EVALUATION TECHNIQUES FOR THE PROTECTIVE BENEFITS OF DUNE SYSTEMS TO COASTAL HAZARDS

5th Coastal Hazards Symposium
Key West 2015

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Abstract

- Quantify and predict the benefit to oceanfront structures of non-traditional dune system using a cross-shore model and synthetic design-storm approach
  - Balance of accuracy, precision, physical process against computation time and data collection requirements
  - Leverage existing and ongoing data sources
  - Determine zones with associated risk levels
- Truth test the approach by hindcasting vs observed damages during Hurricane Sandy
- Motivation:
  - Provide methodology to look at spatial and temporal variations in the risk
  - Demonstrate the benefit of a beach nourishment and dune expansion using synthetic design storms to NJ coastal towns

Presentation Outline

I. Introduction/Background

Project Location, Existing Approaches, Available Data

II. Implemented Methodology

Damage Mechanisms, establishing criteria

III. Results

IV. Conclusions

V. Next Steps

I. Introduction

Project Location

USACE Proposed Project Limits

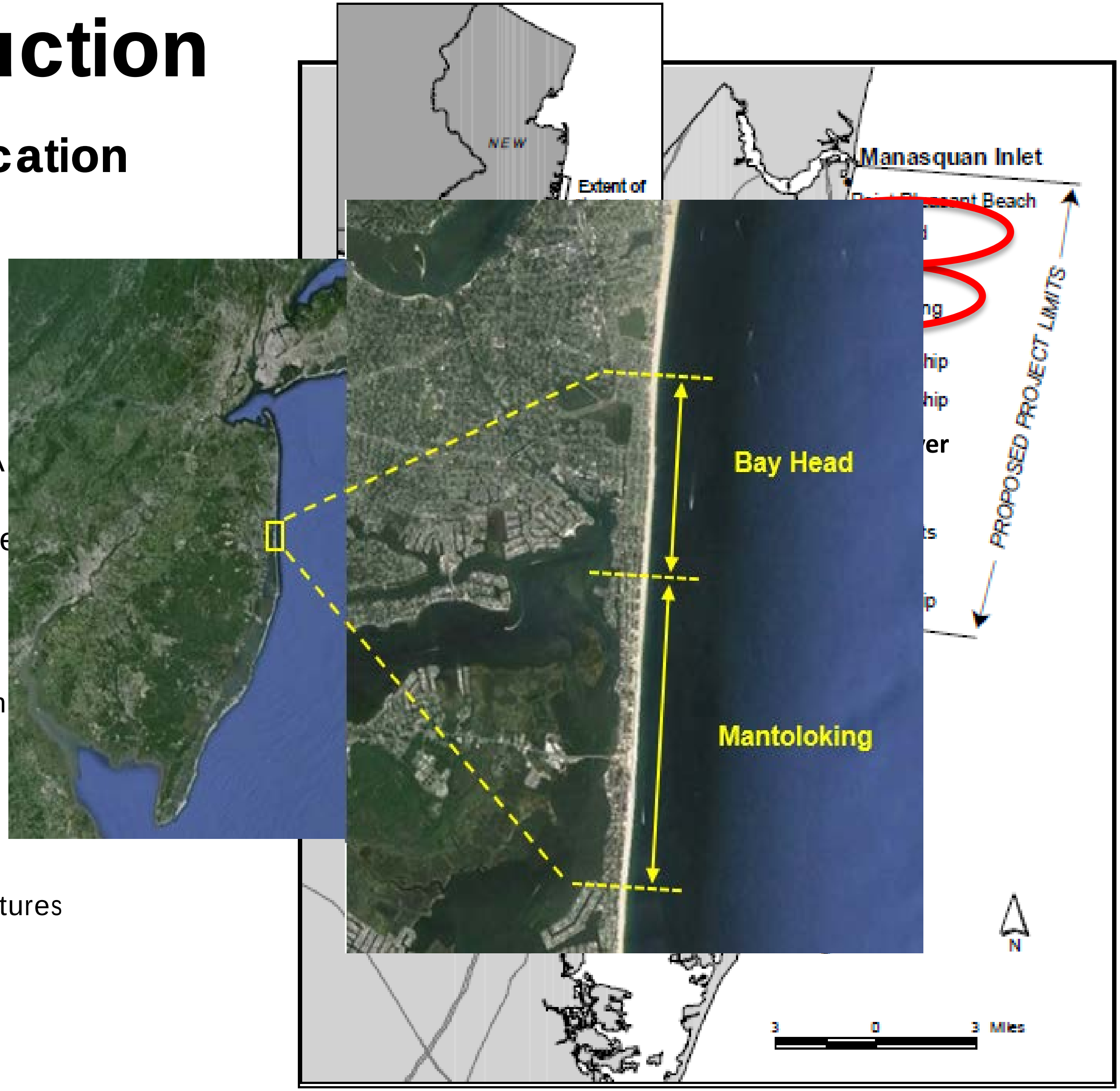
Federal project (USA
Study area extends
from Manasquan Inle
to Barnegat Inlet

Diverse variety of
foundation construction

- Slab on Grade
- CMU Block
- Pile

- 197 Oceanfront structures

(USACE, 2002)



I. Introduction/Background

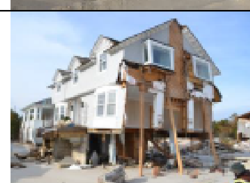
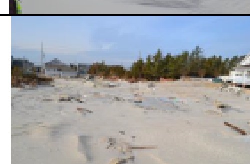
Existing Methods

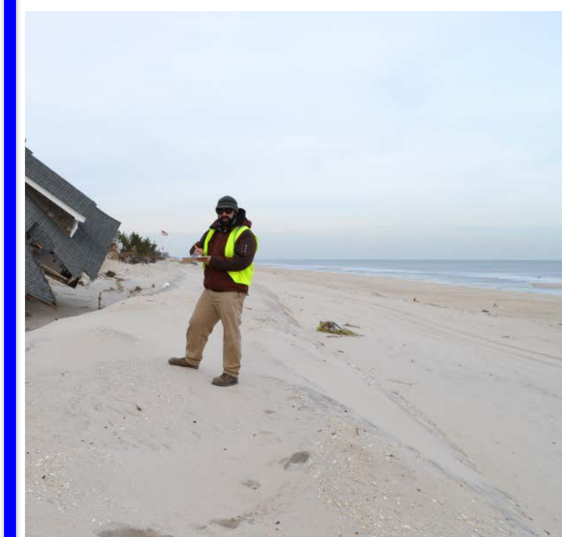
- Property specific analysis
- Manasquan Inlet to Barnegat Inlet Feasibility Study (June 2002, USACE)
- Storm Damage Reduction Benefit Report (USACE)
  - Wise, R.A., and K.D., Watson (2010)
- Modelling multi-hazard hurricane damages on an urbanized coast with a Bayesian Network approach
  - van Verseveld, van Dongerern, Plant, Jager, den Heijer (2015)
- All approaches utilize a cross-shore model (“LHI” or damage mechanism) to predict damage

I. Introduct

- 2012-14 NSF s ricane Sandy *Impacts in Th Communities*
- Observed damag
  - Damage re
  - Photograph
  - Damage ra properties

Table 6: Examples of surveyed houses for each of the different 'Structure Condition' ratings.

