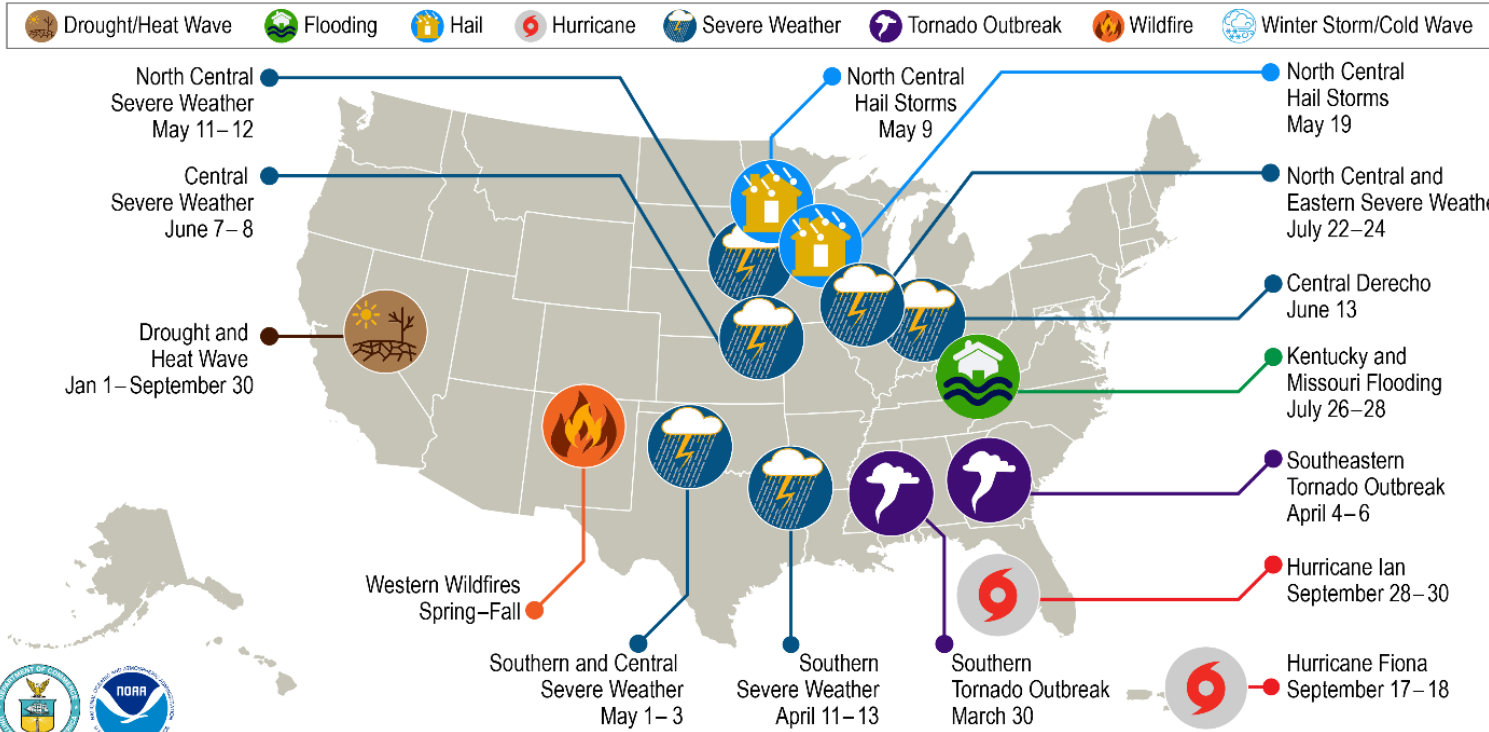


# U.S. 2022 Billion-Dollar Weather and Climate Disasters



This map denotes the approximate location for each of the 15 separate billion-dollar weather and climate disasters that impacted the United States January – September of 2022.

