Stone Harbor Oceanfront Feasibility Study

Borough of Stone Harbor
Natural Resources Subcommittee

December 13, 2022

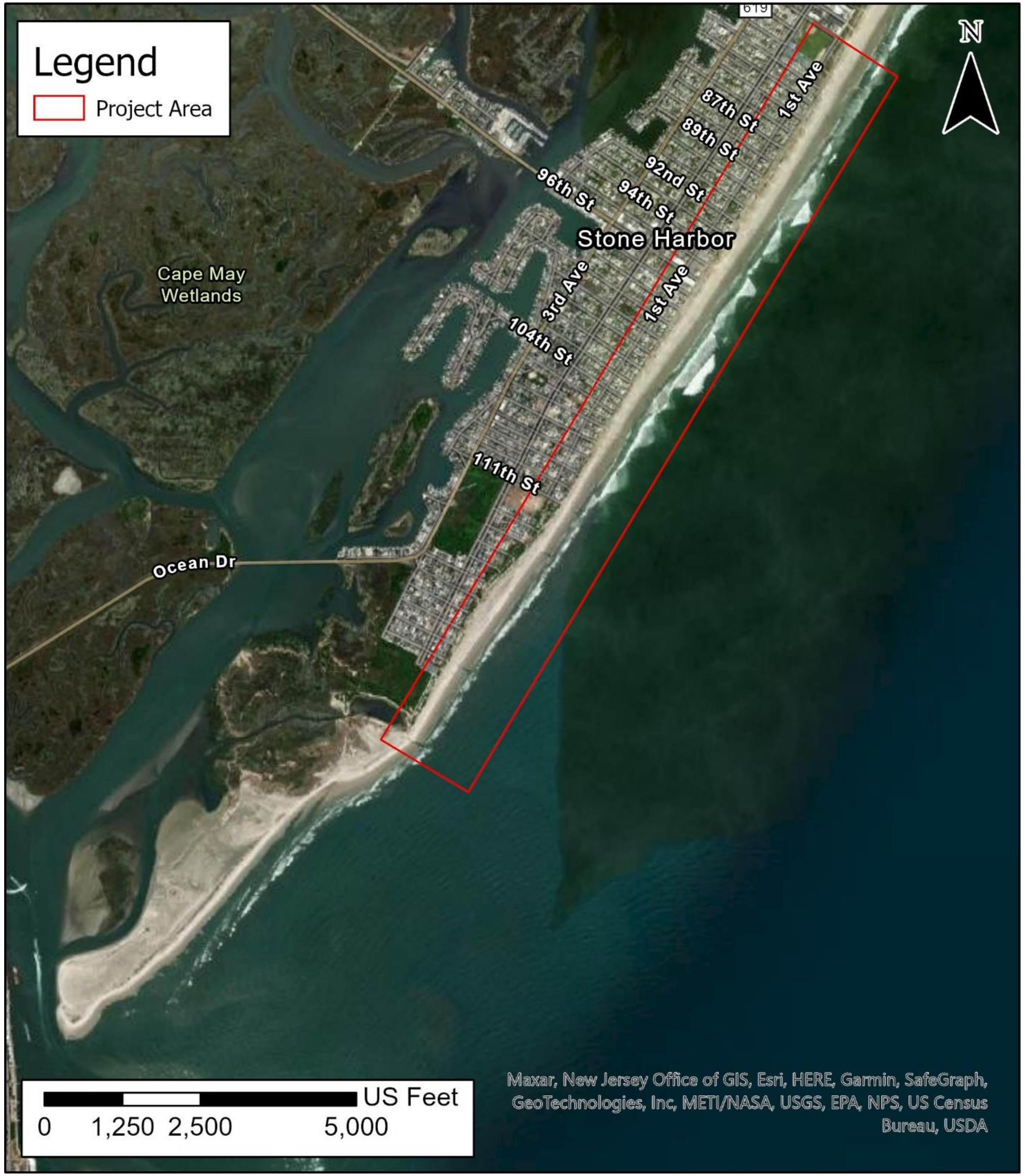
Agenda

1. Purpose and Need
2. Historical Issues and Responses
3. Modeling – Long Term Shoreline Morphology
4. Modeling – Beach Scraping
5. Next Steps

Purpose and Need

Feasibility Study

- Evaluate options for long-term beach maintenance
- Minimize degree of beach disequilibrium between beach fills
- Build resilience along Stone Harbor waterfront – more stable beaches will require a lower degree of emergency response
- Immediate storm responses are covered under General Permit 2 (GP-2) and/or an Individual Permit



Shoreline Morphology - Sediment Transport

- **Erosion is like an "Appetite"**
  - Sediment transport is the movement of sand in the alongshore and cross-shore directions
  - The volume of sand, Q, is dependent on wave height, incident angle and breaker characteristics
- **Seasonally or longer-term, the beach tries to reach an equilibrium based on tides, waves, storms, and sand supply.**
- **If there's enough sand in the littoral system, the beach can be in dynamic equilibrium**
- **If not enough sand, then the waves will erode the beach and dune**
- **Groins/jetties can help to retain sand on the beach longer**

Shoreline Morphology - Sediment Transport

- **If the climate changes, then the amount of erosional "appetite" might change**
- **If the sea level rises, then the "appetite" affects a different part of the beach**
- **Beach nourishment feeds the appetite, and changes it temporarily**
- **Jetties and other structures can alter the appetite until a new equilibrium is found.**
- **Storms cause erosion because the beach is no longer in equilibrium with the larger waves breaking higher up on the beach/dune**

Dune and Beach Morphology – Aeolian (Wind) Transport

- **Wind driven sand transport is responsible for dune building**
- **Potential reservoir of sand**
- **Critical velocity U_c is 15.5 mph**
- Sand must be dry
- Winnowing occurs - dune sand is often slightly smaller grain size than the beach
- D_{50}=0.23mm

$$q_v = \frac{q}{\rho_s(1-p)}$$

Where:

$$q = mass\ transport = K\left[\frac{u_*}{\sqrt{gD}}\right]^3$$

$$K = e^{-9.63+4.91D}$$

D = Mean Grain Size (mm)

ρ_s = Density of Sediment (2650 kg/m^3 for Quartz Sand)

ρ_a = Density of Air (1.225 kg/m^3)

p = Porosity (0.4)

Existing Conditions

Groins/Jetties

Have not been maintained and are not functioning as originally designed

- 84th Street Groin

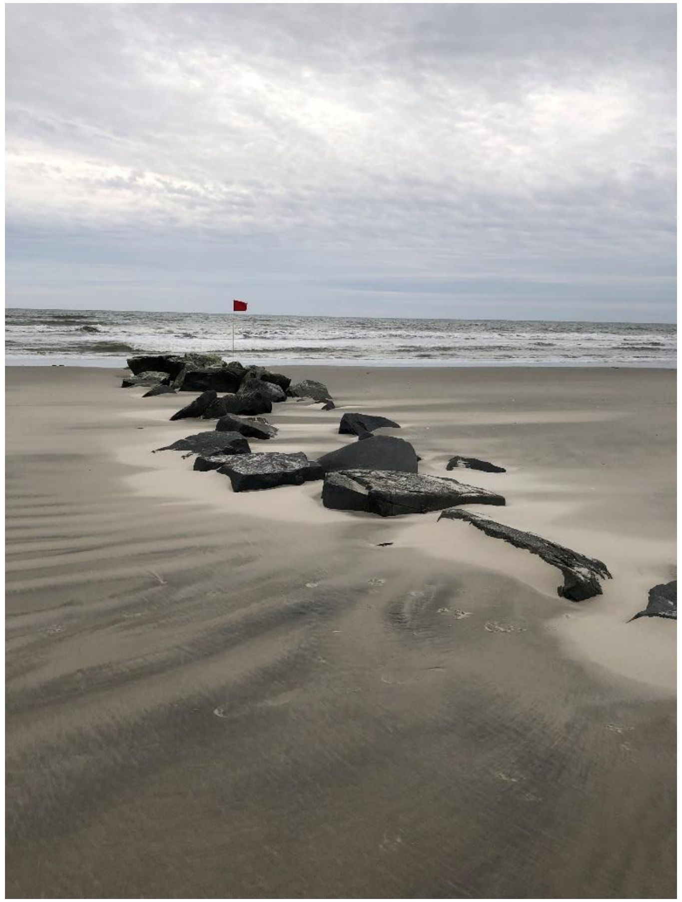


Photo Credit: Mott MacDonald

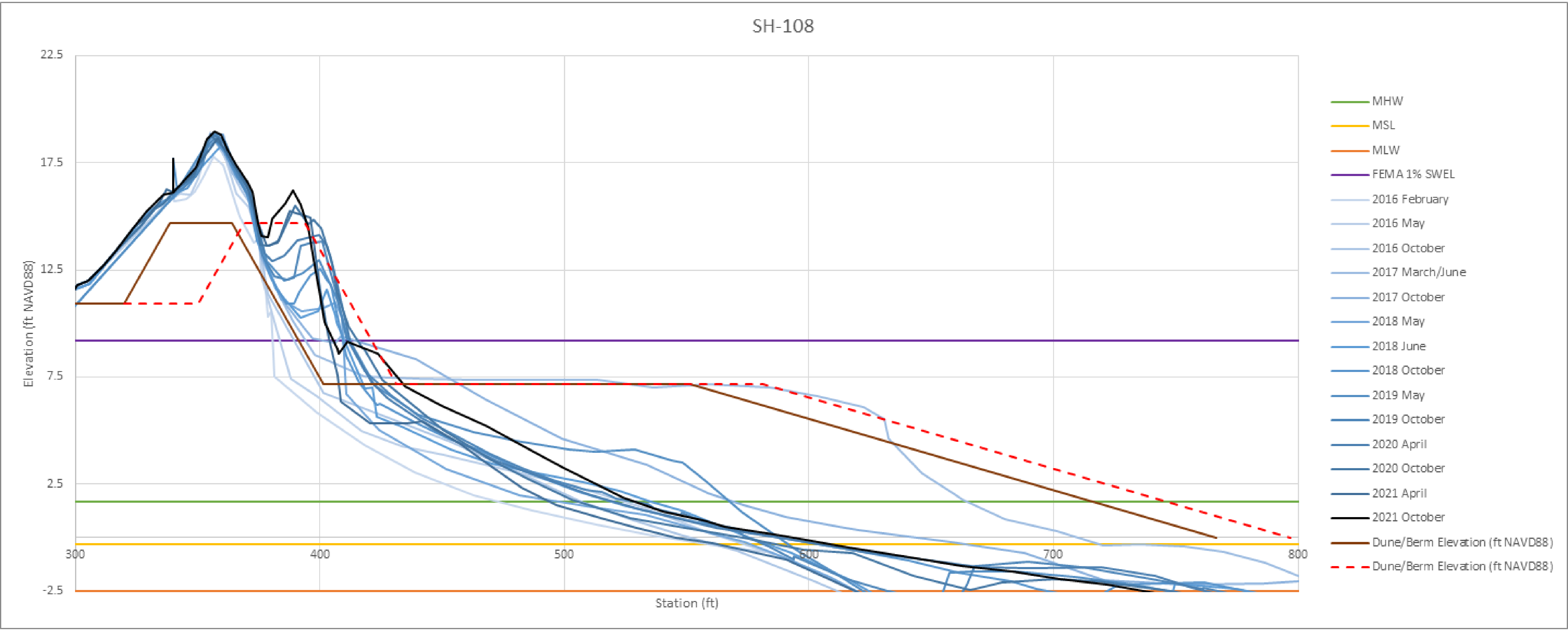
Beach Erosion and Dune Scarping

111th Street after Mother's Day Nor'easter (May 2022)

Photo Credit: Geoffrey Woolery

Beaches

108th Street, Stone Harbor



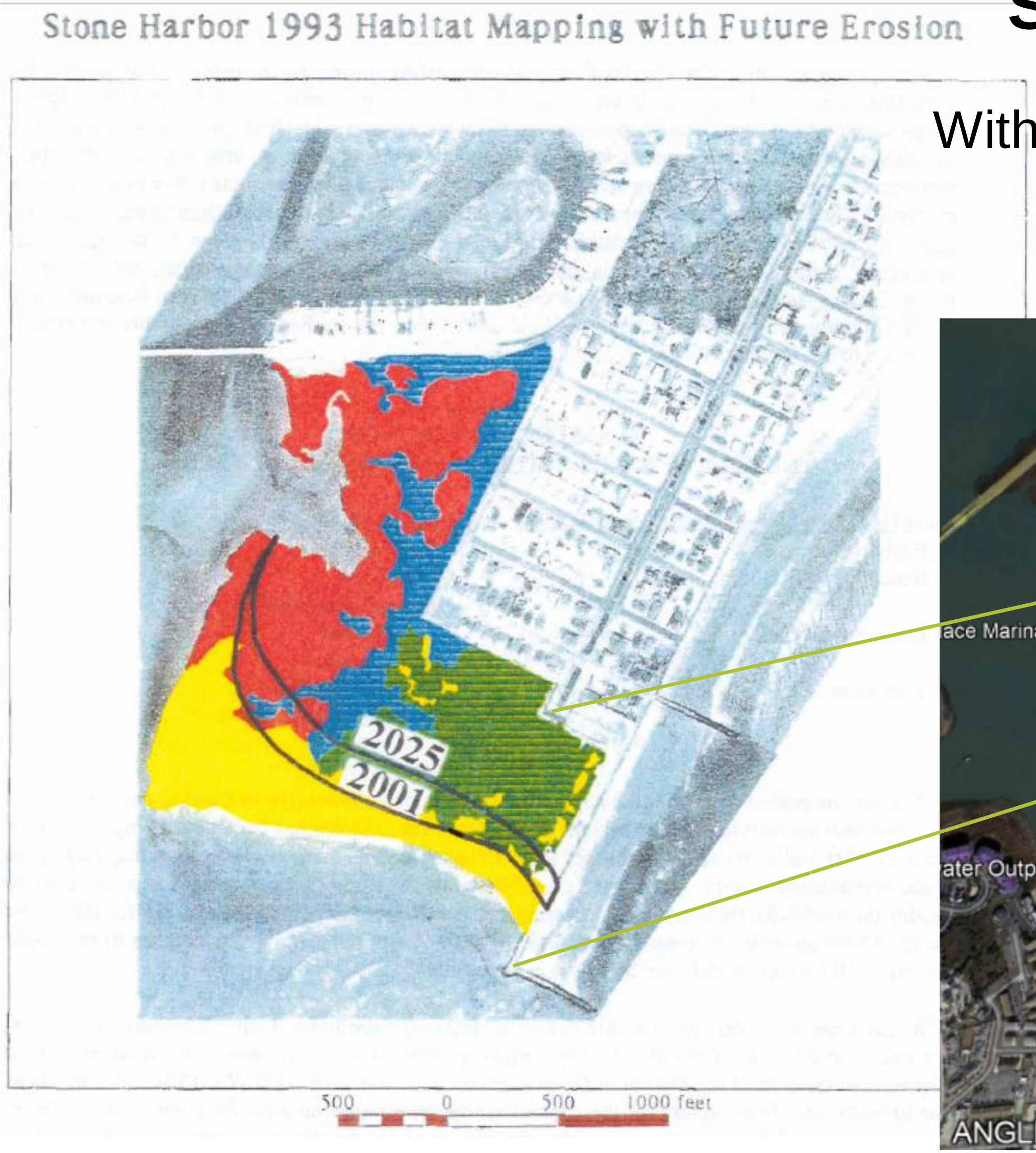
USACE Beach Fills

- 1 State/Local beachfill in 1998
  - 364,221 cubic yards
  - 98th to 111th
  - From Hereford Inlet
- 6 Federal beach fills from 2002 to 2017
  - Initial fill was 2.6 million CY
- Authorized periodic nourishment every 3 years dependent on funding and need