Photo	Structure Condition	Description
	Excellent	Structure is in excellent condition. Possible flood damage inside, but no structural damage.
	Good	Minor damage to garage door. Overall condition of structure is good.
	Fair	Localized damage to porch and siding. Foundation is exposed but has no visible damage.
	Poor	Obvious damage to siding and windows. Visible significant damage to structure's foundation.
	About to Collapse	Entire structure has suffered major damage and is being held up with temporary supports. House is unstable.
	Collapsed	Entire structure has undergone extreme damage, resulting in collapse. Demolition unavoidable.
	Removed	Structure has been completely destroyed or removed off of the foundation. There is no evidence of any surviving portion; all that remains is debris.



I. Introduction/Background

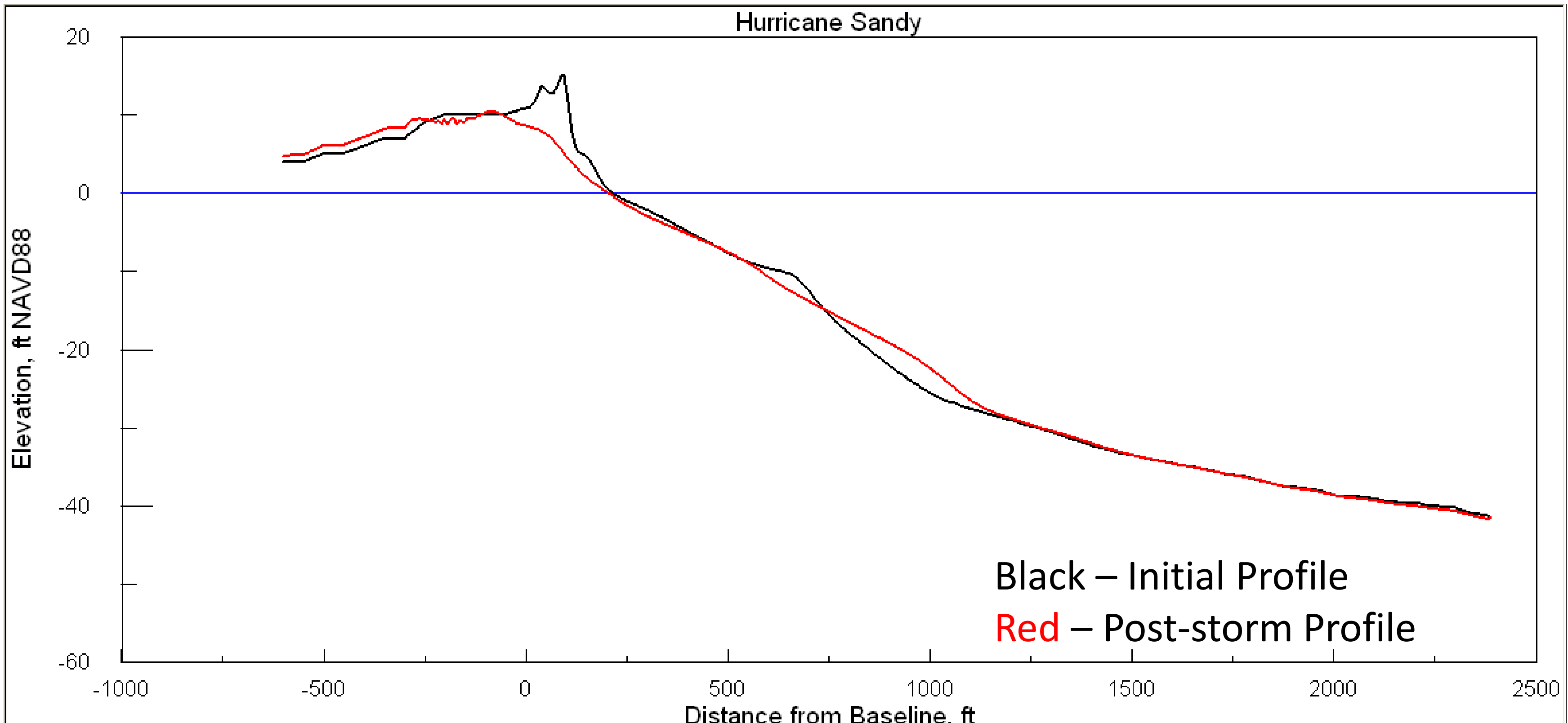
Damage Mechanisms

- Inundation, overtopping, erosion and wave attack

All towns with RTK Water Levels										
Condition	Number	Ground El (avg)	Ground El. (min)	Ground El. (max)	Water El. (avg)	Water El. (min)	Water El. (max)	Water Depth (avg)	Water Depth (min)	Water Depth (max)
Slab On Grade										
Condition	Number	Ground El (avg)	Ground El. (min)	Ground El. (max)	Water El. (avg)	Water El. (min)	Water El. (max)	Water Depth (avg)	Water Depth (min)	Water Depth (max)
CMU										
		Ground El	Ground El.	Ground El.	Water El.	Water El.	Water El.	Water Depth	Water Depth	Water Depth
Piles										
Condition	Number	Ground El (avg)	Ground El. (min)	Ground El. (max)	Water El. (avg)	Water El. (min)	Water El. (max)	Water Depth (avg)	Water Depth (min)	Water Depth (max)
Excellent	0	-	0.00	0.00	-	0.00	0.00	-	0.00	0.00
Good	1	4.13	4.13	4.13	7.71	7.71	7.71	3.58	3.58	3.58
Fair	2	5.13	2.42	7.83	7.96	3.59	12.33	2.83	1.17	4.50
Poor	0	-	0.00	0.00	-	0.00	0.00	-	0.00	0.00
About to Collapse	0	-	0.00	0.00	-	0.00	0.00	-	0.00	0.00
Total	3									

