Stantec

Adaptation to a Changing Climate in the Coastal Zone – A Case Study of Prime Hook National Wildlife Refuge

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Agenda

1. Project Team
2. Historic Shoreline Changes
3. Bruun Rule
4. Modified Bruun Rule
5. Recovery Project
6. Resiliency Project
7. Conclusion

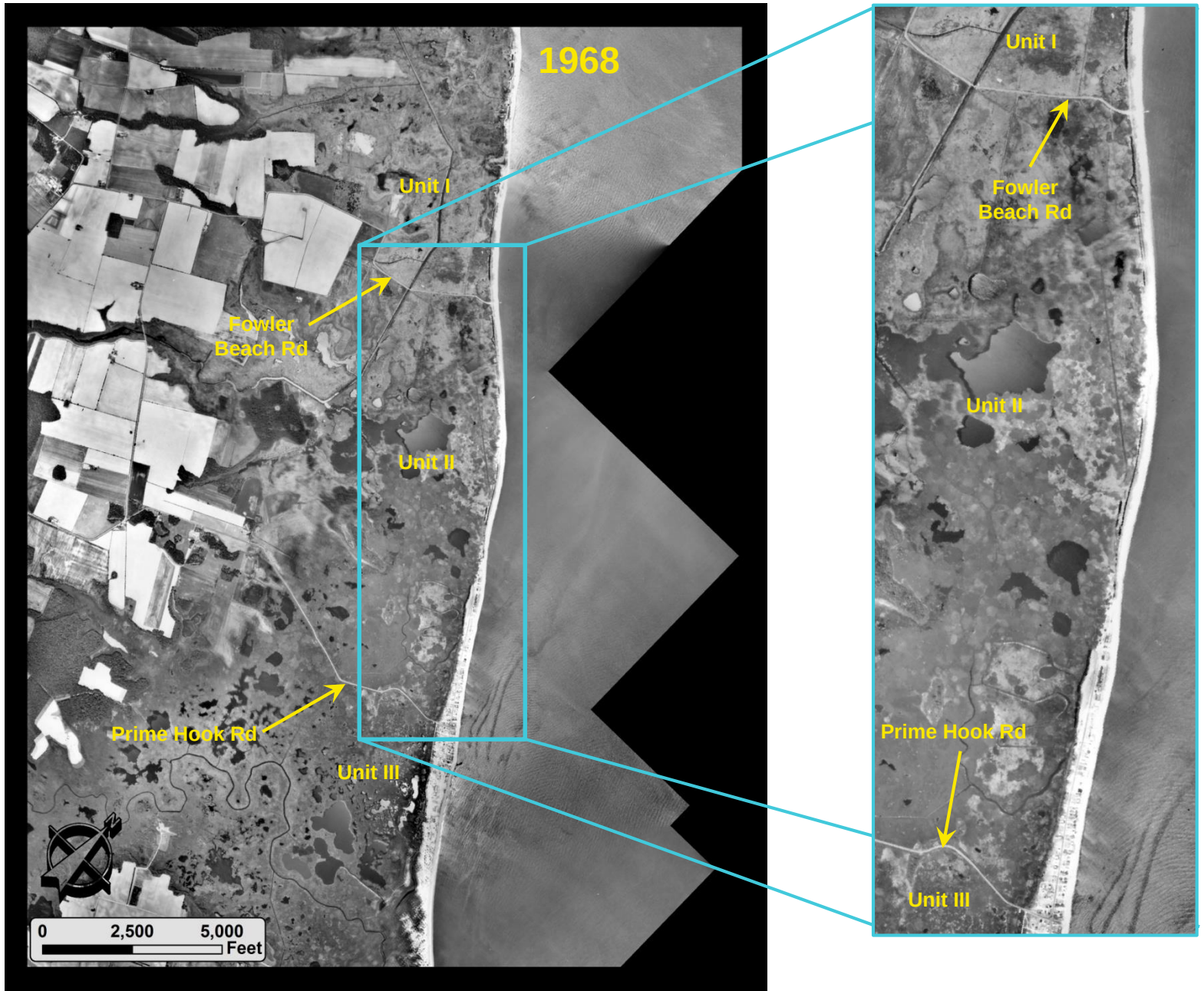
Project Team

US Army Corps of Engineers

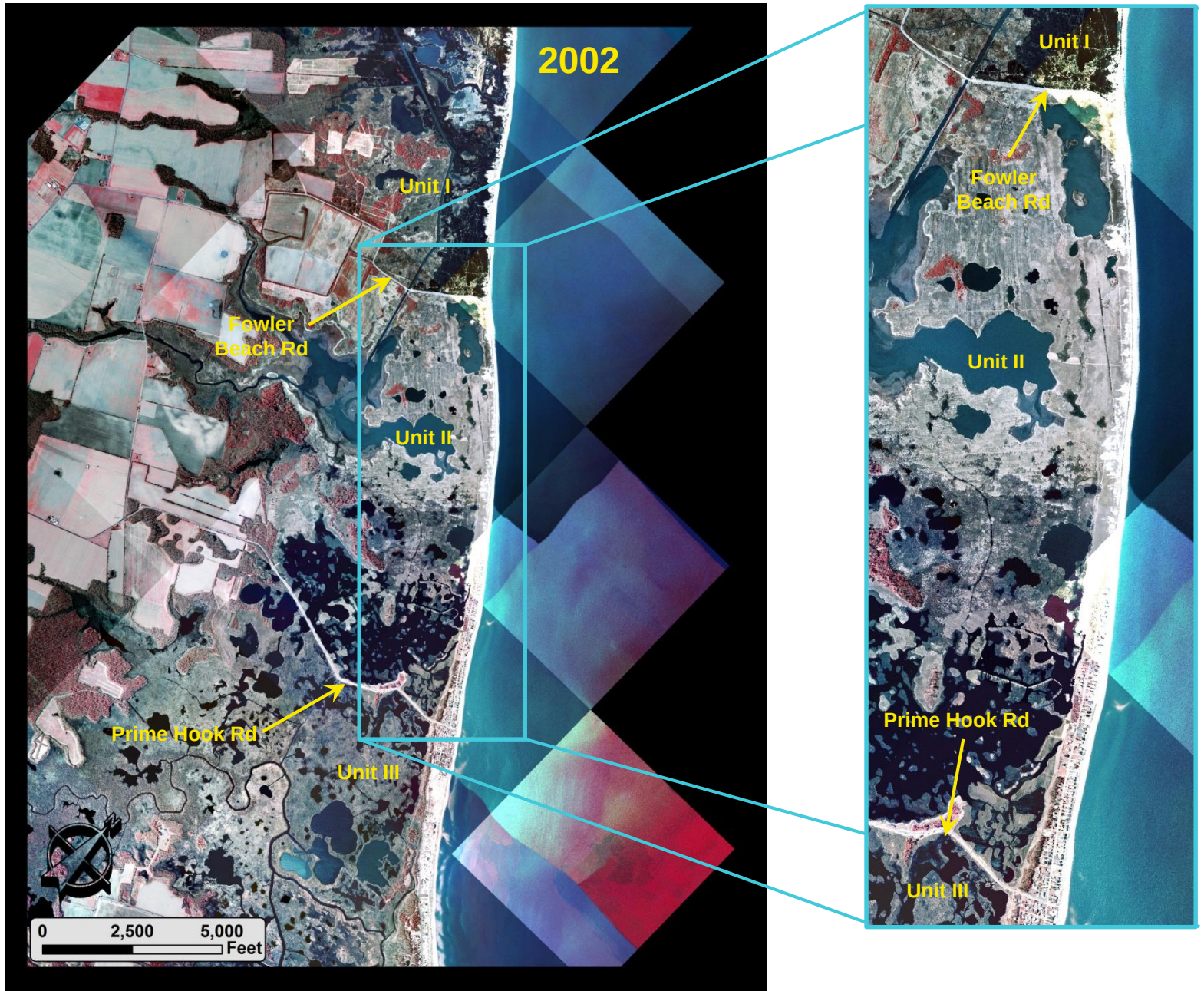
Prime Hook

- National Wildlife Refuge
- State of Delaware
- Founded in 1963
- Approx. 16 sq. miles (40 sq. Km)
- Marshes and shoreline
- 10,000 acres, mostly wetlands
- Four Management Units I, II, III and IV.
- Two central units – Unit II and Unit III – managed as freshwater impoundments for waterfowl habitat through installation of water control structures in 1980's
- Hurricane Sandy brought largest final blow to the system

