TAYLOR ENGINEERING, INC.

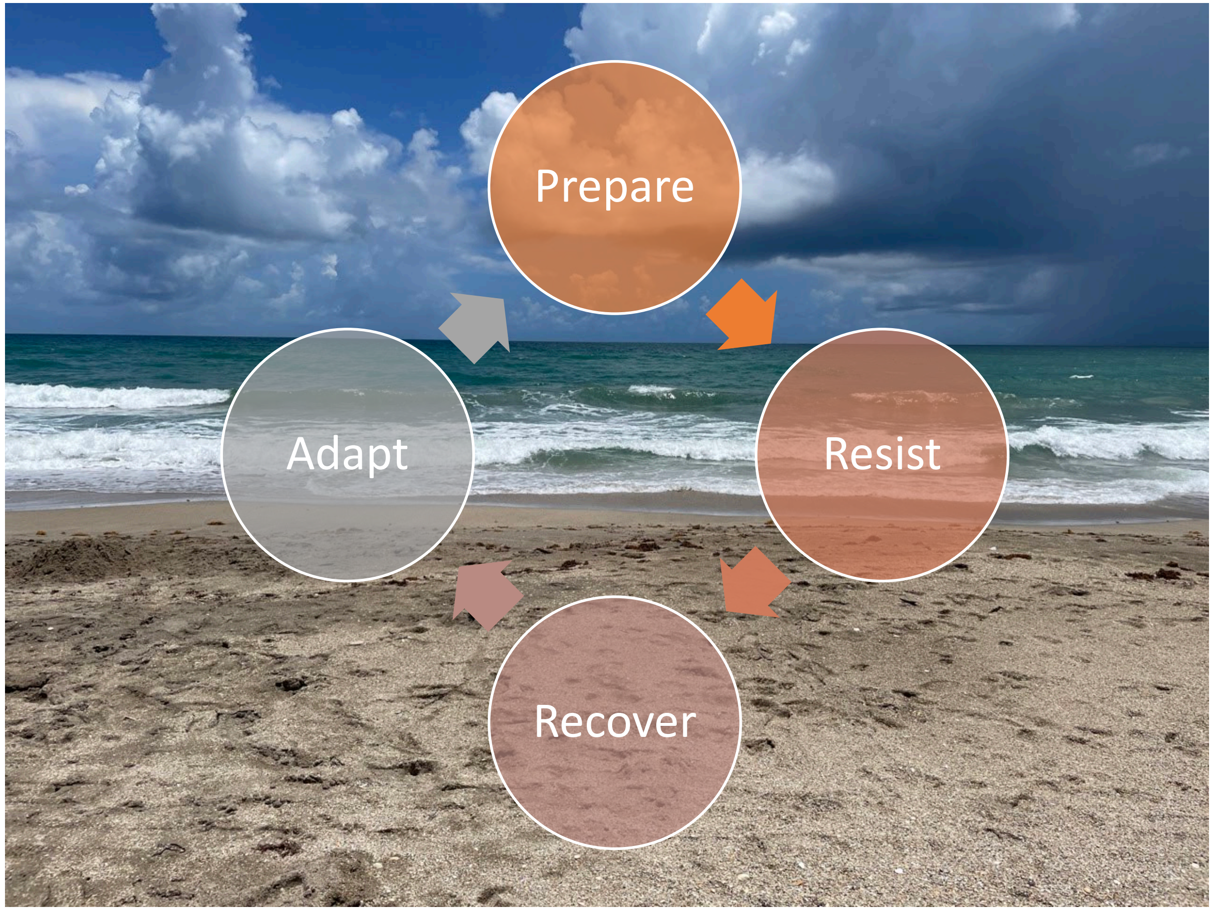
Martin County Four Mile Beach Resilience

June 20, 2023

Wendy Laurent, PE

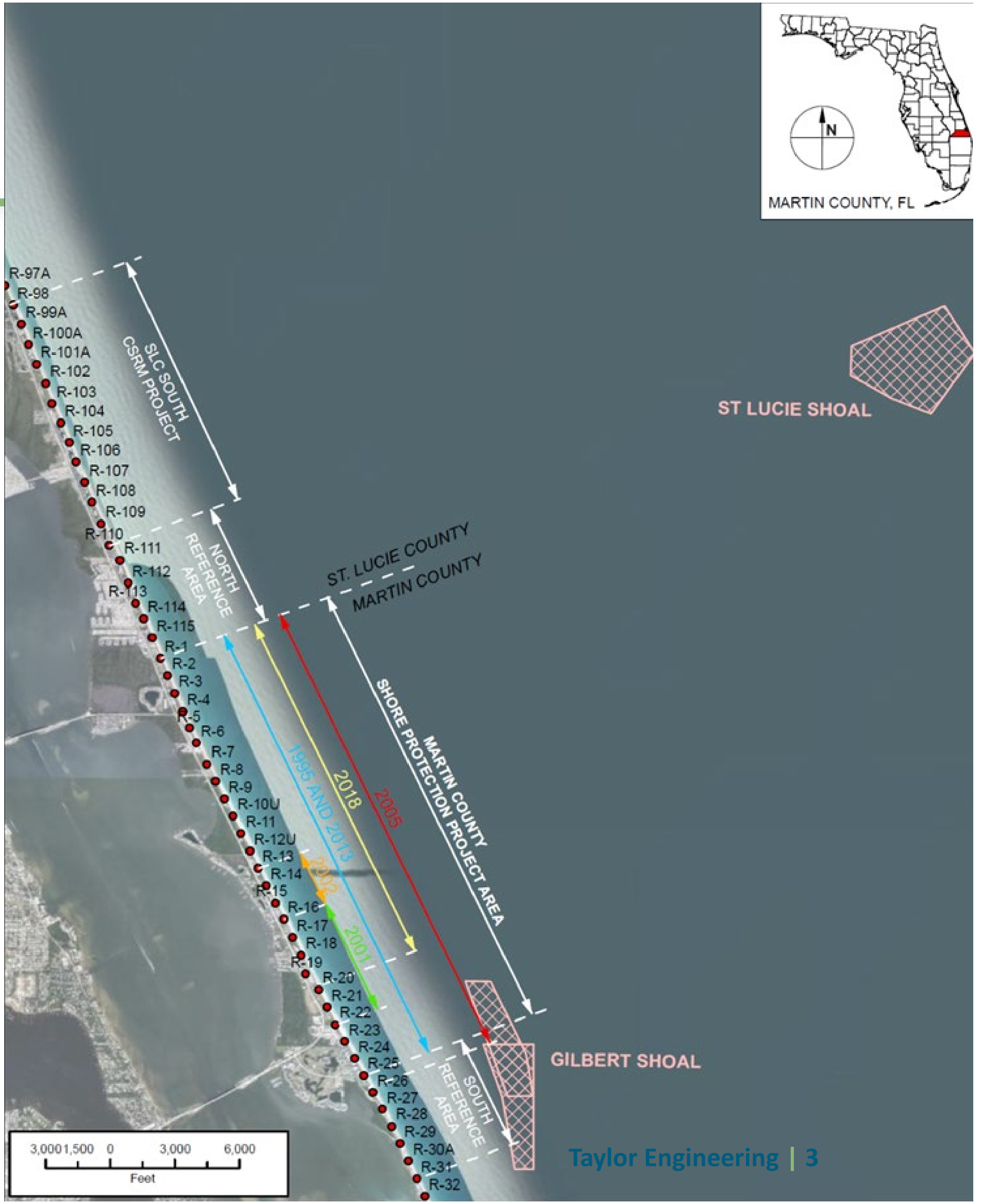
Presentation Outline

- Project Information
- Resilience Metrics
- Beach Resilience Metrics
- Hurricanes Ian and Nicole
- Comparison of Beach Resilience Metrics
- Summary
- Looking Forward
  - prepare, resist, recover, and adapt



Martin County SPP

- Northern-most 4 miles of Martin County (R-1 to R-25)
  - County Line & Glasscock Beach (R-1)
  - South of the Marriott (R-25)
- Provides storm damage reduction in addition to recreation and environmental benefits



