34th Annual National Conference on Beach Preservation Technology

Implementing a Resilient Structure to Protect Coastal and Historic Resources at Brunswick Town/Fort Anderson

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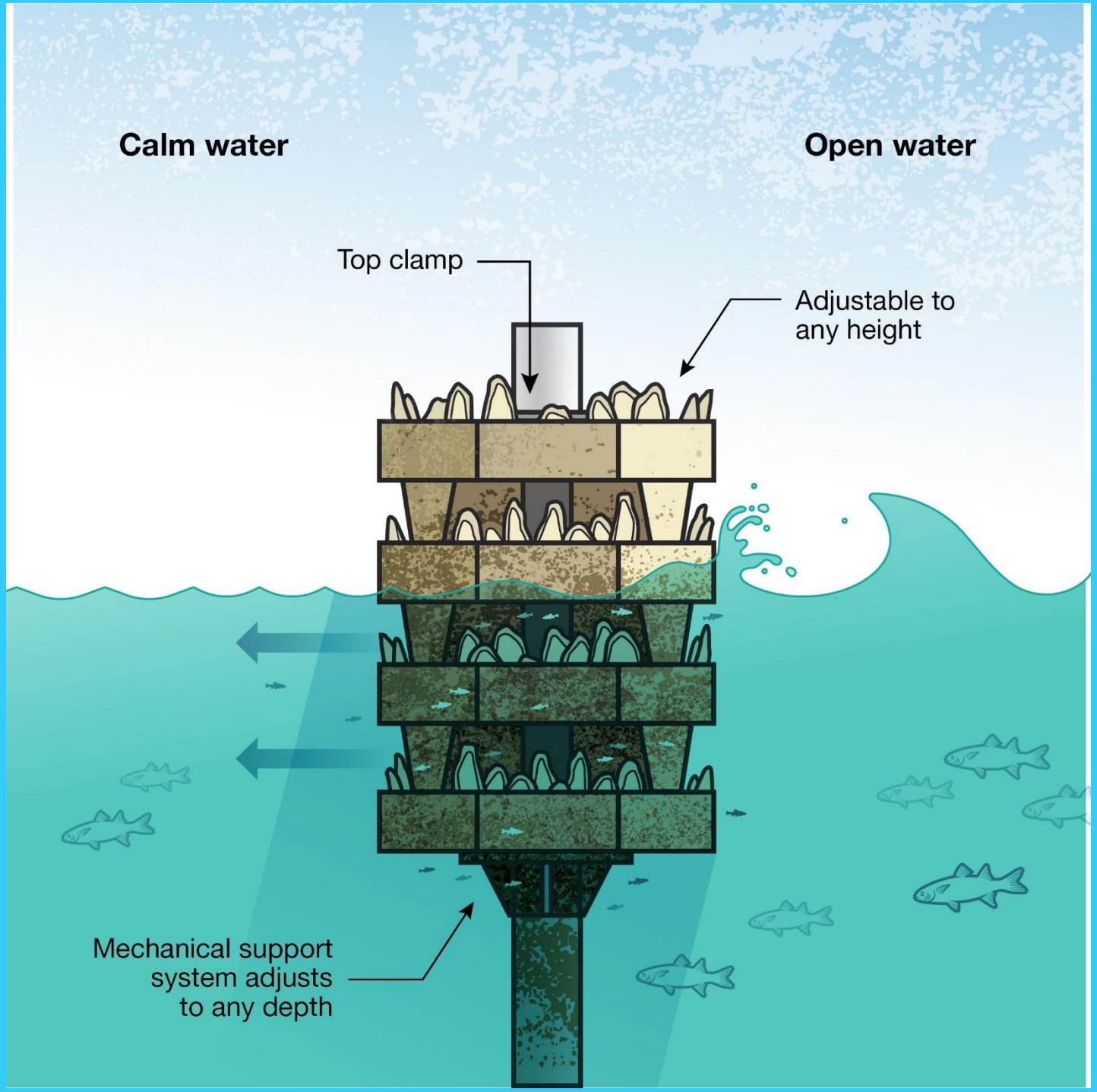
Phillip Todd
04 February 2021

Presentation Overview

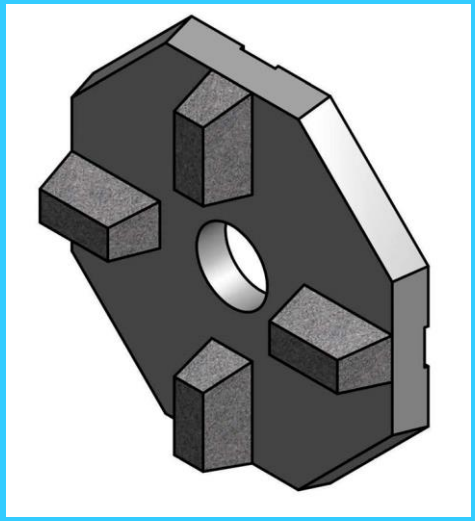
- Reefmaker Technology
- Site History
- Comparison
- Installation
- Monitoring
- Wave Study


Calm water
Open water
Top clamp
Adjustable to any height
Mechanical support system adjusts to any depth

Eco-disks

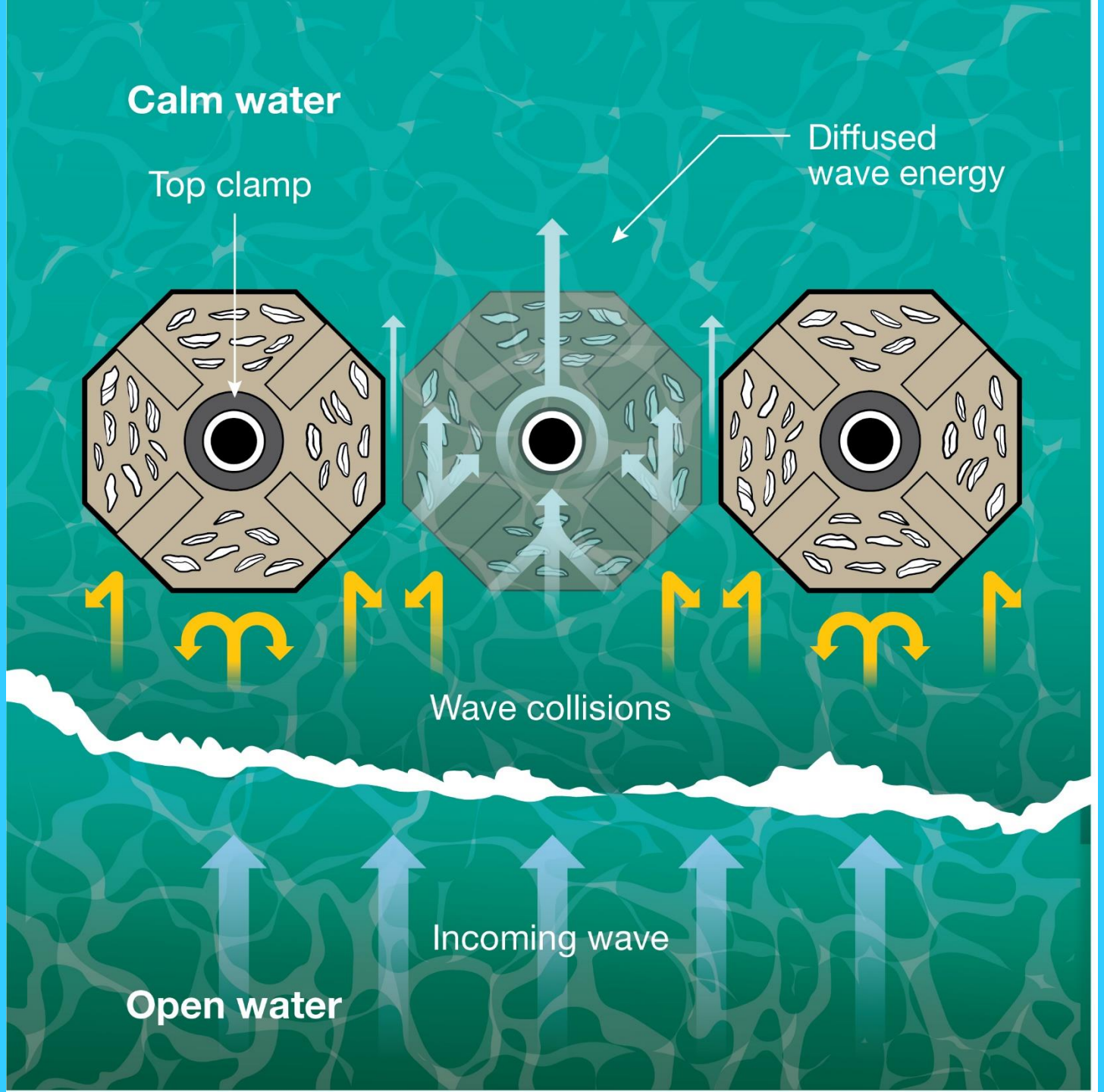
Currently, Eco-disks implemented for

- Low Energy Wave Environment
  - 20% porosity
  - Octagonal Shaped
- High Energy Wave Environment
  - 20% porosity
  - Square & Octagonal Shaped

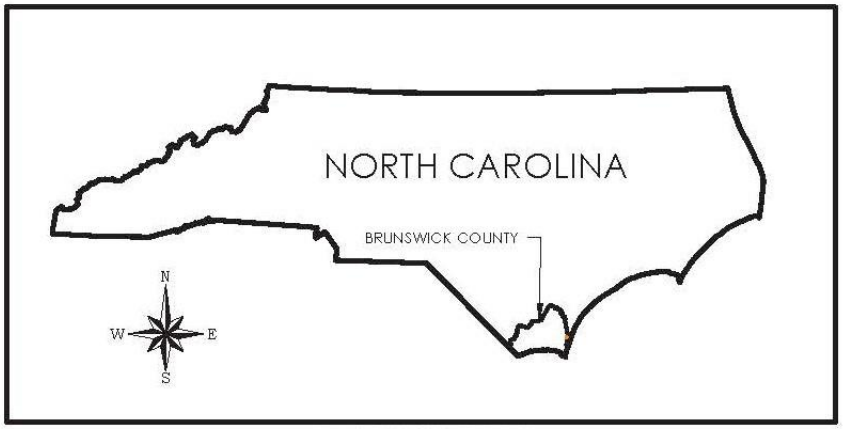


Future Eco-disk structures

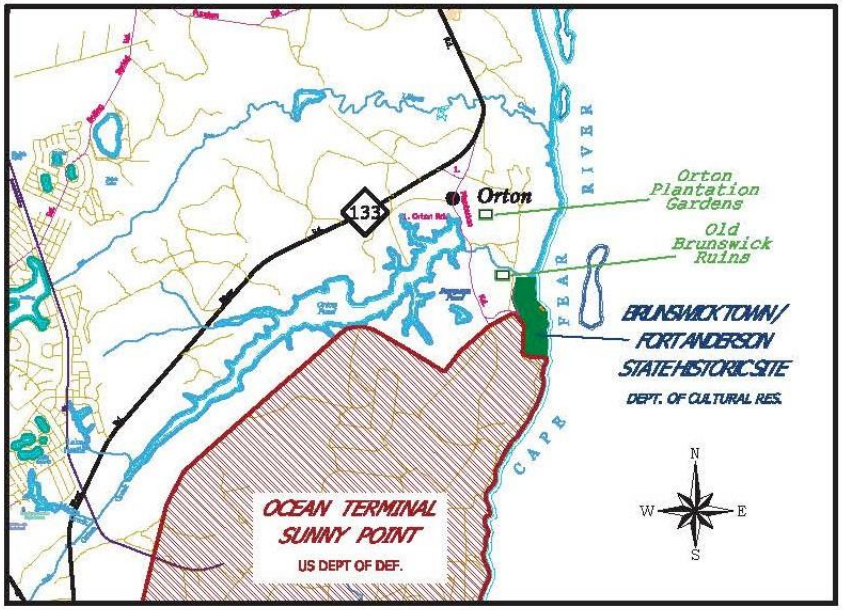
- 0% porosity
- Moderate energy wave environment


Calm water
Top clamp
Diffused
wave energy
Wave collisions
Incoming wave
Open water

