



# Assessing National Park Asset Flood Risk: Retreat, Adapt, Fortify?

April 14, 2020

Materials will be available at: [www.eesi.org/041420data](http://www.eesi.org/041420data)

Tweet about the briefing: [#eesitalk](https://twitter.com/eesitalk) [@eesionline](https://twitter.com/eesionline)



# EESI

Environmental and  
Energy Study Institute

- Founded in **1984** by a **bipartisan** Congressional caucus.
- Now an **independent**, bipartisan **nonprofit** with no Congressional funding.
- We provide **fact-based information** on **energy** and **environmental** policy for Congress and other policymakers.
- We focus on **win-win solutions** to make our energy, buildings, and transportation sectors **sustainable** and **resilient**.

Visit [www.eesi.org](http://www.eesi.org) to:

- View **videos** of our Congressional briefings.
- Sign up to receive our **briefing notices**, and **fact sheets**.
- Subscribe to our newsletters, including ***Climate Change Solutions***.

# COASTAL HAZARDS & SEA-LEVEL RISE ASSET VULNERABILITY ASSESSMENT PROTOCOL: PRESERVING OUR NATIONAL HERITAGE

Program for the Study of Developed  
Shorelines, Western Carolina University

- NPS – Park Facility Management Division - Sustainable Operations Branch
- NPS – Park Facility Management Division - Facilities Planning Branch
- NPS – Climate Change Response Program



## Assets in coastal parks exposed to 1 m of SLR: 103 coastal parks analyzed.

Region	<u>Total Assets Analyzed</u>		<u>High Exposure Results</u>				
	# Assets	CRV	# Assets	% of Total Assets	CRV	% of Total CRV	% Historic <sup>1</sup>
<b>NER</b>	3,683	\$12,558,630,579	1,151	31%	\$5,840,064,747	47%	19%
<b>SER</b>	3,455	\$37,097,656,761	2,762	80%	\$13,493,524,509	36%	14%
<b>PWR</b>	5,074	\$10,373,481,532	481	9%	\$1,609,426,190	16%	11%
<b>IMR</b>	242	\$127,074,693	30	12%	\$41,775,751	33%	0%
<b>AKR</b>	316	\$219,444,614	3	1%	\$107,831	0%	0%
<b>NCR</b>	2,578	\$10,422,456,372	214	8%	\$2,277,767,920	22%	4%
<b>All Units</b>	<b>15,348</b>	<b>\$70,798,744,551</b>	<b>4,641</b>	<b>30%</b>	<b>\$23,262,666,948</b>	<b>33%</b>	<b>15%</b>



# Mission

- The Program for the Study of Developed Shorelines serves as a nexus between coastal science and policy. The PSDS applies innovative approaches to studying and understanding coastal processes, as well as translating new coastal science into sensible, science-based management recommendations. The center also seeks to communicate this science to the general public through traditional and non-traditional outlets.





HOME PSDS WEBSITE PSDS IMAGES ABOUT



# BEACH NOURISHMENT VIEWER

PROGRAM FOR THE STUDY OF DEVELOPED SHORELINES @ WESTERN CAROLINA UNIVERSITY



CLICK ON THE STATE OF INTEREST OR SELECT IT FROM THE LIST:

Select a state





# “A Never-Ending Commitment”: The High Cost of Preserving Vulnerable Beaches

In the wake of hurricanes like Florence, the U.S. government pays to dump truckloads of sand onto eroding beaches, in a cycle that is said to harm ecosystems and disproportionately benefit the rich.

by Lisa Song and Al Shaw, Sept. 27, 2018, 5 a.m. EDT



A beach replenishment project underway at Rockaway Beach in New York in 2014, following Hurricane Sandy. (Carolyn Cole/Los Angeles Times via Getty Images)



**FOLLOW PROPUBLICA**

Twitter

YouTube

**STAY INFORMED**

Get our investigation Big Story newsletter.

Enter your email





# STORM SURGE VIEWER

PROGRAM FOR THE STUDY OF DEVELOPED SHORELINES @ WESTERN CAROLINA UNIVERSITY

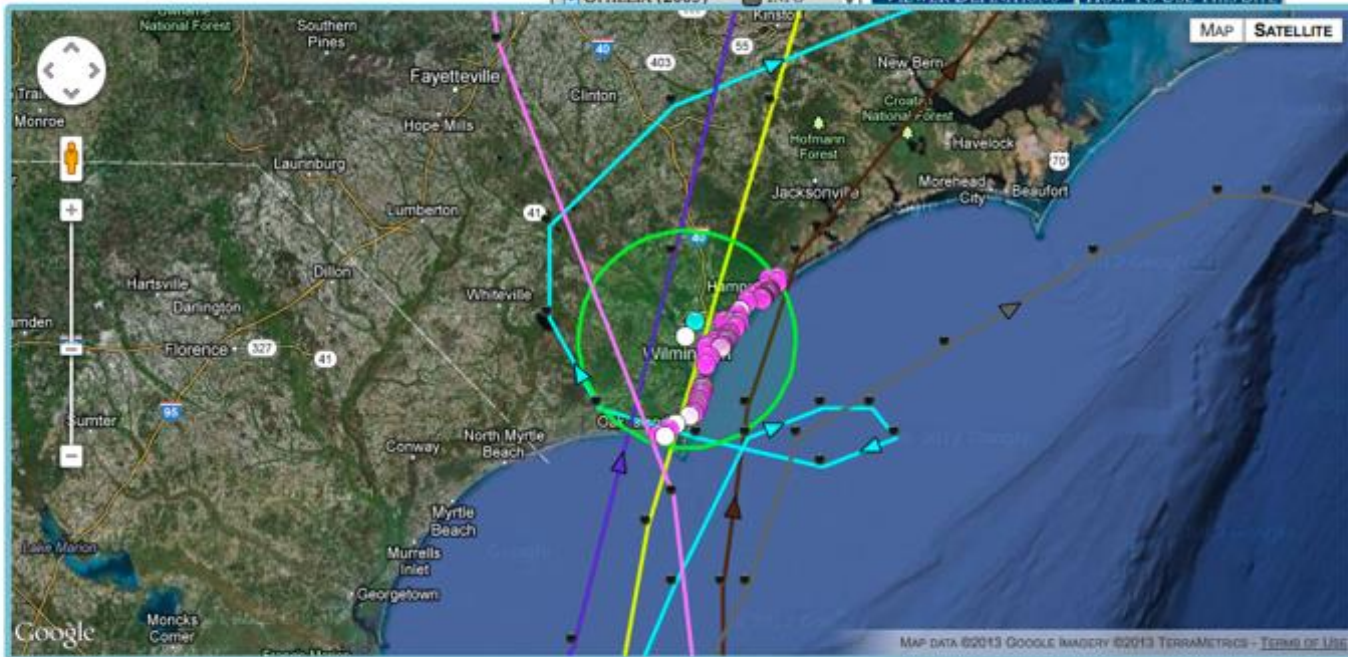


ADDRESS:   
HURRICANE NAME:   
SEARCH RADIUS (MILES):