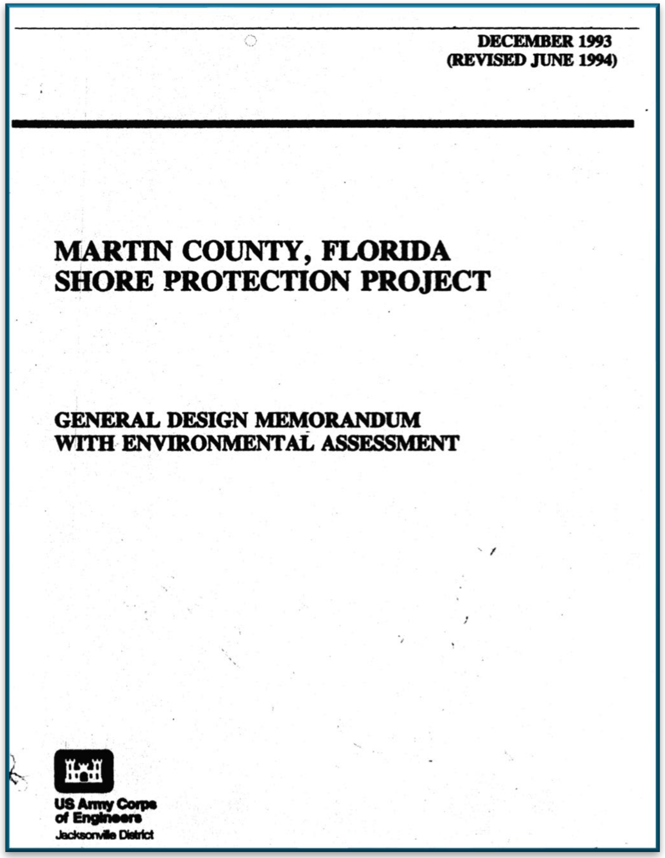
Martin County SPP Resilience

- The County is investigating options to modify the project design in the future to increase the performance of the beach fill and enhance resilience

- Our Path:
  - Summarize project history & available data
  - Analyze historic beach trends
  - Begin discussions with permitting agencies
  - Modeling in XBEACH
  - … recommendations and next steps

Project Authorization

- Authorized in the Water Resource Development Act 1990 (WRDA 1990)
- GDM- General Design Memorandum
  - USACE, 1994
  - Describes the project as:
    - (1) a protective beach berm and storm dune along approximately 4 miles (mi) of Hutchinson Island, FL;
    - (2) periodic nourishment of the restored beach and adjacent shoreline as needed and justified for the life of the project;
    - and (3) extensive, multiyear beach performance monitoring.
  - Federal participation (R-1 to R-23) expires in **2045**



DECEMBER 1993
(REVISED JUNE 1994)

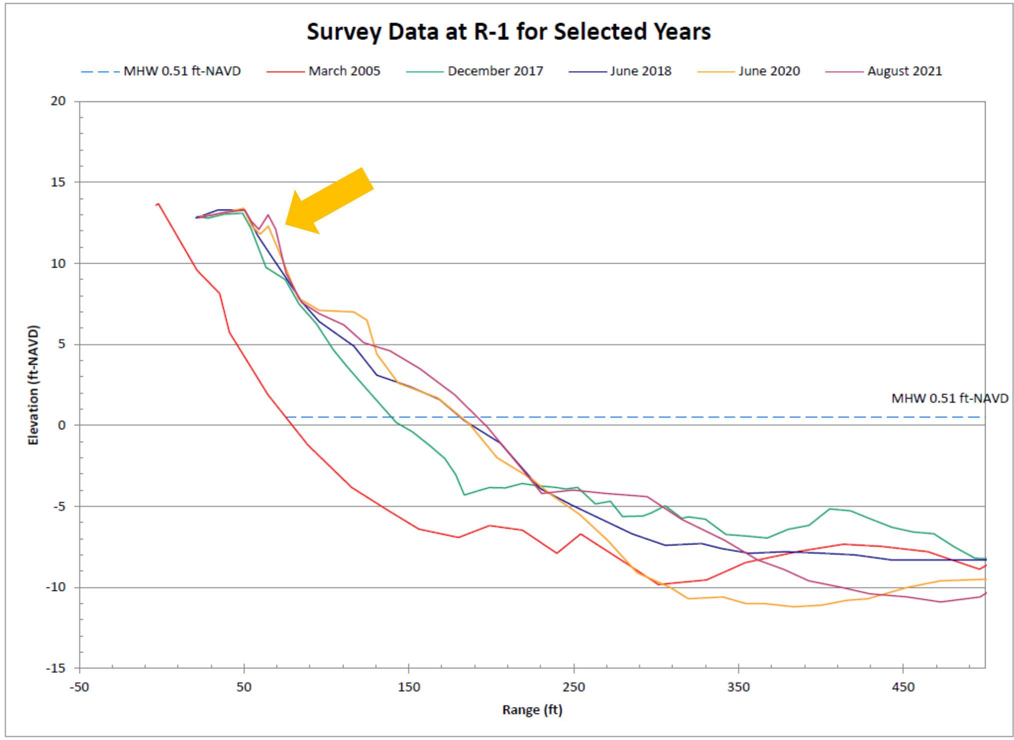
MARTIN COUNTY, FLORIDA
SHORE PROTECTION PROJECT

GENERAL DESIGN MEMORANDUM
WITH ENVIRONMENTAL ASSESSMENT

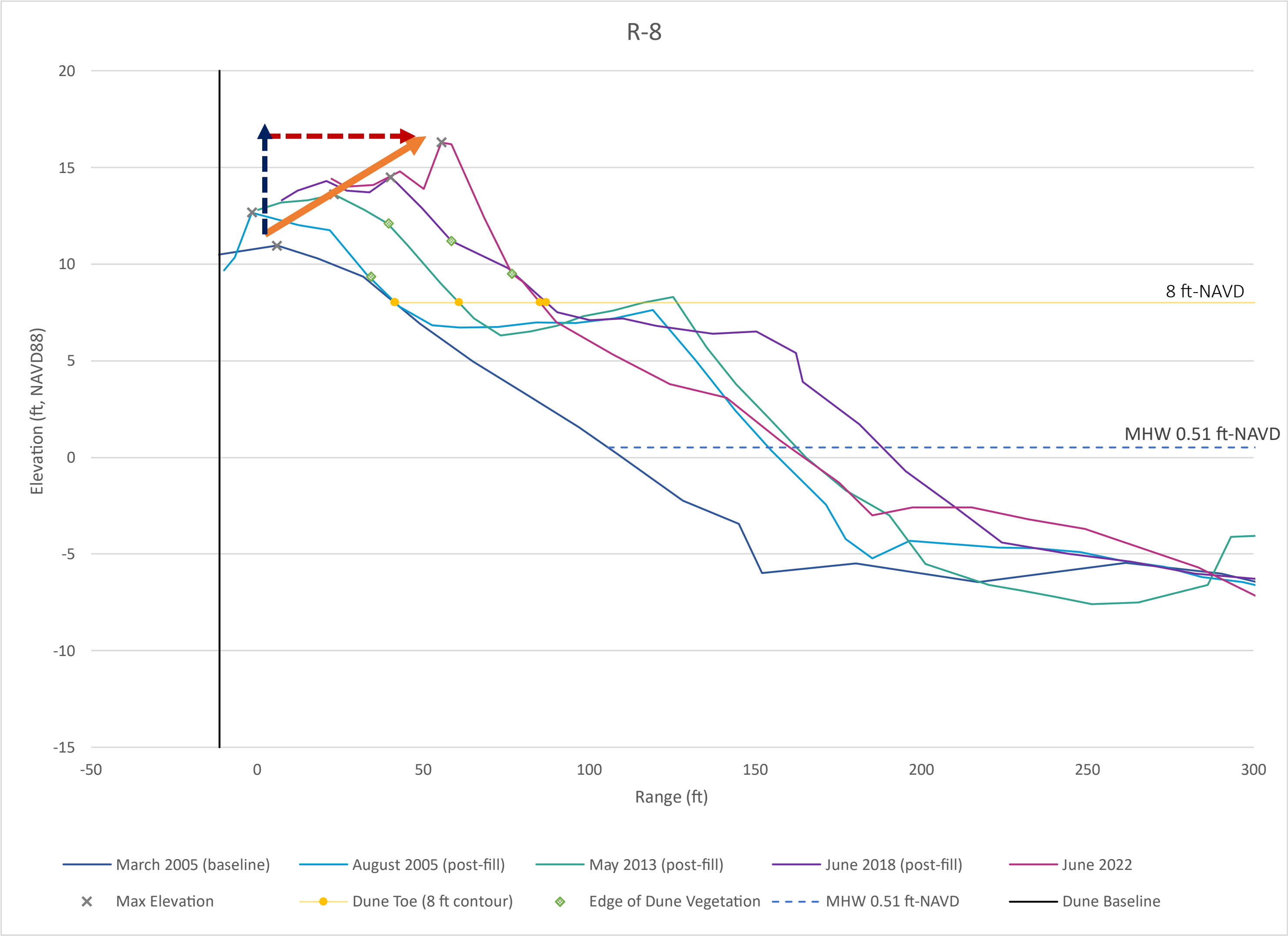
US Army Corps
of Engineers
Jacksonville District

