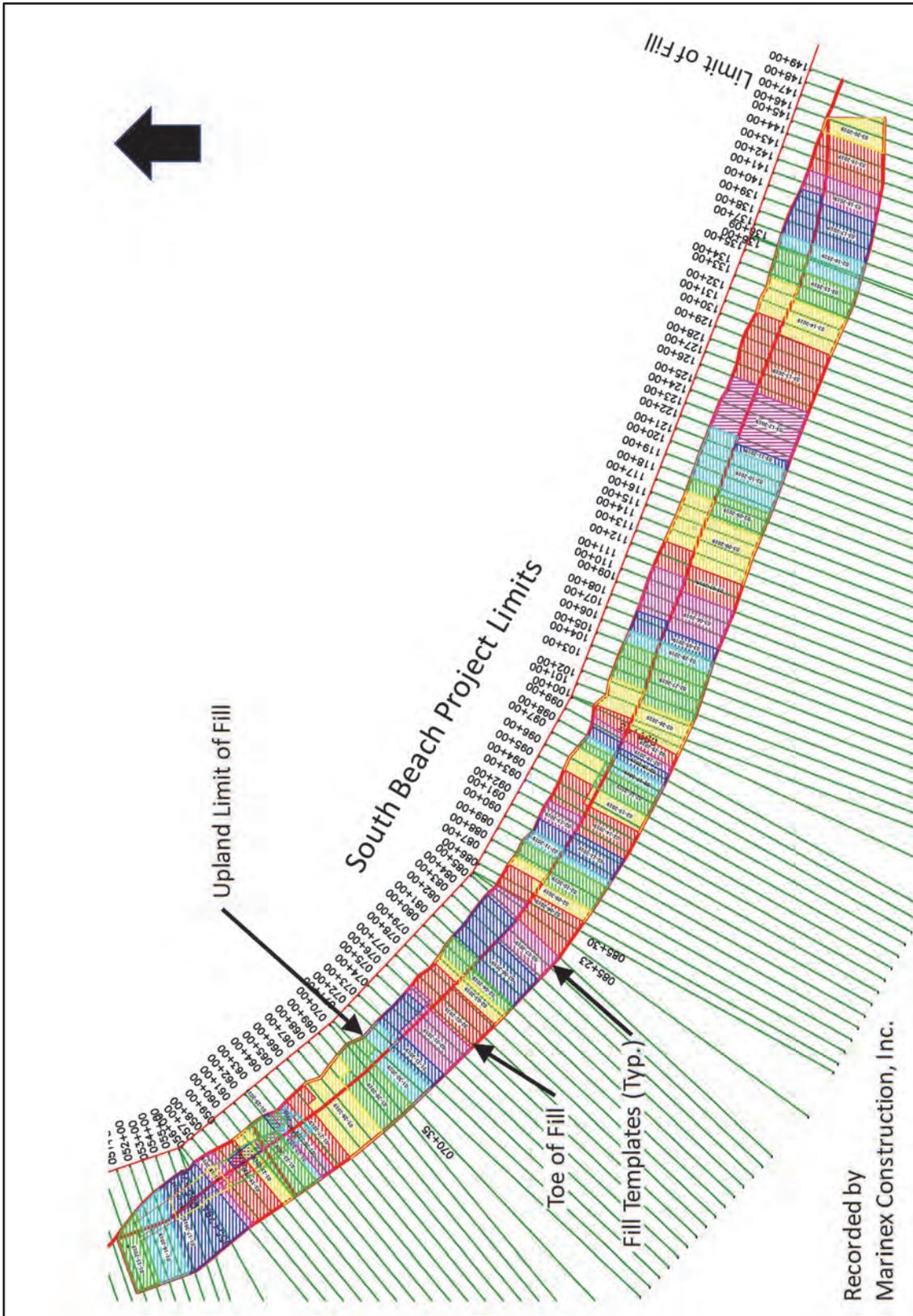
The project design in 2009/10 included the re-establishment or enhancement of the project dune line and associated salt tolerant stabilizing vegetation lost to erosion at the time of construction. The requirement for dune reconstruction was *not* necessary for the most current project. At all locations, the project duneline (with vegetation) was intact due to the existence of some level of pre-project protective beach berm – even after the occurrence of H. Florence which impacted N.C. in September 2018.

It is typically found that with most well maintained beach nourishment projects, net enhancement of the project shorefront occurs over time – at least relative to the eroded pre-project condition. The Village project is no exception. For example, within the entire *engineered* beach project on South Beach extending from Sta. 044+25 eastward to Sta. 202+00, mol. there were approximately 2 Mcy, of sand in place as of May 2018, in comparison to the November 2000 pre-improvement conditions. That (Monitoring Report No. 16) analysis included the beach profile extending from the 1999 upland contour, which is the apparent historical limit of change at this location as documented by 18-years of annual monitoring. It also includes the up-drift sand fillet associated with the placement of the 2015 terminal groin.

As depicted by the typical beach fill templates (**Figure 2.2**) seaward of the project dune feature (and vegetation), the upper flat portion of the 2018/19 construction berm was built to an elevation of +8 ft. NGVD and varied in width initially along the length of the project from approximately 75 to 400 ft. (typ) – the fill taper at the eastern end not included. The initial construction slope was set at 1:15. The construction berm was expected to equilibrate (in places), over the first six months post-construction by 50% or less of its initially placed width. Subsequent to the construction of the 2015 terminal groin the greatest shorefront equilibration is expected to be along the western end of South Beach, eastward from the rock groin through a portion of the sand tube groin field where the shoreline curvature is greatest.



**Figure 2.2:** Beach fill template, as designed and as constructed (width varies).



**Figure 2.3:** Record of daily fill placement operations at South Beach.  
(Marinex Construction, Inc.)

## 2.6 Bidding & Project Cost To Construct

Subsequent to Advertisement, formal bids were received by the Village on 30 July 2018. Three dredging firms submitted qualified bids. The final total bids for the initial Bald Head Island 1.0 Mcy design project were as follows:

	<u>Base Bid</u>
• Norfolk Dredging Co.	\$15,640,000
• Weeks Marine, Inc.	\$12,140,000
• S.J. Hamill Construction., LLC.	\$10,969,000

NOTE: The S.J. Hamill bid proposed the use of their “sister” firm Marinex Construction, Inc.

The relevant costing components of the S.J. Hamill Dredging original bid can be summarized as follows:

• Mobilization/Demobilization	\$ 2,969,000
• Beach Fill 1M cy @ \$7.98/cy	\$ 7,980,000
• Tilling (optional)	<u>\$ 20,000</u>
TOTAL BASE BID	\$10,969,000

On October 18, 2018 Change Order No. 1 was issued. The latter increased the contract pay volume from 1 Mcy to 1.1 Mcy in order to address a Post-Florence FEMA Claim for the portion of South Beach intended for renourishment. The Claim sought reimbursement for a documented 99,417 cy loss associated with the event. The latter occurred between baseline Sta 56+56 and Sta 142+00. As a direct result, the project fill template design was modified accordingly. The final contract amount (after Change Order No. 1) was \$11,767,000 – although it is noted that the optional (\$20K) tilling item was ultimately *not* required by State Regulatory Agencies. The project was determined to be Substantially Complete on 22 March 2019 and Finally Accepted on 31 March 2019 subsequent to demobilization by the Contractor. All BD/AD surveys and other project details are found in the project specific post-Construction Report (Olsen, 2019).

## 2.7 Construction Equipment and General Technique – Dredging & Beach Fill

Marinex Construction, Inc. (a sister firm to S.J. Hamill Construction) constructed the beach fill project. The contractor employed the 24-inch cutter suction dredge (the “Savannah”). Built in 2011, this ocean-certified dredge is 250 ft. long, 49 ft. wide and draws 11 ft. The Savannah’s four (4) pumps total almost 10,000 hp. To perform the required transfer of sand from the offshore borrow site, Marinex mobilized some 21,000+ ft. of

floating, submerged and shore pipe to the project location. A booster pump was used near the end of the project to maintain a high level of production on the longest line.

In order to cross the federal navigation project that separated the Jay Bird Shoal borrow site from Bald Head Island, the contractor elected to lay submerged pipe in the deepest section of the channel gorge near West Beach. Actual beach fill construction extended from January 13, 2019 to 22 March 2019. The dredge's "down time" over this period was approximately 16%. The greatest portion of the lost time resulted from winter weather conditions. On several occasions major storms (or fronts) necessitated removing the dredge from the borrow site into the calmer interior waters of the Cape Fear River until sea state conditions abated. When working unimpeded, the average dredge production realized exceeded 21,000 cy/day.

### **3.0 SAND TUBE GROINFIELD REPLACEMENT (2019)**

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#### **3.1 Groinfield History (Pre-2019)**

A sixteen (16) sand tube groinfield was originally constructed at South Beach by the Village in 1996 to serve as a stabilizing influence on a small scale beach fill constructed at that time. The original structures (LONGARD tubes) installed were up to 300 feet long and when full were uniform in diameter (*i.e.*, @ 70", mol).

In 2005, all of the original sand-filled LONGARD tubes were replaced with custom "tapered" tubes varying from about 4 ft. to 6 ft. in effective height. The tubes also were constructed with a unique spiral seam. In 2005, the effective location of the entire groinfield was shifted slightly westward toward the navigation project. Replacement of the groinfield was required by the Wilmington District as part of the 2005 *engineered beach* renourishment project design. The costs for the 2005 replacement project were paid by the Village.

Similarly, in 2009/10 the Village determined that the groinfield sand tubes again warranted a scheduled replacement as part of the renourishment of the *engineered beach* constructed at that time. The project was competitively bid in October 2009 and the Village received four (4) bids, ranging from \$1,138,735 to \$1,855,000. The effective low base bid was submitted by WECC, Inc., with subcontract services provided by Atlantic Diving & Marine Contractors, Inc. The latter firm had constructed the 2005 sand tube replacement project. The custom tubes were fabricated by Bradley Industrial Textiles. Work began in December 2009 and was determined to be Substantially Complete on 22 April 2010.

In 2015, subsequent to the construction of the 1,300 ft. long rock terminal groin near the inlet, the Village removed the westernmost three (3) geotubes. Since they were well buried in the upland portion of the terminal groin fillet, it was determined that they no longer served a useful purpose.

#### **3.2 2019 Contract Concurrent With The Beach Renourishment Project**

As part of the assessment for the 2018/19 beach renourishment project to be constructed at South Beach by the Village, it was determined that numerous sand tube groins were approaching the end of their effective life and that replacement was warranted. Two permit modifications were required. One allowed for an extension of time beyond April 1<sup>st</sup> and the 2<sup>nd</sup> allowed for both removal and replacement of all remaining thirteen (13) sand tube groins (and underlayments).

Subsequent to the solicitation of competitive bids, the project was awarded to McPherson Marine Services, LLC. The total Contract amount was \$1,204,179.00. This was exclusive of the cost of the tubes. To that end, the Village contracted directly with Bradley

Industrial Textiles well in advance of the award of the above removed/replacement Contract due to the lead time required for fabrication. The cost of the tapered geotextile tubes, a poly-urea coating and delivery was approximately \$320,000 (*i.e.*, 13 tube groins with new underlayments).

The project contractor McPherson Marine Services, LLC. sub-contracted most construction activities to Fish-Tech, Inc. headquartered in Daytona Beach, Florida. The work was initiated on/about 13 February and Substantially Completed by 22 March 2019. Since, portions of the existing geotube groinfield had become buried beneath (and to some degree, northward of) the existing primary dune, certain tube lengths were modified (shortened) so as to minimize excavation impacts to the dune during removal of existing tubes. That is to say, a small portion of “reduced length tubes” were cut off and left undisturbed beneath the dune line landward of a new tube. Reductions in various tube lengths ranged from 25 to 70 ft. Four (4) tubes were not reduced, but installed at their original 300 ft. length. **Figure 3.1** visually depicts the typical sand tube removal/replacement process (2010 photography).



Groin # 8 – Being Removed Prior to Replacement



Groin # 12 – Before Back-Fill



Groin # 2 – Before Fill



Groin # 1 – After Fill

**Figure 3.1:** Sand tube removal/replacement process.

## 4.0 PHYSICAL MONITORING PROGRAM

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### 4.1 Monitoring Baseline & Beach Profiles

**MONITORING BASELINE** The present day Bald Head Island monitoring baseline extends roughly 31,400 ft from the northern end of Row Boat Row (Sta. -014+72), southward along West Beach, around “the Point”, then eastward along South Beach to Cape Fear and finally northward along East Beach (Sta, 284+00). The individual profile stationing and coordinates are listed in **Table 4.1** and graphically depicted in **Figure 4.1**.

**BEACH PROFILES** In order to document and assess any potential adverse effects of the Wilmington Harbor Navigation Channel Navigation project to Bald Head Island, the Village Council initiated a comprehensive beach monitoring program which commenced in 1999. As part of the program onshore and offshore profiles are measured annually at seventy-nine (79) stations spaced approximately 400 ft apart along the roughly 31,400 ft of Bald Head Island’s shorefront. **Table 4.2** summarizes the monitoring surveys conducted to date as part of the monitoring program. The primary focus of this monitoring report (No. 16) is beach profile and shoreline changes occurring over the latest set of surveys (May 2018 to May 2019).

Typically, survey transects extend across the upland berm or from the dune line seaward a distance of up to 3,000 ft. Depending upon the location of the survey profile, this distance corresponds to offshore waters depths of at least -40 ft relative to NGVD within the Cape Fear River Channel and -16 ft-NGVD along the Atlantic Ocean shorefront. In Chapter 5.0, these surveys are intra-compared in order to determine trends in the condition of the beaches of Bald Head Island. Plots of selected historical comparative beach profile data (through May 2019) are provided in **Appendix A**.

Prior to October 2003, fifty-five (55) stations were surveyed as part of the monitoring program. Five (5) additional intermediate stations were added at the Point, commencing with the October 2003 survey. These profile stations were added to more accurately capture the extreme changes that occur at the Point. Seven (7) profiles were added along East Beach (EB-01 to EB-07) beginning with the November 2008 survey. Beginning with the November 2015 survey five (5) profiles were added along Row Boat Row and four (4) were added at the Point, as part of the terminal groin monitoring requirement. Finally, in November 2016, three (3) additional profiles were added along West Beach.

**Table 4.1:** Bald Head Island baseline stationing and beach monitoring profile locations.

Station (Monument)	Station Location		Grid Azi. (Deg.)	Station	Station Location		Grid Azi. (Deg.)
	Easting (FT-NAD83)	Northing (FT-NAD83)			Easting (FT-NAD83)	Northing (FT-NAD83)	
<b>Row Boat Row</b>				084+16 (B-22)	2,303,032.1	40,924.5	219
-014+72 (RB-01)	2,304,277.9	49,117.4	302	088+23 (B-23)	2,303,372.1	40,705.0	214
-012+00 (RB-02)	2,304,068.6	48,776.5	302	092+15 (B-24)	2,303,714.1	40,513.9	209
-008+00 (RB-03)	2,303,937.2	48,538.1	302	097+10 (B-25)	2,304,146.1	40,272.5	206
-004+00 (RB-04)	2,303,728.0	48,197.2	302	102+08 (B-26)	2,304,592.1	40,057.6	204
-003+00 (RB-05)	2,303,518.7	47,856.3	302	106+00 (B-27)	2,304,960.4	39,915.3	201
<b>West Beach</b>				110+00 (B-28)	2,305,333.5	39,771.1	201
000+00 (B-01)	2,303,309.3	47,515.5	302	114+00 (B-29)	2,305,708.5	39,626.3	202
004+00 (B-02)	2,303,100.4	47,174.4	301	118+00 (B-30)	2,306,080.6	39,482.5	202
008+00 (B-03)	2,302,891.5	46,833.3	301	122+00 (B-31)	2,306,451.7	39,339.2	201
010+00 (I-03)	2,302,788.1	46,662.0	301	126+00 (B-32)	2,306,824.0	39,195.3	200
012+00 (B-04)	2,302,682.5	46,492.2	301	130+00 (B-33)	2,307,196.5	39,051.4	200
014+00 (I-04)	2,302,578.8	46,321.1	301	134+00 (B-34)	2,307,569.6	38,907.3	200
016+00 (B-05)	2,302,473.6	46,151.1	301	138+00 (B-35)	2,307,943.9	38,767.8	200
018+00 (I-05)	2,302,369.5	45,980.3	301	142+00 (B-36)	2,308,320.5	38,633.0	200
020+00 (B-06)	2,302,264.7	45,810.0	301	146+00 (B-37)	2,308,697.1	38,498.2	200
024+00 (B-07)	2,302,055.2	45,468.8	302	150+00 (B-38)	2,309,073.8	38,363.4	200
<b>"the Point"</b>				154+00 (B-39)	2,309,452.4	38,228.0	201
028+00 (B-08)	2,301,845.1	45,126.6	303	158+00 (B-40)	2,309,818.8	38,074.6	202
032+00 (B-09)	2,301,566.1	44,843.7	301	162+00 (B-41)	2,310,179.1	37,895.6	203
034+00 (I-09)	2,301,394.4	44,742.0	301	166+00 (B-42)	2,310,539.0	37,716.9	204
036+00 (B-10)	2,301,220.2	44,647.1	299	170+00 (B-43)	2,310,903.5	37,552.0	204
038+00 (I-10)	2,301,043.1	44,550.6	296	174+00 (B-44)	2,311,267.9	37,387.2	204
039+60 (B-11)	2,300,902.6	44,473.9	291	178+00 (B-45)	2,311,632.4	37,222.3	204
041+50 (I-11)	2,300,765.0	44,365.0	287	182+00 (B-46)	2,311,996.9	37,057.4	204
043+47 (B-12)	2,300,757.5	44,167.6	284	186+00 (B-47)	2,312,361.3	36,892.6	204
044+25 (I-12)	2,300,754.6	44,090.2	276	190+00 (B-48)	2,312,725.8	36,727.8	204
045+07 (B-13)	2,300,751.4	44,007.0	268	194+00 (B-49)	2,313,090.2	36,562.9	204
046+00 (I-13)	2,300,784.9	43,920.7	260	198+00 (B-50)	2,313,454.7	36,398.1	204
046+89 (B-14)	2,300,813.7	43,836.0	251	202+00 (B-51)	2,313,819.2	36,233.2	204
049+00 (H-13)	2,300,881.5	43,636.5	247	206+00 (B-52)	2,314,183.6	36,068.4	204
050+50 (I-14)	2,300,913.5	43,541.9	247	210+00 (B-53)	2,314,548.1	35,903.5	204
051+00 (J-14)	2,300,945.8	43,447.1	247	214+00 (B-54)	2,314,912.5	35,738.7	204
052+64 (B-15)	2,300,998.3	43,292.1	243	218+00 (B-55)	2,315,277.0	35,573.8	204
054+00 (I-15)	2,301,042.2	43,163.0	243	<b>East Beach</b>			
<b>South Beach</b>				224+80 (EB-01)	2,315,748.8	36,063.3	90
056+56 (B-16)	2,301,148.7	42,933.8	233	234+80 (EB-02)	2,315,748.8	37,063.3	90
060+51 (B-17)	2,301,399.6	42,628.3	230	244+80 (EB-03)	2,315,748.8	38,063.3	90
065+50 (B-18)	2,301,716.0	42,243.2	229	254+80 (EB-04)	2,315,748.8	39,063.3	90
069+46 (B-19)	2,301,967.6	41,937.0	227	264+80 (EB-05)	2,315,748.8	40,063.3	90
073+39 (B-20)	2,302,246.1	41,660.5	223	274+80 (EB-06)	2,315,748.8	41,063.3	90
076+37 (B-21)	2,302,609.2	41,320.5	222	284+80 (EB-07)	2,315,748.8	42,063.3	90



**Figure 4.1:**  
Island-wide beach monitoring baseline.

**Table 4.2:** Bald Head Island monitoring surveys collected as of May 2018.

<b>Survey Date</b>	<b>Surveyor</b>	<b>Comments</b>
1999 Nov.	Brunswick Surveying., Inc.	16 months pre-construction (2001 disposal)
2000 Nov.	Brunswick Surveying., Inc.	4 months pre-construction (2001 disposal)
2001 Aug.	Brunswick Surveying., Inc.	1 month post-construction (2001 disposal)
2002 July	Brunswick Surveying., Inc.	12 months post-construction (2001 disposal)
2002 Dec.	Brunswick Surveying., Inc.	17 months post-construction (2001 disposal)
2003 May	Brunswick Surveying., Inc.	22 months post-construction (2001 disposal)
2003 Oct.	McKim & Creed	27 months post-construction (2001 disposal)
2004 Apr.	McKim & Creed	33 months post-construction (2001 disposal)
2004 Oct.	McKim & Creed	39 months post-construction (2001 disposal)
2005 Apr.	McKim & Creed	3 months post-construction (2004/05 disposal)
2005 Nov.	McKim & Creed	10 months post-construction (2004/05 disposal)
2006 Apr	McKim & Creed	15 months post-construction (2004/05 disposal)
2006 Nov.	McKim & Creed	22 months post-construction (2004/05 disposal)
2007 June	McKim & Creed	2 months post-construction (2007 disposal)
2007 Nov.	McKim & Creed	7 months post-construction (2007 disposal)
2008 May	McKim & Creed	13 months post-construction (2007 disposal)
2008 Nov.	McKim & Creed	19 months post-construction (2007 disposal)
2009 May	McKim & Creed	25 months post-construction (2007 disposal)
2009 Sept.	Gahagan & Bryant	Survey required by dredge Contractor.
2010 May	McKim & Creed	2 months post-renourishment (09/10)
2010 Sept.	McKim & Creed	6 months post-renourishment (09/10)
2011 May	McKim & Creed	14 months post-renourishment (09/10)
2011 Sept.	McKim & Creed	18 months post-renourishment (09/10)
2012 May	McKim & Creed	26 months post-renourishment (09/10)
2012 Nov.	McKim & Creed	32 months post-renourishment (09/10)
2013 May	McKim & Creed	38 months post-renourishment (09/10)
2013 Nov.	McKim & Creed	44 months post-renourishment (09/10)
2014 May	McKim & Creed	50 months post-renourishment (09/10)
2014 Nov.	McKim & Creed	56 months post-renourishment (09/10)
2015 April	McKim & Creed	1 month post-construction (2015 Disposal)
2015 Nov.	McKim & Creed	8 months post-construction (2015 Disposal)
2016 April	McKim & Creed	13 months post-construction (2015 Disposal)
2016 Oct.	McKim & Creed	19 months post-construction (2015 Disposal)
2017 May	McKim & Creed	26 months post-construction (2015 Disposal)
2018 Nov.	McKim & Creed	32 months post-construction (2015 Disposal)
2018 May	McKim & Creed	38 months post-construction (2015 Disposal)
2019 Sept.	McKim & Creed	Post-Hurricane Florence
2019 May	McKim & Creed	2 months post-renourishment (18/19)

**MHWL SURVEYS** As part of the permit required monitoring for the terminal groin project completed in late 2015, post-construction MHWL surveys were initiated in November 2015. Each survey was specified to begin at the Marina entrance (Sta. 0+00) and extend to St. 75+00, about 3,000 ft eastward of the terminal groin head. On an annual basis, surveys are to be intercompared to assess both updrift fillet conditions and the location of the downdrift shoreline fronting the Cape Fear River.