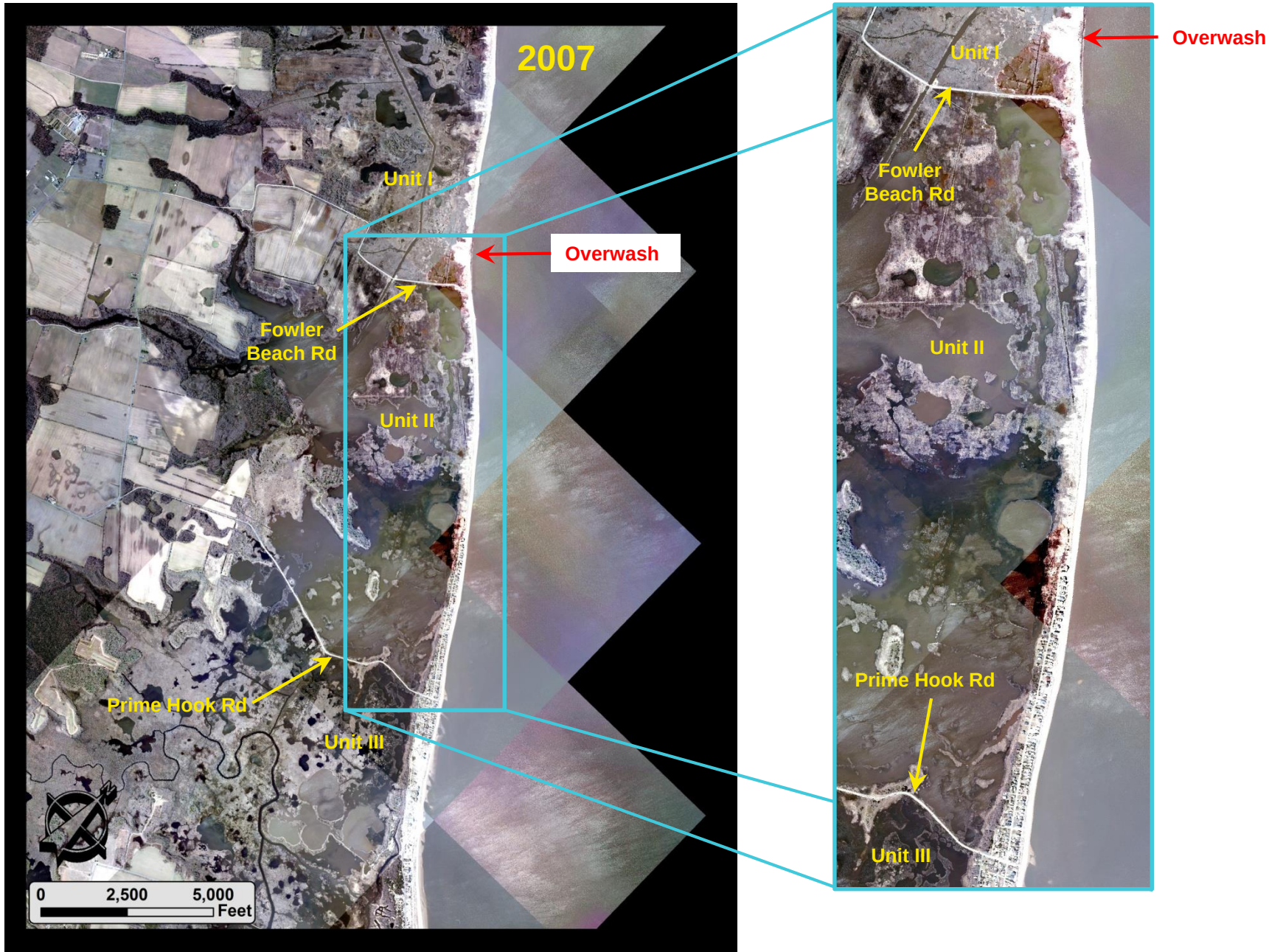
Historical Aerials: 1968



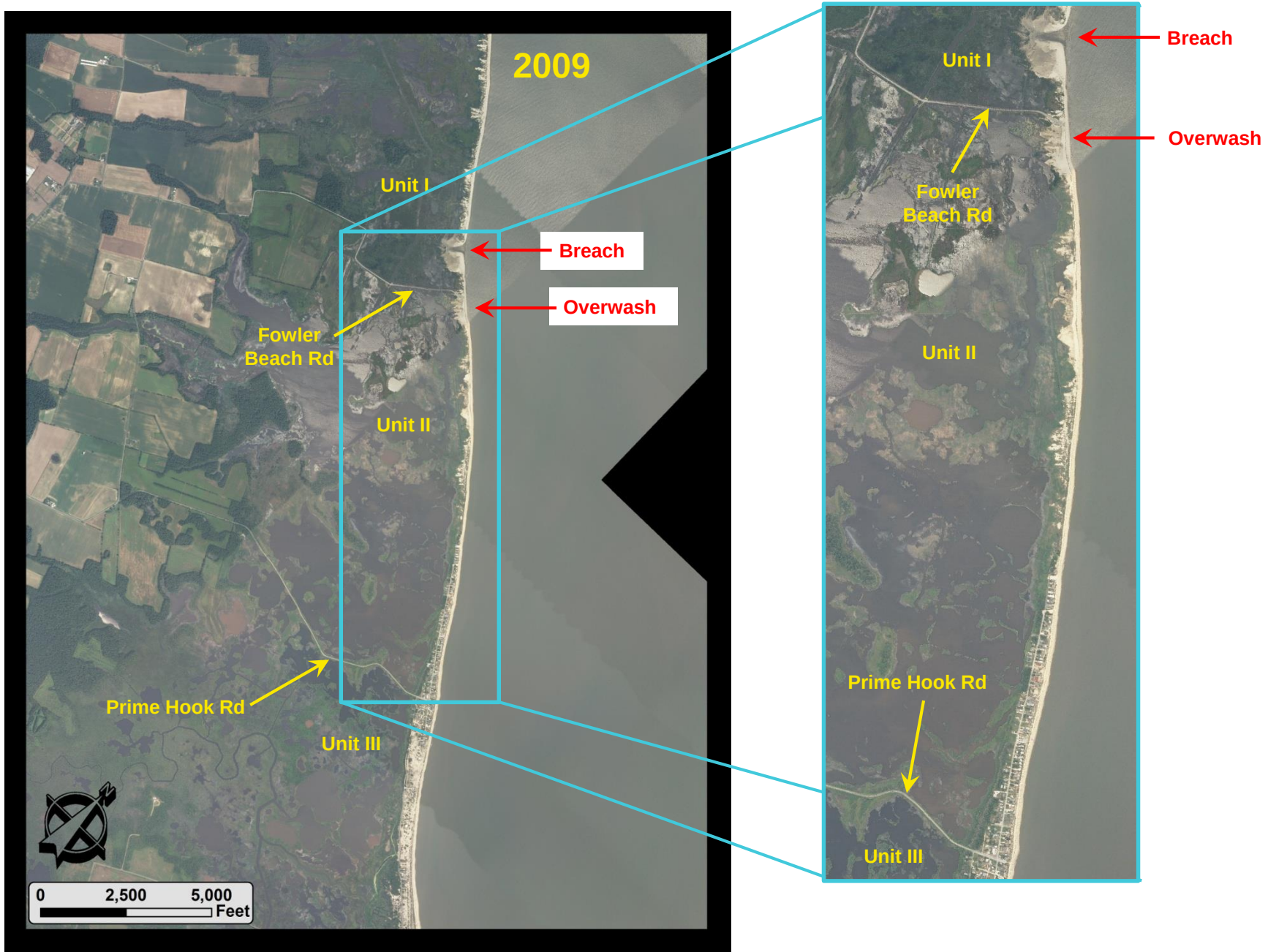
Historical Aerials: 2002



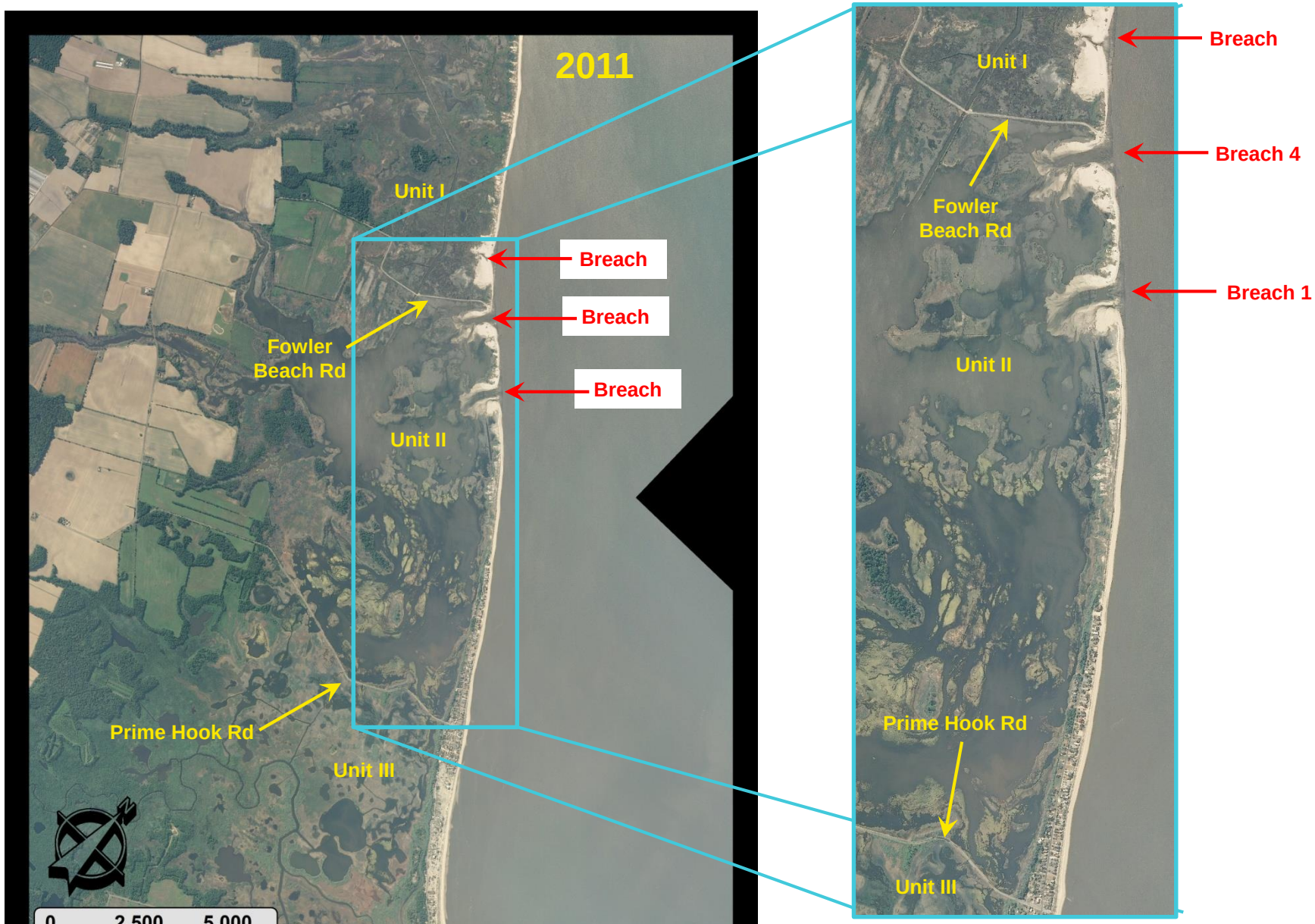
Historical Aerials: 2007



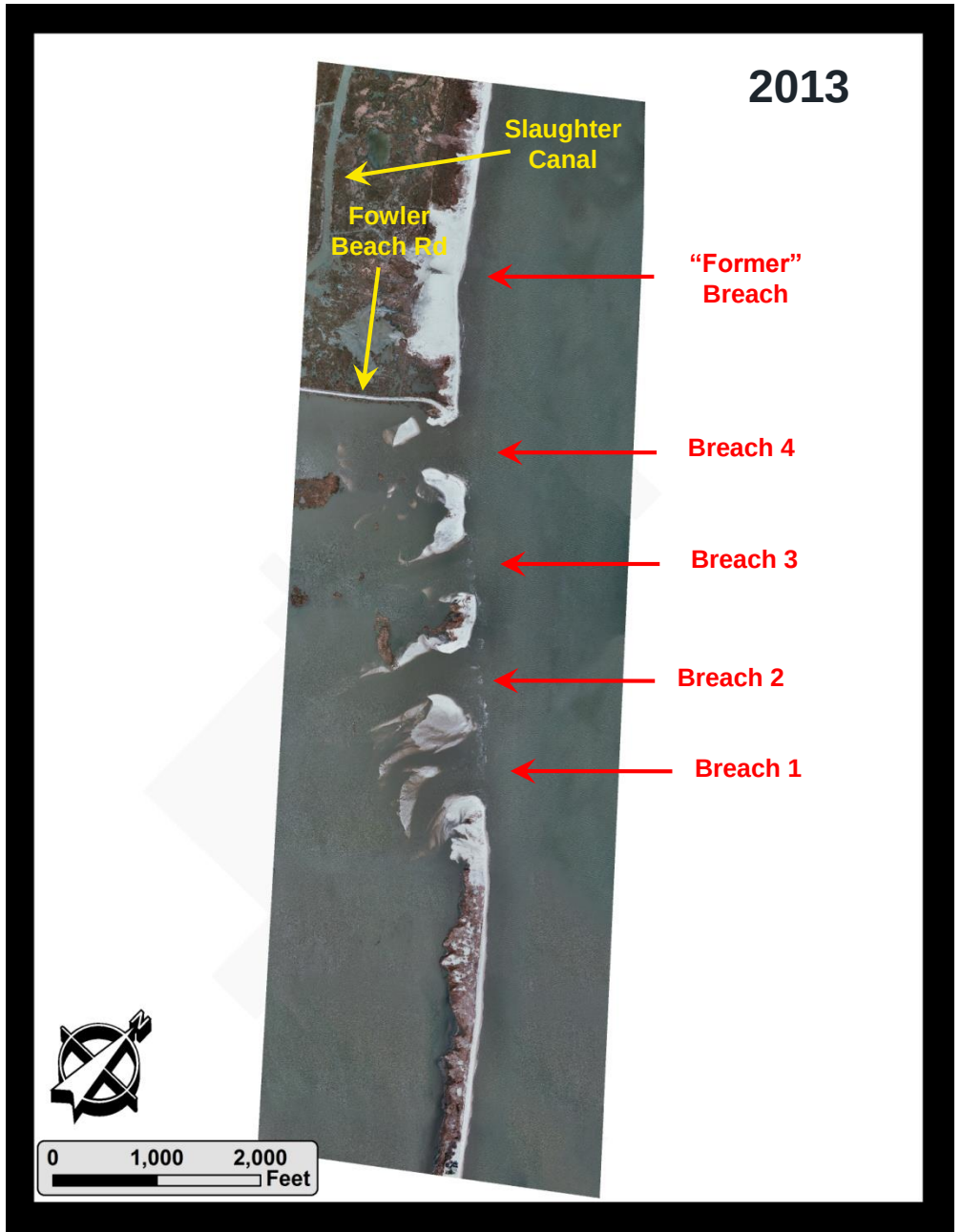
Historical Aerials: 2009



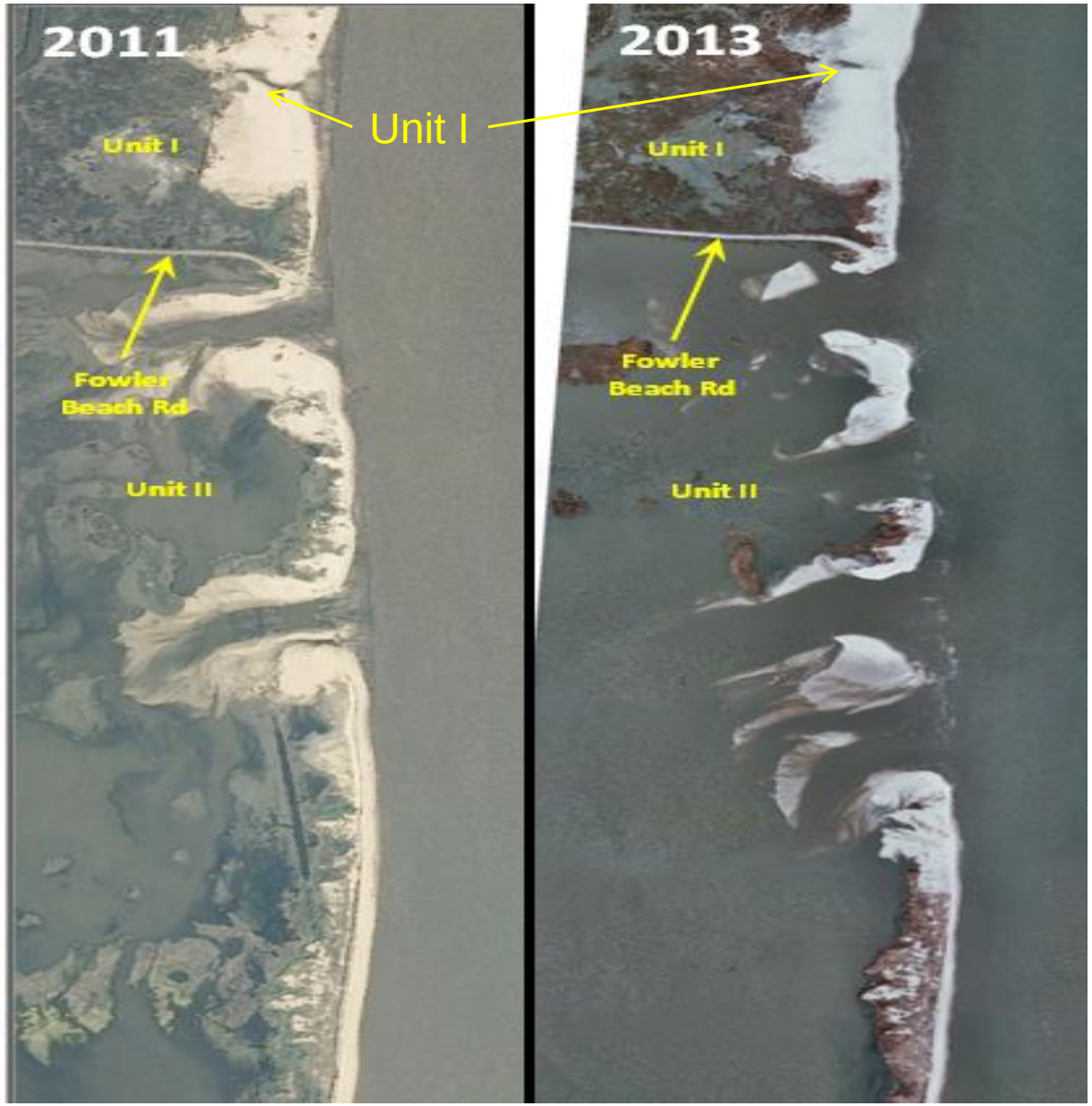
Historical Aerials: 2011



Historical Aerials: 2013



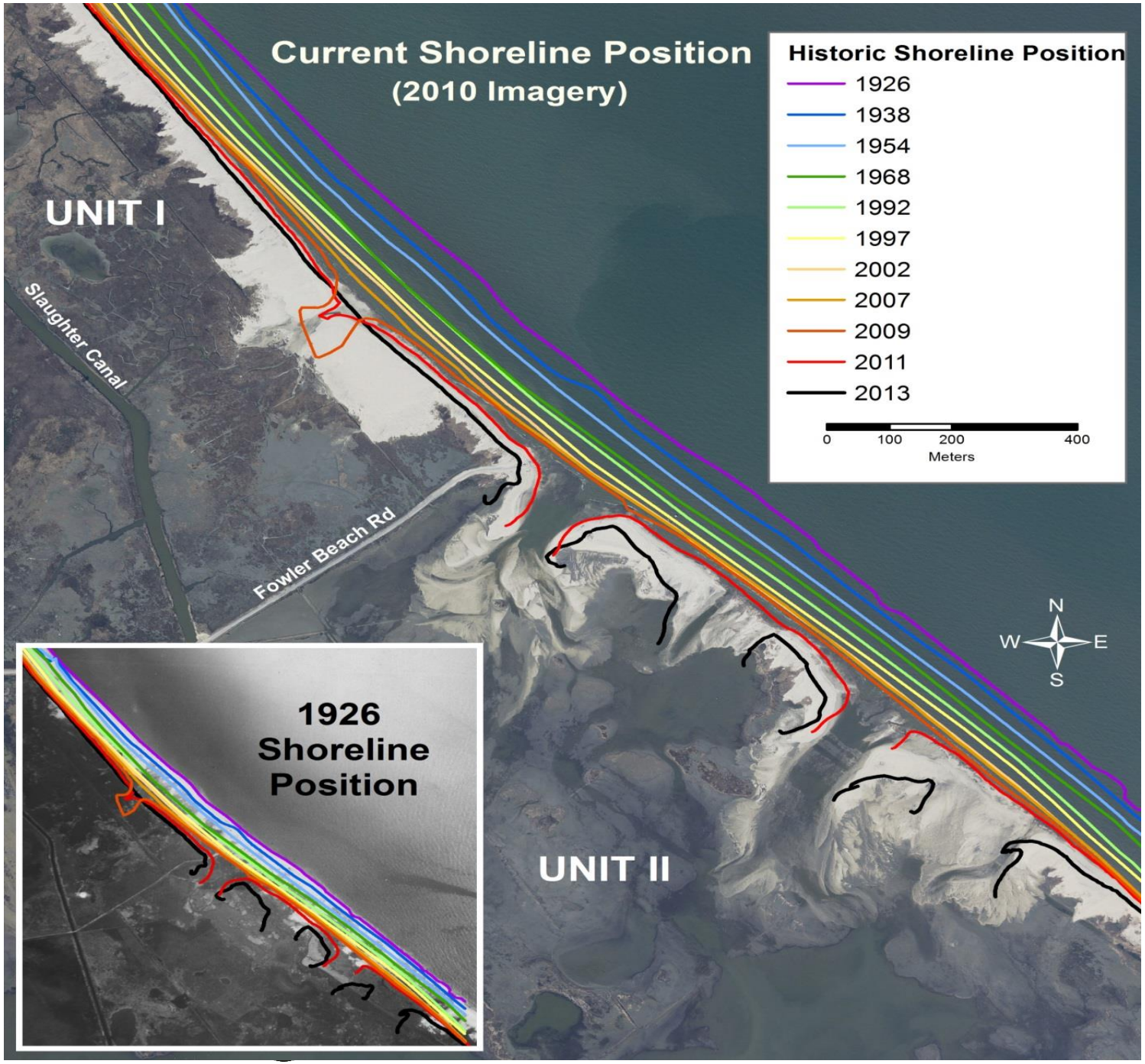
History of *Shoreline Overwashes & Breaches*