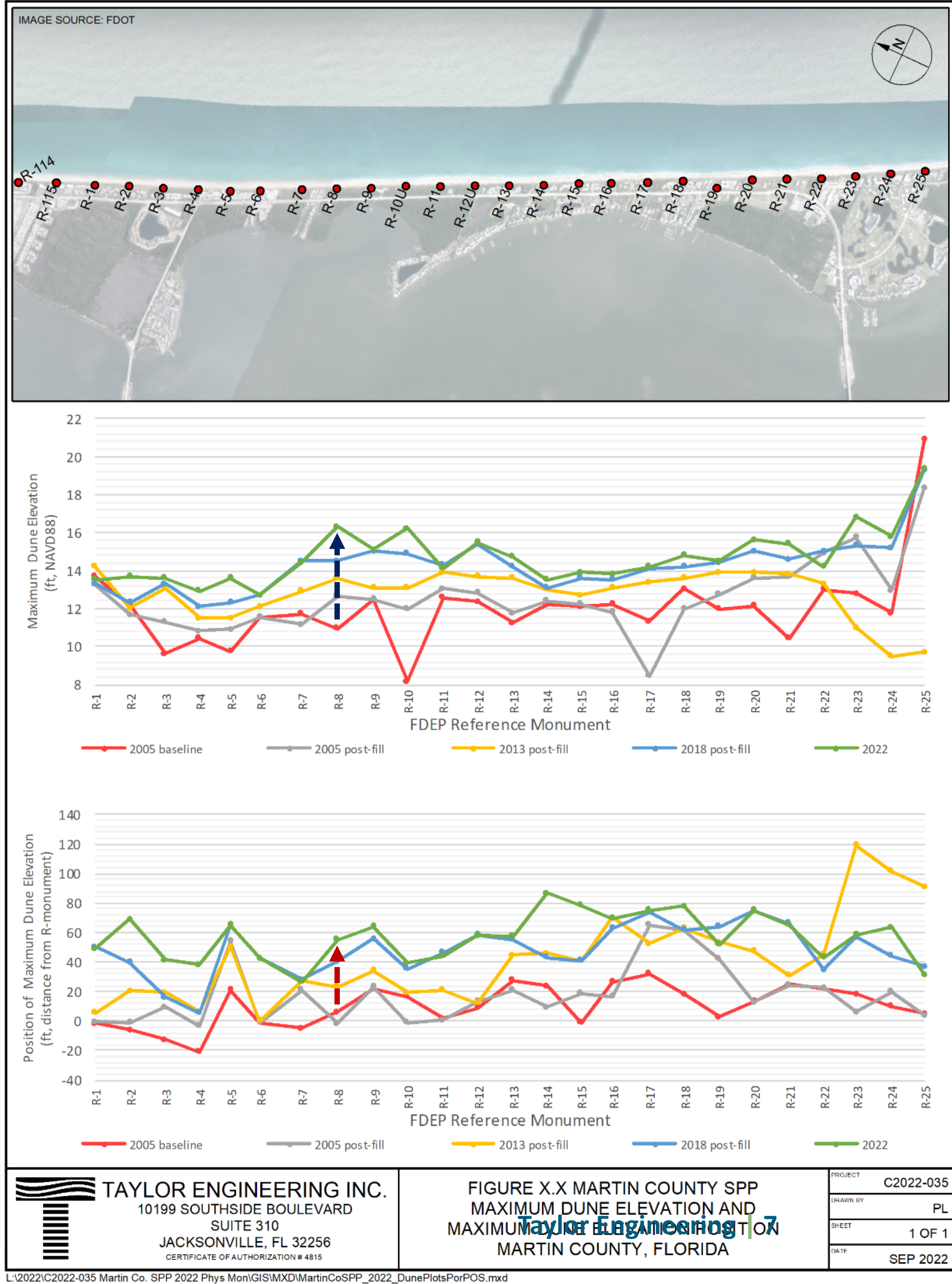
Historic Project Performance

- Performance highly dependent on storm activity
  - Consistent erosion from the sub-aerial and nearshore
  - Slow natural recovery and onshore movement of a sand bar (if conditions allow)
  - Rarely a full recovery and sand moves beyond the monitoring area
- Increased shoreline retreat and/or erosion in the northern portion of the project and increased stability to the south
- Dune growth!