2002	Beach Fill (Sep. 2,611,133 cy); Nor'easter (Oct.); Kyle (Oct., McClellanville, SC, TS, 85 mph)
2003	Presidents Day Storm (Feb.); Isabel (Sep., Outer Banks, NC, Cat 5, 165 mph)
2004	
2005	Wilma (Oct., Yucantan Peninsula, MX, Cat 4, 144 mph)
2006	Florence (Sep., Cat 1, 90 mph)
2007	
2008	Hanna (Sep., Myrtle Beach, SC, Cat 1, 85 mph)
2009	Nor'easter Ida (Nov.); Beach Fill (Nov. 318,362 cy)
2010	Earl (Aug., Nova Scotia, CA, Cat 4, 145 mph)
2011	Beach Fill (Mar. 580,000 cy Response to Nor'easter Ida); Irene (Aug., Outer Banks, NC, Cat 3, 120 mp
2012	Sandy (Oct., Atlantic City, NJ, Cat 3, 110 mph)
2013	Nor'easter (March); Beach Fill (Jul. 674,224 cy Response to Sandy)
2014	
2015	Joaquin (Oct., Cat 4, 155 mph)
2016	Snowzilla (Jan.)
2017	Nor'easter (Jan.); Nor'easter (Mar.); Beach Fill (Mar. 394,000 cy); Beach Fill (May 320,000 cy Response to Nor'easters); Jose (Sep., Cat 3, 155 mph)
2018	Nor'easter (Mar.); Nor'easter (Nov.)
2019	
2020	Fay (Jul., Atlantic City, NJ, TS, 60 mph); Isaias (Aug., Ocean Isle Beach, NC, Cat 1, 85 mph); Zeta (Oct., Cocodrie, LA, Cat 3, 115 mph)
2021	Elsa (Jul., Taylor County,FL, Cat 1, 85 mph); Ida (Port Fourchon, LA, Cat 4, 172 mph)
2022	Mothers Day Storm (May)

Shoreline prediction in 1993 - USACE

Without beachfill project



November 2021 with Federal beachfill project

Groins/Jetties in Stone Harbor

NJ Dept. of Conservation and Economic Development, Project 477, 1956

- 84th St., 92nd St. and 98th St. Groins: 300 feet timber with 120 feet of stone end

NJ Dept. of Conservation and Economic Development, Project 302, 1950

- 106th St. Groin: 310 feet timber with 120 feet of stone end
- 111th St. Groin: 230 feet timber with 120 feet of stone end

NJ Board of Commerce and Navigation, 1943, rebuilt under Project 302, and again in 1970

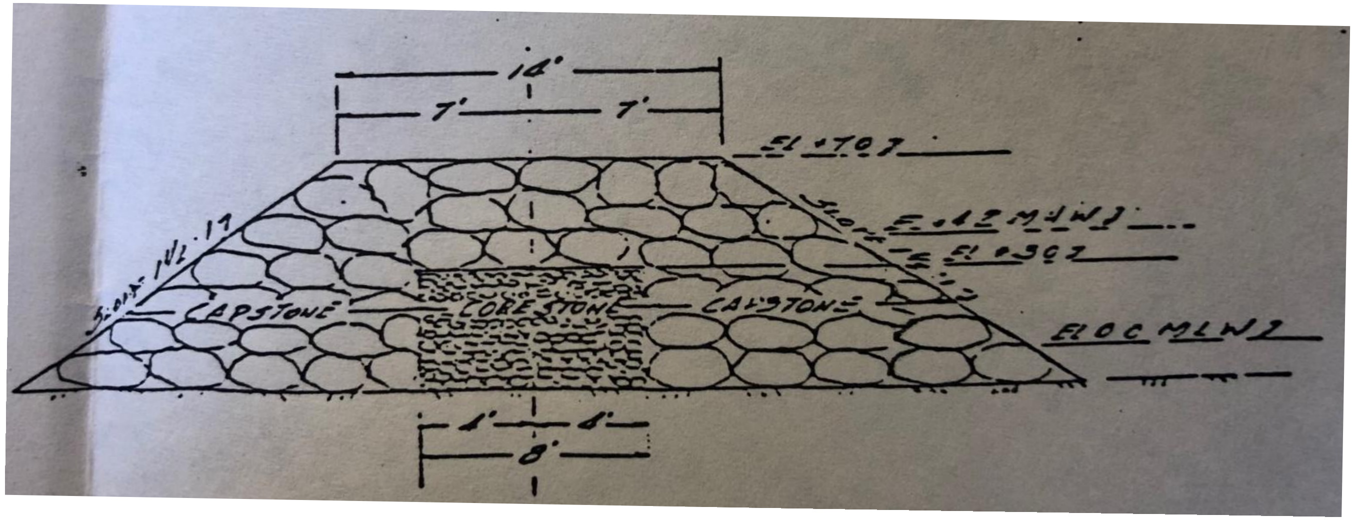
- 114th St. Groin: ~ 500 feet stone

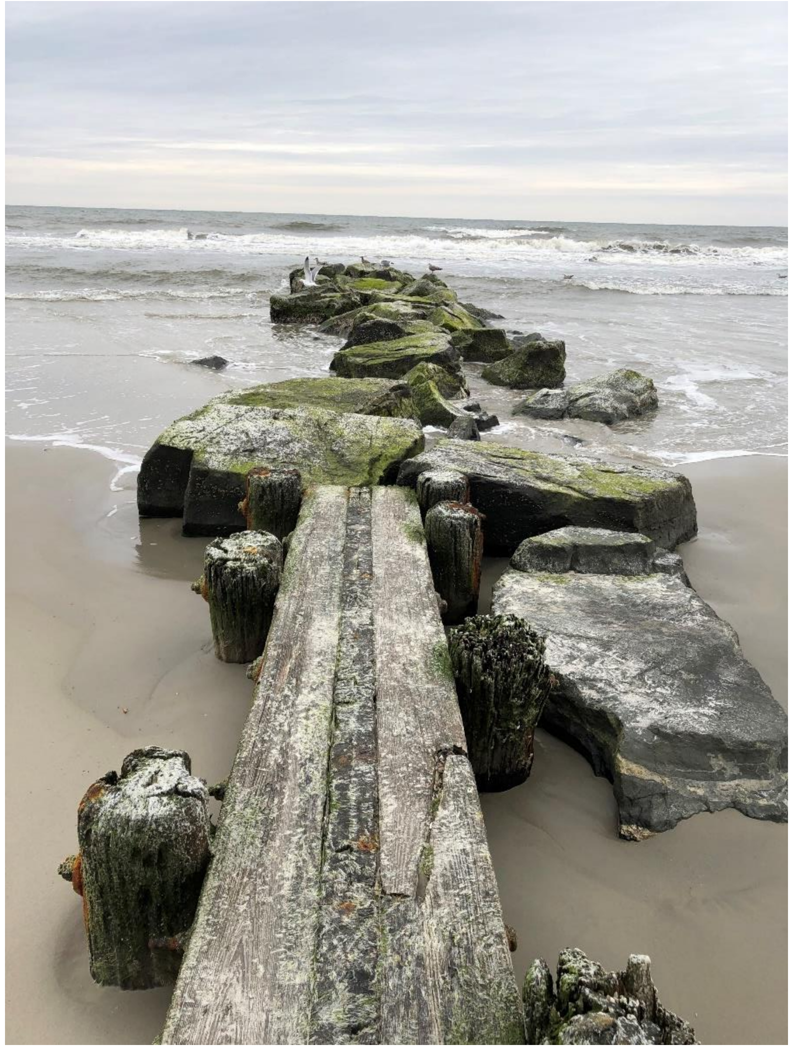
NJ Dept. of Conservation and Economic Development, Project 81.01:420-451-855, 1967

- 122nd St. and 127th St. Groins: 440 feet stone

Example Jetty

- **106th St. Groin: 230 feet timber with 120 feet of stone end**
- **Designed for a lower sea level**
- **All jetties were considered part of the Corps' design in 1997**
- This means that the nourishment volumes were determined based on these groins functioning



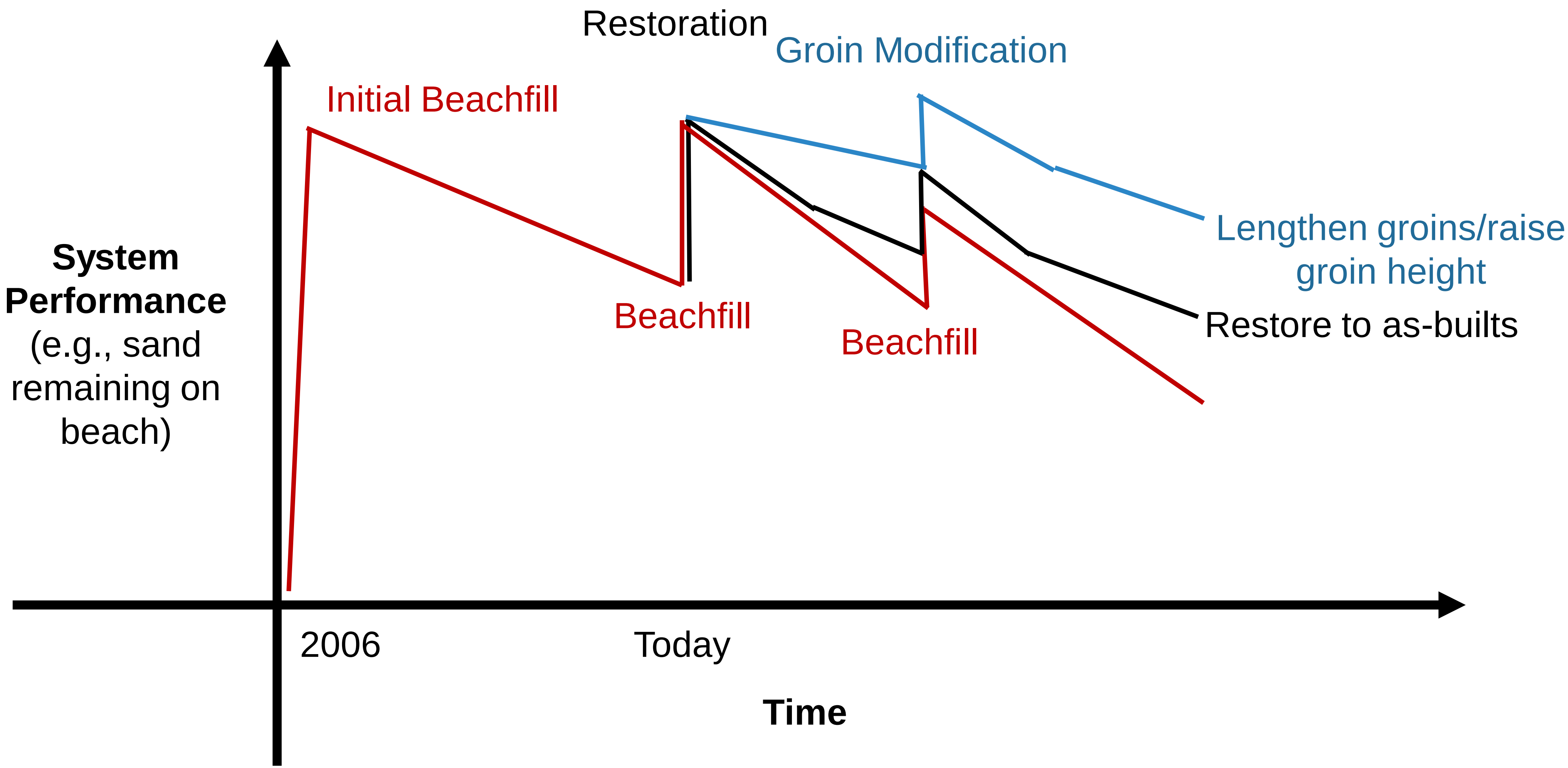


127^{th} Street Groin

Hobie Beach and Stone Harbor Point

- **+7 ft NAVD elevation at landward end**
- **+1 ft NAVD elevation at seaward end**
- **440 linear feet**
- **Unusual design – generally groins have a flat portion on the upper beach to hold sand, then slope down**
- **Existing structure is too short and too low**

Building Resilience – a graphical representation



Proposed Feasibility Study

Conceptual Evaluation

Wide variety of options for evaluation. Cost, effectiveness, and permittability.

Schematic Design

Select a few options that have merit and conduct preliminary designs. Take a more in-depth look at cost, effectiveness, and permittability.

Numerical Modeling

Build the hydrodynamic and sediment transport model. Calibrate and verify the model. Conduct initial Phase 1 modeling of schematic designs.

Propose a Preferred Design(s).

Determine costs for final design and permitting. Permitting will likely require additional modeling

Potential Alternatives to Provide Long-term Beach Maintenance

Category	Option	Model
Groins	Refurbish in present condition	✓
	Lengthen/tighten – remove 111th St groin	✓
	Add groins	
	Porous groin system	
	Sand web/dune fencing	
Dredging	County-wide/community dredging	
	County-owned nearshore dredge	
	Mobile eductor system	
	Geotextile tubes with dredged sand	
Beach management	Obtain sand from Great Channel and/or add olivine	
	Beach scraping	✓
	Sand fencing	
	Sand harvesting	
Breakwaters	Rubble-mound breakwaters	
	Living breakwaters	

Modeling

Long Term Response

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Stone Harbor Long Term Shoreline Morphology

Modeling Process

Step 1 Wave Modeling

Step 2 Shoreline Morphology Modeling

Step 3 Alternatives Analysis

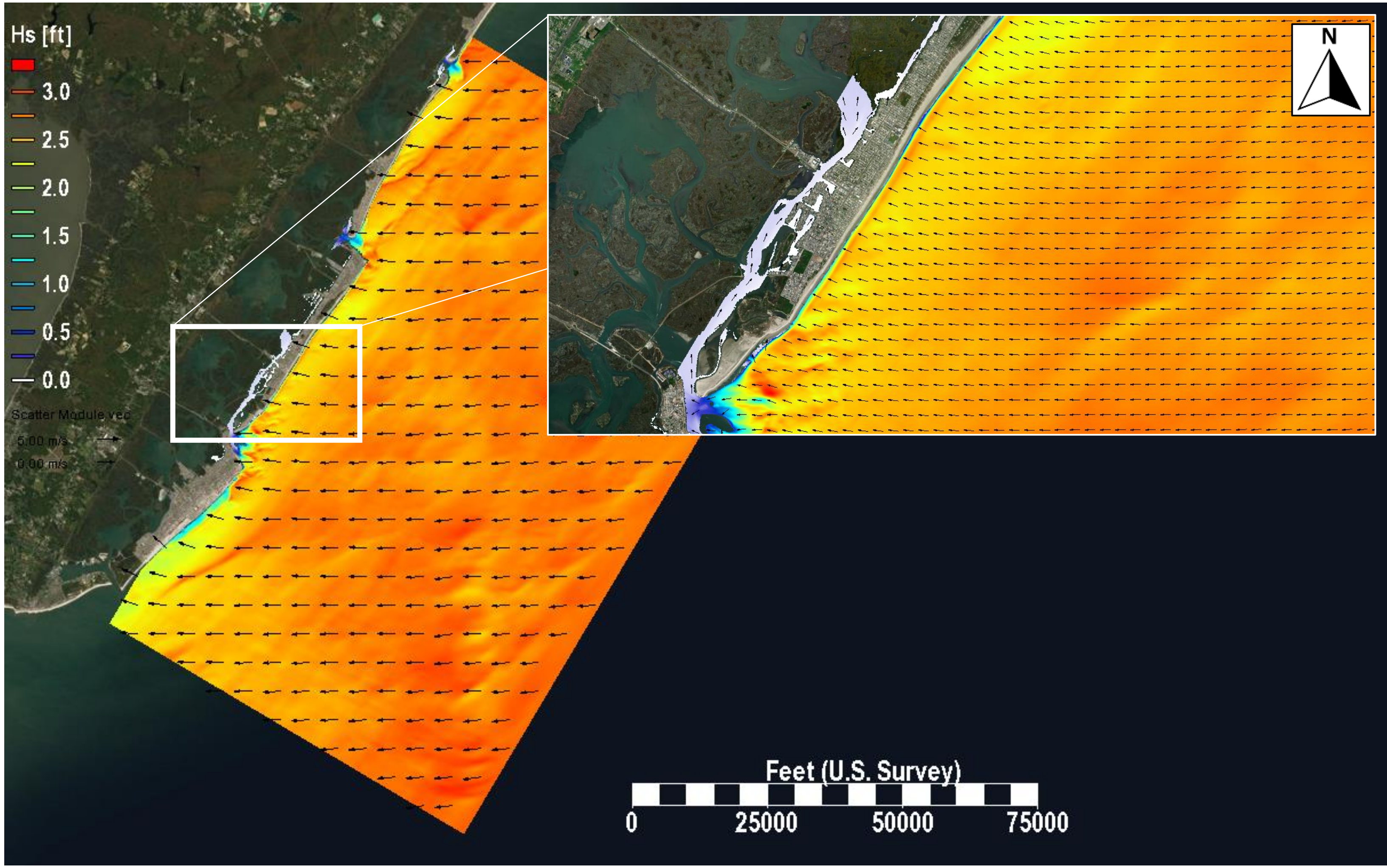
Wave Model

Setup & Typical Results

Numerical modeling conducted to develop long-term nearshore waves.