#### 4.2 Bald Head Creek Borrow Site Surveys

The Bald Head Creek borrow site and adjacent areas utilized for the 2017 Shore Stabilization Project constructed by Marcol Dredging will be monitored at 6 months and thereafter annually for the following 3 years. **Table 4.3** summarizes selected surveys collected to date. The purpose of the monitoring will be to document hydrographic changes throughout the borrow site and in particular areas which were “over-dredged” by the Contractor. Of specific interest to State and Federal regulatory agencies will be the rate of recovery and the composition of the material that infills the area(s) excavated by hydraulic dredge below that addressed by permit. In addition to annual surveys, limited grab samples and sediment analysis will be performed by the firm LMG. The Marcol March 2017 AD Survey is considered as the baseline condition.

**Table 4.3:** Selected Bald Head Creek borrow site surveys collected as of May 2019.

<b>Borrow Site Survey Date</b>	<b>Comment</b>
March 2012	After Dredge (AD) Survey (11/12 Project)
January 2013	10 Months Post-Dredge (11/12 Project)
December 2013	21 Months Post-Dredge (11/12 Project)
April 2015	37 Months Post-Dredge (11/12 Project)
April 2016	49 Months Post-Dredge (11/12 Project)
November 2016	Before Dredge (BD) Survey (16/17 Project)
March 2017	After Dredge (AD) Survey (16/17 Project)
November 2017	7 Months Post-Dredge (11/12 Project)
May 2018	14 Months Post-Dredge (11/12 Project)
May 2019	26 Months Post-Dredge (11/12 Project)

### 4.3 Jay Bird Shoal Borrow Site Surveys

Permits for the beach renourishment project constructed by the Village in 2009/2010 necessitate the resurveying of the Jay Bird Shoal borrow site as part of the annual island-wide monitoring program. **Table 4.4** summarizes the borrow site surveys conducted to date. Specifically, borrow site surveys are required both pre- and post-excavation, as well as at 12-, 24- and 36-months and biennially thereafter. The last scheduled borrow site survey was performed in March 2019 by S.J. Hamill Construction, LLC for purposes of documenting the post-dredge condition. The area typically surveyed is 400-acres ± which includes a buffer area outside the “permitted” limits of work.

**Table 4.4:** Jay Bird Shoal borrow site surveys collected as of May 2019.

<b>Borrow Site Survey Date</b>	<b>Comment</b>
October 2009	Before Dredge (BD) Survey (09/10 Project)
March 2010	After Dredge (AD) Survey (09/10 Project)
May 2011	14 Months Post-Dredge (09/10 Project)
May 2012	26 Months Post-Dredge (09/10 Project)
May 2013	38 Months Post-Dredge (09/10 Project)
April 2015	61 Months Post-Dredge (09/10 Project)
May 2017	86 Months Post-Dredge (09/10 Project)
November 2017	92 Months Post-Dredge (09/10 Project)
May 2018	98 Months Post-Dredge (09/10 Project)
September 2018	98 Months Post-Dredge (09/10 Project)
December 2018	Before Dredge (BD) Survey (18/19 Project)
March 2019	After Dredge (AD) Survey (18/19 Project)

### 4.4 Orthorectified Aerial Photography

In addition to the beach profile surveys, digital color aerial photography of the island’s shoreline has been acquired at a minimum, annually by Greenman-Pedersen, Inc.<sup>5</sup> **Table 4.5** summarizes the aerial photography collected to date as part of the monitoring program. Reproductions of the three most recent aerial photography sets (April 2019, October 2018 and April 2018) are presented in **Appendices B, C and D**, respectively.

<sup>5</sup> Greenman-Pederson, Inc.; 3909 Wrightsville Ave. Suite 200; Wilmington, NC 28403.

**Table 4.5:** Bald Head Island monitoring aerial photography collected as of May 2019.

Photo Date			Comment
Year	Month	Day	
2001	September	NA	2 months post-construction (2001 disposal)
2002	November	14	16 months post-construction (2001 disposal)
2003	April	NA	21 months post-construction (2001 disposal)
2004	January	NA	30 months post-construction (2001 disposal)
2004	May	NA	34 months post-construction (2001 disposal)
2004	October	NA	39 months post-construction (2001 disposal)
2005	May	NA	4 months post-construction (2004/05 disposal)
2005	November	NA	10 months post-construction (2004/05 disposal)
2006	April	NA	15 months post-construction (2004/05 disposal)
2006	October	NA	21 months post-construction (2004/05 disposal)
2007	May	20	1 month post-construction (2007 disposal)
2008	May	13	13 months post-construction (2007 disposal)
2009	January	14	21 months post-construction (2007 disposal)
2009	May	31	25 months post-construction (2007 disposal)
2009	August	26	3 months pre-renourishment (09/10)
2010	April	NA	1 month post-renourishment (09/10)
2011	April	NA	13 months post-nourishment (09/10)
2012	May	NA	26 months post-nourishment (09/10)
2012	December	14	33 months post-nourishment (09/10)
2013	May	14	38 months post-nourishment (09/10)
2013	November	14	44 months post-nourishment (09/10)
2014	May	23	50 months post-nourishment (09/10)
2014	November	03	56 months post-nourishment (09/10)
2015	March	29	Post-construction (2015 Disposal)
2015	August	9	5 months post-construction (2015 Disposal)
2015	November	29	Post-terminal groin construction
2016	April	3	4 months post-construction (T.G.)
2016	October	13	Post-Hurricane Matthew
2017	April	14	5 months Post-Hurricane Matthew
2017	November	27	24 months post-construction (T.G.)
2018	April	19	29 months post-construction (T.G.)
2018	October	14	Post-Hurricane Florence
2019	April	10	1 month post-renourishment (18/19)

## 5.0 MONITORING (SURVEY) RESULTS

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### 5.1 Methodology

For purposes of analysis and discussion, the Bald Head Island monitoring baseline is qualitatively broken into seven (7) shoreline segments, or zones of interest, with significantly varying physiographic characteristics as follows:

- Station -018+72 to -003+00 “Row Boat Row”
- Station -001+60 to 028+00 “West Beach”
- Station 028+00 to 046+00 “The Point” – North of Terminal Groin
- Station 046+00 to 056+56 “The Point” – South of Terminal Groin
- Station 056+56 to 214+00 “South Beach”<sup>6</sup>
- Station 214+00 to 224+80 “Cape Fear Point”<sup>7</sup>
- Station 224+80 to 284+80 “East Beach”

These zones differ slightly from the shoreline segments used in the prior monitoring reports (OAI 2015). More specifically, “the Point” is now divided into two areas rather than one, based upon the location of the recently completed terminal groin. The update is intended to more accurately capture the influence of that structure on the physical processes along the Bald Head Island shoreline. Additionally, the “Row Boat Row” reach was added to the monitoring analysis with the initial monitoring surveys along this reach completed in November 2015.

Alongshore volume changes were calculated using an average end-area method, where the cross-sectional areas are determined by comparing beach profiles at each beach monitoring station above several different vertical datums. This approach allows evaluation of beach changes at different elevations along the project in addition to the total profile.

Average shoreline position changes were spatially weighted based upon the distance between stations due to the non-uniform alongshore spacing of survey monuments.

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<sup>6</sup> East of Sta. 214+00, the remaining 400 ft of surveyed Atlantic oceanfront shoreline becomes part of Cape Fear Point and is not included in the South Beach analysis due to its highly dynamic nature.

<sup>7</sup> The general condition of the Cape Fear spit is qualitatively monitored primarily through controlled aerial photography. This depositional feature is routinely subject to episodic periods of accretion and erosion resulting from eventual detachment via tidal channel breakthrough during storms. It is likewise influenced by beach fill activities and sediment added to the littoral system of South Beach as well as storm waves originating from the east or southeast.

## 5.2 Year 18: Monitoring Program (May 2018 – September 2018 – May 2019)

The May 2018 to May 2019 monitoring period represents the eighteenth year of measured shoreline change following completion of the initial 2001 Federal +1.849 Mcy beach disposal at Bald Head Island. For compliance purposes, the May 2019 survey represents documentation of the latest renourishment project shoreline condition for the +1.1 Mcy beach fill constructed by the Village of Bald Head Island in the winter of 2018/2019 at South Beach. The period also represents the fourth year following completion of the 1.33 Mcy 2015 Federal beach disposal.

Volume changes between condition surveys were computed using the average end-area method above the mean high water line (MHWL; +2.51 ft-NGVD) and the assumed typical depth of closure (-16.0 ft-NGVD). **Tables 5.1** through **5.3** list the computed changes along the Bald Head Island shoreline for the May 2018 – November 2018 – May 2019 survey intervals. **Figures 5.1, 5.2** and **5.3** depict the cumulative and local volume changes for the same intervals. Changes in shoreline position at each station were computed at the MHWL and the seaward edge of berm (+6 ft-NGVD contour). The results are summarized in **Tables 5.4** and **5.5** and graphically depicted in **Figures 5.4** and **5.5** (relative to their November 2000 pre-disposal locations).

## 5.3 West Beach, “The Point” and South Beach: Discussion

### 5.3.1 Survey Period: May 2018 to September 2018 (Hurricane Florence)

This four (4) month survey period represents includes the effects of Hurricane Florence. The September 2018 survey was completed approximately 1 month following Hurricane Florence. Additionally, the September 2018 survey was conducted roughly three years following completion of the terminal groin and 3.5 years following a +1.3 Mcy 2015 federal disposal project at South Beach. For monitoring purposes, the September 2018 survey represents the pre-construction condition for the 2018/19 beach renourishment project.

As depicted in **Figure 5.1**, the island-wide *net* shoreline volume change trend for this period was erosional with -338,800 cy (-14.9 cy/ft) of loss, mol. over the 4 month span above -16 ft-NGVD. Similarly, above the MHWL, the shoreline lost -28,700 cy. Consistent with the volume gains above the MHWL, the berm receded by a spatially weighted average<sup>8</sup> of roughly -23 feet while the MHWL advanced by +7 feet. However, subreaches of the monitored shoreline experienced varied changes over this monitoring period.

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<sup>8</sup> Due to the irregular spacing of the profile stations, the average shoreline changes are weighted based upon the distance between stations and calculated using an average end method.

**Table 5.1: Bald Head Island shoreline volume change (May 2018 to September 2018).**

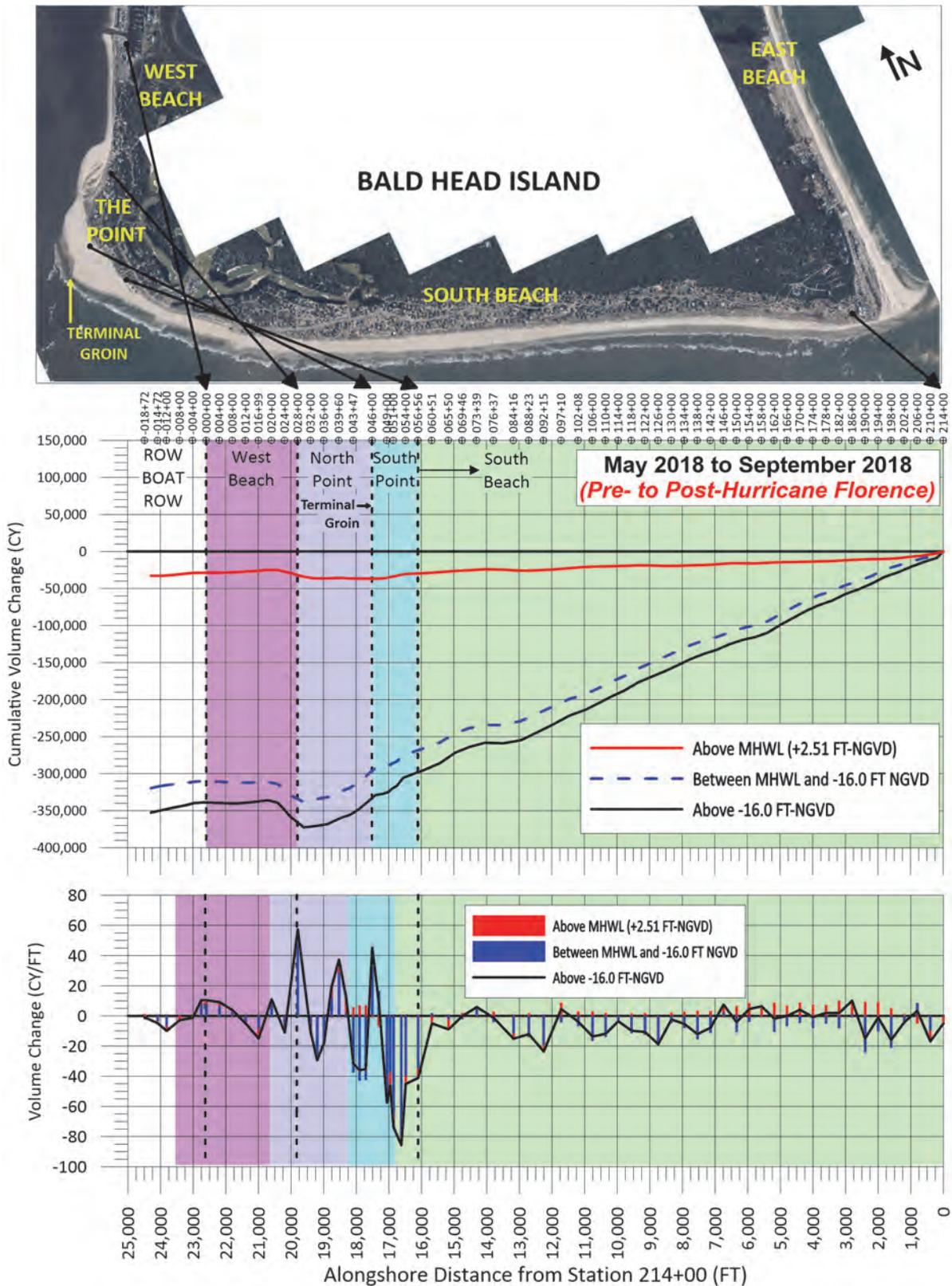
	Start Station	End Station	Reach (FT)	Volume Change		Start Station	End Station	Reach (FT)	Volume Change		
				Above +2.51 (FT)	Above -16 (FT)				Above +2.51 (FT)	Above -16 (FT)	
West Beach	Jetty	000+00	160	0	+400	056+56	060+51	423	-1,400	-8,900	South Beach
	000+00	004+00	400	-100	+700	060+51	065+50	510	-1,600	-14,100	
	004+00	008+00	400	-600	200	065+50	069+46	423	-900	-7,700	
	008+00	010+00	200	-500	-400	069+46	073+39	442	-1,400	-5,700	
	010+00	012+00	200	-700	-800	073+39	076+37	516	+600	+700	
	012+00	014+00	200	-400	-700	076+37	084+16	611	+1,400	-4,100	
	014+00	016+00	200	-800	-1,300	084+16	088+23	471	-500	-9,900	
	016+00	018+00	200	-800	-900	088+23	092+15	455	-1,100	-10,800	
	018+00	020+00	200	+400	+3,300	092+15	097+10	536	-1,900	-12,600	
	020+00	024+00	400	+4,100	+19,600	097+10	102+08	525	-1,600	-7,700	
024+00	028+00	400	+4,800	+13,700	102+08	106+00	436	-600	-9,200		
	<b>Subtotal</b>	<b>2,960</b>	<b>+5,400</b>	<b>+33,800</b>	106+00	110+00	400	-300	-9,000		
Point (North of Groin)	028+00	032+00	395	+2,100	-1,500	110+00	114+00	388	-600	-8,100	
	032+00	034+00	200	+200	-1,300	114+00	118+00	407	-700	-10,700	
	034+00	036+00	210	-100	-1,700	118+00	122+00	413	+200	-7,700	
	036+00	038+00	230	-400	-4,700	122+00	126+00	405	+600	-7,300	
	038+00	039+60	230	-100	-4,500	126+00	130+00	405	-100	-8,200	
	039+60	041+50	220	+600	-3,000	130+00	134+00	398	-700	-8,500	
	041+50	043+47	220	+200	-5,300	134+00	138+00	401	-400	-6,900	
	043+47	044+25	190	0	-6,400	138+00	142+00	400	-1,000	-5,600	
	044+25	045+07	190	0	-7,400	142+00	146+00	400	-1,400	-7,600	
	045+07	046+00	200	0	-7,800	146+00	150+00	399	0	-5,700	
	<b>Subtotal</b>	<b>2,285</b>	<b>+2,500</b>	<b>-43,600</b>	150+00	154+00	385	+200	-3,800		
Point (South of Groin)	046+00	046+89	200	-100	-1,600	154+00	158+00	383	-800	-6,000	
	046+89	049+00	250	-1,200	-2,500	158+00	162+00	386	-900	-10,500	
	049+00	050+50	100	-1,200	-4,100	162+00	166+00	393	-100	-9,400	
	050+50	051+00	100	-1,300	-4,700	166+00	170+00	394	-400	-9,600	
	051+00	052+64	240	-2,100	-10,500	170+00	174+00	400	-500	-7,800	
	052+64	054+00	135	-700	-4,300	174+00	178+00	400	-500	-6,100	
	054+00	056+56	380	-700	-6,600	178+00	182+00	400	-1,000	-8,700	
		<b>Subtotal</b>	<b>1,405</b>	<b>-7,300</b>	<b>-34,300</b>	182+00	186+00	400	-900	-6,300	
<b>Note:</b> Elevations are referenced to NGVD 1929.						186+00	190+00	400	-600	-7,600	
						190+00	194+00	400	-300	-9,200	
						194+00	198+00	400	-900	-6,000	
						198+00	202+00	400	-2,100	-7,500	
						202+00	206+00	400	-1,700	-6,600	
						206+00	210+00	400	-2,900	-5,600	
						210+00	214+00	400	-2,500	-8,700	
						<b>Subtotal</b>	<b>16,105</b>	<b>-29,300</b>	<b>-294,700</b>		
						<b>Bald Head Total</b>	<b>22,755</b>	<b>-28,700</b>	<b>-338,800</b>		