## The Use of Trip Walls to Reduce Storm Vulnerability

Geosyntec  
consultants

ATM  
A Geosyntec Company

Marc Gold PE, CFM | 02.02.2023

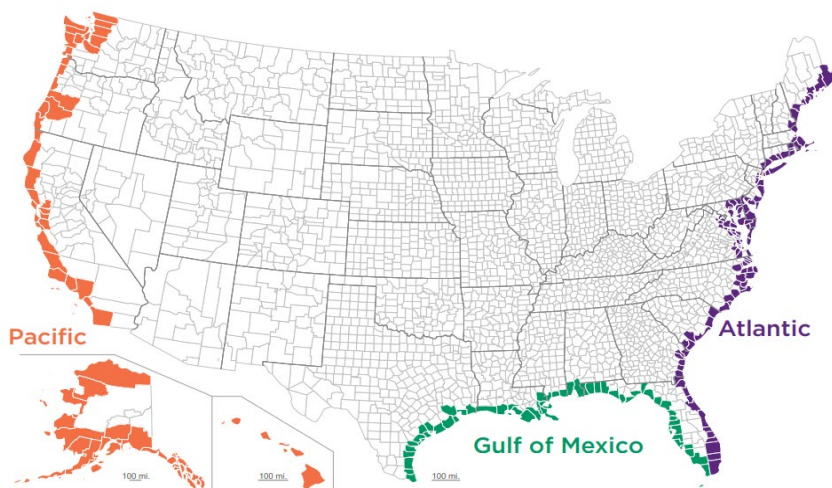


## Trip Wall

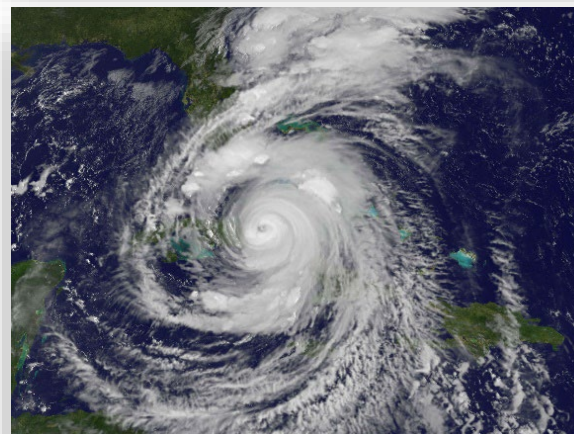


2. The *wave overtopping splash zone* is the area landward of the crest of an overtopped barrier, in cases where the potential 2-percent wave runup exceeds the barrier crest elevation by 3.0 feet or more ( $\Delta R > 3.0$  feet). (See Subsection D.2.8.2.)
3. The *breaking wave height zone* occurs where 3-foot or greater wave heights could occur (this is the area where the wave crest profile is 2.1 feet or more above the total stillwater level).

About 29% of the U.S. population lives in coastal counties. About 19% live in counties at high risk for hurricanes. (U.S. Census Bureau)



*Between 2005 to 2017 loss in property value has been identified at \$15.9 billion due to increased coastal flooding. (First Street Foundation)*