Nearshore waves developed for 39-year timeframe (1980-2019)

Example typical conditions shown on right.



Wave Model

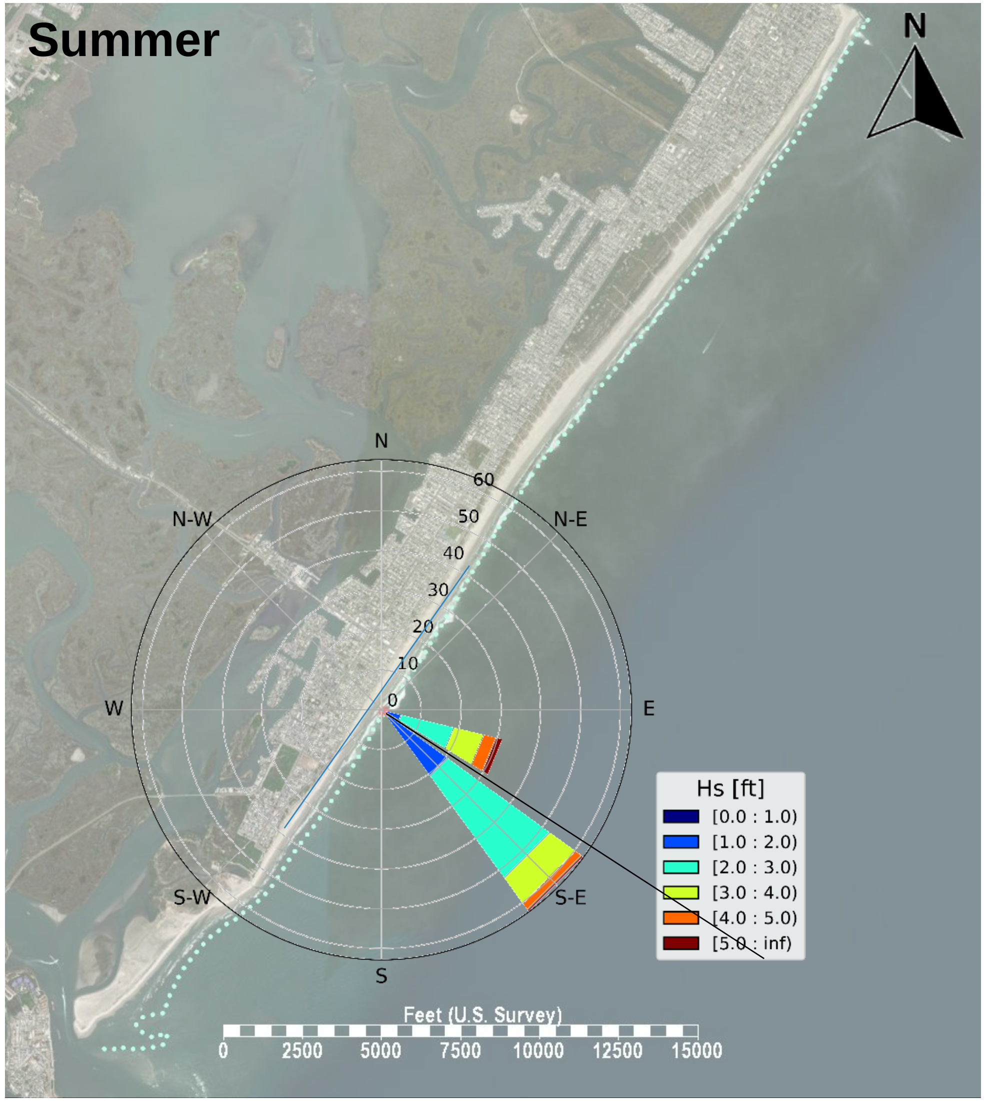
Directional Wave Roses

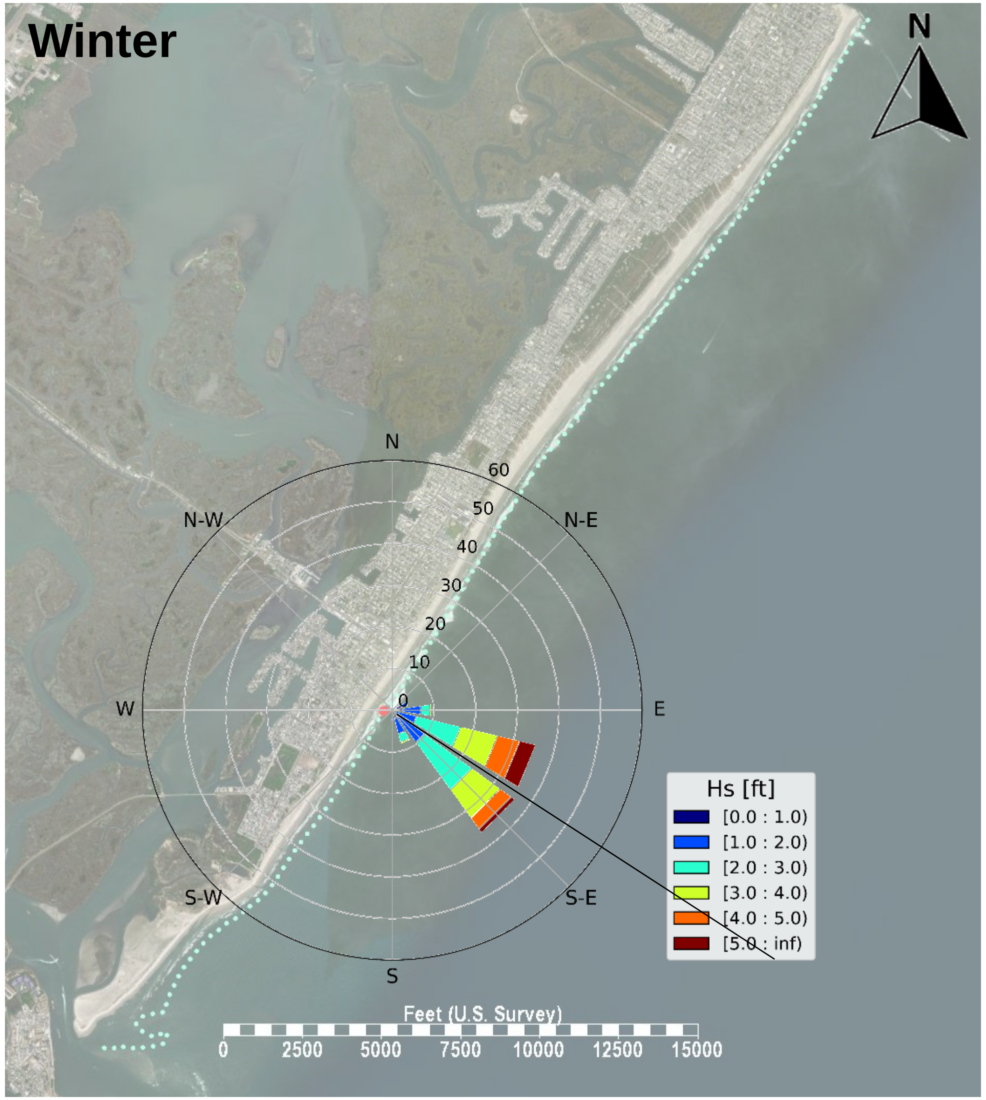
Summer:

- Smaller SE waves. (Bi-Directional Transport)

Winter:

- Larger SSE and SE waves, (more southerly transport)





Shoreline Morphology Model

Setup & Validation

GenCade model used for shoreline morphology (USACE, 2012)

- Simulates long-term shoreline change from wave driven transport.
- Uses waves from long-term wave model.

Calibration period:

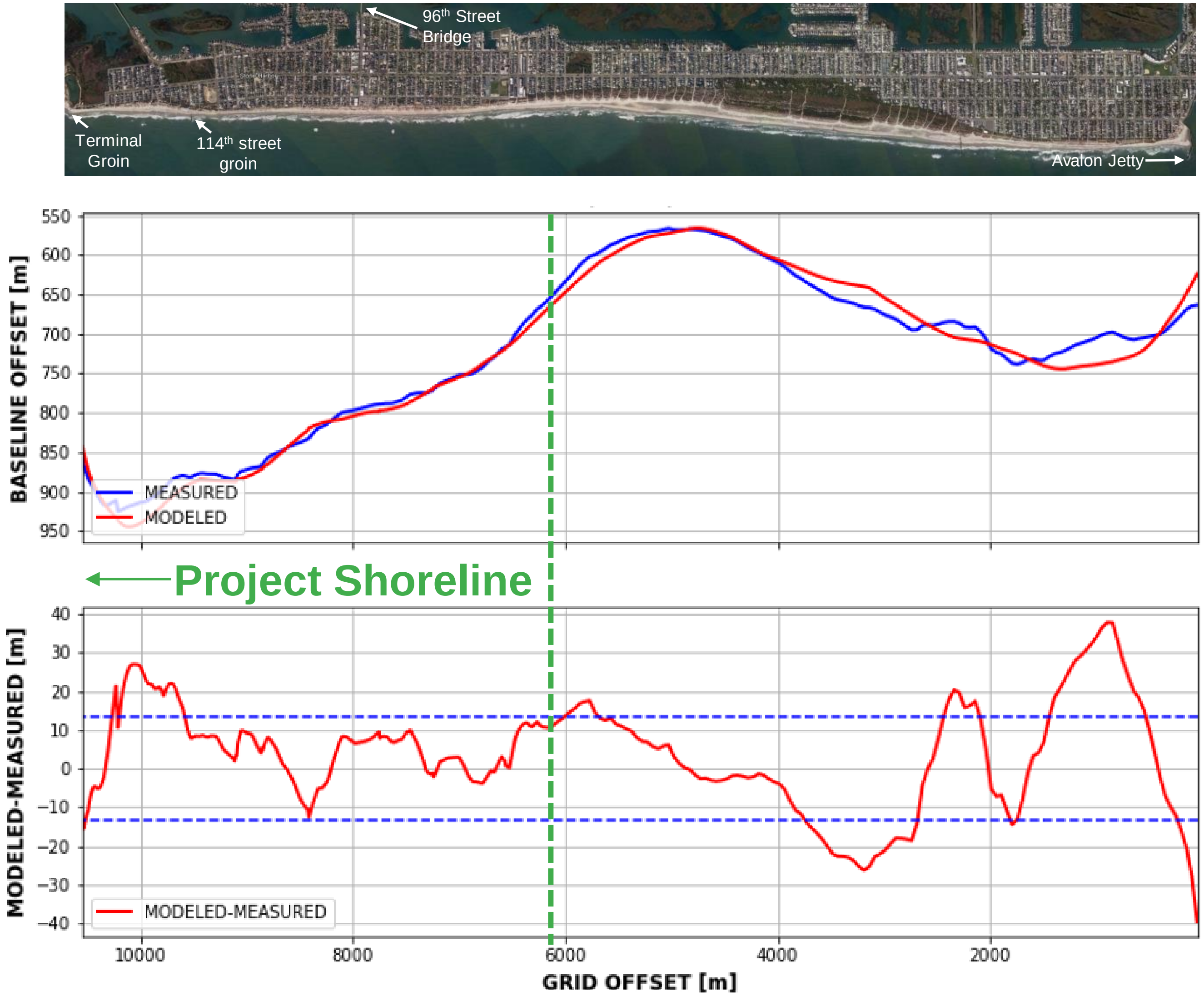
- 2013-2015

Validation period:

- 2006-2008 (results on right)

Good agreement for both calibration (not shown) and validation (shown) periods.

2006-2008 Validation Results



Shoreline Morphology Model – Transport Rates

Existing Conditions – No Beachfill

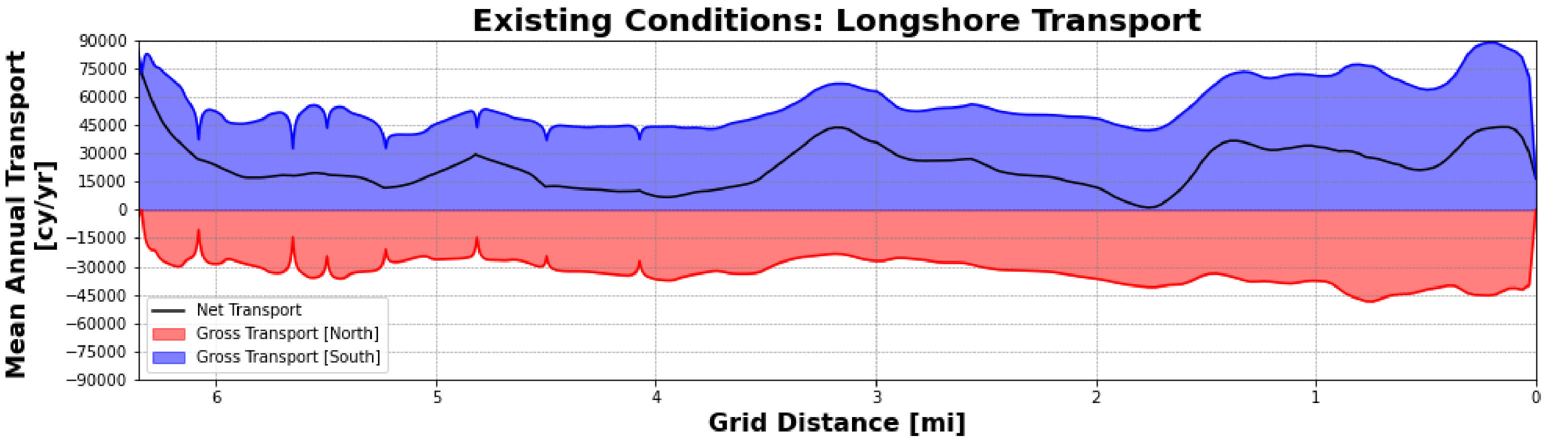
Modeled 3-yr timeframe (expected beach nourishment cycle).

Shoreline position & longshore transport for Existing Conditions on right.

- Dominant (net) Southerly transport, (gross) bi-directionality noted.

- Increased transport near Terminal Groin (127th Street).
- Sand Bypasses since groin compartment is filled
- Porosity is high due to low elevation and length

Overall Yearly Longshore Transport Visualization



Shoreline Morphology Model

Alternative Setup Modeling

Goal:

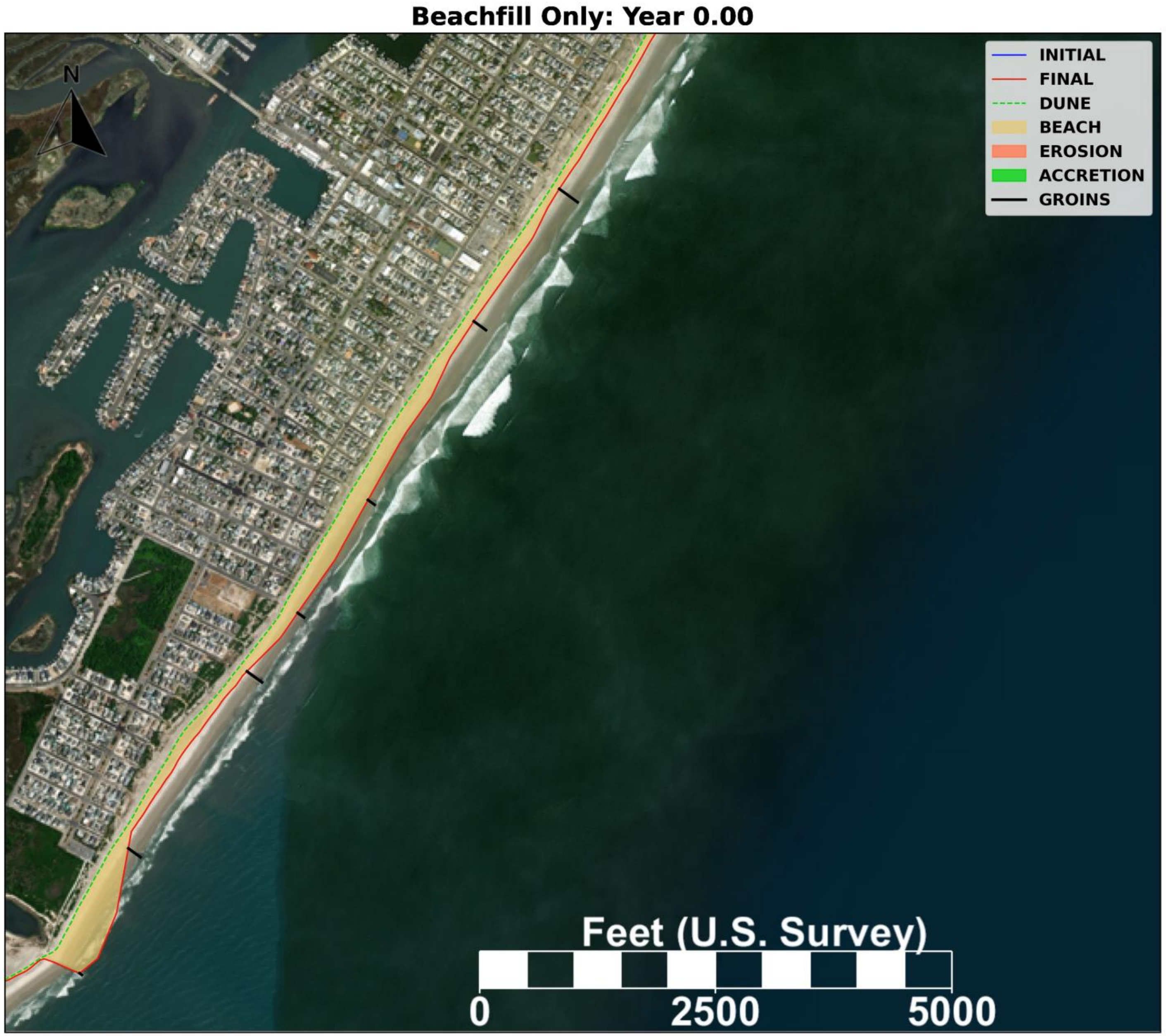
- Determine long-term performance of alternatives to retain USACE beachfill material.