**Table 5.2: Bald Head Island shoreline volume change (September 2018 to May 2019).**

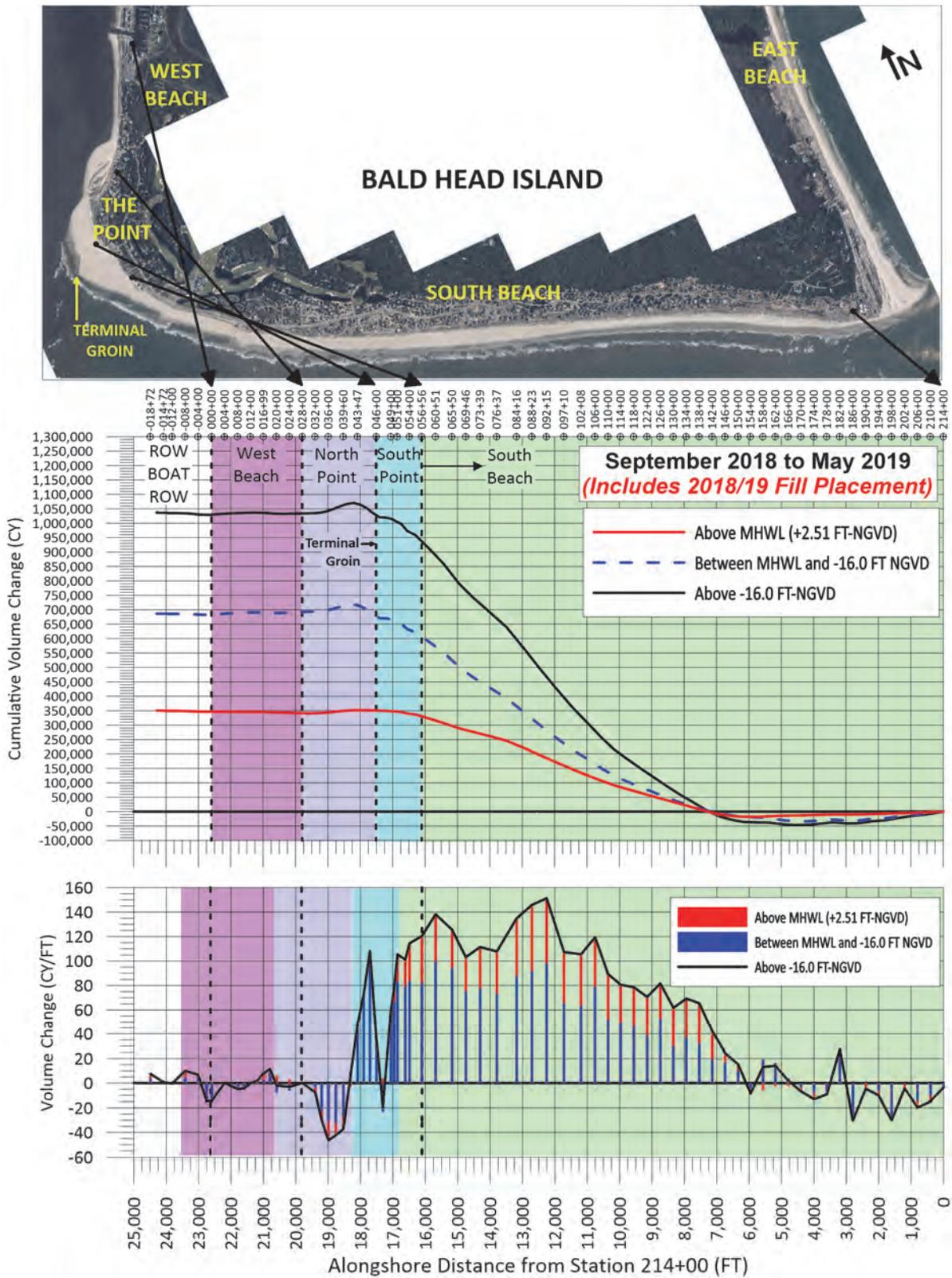
	Start Station	End Station	Reach (FT)	Volume Change		Start Station	End Station	Reach (FT)	Volume Change		
				Above +2.51 (FT)	Above -16 (FT)				Above +2.51 (FT)	Above -16 (FT)	
West Beach	Jetty	000+00	160	+100	-2,300	056+56	060+51	423	+16,400	+54,700	South Beach
	000+00	004+00	400	+400	-2,900	060+51	065+50	510	+17,900	+67,300	
	004+00	008+00	400	+300	-1,000	065+50	069+46	423	+12,500	+48,400	
	008+00	010+00	200	0	-900	069+46	073+39	442	+13,500	+47,400	
	010+00	012+00	200	+200	-400	073+39	076+37	516	+17,500	+56,600	
	012+00	014+00	200	+100	+200	076+37	084+16	611	+24,900	+74,100	
	014+00	016+00	200	+500	+1,000	084+16	088+23	471	+23,800	+66,100	
	016+00	018+00	200	+800	+1,900	088+23	092+15	455	+24,400	+67,600	
	018+00	020+00	200	+900	+1,000	092+15	097+10	536	+25,500	+69,300	
	020+00	024+00	400	+1,800	-1,000	097+10	102+08	525	+22,000	+55,900	
024+00	028+00	400	+700	-600	102+08	106+00	436	+18,000	+49,000		
	<b>Subtotal</b>	<b>2,960</b>	<b>+5,800</b>	<b>-5,000</b>	106+00	110+00	400	+15,600	+41,700		
Point (North of Groin)	028+00	032+00	395	-700	-1,500	110+00	114+00	388	+13,200	+33,000	
	032+00	034+00	200	-1,200	-3,800	114+00	118+00	407	+12,800	+32,400	
	034+00	036+00	210	-2,400	-8,000	118+00	122+00	413	+13,200	+30,800	
	036+00	038+00	230	-2,900	-10,200	122+00	126+00	405	+12,400	+30,800	
	038+00	039+60	230	-2,200	-9,100	126+00	130+00	405	+12,300	+29,000	
	039+60	041+50	220	-1,400	-3,400	130+00	134+00	398	+12,600	+26,100	
	041+50	043+47	220	0	+6,000	134+00	138+00	401	+13,000	+27,000	
	043+47	044+25	190	+300	+11,600	138+00	142+00	400	+11,200	+21,600	
	044+25	045+07	190	+500	+17,200	142+00	146+00	400	+6,000	+13,300	
	045+07	046+00	200	+800	+14,400	146+00	150+00	399	+2,500	+7,900	
	<b>Subtotal</b>	<b>2,285</b>	<b>-9,200</b>	<b>+13,200</b>	150+00	154+00	385	+300	+1,300		
Point (South of Groin)	046+00	046+89	200	+700	+1,700	154+00	158+00	383	-1,900	+900	
	046+89	049+00	250	+1,200	+5,100	158+00	162+00	386	-1,700	+5,200	
	049+00	050+50	100	+900	+6,900	162+00	166+00	393	-900	+3,100	
	050+50	051+00	100	+1,700	+9,200	166+00	170+00	394	-1,100	-900	
	051+00	052+64	240	+5,300	+24,800	170+00	174+00	400	-1,600	-4,000	
	052+64	054+00	135	+3,600	+14,600	174+00	178+00	400	-900	-4,500	
	054+00	056+56	380	+13,200	+44,600	178+00	182+00	400	+100	+3,700	
		<b>Subtotal</b>	<b>1,405</b>	<b>+26,600</b>	<b>+106,900</b>	182+00	186+00	400	-200	-600	
<b>Note:</b> Elevations are referenced to NGVD 1929.						186+00	190+00	400	-1,200	-7,000	
						190+00	194+00	400	-1,700	-3,000	
						194+00	198+00	400	-1,200	-8,000	
						198+00	202+00	400	-1,100	-6,800	
						202+00	206+00	400	-1,700	-4,800	
						206+00	210+00	400	-1,900	-6,900	
						210+00	214+00	400	-900	-3,700	
						<b>Subtotal</b>	<b>16,105</b>	<b>+323,600</b>	<b>+914,000</b>		
						<b>Bald Head Total</b>	<b>22,755</b>	<b>+346,800</b>	<b>+1,029,100</b>		

**Table 5.3: Bald Head Island shoreline volume change (May 2018 to May 2019).**

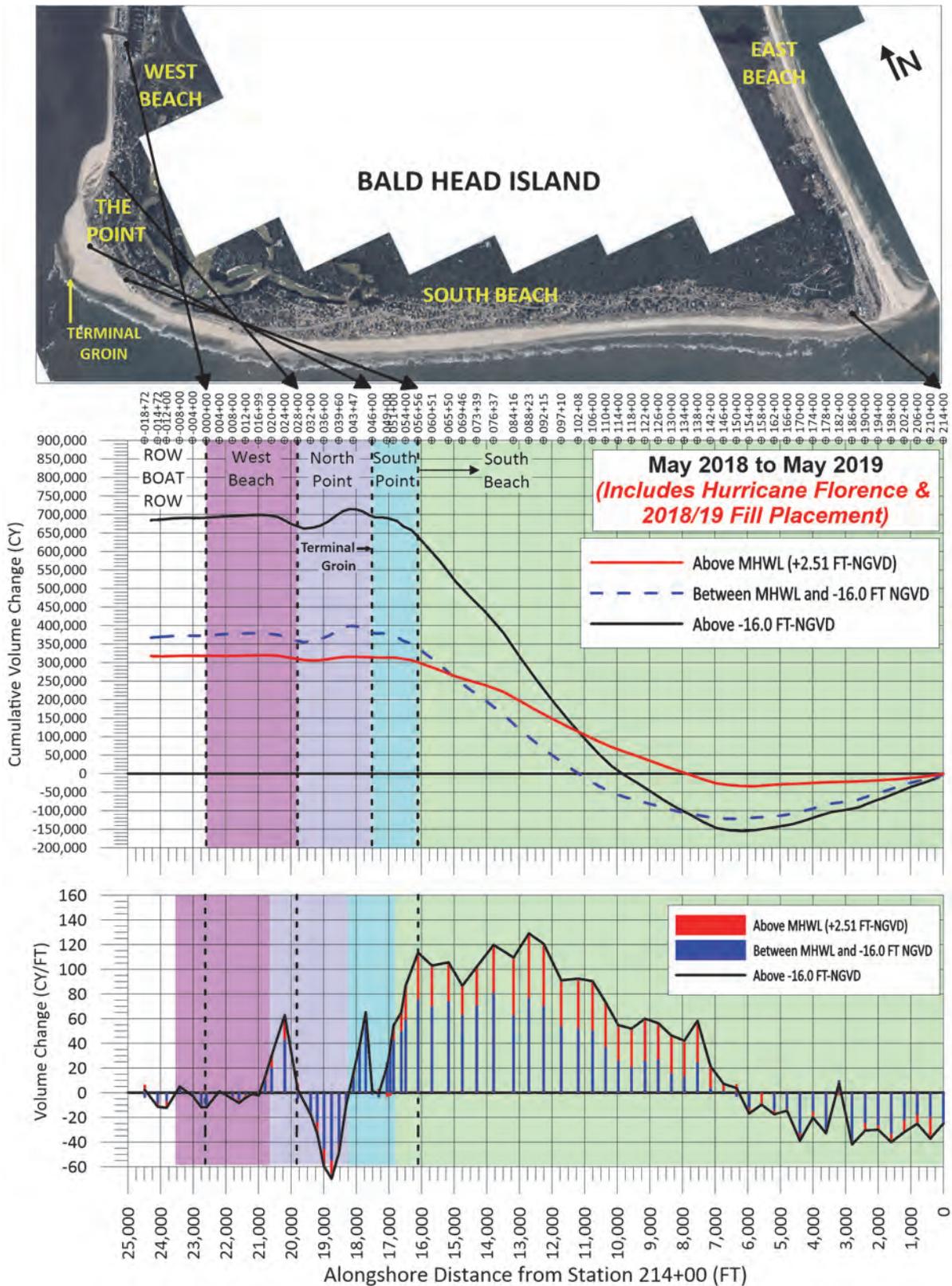
	Start Station	End Station	Reach (FT)	Volume Change		Start Station	End Station	Reach (FT)	Volume Change		
				Above +2.51 (FT)	Above -16 (FT)				Above +2.51 (FT)	Above -16 (FT)	
West Beach	Jetty	000+00	160	+100	-1,900	056+56	060+51	423	+14,900	+45,800	South Beach
	000+00	004+00	400	+300	-2,100	060+51	065+50	510	+16,300	+53,200	
	004+00	008+00	400	-300	-800	065+50	069+46	423	+11,600	+40,700	
	008+00	010+00	200	-500	-1,300	069+46	073+39	442	+12,100	+41,700	
	010+00	012+00	200	-500	-1,200	073+39	076+37	516	+18,100	+57,200	
	012+00	014+00	200	-200	-500	076+37	084+16	611	+26,300	+70,000	
	014+00	016+00	200	-300	-300	084+16	088+23	471	+23,300	+56,200	
	016+00	018+00	200	0	+1,100	088+23	092+15	455	+23,300	+56,800	
	018+00	020+00	200	+1,300	+4,300	092+15	097+10	536	+23,600	+56,700	
	020+00	024+00	400	+5,900	+18,600	097+10	102+08	525	+20,400	+48,200	
024+00	028+00	400	+5,500	+13,100	102+08	106+00	436	+17,500	+39,800		
	<b>Subtotal</b>	<b>2,960</b>	<b>+11,300</b>	<b>+29,000</b>	106+00	110+00	400	+15,200	+32,700		
Point (North of Groin)	028+00	032+00	395	+1,400	-3,000	110+00	114+00	388	+12,600	+24,900	
	032+00	034+00	200	-1,000	-5,100	114+00	118+00	407	+12,200	+21,700	
	034+00	036+00	210	-2,400	-9,700	118+00	122+00	413	+13,400	+23,100	
	036+00	038+00	230	-3,300	-14,900	122+00	126+00	405	+12,900	+23,600	
	038+00	039+60	230	-2,400	-13,600	126+00	130+00	405	+12,200	+20,800	
	039+60	041+50	220	-800	-6,400	130+00	134+00	398	+11,900	+17,600	
	041+50	043+47	220	+100	+700	134+00	138+00	401	+12,600	+20,100	
	043+47	044+25	190	+300	+5,100	138+00	142+00	400	+10,200	+15,900	
	044+25	045+07	190	+500	+9,800	142+00	146+00	400	+4,600	+5,700	
	045+07	046+00	200	+800	+6,600	146+00	150+00	399	+2,500	+2,200	
	<b>Subtotal</b>	<b>2,285</b>	<b>-6,800</b>	<b>-30,500</b>	150+00	154+00	385	+500	-2,500		
Point (South of Groin)	046+00	046+89	200	+600	+100	154+00	158+00	383	-2,700	-5,100	
	046+89	049+00	250	0	+2,600	158+00	162+00	386	-2,500	-5,200	
	049+00	050+50	100	-300	+2,800	162+00	166+00	393	-1,000	-6,300	
	050+50	051+00	100	+500	+4,500	166+00	170+00	394	-1,500	-10,500	
	051+00	052+64	240	+3,300	+14,300	170+00	174+00	400	-2,100	-11,800	
	052+64	054+00	135	+2,900	+10,300	174+00	178+00	400	-1,400	-10,600	
	054+00	056+56	380	+12,500	+38,100	178+00	182+00	400	-900	-5,000	
		<b>Subtotal</b>	<b>1,405</b>	<b>+19,500</b>	<b>+72,700</b>	182+00	186+00	400	-1,000	-6,800	
<b>Note:</b> Elevations are referenced to NGVD 1929.						186+00	190+00	400	-1,800	-14,500	
						190+00	194+00	400	-2,000	-12,100	
						194+00	198+00	400	-2,100	-14,000	
						198+00	202+00	400	-3,300	-14,400	
						202+00	206+00	400	-3,400	-11,400	
						206+00	210+00	400	-4,900	-12,500	
						210+00	214+00	400	-3,400	-12,400	
						<b>Subtotal</b>	<b>16,105</b>	<b>+294,200</b>	<b>+619,500</b>		
						<b>Bald Head Total</b>	<b>22,755</b>	<b>+318,200</b>	<b>+690,700</b>		



**Figure 5.1:** Volume change along the Bald Head Island shoreline between May 2018 and September 2018.



**Figure 5.2:** Volume change along the Bald Head Island shoreline between September 2018 and May 2019.



**Figure 5.3:** Volume change along the Bald Head Island shoreline between May 2018 and May 2019 (Year 17).

**Table 5.4:** Location of the **BERM** (+6.0 ft-NGVD) relative to the November 2000 (pre-2001 fill) location for selected monitoring surveys.

	Station	Location Relative to Nov. 2000				Station	Location Relative to Nov. 2000		
		May 2018	Sept. 2018	May 2019			May 2018	Sept. 2018	May 2019
<b>West Beach</b>	000+00	+108.5	+112.3	+106.0	<b>South Beach</b>	060+51	+3.0	-41.8	+154.2
	004+00	+18.3	-5.1	+12.0		065+50	+18.8	+6.2	+155.6
	008+00	+9.6	-5.9	-2.0		069+46	+78.5	+41.2	+191.9
	010+00	No November 2000 profile				073+39	+125.3	+85.8	+248.4
	012+00	+45.0	+22.0	+31.4		076+37	+122.9	+121.7	+273.0
	014+00	No November 2000 profile				084+16	+117.3	+112.5	+333.4
	016+00	+26.6	+4.5	+26.7		088+23	+140.6	+110.0	+377.9
	018+00	No November 2000 profile				092+15	+128.4	+84.8	+361.8
	020+00	+55.2	+70.9	+181.9		097+10	+107.6	+60.5	+292.9
	024+00	+342.8	+334.7	+407.9		102+08	+64.7	+30.2	+261.4
028+00	+396.1	+377.5	+363.5	106+00	+69.8	+41.9	+257.9		
<b>Point (North of Groin)</b>	032+00	+255.4	+230.8	+199.2	110+00	+86.4	+52.5	+254.8	
	034+00	No November 2000 profile			114+00	+104.7	+66.4	+259.9	
	036+00	+102.4	+84.6	+2.3	118+00	+128.2	+89.6	+275.1	
	038+00	No November 2000 profile			122+00	+151.2	+192.1	+312.4	
	039+60	-20.2	-55.1	-102.4	126+00	+188.2	+152.0	+330.3	
	041+50	No November 2000 profile			130+00	+191.1	+221.4	+337.2	
	043+47	-76.7	-110.5	-78.3	134+00	+204.7	+228.4	+345.8	
	044+25	No November 2000 profile			138+00	+189.5	+149.0	+333.3	
	045+07	+1.8	+9.0	+32.8	142+00	+204.7	+147.0	+292.3	
046+00	No November 2000 profile			146+00	+178.1	+142.9	+246.5		
<b>Point (South of Groin)</b>	046+89	+253.7	+232.4	+229.6	150+00	+174.6	+214.0	+202.2	
	049+00	No November 2000 profile			154+00	+171.5	+125.4	+123.8	
	050+50	No November 2000 profile			158+00	+162.8	+183.1	+126.7	
	051+00	No November 2000 profile			162+00	+151.0	+112.8	+117.9	
	052+64	+163.0	+123.3	+259.8	166+00	+158.0	+123.7	+139.3	
	054+00	No November 2000 profile			170+00	+146.1	+115.7	+115.6	
	056+56	+32.8	+7.6	+204.0	174+00	+125.5	+92.5	+98.0	
Positive values indicate shoreline advance relative to the pre-construction location. Negative values indicate shoreline erosion and are highlighted in red.					178+00	+134.7	+110.4	+123.0	
					182+00	+143.3	+111.8	+128.4	
					186+00	+125.9	+99.4	+105.9	
					190+00	+129.3	+101.7	+102.0	
					194+00	+121.2	+99.7	+92.0	
					198+00	+101.0	+81.2	+68.1	
					202+00	+84.9	+66.9	+55.7	
					206+00	-14.6	-26.3	-44.5	
					210+00	-90.5	-105.9	-139.7	
					214+00	-198.8	-237.7	-249.0	

**Table 5.5:** Location of the **MHWL** (+2.51 ft-NGVD) relative to the November 2000 (pre-2001 fill) location for selected monitoring surveys.