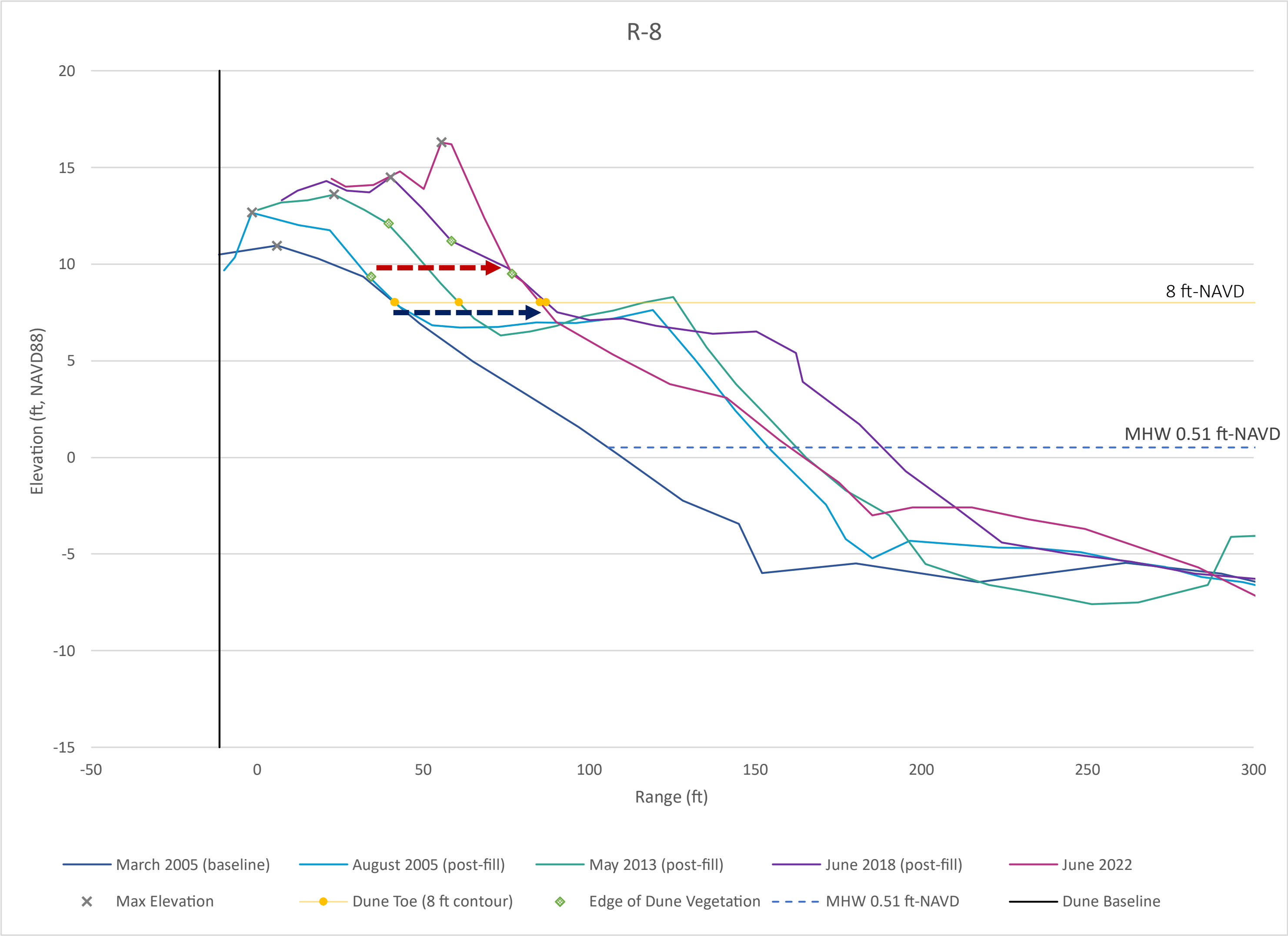


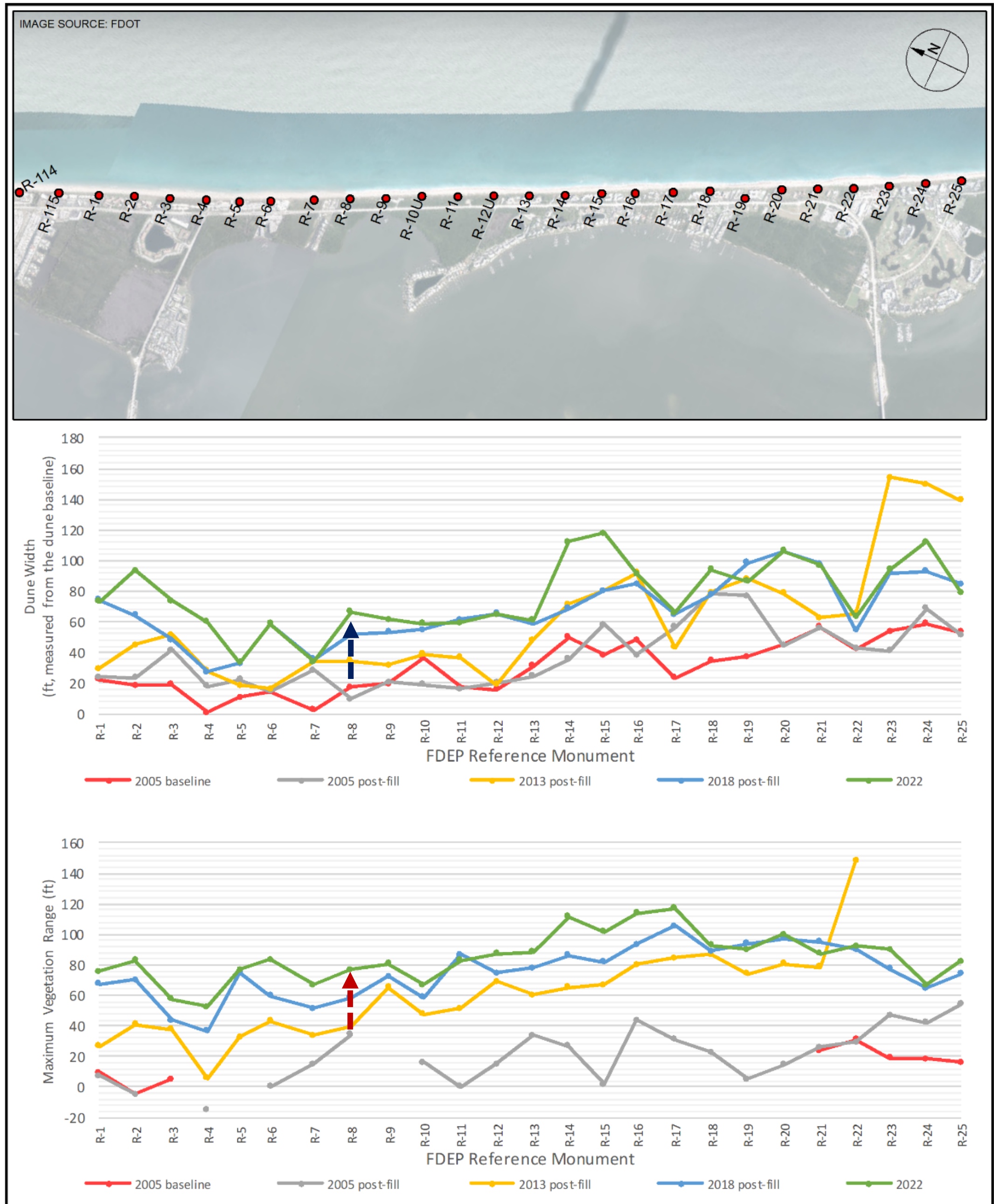
Dune Growth– maximum elevation





Dune Growth– dune width and edge of veg





TAYLOR ENGINEERING INC.
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CERTIFICATE OF AUTHORIZATION # 4815

FIGURE X.X MARTIN COUNTY SPP
MAXIMUM DUNE WIDTH AND
MAXIMUM VEGETATION WIDTH
MARTIN COUNTY, FLORIDA

PROJECT	C2022-035
DRAWN BY	PL
SHEET	1 OF 1
DATE	SEP 2022

L:\2022\C2022-035 Martin Co. SPP 2022 Phys Mon\GIS\MXD\MartinCoSPP_2022_DunePlotsPorWdthVeg.mxd

Beach Nourishment History and Design Templates

Project Year	Placed Volume (cy)	Placement Area	Borrow Area
1995	1,340,000	R-1 to R-25	Gilbert Shoal
2001	178,000	R-16.2 to R-22.3	Gilbert Shoal
2002	126,000	R-13.5 to R-16.2	Gilbert Shoal
2005	885,000	R-1 to R-25.6	Gilbert Shoal
2013	613,017	R-1 to R-25	St. Lucie Shoal
2018	427,763	R-1 to R-19.8	St. Lucie Shoal

3,567,780 cy

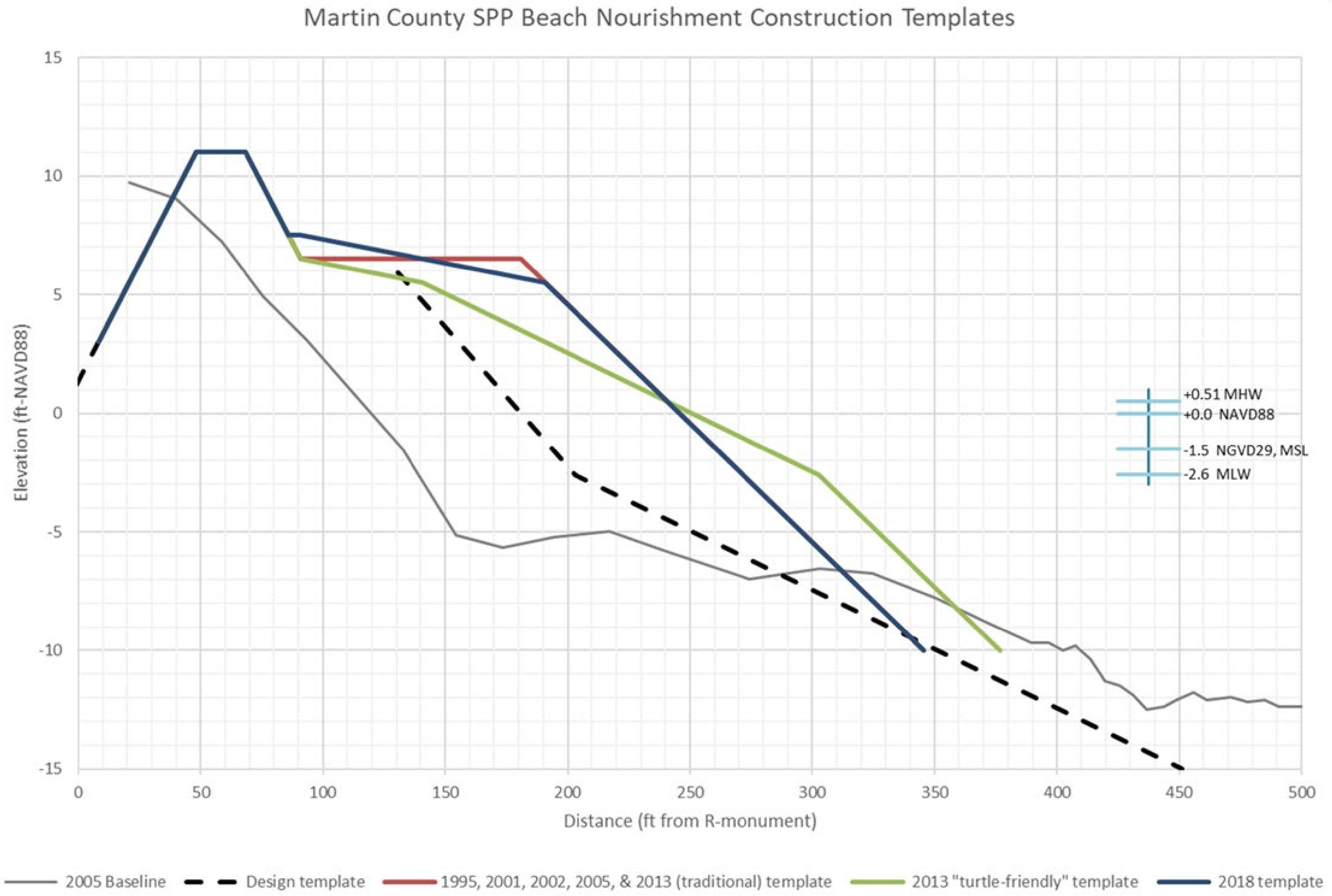
2,229,780 cy over 17 years

* Flood Control & Coastal Emergencies (FCCE) funding; 20-30% of volume

<u>GDM</u>: Renourishment of 589,000 cy every 11 years (53,600 cy/yr)