- DIANA (1984)  INFO
- ERNESTO (2006)  INFO
- FRAN (1996)  INFO
- IRENE (2011)  INFO
- OPHIELLA (2005)  INFO

- VIEW SURGE/HIGH WATER MARKS
- VIEW HURRICANE PATH

[VIEWER DEFINITIONS](#) [HOW TO USE THIS SITE](#)





# www.beachcare.org sand mining database

Beachcare | BEACH ISSUES | LEARN ABOUT BEACHES | GET INVOLVED | BEACHCARE JUNIOR | ABOUT US | FILMS | NEWS | BLOG

## INFORM EDUCATE PROTECT CELEBRATE


LEARN MORE >>

### PSDS IMAGE LIBRARY

WCU Program for the Study of Sustainable Development (PSDS) maintains an image library and development changes along shorelines in the United States by over 30 years and being the first. These images provide you an overview of coastal resources.

[VIEW SITE](#)


#### BEACHCARE FILMS



**North Carolina's Legislation on Hardened Structures Reauthorized**  
North Carolina has prohibited hardened structures on its beaches and made for more than two decades. Watch now...

[VIEW ALL >>](#)


#### BEACHCARE NEWS



**Clutter Mining is Destroying Famous Sand Dunes**  
Recent tourism is in danger of becoming an island. Read more...

[VIEW ALL >>](#)


#### BEACHCARE BLOG



**Use of Hardened Beach Structures to Slow Erosion**  
While the use of hardened beach structures are reduced, there is little study over what they do besides over time. Read more...

[VIEW ALL >>](#)

### BEACH SAND MINING IS HAPPENING AROUND THE WORLD RIGHT NOW.



[LEARN HOW IT AFFECTS OUR BEACHES >>](#)

#### BEACH OF THE MONTH

Virginia Beach, VA  
April 2009  
[Read more...](#)

#### PHOTO OF THE MONTH

Shoreline by Lisa Wong  
April 2009  
[Read more...](#)

**SIGN UP TO BECOME A BEACHCARE MEMBER >>**

©2009 Beachcare. All Rights Reserved. | [Legal Notice](#) | [Privacy Policy](#) | [Contact Us](#)

Beachcare Exclusive | Beach Sand Mining Database

Country	Name	Region	Day	Month	Year	Type	URL or Title	Funding	Lead Source
Australia	Sand Mining	New South Wales	17	Oct	1994	Government	<a href="#">View Source</a>	0	0
Australia	Offshore Sand Mining	Offshore	15	May	1994	Journal	Determining the Limits of Beach-Adjacent Sand Systems and the Impact of Offshore Coastal Sand Mining	None Stated	0
Canada	Offshore Sand Mining	Gulf of St. Lawrence	15	May	1994	Journal	Guests: sand's depletion from a Dredged Marine Deposit Site	None Stated	0
South Africa	Sand Mining		Mar	1994	Journal	<a href="#">View Source</a>	0	0	
South Africa	Sand Mining		Mar	1994	Non-Governmental	<a href="#">View Source</a>	0	0	
Australia	Sand Mining	Queensland	9	Apr	1997	News	<a href="#">View Source</a>	0	0
New Zealand	Sand Mining	Pacific/Mangonui coastline	Sep	1999	Non-profit	<a href="#">View Source</a>	0	0	
Malaysia	Sand Mining		15	Sep	1999	Forum	<a href="#">View Source</a>	0	0
United States	Sand Mining	California	24	Mar	2000	Personal	<a href="#">View Source</a>	0	0
United States	Sand Mining	Michigan	13	Nov	2000	Government	<a href="#">View Source</a>	0	0
Caribbean	Sand Mining	Caribbean	21	May	2001	Subsidiary	<a href="#">View Source</a>	0	0
Indonesia	Sand Mining	Riau Islands	Nov	2001	News	<a href="#">View Source</a>	0	0	
United States	Sand Mining	Michigan	2001	Government	<a href="#">View Source PDF</a>	0	0		
United States		Mid-Atlantic coast	8	Nov	2001	Journal	An Investigation of Potential Consequences of Marine Mining in Shallow Water: An Example from the Mid-Atlantic Coast of the United States	Government	Minerals Management Service, STTRNA
England	Sand Mining		26	Sep	2001	News	<a href="#">View Source</a>	0	0
Norway	Water Turbidity		Fall	2001	Journal	Consequences of Sediment Discharge from Dune Mining at Elizabeth Bay, Norway	Government	CSF - Council for Scientific and Industrial Research (South Africa)	
Spain	Sand Mining		2002	Government	<a href="#">View Source PDF</a>	0	0		
Tanzania	Sand Mining		18	May	2002	Journal	Coastal Erosion and Environmental Impacts in Tanzania: A Case Study in Bagamoyo	None Stated	0
Argentina	Coastal Flooding	Buenos Aires and Victoria	13	Sep	2002	Journal	Coastal processes and environmental impacts in the Buenos Aires (Argentina) and Victoria (B.C.) Beaches	None Stated	0
Australia	Sand Mining	Queensland	27	Feb	2003	Conservation Group	<a href="#">View Source</a>	0	0
India	Sand Mining	Varanasi	31	Jul	2003	News	<a href="#">View Source</a>	0	0
India	Sand Mining	Alappuzha	Aug	2003	News	<a href="#">View Source</a>	0	0	
India	Sand Mining	Alappuzha	14	Nov	2003	News	<a href="#">View Source</a>	0	0
India	Sand Mining	Alappuzha	Dec	2003	Journal	<a href="#">View Source PDF</a>	0	0	
Poland	Sand Mining	New Islands	31	Oct	2003	NCO	<a href="#">View Source</a>	0	0
New Zealand	Sand Mining	Auckland	2003	Government	<a href="#">View Source</a>	0	0		
New Zealand	Sand Mining		9	Apr	2003	News	<a href="#">View Source</a>	0	0
Singapore	Sand Mining		31	Jul	2003	News	<a href="#">View Source</a>	0	0
South Africa	Sand Mining		9	Jul	2003	Non-profit	<a href="#">View Source</a>	0	0
United States	coastal erosion	California	22	Aug	2003	Non-profit	<a href="#">View Source</a>	0	0
United States	Offshore Sand Mining	Maryland and Delaware	8	Nov	2003	Journal	Potential Impacts of Sand Mining Offshore of Maryland and Delaware: Part 2 - Biological Considerations	Government	Minerals Management Service
United States	Offshore Sand Mining	Maryland and Delaware	8	Nov	2003	Journal	Potential Impacts of Sand Mining Offshore of Maryland and Delaware: Part 1 - Impacts on Physical Geomorphologic Processes	Government	Minerals Management Service