	Station	Location Relative to Nov. 2000				Station	Location Relative to Nov. 2000		
		May 2018	Sept. 2018	May 2019			May 2018	Sept. 2018	May 2019
<b>West Beach</b>	000+00	+105.6	+100.0	+95.0	<b>South Beach</b>	060+51	-11.0	-37.3	+160.7
	004+00	+19.8	+14.5	+14.8		065+50	+7.7	+8.4	+169.0
	008+00	+14.6	+11.9	+8.6		069+46	+74.7	+54.6	+177.8
	010+00	No November 2000 profile				073+39	+120.6	+102.4	+240.3
	012+00	+1.1	-10.7	-0.4		076+37	+130.5	+150.2	+345.6
	014+00	No November 2000 profile				084+16	+110.7	+116.8	+356.5
	016+00	+5.4	-6.8	+21.0		088+23	+155.1	+137.4	+388.0
	018+00	No November 2000 profile				092+15	+138.0	+124.9	+351.9
	020+00	+151.2	+179.0	+195.2		097+10	+108.5	+122.0	+288.8
	024+00	+339.2	+436.2	+419.2		102+08	+68.7	+101.8	+254.9
028+00	+316.1	+282.4	+284.0	106+00	+85.4	+102.1	+261.3		
<b>Point (North of Groin)</b>	032+00	+175.3	+147.4	+133.4	110+00	+80.8	+111.4	+250.1	
	034+00	No November 2000 profile			114+00	+110.7	+128.6	+257.3	
	036+00	+50.6	+24.9	-61.7	118+00	+137.6	+156.9	+273.5	
	038+00	No November 2000 profile			122+00	+167.9	+175.0	+297.4	
	039+60	-69.8	-50.9	-136.0	126+00	+185.0	+200.2	+320.6	
	041+50	No November 2000 profile			130+00	+188.5	+207.9	+326.2	
	043+47	-151.3	-155.3	-162.1	134+00	+204.7	+219.7	+337.8	
	044+25	No November 2000 profile			138+00	+191.1	+214.2	+315.3	
	045+07	+42.1	+8.7	+20.8	142+00	+193.2	+208.0	+281.3	
046+00	No November 2000 profile			146+00	+173.2	+189.7	+238.2		
<b>Point (South of Groin)</b>	046+89	+275.1	+267.7	+296.8	150+00	+164.6	+198.0	+209.6	
	049+00	No November 2000 profile			154+00	+165.3	+174.0	+153.5	
	050+50	No November 2000 profile			158+00	+159.2	+171.5	+141.8	
	051+00	No November 2000 profile			162+00	+140.9	+163.8	+149.8	
	052+64	+148.1	+110.8	+264.1	166+00	+138.5	+167.4	+153.0	
	054+00	No November 2000 profile			170+00	+131.6	+149.9	+139.4	
	056+56	+13.7	+12.5	+199.4	174+00	+128.5	+153.0	+128.1	
Positive values indicate shoreline advance relative to the pre-construction location. Negative values indicate shoreline erosion and are highlighted in red.					178+00	+164.7	+183.6	+153.1	
					182+00	+150.6	+169.0	+154.2	
					186+00	+130.7	+160.1	+130.3	
					190+00	+131.7	+151.5	+95.4	
					194+00	+117.2	+145.9	+97.1	
					198+00	+96.1	+133.0	+85.0	
					202+00	+64.6	+98.1	+54.5	
					206+00	-39.8	-5.4	-50.3	
					210+00	-122.8	-124.0	-141.5	
					214+00	-213.0	-246.1	-231.7	

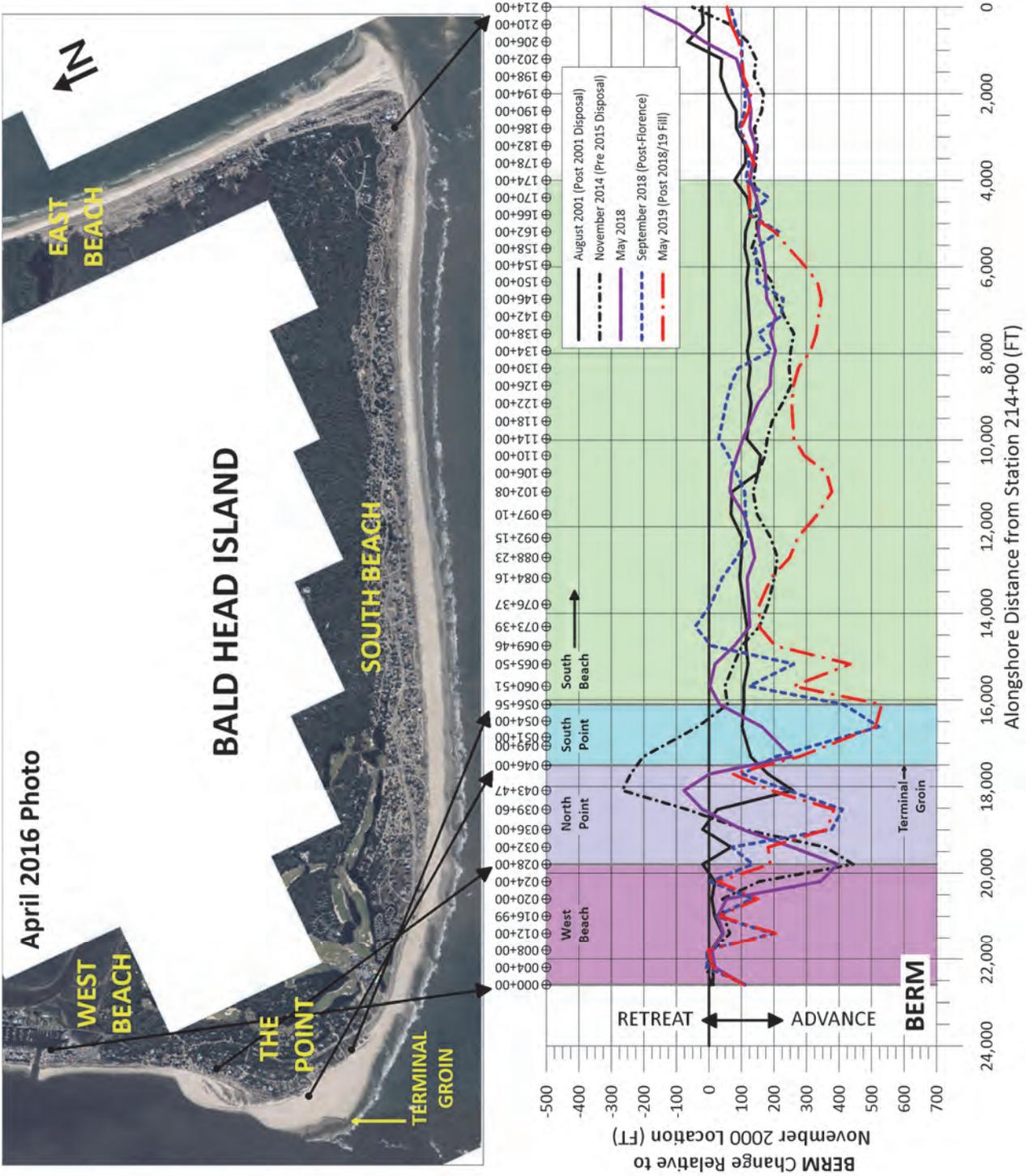


Figure 5.4: Location of the BERM (+6.00 ft-NGVD) relative to the Nov. 2000 (pre-2001 fill) location.

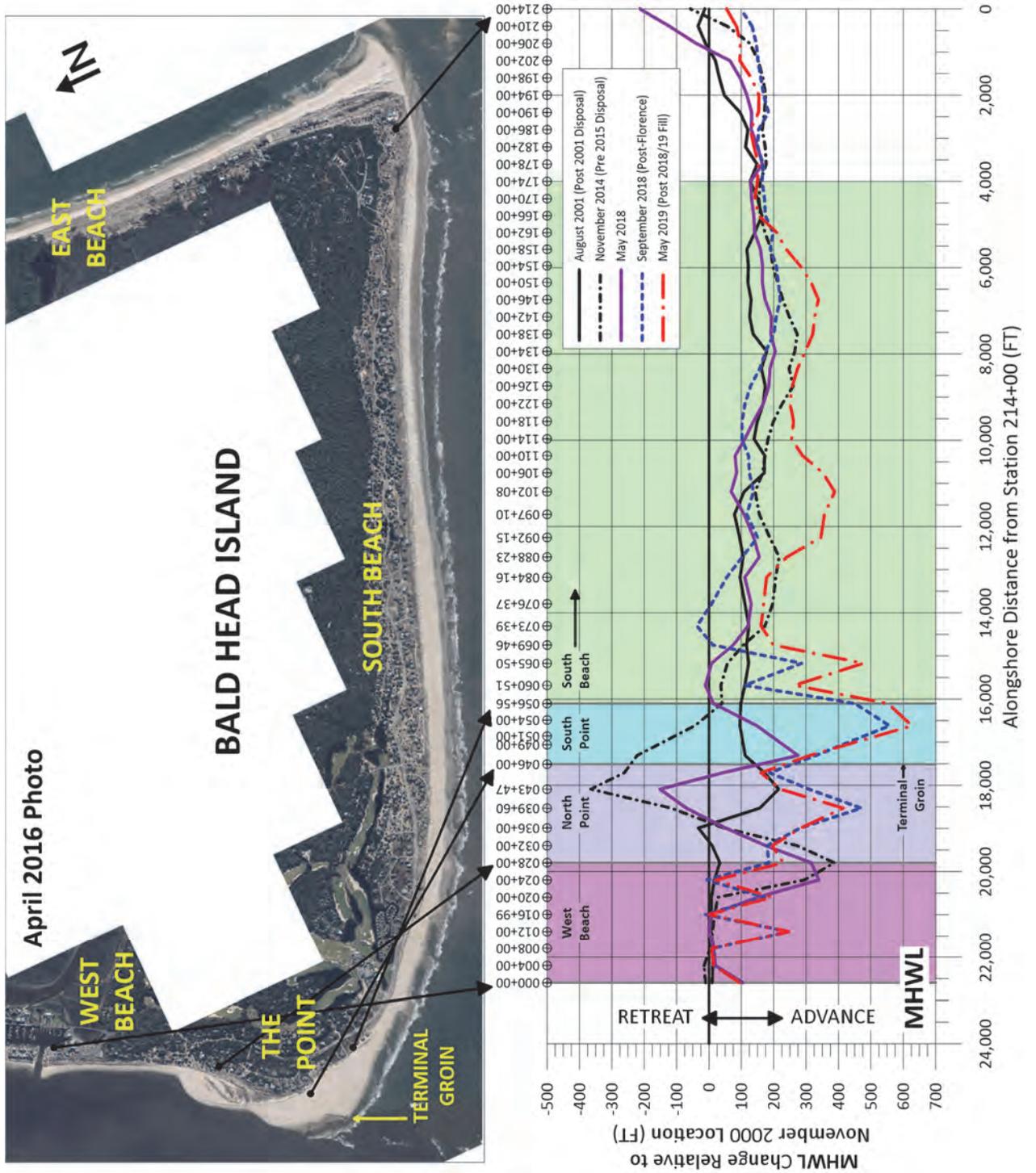


Figure 5.5: Location of the MHWL (+2.51 ft-NGVD) relative to the Nov. 2000 (pre-2001 fill) location.

In the net, West Beach was relatively stable during this period with gains of +5,400 cy above the MHWL and +28,400 cy between the MHWL and the -16 ft-NGVD contour. Overall West Beach gained roughly +33,800 cy above the -16 ft contour. Most of the gains occurred along the southernmost 1,000 ft of West Beach, adjacent to the Point. Along this reach (Sta 018+00 to 024+00), the beach gained +36,600 cy above -16 ft. Along the remaining 1,960 ft of West Beach, the shoreline lost a net -2,800 cy. During this period, the berm receded by an average of -11 ft while the MHWL advanced by 10 ft.

The entire 3,690 ft of “the Point” shoreline (Sta. 28+00 to 56+56) was net erosional during this monitoring period, losing -77,900 cy above -16 ft-NGVD. For purposes of evaluating the impacts of the terminal groin completed in November 2015, “the Point” shoreline is subdivided into two reaches with Sta. 46+00, the approximate location of the terminal groin, as the dividing station. North of the terminal groin (Sta. 28+00 to 46+00), the shoreline gained +2,500 cy above the MHWL and lost -43,600 cy above -16 ft-NGVD. Along this reach, the berm receded by roughly -29 ft on average and the MHWL by -12 ft. South of the terminal groin (Sta. 46+00 to 56+56), the shoreline lost -7,300 cy above the MHWL and -34,300 cy above the -16 ft-NGVD contour. Similarly, the berm and MHWL retreated by averages of -40 ft and -37 ft, respectively.

South Beach was net erosional during the period, losing roughly -29,300 cy above the MHWL and -294,700 cy above -16 ft-NGVD. All but one (37 of 38) of the monitoring stations (28 of 38) were net erosional above -16 ft-NGVD. During this period, the berm receded by an average of -23 ft while the MHWL advanced by 13 ft.

### **5.3.2 Survey Period: September 2018 to May 2019 (Fill Placement)**

This eight (8) month survey period includes the direct placement of approximately 1.1 Mcy of sand during the 18/19 beach renourishment project along South Beach between 044+25 to roughly Sta. 202+00. As depicted in **Figure 5.2**, the island-wide *net* volume change was a gain of approximately +1,029,100 cy (+45.2 cy/ft) above -16 ft-NGVD. Consistent with the overall volume losses, the berm and MHWL advanced by spatially weighted averages of roughly +84 ft and +61 ft, respectively, along the approximate 22,755 ft of shoreline (West Beach, “the Point”, and South Beach).

In the net, West Beach was relatively stable during this period with a gain of +5,800 cy above the MHWL and a loss of -10,800 cy between the MHWL and the -16 ft-NGVD contour. Overall West Beach lost roughly -5,000 cy above the -16 ft contour. During this period, the berm and MHWL advanced by weighted averages of +30 and +4 ft, respectively.

Along “the Point” shoreline north of the terminal groin, the beach lost -9,200 cy above the MHWL and gained +13,200 cy above the -16 ft-NGVD contour. During this period, the berm retreated by an average of -18 ft and the MHWL by -35 ft. Along “the Point” shoreline south of the terminal groin, the beach gained +106,900 cy above -16 ft-NGVD. Most of this gain occurred along the eastern portion of the point in the area of direct sand placement. During this period, the berm advanced by an average of +96 ft and the MHWL by +115 ft.

South Beach received the majority of beach fill placement. During this period, this reach gained 323,600 cy above the MHWL and +914,000 above -16 ft-NGVD. Similarly, the berm and MHWL advanced by spatially weighted averages of roughly +107 ft and +80 ft, respectively.

### **5.3.3 Year 18 Monitoring Results: May 2018 to May 2019 (Excluding East Beach & Row Boat Row)**

Year 18 includes the direct effects of Hurricane Florence (September 2018 and the placement of approximately 1.1 Mcy during the 18/19 beach renourishment (December 2018 to March 2019). During Year 18 in its entirety, the island experienced a net gain of +690,700 cy (+30.4 cy/ft) above the -16 ft contour. Above the MHWL, the island gained +318,200 cy (+14.0 cy/ft).

Along West Beach, the shoreline gained approximately +11,300 cy above the MHWL and +29,000 cy above -16 ft-NGVD. During this period, the berm advanced by an average of +19 ft and the MHWL advanced by +14 ft.

The entire Point shoreline (north and south of the terminal groin), experienced a net gains of roughly +12,700 cy above the MHWL and +42,200 cy above -16 ft-NGVD. During this period, the berm retreated by an average of 8 ft and the MHWL advanced by 1 ft.

The South Beach shorefront, which received the majority of the 2018/19 beach placement gained +294,200 cy above the MHWL and +619,500 cy above -16 ft-NGVD. During this period, the berm and MHWL advanced by averages of +84 ft and +93 ft, respectively.

### 5.3.4 Long-Term Beach Changes: November 2000 to May 2019

For purposes of tracking gross sand placement performance, **Figure 5.6** plots a time history of cumulative volume change relative to November 2000 conditions. **Figure 5.7** presents net volumetric change (alongshore above -16 ft NGVD) for the maximum period of comparison to date (*i.e.* November 2000 and May 2019). In both figures the effects of direct sand placement over time are included. As with other similar analyses over the last decade, East Beach, Cape Fear and Row Boat Row are excluded from this analysis.

The classic “saw-tooth” effects of episodic sand placement, as reflected in **Figure 5.6**, are indicative of the periodic infusion of sand along South Beach at Bald Head Island associated with the placement of sand during initial construction of the channel deepening project, three (3) subsequent beach disposal operations pursuant to the WHSMP, the proactive beach renourishment project constructed by the Village in 2009/10 and to a smaller degree the emergency fill of 2012. The Village 1.85 Mcy fill was constructed with the knowledge gained through monitoring that certain irreparable large-scale impacts to Bald Head Island would predictably occur as a direct result of the proposed diversion of channel maintenance material in 2009 to Oak Island. *Note – a similar diversion of Federal sand will occur in the summer of 2018.* As a result of the 2018 federal sand disposal at Oak Island, the Village constructed a 1.1 Mcy interim beach fill at South Beach in the fall/winter of 2018/19.

**Table 5.6** presents a chronology of sediment volumes (measured in-place) for the three (3) segments of shoreline noted between the benchmark survey of November 2000 and present (*i.e.* May 2019). Currently, within the **approximate** 22,755 ft of shoreline considered, there is a net gain of +2,992,000 cy. However, after removing the effects of the sand artificially placed along the Bald Head Island shoreline since the 2000 deepening project, the net change in Island-wide volume (exclusive of East Beach and the Cape Fear Point) is a measured sediment *loss* of -7,190,800 cy. It is important to note that the chronology of sand volumes presented by this Table reflects the *actual volumes* of sand *measured in-place* by survey and therefore is not related to projections based upon *estimated* volumes dredged in the channel or borrow site, *estimated* sand volumes placed, contractual “net pay” volumes, etc.

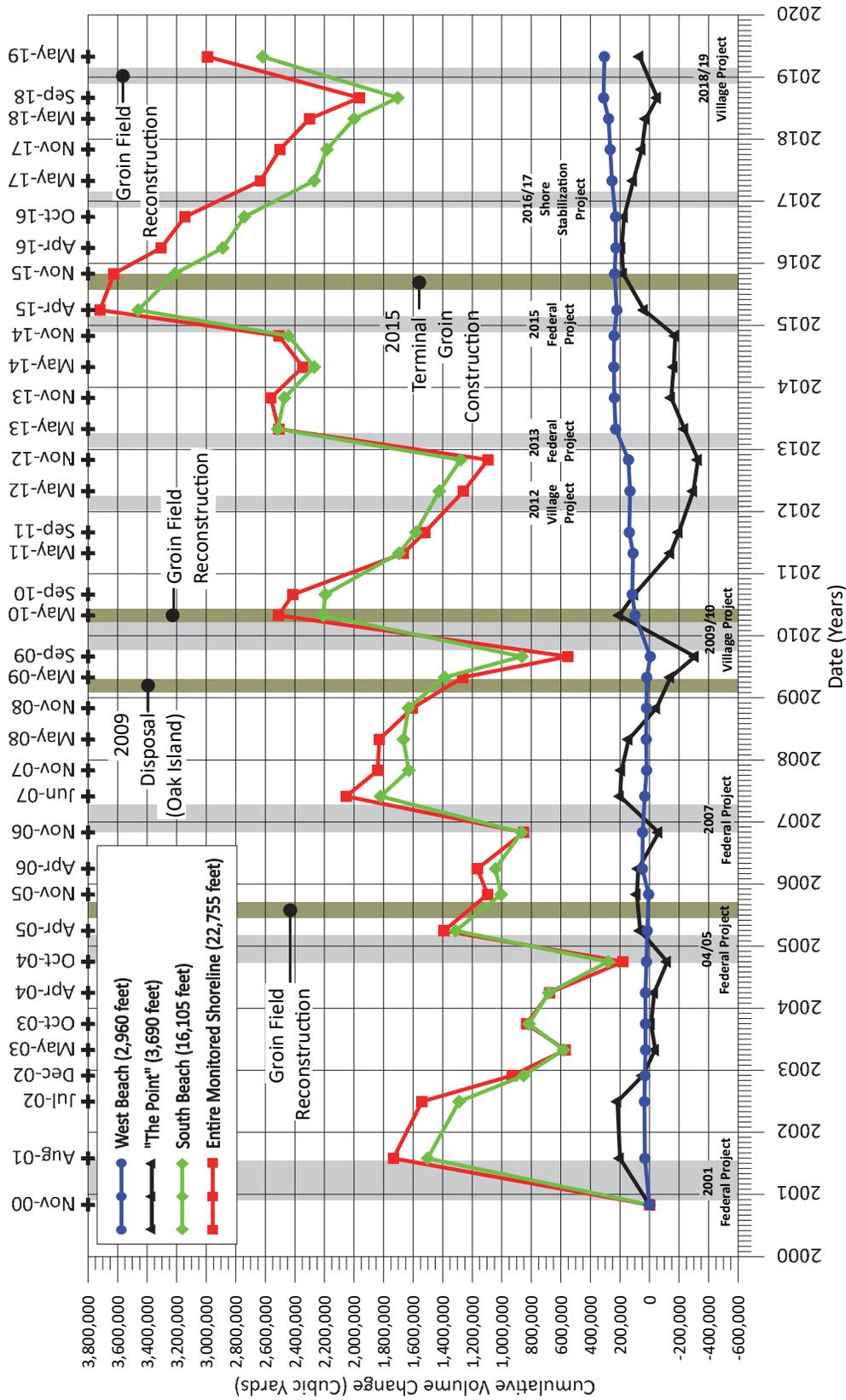


Figure 5.6: Cumulative volume change (above -16 ft-NGVD) relative to November 2000 conditions.