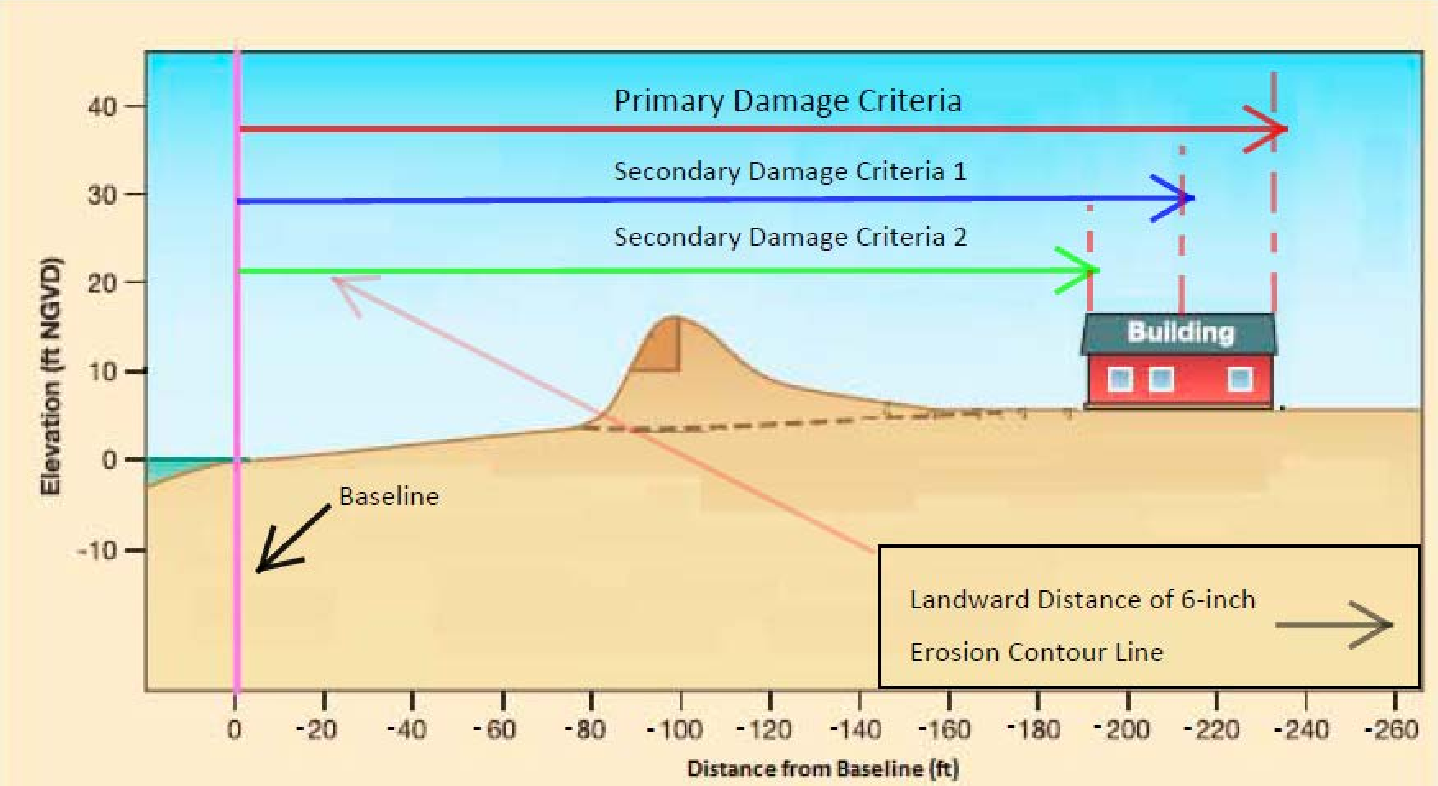
II. Methodology

Established Methodology – Erosion Failure Criteria



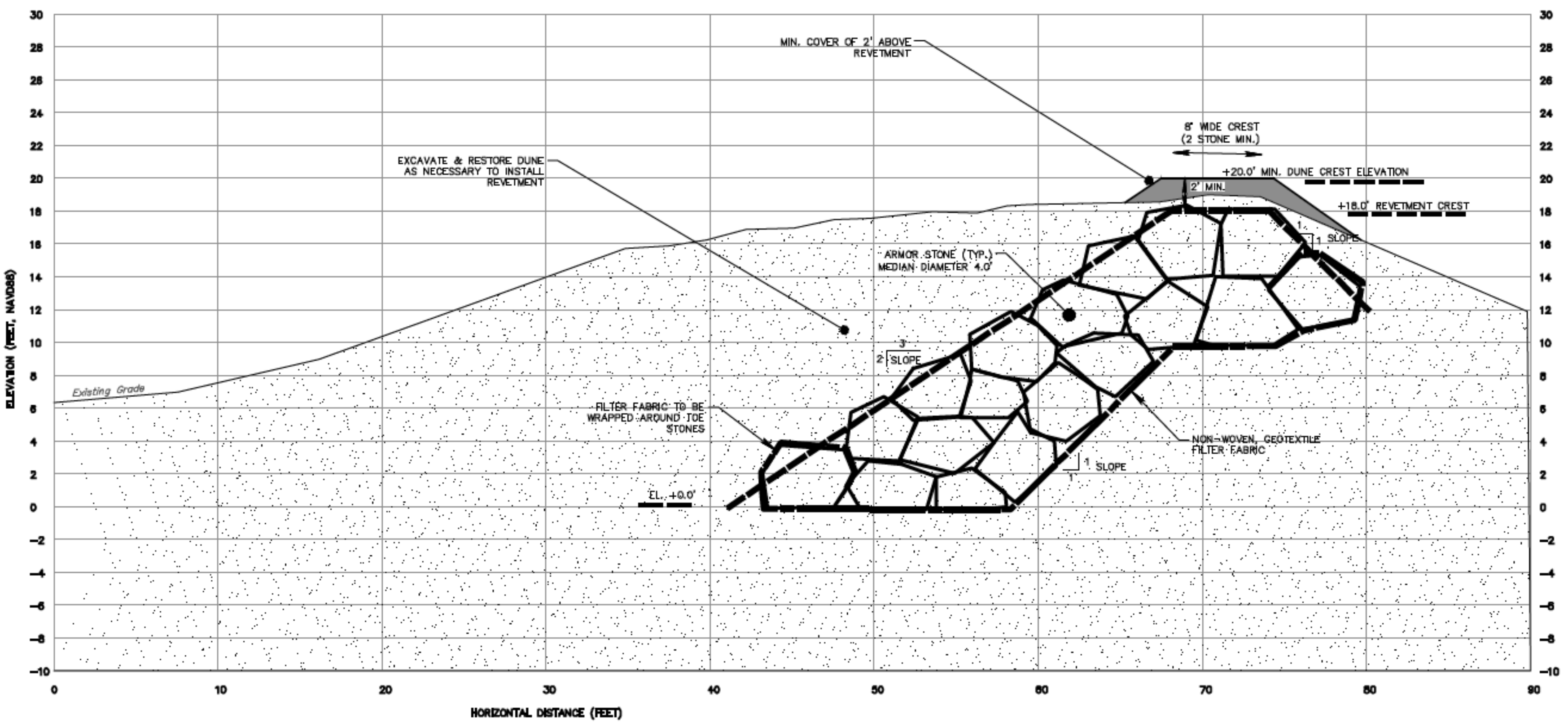
II. Methodology