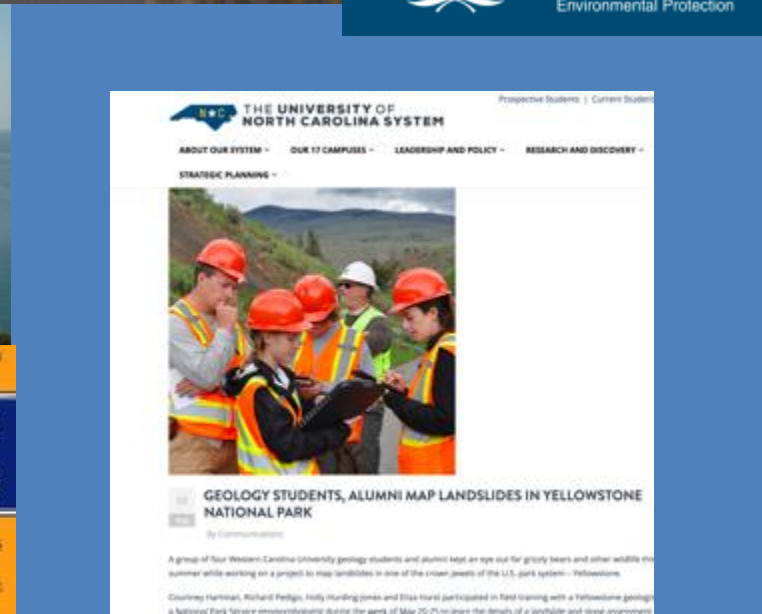
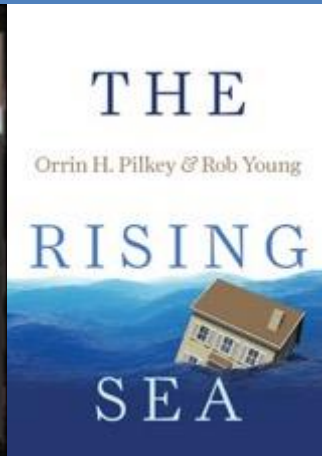
20 April 2009

www.psd.wcu.edu  
www.beachcare.org



# Program for the Study of Developed Shorelines

It's all about communicating





# PRIMARY GOALS



PROGRAM FOR  
THE STUDY OF  
DEVELOPED  
SHORELINES



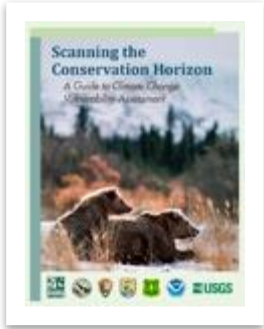
- Asset level protocol: Create methodology for assessing vulnerability of NPS assets to coastal hazards & SLR (structures + transportation assets)
- Standardize methodology to allow comparison across regions
- Use consistent data sources: established & reliable data, universal & georeferenced, likely to be updated & maintained
- Provide actionable information!!! Decision-makers don't need a bunch of additional hazard maps to look through.
- Integrate the VA scoring into all park planning, short- and long-term







# CONCEPTUAL DESIGN



## METRICS OF VULNERABILITY: NATURAL RESOURCES



### Exposure

if a resource is located in an area experiencing climate change & coastal hazards

### Sensitivity

how a resource fares when exposed to an impact

### Adaptive capacity

the ability of the resource to adjust or cope with impacts





# CONCEPTUAL DESIGN



**ADAPTIVE CAPACITY**

**SLR = MIGRATION UPLAND**



**ADAPTIVE CAPACITY**

**SLR = DEPENDS**





# CONCEPTUAL DESIGN



## METRICS OF VULNERABILITY: INFRASTRUCTURE



Adaptive  
Capacity

- ✓ Still significant, but addressed separately
- ✓ Not part of vulnerability formula/score
- ✓ **Adaptation actions are developed at the end of the assessment**



# COASTAL HAZARD & SLR **EXPOSURE** INDICATORS



**INDICATORS:** FACTORS/DATA TO CONSIDER WHEN ANALYZING EXPOSURE OF AN ASSET

INDICATOR	DATA SOURCES
<p><b>FLOODING POTENTIAL</b> 1% ANNUAL FLOOD CHANCE ± VELOCITY/WAVES</p>	<ul style="list-style-type: none"> <li>FEMA Flood Zones (VE or AE); LiDAR DEM or other elevation model</li> </ul>
<p><b>EXTREME EVENT FLOODING</b> STORM SURGE, TSUNAMI, EXTREME HIGH WATER</p>	<ul style="list-style-type: none"> <li>NPS-specific SLOSH model; tsunami models; tide gage recorded extreme high water data</li> </ul>
<p><b>SEA-LEVEL RISE INUNDATION</b> 2050 PROJECTION</p>	<ul style="list-style-type: none"> <li>NPS-specific SLR modeling; LiDAR DEM or other elevation model</li> </ul>
<p><b>SHORELINE CHANGE</b> EROSION, COASTAL PROXIMITY, CLIFF RETREAT</p>	<ul style="list-style-type: none"> <li>State or USGS erosion rate buffers; cliff retreat rate buffers; shoreline proximity buffers</li> </ul>
<p><b>REPORTED COASTAL HAZARDS</b> HISTORIC FLOODING, VISIBLE SLOPE INSTABILITY</p>	<ul style="list-style-type: none"> <li>Park surveys/questionnaire results; storm imagery &amp; reconnaissance</li> </ul>

- Goal: consistent data sources across parks (when possible)*
- Exposure time frame: 2050*





# FLOODING POTENTIAL INDICATOR DATA

*Data:*  
**FEMA High Risk  
Flood Zones  
(VE and A Zones)**

*Lighthouse*



**Data Source: FEMA**

**VE (Highest Hazard):** Areas subject to inundation by the **1-percent-annual-chance flood event with additional hazards due to storm-induced velocity wave action**. Base Flood Elevations (BFEs) derived from detailed hydraulic analyses are shown. Mandatory flood insurance purchase requirements and floodplain management standards apply.

**AE (or other A):** Areas subject to inundation by the **1-percent-annual-chance flood event** determined by detailed methods. Base Flood Elevations (BFEs) are shown. Mandatory flood insurance purchase requirements and floodplain management standards apply.