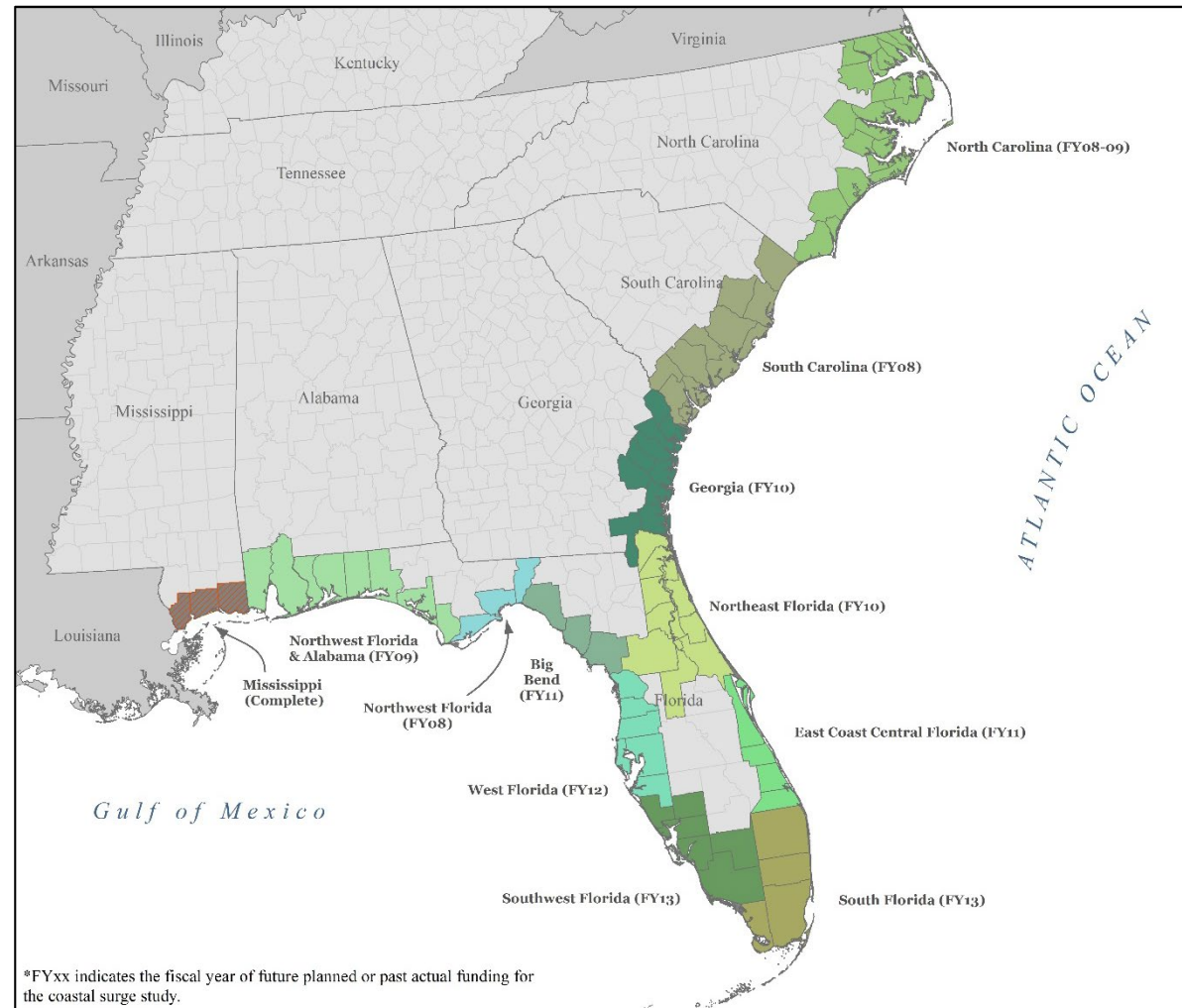


**Hurricane Irma Image from NASA (2017)**

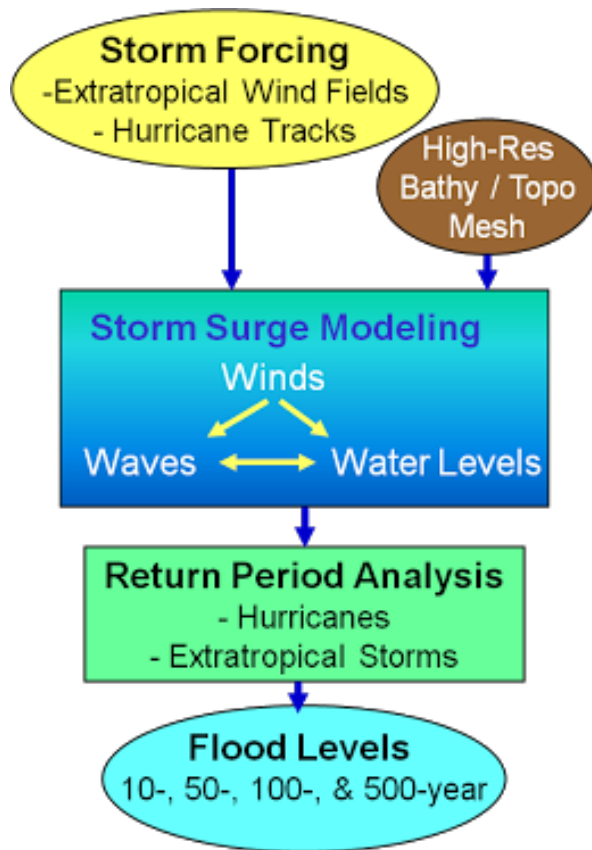
*Estimated costs for improved infrastructure to protect from invading seas is \$400 billion. (Center for Climate Integrity)*