Established Methodology – Erosion Failure Criteria

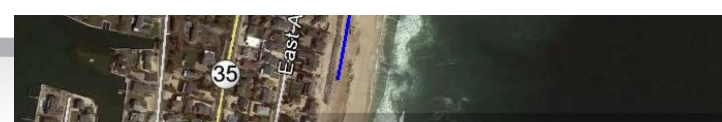


II. Methodology

Bay Head, NJ

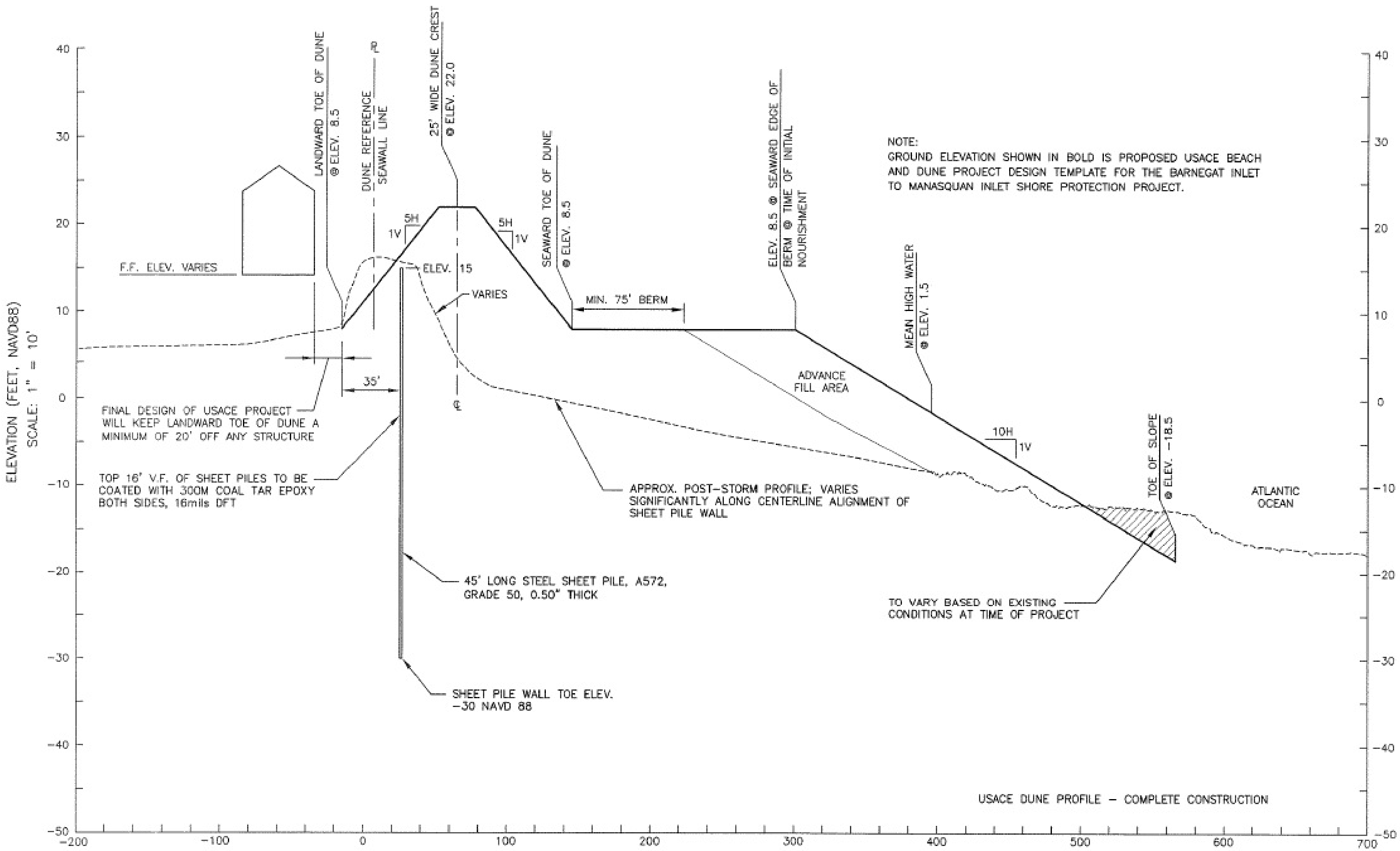


A
A
TYPICAL DESIGN SECTION
1" = 8'