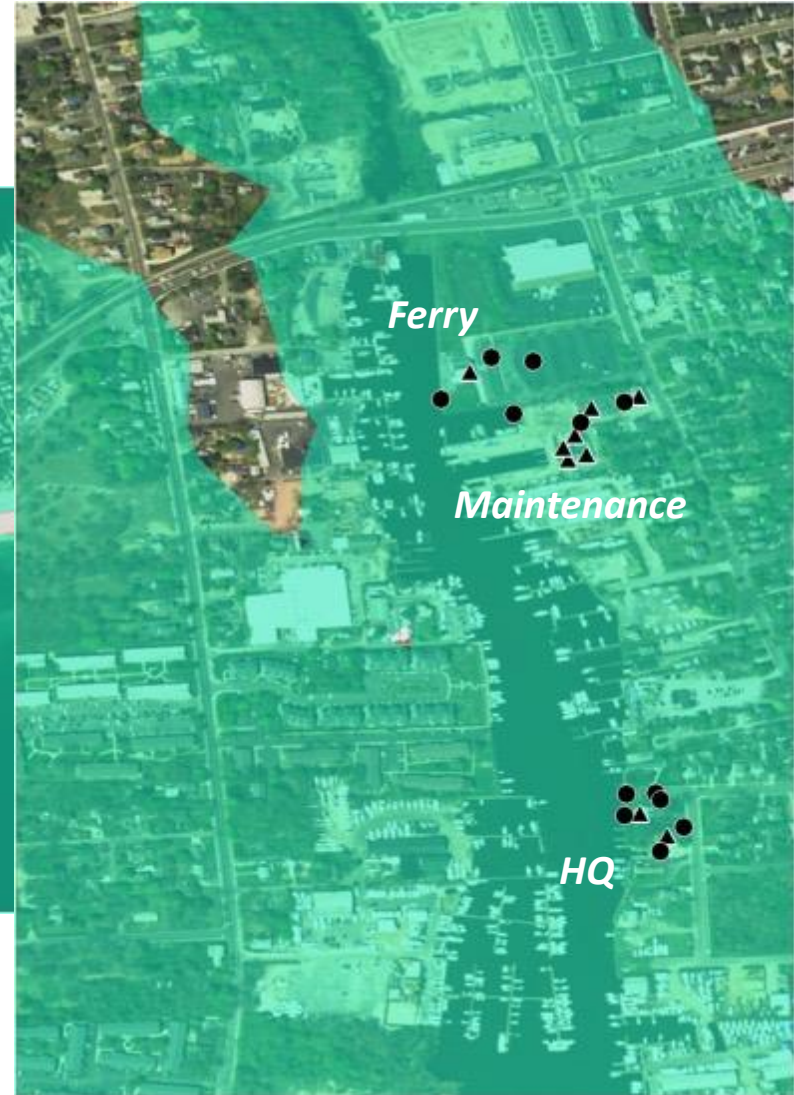
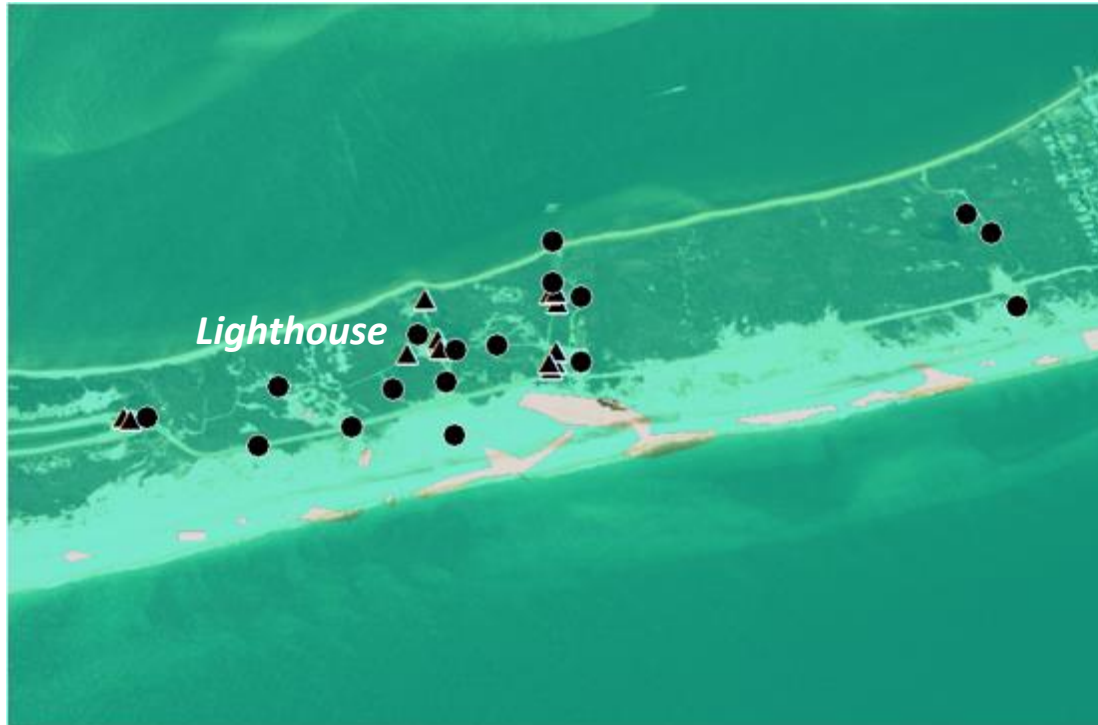




# EXTREME EVENT FLOODING INDICATOR DATA



Data:  
Storm Surge Cat 3 SLOSH Model



Data Source: NPS CCRP



# SLR INUNDATION INDICATOR DATA



**Data:**  
*Sea-level rise (SLR)*



**Data Info:** NPS-specific SLR models 2050  
Intermediate Projection (obtained from  
NPS Climate Change Response Program)





# SHORELINE CHANGE INDICATOR DATA



*Data: 35-year erosion buffer zones & coastal proximity buffers*

*Data Source: USGS Erosion Rates*





# COASTAL HAZARDS FIELD DATA FROM PAST EVENTS



**Data Sources:  
Historical Flooding  
Reports (Questionnaire) &  
Storm Imagery**



## Historical Flooding Data

<https://arcg.is/1Gq0yy>

Has the SITE or LAND AREA near any of the following assets been flooded in previous storm events?

\* This question is referring to the *site or land area* around an asset. Even if the asset was not built during a particular storm, we would like to know if that location has been flooded in the past. Please note in the comments if the flooding is non-coastal (e.g., heavy rainfall, ponding, or drainage issues).