# FEMA Flood Mapping Overview

- FEMA Maps - Risk Analysis – Coastal and Upland
- Nationwide Efforts
- Updated Every ~7-15 Years



## Surge Analysis



## Wave Analysis

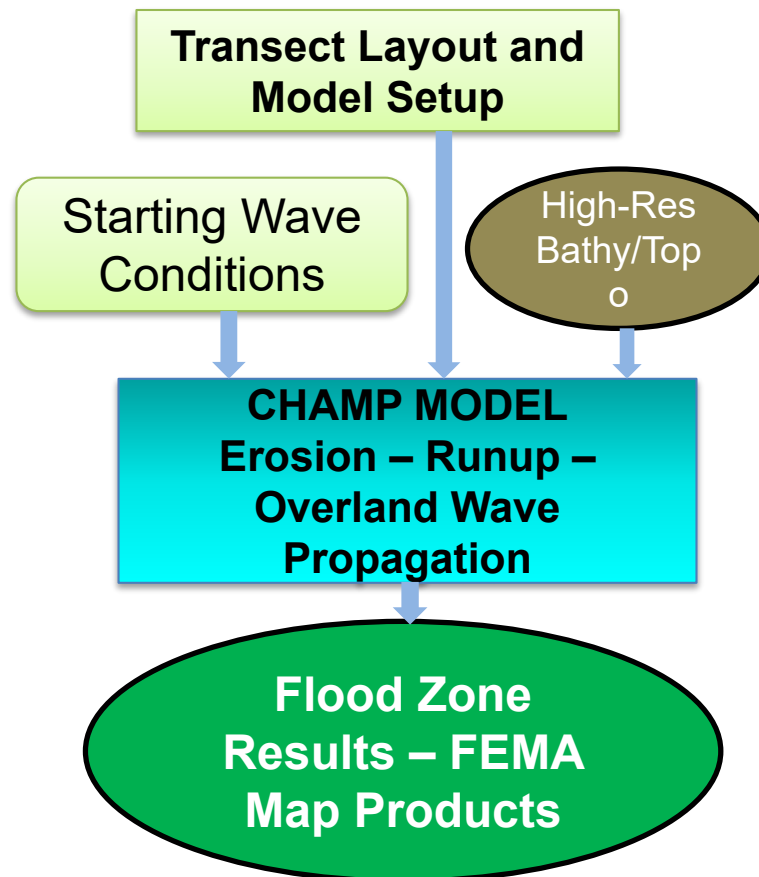
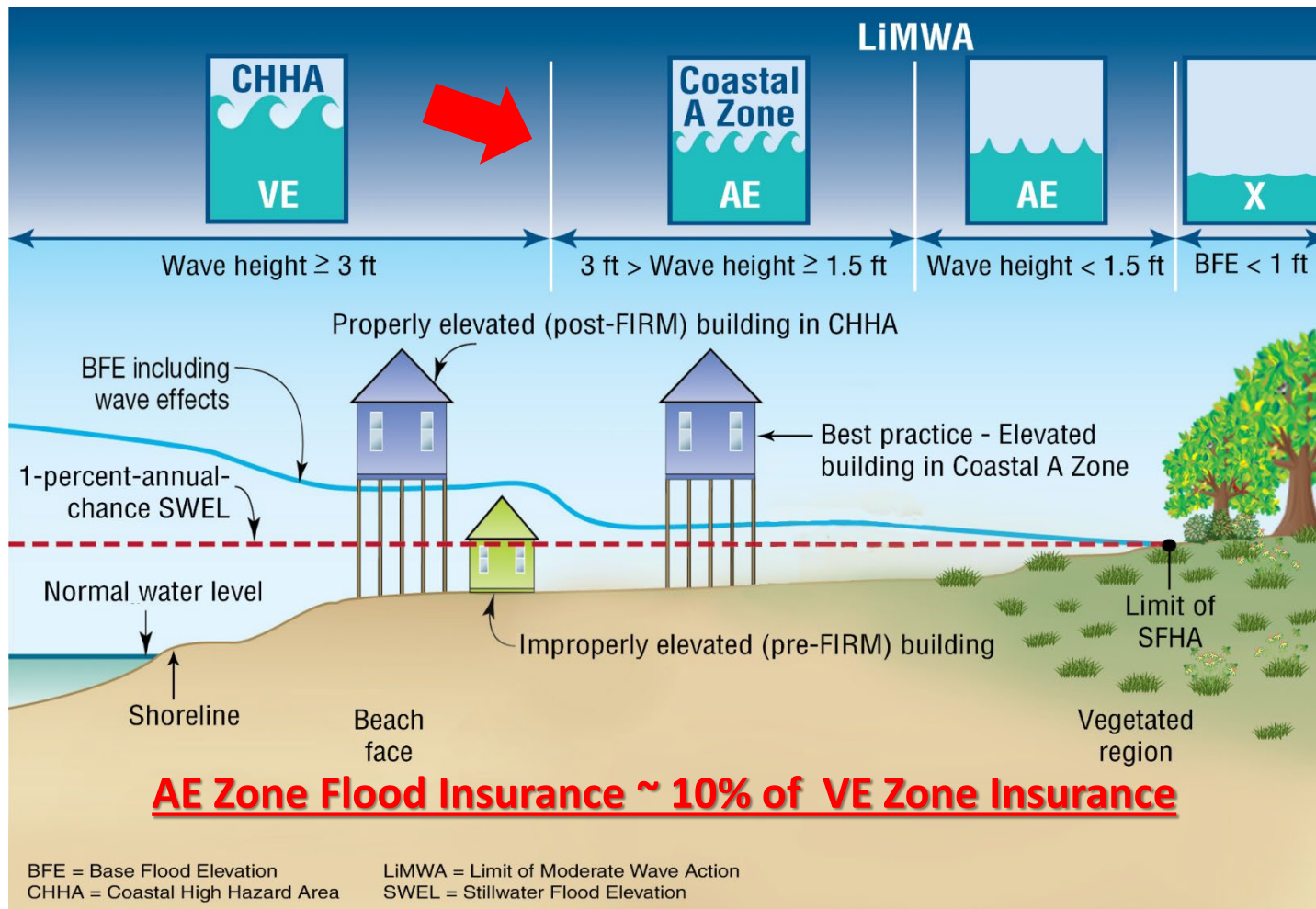