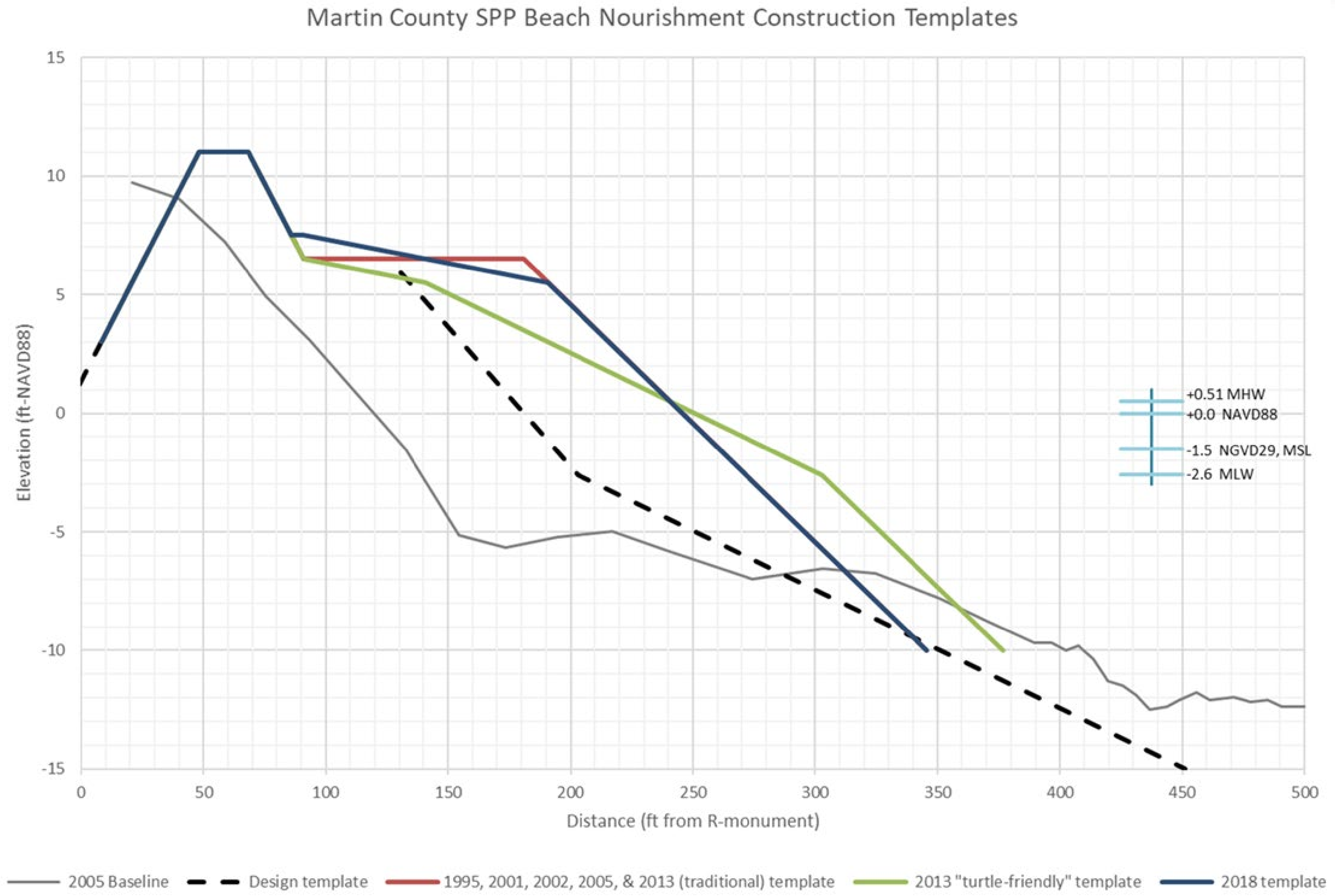
<u>LRR:</u> Renourishment of 787,800 cy every 13 years (60,600 cy/yr)

Project Design Parameters



- 4 construction templates
  - Advanced fill
- Variable reference datums
  - Tidal vs geodetic datums
    - *MHW; MSL; MLW*
    - *NAVD88; NGVD29*

Project Design Parameters



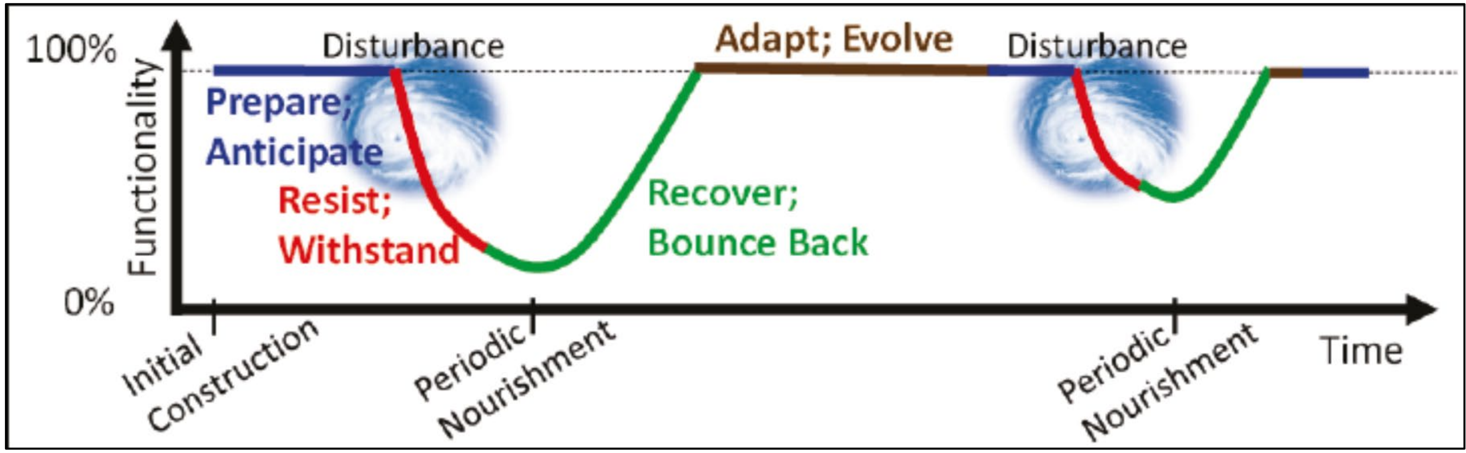
Design template – –

- Dune- 20 ft wide crest, +12.5 ft above MSL
- Berm- 35 ft wide, +8.0 ft above MSL
- Foreshore slope- 1V:8.5H to MLW then 1V:20H
- Construction template features ~80 ft extension of the berm

Resilience Defined

- Resilience is defined by *Executive Order 13653* as the ability to:
  - ➢ Anticipate,
  - ➢ Prepare for,
  - ➢ And adapt

  to changing conditions and:
  - ➢ Withstand,
  - ➢ Respond to,
  - ➢ And recover rapidly from disruptions



- Resilience is a ***trait***
- How can we measure resilience? What are the metrics?