- **2006 – Hurricane Ernesto**
  - In Unit I only
  - Rejuvenated the Unit I salt marsh
  - Decision not to repair, natural salt marsh
- **2008 – Mother's Day Storm**
  - Moderate overwash in Unit II
  - Repaired in October 2008
  - 2009 freshwater vegetation management successful
- **2009 – October/November Nor'Easters**
  - Two breaches formed in Unit II
  - Salt marsh fared well
  - Impounded freshwater wetlands experienced peat loss and rapid conversion to mostly open water
  - Reconsidered wetland management
- **2012 – Hurricane Sandy**
  - Two new large breaches
  - Total breached area nearly tripled

Meanwhile, an unhappy public…

- Prime Hook Road (divides Units II and III) was only route in and out of a beach community, and now flooded regularly; Many locals considered "life and limb" to be at risk
- Locals passionate, well-organized, politically connected; Media didn't appear to be on our side
- Meanwhile… Others opposed our plans to take any action at all, resulting in legal delays and a very polarized debate
- As the CCP process pressed on… "Answers are coming," we told them



In 65 years, from 1926 to 1992, the shoreline receded about 300 feet.

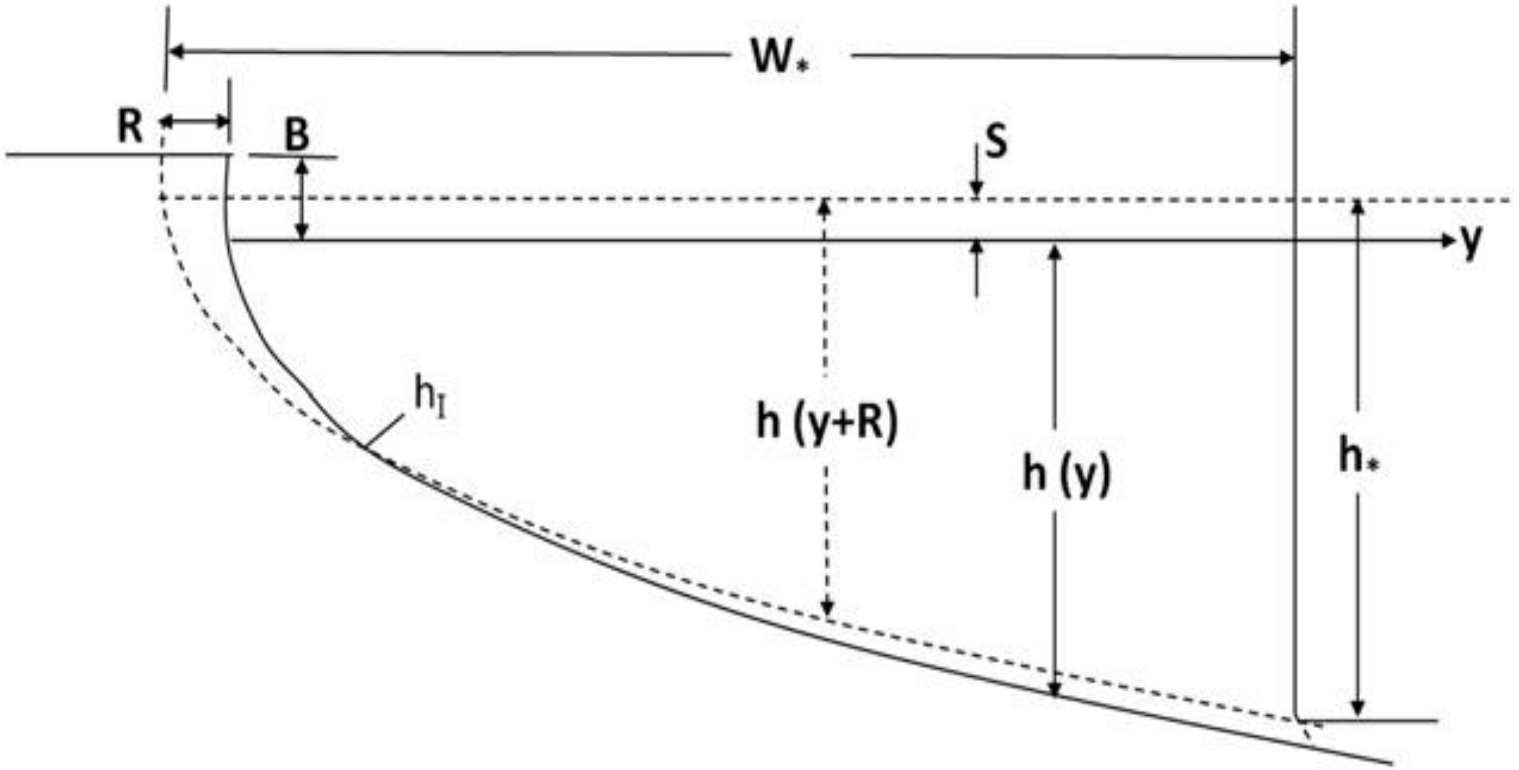
1992-2012 (20 years) to recede about 200 feet more, to its current position.