FMSS Asset Information					Record Answers (add x)	Comments (clarifications, unsure, unfamiliar with asset, etc.)
#	Asset Code	Year Built	FMSS Code	Asset Description	Yes	
1	4100	1964	111677	BU-BB-Sun Shelter		<i>Click here to add any comments</i>
2	4100	1964	105369	BU-BB-Snack Bar		<i>Click here to add any comments</i>
3	4100	1964	105370	BU-BB-Restrooms/Utility Room		<i>Click here to add any comments</i>





# EXPOSURE SCORING & RESULTS



Flooding Indicator

Surge Indicator

SLR Indicator

Erosion/Coastal Proximity Indicator

Historical Flooding Indicator

**TOTAL EXPOSURE SCORE**



## Exposure Scoring

# of Exp Zones	Raw Score	Final Score	Rank
4-5	17-20	4	High
2-3	11-14	3	Moderate
1	8	2	Low
0	5	1	Minimal

## Exposure Scoring & Rank Definitions

**Overall:** This methodology is meant to assess the exposure of each asset to multiple coastal hazards and climate change factors combined (i.e., erosion, flooding, storm surge, sea-level rise, and historical flooding)

**High:** A ranking of "high" means that an asset is in a location that intersects at least 4 exposure indicators. This means the asset may not be within 1 of the 5 coastal hazard and SLR exposure indicator zones.

**Moderate:** A ranking of "moderate" means that an asset is in a location that intersects 2 or 3 exposure indicators. This means the asset may not be within 2 or 3 of the coastal hazard and SLR exposure indicator zones.

**Low:** A ranking of "low" means that an asset is in a location that intersects only 1 exposure indicator hazard zone. This means the asset is only within 1 of the 5 coastal hazard and SLR exposure indicator zones; the asset could still be seriously impacted by one hazard.

**Minimal:** A ranking of "minimal" means that an asset is not in ANY of the coastal hazard and SLR exposure indicator zones. This does not mean that the asset has no exposure, but instead, that the current data does not overlap with the location of the asset.

# EXPOSURE SCORING & DRAFT RESULTS



Back Next

## Exposure Analysis Data Results

[Definitions of WCU Columns on Next Sheet \(Click Here to View\)](#)

ID	Location	Area	Step 1: Score for Exposure Indicator Zones				Step 2	Step 3	Step 4	Step 5	Step 6	Step 7		
			1a. FEMA VE Zone Score	1b. FEMA A Zone Score	1c. Erosion Proximity Score	1d. SLR Score	1e. Surge Cat 3 Score	1f. Historic Flooding Score	Raw Score from Step 1	Binned Score Raw	VE Zone Auto High Score	Exposure Score Unmod	WCU Flagged Asset	Exposure Score
1	Q-00000154-HO-TA-154 Ocean Qtrs	TA	4		1	1	4	1					4	high
2	BU-HQ-76 Park Headquarters	HQ		4	4	1	4	4					4	high
3	BU-HQ-72 Headquarters Annex	HQ		4	4	1	4	4					4	high
4	Q-00000103-HO-SH-103 Sailors Haven Housing Unit	SH	4		1	1	4	1					3	moderate
5	BU-HQ-73 Patchogue Boat House	HQ		4	4	1	4	4					4	high
6	BU-HQ-77 PMF Maintenance Facility	HQ		1	1	1	4	1					2	low
7	BU-HQ-78 Vehicle Vessel Shop	HQ		4	4	1	4	4					4	high
8	Q-00000006-HO-WH-06 Qtrs #6	WH		4	1	1	4	1					3	moderate
9	Q-00000002-HO-WH-02 Qtrs #2	WH		4	1	1	4	1					3	moderate
10	BU-HQ-79 PMF Warehouse	HQ		4	1	1	4	4					3	moderate
11	Q-00000003-HO-WH-03 Qtrs #3	WH		4	1	1	4	1					3	moderate
12	Q-00000004-HO-WH-04 Qtrs #4	WH		4	1	1	4	1					3	moderate
13	Q-00000005-HO-WH-05 Qtrs #5	WH		4	1	1	4	1					3	moderate
14	Q-00000007-HO-WH-07 Qtrs #7	WH		4	1	1	4	1					3	moderate
15	BU-HQ-81 River Room (Conference)	HQ		4	1	1	4	4					3	moderate
16	Q-00000008-HO-WH-08 Qtrs #8	WH		4	1	1	4	1					3	moderate
17	Q-00000009-HO-WH-09 Qtrs #9	WH		4	1	1	4	1					3	moderate
18	Q-00000010-HO-WH-10 Qtrs #10	WH		4	1	1	4	1					3	moderate
19	Q-00000011-HO-WH-11 Qtrs #11	WH		4	1	1	4	1					3	moderate
20	Q-00000012-HO-WH-12 Qtrs #12	WH		4	1	1	4	1					3	moderate
21	Q-00000001-HO-WH-01 Qtrs#1	WH		4	1	1	4	1					3	moderate
22	BU-WF-224 Curatorial Storage	WF		1	1	1	4	1					2	low
23	BU-LS-219 Single Story Connector Bldg	LS		4	1	1	4	1					3	moderate
24	Q-00000151-HO-CA-151 Carrington House	CA	4		1	1	4	1					4	high
25	BU-LS-93a Comfort Station	LS		4	1	1	4	1					3	moderate
26	Q-00000152-HO-CA-152 Carrington Cottage	CA		4	1	1	4	1					3	moderate
27	Q-00000104-HO-SH-102 Qtrs#102	SH		4	1	1	4	1					3	moderate
28	BU-SH-107 Comfort Station	SH		4	1	1	4	1					3	moderate
29	BU-SH-104 Visitor Center	SH		4	4	1	4	1					3	moderate
30	BU-OP-51 Wilderness Visitor Center	OP	4		1	1	4	1					4	high
31	BU-TA-156 Maintenance Shop	TA		4	1	1	4	1					3	moderate
32	BU-TA-157 Comfort Station	TA		4	4	1	4	1					3	moderate
33	BU-TA-158 Pump House	TA	4		1	1	4	1					4	high





# EXPOSURE MAPS



## Lighthouse Area

### FIIS Transportation Exposure

#### Rank

- high
- moderate
- low
- minimal

### FIIS Structures Exposure

#### Rank

- ▲ high
- ▲ moderate
- ▲ low
- ▲ minimal







# EXPOSURE MAPS



## Barrett Beach/ Talisman Area

**FIIS Transportation Exposure**

**Rank**

- high
- moderate
- low
- minimal

**FIIS Structures Exposure**

**Rank**

- ▲ high
- ▲ moderate
- ▲ low
- ▲ minimal





# COASTAL HAZARD & SLR SENSITIVITY INDICATORS



**INDICATORS:** FACTORS/DATA TO CONSIDER WHEN ANALYZING SENSITIVITY OF AN ASSET

INDICATOR		COMMON DATA SOURCES
<input checked="" type="checkbox"/>	<b>FLOOD DAMAGE POTENTIAL</b>	<ul style="list-style-type: none"><li>• Direct field measurement: threshold elevation, park personnel surveys/interviews, field surveys</li></ul>
<input checked="" type="checkbox"/>	<b>STORM RESISTANCE &amp; CONDITION</b>	<ul style="list-style-type: none"><li>• Park personnel surveys/interviews, FMSS</li></ul>
<input checked="" type="checkbox"/>	<b>HISTORICAL DAMAGE</b>	<ul style="list-style-type: none"><li>• Park personnel surveys/interviews, park documents/reports</li></ul>
<input checked="" type="checkbox"/>	<b>PROTECTIVE ENGINEERING</b>	<ul style="list-style-type: none"><li>• Park personnel surveys/interviews, coastal engineering inventory (WCU/OSU), field surveys</li></ul>



# SENSITIVITY INFORMATION – PARK QUESTIONNAIRE

Are any of the following assets elevated at least 5 feet above local ground level (including critical utilities)?