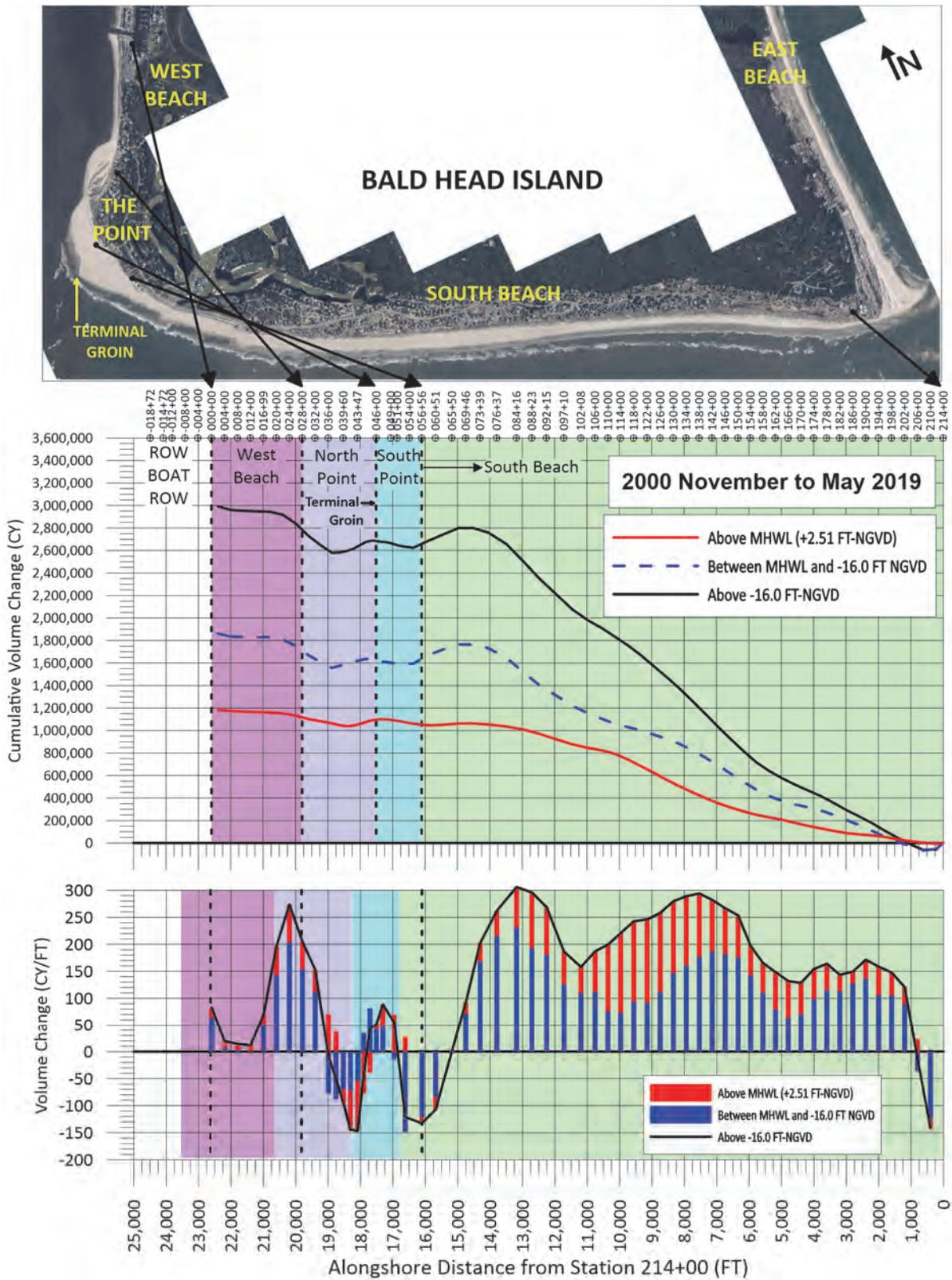


Figure 5.7: Volume change along the Bald Head Island shoreline between November 2000 and May 2019.

**Table 5.6:** Bald Head Island historic net volume change above -16 ft-NGVD (presumed closure depth).

Period	Start Date	End Date	Span (Months)	Volume Change Above -16 ft-NGVD (CY)			
				West Beach	The Point	South Beach	Total
Construction <sup>1</sup>	Nov. 2000	Aug. 2001	9	+31,900	+199,500	+1,501,800	+1,733,200
Year 1	Aug. 2001	Jul. 2002	11	+2,900	+17,400	-213,300	-193,000
Year 2	Jul. 2002	May 2003	10	-8,000	-255,500	-707,400	-970,900
Year 3	May 2003	Apr. 2004	11	+1,000	+6,500	+99,900	+107,400
Year 4 (2004/05 Project) <sup>2</sup>	Apr. 2004	Apr. 2005	12	-11,800	+94,700	+631,200	+714,100
Year 5 (2006 WB Project) <sup>3</sup>	Apr. 2005	Apr. 2006	12	+32,000	+13,300	-270,200	-224,900
Year 6 (2007 Project) <sup>4</sup>	Apr. 2006	Jun. 2007	14	-15,400	+123,500	+778,100	+886,200
Year 7	Jun. 2007	May 2008	11	-10,300	-58,200	-154,600	-223,100
Year 8	May 2008	May 2009	12	-3,400	-282,800	-278,200	-564,400
Year 9 (2009/10 Project) <sup>5</sup>	May 2009	May 2010	12	+79,300	+346,000	+821,300	+1,246,600
Year 10	May 2010	May 2011	12	+13,200	-346,100	-512,700	-845,600
Year 11 (2012 Beach Fill) <sup>6</sup>	May 2011	May 2012	12	+20,800	-154,600	-273,300	-407,100
Year 12 (2013 Disposal) Project <sup>7</sup>	May 2012	May 2013	12	+97,600	+59,800	+1,093,900	+1,251,300
Year 13	May 2013	May 2014	12	+11,600	+72,100	-247,500	-163,800
Year 14 (2015 Disposal) Project <sup>8</sup>	May 2014	April 2015	11	-20,400	+201,800	+1,191,800	+1,373,200
Year 15	April 2015	April 2016	12	+7,200	+151,800	-572,500	-413,500
Year 16	April 2016	May 2017	13	+25,500	-79,000	-619,000	-672,500
Year 17	May 2017	May 2018	12	+23,200	-84,600	-270,500	-331,900
Year 18 (2018/19 Beach Fill) <sup>10</sup>	May 2018	May 2019	12	+29,000	+42,200	+619,500	+690,700
Pre-2000 Construction to Year 18	Nov. 2000	May 2019	222	+305,900	+67,800	+2,618,300	+2,992,000
Pre-2000 Construction to Year 18 (10,182,800 CY of Fill Removed)	Nov. 2000	May 2019	222	NA	NA	NA	-7,190,800

<sup>1</sup> 2001 Initial Disposal (1,849,500± CY); <sup>2</sup> 2005 Beach Disposal (1,217,000± CY); <sup>3</sup> 2006 West Beach Fill (47,800± CY)

<sup>4</sup> 2007 Beach Disposal (978,500± CY); <sup>5</sup> 2009/10 Beach Fill (1,850,000± CY); <sup>6</sup> 2012 Beach Fill (138,000 ± CY)

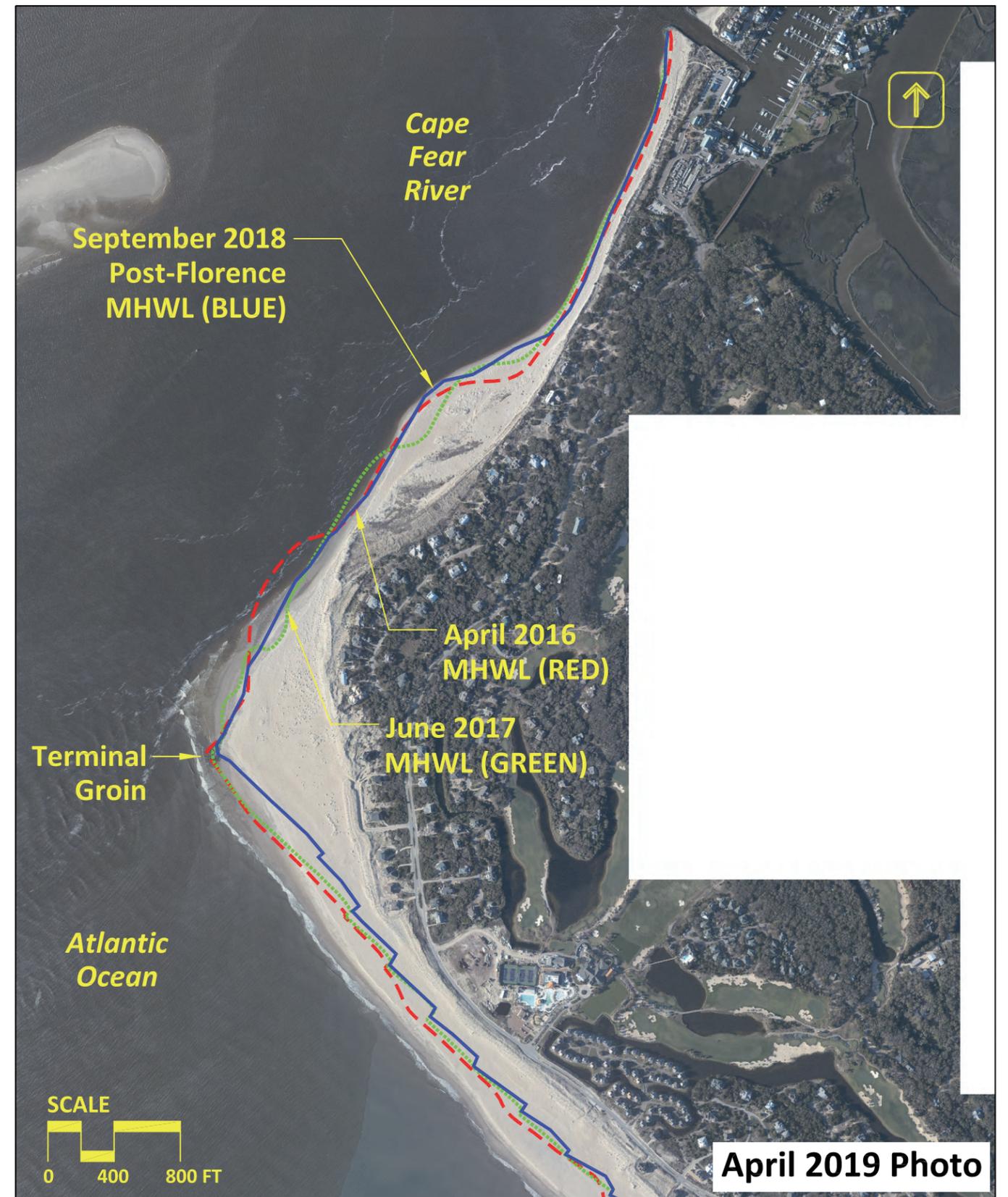
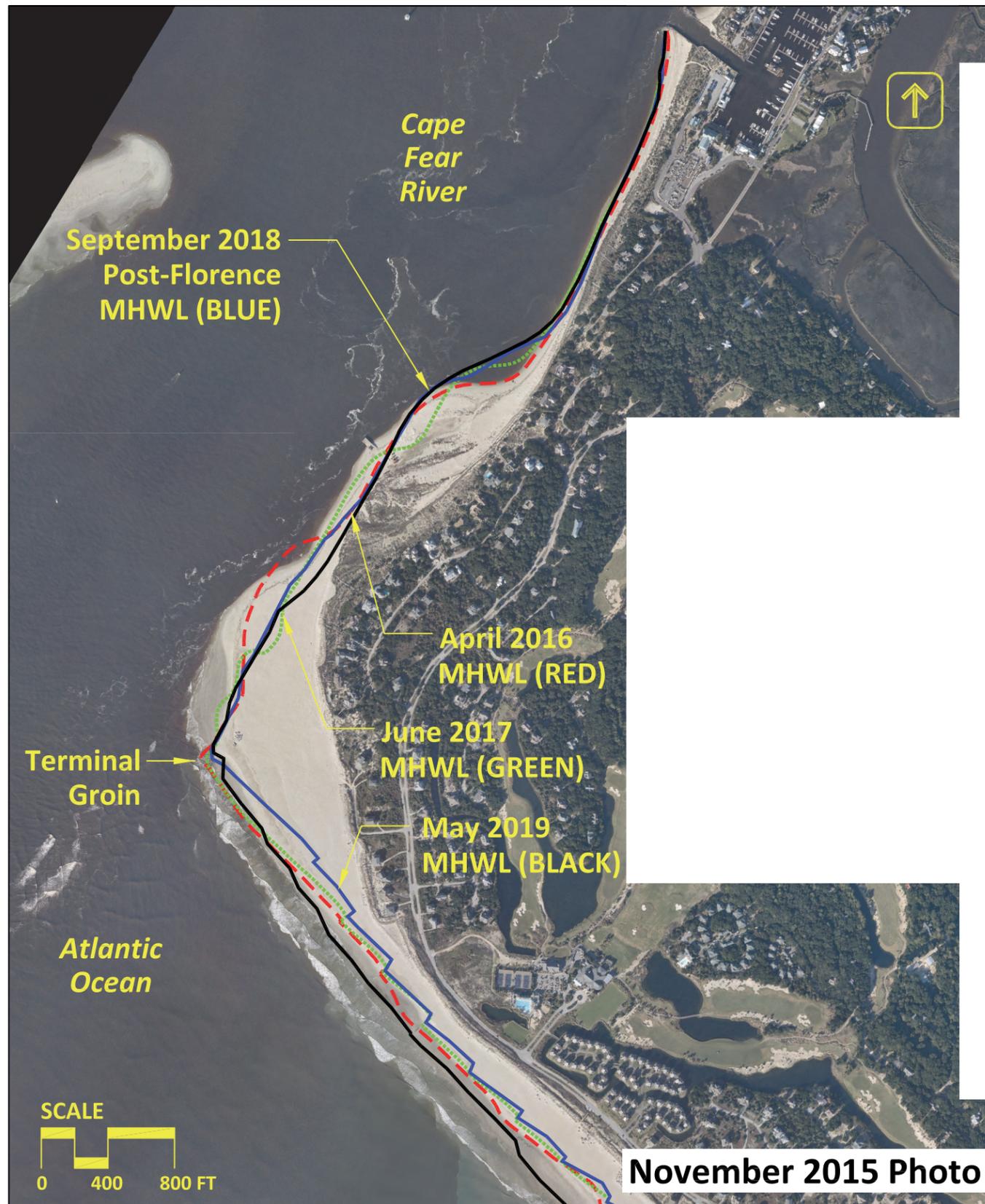
<sup>7</sup> 2013 Beach Disposal Fill (1,658,000 ± CY); <sup>8</sup> 2015 Beach Disposal Fill (1,320,000 ± CY);

<sup>9</sup> 2016/17 Beach Disposal (24,000± CY); <sup>10</sup> 2018/19 Beach Fill (1,100,000± CY)

The estimated *average* annual loss of sand from the monitored section of Bald Head Island shorefront (excluding East Beach and Row Boat Row) since November 2000, is approximately 388,700 cy per year. The assignment of an “average” annual long-term rate of sand loss at Bald Head Island however, is *not* necessarily a meaningful indicator of navigation project impact. Such an “average rate” is temporally biased by periods of beach fill equilibration, groin field effectiveness, the occurrence of episodic destabilizing dredging events in close proximity to the island, as well as other physiographic phenomena temporally affecting annualized quantities of alongshore sediment transport – from Bald Head Island – to the navigation channel, -- including meteorological effects.

### **5.3.5 MHWL Shoreline Position**

As part of the permit required monitoring for the terminal groin project completed in late 2015, the MHWL was surveyed in December 2015 (post-construction), April 2016 (5 months post-construction), June 2017 (19 months post-construction), May 2018 (30 months post-construction), September 2018 (post-Florence) and May 2019 (post-fill). The surveys completed to date are plotted in **Figure 5.8**. The purpose of the surveys is to be able to intercompare and assess both updrift fillet conditions and the location of the downdrift shoreline fronting the Cape Fear River. Through May 2019, terminal groin project performance – based upon monitoring – has been both as intended and as predicted.



**Figure 5.8:**  
MHWL positions in the vicinity of the terminal groin Bald Head Island, NC

### 5.3.6 Chronology of the Point

Since the construction of the Wilmington Harbor Channel Deepening Project – in about 2001, the spatial configuration of the spit feature (known as the “Point”) located at the juncture of South Beach and the entrance channel, has been a focal point of the Village’s monitoring program. Accordingly, the chronology of the Point’s condition and evolution over time is indicative of the dynamic interaction between the ever increasing rate of sand transport westward along South Beach and the man-altered inlet hydrodynamics, as well as episodic dredging operations which result in sand removal from the island’s littoral system. In its simplest sense, the Point has historically been to a large degree, a visual indicator of the processes involved and a potential “bellwether” as to direct and indirect impacts associated with the Navigation Project – irrespective of proactive or remedial actions specified within the Wilmington Harbor Sand Management Plan. The latter take the form of alongshore sand placement events intended to mitigate adverse impacts associated with both project construction in 2000 and episodic channel maintenance required to ensure navigability.

**Appendix E** includes a high resolution visual chronology of the Point from 1998 to April 2018. Demarcated on each photo panel are the approximate September 2001 (blue line) and April 2018 (red line) apparent vegetation lines. Also placed on each photo are two reference marks (green dots). The variation in spit configuration from the before navigation improvement project photos (1998 and 1999) throughout the last approximate eighteen years for pre- and post-fill timeframes can be easily visualized. Similarly, the advance and recession of the Point, as well as its consistent *net northerly migration* are self-evident. An additional perspective can be gained by an assessment of the locations of the pre-project and present day “vegetation lines” over the 1998 through 2018 timeframe. As had been concluded throughout the numerous years of comprehensive beach monitoring funded by the Village of Bald Head Island – improved conditions along the westernmost segment of South Beach and the Point were documented to last only about 2 years after each federal disposal event – prior to terminal groin construction in 2015.

Both long term monitoring, as well as numerical modeling of the Cape Fear River Entrance by Olsen Associates, Inc. (Olsen 2013a), and the abutting Bald Head Island shoreline, indicated that additional structural measures were warranted. As the westernmost segment of South Beach shoreline has “rolled back,” the annualized rate of littoral transport at that location has correspondingly increased. Hence, in 2012 the Village initiated the permitting for a 1,300 ft terminal structure intended to both reorient the effective updrift shoreline alignment (so as to reduce annual sediment losses) and to allow for the reconstruction of a protective beach where one now could not be reliably established through sand placement alone. That project was constructed during the summer of 2015. Subsequently, monitoring reports now document “new dynamic” predicted to result from the implementation of the terminal groin structure. Analytical predictions of shoreline change to

both the updrift and downdrift shorelines abutting the structure – via DELFT 3D modeling – were discussed in a detailed report formulated for purposes of both design and permitting of the terminal groin (Olsen 2013a). Additional monitoring data required by Permit are intended to assist in the quantification of the terminal groin effects on littoral processes and resultant shoreline reconfiguration. These include additional transects in the vicinity of the structure as well as an approximate MHWL delineation performed by survey every 6-months.

For the May 2018 to May 2019 monitoring period, the inlet facing shoreline adjacent to the terminal groin continues to realign (as predicted) and adjust to a new equilibrium condition. An intertidal spit formation forms on the inlet side of the structure as a result of sediment transported from South Beach through or across the structure. Updrift thereof, portions of the historical Point continue to migrate northward as they did prior to terminal groin construction. This is best represented by the surveyed MHWL locations depicted in **Figure 5.8**. It has been noted previously that the majority of the terminal groin was constructed “in the dry” – with only the distal head of the structure evident at completion in late 2015. Since that time, portions of the federal disposal located berm westward of the new structure have receded as a new equilibrium condition evolves.