Sea Level Rise (SLR)?

Overwash along refuge:

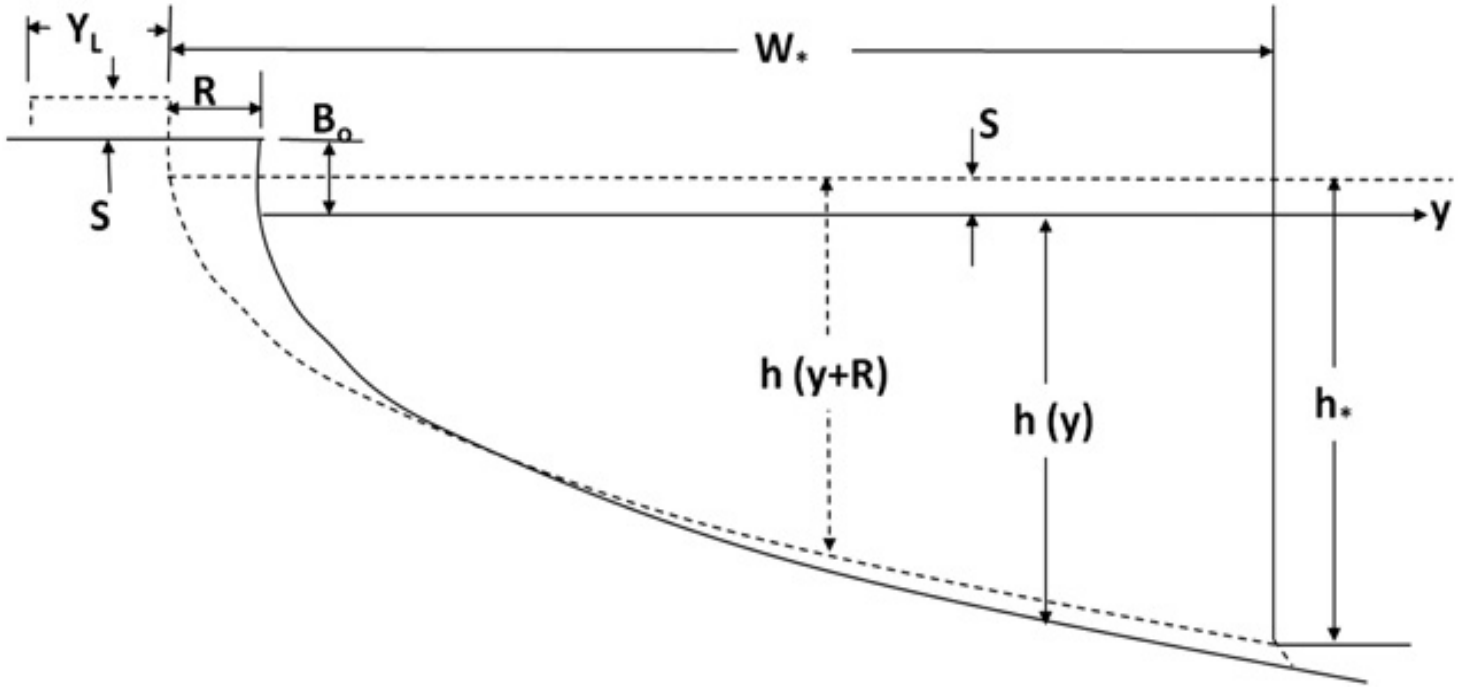
1991/92
1998
2006
2008
2009
2011
2013 – post-Sandy!

Bruun Rule



$$R = S\,\frac{W_*}{h_* + B_o}$$

Modified Bruun Rule



$$R \cong S \frac{W_* + V_D/S}{h_* + B_o}$$

Sea Level Rise and other Variables

The sea level rise (h)	3.42 mm/yr
Depth of closure (d_c)	1.83 m
The height from the waterline to the top of the dune (d_d)	1.80 m
The distance from the shoreline to the depth of closure (x_c)	182.88 m
The height from the depth of closure to the new sea level (h_*)	1.86 m
The distance from the top of the dunes to the depth of closure (W_*)	184.57 m
The landward extent of overwash (Y_L)	38.11 m

Bruun Rule Calculation

$$R = \frac{X_c(h)}{d_d + d_c}$$

$$R = \frac{182.88m(0.00342m/yr)}{1.8m + 1.83m}$$

$$\boxed{R = 0.17m/yr}$$

R: Shoreline Retreat

Modified Bruun Rule Calculation

$$R = (W_* + Y_L)\ln(\frac{h_* + d_d}{h_* + d_d - h})$$

$$R = (184.57m + 38.11m)\ln(\frac{1.86m + 1.8m}{1.86m + 1.8m - 0.00342m/yr})$$

$$\boxed{R = 0.21m/yr}$$

Measured Shoreline Data

Time Period	Shoreline Retreat (m/yr)
1937-1954	0.85
1954-1968	1.46
1968-1992	1.25
1992-2007	1.86
1997-2012	3.05

Results

- Bruun and Modified Bruun Rules did not predict the total amount of shoreline retreat – experienced historically
- Suggest of factors are contributing to shoreline retreat:
  - Storm Impacts
  - Frequency of Storm Events
  - Lack of Sediment
  - Condition of shoreline in area of breaches – lack of marshes
  - Back Barrier