Approach:

- Model 3-years of shoreline change based on representative wave conditions.

Output:

- Weekly output of modeled shoreline position.
- Example for with beachfill conditions shown to right.



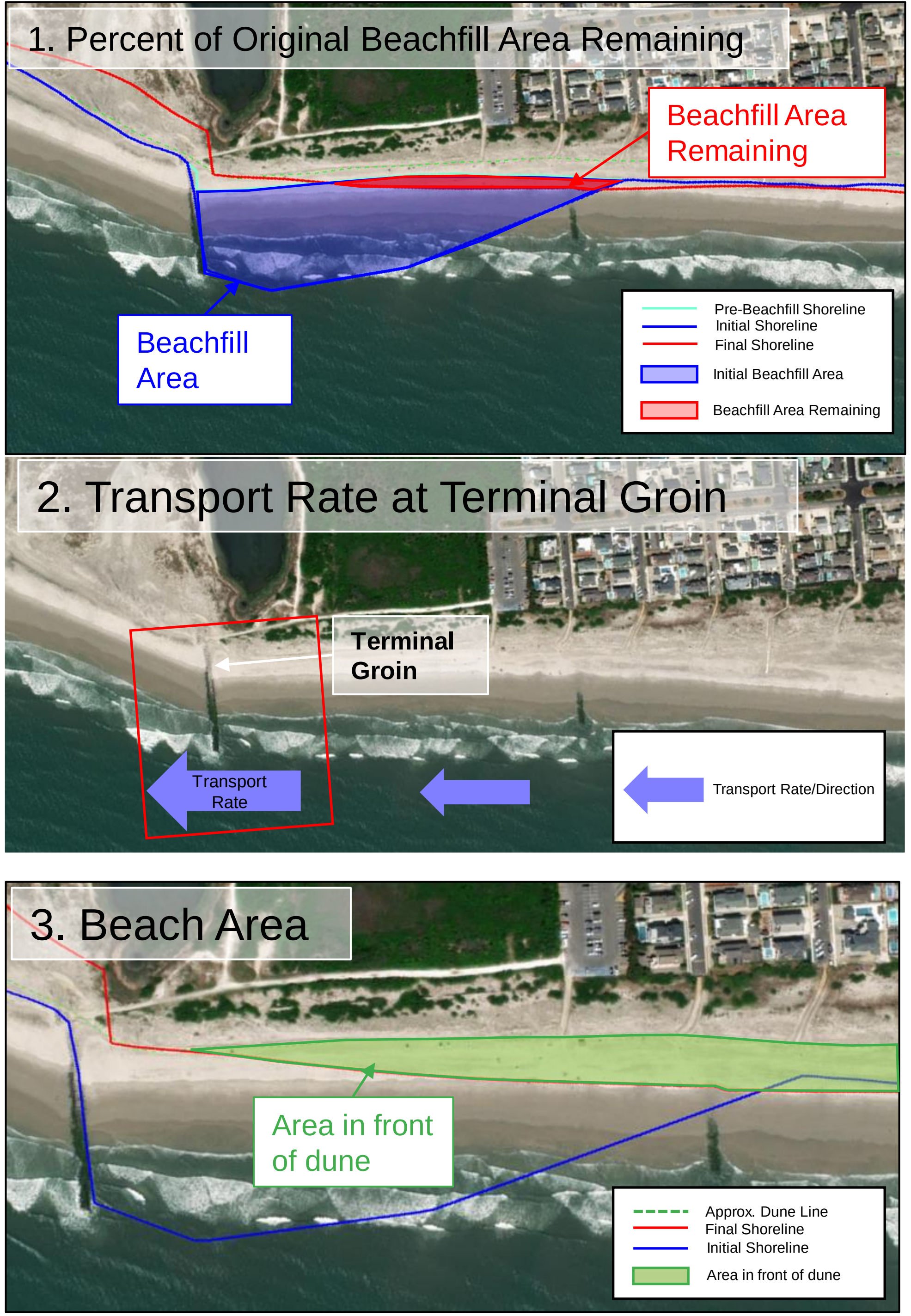
Shoreline Morphology Model

Performance Metrics

Performance Metrics (All at year 3):

1. Percent of original beachfill area remaining at year 3
2. Longshore Transport (cy/yer) past terminal groin
3. Beach Area in front of dune line [acres]

Visualization of Performance Metrics



Shoreline Morphology Model

Existing Conditions – Year 3

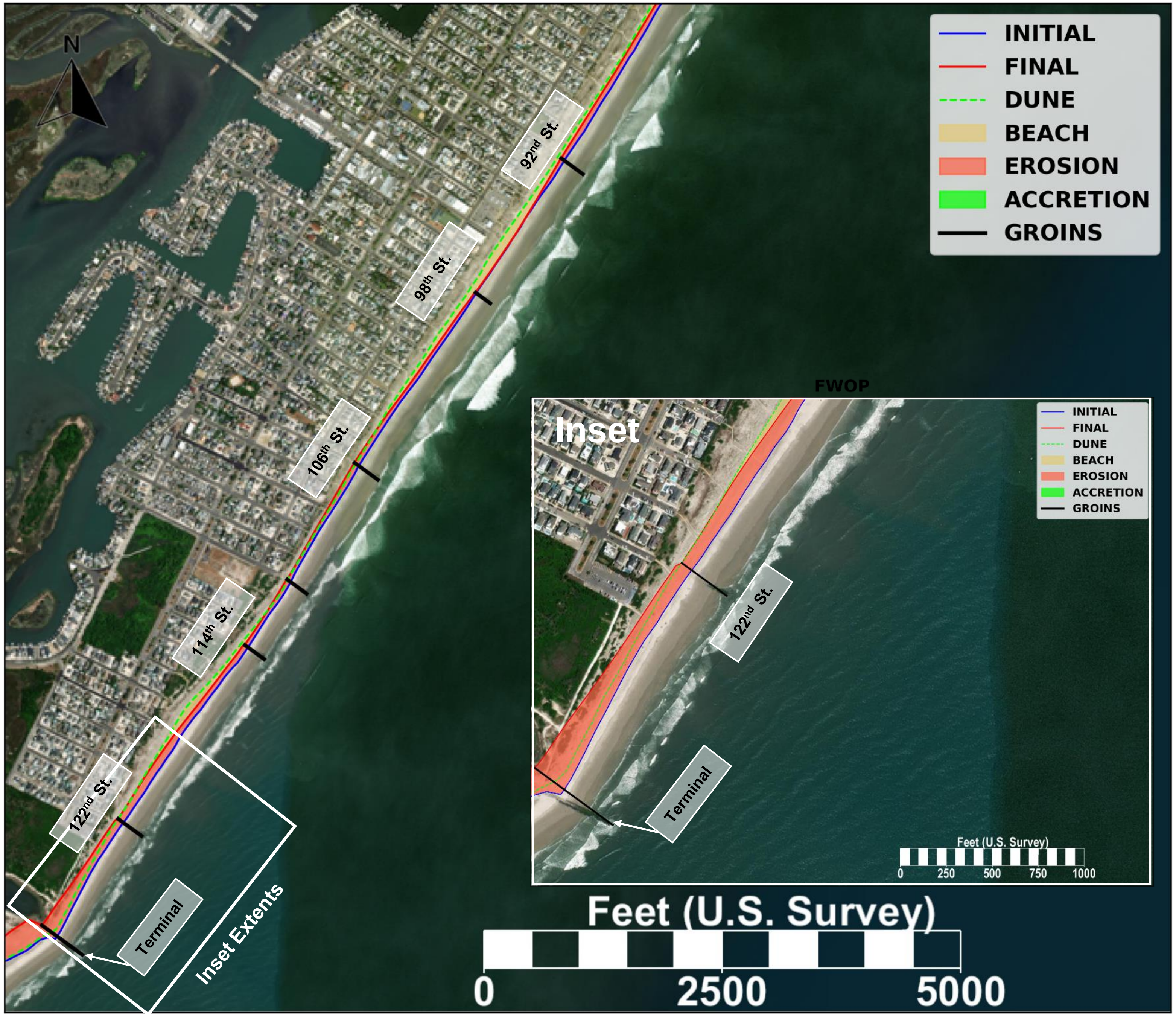
Description:

- No Beachfill included in this model run
- No changes to groins made.

Performance Metrics (at Year 3):

- Percent of Beachfill Remaining [%]: **--**
- Transport Past Terminal Groin, [kcy/yr]: **72.5**
- Area Seaward of Dune Line [acres]: **3,200**

FWOP



Shoreline Morphology Model

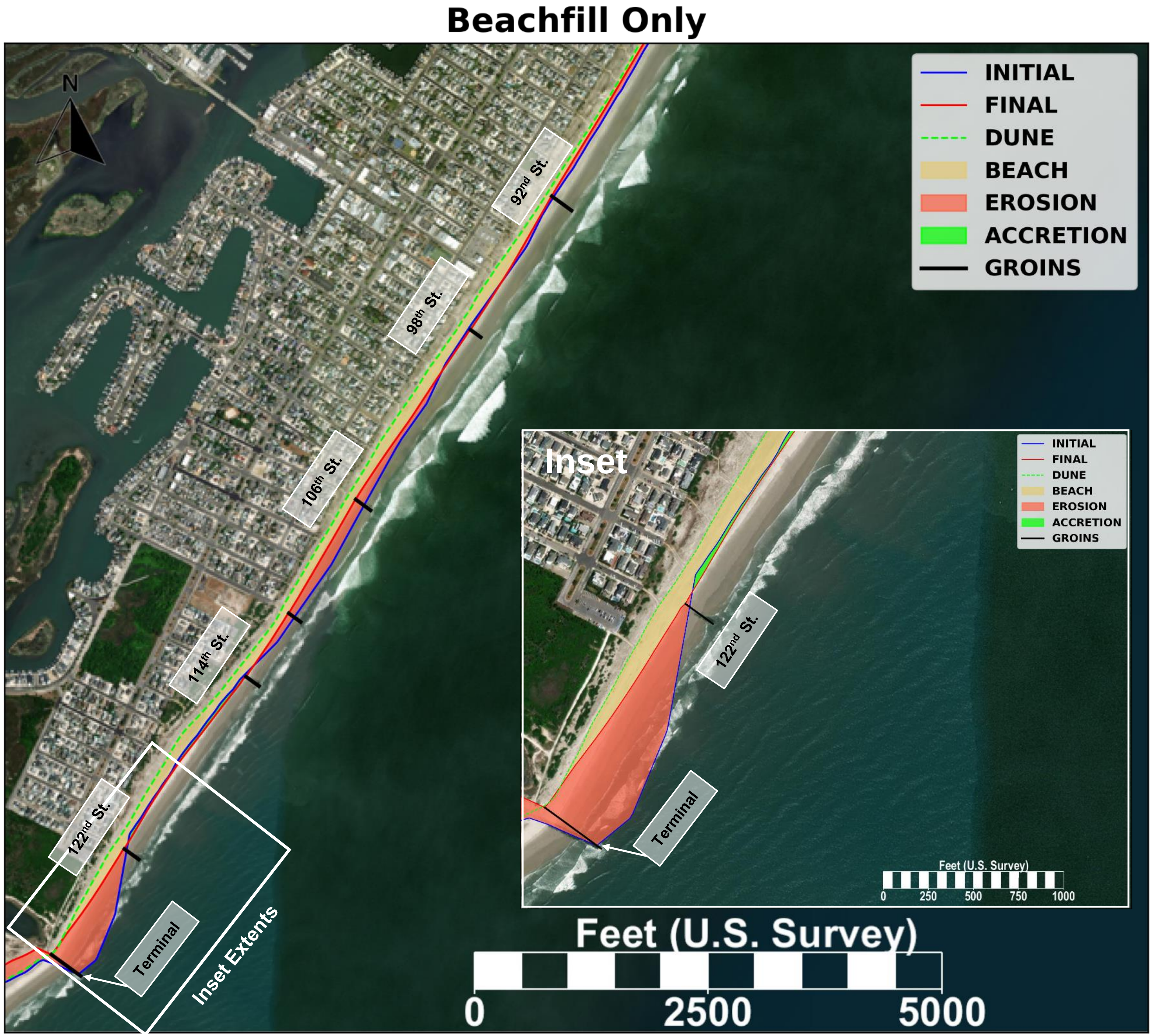
Beachfill Only – Year 3

Description:

- Includes USACE proposed beach berm.
- No changes to groins made.

Performance Metrics (at Year 3):

- Percent of Beachfill Remaining [%]: **26%**
- Transport Past Terminal Groin, [kcy/yr]: **104.8**
- Area Seaward of Dune Line [acres]: **21,400**



Shoreline Morphology Model

Alternatives

Alt	Description
Alt 1	Removes 111th street groin, tightens 98th and south.
Alt 2	Removes 111th street groin, tightens 98th and south. Extends terminal groin by 100 feet.
Alt 3	Removes 111th street groin, tightens 98th and south. Extends terminal groin by 250 feet.
Alt 4	Removes 111th street groin, tightens 98th and south. Extends terminal groin by 500 feet.
Alt 5	Removes 111th street groin, tightens 98th and south. Extends terminal groin by 500 feet. Extends 98th to 122nd by 100 feet.
Alt 6	Removes 111th street groin, tightens 98th and south. Extends terminal groin by 250 feet. Extends 98th to 122nd by 50 feet.

Shoreline Morphology Model

Zoomed View of 105th – 114th Street

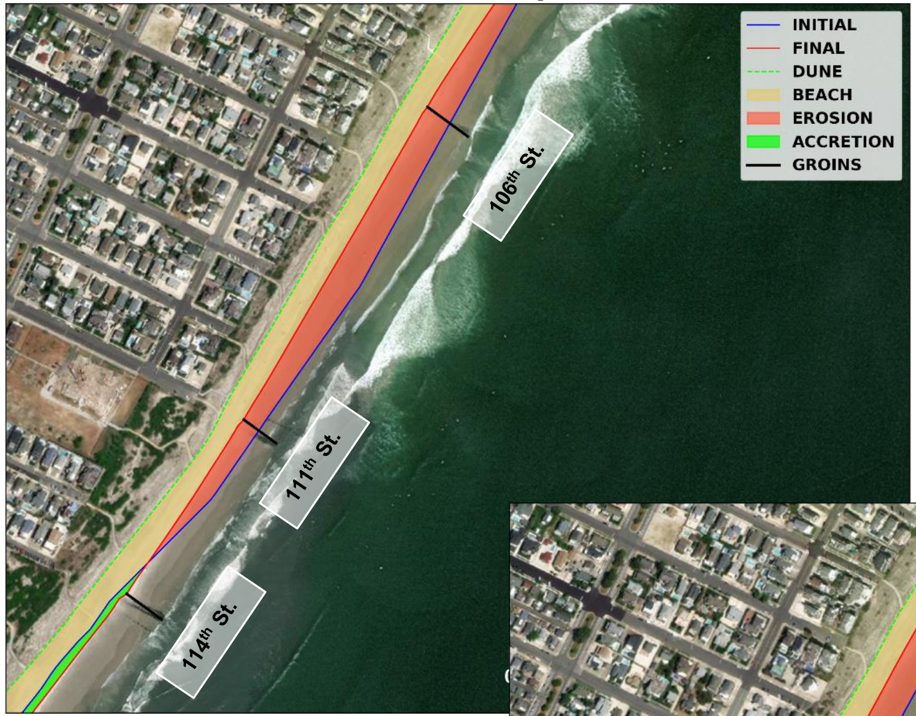
Model performance further from terminal groin very similar for beachfill only, and with alternatives.