II. Methodology

Mantoloking, NJ



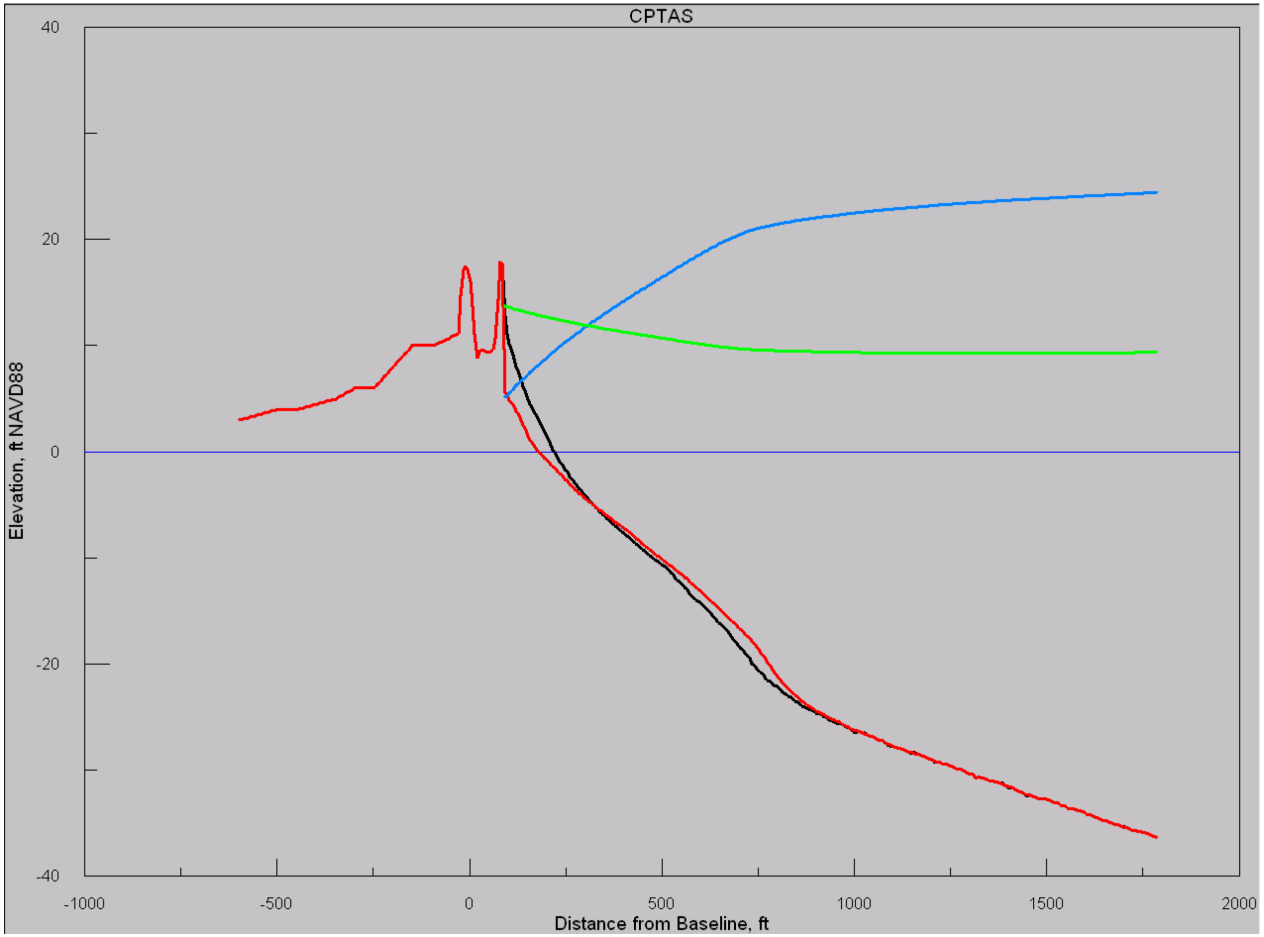
II. Methodology

Limitations

- Erosion shoreward limited by the seawall
- Results were not representative damages observed in Hurricar Sandy
- Need to capture Overtopping
- Owen (1980)
    - Estimate Overtopping