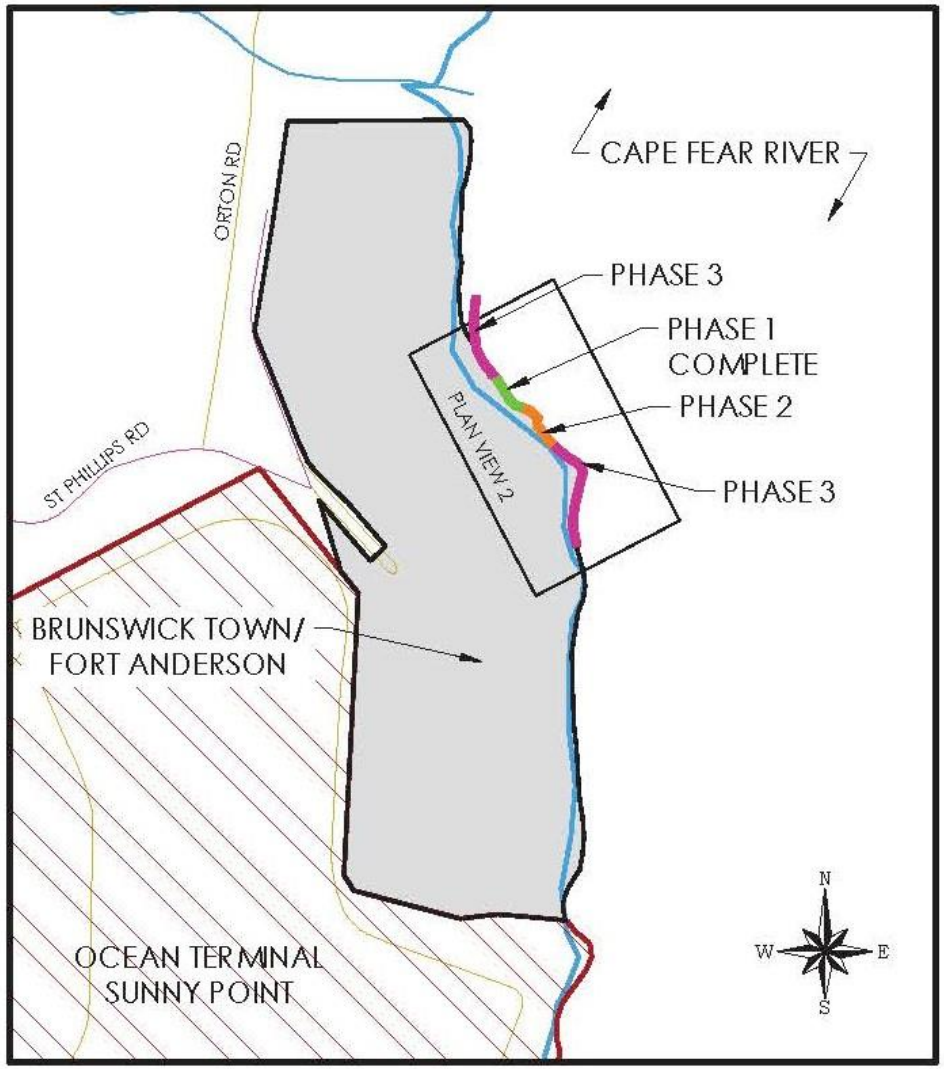
BT-FA - Location



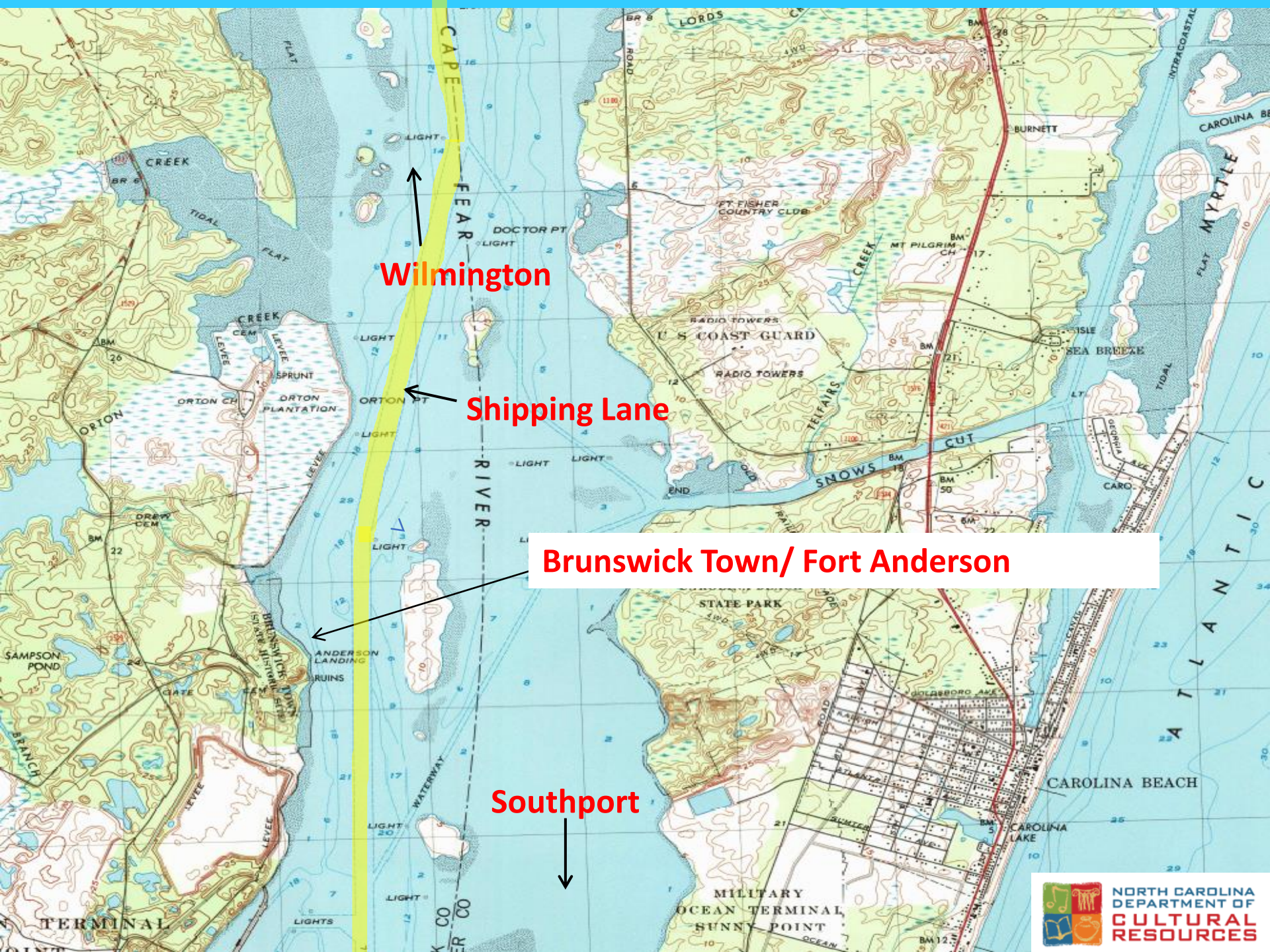
STATE/COUNTY MAP



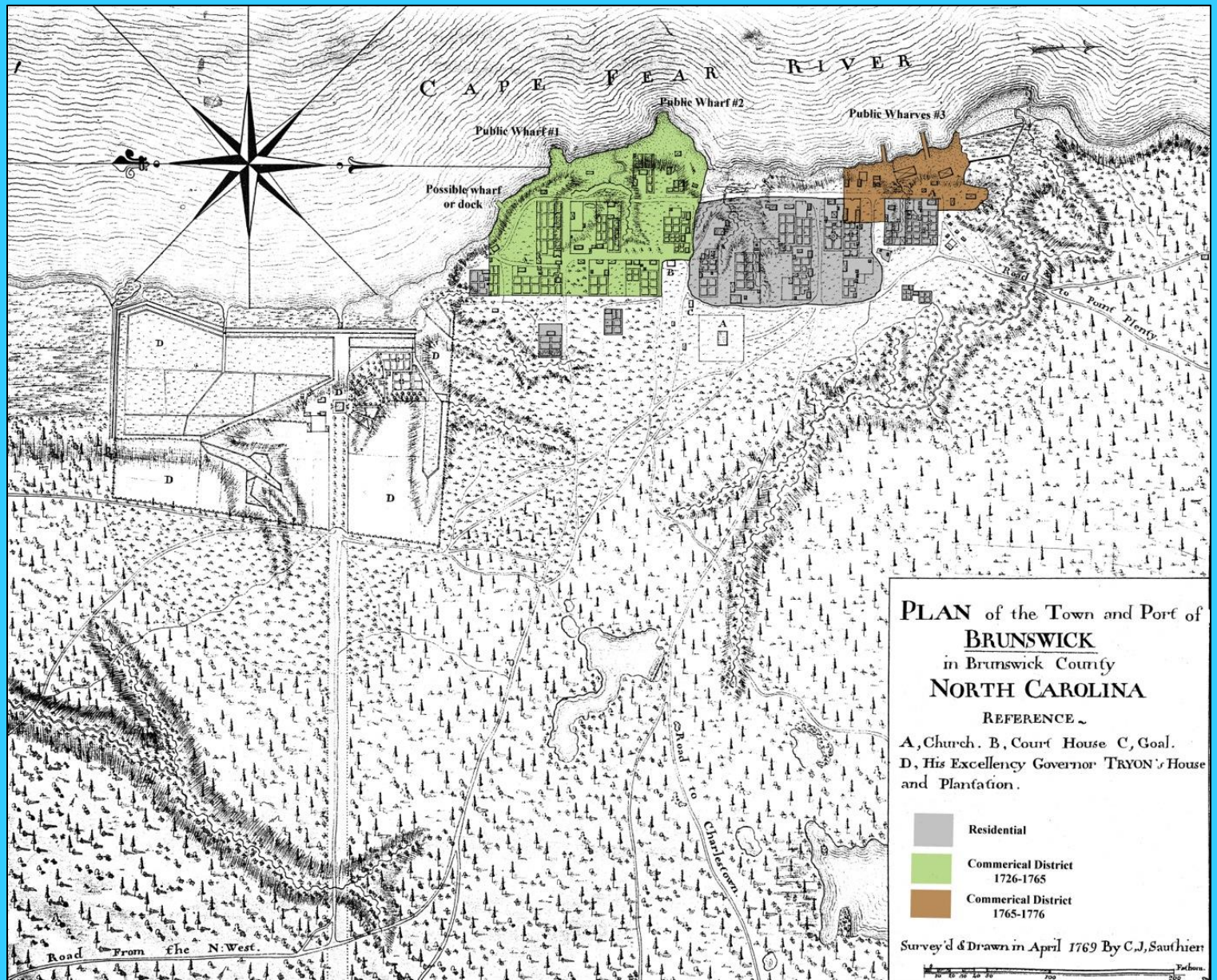
VICINITY MAP



GENERAL SITE MAP

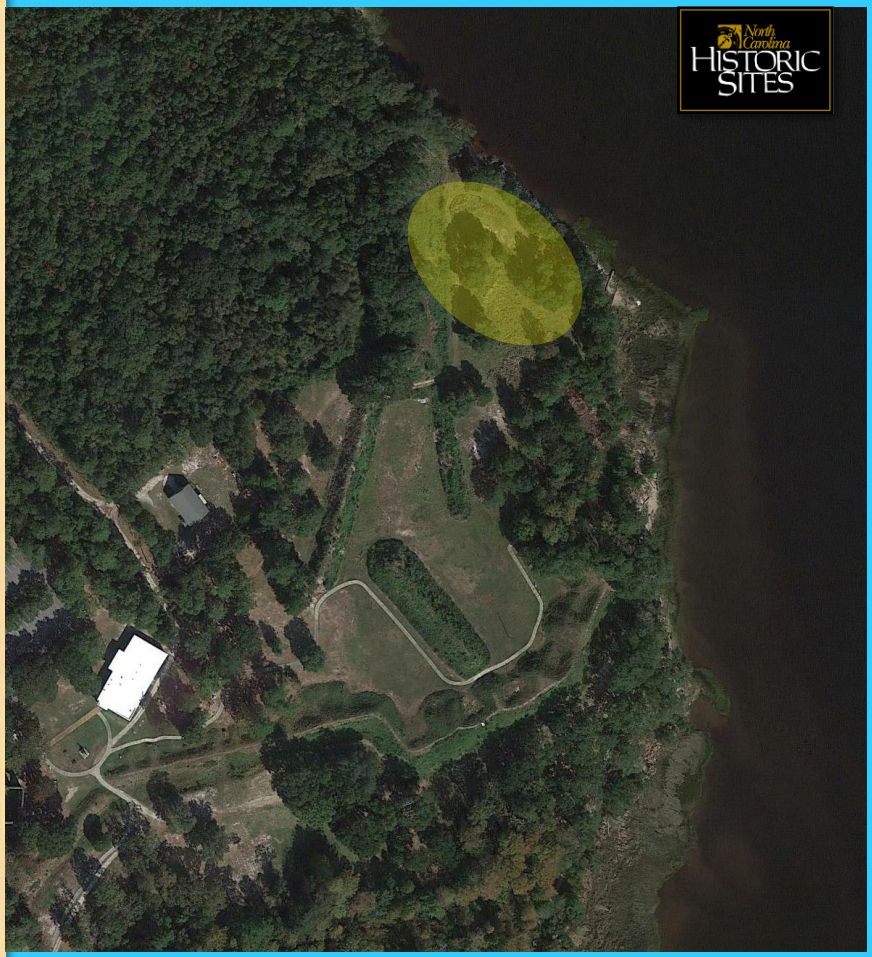

Wilmington
Shipping Lane
Brunswick Town/ Fort Anderson
Southport
CAPE FEAR RIVER
ATLANTIC
CAROLINA BEACH
SUNNY POINT
MILITARY OCEAN TERMINAL
U S COAST GUARD
RADIO TOWERS
FT FISHER COUNTRY CLUB
SNOWS CUT
ANDERSON LANDING RUINS
ORTON PLANTATION
DOCTOR PT
ORTON PT
SEA BREEZE
BURNETT
MT PILGRIM CH
SAMPSON POND
STATE PARK
CAROLINA LAKE
NORTH CAROLINA DEPARTMENT OF CULTURAL RESOURCES