Figure - [www.r3coastal.com](http://www.r3coastal.com)

# FEMA Flood Zones



# FEMA Flood Map



## Coastal High Hazard Area – VE Zone

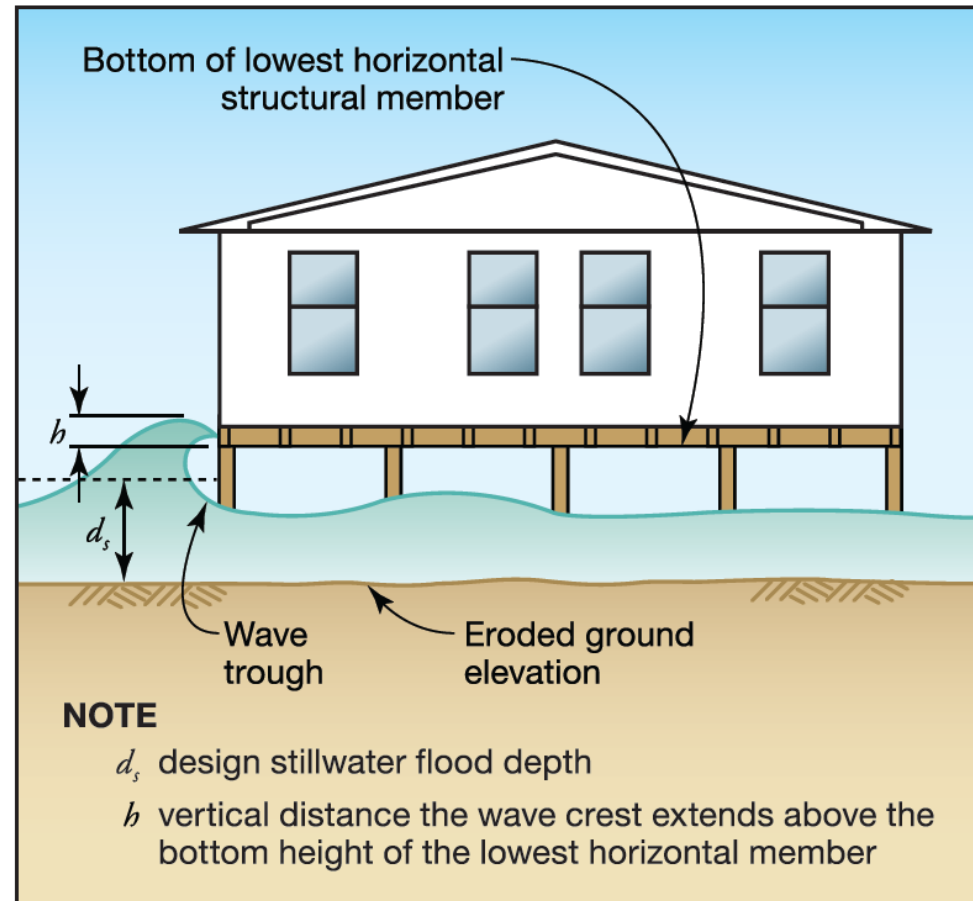
1. The *wave runup zone* occurs where the (eroded) ground profile is 3.0 feet or more below the 2-percent wave runup elevation
2. The *wave overtopping splash zone* is the area landward of the crest of an overtopped barrier, in cases where the potential 2-percent wave runup exceeds the barrier crest elevation by 3.0 feet or more ( $\Delta R > 3.0$  feet). (See Subsection D.2.8.2.)
3. The *breaking wave height zone* occurs where 3-foot or greater wave heights could occur (this is the area where the wave crest profile is 2.1 feet or more above the total stillwater level).
4. The *primary frontal dune zone*, as defined in 44 CFR Section 59.1 of the NFIP regulations.

### Furthest Inland Limit Gets Mapped



## Plan and Design for Flood Elevations and Flood Loads

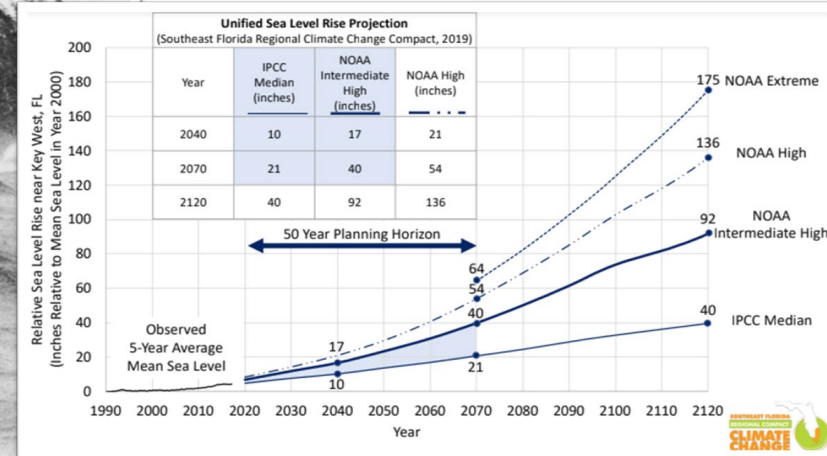
- Local Building Regulations
- FEMA Coastal Construction Manual
- ASCE 7 and International Building Code (IBC)
- Additional Considerations
- Saltwater/Salt Air Damage
- Wind Loads
- Floodproofing is an option