## 5.4 East Beach Shoreline Conditions

In November 2008, East Beach was added to the island-wide beach monitoring program<sup>9</sup>. Profiles along the East Beach shoreline are collected at seven (7) monitoring stations starting just north of Cape Fear and extending approximately 6,000 feet northward along the Onslow Bay facing shoreline (see **Figure 2.1**). Plots of these profiles are provided at the end of **Appendix A (Figures A-70 to A-76)**. **Tables 5.7** and **5.8** summarize the shoreline and volume changes measured during the May 2018 to September 2018 to May 2019 monitoring periods.

During the May 2018 to September 2018 summer period, the East Beach shoreline was accretional, gaining +9,300 cy (+1.6 cy/ft) above the MHWL and +50,800 cy (+8.5 cy/ft) above -16 ft-NGVD. During this same period the backshore berm (at elevation +6 ft-NGVD) advanced by a spatially weighted average<sup>10</sup> of +50.9 ft while the MHWL advanced by an average of +18.6 ft. However, the average advance at both the MHWL and berm are *heavily influenced* by the large advancement at the southernmost station, STA 224+80, located immediately north of Cape Fear. At this station, the berm, and MHWL advanced by 340.8 and 104.7 ft, respectively. This advancement is evident in **Figure 5.9** which depicts the April 2018, October 2018 and April 2019 aerial photographs along East Beach.

During the September 2018 to May 2019 winter period, the East Beach shoreline gained approximately +300 cy (+0.1 cy/ft) above the MHWL and +98,800 cy (+16.5 cy/ft) below the MHWL for a net total change above -16 ft-NGVD of +99,100 cy (+16.5 cy/ft). During this same period the berm retreated by a spatially weighted average of +50.0 ft while the berm receded by an average of -6.5 ft. However, the average retreat at the berm is *heavily influenced* by the large retreat (-336.3 ft) at the southernmost station, STA 224+80, located immediately north of Cape Fear. After removing this station from the weighted average, the average retreat of the berm is -2.3 ft.

**Table 5.10** summarizes shoreline and volume changes measured over the entire period of survey record (November 2008 – May 2019). Over the 127-month period, the East Beach shoreline gained approximately +96,800 cy above the MHWL and +342,300 cy above the -16 ft-NGVD contour. Likewise, the backshore berm and MHWL advanced by weighted averages of +20.8 ft and +90.2 ft, respectively over this period. However, most of these shoreline gains occurred immediately adjacent to Cape Fear (Sta. 224+80 to 254+80).

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<sup>9</sup> Profiles were not acquired at East Beach in the fall of 2009

<sup>10</sup> Due to the irregular spacing of the profile stations, the average shoreline changes are weighted based upon the distance between stations and calculated using an average end method.

**Table 5.7:** East Beach shoreline and volume changes between May 2018 and September 2018.

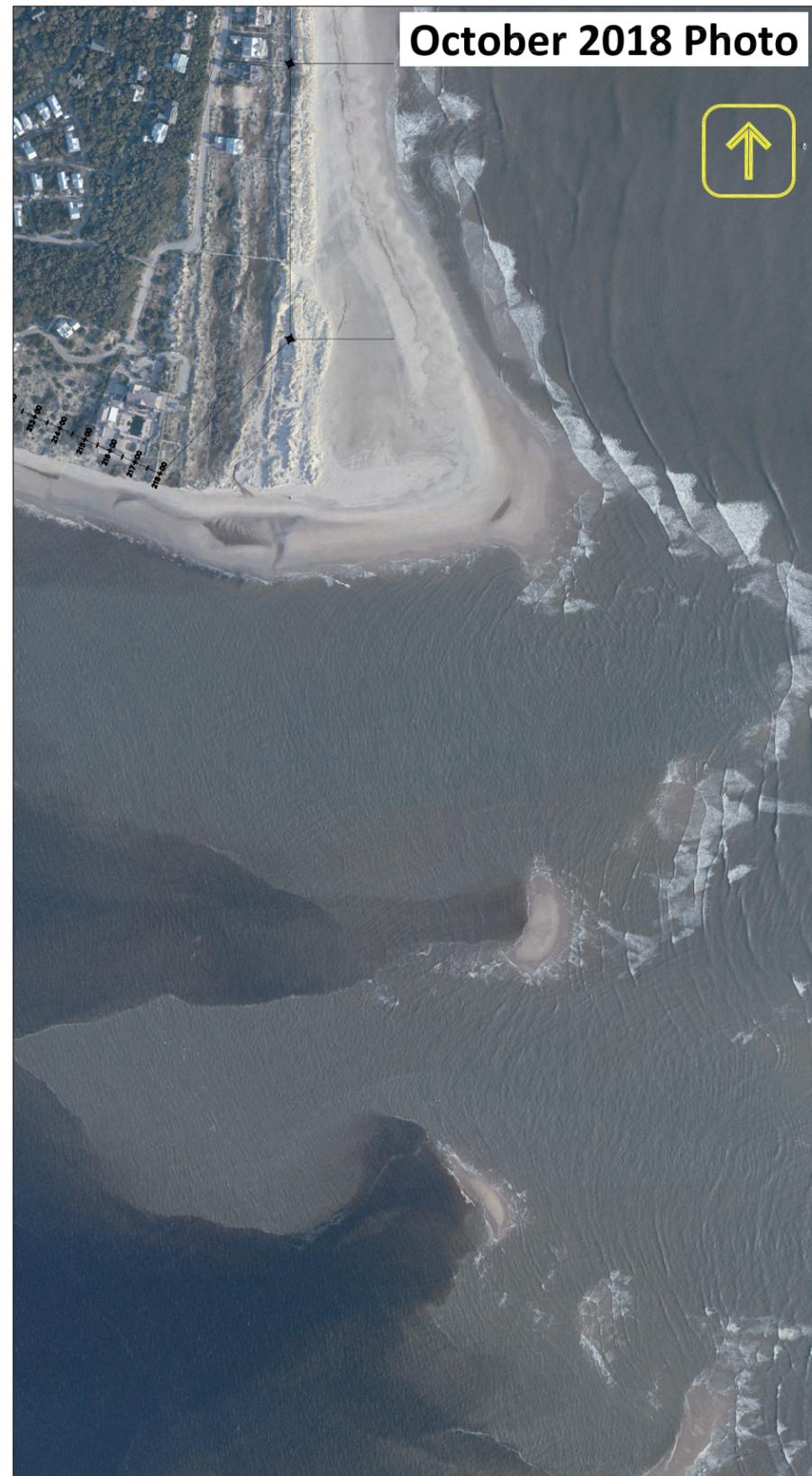
Station	Reach (FT)	Volume Change (CY)		Shoreline Change (FT)	
		Above MHWL (+2.51 FT)	Above -16 FT	Berm (+6 FT)	MHWL (+2.51 FT)
224+80				+340.8	+104.7
	1,000	+7,900	+20,400		
234+80				-51.0	+7.5
	1,000	-600	+5,300		
244+80				+19.7	+21.1
	1,000	+400	-9,300		
254+80				+24.0	+2.1
	1,000	+300	-200		
264+80				+15.0	-5.4
	1,000	+300	+15,200		
274+80				+3.2	+0.9
	1,000	+1,000	+19,400		
284+80				+4.6	-0.5
<b>Total</b>	<b>6,000</b>	<b>+9,300</b>	<b>+50,800</b>	<b>+50.9 (AVG)</b>	<b>+18.6 (AVG)</b>

**Table 5.8:** East Beach shoreline and volume changes between September 2018 and May 2019.

Station	Reach (FT)	Volume Change		Shoreline Change (FT)	
		Above MHWL (+2.51 FT)	Above -16 FT	Berm (+6 FT)	MHWL (+2.51 FT)
224+80				-336.3	-86
	1,000	-3,900	-1,800		
234+80				-28.4	+14.8
	1,000	+1,600	+21,700		
244+80				-28.7	-16.0
	1,000	+300	+33,500		
254+80				+22.1	+17.6
	1,000	+500	+25,100		
264+80				-21.2	-4.2
	1,000	-100	+9,900		
274+80				+25.1	+5.6
	1,000	+1,900	+10,700		
284+80				+17.1	+22.6
<b>Total</b>	<b>6,000</b>	<b>+300</b>	<b>+99,100</b>	<b>-50.0 (AVG)</b>	<b>-6.5 (AVG)</b>

**Table 5.9:** Volume changes along East Beach (Sta. 224+80 to 284+80).

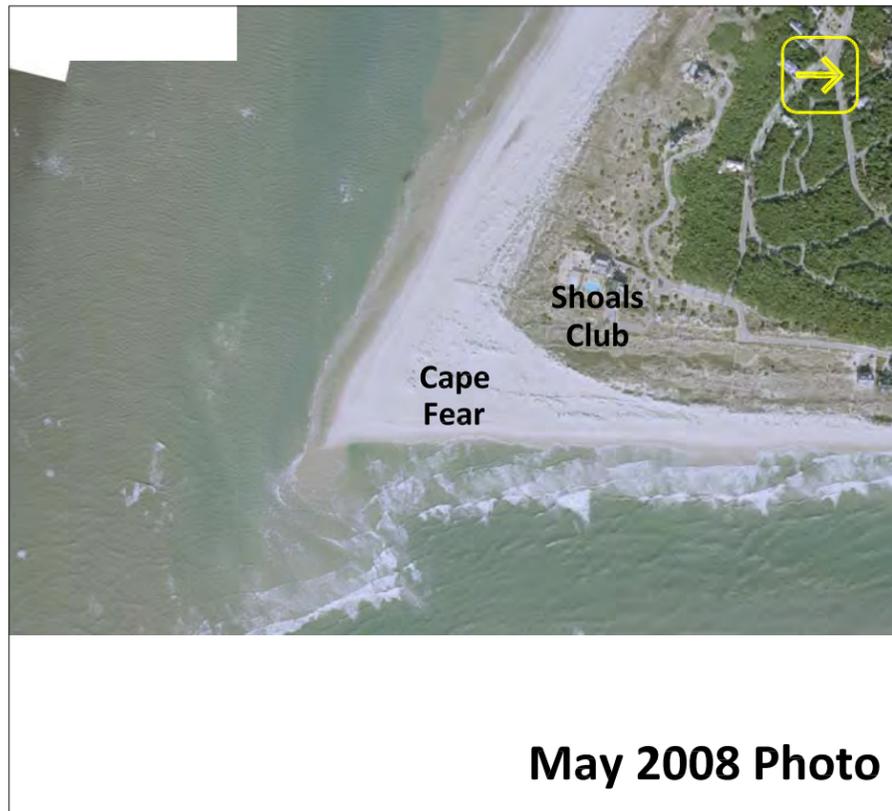
Survey Period	Volume Change Above Datum (CY)		
	Above MHWL (+2.51 ft-NGVD)	Below MHWL to -16 ft-NGVD	Total Change Above -16 ft-NGVD
November 2008 to May 2009	+700	-65,600	-64,900
May 2009 to May 2010	-23,300	-8,600	-31,900
May 2010 to May 2011	+10,600	+18,000	+28,600
May 2011 to May 2012	+5,700	+87,700	+93,400
May 2012 to May 2013	+20,000	-41,600	-21,600
May 2013 to May 2014	+17,700	+105,200	+122,900
May 2014 to April 2015	-900	+44,100	+43,200
April 2015 to April 2016	+20,800	-400	+20,400
April 2016 to May 2017	+4,500	+38,200	+42,700
May 2017 to May 2018	+31,400	+25,000	+56,400
May 2018 to May 2019	+9,600	+140,300	+149,900
<b>November 2008 to May 2019</b>	<b>+96,800</b>	<b>+342,300</b>	<b>+439,100</b>



**Figure 5.9:**  
Cape Fear aerial photography  
Bald Head Island, NC

As demonstrated by the survey and photographic data (**Figure 5.9**), it can be reasonably assumed that the condition of East Beach at any one time is, has been and will continue to be highly influenced by the configuration of the depositional spit and shoals associated with the “Cape Fear Point”. Of further interest are the variations in spit size and orientation over the 11 years (2008-2019) which are depicted by **Figure 5.10**. In its simplest sense, the Cape Fear spit is a highly dynamic feature which is influenced by sand supply originating from both the west (along South Beach) and the north (along East Beach). The Point is also susceptible to storm waves originating from *both* the west (Atlantic Ocean) and the east (Onslow Bay) and resultant tidal channels which episodically break through and subsequently influence localized patterns of sand deposition (or erosion).

Although the location of the Cape Fear spit has been beneficial to East Beach properties, it has caused significant shoreline and dune recession seaward of the South Beach Shoals Club facility. That section of shorefront is monitored via beach profiles B-54 and B-55 (Sta. 214+00 and 218+00). The Shoals Club lies approximately mid-way between these two survey stations. May 2019 shoreline conditions are visually shown by **Figure B-9** (Appendix B – May 2019 Aerial Photography – page B-10). Since November 2000, the MHWL at profile B-54 has receded by -232 ft, or about -12 ft/yr. At B-55, over the same period of time, the MHWL has receded -294 ft, or about -16 ft/yr. More recently however, between November 2014 and May 2019, the MHWL at B-55 had receded by about -124 ft which equates to a rate of -28 ft/yr.



**Figure 5.10:**  
Cape Fear aerial photography  
Bald Head Island, NC

## 5.5 Row Boat Row Shoreline Conditions

In November 2015, the “Row Boat Row” shoreline was added to the island-wide beach monitoring program. Survey data are collected at five (5) monitoring stations starting just north of the marina entrance and extending approximately 1,500 feet northward along the Cape Fear River facing shoreline (see **Figure 4.1**). Plots of these profiles are provided at the beginning of **Appendix A (Figures A-1 to A-5)**. **Tables 5.10** and **5.11** summarize the shoreline and volume changes measured during the May 2018 to September 2018 to May 2019 monitoring period (12 months).

In early 2017, after completion of a 26,000 cy beach fill placed by Marcol Dredging along the Row Boat Row shoreline, two detached rock breakwaters were constructed by Intra Coastal Marine Construction. Final acceptance of the project occurred in July 2017. Subsequently, the shorefront within the influence of the two shore parallel structures has begun to equilibrate into a series of discrete crenulate features between tombolos which extend from the center of each breakwater in a landward direction (**Figure 5.11**).

During the monitoring year (May 2018 to May 2019), the shoreline showed net losses of roughly -800 cy (-0.5 cy/ft) above the MHWL and -6,200 cy (-3.9 cy/ft) above -16 ft-NGVD. Similarly, the berm and MHWL receded by weighted averages of -3.9 ft and -13.6 ft, respectively over this period. This is irrespective of several sand bypass operations associated with marina channel maintenance.



**Figure 5.11:** Northward looking view of the Row-Boat-Row shoreline detached breakwaters. (April 2019 Photo)

**Table 5.10:** Row Boat Row shoreline and volume changes between May 2018 and September 2018.

Station	Reach (FT)	Volume Change (CY)		Shoreline Change (FT)	
		Above MHWL (+2.51 FT)	Above -16 FT	Berm (+6 FT)	MHWL (+2.51 FT)
-018+72				+14.9	-1.1
	400	-100	-3,400		
-014+72				-5.0	-14.9
	272	-1,200	-3,300		
-012+00				-11.9	-14.5
	400	-1,800	-3,400		
-008+00				-14.8	-7.8
	400	-1,000	-2,900		
-004+00				-7.2	-17.9
	100	-200	-900		
Marina					
<b>Total</b>	<b>1,572</b>	<b>-4,300</b>	<b>-13,900</b>	<b>-6.9 (AVG)</b>	<b>-11.8 (AVG)</b>

**Table 5.11:** Row Boat Row shoreline and volume changes between September 2018 and May 2019.

Station	Reach (FT)	Volume Change (CY)		Shoreline Change (FT)	
		Above MHWL (+2.51 FT)	Above -16 FT	Berm (+6 FT)	MHWL (+2.51 FT)
-018+72				+7.3	-14.7
	400	+800	+1,600		
-014+72				-14.1	-16.6
	272	+100	+100		
-012+00				-11.9	-11.2
	400	+1,200	+1,900		
-008+00				+21.5	+17.3
	400	+1,300	+3,400		
-004+00				+11.5	+8.4
	100	+100	+700		
Marina					
<b>Total</b>	<b>1,572</b>	<b>+3,500</b>	<b>+7,700</b>	<b>+3.0 (AVG)</b>	<b>-1.8 (AVG)</b>

**Note** – Volumes of sand associates with multiple sand bypass operations since 2017 have not been accounted for in these tables.

## 6.0 BORROW SITE MONITORING (SURVEY) RESULTS

### 6.1 Borrow Site Evaluation – Bald Head Creek

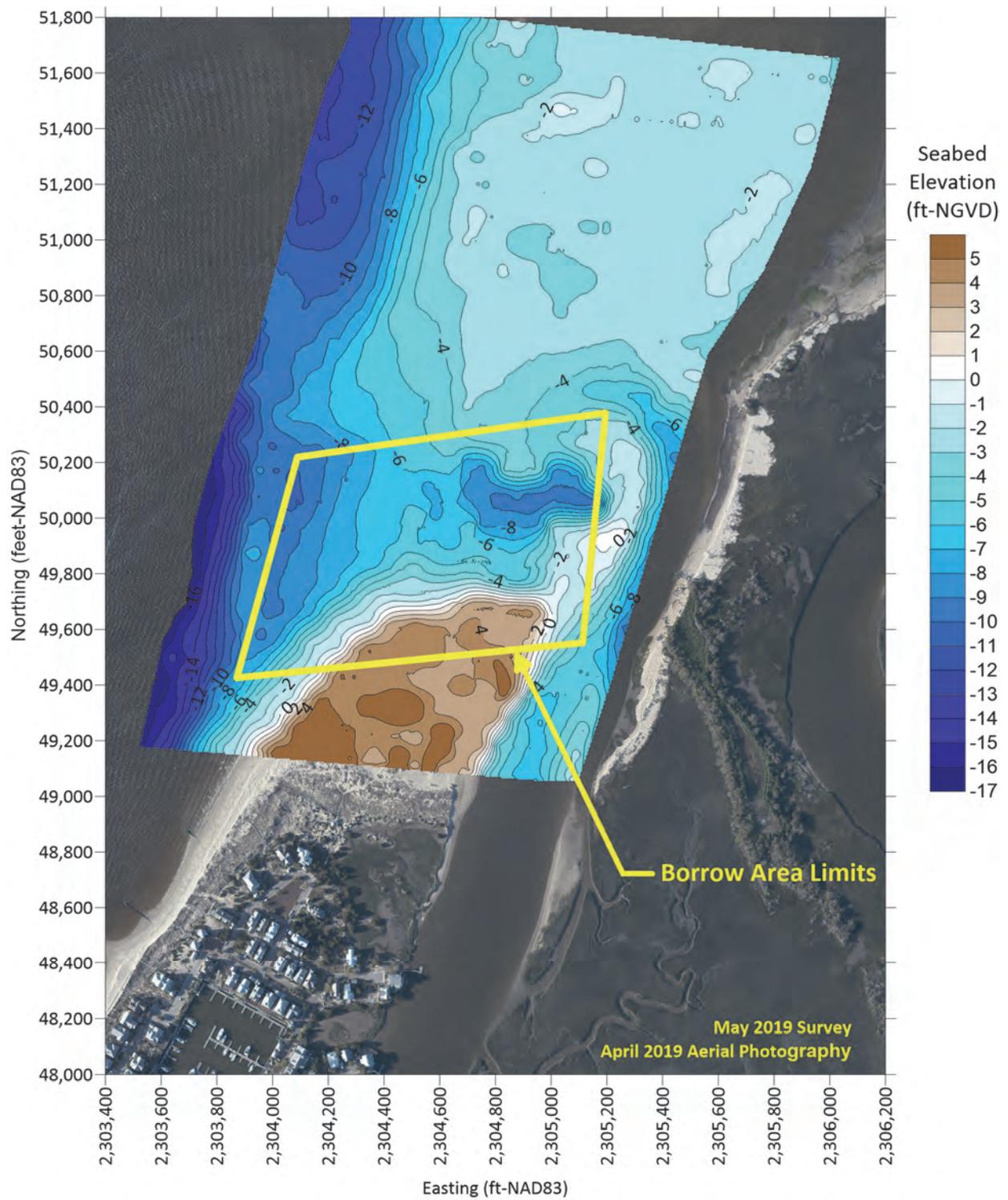
A small-scale beach restoration project utilizing sand from the Bald Head Creek borrow site was constructed between December 2016 and March 2017 along the West Beach and Row Boat Row shorefronts. Approximately 48,700 cy were dredged from the northeastern corner of the permitted borrow site. This same borrow site was utilized for the 2012 Post-Irene small scale mitigation project and continues to be resurveyed annually. Approximately 138,000 cy of sand were dredged from the borrow site between January and February 2012.