Brunswick Town - History



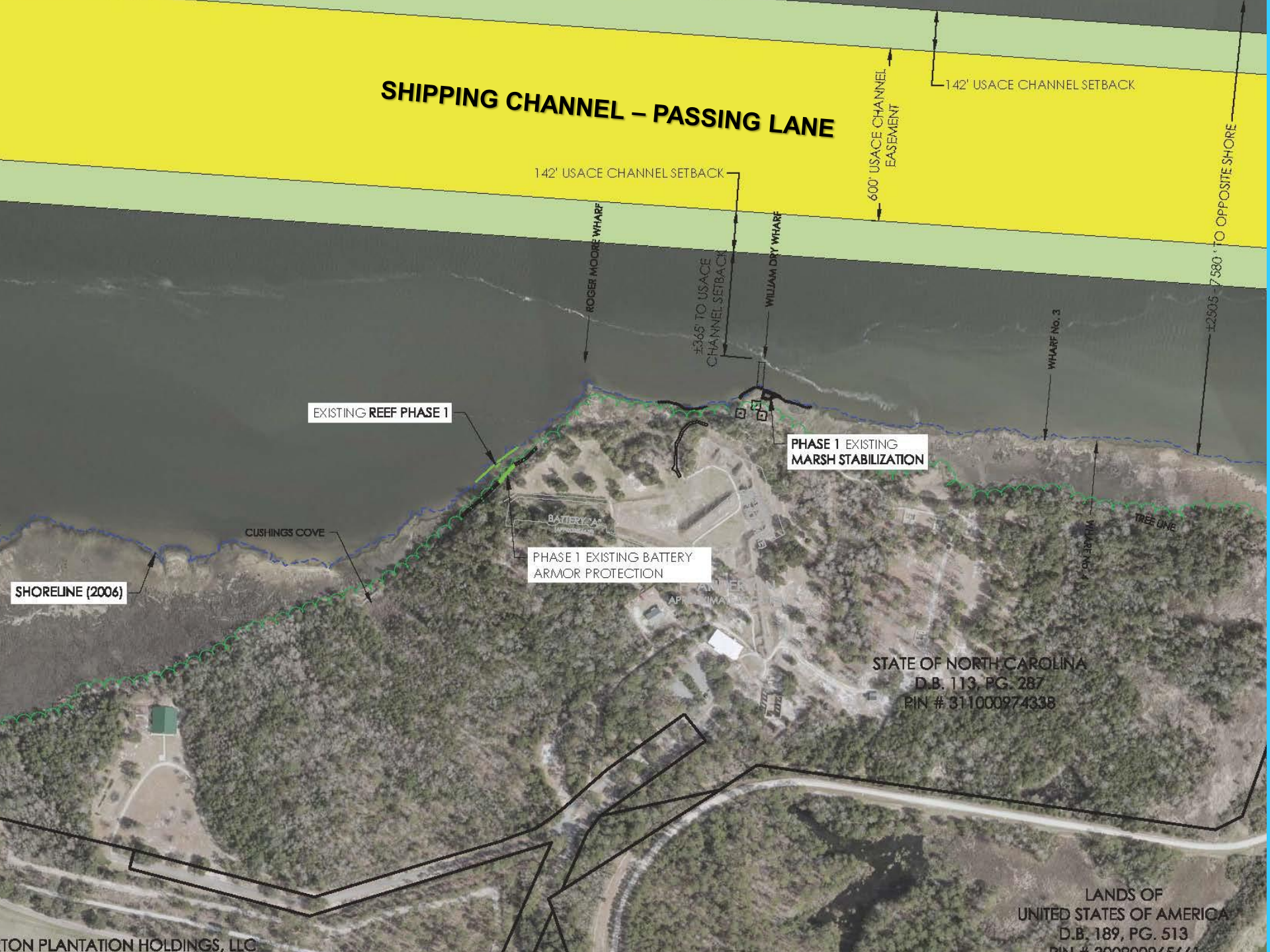
Brunswick Town - History

Fort Anderson - History



Brunswick Town/ Fort Anderson

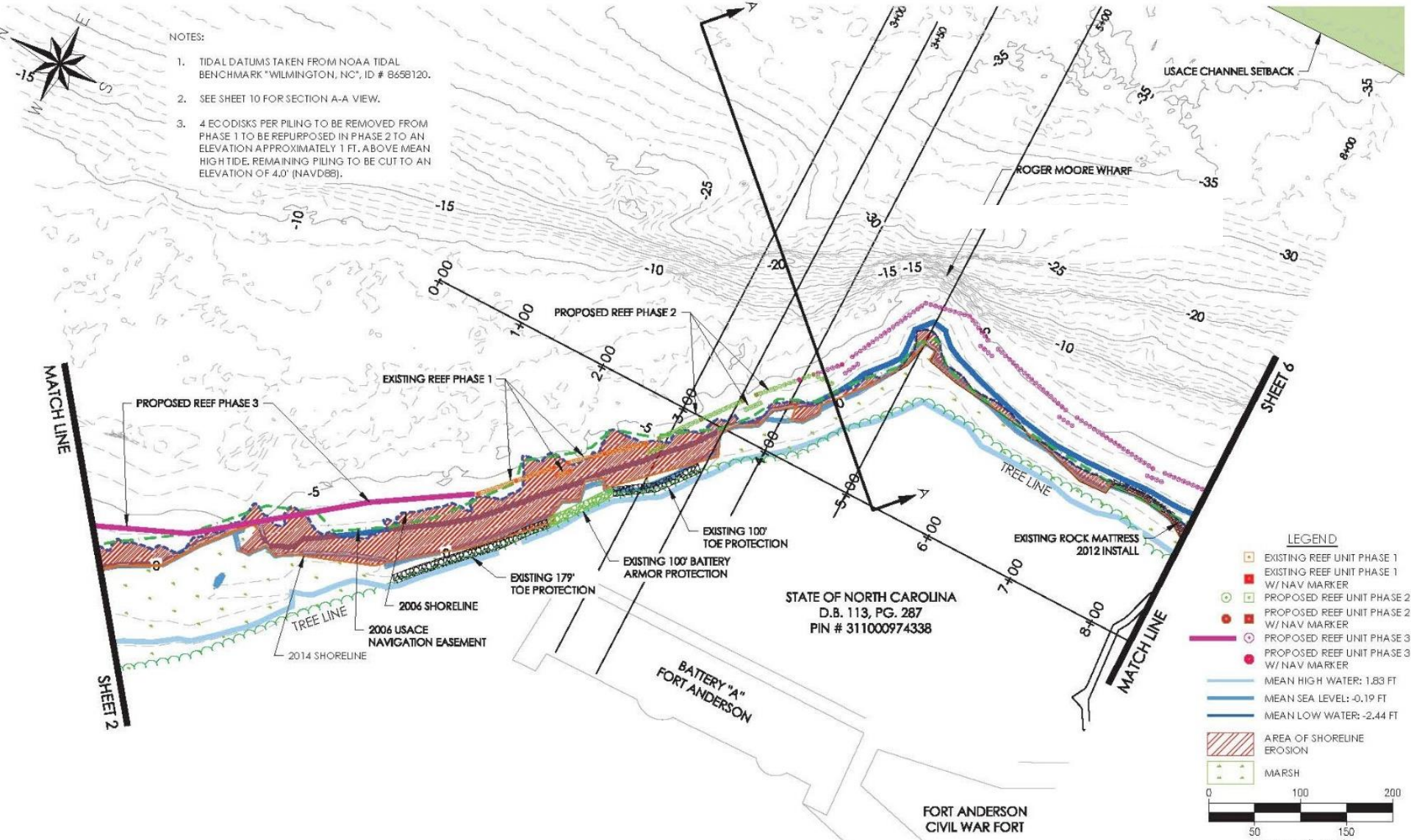
Shipping channel dredged in 2006


SHIPPING CHANNEL – PASSING LANE
142' USACE CHANNEL SETBACK
600' USACE CHANNEL EASEMENT
142' USACE CHANNEL SETBACK
±2505 - 7,580' TO OPPOSITE SHORE
ROGER MOORE WHARF
±365' TO USACE CHANNEL SETBACK
WILLIAM DRY WHARF
WHARF No. 3
EXISTING REEF PHASE 1
PHASE 1 EXISTING MARSH STABILIZATION
BATTERY
TREE LINE
CUSHINGS COVE
PHASE 1 EXISTING BATTERY ARMOR PROTECTION
SHORELINE (2006)
STATE OF NORTH CAROLINA
D.B. 113, PG. 287
PIN # 311000974338
LANDS OF
UNITED STATES OF AMERICA
D.B. 189, PG. 513
TON PLANTATION HOLDINGS, LLC

PORT OF WILMINGTON

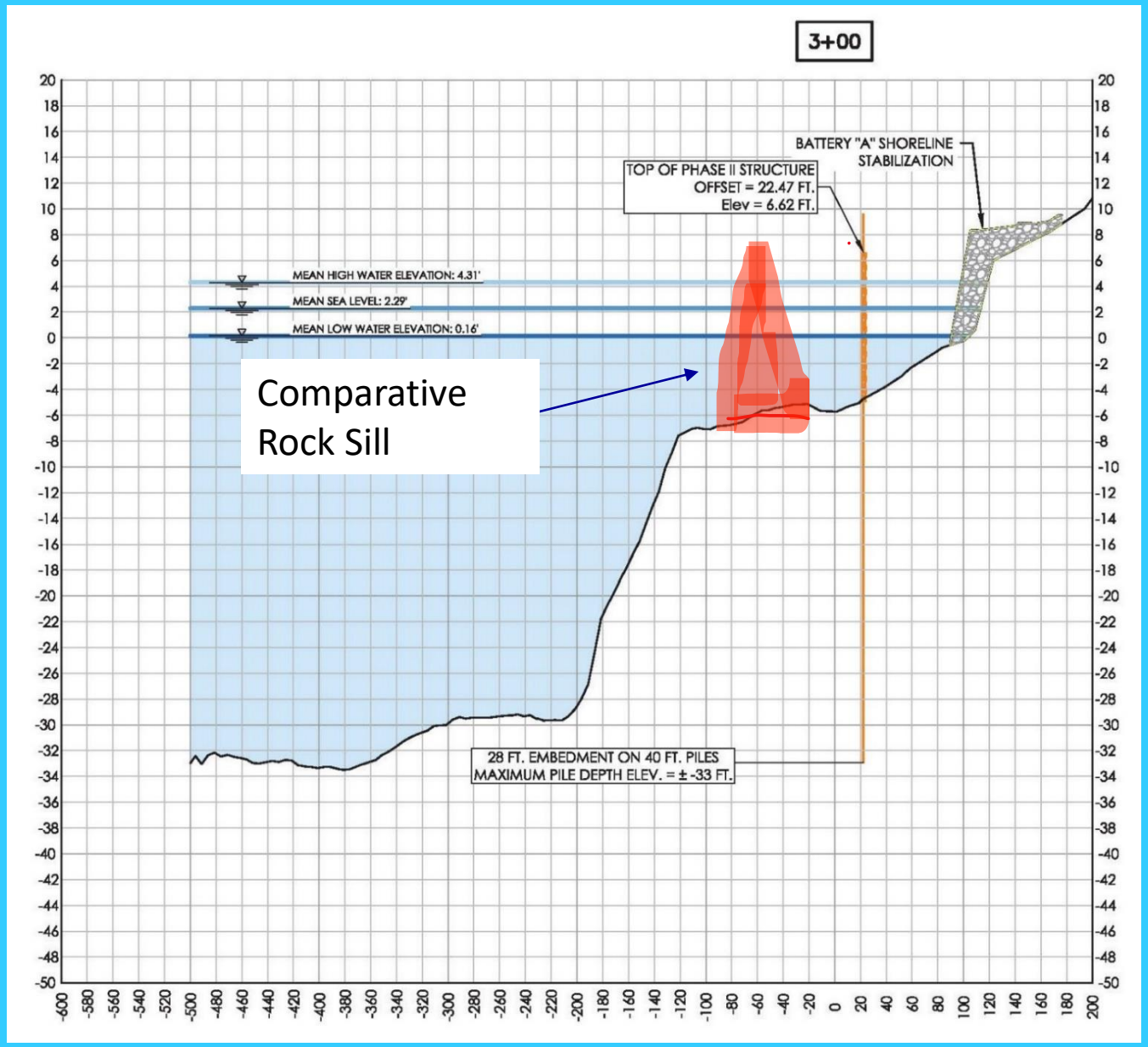
FORT ANDERSON

Jim McKee, Site Manager of Brunswick Town/Fort Anderson State Historic Site, "From 2008 – 2013, the site has lost 75-120' of shoreline"

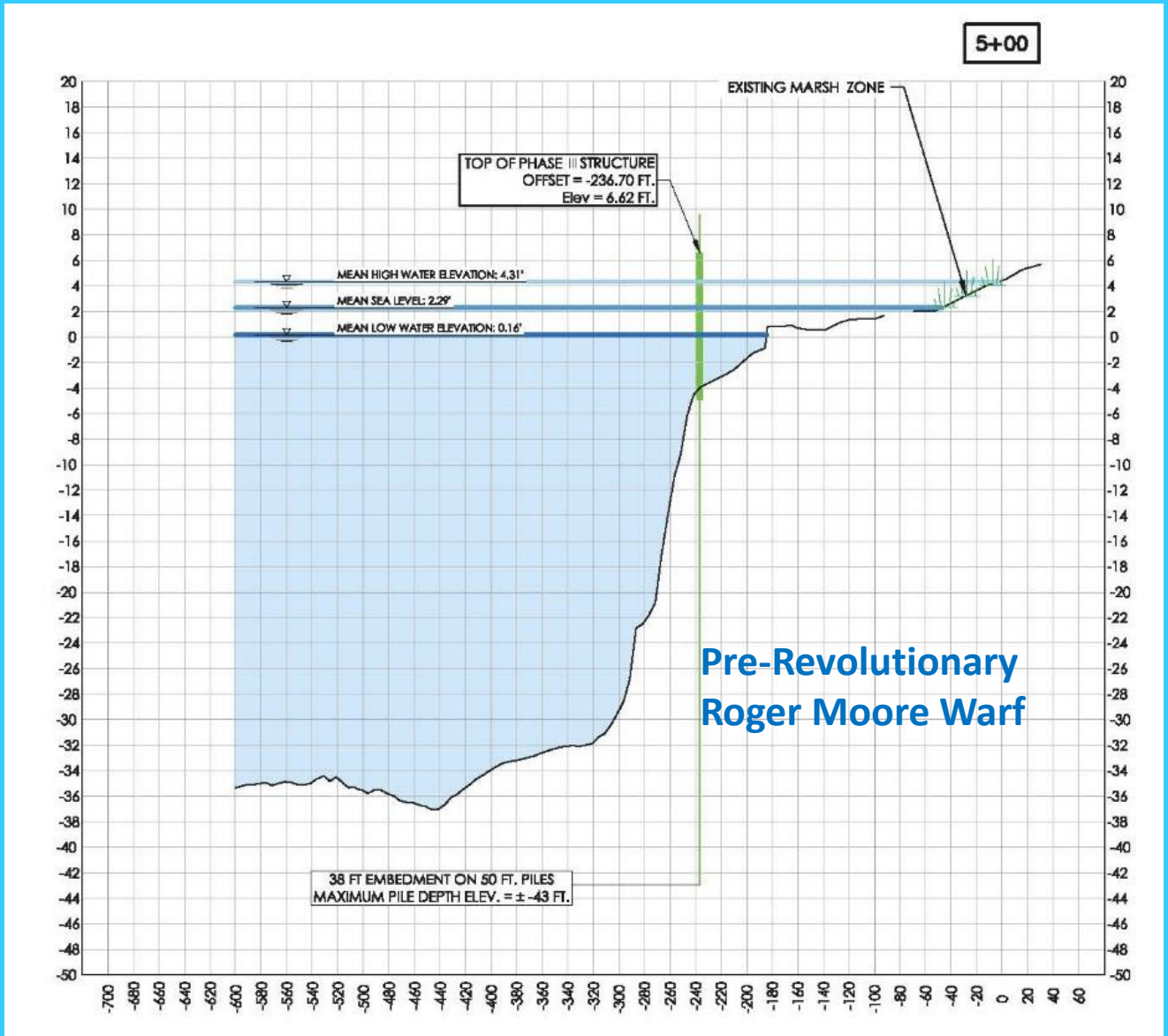


Living Shoreline/ Rock Sill vs RM

RM vs Rock Sill – Phase 1



RM vs Rock Sill – Phase 3



Why RM instead of a Rock Sill?