Examples include: 1) assets on stilts or pilings, or 2) assets built on artificial fill material above local ground level. NOTE: If elevated, but not quite 5 feet, indicate in comments

FMSS Asset Information

Record Answers (add x)

Comments (clarifications, unsure, unfamiliar with asset, etc.)

Are any of the following assets built to resist flood/wave storm damage?

Examples include: 1) assets built to specific storm-resistant standards/engineering codes, or 2) assets particularly or inherently resistant to other forms of damage or deterioration (e.g., fortifications). Do not consider the LOCATION of the asset in your response, but instead focus completely on construction.

FMSS Asset Information

Record Answers (add x)

Comments (clarifications, unsure, unfamiliar with asset, etc.)

Are any of the assets listed below particularly vulnerable to flood/wave damage due to condition?

\*In other words, is the asset in poor condition due to deterioration, lack of maintenance, etc.? DO NOT consider the location of the asset (even if it is near the water or commonly flooded), only consider the physical condition of the asset itself. The condition should be considered **independent** of the asset's location.

FMSS Asset Information

Record Answers (add x)

Comments (clarifications, unsure, unfamiliar with asset, etc.)

Have any of the following assets been significantly DAMAGED in previous storm/flooding events (water/wave damage only)?

\* This question is focused on the actual damage to an asset from an event (the prior flooding question is about the LAND near the asset being inundated)

FMSS Asset Information

Record Answers (add x)

Comments (clarifications, unsure, unfamiliar with asset, etc.)

Are any of the following assets currently being protected by an engineered structure (e.g., seawall, bulkhead) or other major engineering (e.g. drainage, major landscape modification, major restored landscape)?

FMSS Asset Information

Record Answers (add x)

Comments (clarifications, unsure, unfamiliar with asset, etc.)

#	Asset Code	Year Built	FMSS Code	Asset Description	Yes	Comments
42	4100	1964	15935	Q-00000154-HO-TA-154 Ocean Qtrs		<a href="#">Click here to add any comments</a>
7	4100	1950	18216	BU-HQ-76 Park Headquarters		<a href="#">Click here to add any comments</a>



# COASTAL HAZARD & SLR SENSITIVITY INDICATORS



## THRESHOLD ELEVATION DATA COLLECTION

NPS Resource Information Services Division (Brian Diethorn & Tim Smith)

WCU: Verifying Sensitivity Indicator (Q1: Elevated)

			Sensitivity Analysis Data Results											
			<a href="#">Definitions of WCU Columns on Next Sheet (Click Here to View)</a>											
ID	Location	Area	Flood Damage Potential (Elevated) (Q2)	BFE (ft, NAVD88)	Threshold Elev (ft, NAVD88)	Threshold Above or Below BFE	Storm Resist; Condition (Q3, Q4)		Historical Damage (Q5)	Protective Engineering (Q6)	Step 2		Step 4	
											Flagged Asset	Sensitivity Score	Sensitivity Rank	
28	BU-SH-107 Comfort Station	SH	4	9.0	6.430	Below	4	1	1	4		3	moderate	
29	BU-SH-104 Visitor Center	SH	1	8.0	12.467	Above*	4	1	1	1	Q2/BFE. & Q6. See Notes	2	low	
30	BU-OP-51 Wilderness Visitor Center	OP	1	16.0			4	1	1	4	Q2/BFE. See notes	3	moderate	
31	BU-TA-156 Maintenance Shop	TA	4	13.0	8.169	Below	4	4	1	4		4	high	
32	BU-TA-157 Comfort Station	TA	4	10.0	8.465	Below	4	1	1	4		3	moderate	
33	BU-TA-158 Pump House	TA	4	16.0	8.071	Below	4	1	1	4		3	moderate	
34	BU-WH-13 Marina Store	WH	1	7.0	7.415	Above	4	1	1	1	Q2/BFE. & Q6. See Notes	2	low	
35	BU-LS-94 Annex Garage	LS	4	9.0	3.707	Below	4	1	4	4		4	high	
36	BU-LS-96 Store House	LS	4	8.0	5.217	Below	4	1	1	4		3	moderate	
37	BU-LS-97 Oil House	LS	4	8.0	5.807	Below	4	1	1	4		3	moderate	
38	BU-LS-98 Tool House	LS	4	8.0	5.840	Below	4	1						
39	BU-LS-99 Lighthouse Boat House	LS	1	7.0	8.924	Above*	4	1						
40	BU-WH-20 Maintenance Shop	WH	4	8.0	3.773	Below	4	1						
41	BU-WH-22 Flammable Storage Bldg.	WH	4	8.0	3.215	Below	4	1						
42	BU-IS-91 Fire Island Light House	IS	1	7.0	15.486	Above*	4	1						
43	BU-LS-92 Keepers Qtrs	LS	1	8.0	13.845	Above*	4	1						
44	BU-LS-95 Check Station	LS	4	9.0	6.255	Below	4	1						
45	Q-00SHBARN-HO-SH-105 Horse Barn	SH	4	13.0	4.035	Below	4	1						
46	BU-SH-106 Gift Shop & Snack Bar	SH	4	8.0	5.052	Below	4	1						
47	BU-SH-109 Maintenance Shop	SH	4	9.0	3.609	Below	4	1						
48	BU-SH-111 Garbage Bldg.	SH	4	9.0	2.100	Below	4	1						
49	BU-WF-222 Turf Equipment Storage Building	WF	4	-	20.112		4	1						
50	BU-WF-223 Fire Cache Storage Building	WF	4	-	19.324		4	1						
51	BU-WF-221 Flammable Storage Building	WF	4	-	17.848		4	1						
52	BU-WH-14 Dockmaster Office	WH	4	7.0	5.085	Below	4	1						
53	BU-WH-15 Storage Bldg	WH	4	7.0	2.854	Below	4	1						
54	BU-WH-16 Visitor Center	WH	1	7.0	7.087	Above	4	1						
55	BU-WH-17 Marina Restroom	WH	1	7.0	7.119	Above	4	1						
56	BU-WH-21 First Aid Room	WH	4	7.0	2.920	Below*	4	1						