- Top: Beachfill Only (i.e. no changes to groins).

- Bottom: Alt 5
  - 500’ Extension of Terminal Groins
  - 100’ Extension of 98th,106th, 114th, 122nd groins.
  - Removal of 111th street Groin.

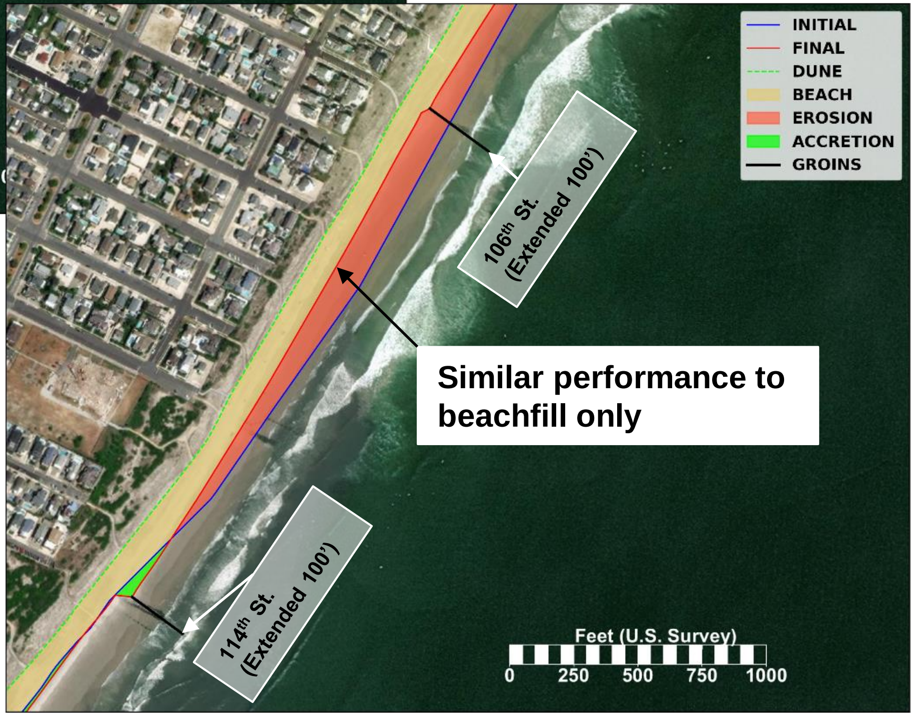
Beachfill Only

Beachfill Only



Alt 5

Alt5

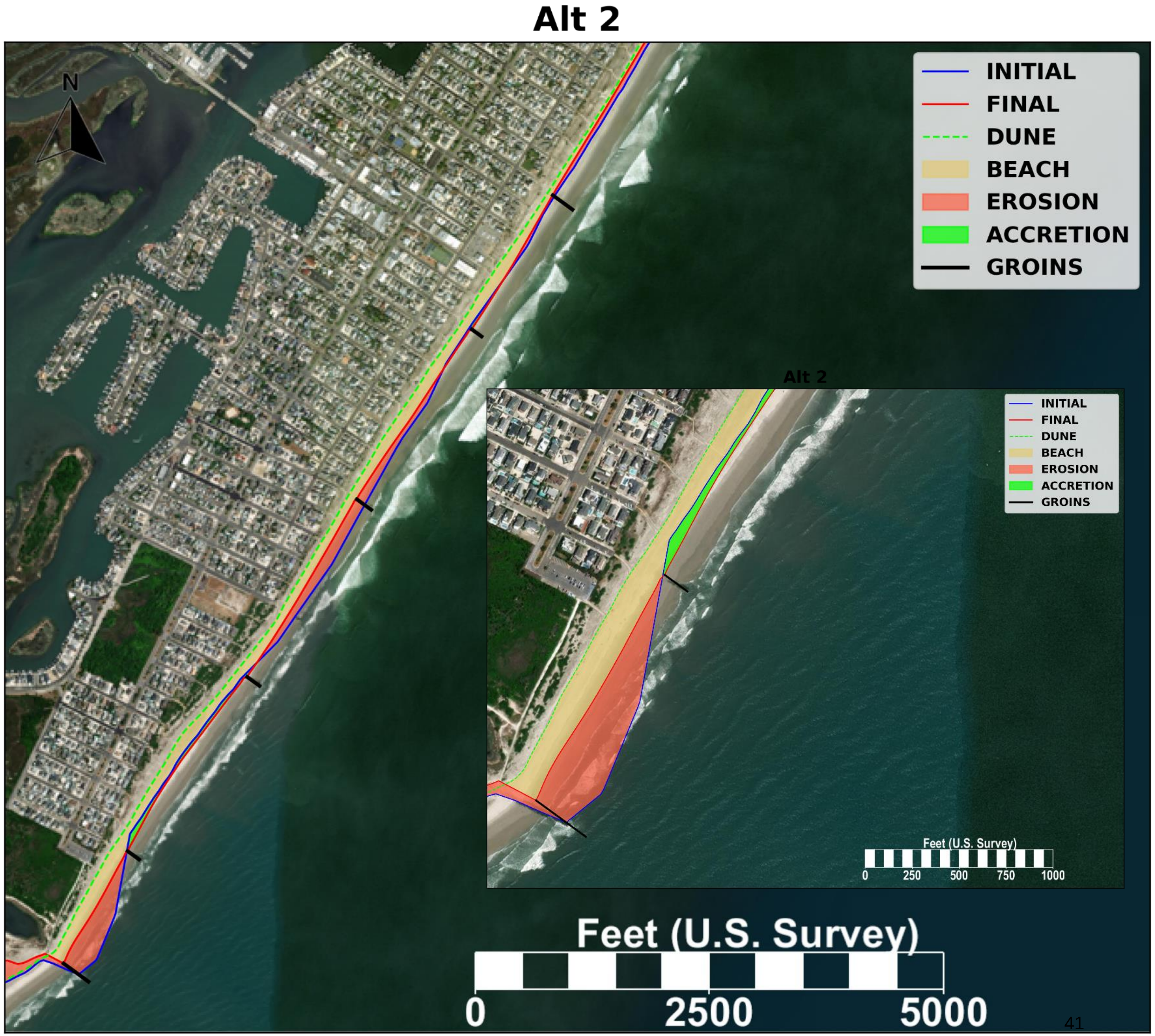


Test – without 111th

Is removal of 111th street worth it?

- Beachfill Remaining (pct, year 3):
  - 42.4%

- Area Seaward of Duneline (dry beach, year 3):
  - 24,827



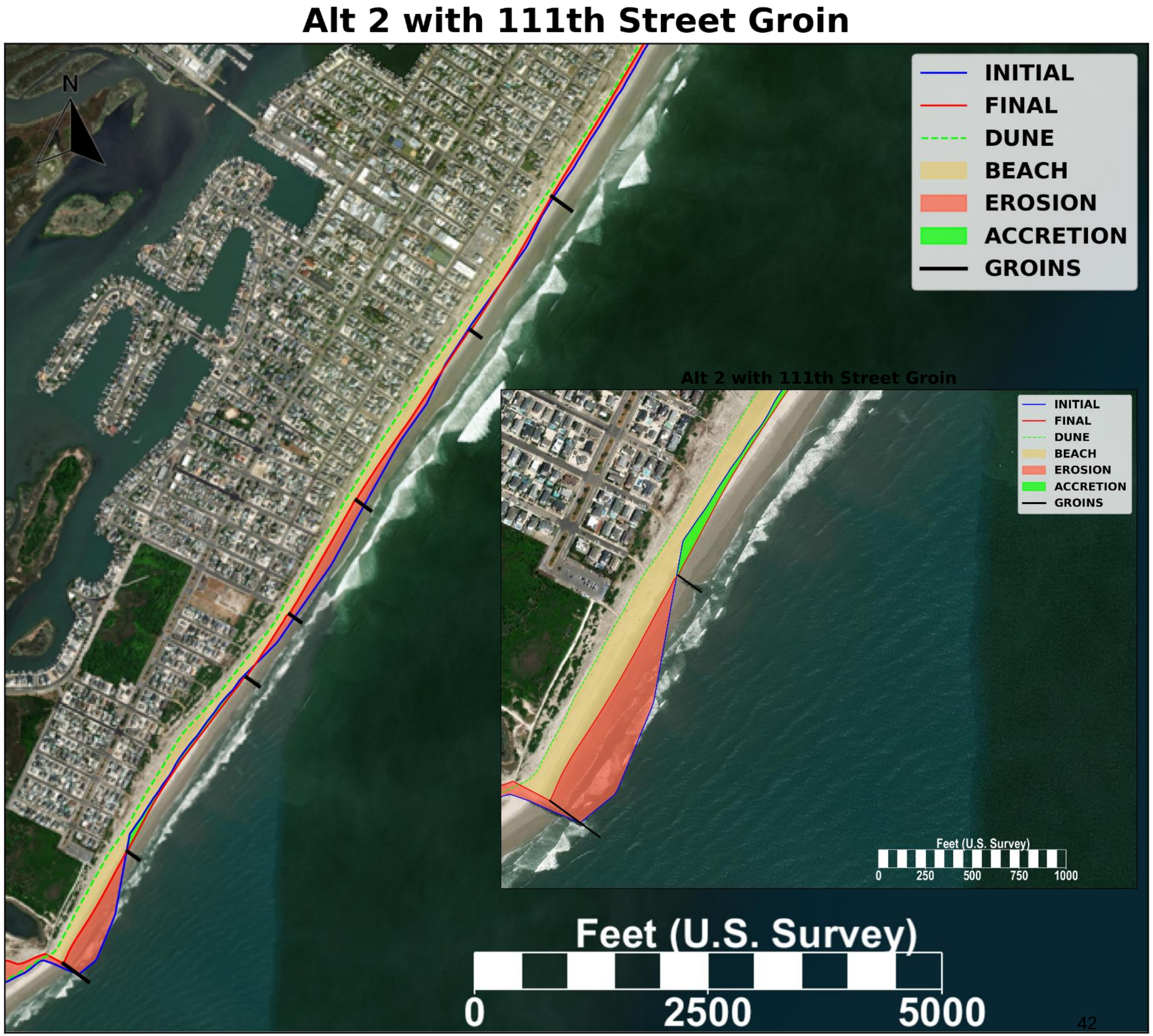
Test – with 111th

Is removal of 111th street worth it?

- Beachfill Remaining (pct, year 3):
  - 42.4%

- Area Seaward of Duneline (dry beach, year 3):
  - 24,821

Conclusion: Only remove 111th if there are safety/aesthetic concerns. No performance improvement from removing.



Shoreline Morphology Model

Initial Conclusions

1. **Continued beachfills on a 3-year cycle are essential to maintaining equilibrium of the beach**

2. **Tightening (refurbishing) groins provides benefit (9% increase in percent of beachfill remaining at year 3).**

3. **Extending the terminal groin (127th Street) provides the greatest benefit and is recommended for additional modeling.**

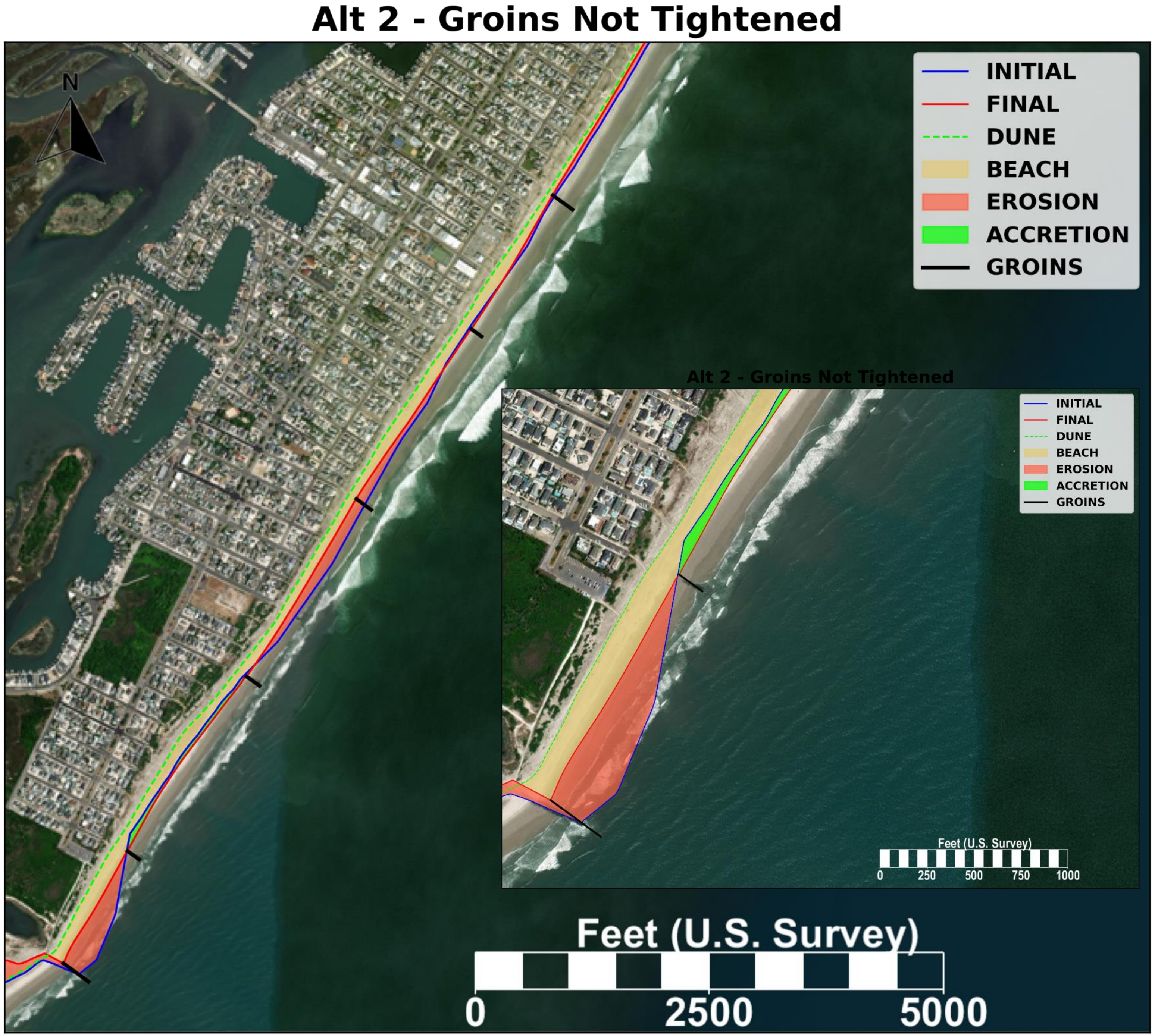
4. **Removal of the 111th Street Groin has little to no benefit**

Test – No groins Tightened

Is tightening 98th-122nd street groins worth it?