**Figure 6.1** presents the seabed conditions within the vicinity of the borrow site as of the most recent monitoring survey (May 2019). **Figure 6.2** presents the relative seabed elevation change over the past monitoring year (May 2018 to May 2019) and **Figure 6.3** presents the seabed elevation change since project completion (May 2018 to May 2019).

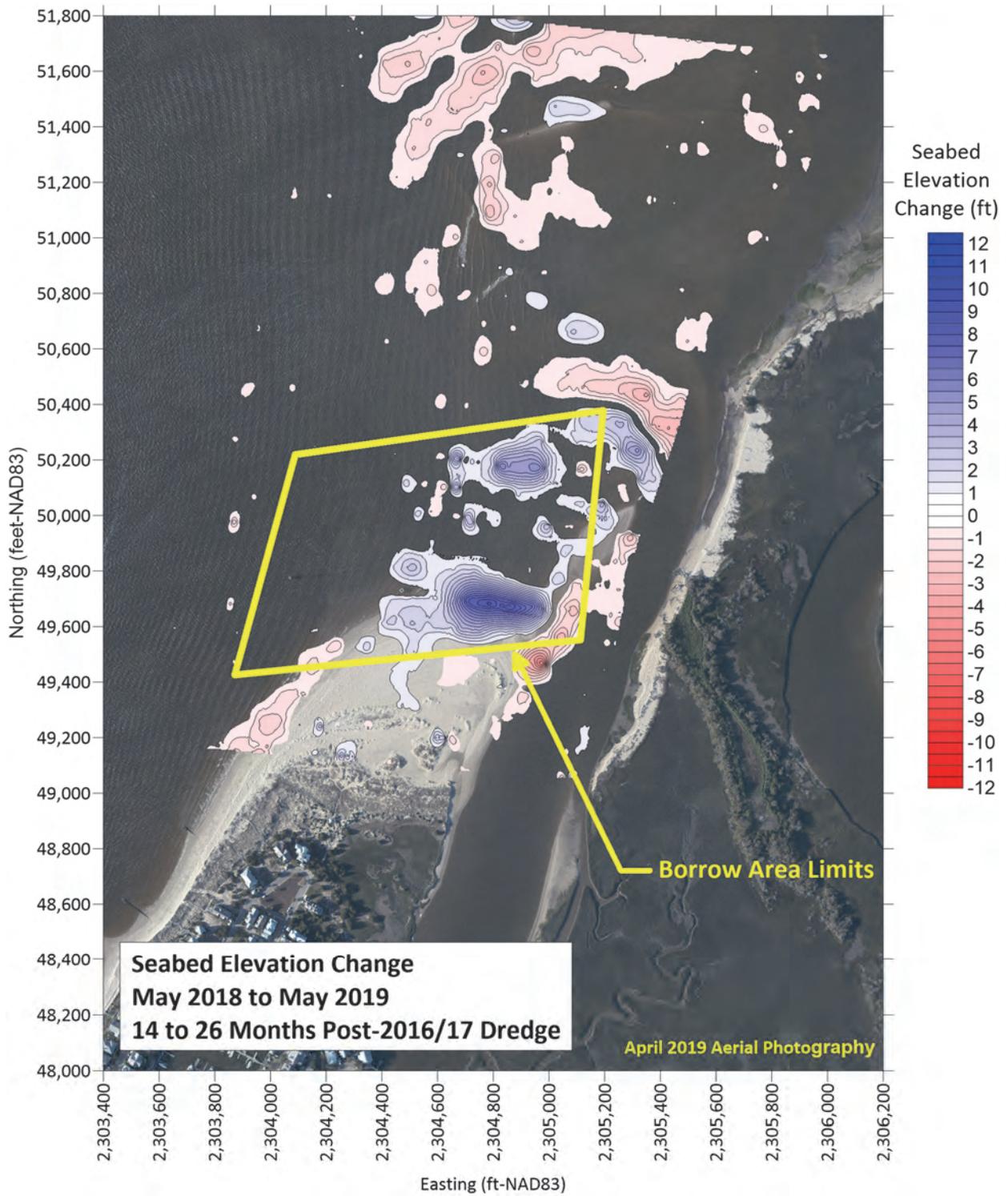
The most recent monitoring year (May 2018 to May 2019) represents the second year following completion of 2016/17 dredging of the borrow site. During this period, the borrow site gained +29,700 cy within the entire permitted limits (both excavated and unexcavated). Within the approximate 2016 excavation limits, the borrow site gained +10,700 cy during this period and a total of +23,100 cy since project completion or roughly 47 percent of the dredged volume (-48,700 cy). In the 7 years since the completion of the initial dredging project (March 2012 to May 2019), the area within the limits of the permitted borrow site has gained +75,300 cy.

**Table 6.1:** Bald Head Creek borrow site volume changes (within permitted limits).

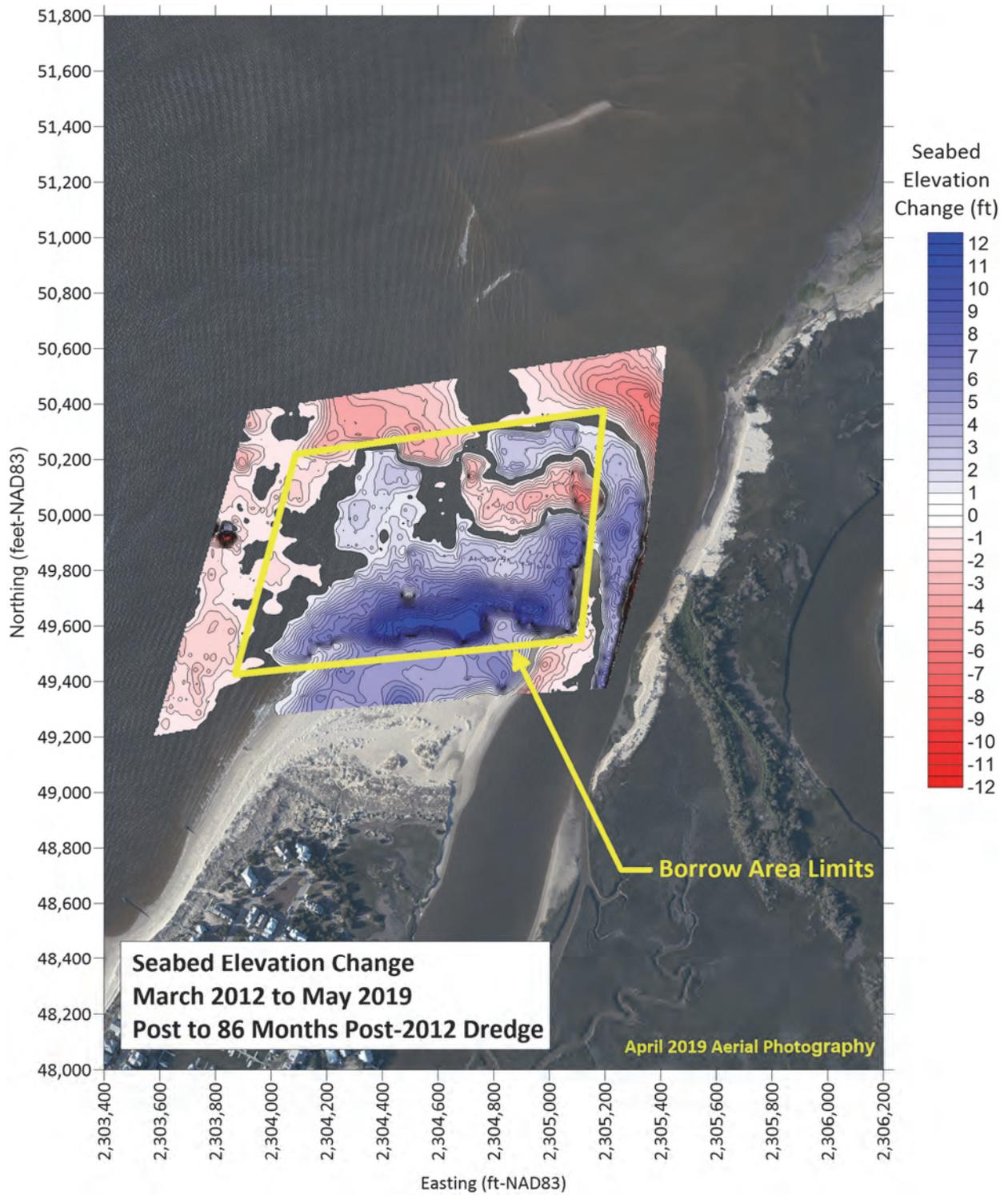
Survey Period	Duration	Volume Change (CY)		
		Gross Gain	Gross Loss	Net Change
March 2012 to January 2013 (AD to Year 1)	10 months	+22,400	-10,600	<b>+11,800</b>
January 2013 to December 2013 (Year 1 to Year 2)	11 months	+21,800	-1,800	<b>+20,000</b>
December 2013 to April 2015 (Year 2 to Year 3)	16 months	+34,700	-1,200	<b>+33,500</b>
April 2015 to April 2016 (Year 3 to Year 4)	12 months	+15,600	-10,900	<b>+4,700</b>
April 2016 to November 2016 (Year 4 to Year 4.5)	7 months	+9,700	-2,000	<b>+7,700</b>
November 2016 to March 2017 (2016/17 Construction Period)	4 months	+1,800	-55,000	<b>-53,200</b>
March 2017 to May 2018 (Year 5 to Year 6)	14 months	+30,500	-9,400	<b>+21,100</b>
May 2018 to May 2019 (Year 6 to Year 7)	12 months	+32,800	-3,100	<b>+29,700</b>
<b>Since Construction (March 2012 to May 2019)</b>	<b>86 months</b>	<b>+169,300</b>	<b>-94,000</b>	<b>+75,300</b>



**Figure 6.1:** Existing Bald Head Creek borrow site conditions (May 2019 survey).



**Figure 6.2:** Bald Head Creek borrow site seabed elevation changes post-2016/17 project (May 2018 to May 2019).



**Figure 6.3:** Bald Head Creek borrow site seabed elevation changes post-2012 project (March 2012) to May 2019.

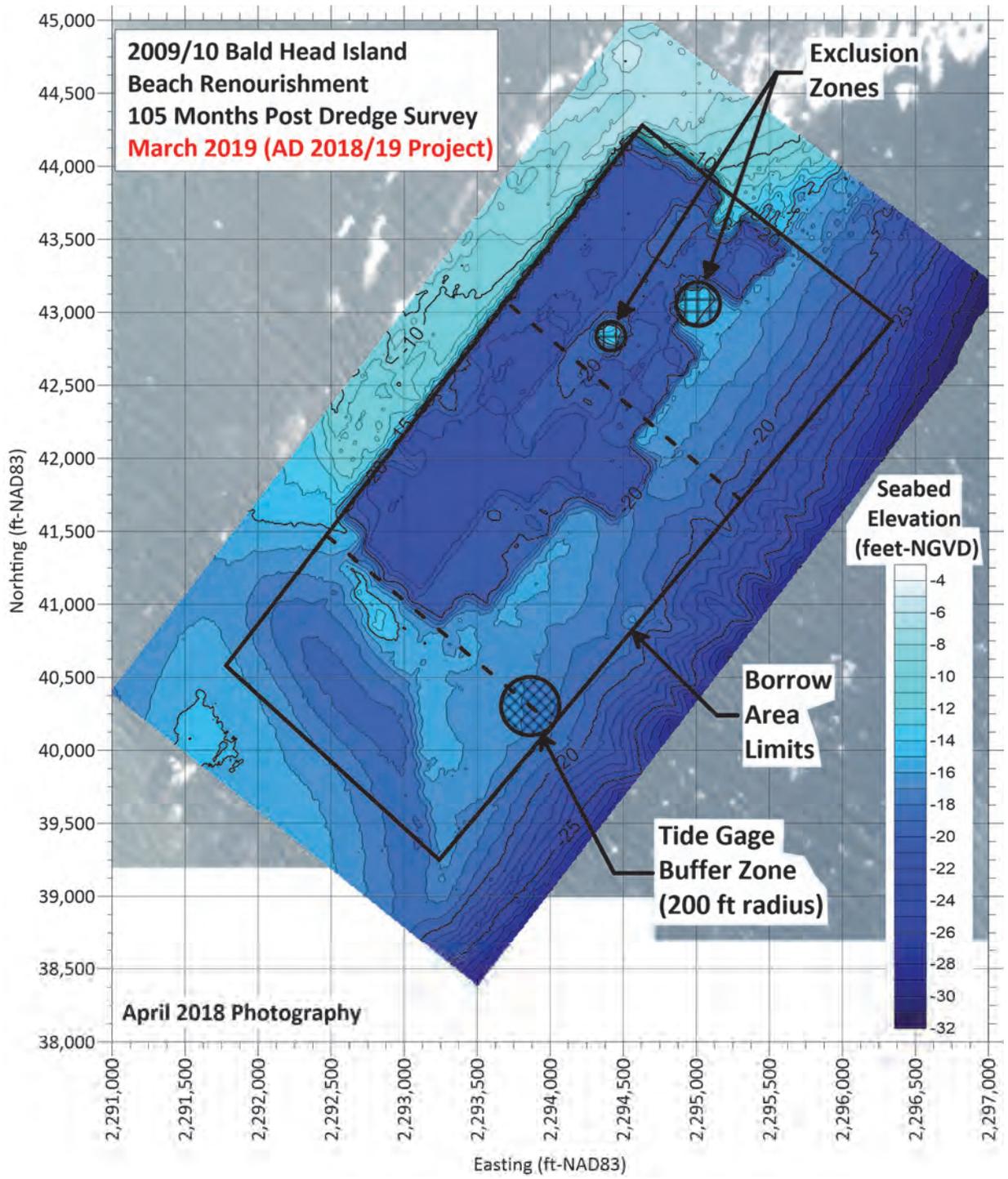
## 6.2 Borrow Site Evaluation – Jay Bird Shoals

Pursuant to permit requirements for the 09/10 project, the Jay Bird Shoal borrow site was last surveyed in March 2019. The borrow site was also utilized during the 18/19 project during which approximately 1.1 Mcy was excavated. **Table 6.2** summarizes the volume changes within the 09/10 *excavated* borrow site limits<sup>11</sup> between the monitoring surveys conducted to date. **Figure 6.4** depicts the most recent 9-year post 2009/10 project (108 months) borrow site condition as surveyed in March 2018. **Figure 6.5** depicts the changes between the May 2018 and December 2018 surveys, immediately prior to the 18/19 project excavations. **Figure 6.6** depicts the seabed elevation changes during the 105 months since 09/10 project construction to immediately before 18/19 project construction (March 2010 to December 2018). **Figure 6.7** depicts the seabed elevations resulting from the 18/19 project construction (December 2018 to March 2019, BD/AD).

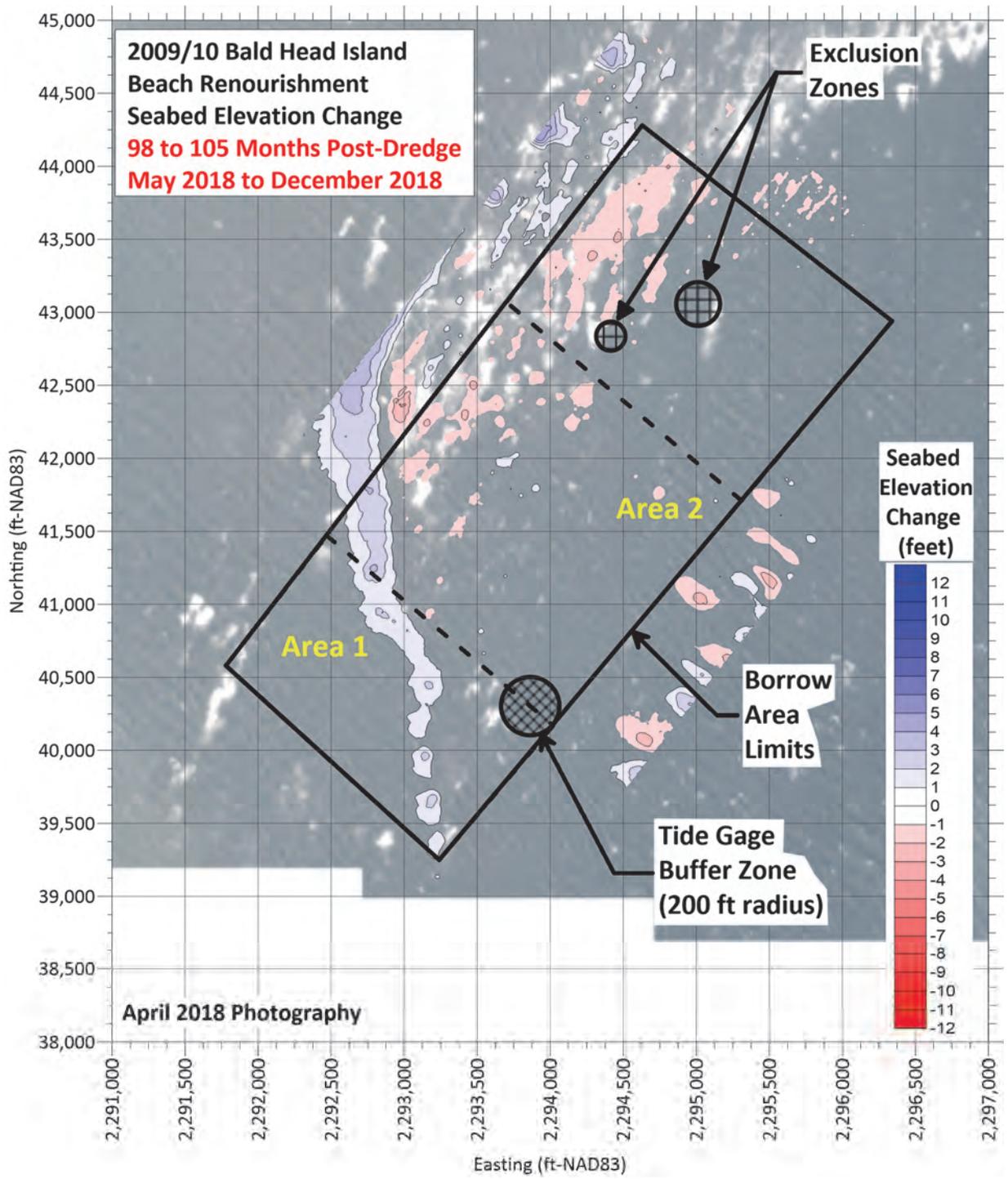
**Table 6.2:** Jay Bird Shoals borrow site volume changes (09/10 *EXCAVATED* limits).