# SENSITIVITY & VULNERABILITY SCORING



**+**

Flood Damage Potential Indicator  
Storm Resistance/Condition Indicator  
Historical Damage Indicator  
Adaptive Protection Indicator

---

**TOTAL SENSITIVITY SCORE**

**+**

**EXPOSURE SCORE**  
**SENSITIVITY SCORE**

---

**TOTAL VULNERABILITY SCORE**

*\*Formula for Structures (slightly different for bridges/transportation)*

Sensitivity Analysis Data Results		Definitions of WCU Columns on Next Sheet (Click Here to View)															
ID	Location	Area	Flood Damage Potential (Elevated) (Q2)	BFE (ft, NAVD88)	Threshold Elev (ft, NAVD88)	Threshold Above or Below BFE	Storm Resist; Condition (Q3, Q4)			Historical Damage (Q5)		Protective Engineering (Q6)		Step 2		Step 4	
							Q3	Q4	Q5	Q6	Flagged Asset	Sensitivity Score	Sensitivity Rank				
1	Q-0000154-HO-TA-154 Ocean Qtrs	TA	1	17.0	16.995	Above	4	1	1	4	Q2/BFE. See notes		3	moderate			
2	BU-HQ-76 Park Headquarters	HQ	4	6.0	5.938	Below	4	1	4	1	Q6. See Notes		3	moderate			

Vulnerability Assessment Data Results		Definitions of WCU Columns on Next Sheet (Click Here to View)											
ID	Location	Area	Metrics of Vulnerability		Vulnerability			Geospatial Data		Location Code	Asset Code		
			Exposure	Sensitivity	Raw Score	Final Score	Final Rank	Latitude	Longitude				
1	Q-0000154-HO-TA-154 Ocean Qtrs	TA	4	3	7	4	high	40.671489	-73.042135	15935	4100		
2	BU-HQ-76 Park Headquarters	HQ	4	3	7	4	high	40.755070	-73.017100	18216	4100		
3	BU-HQ-72 Headquarters Annex	HQ	4	3	7	4	high	40.754854	-73.016833	18749	4100		
4	Q-0000103-HO-SH-103 Sailors Haven Housing Unit	SH	3	4	7	4	high	40.656735	-73.103130	18750	4100		
5	BU-HQ-73 Patchogue Boat House	HQ	4	4	8	4	high	40.758529	-73.017806	18751	4100		
6	BU-HQ-77 PMF Maintenance Facility	HQ	2	4	6	3	moderate	40.759152	-73.017112	18752	4100		
7	BU-HQ-78 Vehicle Vessel Shop	HQ	4	3	7	4	high	40.758651	-73.017852	18753	4100		
8	Q-0000006-HO-WH-06 Qtrs #6	WH	3	3	6	3	moderate	40.690210	-72.990711	18756	4100		





# VULNERABILITY RESULTS & MAPS



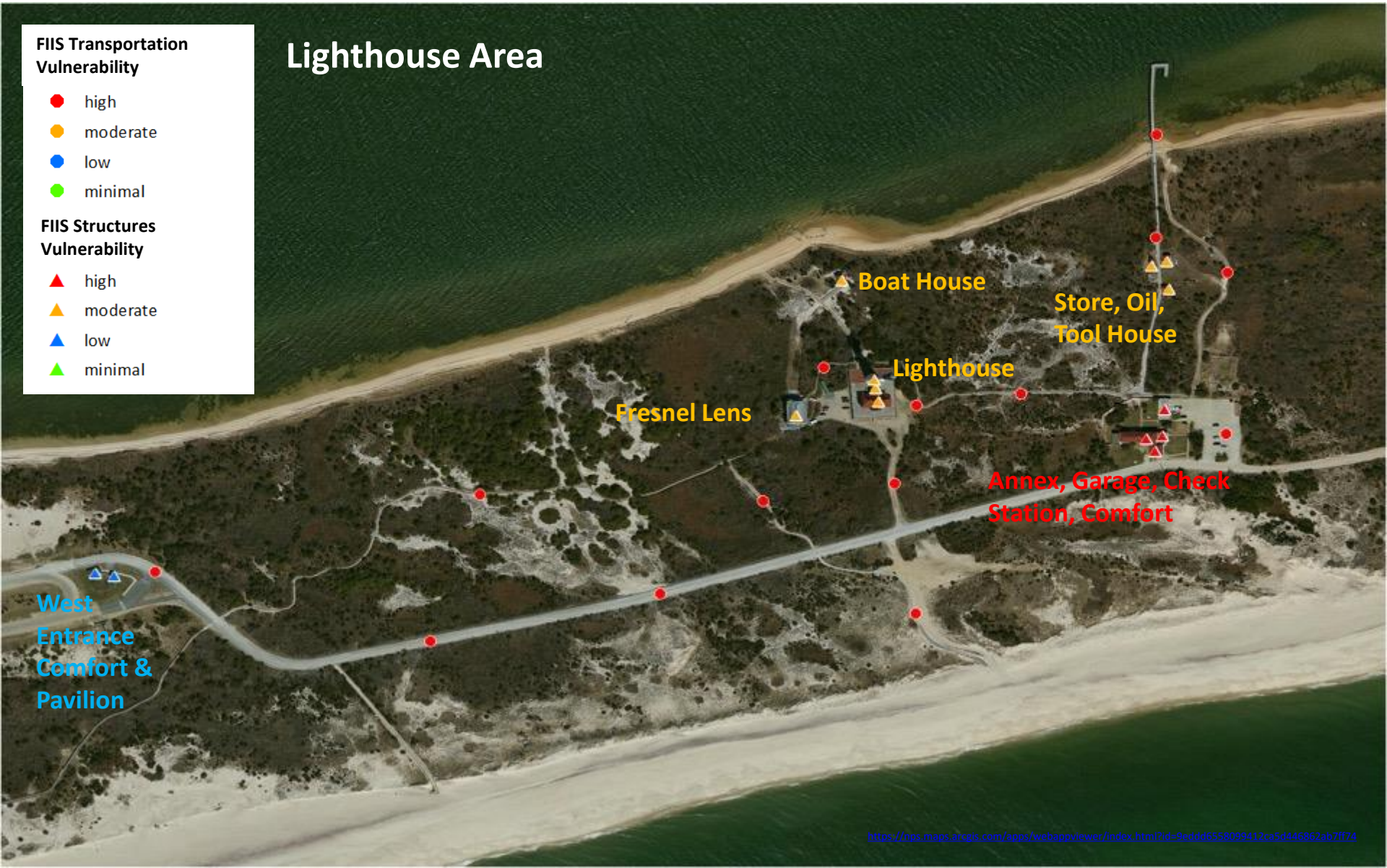
## Lighthouse Area

### FIIS Transportation Vulnerability

- high
- moderate
- low
- minimal

### FIIS Structures Vulnerability

- ▲ high
- ▲ moderate
- ▲ low
- ▲ minimal







# DRAFT STATISTICS



## FIIS Structures Summary & Statistics

### Vulnerability Statistics

Total # Structures Analyzed	98
# High Vulnerability	31
# Mod Vulnerability	38
# Low Vulnerability	13
# Minimal Vulnerability	16
% High Vulnerability	32%
% Moderate Vulnerability	39%
% Low Vulnerability	13%
% Minimal Vulnerability	16%