- Beachfill Remaining (pct, year 3):
  - 42.5%

- Area Seaward of Duneline (dry beach, year 3):
  - 24,800



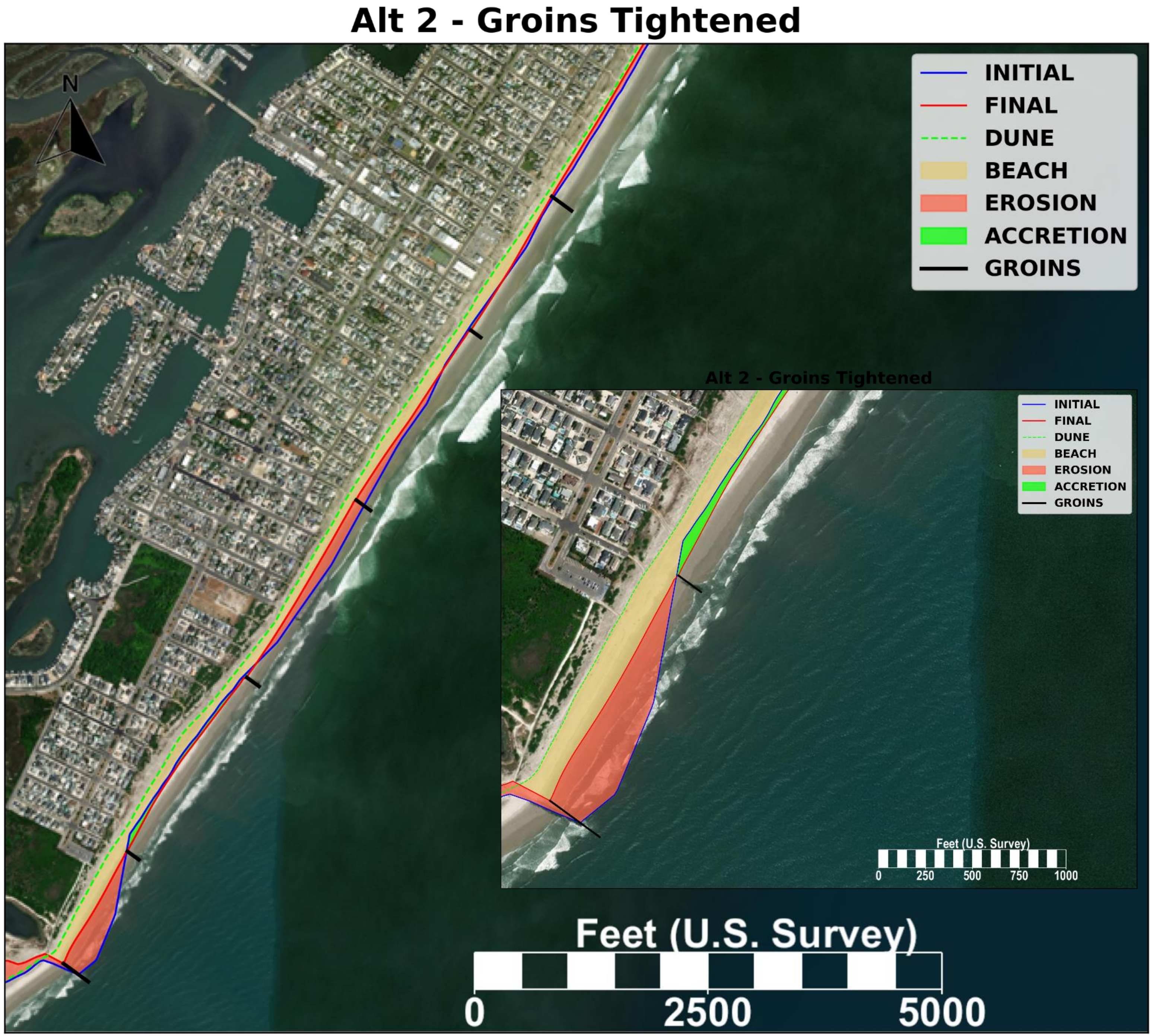
Test – All Tightened

Is tightening 98th-122nd street groins worth it?

- Beachfill Remaining (pct, year 3):
  - 42.5%

- Area Seaward of Duneline (dry beach, year 3):
  - 24,800

Conclusion: Only tighten 98th – 122nd if there are safety/aesthetic concerns.
No performance improvement from tightening.

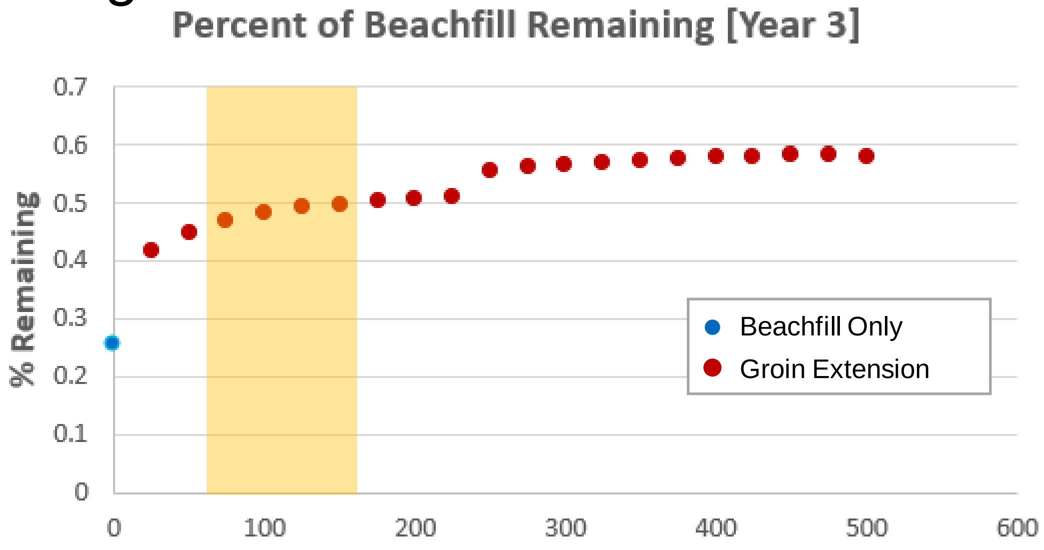


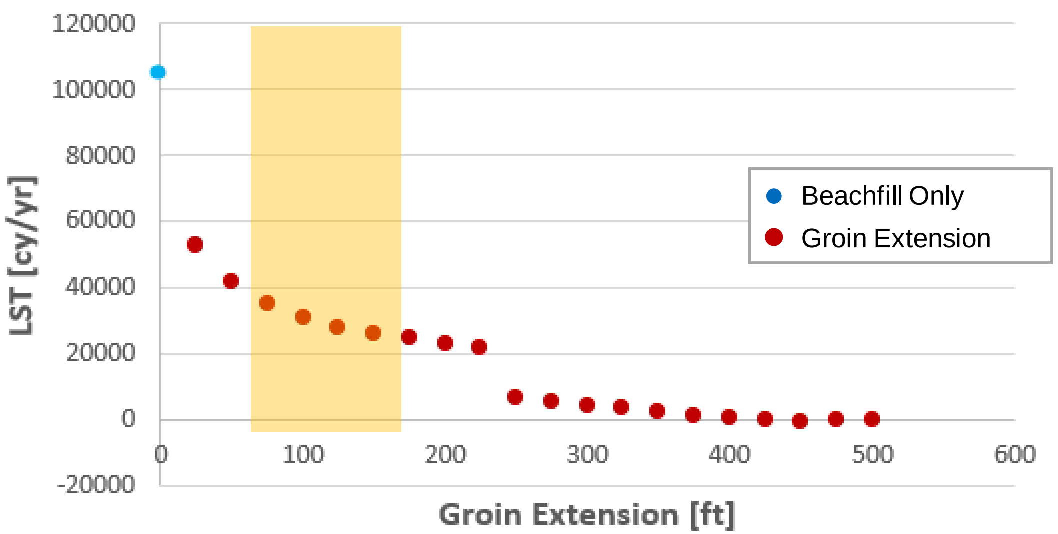
Test 3 – 3 years

What's the best bang for the buck for lengthening the 127th Street Groin

- Includes beachfill at year 0.
- Groin Extension Lengths tested:
  - 0' to 500'

- Performance curves on the right:
  - % of Beachfill Remaining, Year 3 (top)
  - Downdrift transport rate, median yearly (bottom)





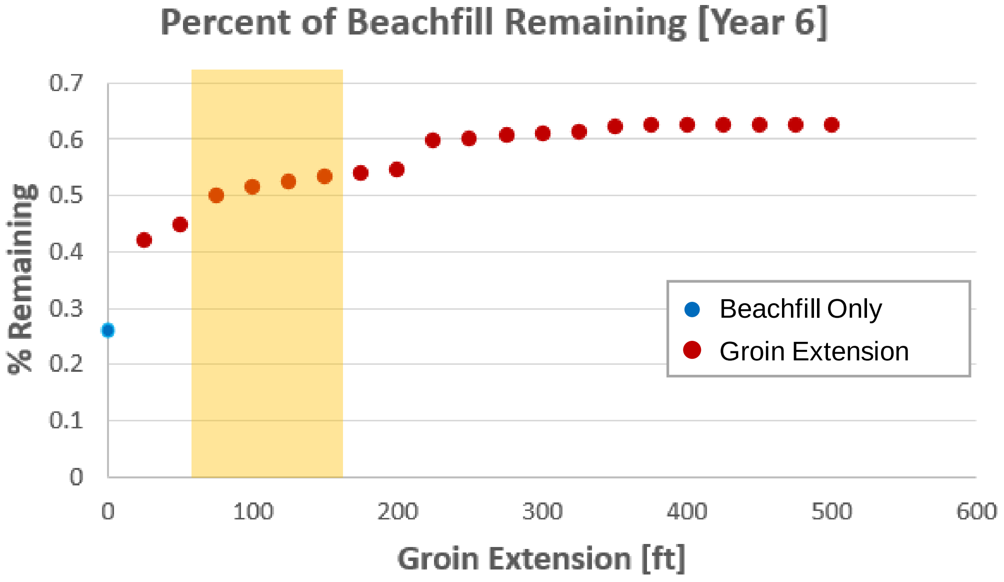
Conclusion: Somewhere in the 75-150' extension range looks best.

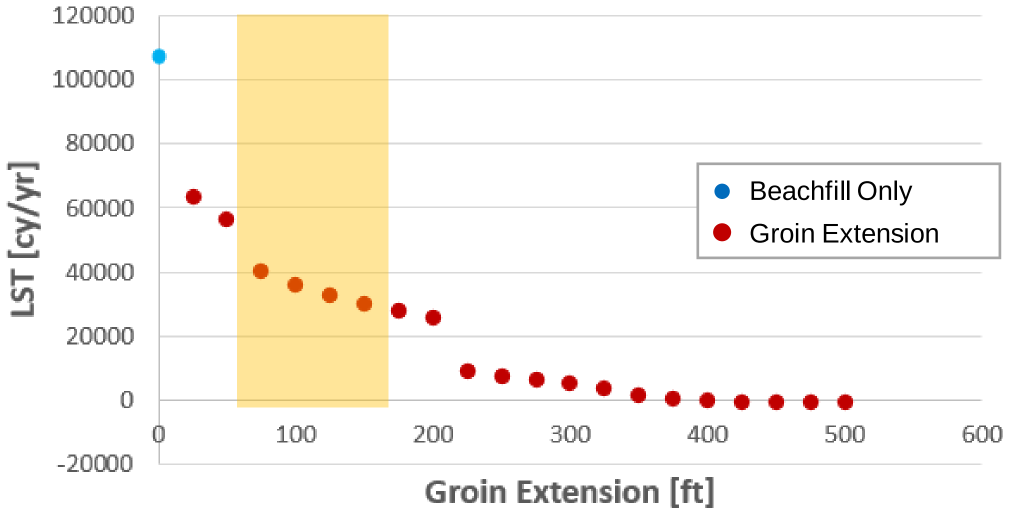
Test 3 – 6 years

What's the best bang for the buck for lengthening the 127th Street Groin

- Includes beach fills at year 0 & 3.
- Groin Extension Lengths tested:
    - 0' to 500'

- Performance curves on the right:
    - % of Beachfill Remaining, Year 3 (top)
    - Downdrift transport rate, median yearly (bottom)





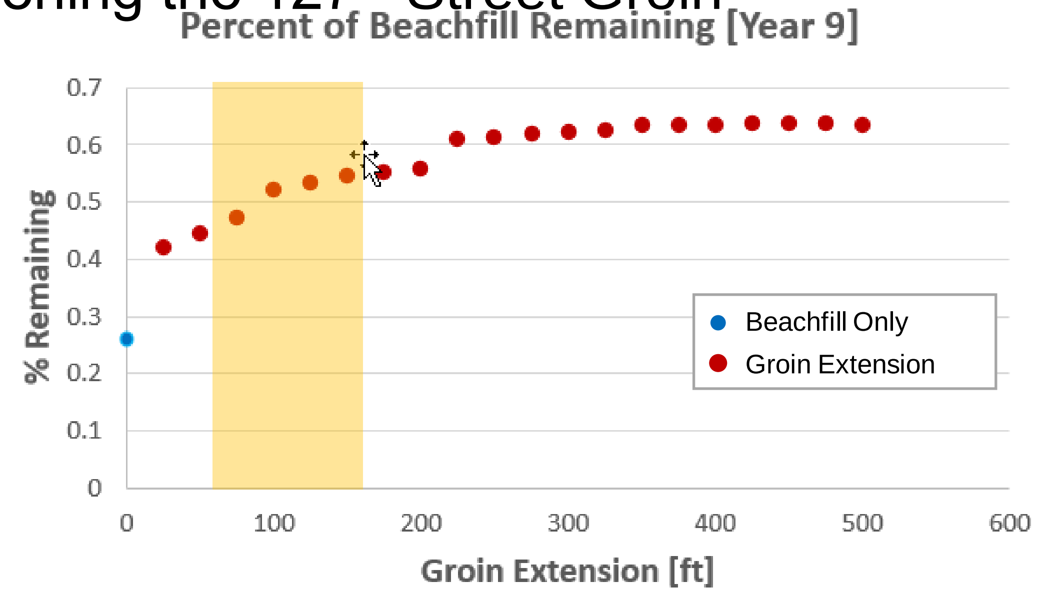
Conclusion: Somewhere in the 75-150' extension range looks best.

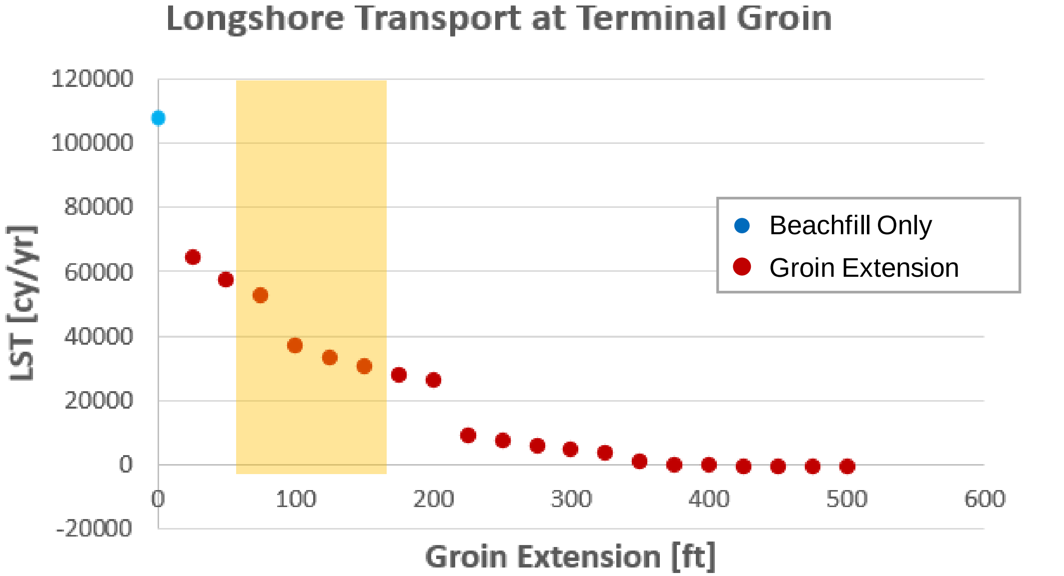
Test 3 – 9 years

What's the best bang for the buck for lengthening the 127th Street Groin

- Includes beach fills at year 0, 3, 6.
- Groin Extension Lengths tested:
  - 0' to 500'

- Performance curves on the right:
  - % of Beachfill Remaining, Year 3 (top)
  - Downdrift transport rate, median yearly (bottom)





Conclusion: Somwhere in the 75-150' extension range looks best.