- Works in horizontally limited areas
- Dissipates destructive wave energy
- Works in high energy environments
- Provides habitat for marine fauna, sessile and non-sessile organisms
- Sets base unit above the substrate
  - Minimizing scour
  - Minimizing sand/sediment re-distribution
- Minimizes 'foot print' impact to substrate
  - 12" diameter per fiberglass pile (0.785 ft^2 per piling)
  - Reefmaker – 500 ft long structure = 78.5 ft^2
  - Rock Sill – 500 ft long with 2:1 slopes = 10,000 ft^2
- Permits flushing along the entire shoreline
- Allows for modular construction
- Enables easy adjustments to accommodate for sea level rise (SLR)

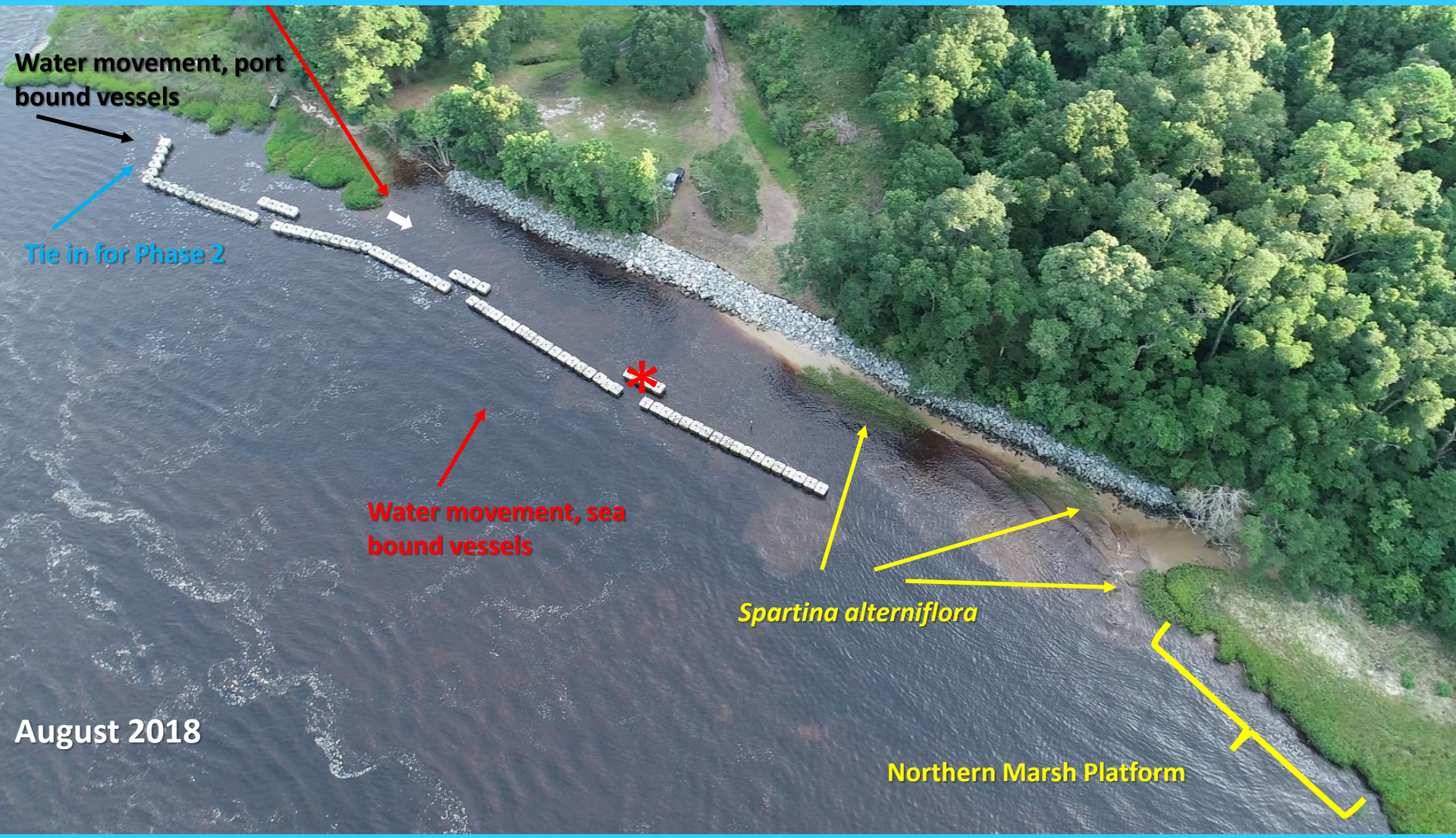
Reefmaker Installation

After Phase 1, …

- Assessed Initial Project
  - Height
  - Structure Shape
  - Wave Direction
- Monitoring – (9/2017 to 6/2018)
  - Accretion
  - Wave Energy
- Monitoring – (6/2018 to 5/2019)
  - Accretion
  - Wave Energy
  - Cameras
  - Vegetation

Reefmaker Installation

Reefmaker Monitoring



RM in Action – Drone View

Phase 1 (220’) – completed August 2017

Video Date – December 2017

Click hyperlink to see video

https://drive.google.com/file/d/1HNPDp8ZwGIKjyHtmr_1j6V2-bboaf-1X/view

Note:

- Wave energy contrast at structure and up/down river
- Wave energy reflected back into the river
- Sedimentation at the structure and upriver at end of video

RM in Action – Land View

Phase 1 (220') – completed August 2017

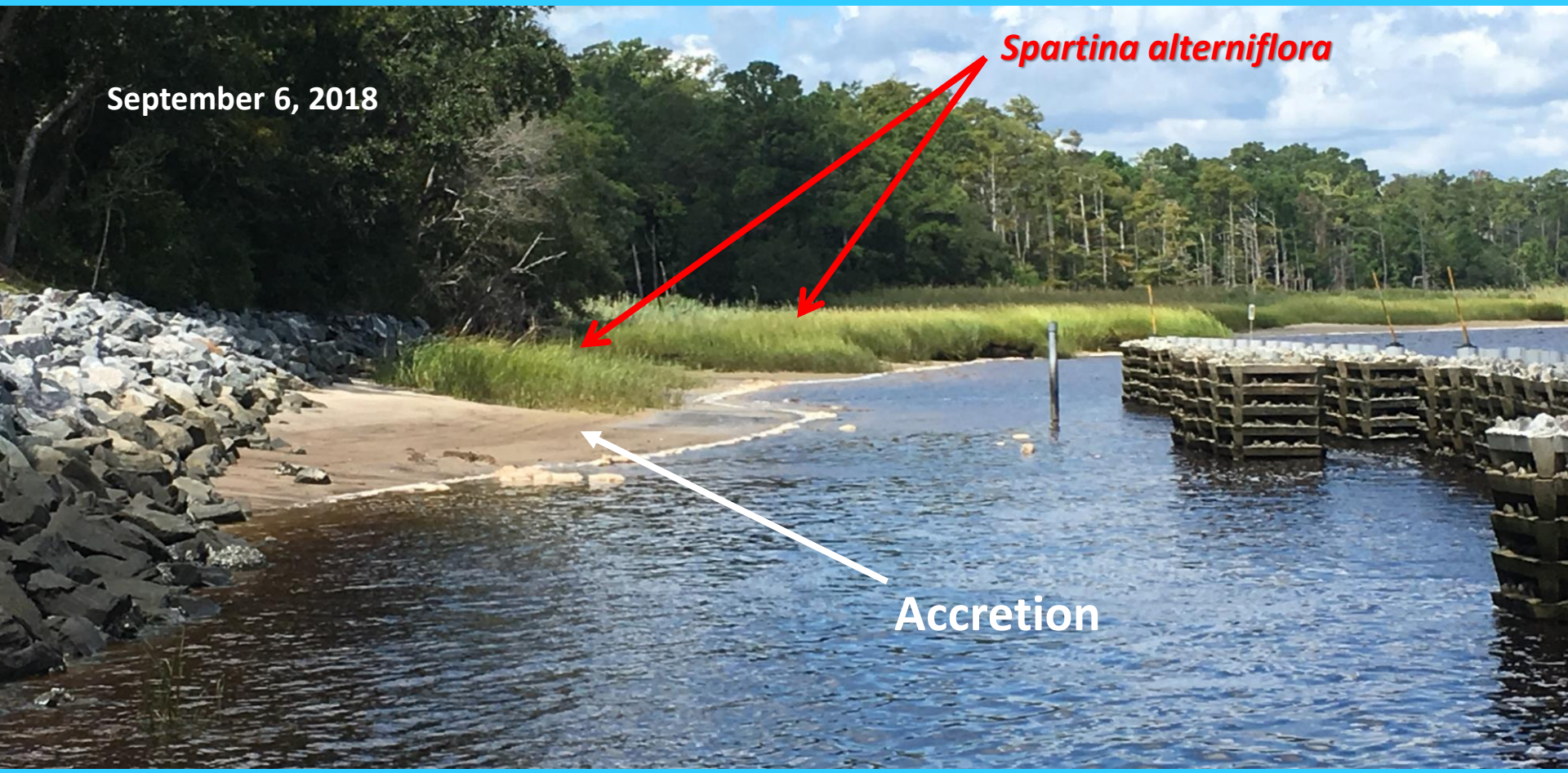
Video Date – April 2018

Click hyperlink to see video

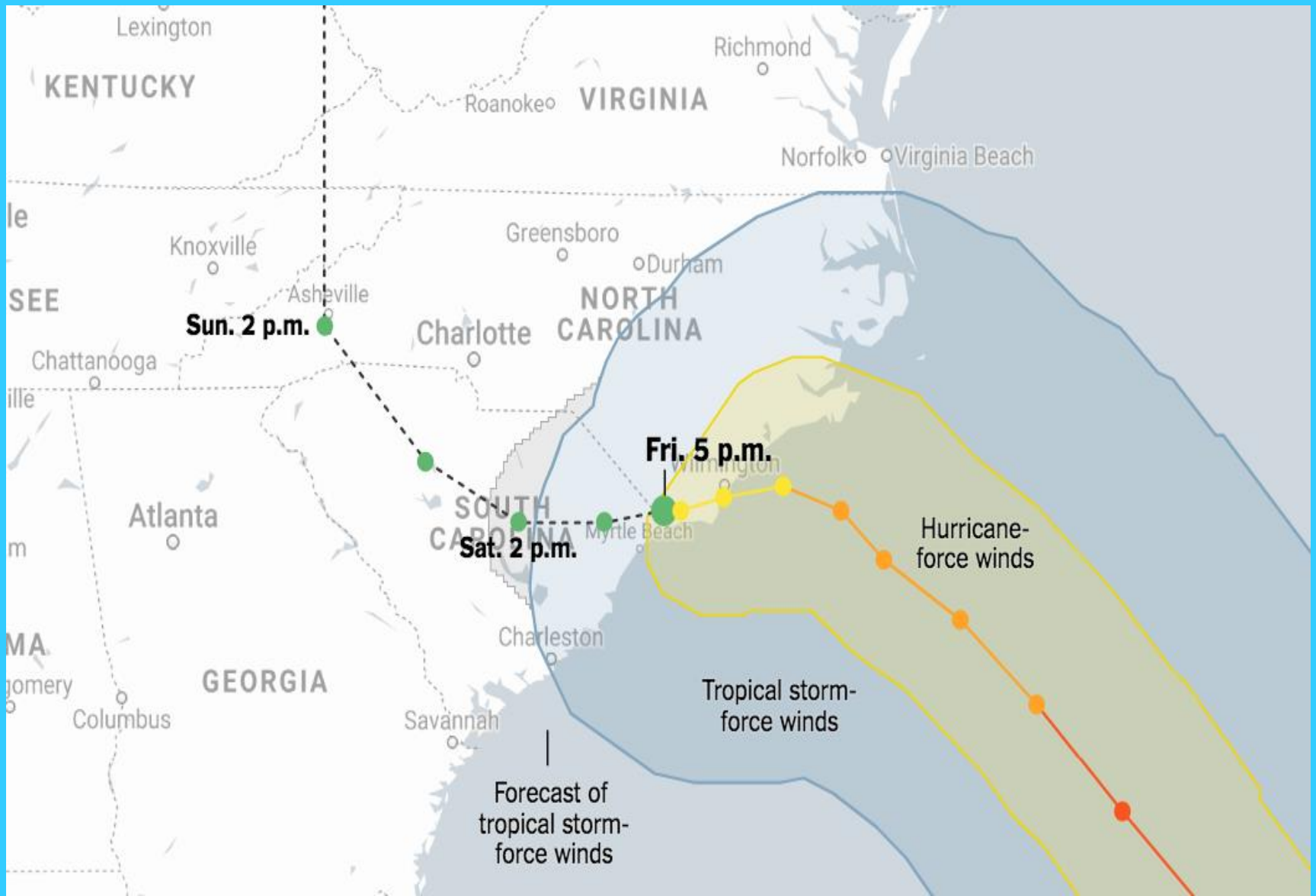
https://www.youtube.com/watch?v=CLGbZgIzQSk&feature=youtu.be