II. Methodology

Model Response Bay Head, NJ



Initial Profile - Black

Profile Response – Red

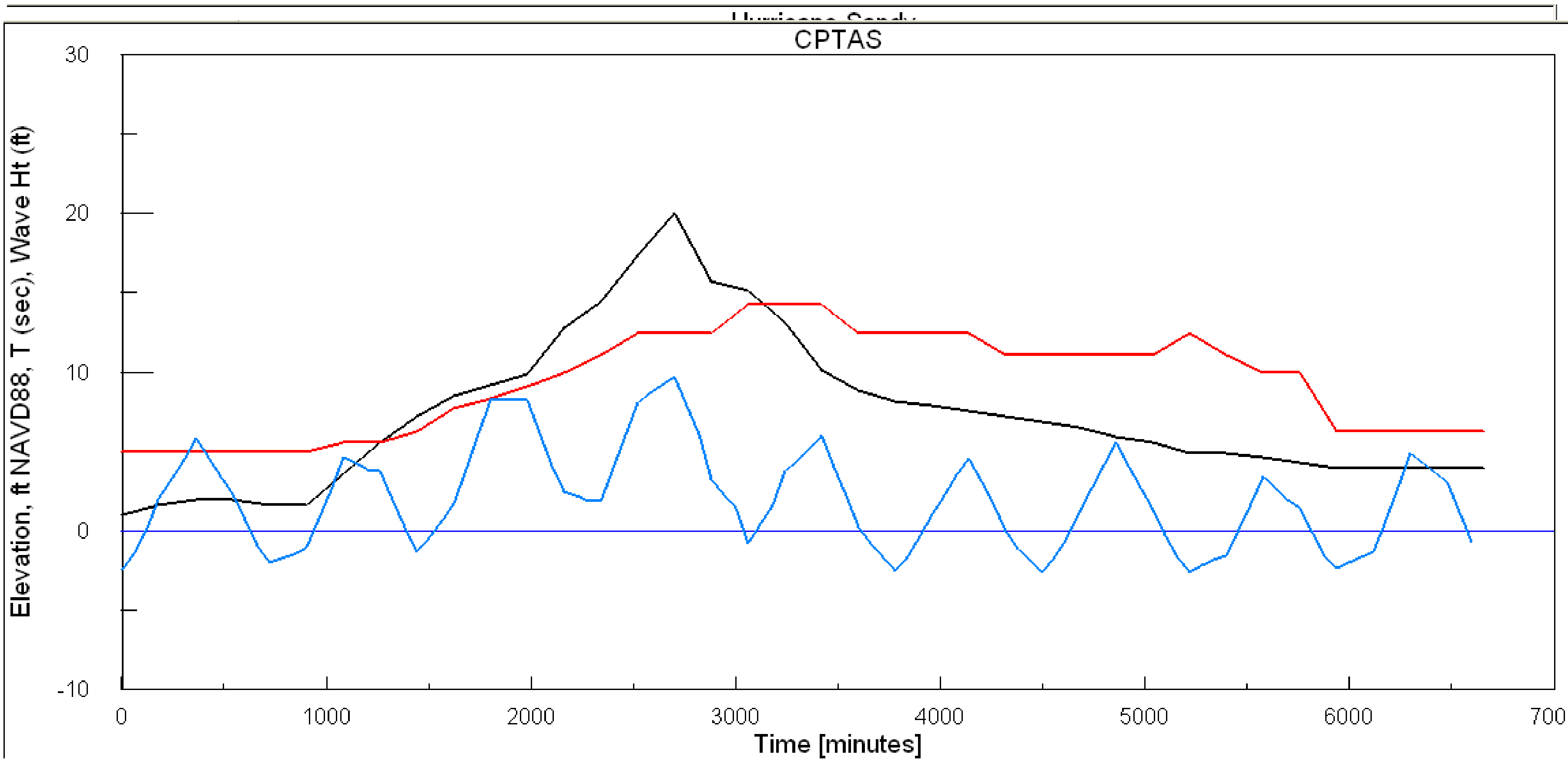
Maximum Water Elevation – Green

Maximum Significant Wave Height – Blue

Modeled profile response for 100-year storm

II. Methodology

Time Series



III. Results – Hindcast Hurricane Sandy

III. Results

Erosion Analysis

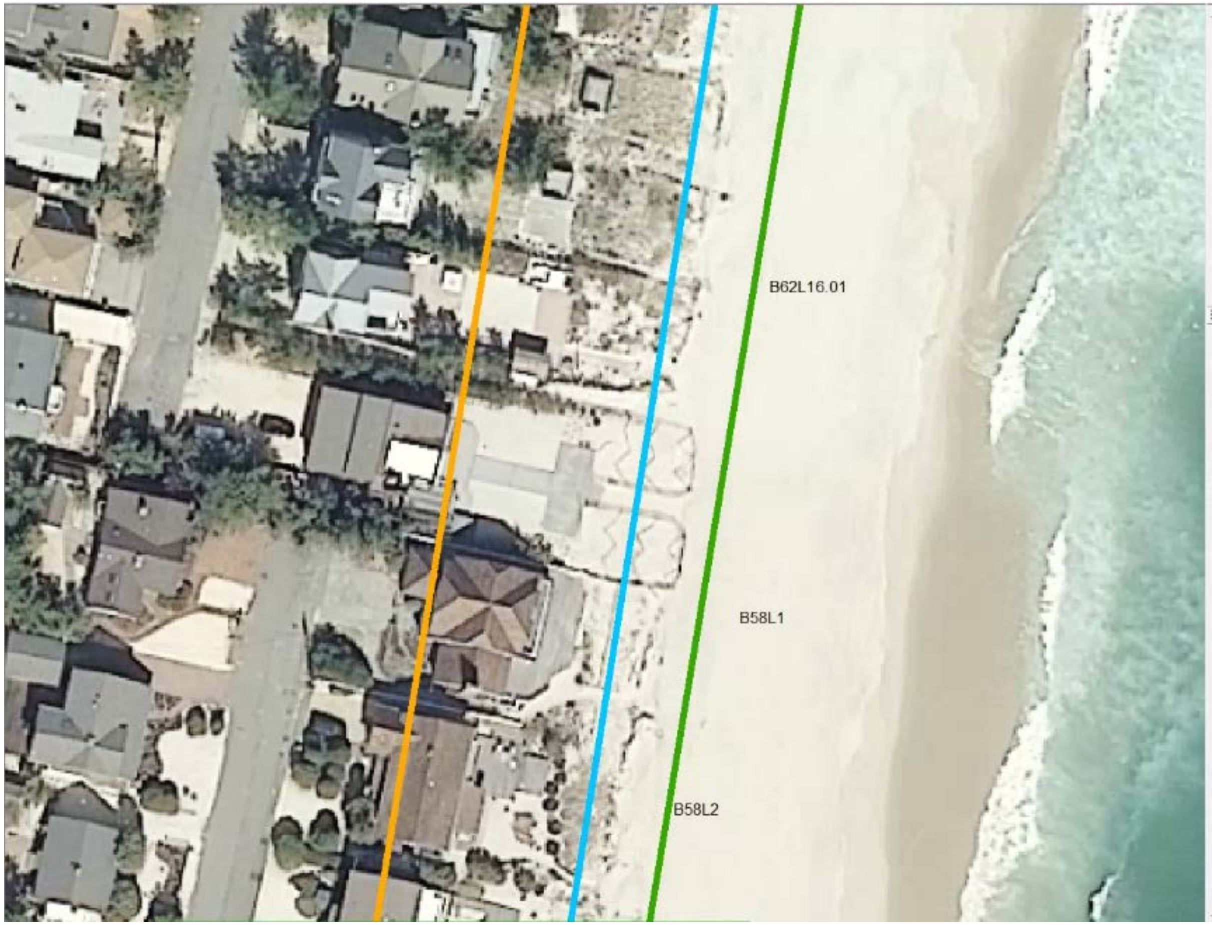
- Landward limit of the 0.5-ft erosion line for 50-year storm

Without Dune or Beachfill

With Seawall
(w/out Beachfill)

With Project

(w/ Seawall and Beachfill)



III. Results

Overtopping

- Overtopping without beachfill
- Structures still at risk without beachfill
- Need both dune and beachfill working together
- 50-year storm

III. Results

Analysis of Protective Bene

Damage Level Percentages for First Row Structures with Rock Seawall Protection					
Damage Mechanism	None (%)	Minor (%)	Moderate (%)	Major (%)	Severe (%)
Wave	26.42	39.62	22.64	11.32	0.00
Scour/HVF	28.30	39.62	18.87	13.21	0.00
Debris	92.45	5.66	1.89	0.00	0.00

Walling (2015)