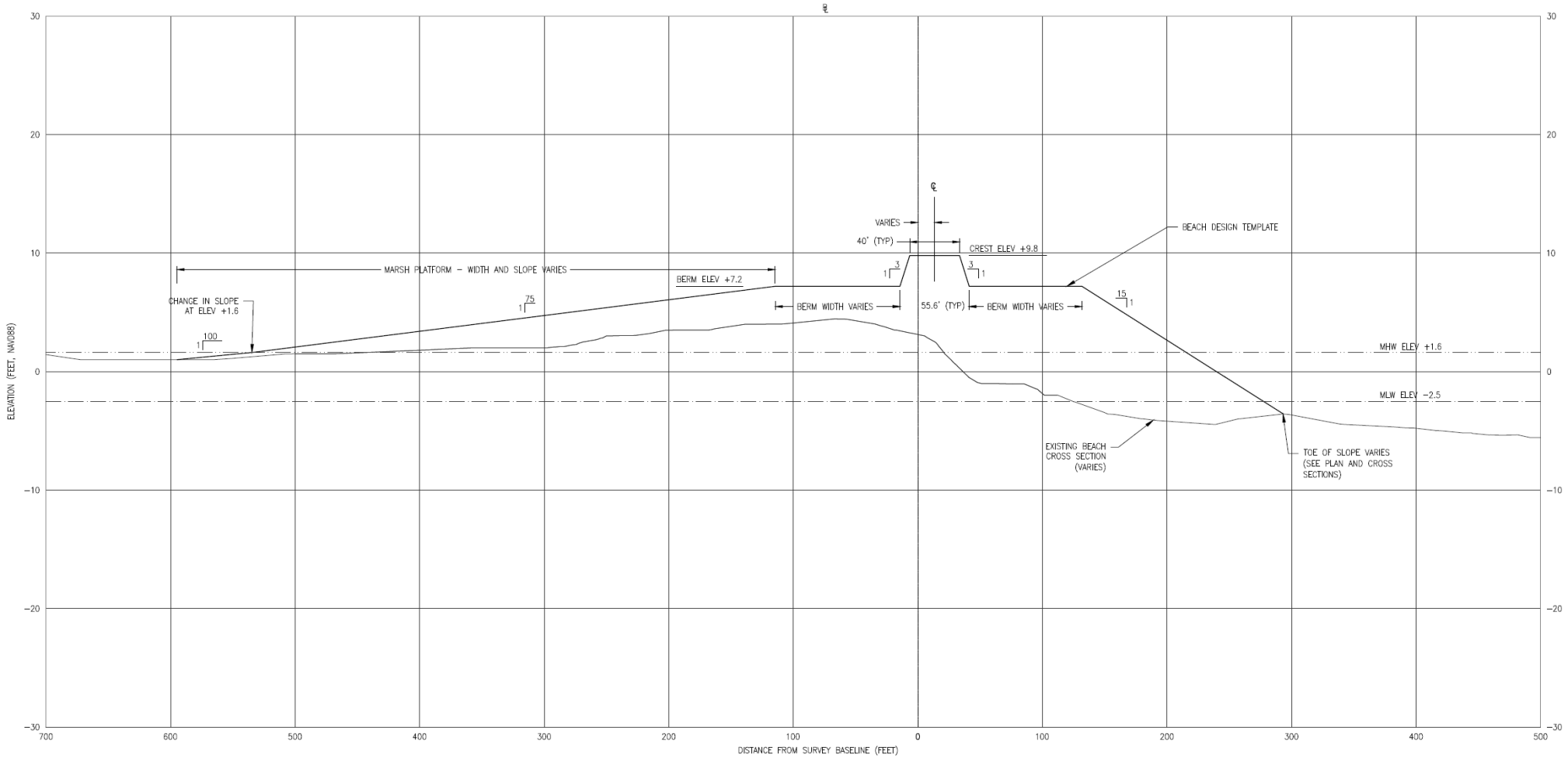

Unit I


Unit II

Beach, Dune and Back-Barrier Restoration
Sandy Recovery Project

- Close breaches, Restore dunes
- *1.41* Million cubic yards of sediment
- About 8,900 linear feet

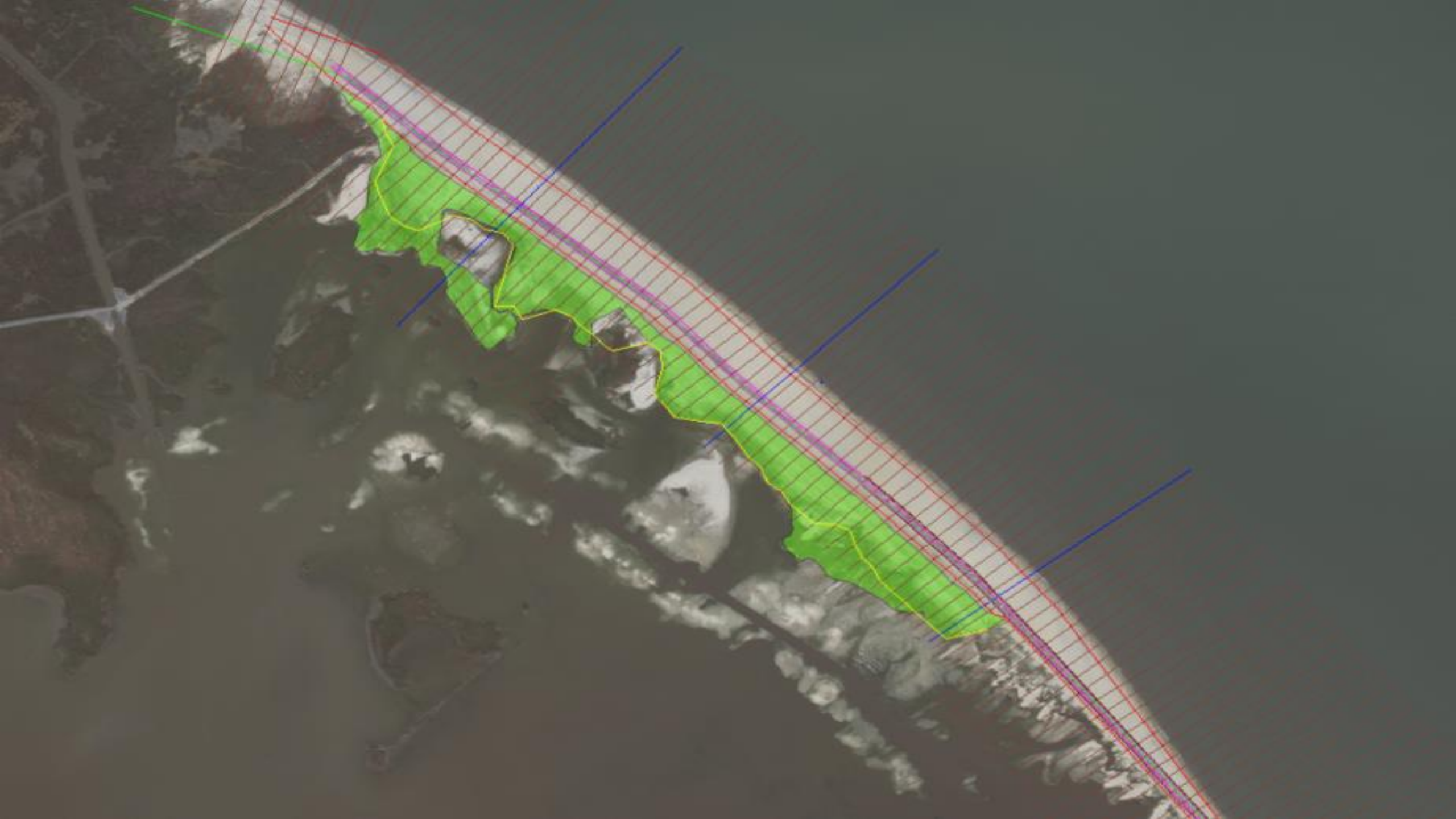
- Create marsh platform (bac-barrier) behind restored dune
  - 60 total acres
  - Extend about 100 to 600 feet into back barrier marsh