Reefmaker Monitoring

Reefmaker Monitoring



Hurricane Florence



Hurricane Florence comes ashore … September 13-16, 2018

Video is from Southport, NC – approximately 10 miles down river from

Brunswick Town/ Fort Anderson (BTFA) site

Structure at BTFA sustains several high storm surges

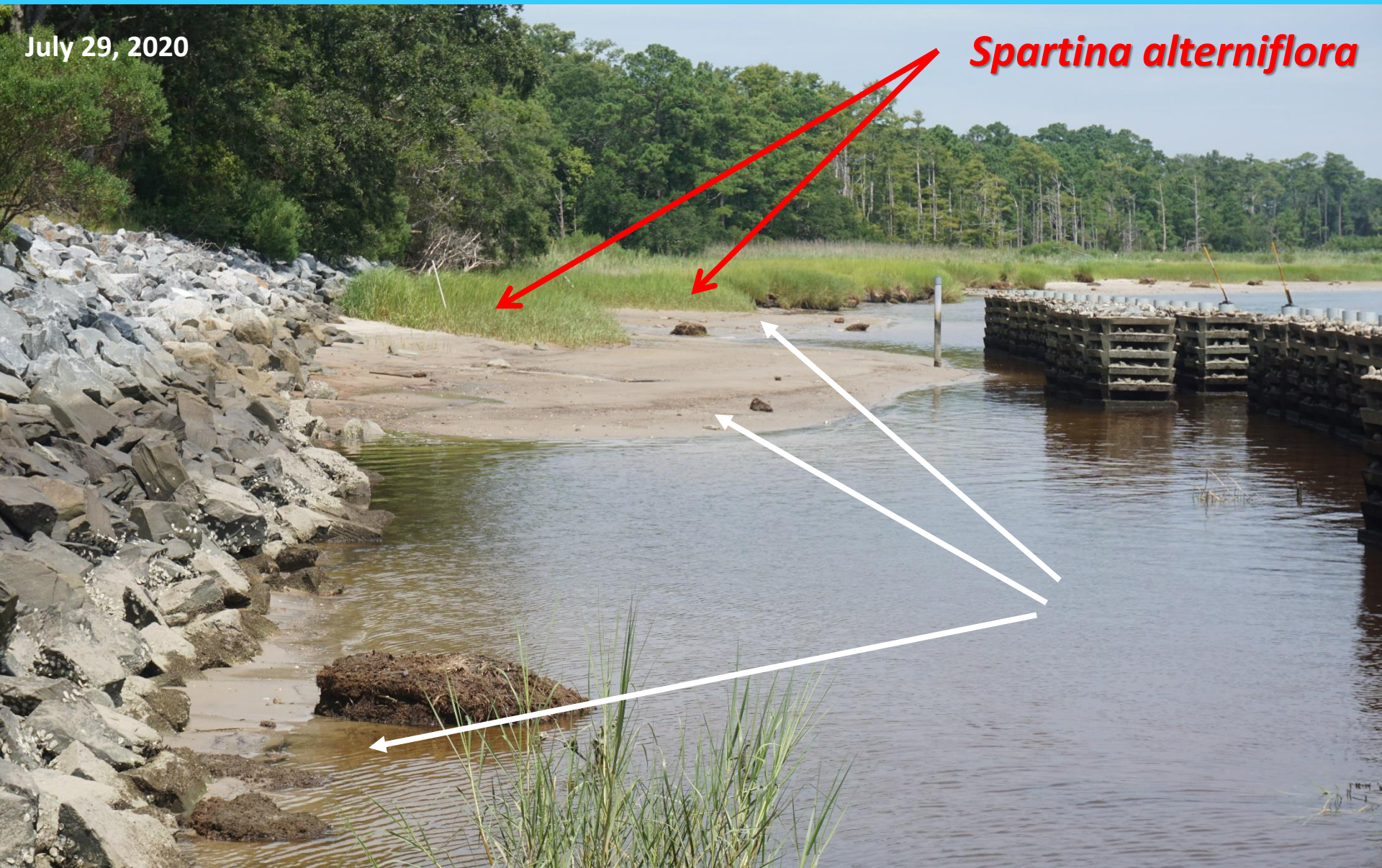
Click hyperlink to see video

https://www.youtube.com/watch?v=pcTmexEoMOQ

Reefmaker Monitoring

Reefmaker Monitoring

Reefmaker Monitoring



Reefmaker Monitoring

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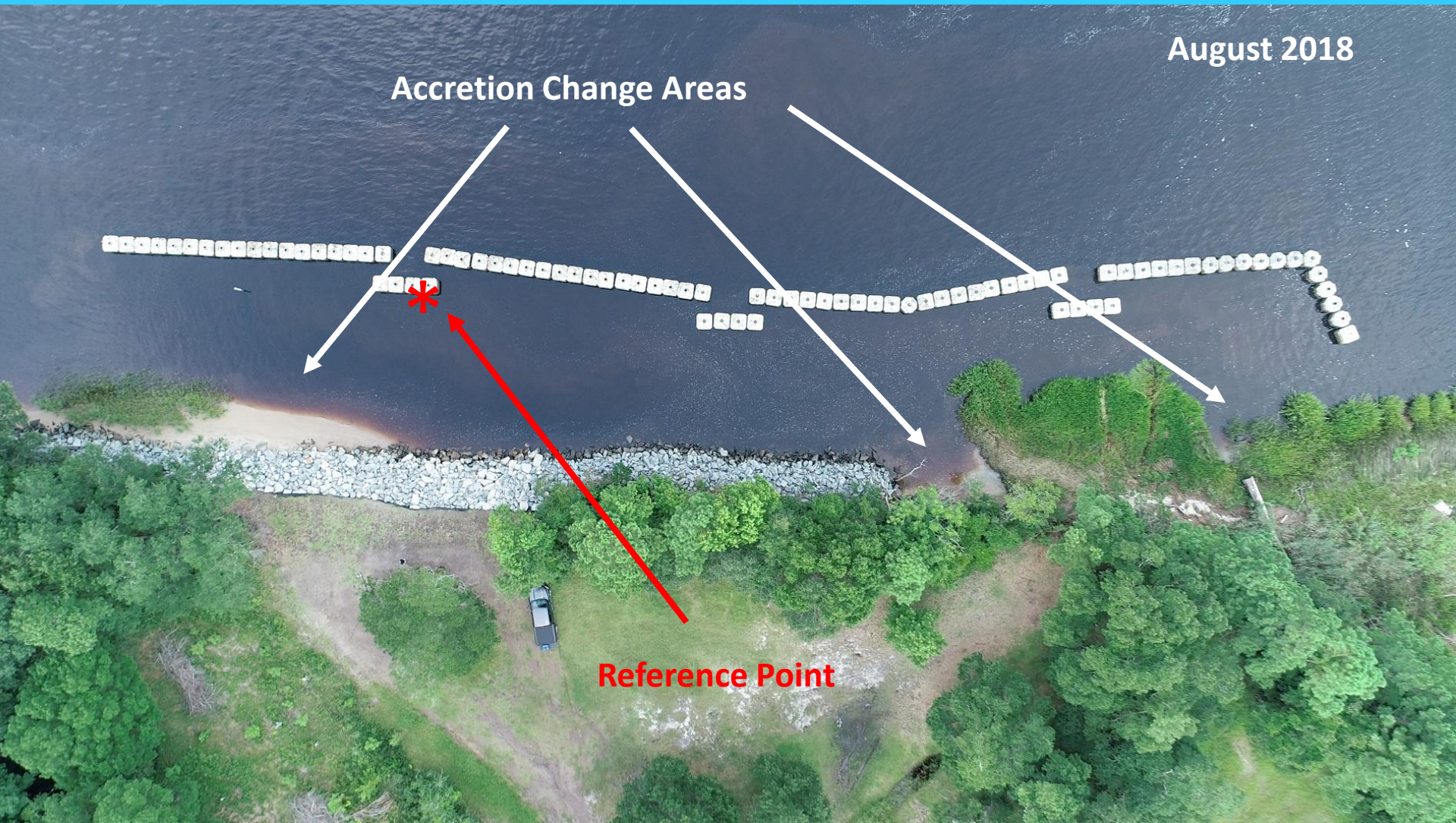

Reefmaker Monitoring

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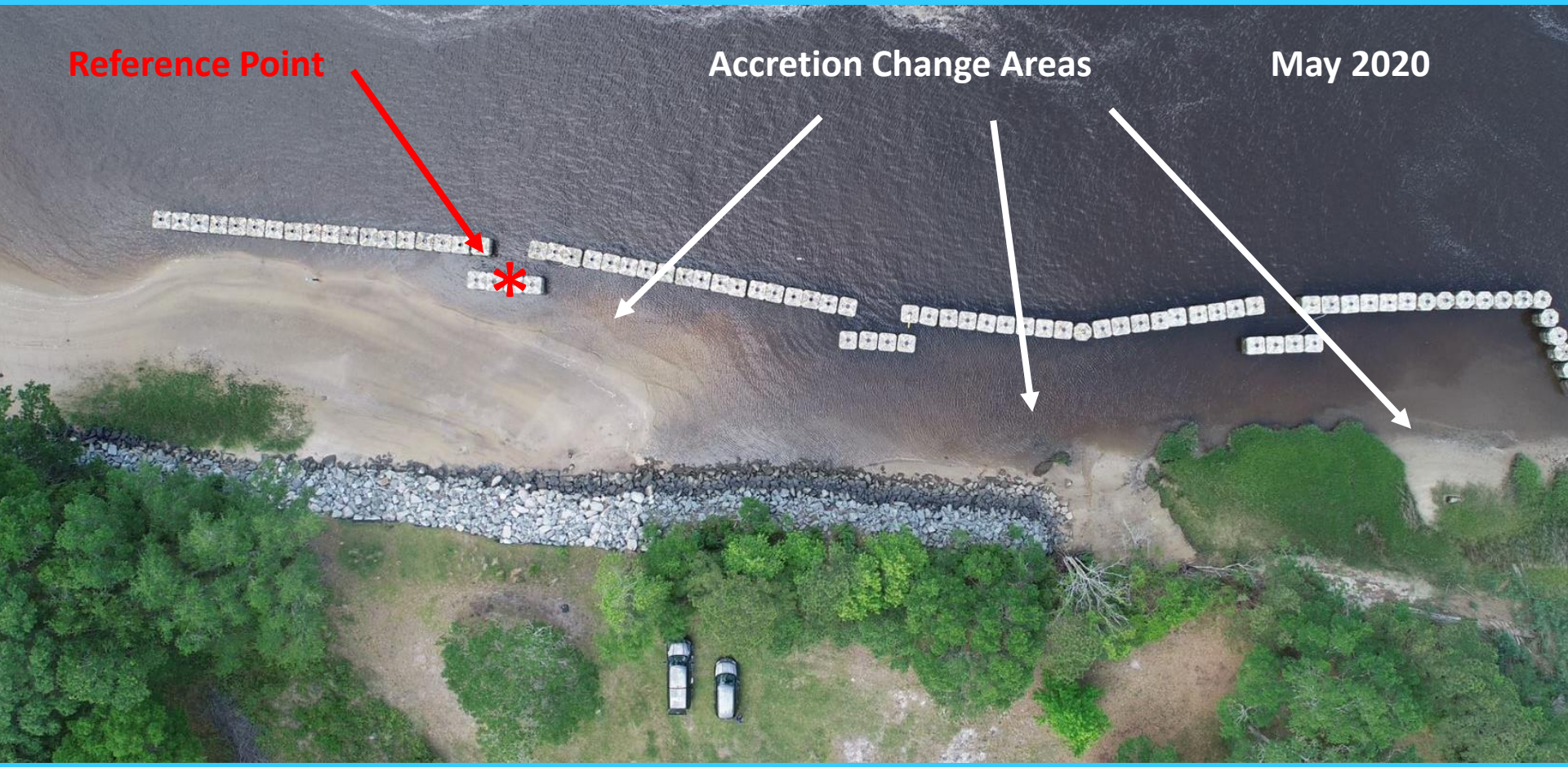