Resilience Metrics

- Depends on what system you want to evaluate as resilient:
  - Economic
  - Social/Human
  - Environmental
  - Transportation
  - Power/Energy
- Specific to coastal infrastructure, measure damage caused by:
  - Inundation
  - Wave Damage
  - Erosion

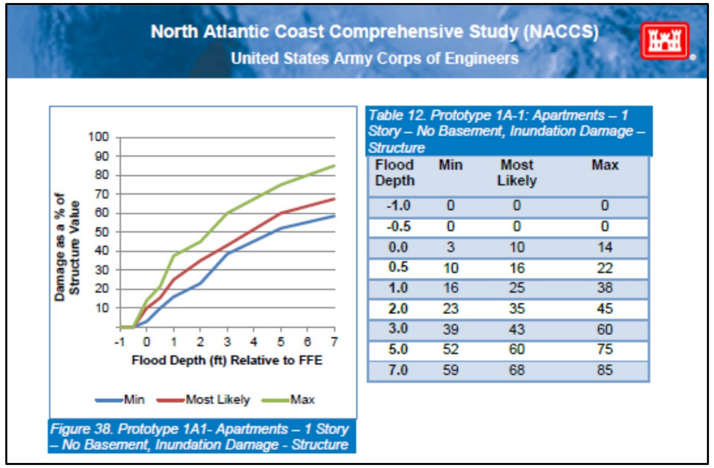

North Atlantic Coast Comprehensive Study (NACCS)
United States Army Corps of Engineers

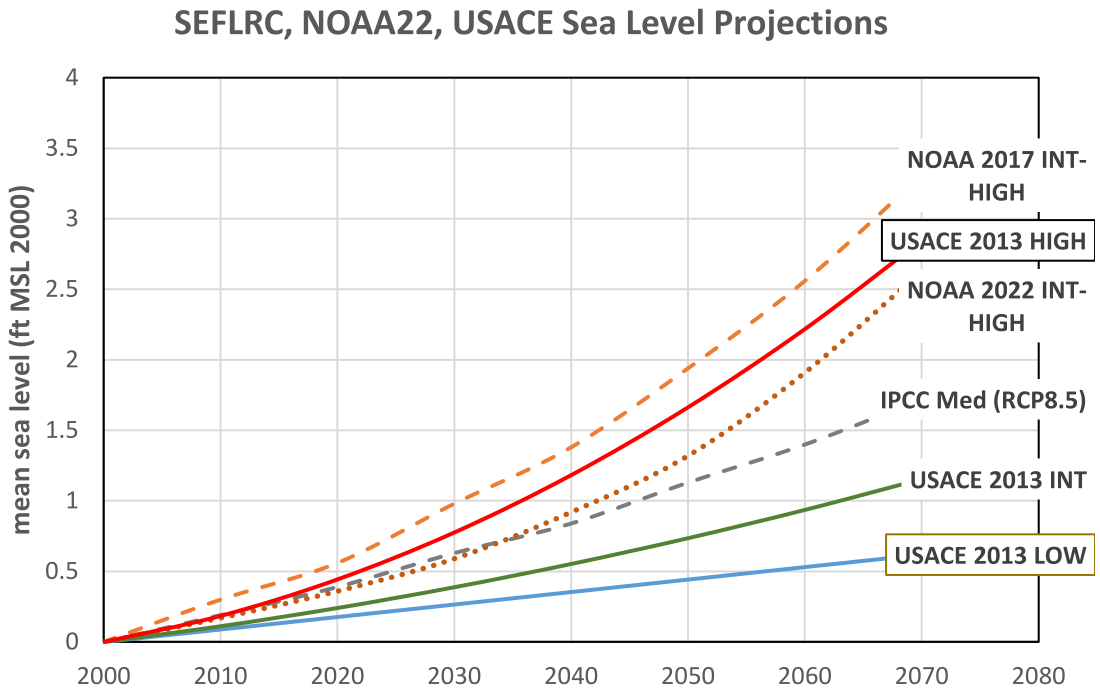
Figure 38. Prototype 1A1- Apartments – 1 Story – No Basement, Inundation Damage - Structure

Table 12. Prototype 1A-1: Apartments – 1 Story – No Basement, Inundation Damage – Structure

Flood Depth	Min	Most Likely	Max
-1.0	0	0	0
-0.5	0	0	0
0.0	3	10	14
0.5	10	16	22
1.0	16	25	38
2.0	23	35	45
3.0	39	43	60
5.0	52	60	75
7.0	59	68	85

Resilience to Sea Level Rise

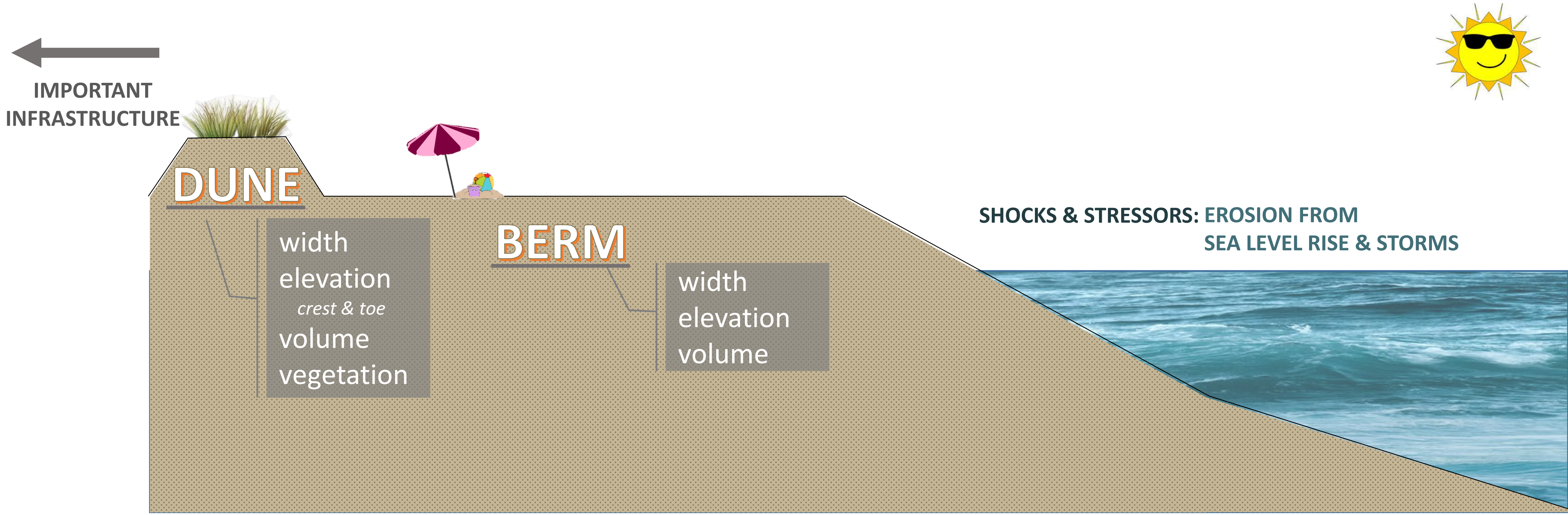
- Resilience is defined as the ability to:
  - ➢ Anticipate,
  - ➢ Prepare for,
  - ➢ And adapt
- Adaptation is an *action*
  - ➢ Requires planning



- What planning/SLR scenario to use?
- From Martin County SPP's 1993 General Design Memorandum:

67. A contributing factor to the susceptibility to storm damage is relative sea level rise. If the upper limit of relative sea level rise actually occurs, it will increase the shoreline recession and storm damages estimated within this report.

How to Measure Beach Resilience



How to Measure Beach Resilience

Simple

- Elevations
  - Contour tracking (MHW, berm, dune)
  - Maximum elevation (dune)
- Width/shoreline position
- Volume analysis
- Vegetation coverage

SHOCKS & STRESSORS

-Sea level rise

-Storm intensity, frequency, and duration

-Recovery rate

Complex

- Beach Change Envelope (USGS)
- Buffer Width (USACE)
- Coastal Vulnerability Index (USGS)
- Coastal Resilience Index (USACE- ASBPA, APTIM)
- (Dune) Engineering Design Parameter (Stevens)

short-term response/storm damage reduction benefits

Beach Condition 06/22

Beach Condition 9/26/22 (Pre-Ian)

Beach Condition 9/28/22 (During Ian)

Beach Condition 9/28/22 (During Ian)

Beach Condition 9/29/22 (Post-Ian)