Survey Period	Duration	Volume Change (CY)		
		Gross Gain	Gross Loss	Net Change
October 2009 to March 2010 (Construction)	5 months	+6,000	-1,791,400	-1,785,400
March 2010 to May 2011 (Year 1 Post-Construction)	14 months	+259,400	-36,800	+222,600
May 2011 to May 2012 (Year 2 Post-Construction)	12 months	+84,700	-39,000	+45,700
May 2012 to May 2013 (Year 3 Post-Construction)	12 months	+155,300	-13,300	+142,000
May 2013 to April 2015 (Years 4 & 5 Post-Construction)	23 months	+249,700	-54,700	+195,000
April 2015 to May 2017 (Years 6 & 7 Post-Construction)	25 months	+141,800	-135,500	+6,300
May 2017 to May 2018 (Year 8 Post-Construction)	12 months	+89,500	-39,400	+50,100
May 2018 to September 2018	4 months	+23,100	-123,400	-100,300
September 2018 to December 2018	3 months	+122,200	-3,300	+118,900
December 2018 to March 2019 (BD/AD 18/19 Project)	3 months	+59,700	-647,000	-587,300
<b>Since Construction (March 2010 to December 2018)</b>	105 months	<b>+1,125,700</b>	<b>-445,400</b>	<b>+680,300</b>
<b>Since Construction (March 2010 to March 2019)</b>	108 months	<b>+1,185,400</b>	<b>-1,092,400</b>	<b>+93,000</b>

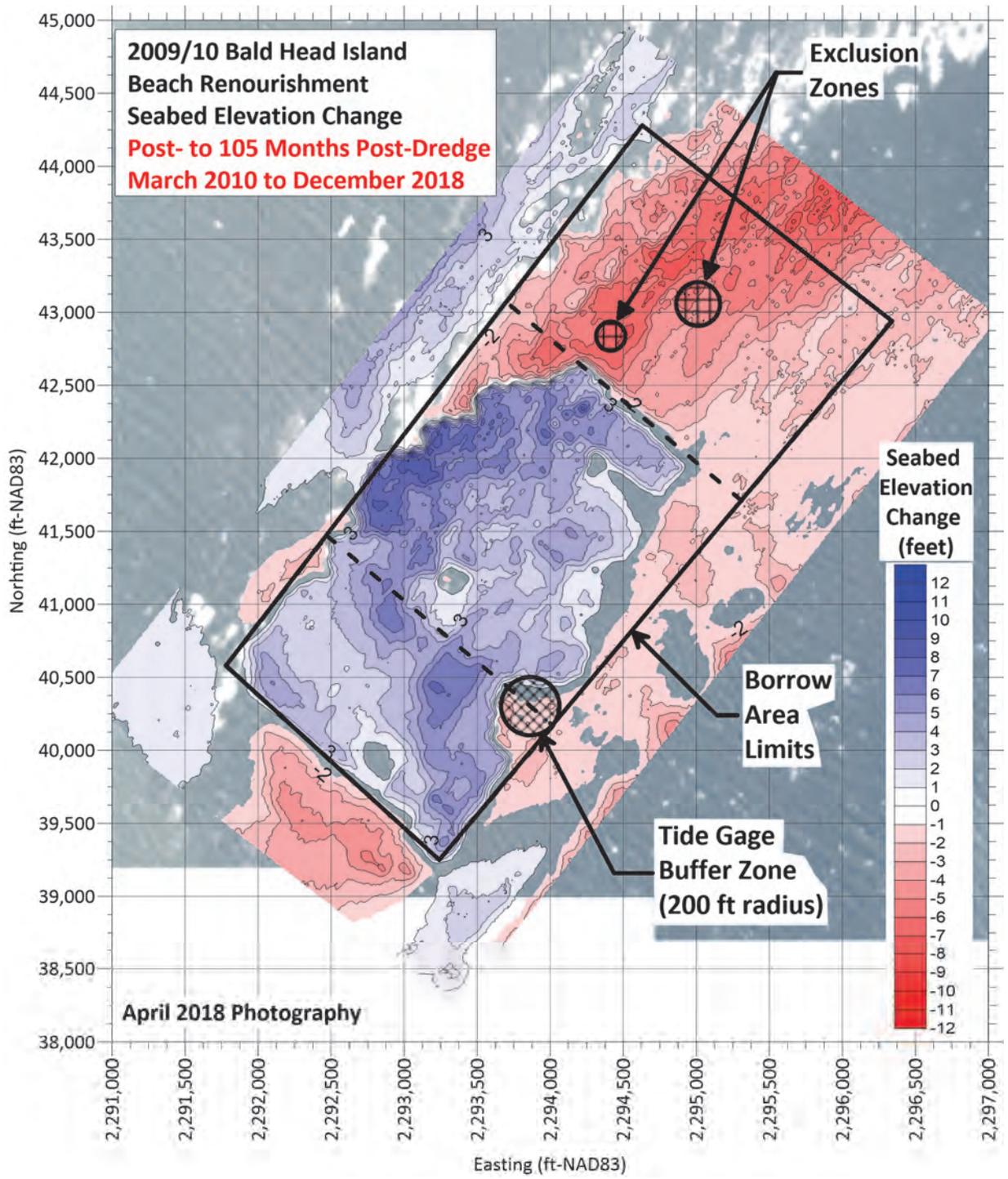
<sup>11</sup> Excavation occurred with Areas 1 & 2 (minus the exclusion zones) depicted in **Figure 6.5**.



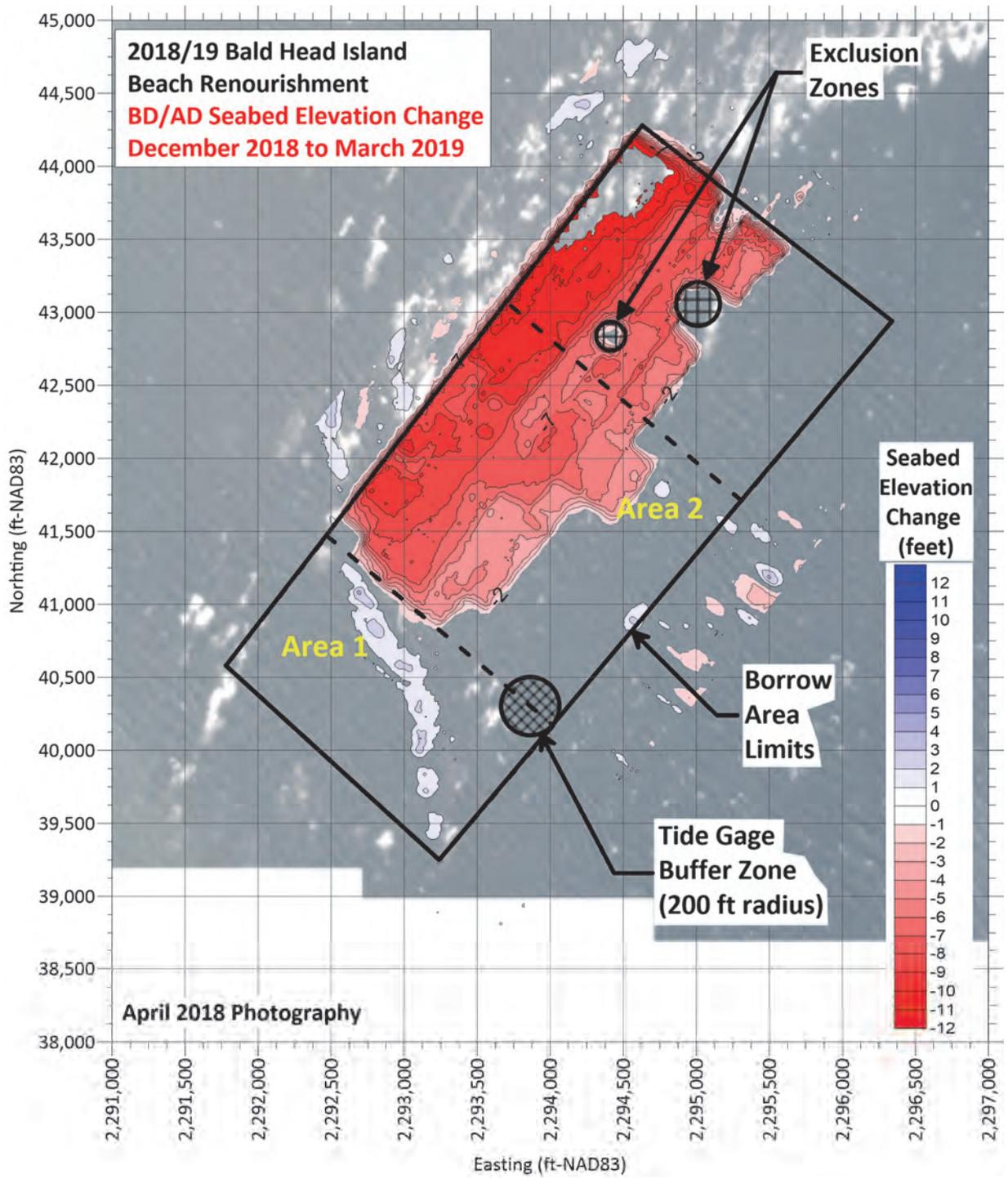
**Figure 6.4:** 108 months post-dredge 09/10 project (March 2019) Jay Bird Shoal borrow site conditions (BD/AD 18/19 project).



**Figure 6.5:** Jay Bird Shoals seabed elevation changes 98 to 105 months post-dredge (May 2018 to December 2018).



**Figure 6.6:** Jay Bird Shoals seabed elevation changes since 09/10 project completion (March 2010 to December 2018).



**Figure 6.7:** Jay Bird Shoals seabed elevation changes during construction of the 18/19 project construction (December 2018 to March 2019).

During the Year 9 monitoring period, prior to the 18/19 excavation (May 2018 to December 2018), the borrow site gained approximately +18,600 cy within the entire 09/10 *excavated* area. In the nine years since project completion (March 2010 to December 2018), the 09/10 *excavated* area gained roughly +680,300 cy or approximately 37 percent of the estimated dredge volume (-1,835,700 cy). Overall, within the *permitted* limits (both excavated and unexcavated), the borrow site gained +233,300 cy during this same period.

During construction of the 18/19 project, the borrow site gained approximately -587,300 cy within the entire 09/10 *excavated* area. Within the *permitted* limits (both excavated and unexcavated), the borrow site lost -1,063,100 cy during this period.

## **7.0 ONGOING PLANNED OR PROPOSED ACTIVITIES**

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**Development of a Frying Pan Shoals Borrow Site** In early 2017, the Village submitted permit applications with associated in-depth geotechnical studies and environmental analyses necessary to develop a long-term (and large scale) borrow site located within Frying Pan Shoals. The purpose of such a borrow site was to ensure compliance with Permit conditions necessitating the maintenance of the updrift fillet associated with the 2015 terminal groin project and to allow for large-scale beach renourishment of South Beach. Historically, sand placement from an alternate site has been required due to the scheduled hiatus in the disposal of channel maintenance sand on Bald Head Island by the Wilmington District, USACOE. To that end, pursuant to the exiting tenets of the Wilmington Sand Management Plan, all beach quality channel maintenance material excavated in the summer of 2018 was placed at Oak Island.

In June 2017, the National Marine Fisheries Service (NMFS) issued concerns related to permits associated with the near-term use of the Frying Pan Shoals (FPS) borrow site *without first exploring and exhausting other viable sand source alternatives*. Realistically, the only alternate borrow area available for near-term sand placement at Bald Head Island (BHI) was sand remaining in the previously permitted Jay Bird Shoals (JBS) borrow site. Accordingly, in consideration of the NMFS request, the Village agreed to withdraw their application and prioritize the use of the previously authorized borrow site permitted at JBS (including both a partially “recovered” area dredged in 2009/10 and the remaining undredged portion of the borrow site). With the virtual depletion the Jay Bird Shoals borrow site, resulting from the 2018/19 renourishment project, the Village intends to reinitiate the permitting of a long-term borrow site located within Frying Pan Shoals in 2019.

## 8.0 SUMMARY AND CONCLUSIONS

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The most recent Wilmington Harbor Inner Ocean Bar maintenance dredging of Bald Head Shoal Channel Reach 2, and the Smith Island Channel segment was initiated in the summer months of May/June 2018. Approximately 1.15 Mcy of sand excavated during that operation were placed at Oak Island pursuant to the terms of the Wilmington Harbor Sand Management Plan (WHSMP). Subsequent to federal beach disposal on Oak Island, Bald Head Island will be the recipient of the next two *future* beach disposal operations in accordance with the continued implementation of a present day WHSMP. Prior to that time (with the next disposal *estimated* to be spring of 2021) the need to offset annual erosional losses at South Beach on Bald Head Island, as well as to maintain the updrift fillet of the terminal groin constructed in 2015, necessitated that the Village design and permit a 1 Mcy *interim* beach fill project. The latter was constructed between 13 January 2019 and 22 March 2019. The project borrow site was Jay Bird Shoals. Work was performed by Marinex Construction, Inc. The final fill volume was 1.1 Mcy due to the addition of a Post-Florence FEMA Claim for documented storm related losses from the *engineered beach* in September 2018 (Olsen 2018). The final resultant renourishment contract amount was \$11,767,000.

As part of the assessment for the 2019 beach renourishment project to be constructed at South Beach by the Village, it was determined that numerous sand tube groins had reached the end of their effective life and that replacement was warranted. Permits allowed for both an extension of time beyond April 1<sup>st</sup> for *both removal and replacement* of all remaining thirteen (13) sand tube groins (and underlayments). Subsequent to the solicitation of competitive bids, the geotube replacement project was awarded to McPherson Marine Services, LLC. The total Contract amount was \$1,204,179.00. This was exclusive of the cost of tubes. The cost of the custom geotextile tubes, a poly-urea coating and delivery was approximately \$320,000 (*i.e.* 13 tube groins with new underlayments). The work was initiated on/about 13 February and Substantially Completed by 22 March 2019. A *Post-Construction Report*, formulated to document the 2018-2019 project, details all elements of work performed by both contractors (Olsen 2019).

By about 2013, the results of a comprehensive annual beach monitoring program initiated in 2000 by the Village of Bald Head Island yielded the conclusion that sand placement alone could *not* successfully offset navigation channel impacts to the west end of South Beach which have been typically manifest in chronic rates of erosion and a consistent northerly recession of the shorefront. Accordingly, the Village was ultimately forced to “change the existing dynamic” by constructing a single terminal groin designed to complement the placement of beach fill at the persistent South Beach erosional “hot spot”.

The project was permitted to be constructed in two phases – with Phase 2 being optional. Simplistically, the structure was designed to serve as a “template” for fill material placed eastward thereof on South Beach. The Phase 1 1,300 ft. long terminal groin (completed in Nov. 2015), was designed however as a “leaky” structure (*i.e.* semi-permeable) so as to provide for some level of continued sand transport to West Beach and portions of the Point (located both westward and northward of the groin stem). Through May 2019, terminal groin project performance – based upon monitoring – has been both as intended – and as predicted.

Between November 2000 and April 2015, Bald Head Island had received about 7.0 Mcy, mol of sand from the initial widening/deepening and four (4) subsequent maintenance dredging operations for the Wilmington Harbor Navigation Project entrance channel. Including 2019, the Village has placed another 3.2Mcy along the West Beach and South Beach shorelines. Accordingly, in the net Bald Head Island has experienced a total estimated sand placement volume of approximately 10.2 Mcy since 2000 at those two locations – with South Beach receiving some 90% or more of the total.

Conversely, the *gross* volumetric sediment *loss* over the November 2000 to May 2019 (post-fill) monitoring timeframe is conservatively computed at -7.191 Mcy, or approximately -388,700 cy per year – on “average”. This “loss” addresses the continuous section of Bald Head Island shorefront extending from the marina entrance to the Cape Fear spit. The assignment of an *average annual* long-term rate of sand loss at Bald Head Island however, has *not* necessarily been a meaningful indicator of navigation project impact. Such an average rate is often temporally biased by periods of beach fill equilibration, groinfield “effectiveness,” major storm events (such as Hurricane Florence), the occurrence of episodic destabilization dredging events in close proximity to the island, as well as other physiographic phenomena temporally affecting annualized quantities of alongshore sediment transport – from Bald Head Island. In addition, the island’s littoral system continues to adjust to the quasi-stabilizing effect of the terminal groin in existence only since 2015. Along South Beach per se, there has been historically a “nodal point” some 7,000 ft. eastward of the terminal groin (approx. STA 116+00). At or close to the nodal point, the directionality of *net littoral transport* on an annual basis changes from West (toward the groin) to East (toward Cape Fear). *Note* – depending on wave climatology, the condition and exposure of the sand tube groinfield, as well as other factors, the effective location of the nodal point can vary slightly along South Beach from year to year. Currently, within the 22,755 shoreline influenced by sand placed since 2000, some 2.992 Mcy remain in the littoral system (measured above elevation -16 ft. NGVD 29). This includes the 1.1 Mcy beach fill recently constructed in early 2019.

Although not directly impacted by long-term navigation channel improvements and maintenance of the Cape Fear River entrance, the Village Council elected to initiate monitoring of the East Beach shorefront at Bald Head Island in November 2008. Since that time, it is observed that East Beach can undergo strong seasonal variations of beach width and profile volume to a large degree dependent upon storm frequency and intensity, as well as the ever-changing configuration of the Cape Fear spit. The most recent May 2019 survey data show a net shoreline accretion of approximately 149,900 cy (above elevation -16 ft NGVD) throughout the 6,000 ft East Beach shoreline lying northward of Cape Fear over the last 12 months. Between November 2008 and May 2019, the total change has been +439,100 cy. Most of this volume is associated with accretion of the Cape Fear spit facing Onslow Bay.

Unfortunately, recent configurations of the Cape Fear spit deemed beneficial to East Beach have resulted in a high rate of erosion and duneline recession along the easternmost section of South Beach – directly seaward of the Shoals Club facility. For example, between 2000 and 2019, the average MHWL erosion rate at this general location has been about -14 ft/yr.

In 2019, the Village was required by Permit to perform the 9<sup>th</sup> year of monitoring for the Jay Bird Shoals borrow site utilized to construct the non-federal 1.85 Mcy beach fill sponsored by the Village in 09/10. The computed change within the monitored survey area (excavated and unexcavated) was a *net* gain of approximately 93,000 cy over the 108 month monitoring period following initial project construction. As noted previously however, the Village built a 1.1 Mcy fill project in 2018/19 utilizing the Jay Bird Shoal borrow site immediately prior to the March survey.

After the extension of the two marina entrance channel jetties in 2015, reduced shoaling within the navigation channel resulted in a corresponding reduced volume of disposal sand being placed along the Row Boat Row shoreline. Although the Village had planned to continue to proactively bypass sand from the south jetty fillet (at the distal end of West Beach) to the Row Boat Row shorefront, it became clear that the existing four (4) low level timber groins would not be capable of providing an acceptable level of shoreline stabilization at that location – i.e. with a significant reduction in episodic sand placement.

Hence, near the end of the 2017 monitoring period, the Village initiated construction of two (2) shore parallel detached rock breakwaters located north of the marina entrance seaward of the Row Boat Row shoreline. The placement of breakwaters between existing groins northward of the marina entrance was intended to combine the attributes of each of the two types of stabilization structure so as to reduce the rate of sediment transport from the

eroding shoreline caused principally by ferry/barge generated waves. The subject expanded shore stabilization project (detached breakwaters *and* existing groinfield) was designed to have a sand fill prior to construction. The source of the fill was the exiting Bald Head Creek borrow area. A previously permitted Bald Head Creek borrow area was dredged in early 2017 by Marcol Dredging. Some 26,000 cy were placed at Row Boat Row prior to breakwater implementation. Since that time several channel maintenance/sand bypass operations have occurred.

A small-scale borrow site was developed with Bald Head Creek in 2012. Since that time, the borrow site has been excavated for purposes of constructing small-scale fill projects at Row Boat Row or West Beach on three separate occasions. Historically, much of the borrow site's physical "recovery" has been due to marina channel and sand bypass operations. In the seven years since the initial dredging project (2012-2019) the area within the limits of the permitted borrow site has experienced a net gain of +75,300 cy.

In the spring of 2017, the Village submitted permit applications accompanied by indepth geotechnical studies and environmental analyses necessary to develop a long term (and large scale) borrow site located within Frying Pan Shoals. The purpose of such a borrow site was to both ensure compliance with Permit conditions necessitating the maintenance of the updrift fillet associated with the 2015 terminal groin project and to provide a long-term source of beach quality material sufficient to meet future South Beach renourishment requirements. It was originally anticipated that the borrow site would be needed for limited sand placement along South Beach in 2018/19. That conclusion resulted from the scheduled hiatus in the disposal of channel maintenance sand on Bald Head Island by the Wilmington District, USACOE. Pursuant to the existing tenets of the Wilmington Harbor Sand Management Plan, all beach quality channel maintenance material excavated in the summer of 2018 was placed at Oak Island.

In June 2017 however, the National Marine Fisheries Service (NMFS) issued concerns related to the near term use of a Frying Pan Shoals (FPS) borrow site *without first exploring and exhausting other viable sand-source alternatives*. Realistically, the only alternate borrow area available for near term sand placement at Bald Head Island (BHI) was sand remaining in the previously permitted JBS borrow site. Accordingly, in consideration of the NMFS request the Village agreed to withdraw their Application and to prioritize the use of the previously authorized borrow site permitted at Jay Bird Shoals (JBS) (including both the partially recovered area dredged in 2009/10 and a remaining undredged portion of the borrow site. For purposes of doing so, the Village was instructed to seek modifications to the existing terminal groin permits which had included proposals for renourishment of the shoreline bordering the terminal groin via the use of alternate sand sources – one of which

included Jay Bird Shoals. With the documented depletion of the Jay Bird Shoals borrow site resulting from the 2018/19 renourishment project, the Village intends to reinitiate the permitting of a long term borrow site located within Frying Pan Shoals in 2019.

An important secondary precept of the spring of 2019 beach fill project constructed by the Village was to allow for the replacement of a sand tube groinfield which had become damaged over time. During renourishment, the groin field in its entirety was covered by beach fill. This allowed a second contractor to excavate and replace all 13 sand tube groins “in the dry”.

The original Permits for construction of the terminal groin at Bald Head Island stipulated that if the permittee elected to dredge more than 250,000 cy from the Jay Bird Shoals borrow site after 2015, limited additional monitoring of the eastern end of Oak Island must be performed. At the scheduled time of the last routine island wide survey at Bald Head Island (*i.e.* November 2018), the Village initiated the requisite monitoring at Oak Island (Caswell Beach). The first report of findings for Oak Island will follow a scheduled November 2019 monitoring survey. That will allow for a full year of change representing both pre-and post-dredging conditions within the Jay Bird Shoals borrow site. Those findings will be addressed by a stand-alone report.

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