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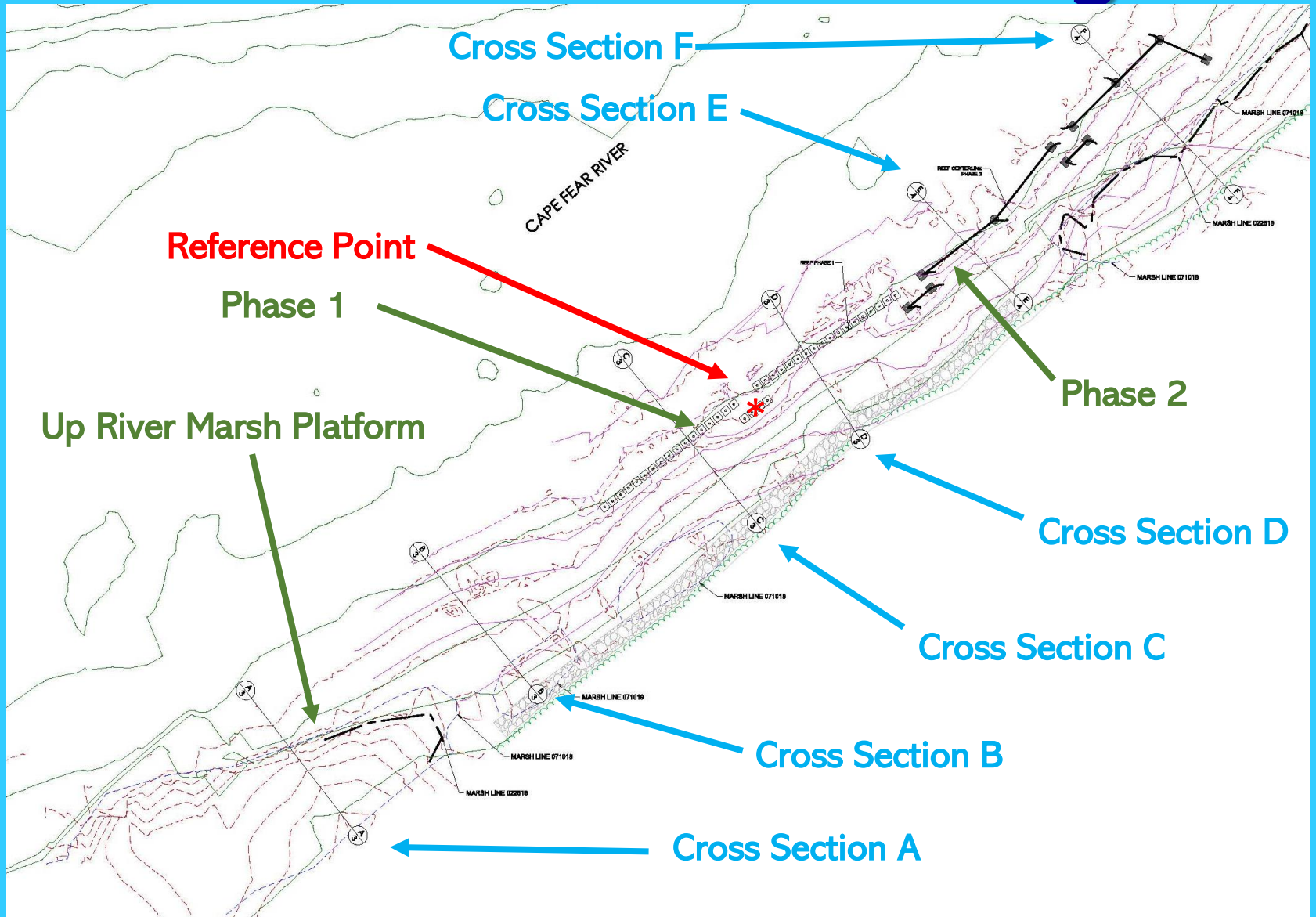

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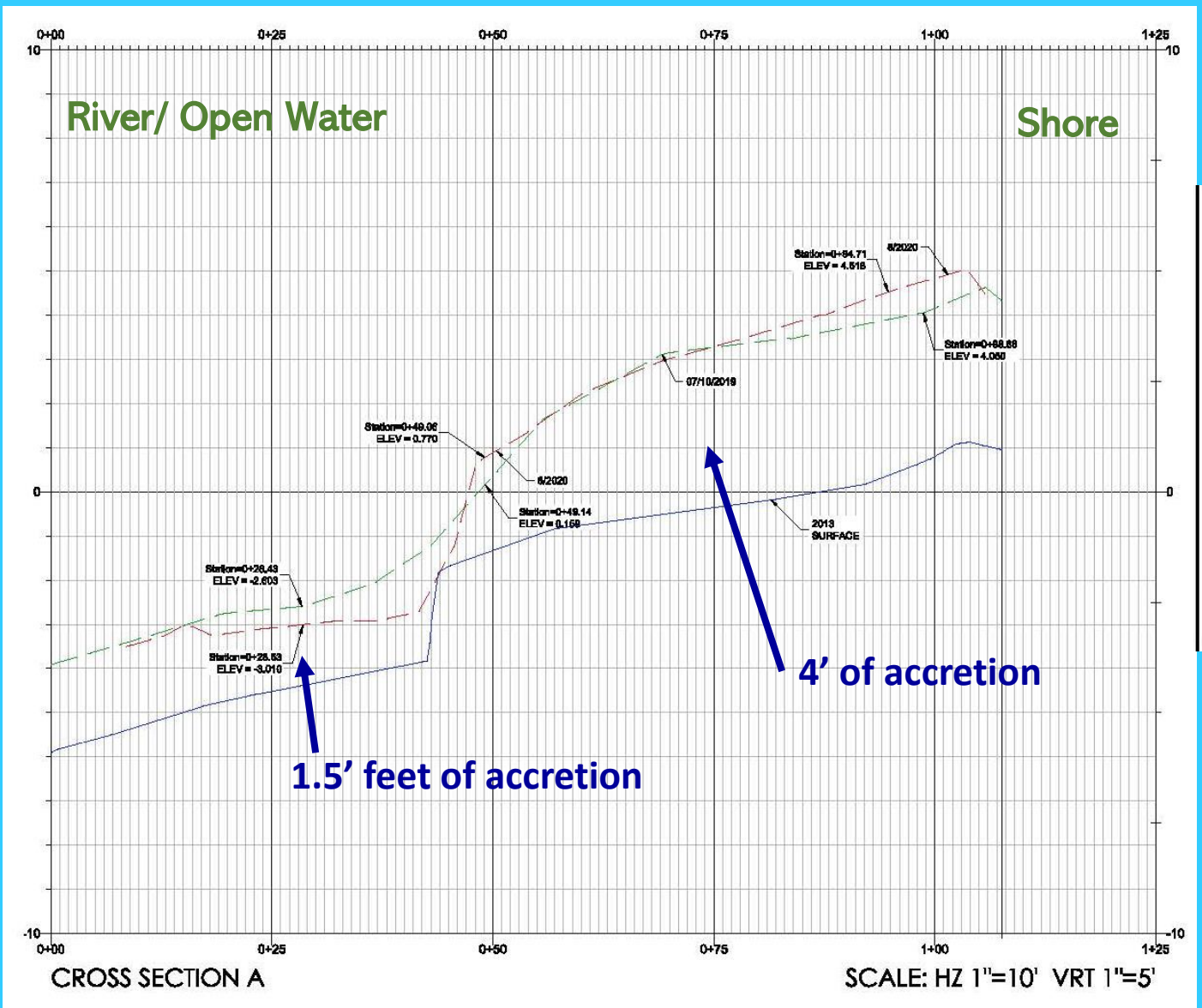

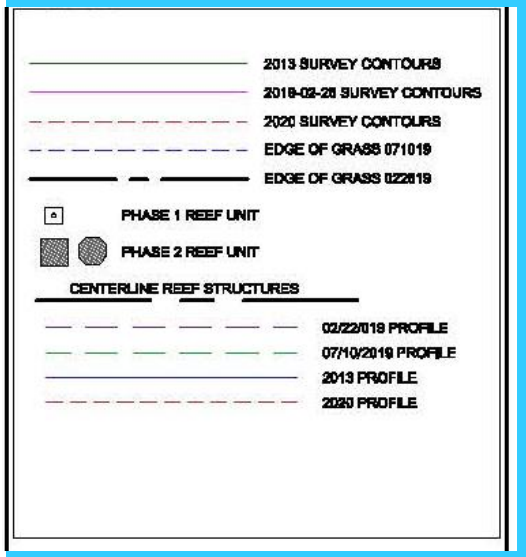

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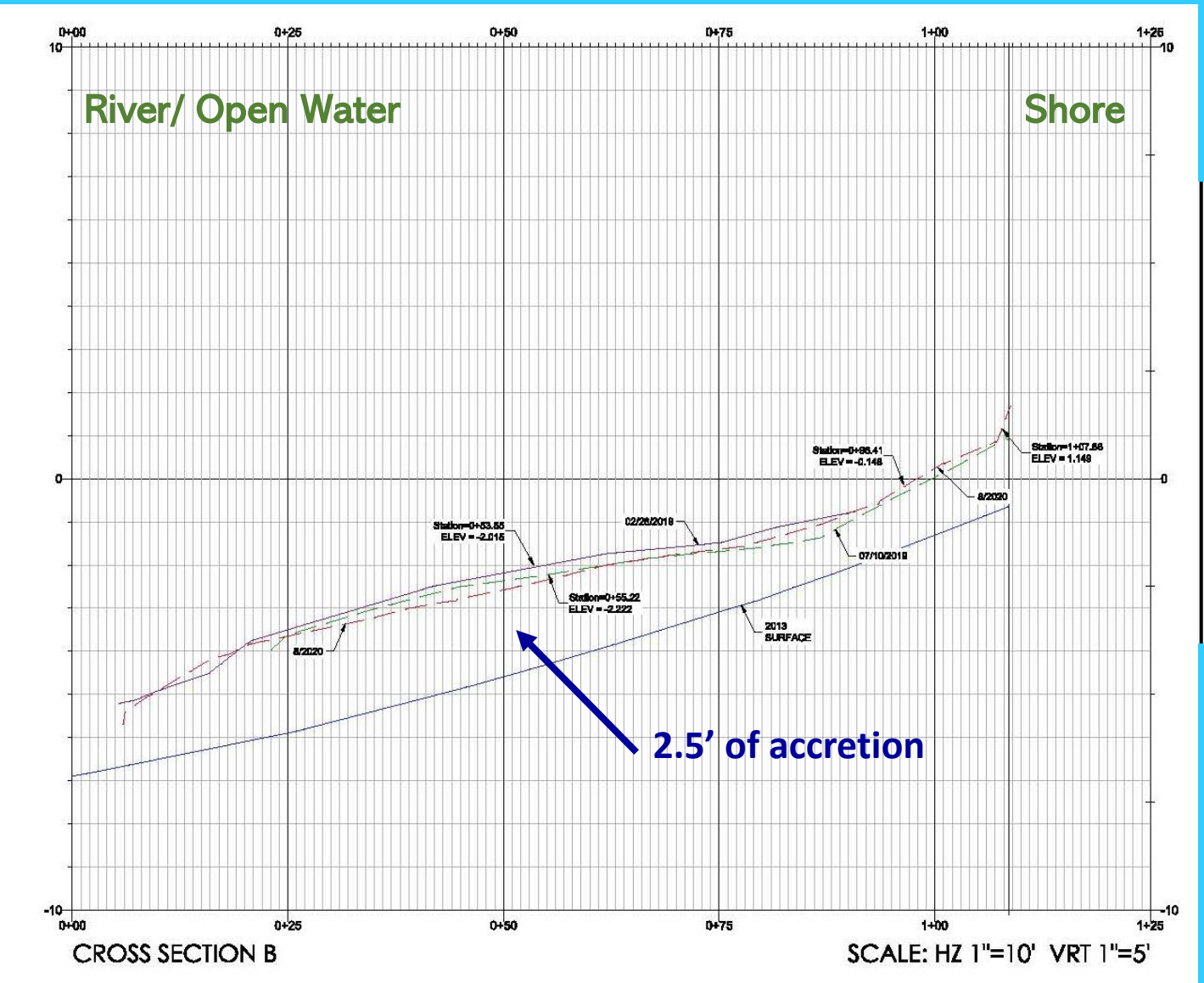
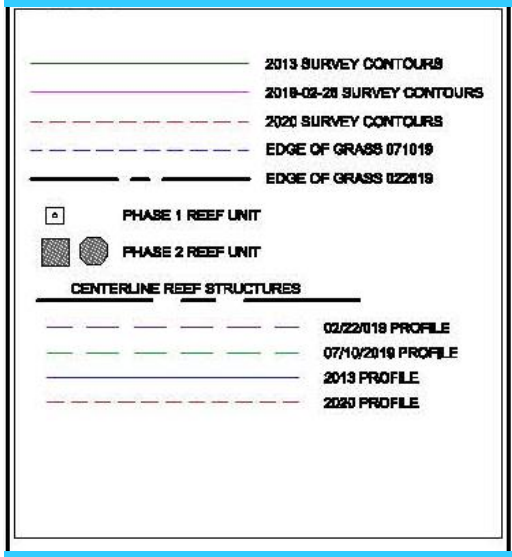
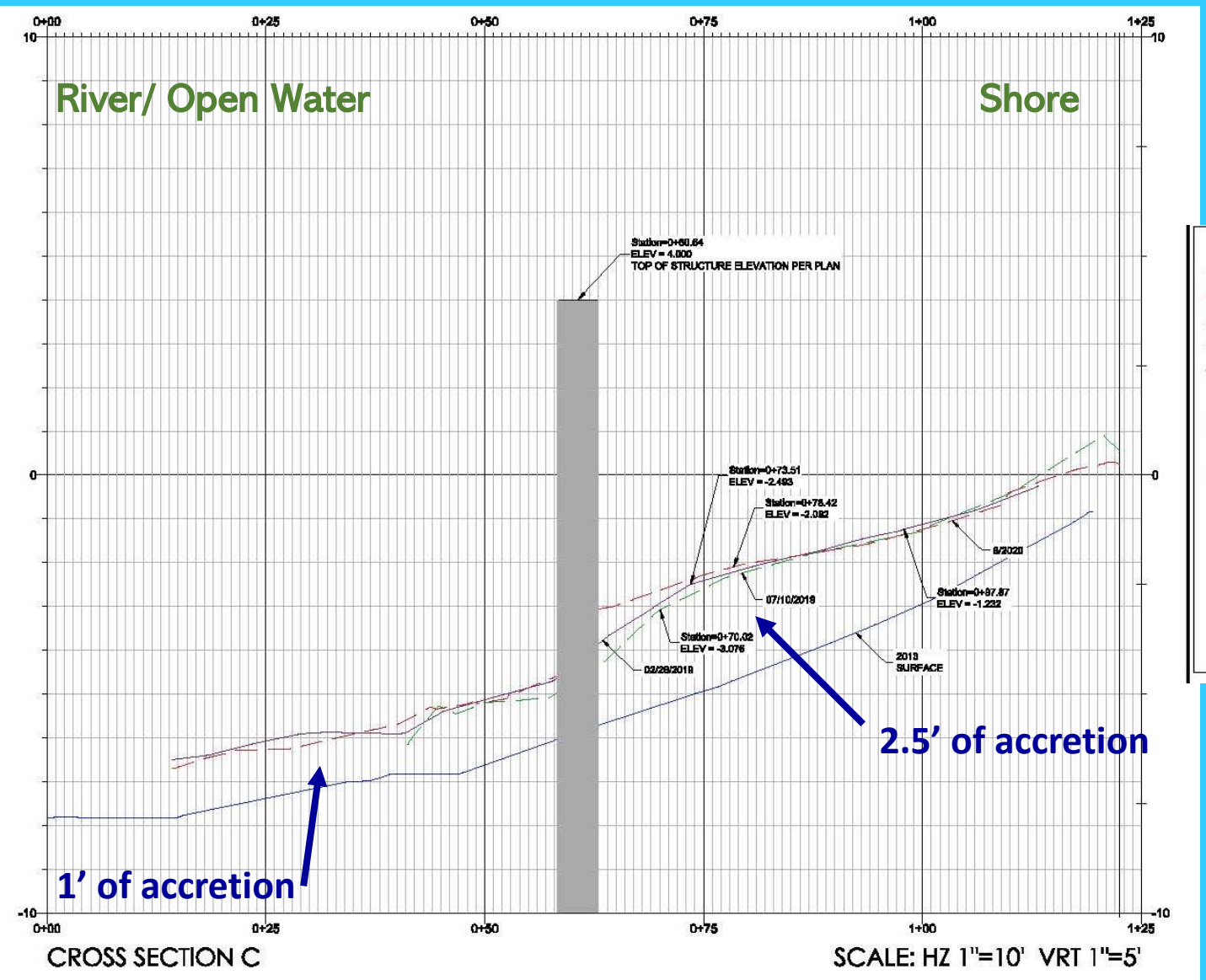
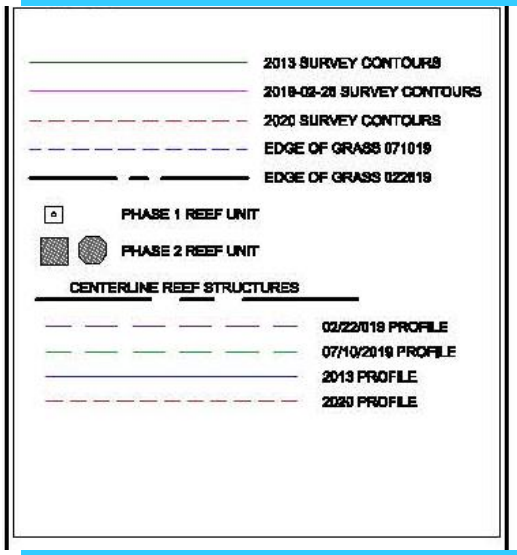