1 TYPICAL SECTION - PRIME HOOK
SCALE: AS SHOWN

40 0 40 80
SCALE IN FEET

Typical Section




October
Prior to
Construction


November


December


January

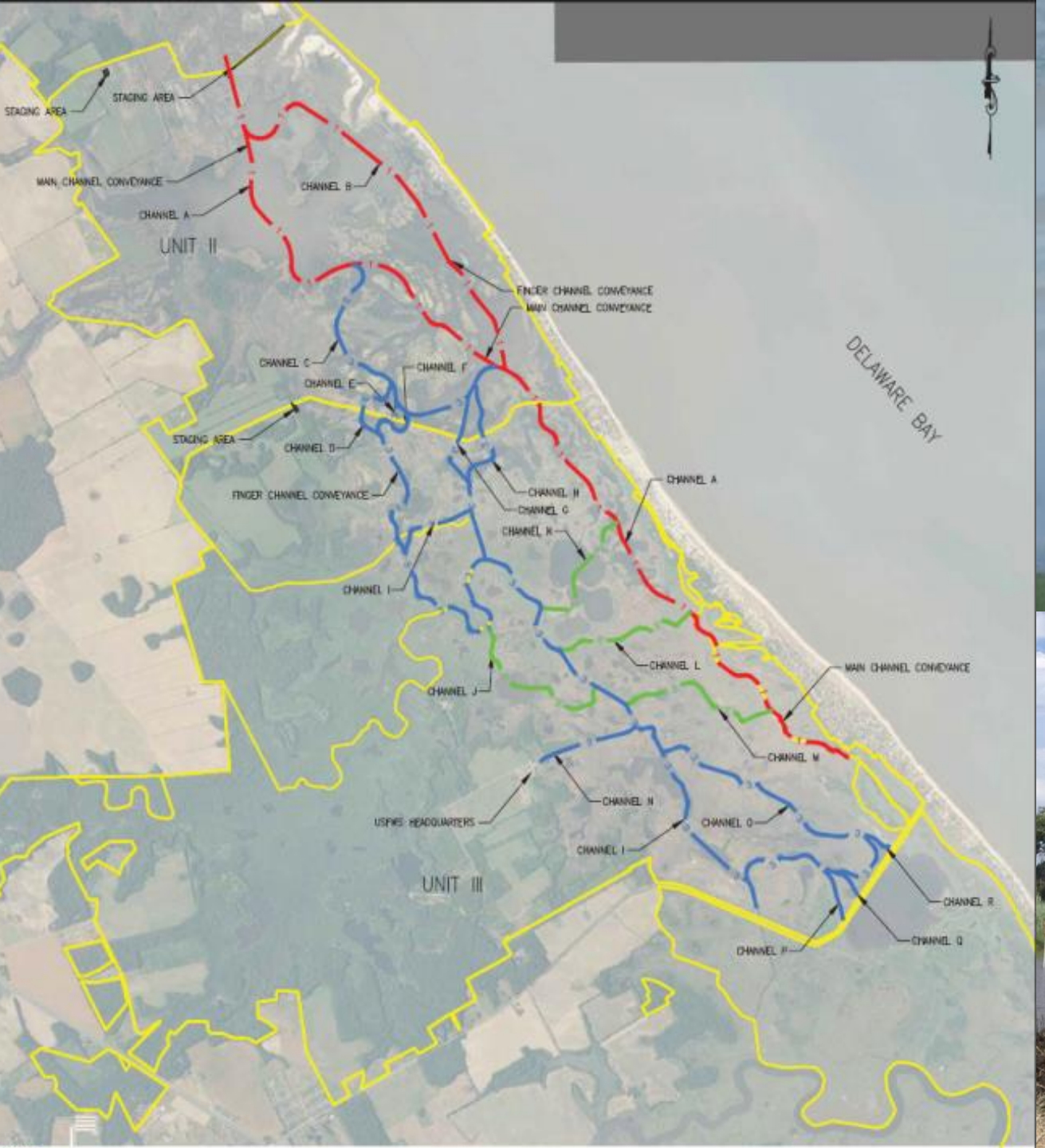

January


March – Final Project

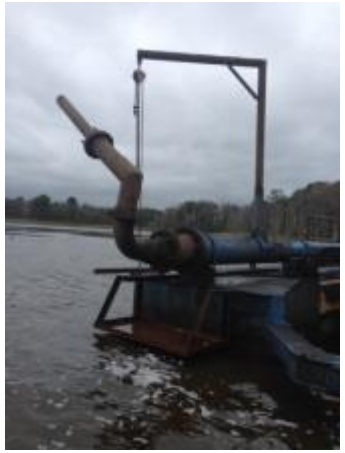

Prime Hook
April 2017
Legend
Google earth
N
3000 ft

Marsh Interior Restoration
Sandy Resiliency Project

- *Begin to rebuild ecosystem processes*
- Improve tidal circulation by creating conveyance channel network
  - ~ 25 Miles of channels -
- Use material from on-site dredging work to restore lost elevation in some areas of the marsh interior (thin-layer application)
  - Kinda…….more of a disposal mechanism
  - ~600,000 cy


STAGING AREA
STAGING AREA
MAIN CHANNEL CONVEYANCE
CHANNEL A
CHANNEL B
UNIT II
FINGER CHANNEL CONVEYANCE
MAIN CHANNEL CONVEYANCE
CHANNEL C
CHANNEL E
CHANNEL F
STAGING AREA
CHANNEL D
FINGER CHANNEL CONVEYANCE
CHANNEL H
CHANNEL G
CHANNEL K
CHANNEL A
CHANNEL I
CHANNEL L
MAIN CHANNEL CONVEYANCE
CHANNEL J
CHANNEL M
CHANNEL N
USFWS HEADQUARTERS
CHANNEL O
CHANNEL I
UNIT III
CHANNEL R
CHANNEL Q
CHANNEL P
DELAWARE BAY

Nozzle Designs



Discharge on to Shallow Open Water

Conclusion

- Bruun and Modified Bruun Rules did not account for total shoreline retreat
- Largest Post-Hurricane Sandy Recovery and Restoration Project
- Construction cost - $40 mil
- Restored 5,000 acres of marsh
- Restored 2 miles of shoreline

Thank You

Questions?

USFWS Photo