Aerial Images

100’ Groin Extension

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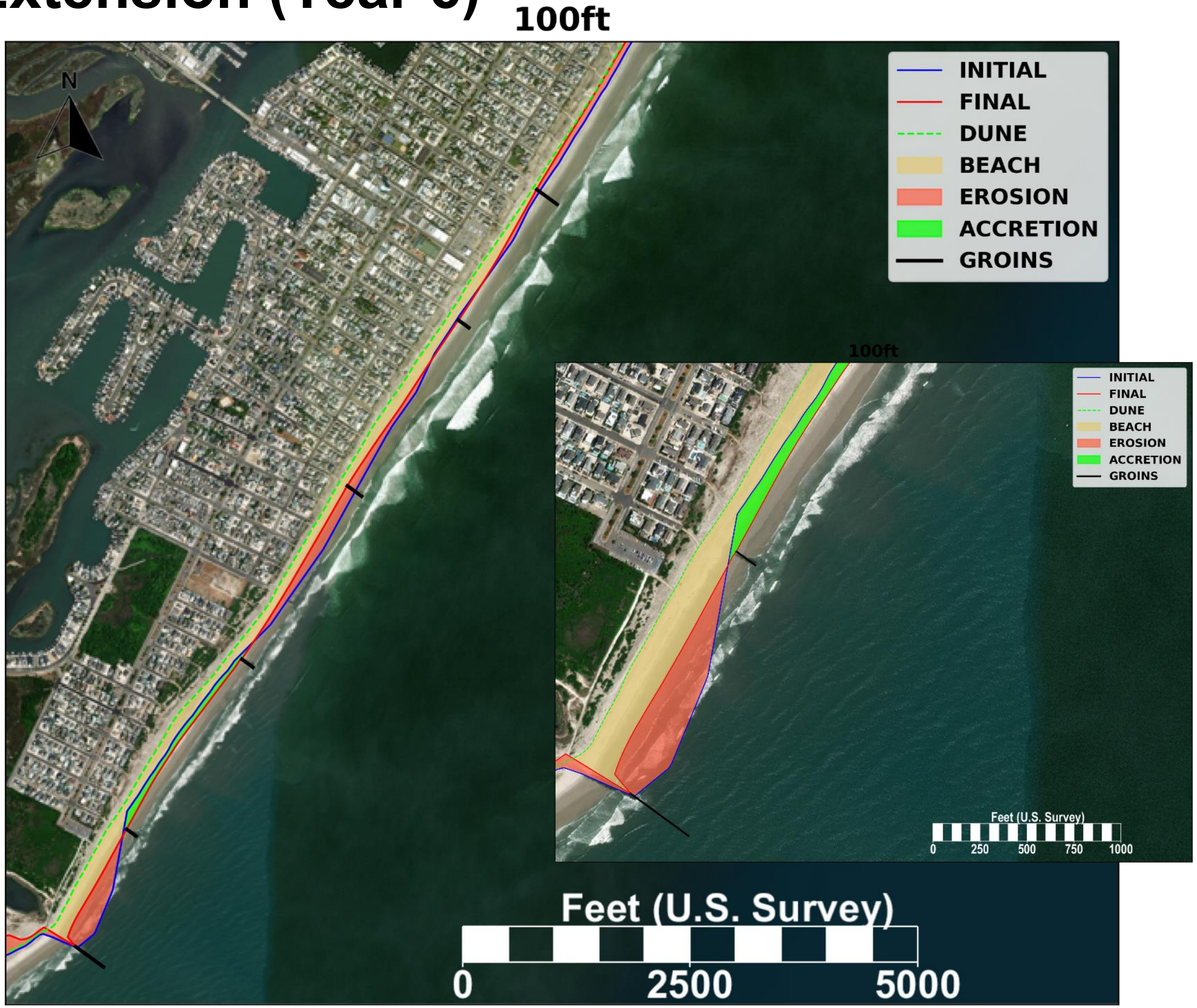
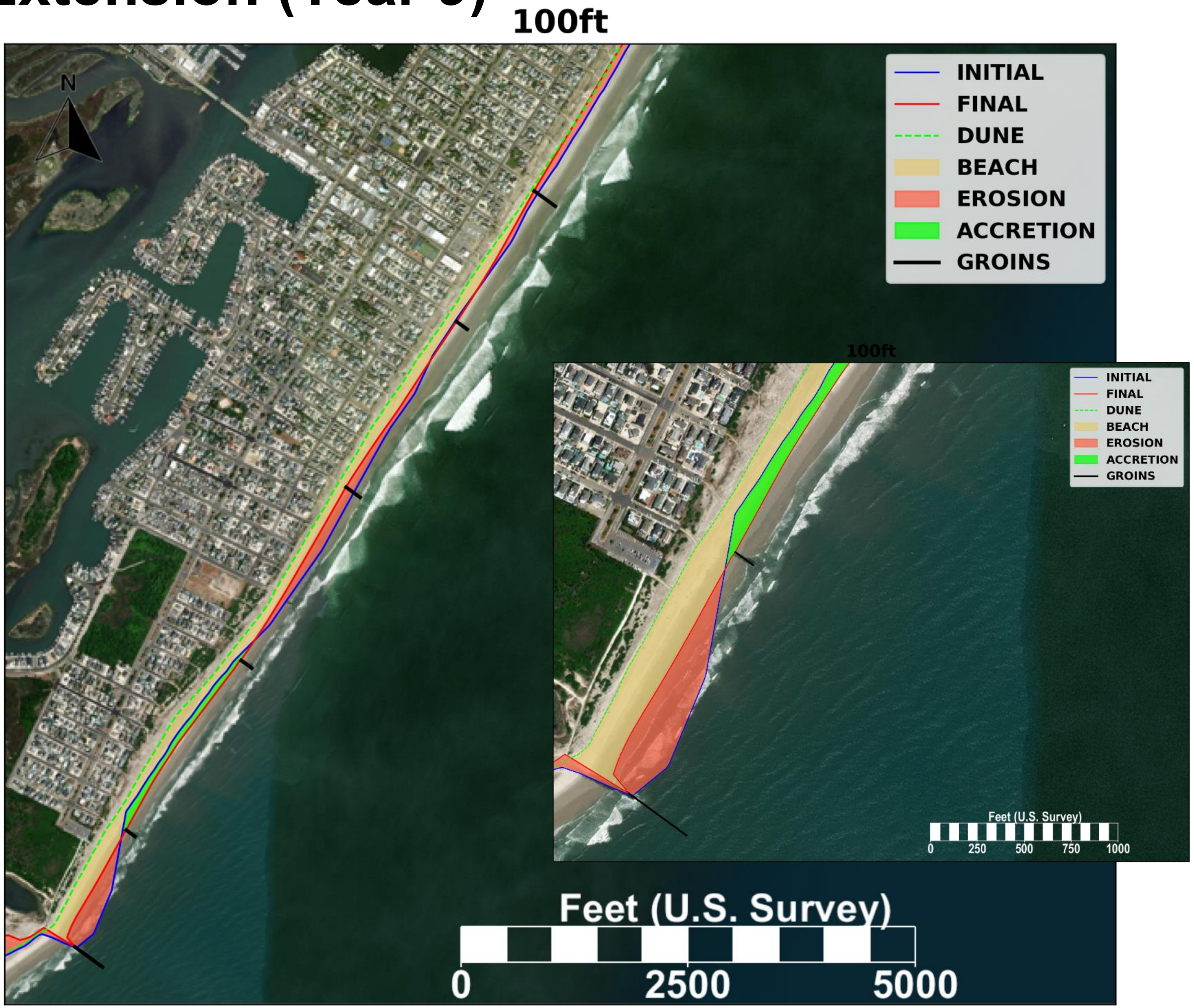
Test 2 – 100' Extension (Year 3)

Test 2 – 100’ Extension (Year 6)



Test 2 – 100’ Extension (Year 9)



Modeling Beach Scraping

Short Term Response

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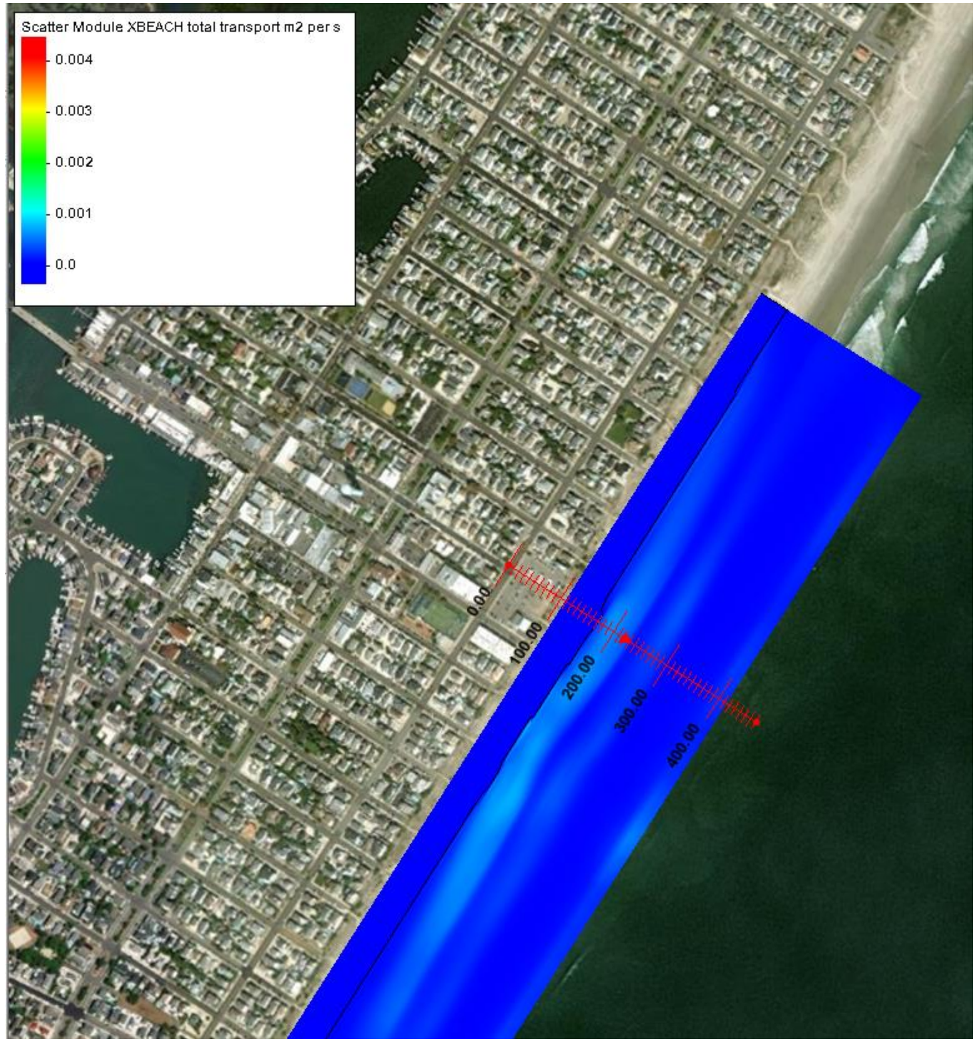
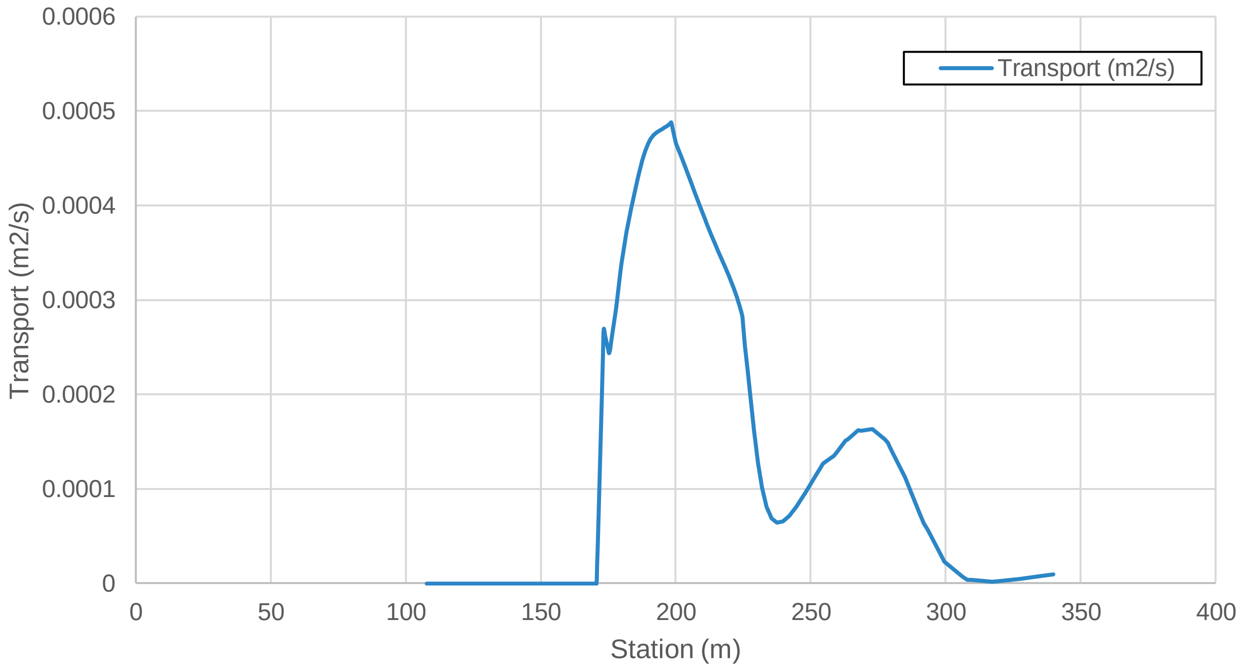
Example Cross-shore Location of Sediment Transport





Beach Scraping

Concept

Avalon Experience

- Sand harvested from 33rd to 40th Streets and transported north by truck to the vicinity of 11th Street.
- The borrow areas filled in rapidly
- Most recent project size ~60,000 cubic yards