Reefmaker Monitoring





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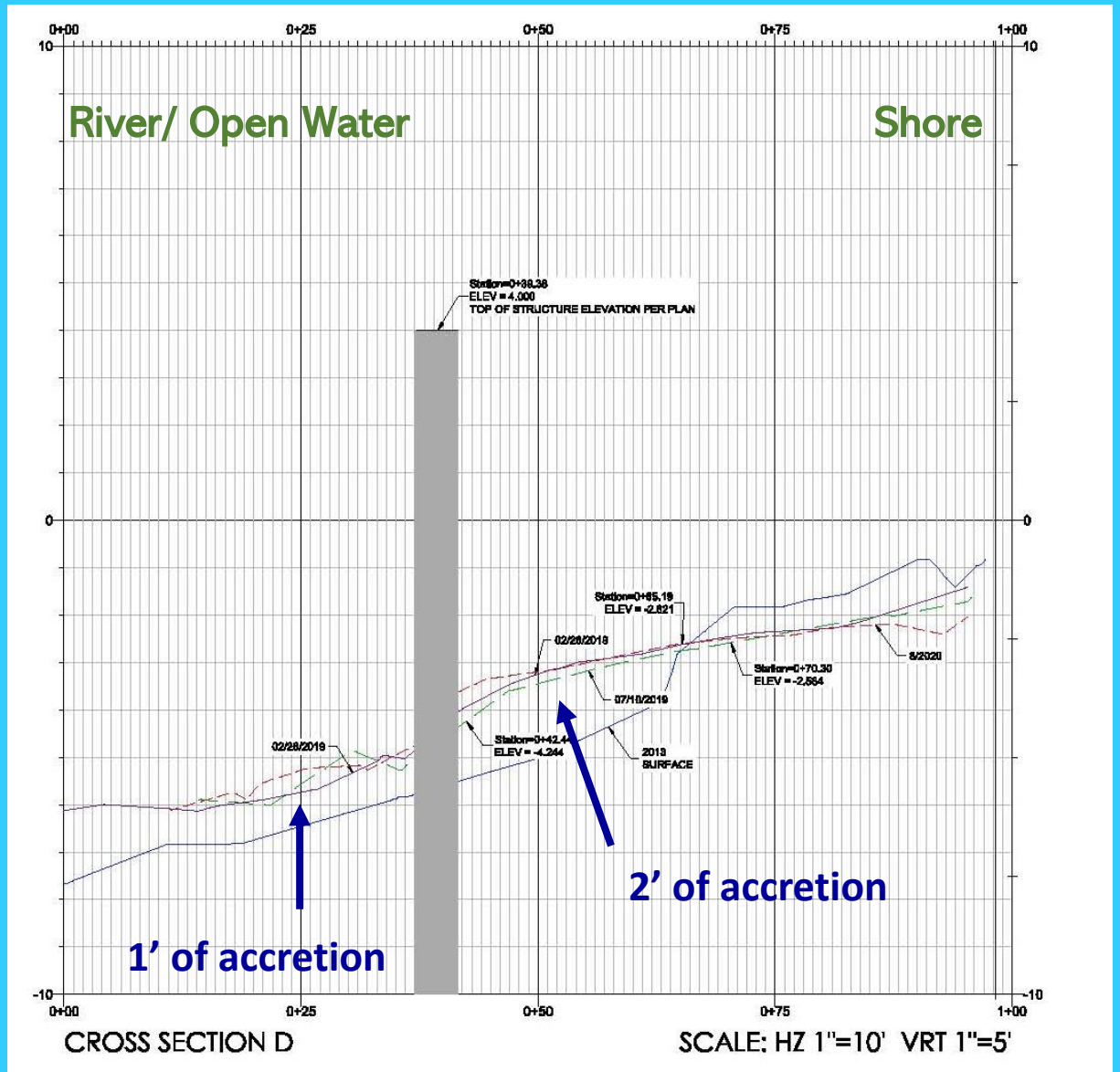

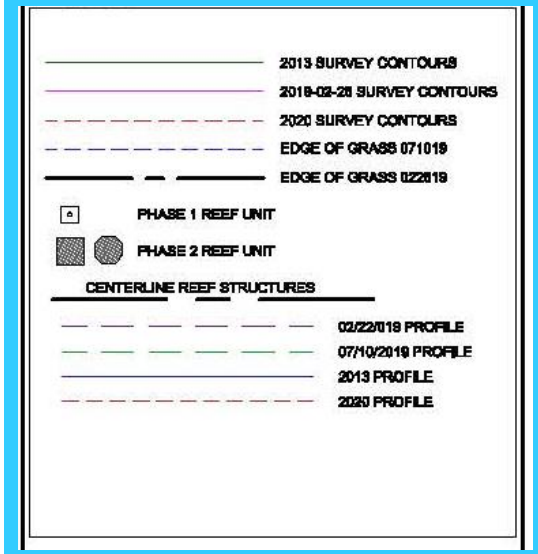

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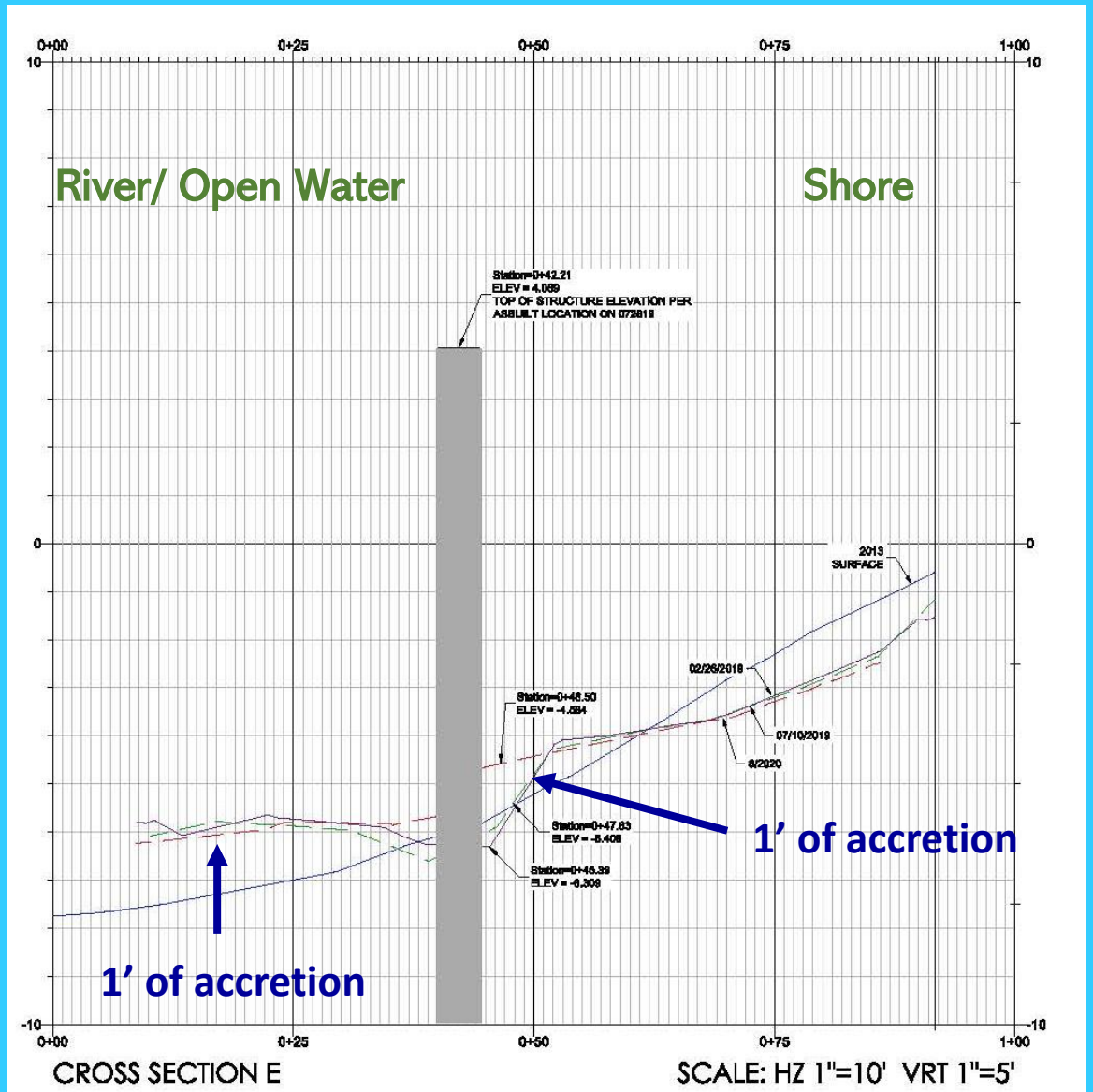
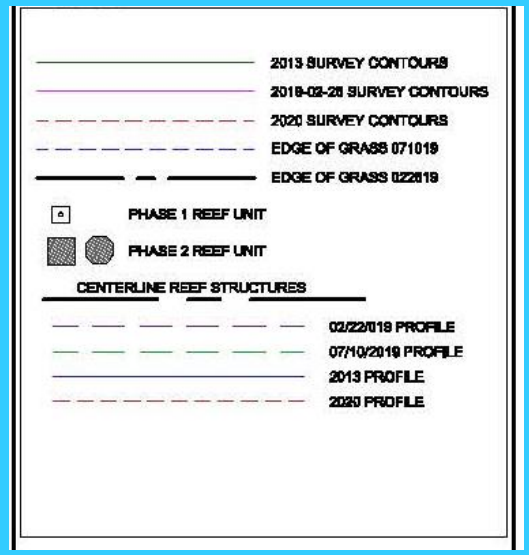
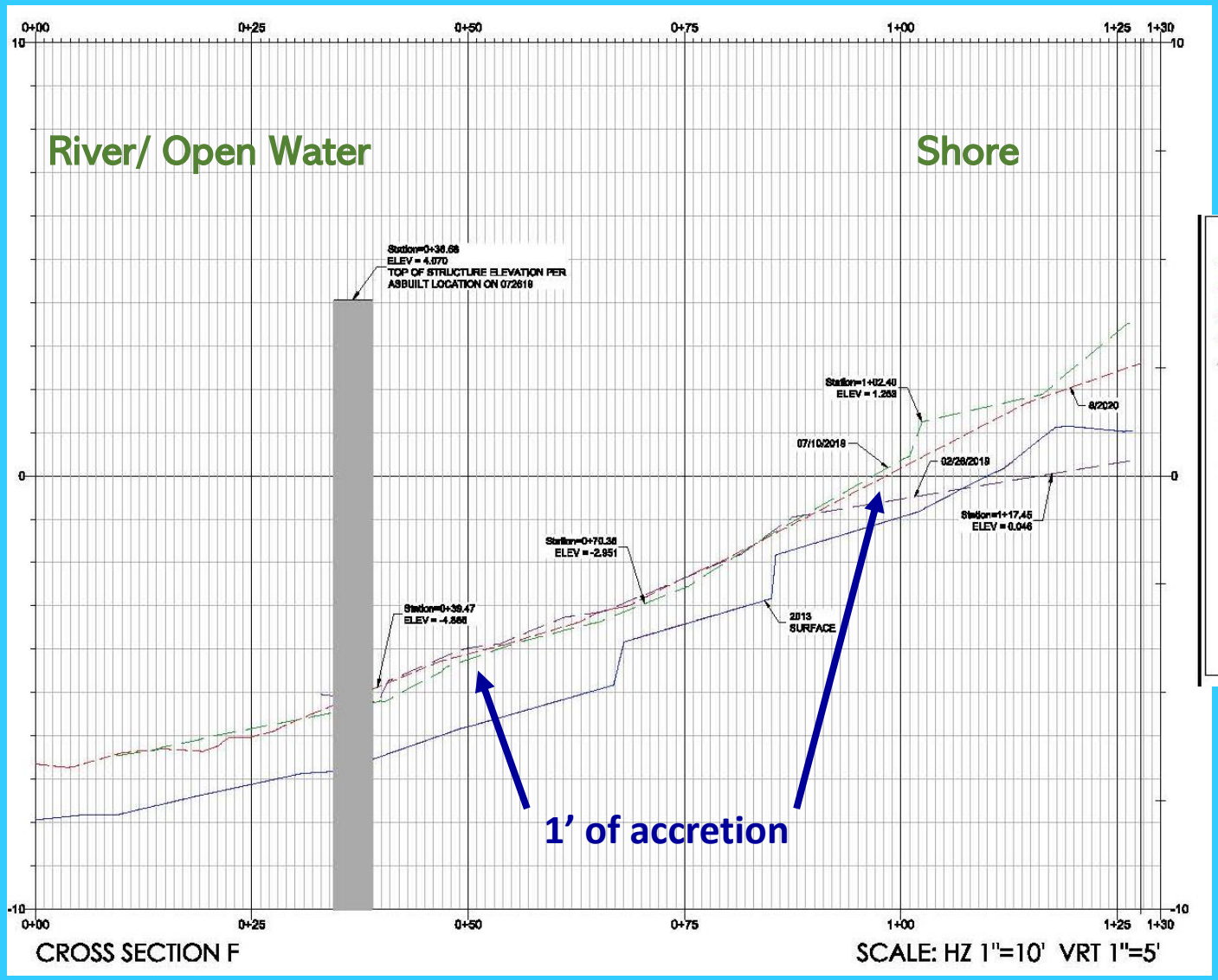
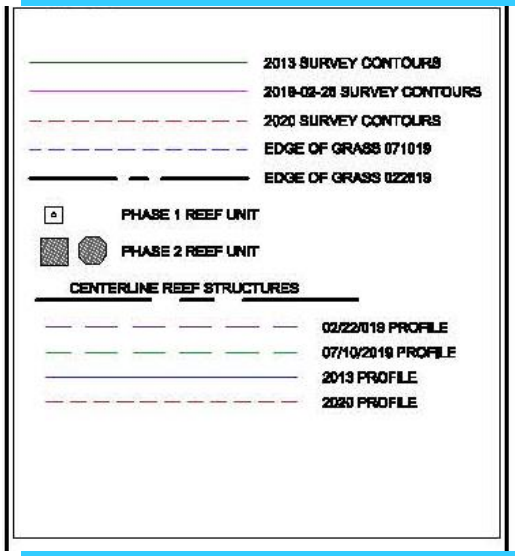