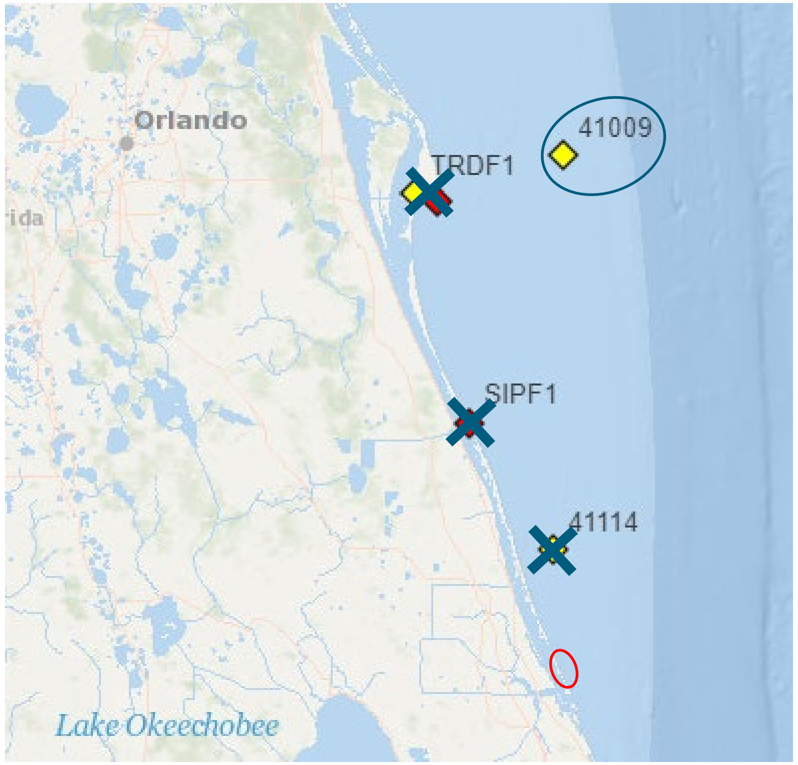
Beach Condition 11/7/22 (Pre-Nicole)

Beach Condition 11/9/22 (During-Nicole)

Beach Condition 11/10/22 (Post-Nicole)

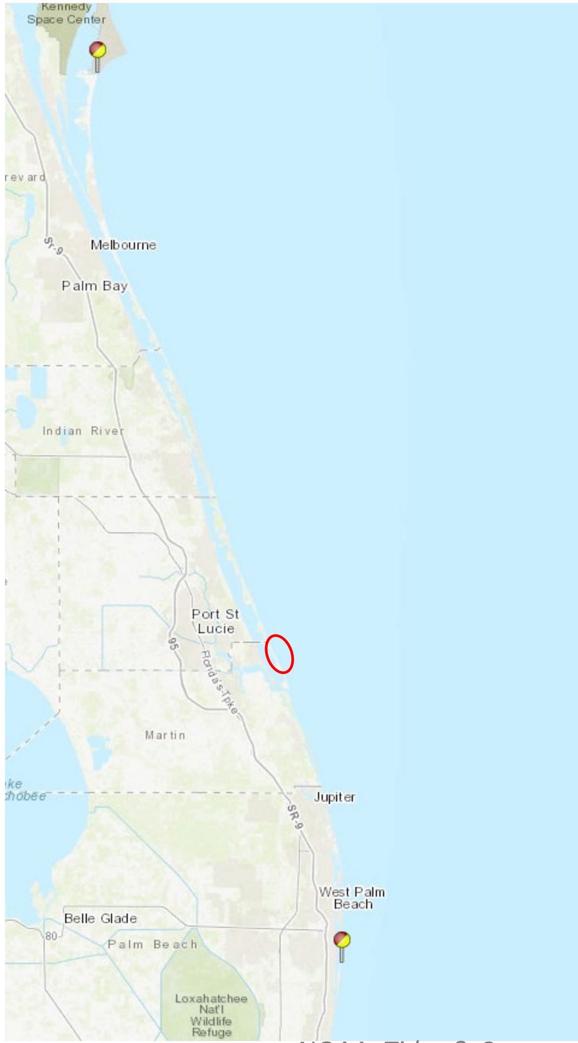
Beach Condition 11/15/22 (Post-Nicole)

Input Parameters- Wave & Water Level Data



NOAA, National Data Buoy Center

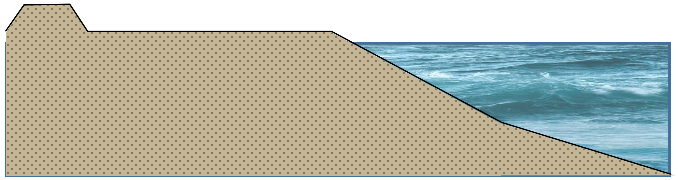
- Jensen Beach Wave Buoy
  - 0.42 miles offshore; depth ~33ft
- NOAA National Data Buoy Center (NDBC)
- USGS Flood Event Viewer
- NOAA Tides and Currents



NOAA, Tides & Currents

Application of Resilience Indices on the SPP

Contour Tracking & Volume Analysis



- Berm width
- Berm elevation
- Berm volume
- Dune width
- Dune elevation
- Dune volume
- ~~Water level~~
- ~~Wave information~~
- ~~Other:~~

Coastal Resilience Index

$$CRI = a + b + c + d + e$$

a= $\frac{PE}{PE_0}$ c= $\frac{PW-MR}{PW_o}$ d= $\frac{DE-(MS+MHW)}{CF_o}$

b= $\frac{PE*PW*(1-s)}{PE_0*PW_o}$ e= $\frac{WR_o}{WR}$

- Berm width
- Berm elevation
- ~~Berm volume~~
- Dune width
- Dune elevation
- ~~Dune volume~~
- Water level
- Wave information- Runup
- Other: fines

Engineering Design Parameter

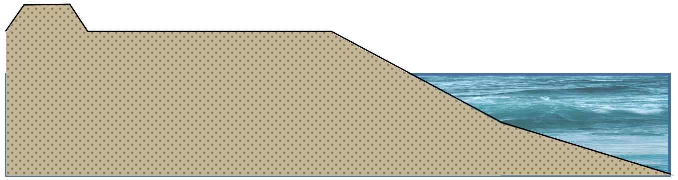
$$EDP = \frac{intensity}{resilience} = \frac{PEI^4}{B_{width}^2 * D_{vol}}$$

$$SEI = \sum_{t_d} IEI(t_i) = \sum_{t_d} W_*(t_i)\left[\frac{0.068H_b(t_i)+S(t_i)}{B+1.28H_b(t_i)}\right]$$

- Berm width
- Berm elevation
- ~~Berm volume~~
- ~~Dune width~~
- ~~Dune elevation~~
- Dune volume
- Water level
- Wave information- H_b
- Other: width of active surf zone