### Exposure Statistics

Total # Structures Analyzed	98
# High Exposure	15
# Mod Exposure	58
# Low Exposure	9
# Minimal Exposure	16
% High Exposure	15%
% Moderate Exposure	59%
% Low Exposure	9%
% Minimal Exposure	16%

### Sensitivity Statistics

Total # Structures Analyzed	82
# High Sensitivity	19
# Mod Sensitivity	58
# Low Sensitivity	5
excluded (min exposure)	16
% High Sensitivity	23%
% Moderate Sensitivity	71%
% Low Sensitivity	6%

# High or Moderate With API $\geq$ 70	3
% of Total Structures	3%
% of High/Mod Structures	4%

# High or Moderate With OB 1 or 2	10
% of Total Structures	10%
% of High/Mod Structures	14%

## FIIS Transportation Summary & Statistics

### Vulnerability Statistics

Total # Structures Analyzed	88
# High Vulnerability	73
# Mod Vulnerability	11
# Low Vulnerability	0
# Minimal Vulnerability	4
% High Vulnerability	83%
% Moderate Vulnerability	13%
% Low Vulnerability	0%
% Minimal Vulnerability	5%

### Exposure Statistics

Total # Structures Analyzed	88
# High Exposure	36
# Mod Exposure	44
# Low Exposure	4
# Minimal Exposure	4
% High Exposure	41%
% Moderate Exposure	50%
% Low Exposure	5%
% Minimal Exposure	5%

### Sensitivity Statistics

Total # Structures Analyzed	84
# High Sensitivity	65
# Mod Sensitivity	16
# Low Sensitivity	3
excluded (min exposure)	4
% High Sensitivity	77%
% Moderate Sensitivity	19%
% Low Sensitivity	4%

# High or Moderate With API $\geq$ 70	7
% of Total Structures	8%
% of High/Mod Structures	8%

# High or Moderate With OB 1 or 2	5
% of Total Structures	6%
% of High/Mod Structures	6%



PROGRAM FOR  
THE STUDY OF  
DEVELOPED  
SHORELINES

Western  
Carolina  
UNIVERSITY



# ADAPTATION STRATEGIES



- ✓ Taking **adaptation actions** can reduce an asset's **exposure** and/or **sensitivity**, which in turn, lowers its overall **vulnerability**.

ADAPTATION ACTION	ASSET TYPE	EFFECT ON VULNERABILITY & RATIONALE
✓ <b>ELEVATE</b>	Structures & Transportation	Reduces the <b>sensitivity</b> of the asset; elevating an asset (pilings or artificial fill) reduces the risk of flood damage.
✓ <b>RELOCATE</b>	Structures & Transportation	Reduces the <b>exposure</b> of the asset; relocating the asset to a lower risk area reduces the likelihood that it will experience impacts from coastal hazards/SLR.
✓ <b>PROTECT/ENGINEER</b>	Structures & Transportation	Reduces the <b>exposure</b> and/or <b>sensitivity</b> of the asset; protecting the asset by an engineered structure (e.g., seawalls) or landscape modifications (e.g., drainage, nourishment, restoration) can reduce the likelihood that the asset will experience, or obtain damage from, coastal hazards/SLR.
✓ <b>DECOMMISSION &amp; REMOVE</b>	Structures & Transportation	Eliminates the vulnerable asset
✓ <b>STORM-RESISTANT REDESIGN</b>	Structures & Transportation	Reduces the <b>sensitivity</b> of the asset; redesigning the asset to be more storm-resistant can reduce the likelihood of damage from coastal hazards/SLR.
✓ <b>ENGINEERING DOWNGRADE</b>	Transportation	Reduces the <b>sensitivity</b> of the asset; downgrading the amount of engineering (i.e., replacing paved parking lot with shell material lot) can reduce the cost of rebuilding after damage and give more flexibility for replacement.







# Application

- It's not just where the water will be, but what happens when it gets there.
- Provides details at the asset level embedded within existing asset-management database
- These data are being used in multiple ways:
  - Short-term planning, spending, maintenance
  - Post-storm rebuilding
  - Long-term planning for cultural resources (e.g. Portsmouth Village, Cape Lookout, NS)



# Benefits

- Clear, science-based guidance for the allocation of limited funding for maintenance, improvement, and rebuilding of park infrastructure.
- Data to support the funding of adaptation/resilience projects for infrastructure and historic structures that are mission critical.
- The best way to protect natural resources in coastal parks is to make very wise decisions about your infrastructure.

---

# Coastal Hazards Infrastructure Vulnerability Assessment

## Duck, North Carolina

---

*February 2020*



**Program for the Study of Developed Shorelines**  
Western Carolina University  
Cullowhee, NC 28723



**Western**  
Carolina  
UNIVERSITY





**Figure 7.** Coastal hazard vulnerability results for roads and select buildings in south Duck, near the town commercial center. Select assets are labeled.



# Questions?

- PSDS Team:
  - Andy Coburn, Associate Director
  - Blair Tormey, Coastal Research Scientist
  - Katie Peak, Coastal Research Scientist
  - Holli Thompson, Program Manager
  
  - Rob Young, Director
    - Follow me on LinkedIn
    - Follow us on FB: <https://www.facebook.com/WCUPSDS/>
    - Contact me at [ryoung@wcu.edu](mailto:ryoung@wcu.edu)



## **Assessing National Park Asset Flood Risk: Retreat, Adapt, Fortify?**

What did you think of the briefing?  
Please take 2 minutes to let us know at:  
[www.eesi.org/survey](http://www.eesi.org/survey)

Materials will be available at: [www.eesi.org/041420data](http://www.eesi.org/041420data)

Tweet about the briefing: [#eesitalk](https://twitter.com/eesitalk) [@eesionline](https://twitter.com/eesionline)