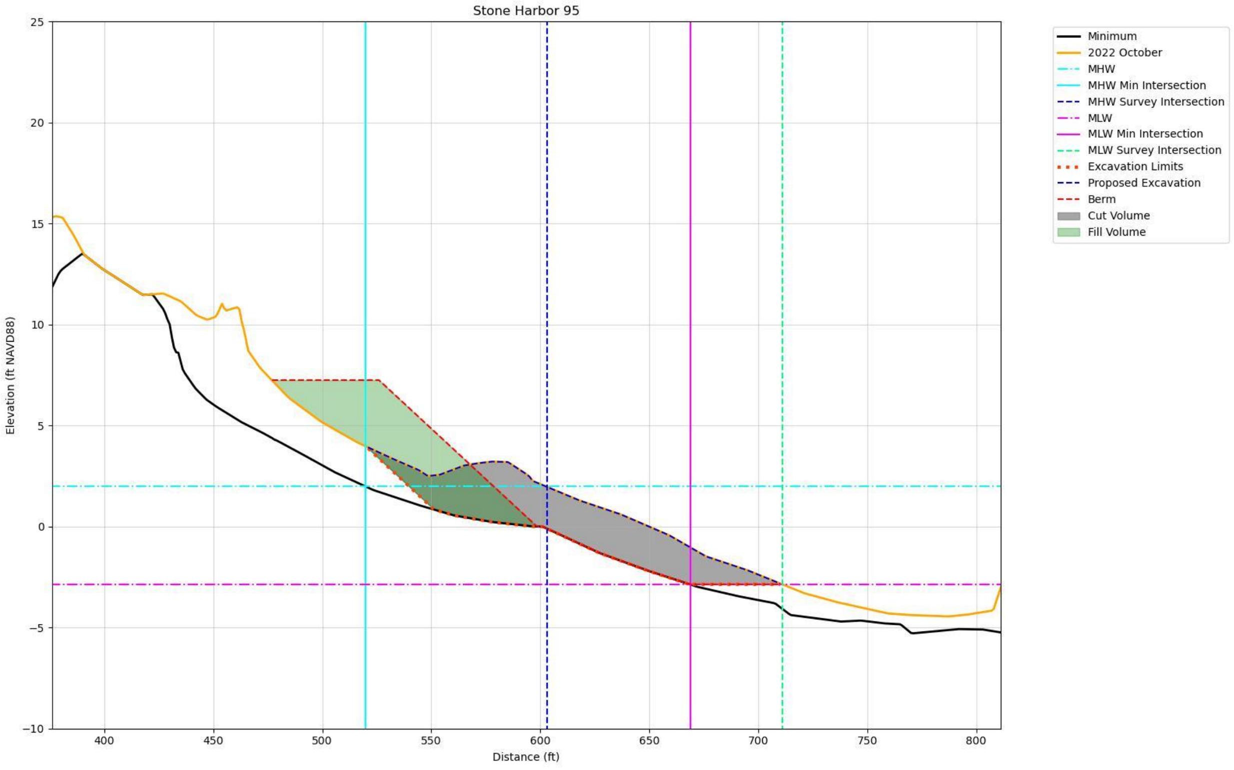
Stone Harbor Concept

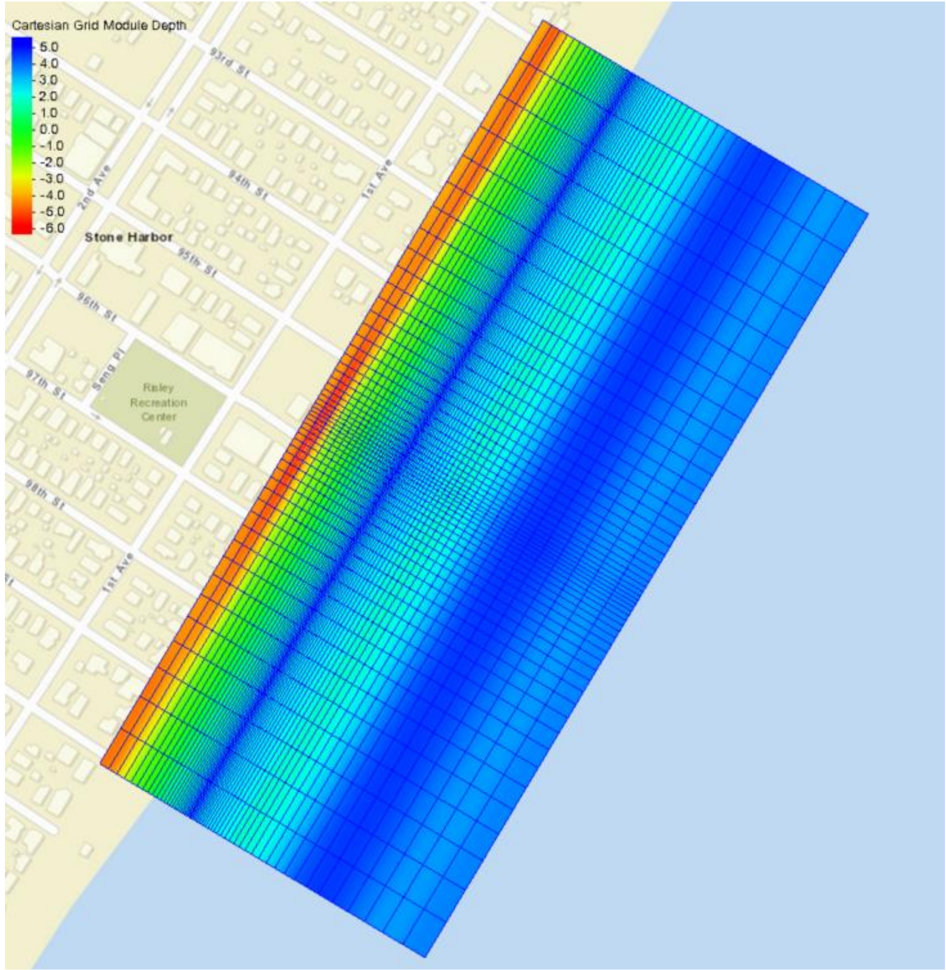
- Sand would be harvested in the active surf zone and placed above MHW
- Project would be accomplished during the late spring (March to early April) which is when the wave conditions change from net southerly transport (erosive) to net northerly transport (accretionary)
- Conditions in the borrow zone would be monitored to ensure natural refilling within a two-week window, then would start over.
- The purpose of the XBeach modeling is to look a rates of infilling and redistribution of sand

XBeach Model

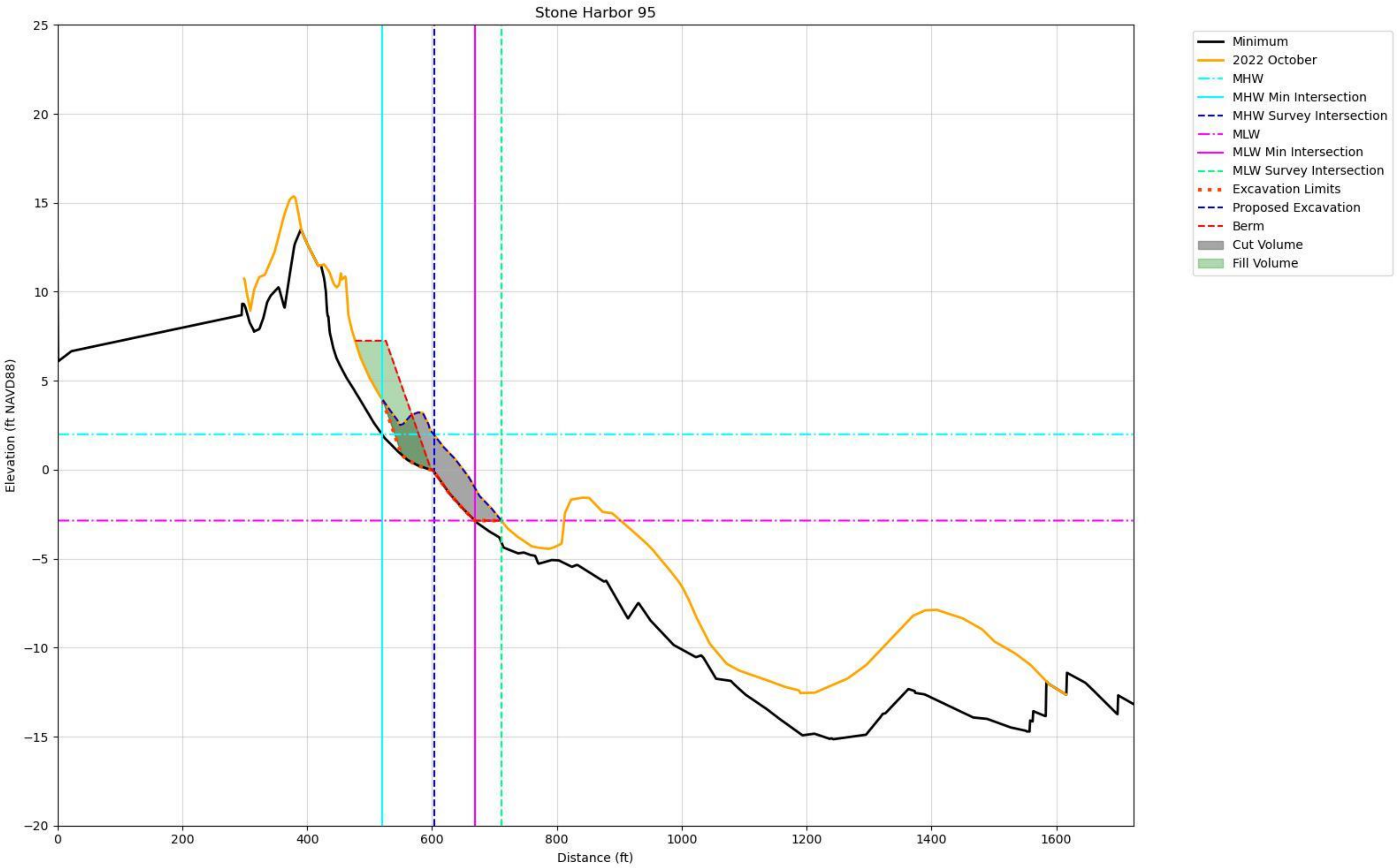
2D Grid

95th Street Cross-Section





Beach Scraping

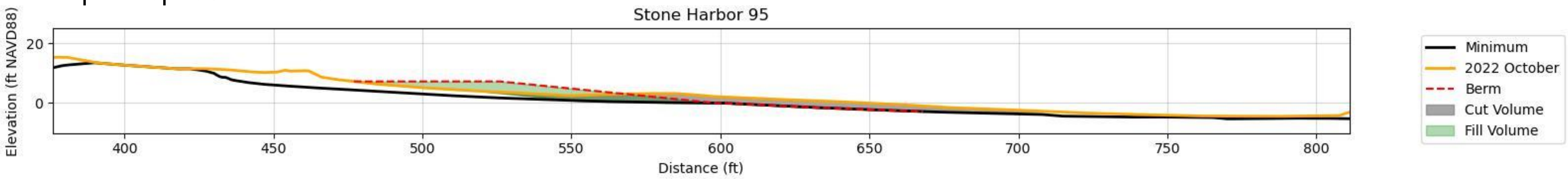


Beach Scraping

Berm Sizing

- Based on calculated available cut volume from surveyed cross-sections
- **Available cut volume:** 138,800 yd^3
- **Proposed template volume:** 50,000 yd^3
- Template
  - Berm slope: 10H:1V
  - Berm width: 25 ft
  - Berm height: 7.25 ft NAVD88

Equal Aspect/1:1 Ratio



Next Steps

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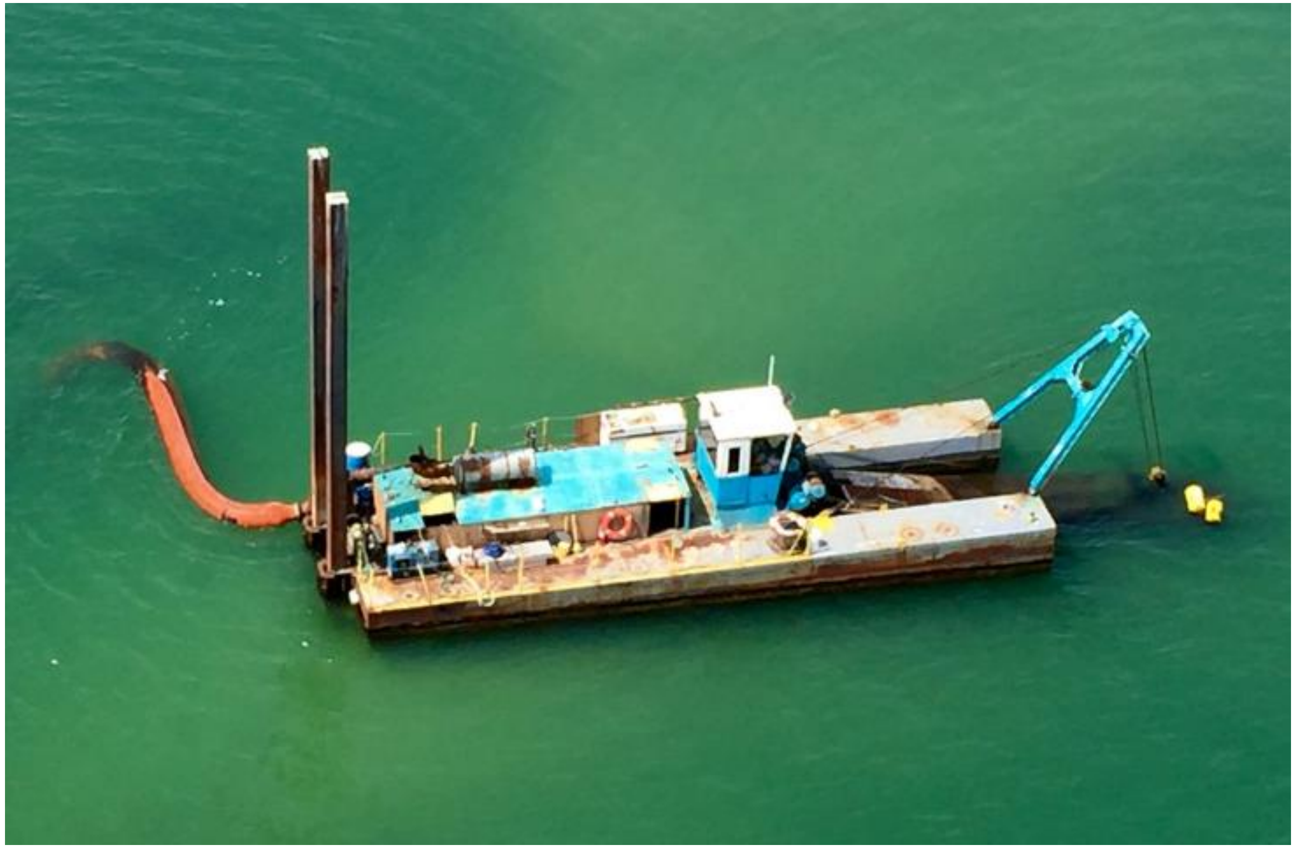
Future Work

- Complete modeling for beach scraping concept
- Develop cost estimates for alternatives to optimize
- Finalize Feasibility Report
- Initiate conversations with neighboring communities about joint ownership/operation of small hydraulic dredge
- Present beach scraping to NJDEP as part of other potential beach maintenance activities under an Individual Permit.
  - Beach Scraping
  - Trucking sand
  - Placement of clean sand from bay and thorofare sources
  - Repair of access to Stone Harbor Point
  - Temporary capture of wind-blown sand and transport to northerly beaches

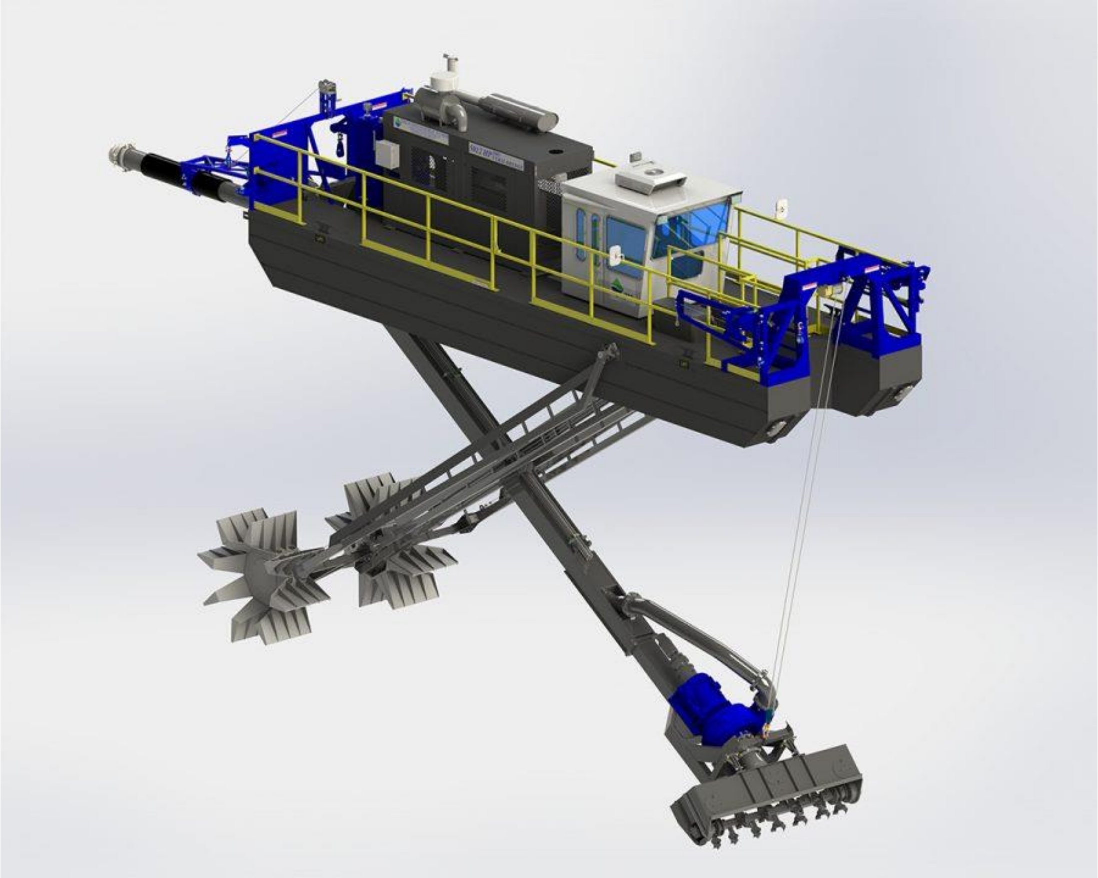
Dredging

- Initiate conversations with County / neighboring communities about joint ownership/operation of small hydraulic dredge
- 10-in Ellicot 370 Dredge $200,000 used
- 12-in DSC Dredge, 35-ft water depth $375,000 used



Dredging

- IMS 5012 self-propelled
- Great for dredging slips



Dredging

- Capital Costs
  - Dredge
  - Piping
  - Means of transporting (flatbed, etc.)
  - Support vessel(s)

- Operational Costs
  - Permits
  - Fuel
  - Personnel
  - Training
  - Repair and Maintenance

MOTT MACDONALD

Feasibility Study Team

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Thank you