Application of Resilience Indices on the SPP

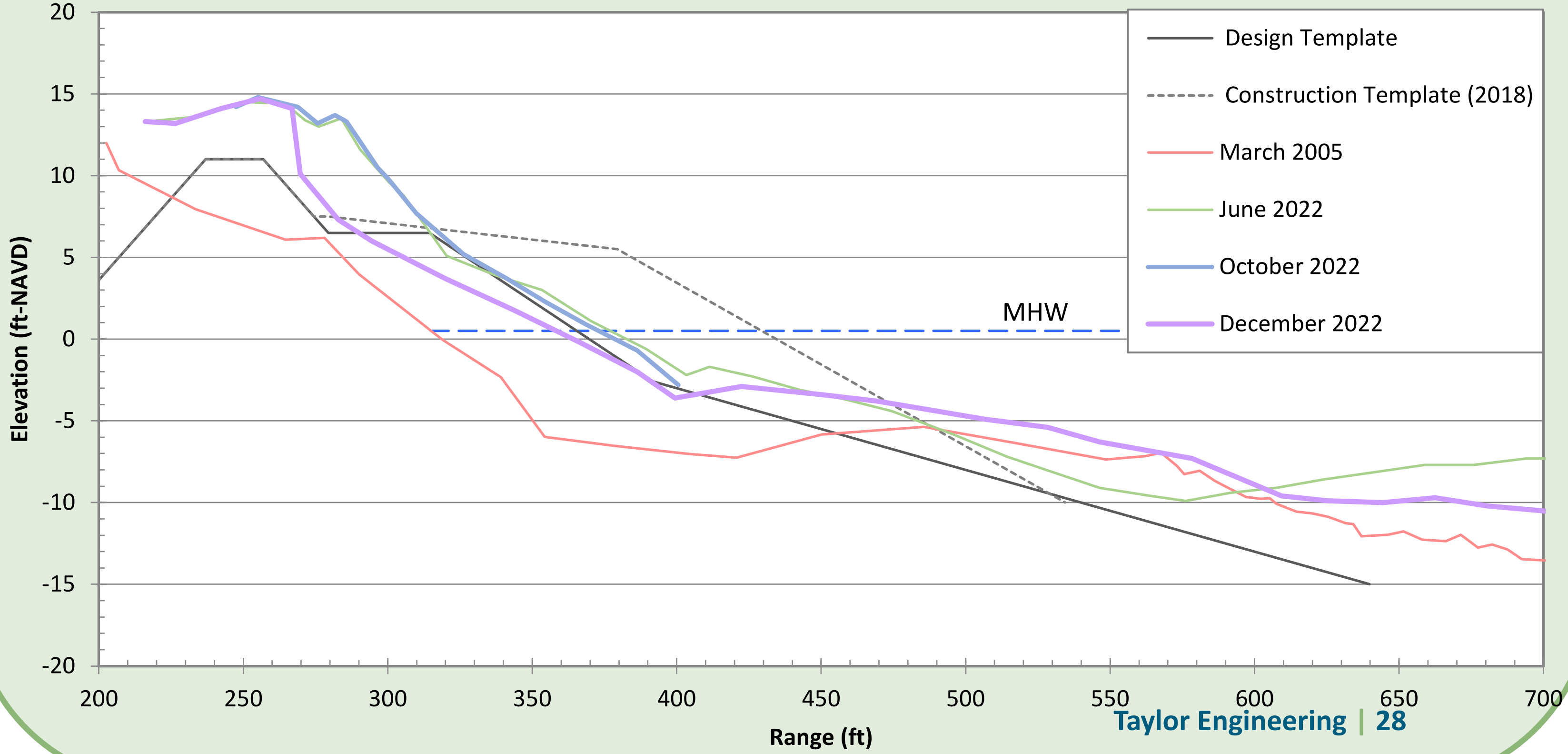
Contour Tracking & Volume Analysis



	Δ shoreline position (ft)	subaerial Δ vol (cy/ft)
DESIGN TEMPLATE	--	--
JUNE 2022	12	-0.3
OCTOBER 2022	8	+0.5
DECEMBER 2022	-7	-11.4

PROJECT AREA

	DESIGN - JUNE	JUNE - OCT	OCT - DEC
Δ shoreline position (ft)	46.6	-1.8	0.2
subaerial Δ vol (cy/ft)	-0.01	-2.6	-2.7



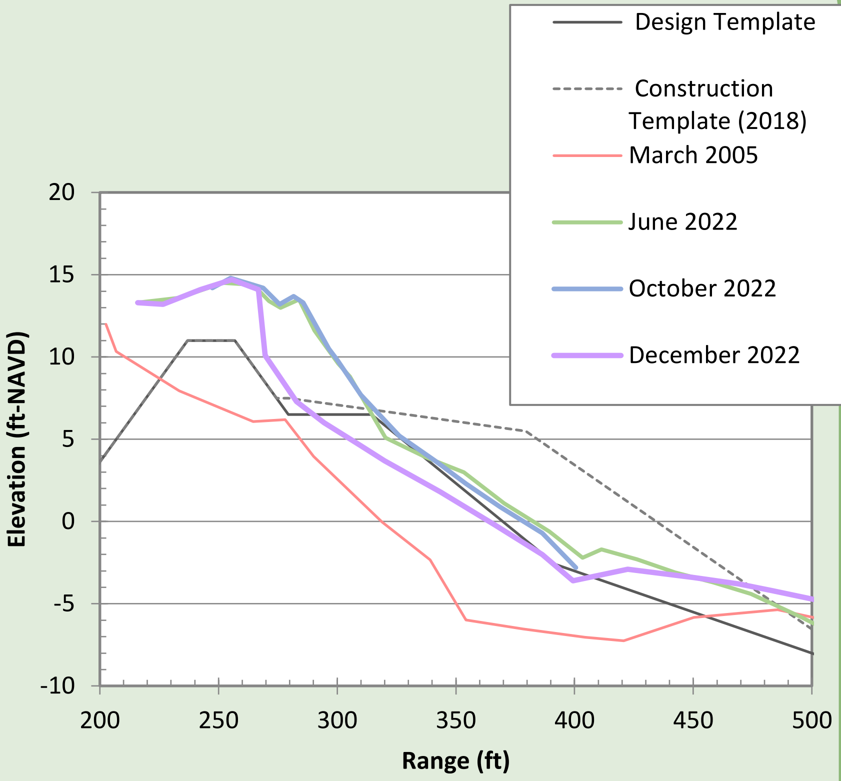
Application of Resilience Indices on the SPP

RESILIENCE INDEX		JUNE-OCT	OCT-DEC
a	PE	-	-0.1
b	VD	-	-0.2
c	PW	-0.3	+0.1
d	CF	-0.2	-0.2
e	WR	-0.9	-0.2
CRI		**-1.4**	**-0.6**

Coastal Resilience Index

$$CRI = a + b + c + d + e$$

		change in resilience factors
DESIGN TEMPLATE	--	
JUNE 2022	6.2	
OCTOBER 2022	4.8	c PW -0.3 d CF -0.2 e WR -0.9
DECEMBER 2022	4.2	a PE -0.1 b VD -0.2 c PW +0.1 d CF -0.2 e WR -0.2



Application of Resilience Indices on the SPP

	DESIGN TEMP	JUNE 2022	OCT 2022	DEC 2022
INTENSITY	2	3	26	46
RESILIENCE	33,600	70,600	64,500	63,400
EDP	**0.00038**	**0.00076**	**6.7**	**70.9**

	DESIGN TEMP	JUNE 2022	OCT 2022	DEC 2022
INTENSITY	↓↓	↓	↑↑	↑↑↑
RESILIENCE	↓↓↓	↑↑	↓↓	↓
EDP	low INT- avg annual conditions low RES- dune volume	low INT- avg conditions high RES- dune volume	high INT- Ian low RES- decrease in berm width	very high INT- Nicole low RES- decrease in dune vol, increase in berm width

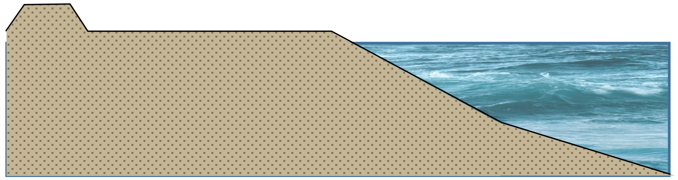
Low EDP- resilient beach and/or low intensity storm
High EDP- vulnerable beach and/or high intensity storm

Engineering Design Parameter

$$EDP = \frac{intensity}{resilience} = \frac{PEI^4}{B_{width}^2 * D_{vol}}$$

DESIGN TEMPLATE	0.00038	↓↓ Intensity ↓↓↓ Resilience
JUNE 2022	0.00076	↓ Intensity ↑↑ Resilience
OCTOBER 2022	6.7	↑↑ Intensity ↓↓ Resilience
DECEMBER 2022	70.9	↑↑↑ Intensity ↓ Resilience

Application of Resilience Indices on the SPP



	Contour Tracking & Volume Analysis: Δ shoreline position (ft)	subaerial Δ vol (cy/ft)	Coastal Resilience Index: $CRI = a + b + c + d + e$	change in resilience factors	Engineering Design Parameter: $EDP = \frac{intensity}{resilience} = \frac{PEI^4}{B_{width}^2 * D_{vol}}$	
DESIGN TEMPLATE	--	--	--		0.00038	↓↓ Intensity ↓↓↓ Resilience
JUNE 2022	12	-0.3	6.2		0.00076	↓ Intensity ↑↑ Resilience
OCTOBER 2022	8	+0.5	4.8	c PW -0.3 d CF -0.2 e WR -0.9	6.7	↑↑ Intensity ↓↓ Resilience
DECEMBER 2022	-7	-11.4	4.2	a PE -0.1 b VD -0.2 c PW -0.1 d CF -0.2 e WR -0.2	70.9	↑↑↑ Intensity ↓ Resilience

Conclusions

- Beach resilience directly related to "buffer" volume and recovery time/conditions
- Many ways to measure beach resilience… which way is the best?
  - Martin SPP is a good candidate for testing resilience measures due to its extensive survey data and buoy
    - Provides necessary data for long term planning and innovation that is needed to protect coastal infrastructure against our current and future stressors
  - Resilience indices highly dependent on distribution of terms… should these be beach specific?
  - Selection of parameters is subjective; assumptions often needed

- *How do we make changes to a project over the project lifetime due to SLR or increased erosion rates?* prepare, resist, recover, and ADAPT

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