74% vs 67%

Shoreline			20-year				50-year				100-year				200-year				500-year			
Town		Total No.	w/out Project		w/ Project		w/out Project		w/ Project		w/out Project		w/ Project		w/out Project		w/ Project		w/out Project		w/ Project	
			Minor	Severe	Minor	Severe	Minor	Severe	Minor	Severe	Minor	Severe	Minor	Severe	Minor	Severe	Minor	Severe	Minor	Severe	Minor	Severe
Bay Head	TOTAL	73	10	0	0	0	19	16	0	0	29	20	3	0	28	21	5	0	21	38	13	5
	Percent	-	14%	0%	0%	0%	26%	22%	0%	0%	40%	27%	4%	0%	38%	29%	7%	0%	29%	52%	18%	7%
	Effectiveness		100%				100%				94%				90%				69%			
Mantoloking	TOTAL	14	0	0	0	0	11	0	0	0	7	4	0	0	7	4	0	0	5	6	2	0
	Percent	-	0%	0%	0%	0%	15%	0%	0%	0%	10%	5%	0%	0%	10%	5%	0%	0%	7%	8%	3%	0%
	Effectiveness		-				100%				100%				100%				82%			
Brick	TOTAL	29	0	0	0	0	5	6	0	0	17	10	0	0	11	16	0	0	11	17	0	0
	Percent	-	0%	0%	0%	0%	17%	21%	0%	0%	59%	34%	0%	0%	38%	55%	0%	0%	38%	59%	0%	0%
	Effectiveness		-				100%				100%				100%				100%			

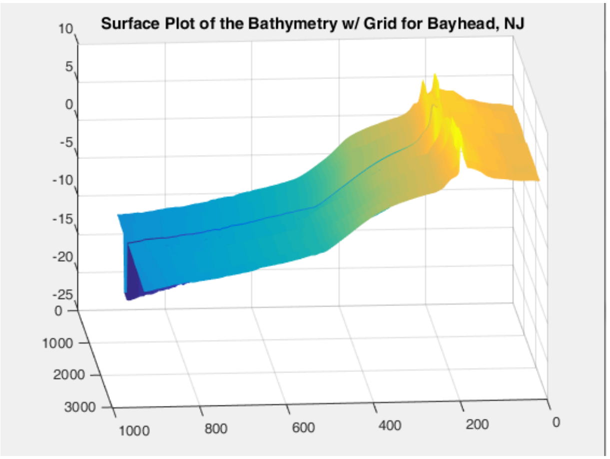
IV. Conclusions

- Methodology has reasonable skill in hindcasting damage zones when compared to observations
  - 12 of 13 (92.3%) Severely Damaged in Bayhead 1st row during Hurricane Sandy
  - 3 of 4 (75%) for Severely Damaged in 2nd row
- Flexible enough to account for the beach nourishment and various dune core materials

More Generally:

- Further demonstrates use of impermeable cores in dunes can successfully help mitigate hazards but not alone; overtopping can control (Basco 1999, Irish 2013, Walling 2014, 2015)
- Must work with a sufficiently healthy beach

V. Next Steps….



- XBeach
  - Comparison of models
    - 1D & 2D
  - Account for effects of hard structures in dune erosion/overwash (Nederhoff, 2014)
- Generally
  - Include Mantoloking
  - Account for sea level rise and long term erosion rates
  - Utilize ongoing beach profiles
    - Run on annual/semi-annual basis; track temporal and spatial variations - feeder beaches