Reefmaker Monitoring





Wave Attenuation Study

Performed by 3rd Party

- 9/13/19 – 10/15/19
- Vessel Generated Wave
- Wind Fetch Wave

Wave Attenuation Study

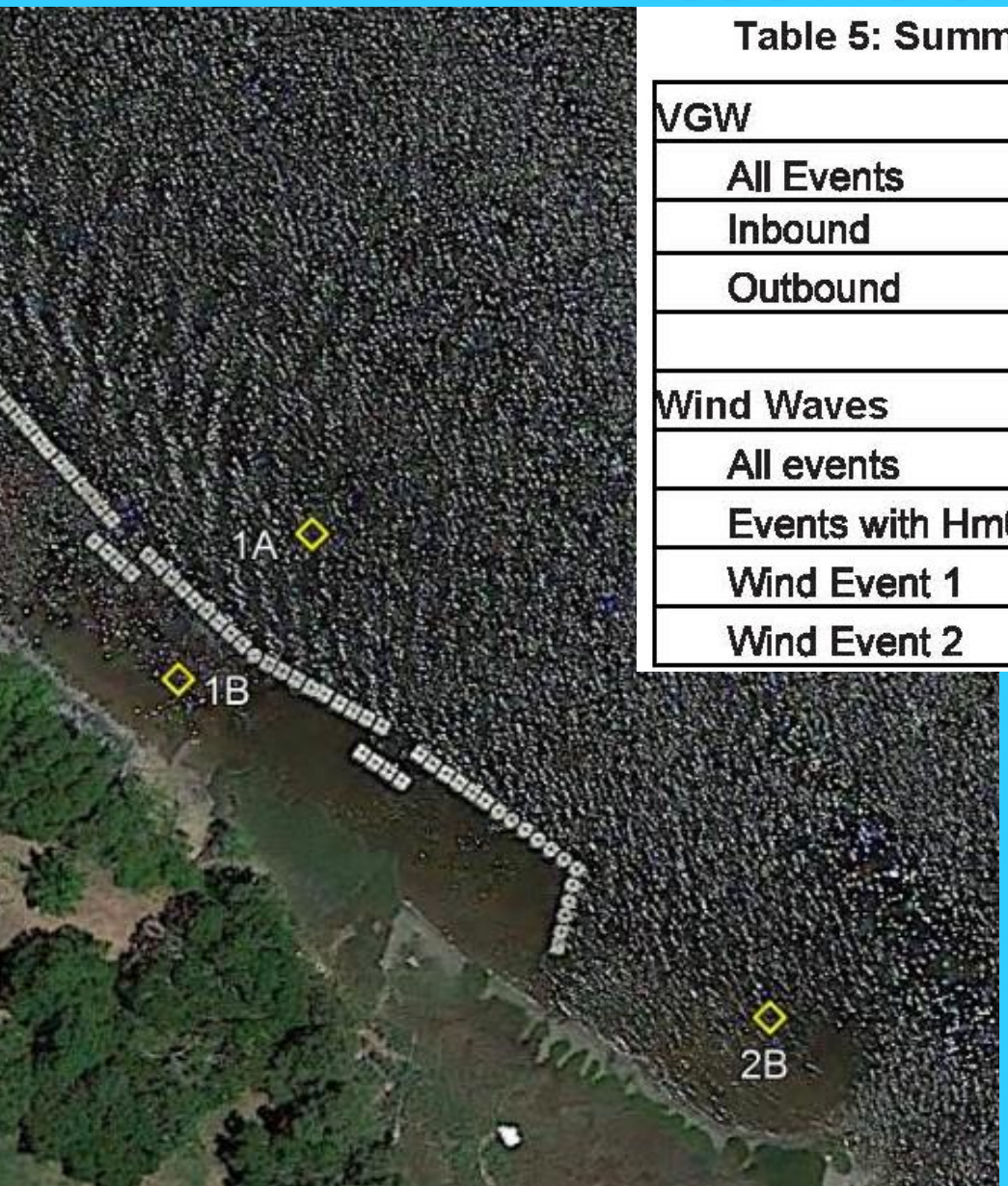


Table 5: Summary of Wave Transmission Coefficients

VGW	K_t	E_t	$Hmax_t$
All Events	0.59	0.39	0.54
Inbound	0.37	0.16	0.35
Outbound	0.72	0.53	0.73
Wind Waves	KW_t	EW_t	
All events	0.78	NA	
Events with Hm0>0.1	0.64	0.39	
Wind Event 1	0.68	0.51	
Wind Event 2	0.68	0.43	

37 VGW incidents

- 23 outbound
- 14 inbound

2 Wind incidents

- Winds from N/NE (= outbound)

Wave Attenuation Study

US Army Engineer Research & Development Center

Conducting Wave Studies on:

- 20% porous structure
- 0% porous structure

Technical report coming, & the fact sheet notes:

Testing of the system is ongoing, including a second configuration, but wave transmission between 40% and 57% have been measured with a strong dependence on the wave period. This transmission represents a decrease in wave energy between 67 and 84% while maintaining the exchange of water between both sides of the structure.

October 2020

Summary of Testing on the Living Wave Barrier for Walter Marine/Reefmaker

By Duncan Bryant and Leigh Provost

The U.S Army Engineer Research and Development Center (ERDC) was approached by Walter Marine/Reefmaker to perform wave transmission testing on a novel wave attenuator product and entered into a Testing Service Agreement on April 6, 2020. Walter Marine/Reefmaker has developed a novel, pile driven based wave attenuation product for use in estuarine and off-shore environments in contrast to conventional rubble mound structures that create a barrier to flushing, affecting sediment transport and water quality. Piles are driven into the sediment at a specified spacing, then pre-cast concrete units are slid onto the piles and anchored. This design eliminates the need for excessive fill material typical of rubble mound structures.

A scaled physical model flume study is being conducted to measure the wave reflection and wave transmission of the system in estuarine conditions. Estuarine conditions for this study are characterized by wave heights between 1 and 6.5 ft and wave periods of 2.5 to 8s. This range covers the daily and extreme wave conditions in most estuaries. Provided the concrete units have a width of approximately 58 inches, the capabilities of the ERDC-CHL wave machine in the 1.5 meter flume, and the model constructability, a scale of 1 to 5.16 is being used. This results in model concrete unit widths of approximately 11.24 inches wide, model wave periods between 1.1 and 3.5 seconds, and model wave heights between 0.19 and 0.79ft.

Figure 1. Comparison between installed Living Wave Barrier and 1 to 5.16 scale model.

Testing of the system is ongoing including a second configuration, but wave transmission between 40% and 57% have been measured with a strong dependence on the wave period. This transmission represents a decrease in wave energy between 67 and 84% while maintaining the exchange of water between both sides of the structure.

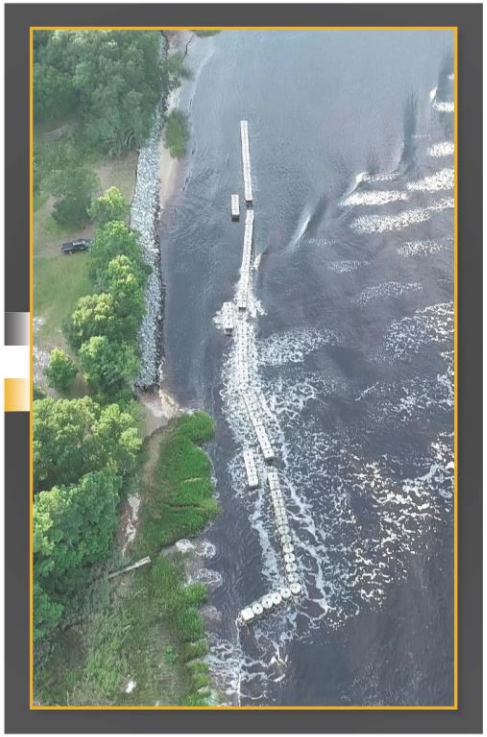
POC: Duncan B. Bryant, PhD PE, duncan.bryant@usace.army.mil , (601)634-3898


Tropical Storm Isaias Forecast
Hurricane Eye
Crossed Over BTFA
August 4, 2020
Tue PM
65 mph
Tue Early AM
70 mph

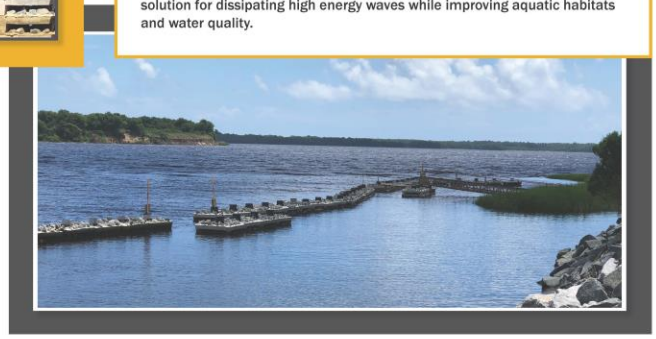
2019 Engineering Excellence Award Winner

American Council of Engineering Companies of North Carolina

Brunswick Town - Fort Anderson Shoreline Stabilization | Brunswick County, North Carolina



Beginning in 2008, the NC Department of Natural and Cultural Resources observed unprecedented shoreline erosion at their Brunswick Town - Fort Anderson State Historic Site located on the lower Cape Fear River. Shoreline erosion caused by constant tidal forces and dynamic wave action threatened to destroy the Site's historic wharfs and the earthen batteries of Fort Anderson. DNCR challenged North State Engineering to design a wave attenuation system which could protect the Site's natural and cultural resources, minimize environmental impacts, and enhance sediment capture for the reestablishment of the degraded marsh and shoreline. North State Engineering designed, adapted, and supervised the construction of an innovative solution- the Reefmaker Ecosystem, for Phase 2. Recent monitoring indicates that Reefmaker Ecosystem has proven to be the right solution for dissipating high energy waves while improving aquatic habitats and water quality.



LEFT: Aerial photograph of Phase 2 (octagonal discs) of the Reefmaker Ecosystem in action. The medium sized container ship traveling at rough 13 knots (15 mph) creates a very dynamic wave as it transits from the Port of Wilmington. The Reefmaker Ecosystem is highly effective at dissipating and reflecting the wave energy while maintaining flushing through the entire length of the structure.

CENTER: The Reefmaker Ecosystem – Phase 2 prepares to dissipate a larger container ship's wake as it transits up the Cape Fear river to the Port of Wilmington. The octagonal design of the concrete stacked discs creates an irregular surface profile ideal for dissipating the wave energy of the ship's wake. The spacing and voids between the discs allows for flushing along the entire structure which promotes sediment transfer and aquatic habitat. Pile clamps hold the structures off the riverbed. As sediment accumulates behind the structures, marsh grass will naturally reestablish and provide a natural buffer to the Site's shoreline.

RIGHT: Prior to 2008, marsh grasses extended over 80 feet from the shoreline at this location. In 2016, Hurricane Matthew eliminated the marsh grasses and eroded the bank to less than 50 feet from Fort Anderson's earthen battery "A". Phase 2 was completed in August 2018.

Nomination Criteria: The project should relate to EWN key elements

1. Using science and engineering to produce operational efficiencies.
2. Using natural processes to maximum benefit.
3. Increasing the value provided by the project to include social, environmental, and economic benefits.
4. Using collaborative processes to organize and focus interests, stakeholders, and partners.

Project Submitted for ATLAS Volume 2

March 2021 Announcement

Questions?

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