References

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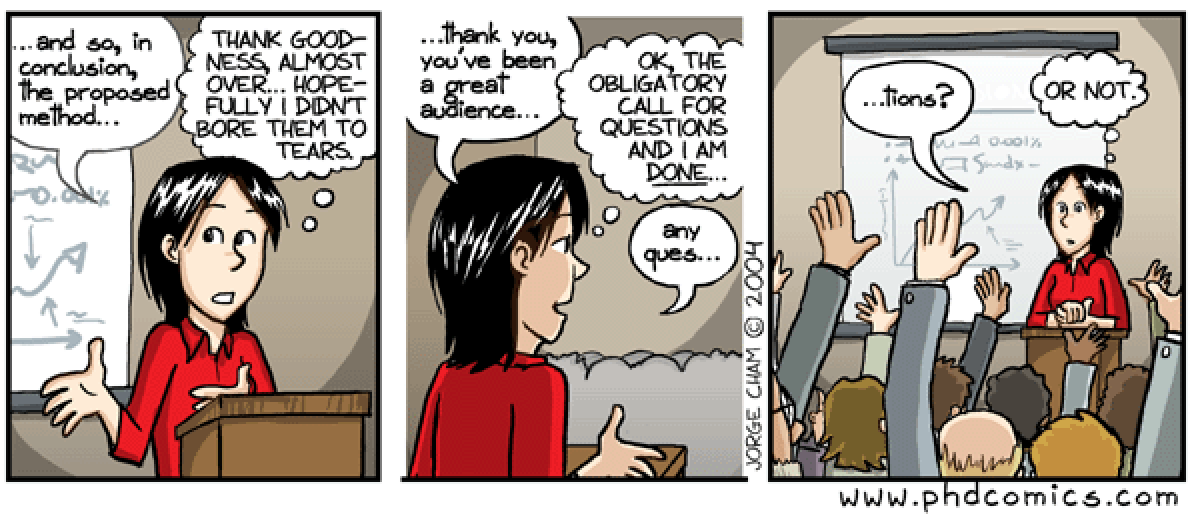
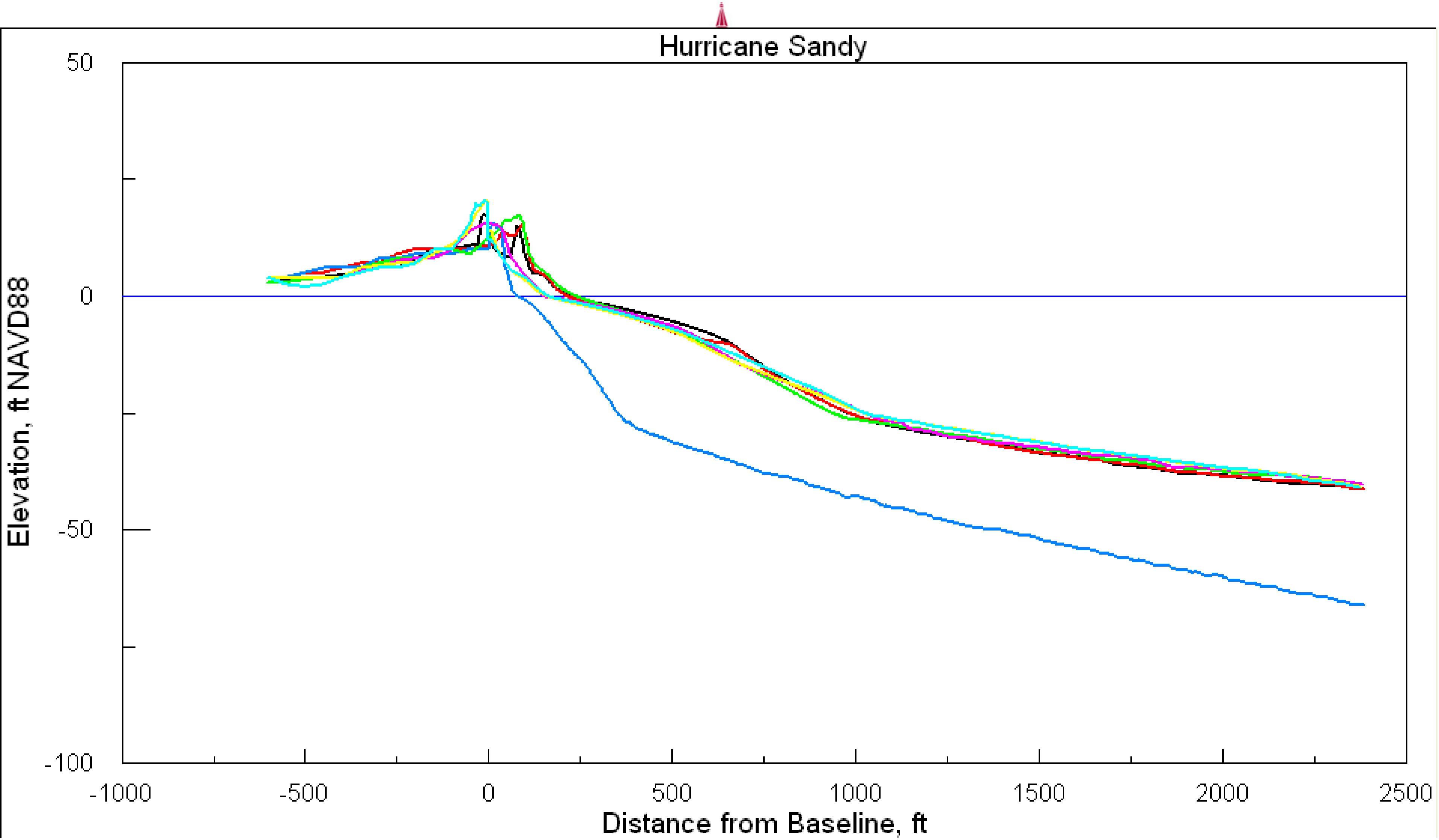
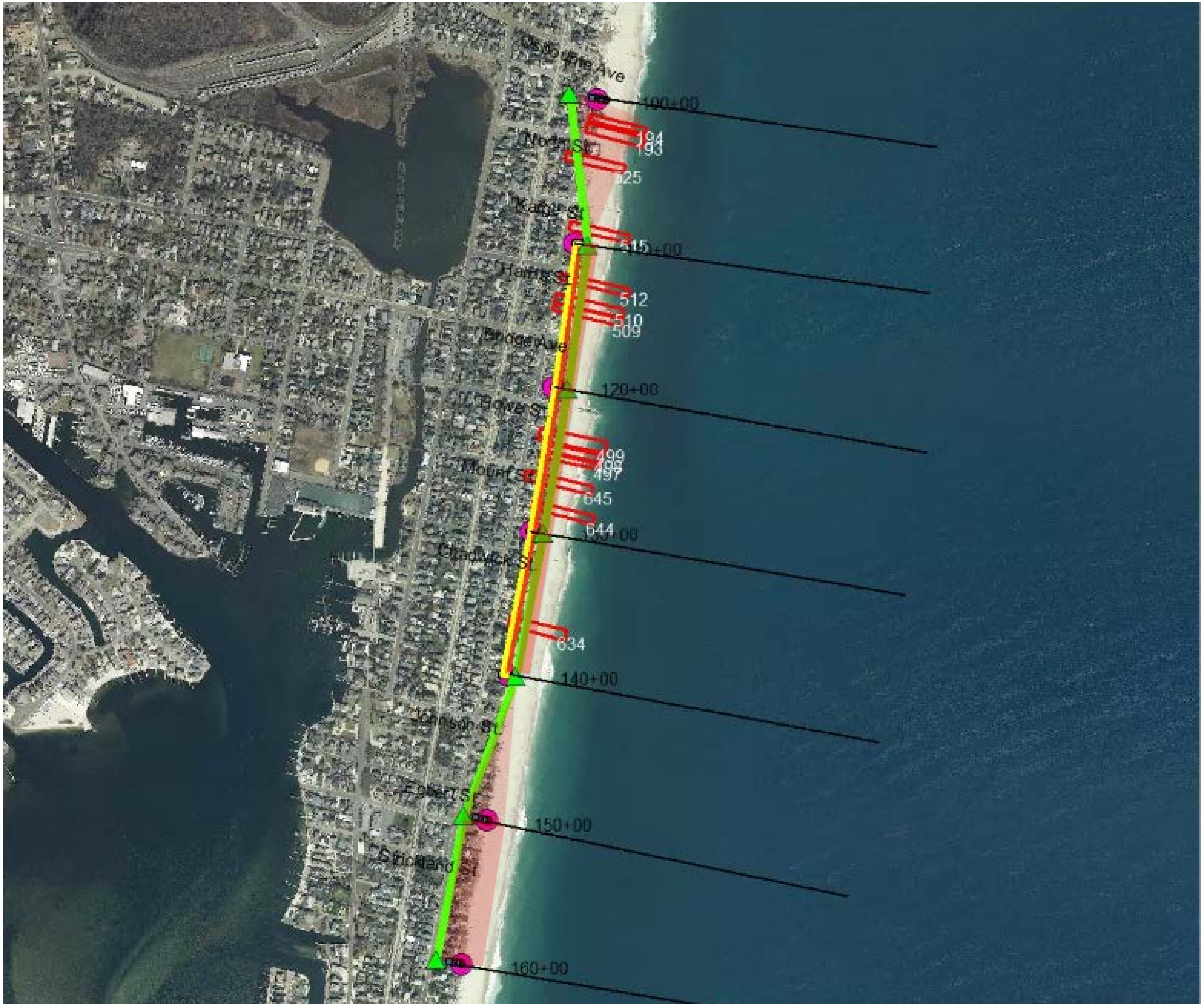



Hurricane Sandy
Elevation, ft NAVD88
Distance from Baseline, ft
50
0
-50
-100
-1000
-500
0
500
1000
1500
2000
2500



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North St
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Harris St
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Bridge Ave
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Johnson St
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Strickland St
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