# Key Climate Change Impacts to Coastal Communities

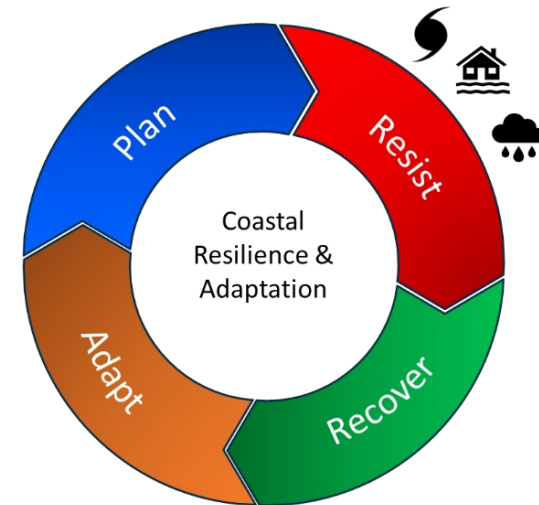
- **Causes**

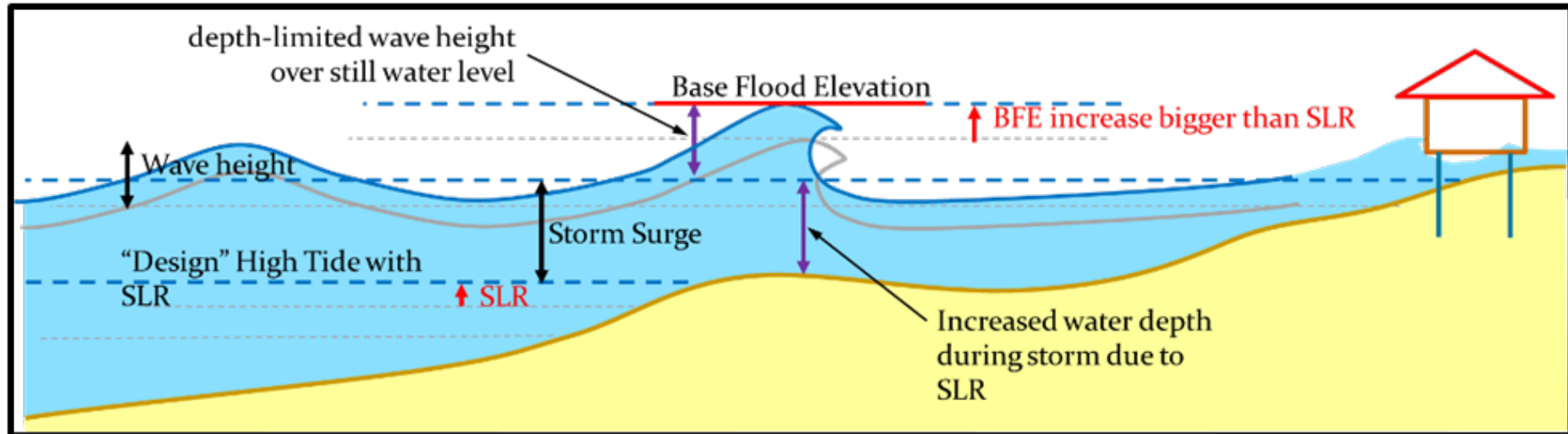
- Sea Level Rise (SLR)
- Increased Storm Intensity
- Increased Rainfall
- Increased Erosion



- **Threats**

- Storm Surge
- Tidal (sunny day) Flooding
- Shoreline Recession
- Compound Flooding





Modified from Biondi and Guannel (2018)

**Base Flood Elevation = BFE is the total 100-yr Flood Elevation (includes surge and waves)**

**Coastal BFEs Increase by more than just SLR!**

# Understanding Risks – Plan for the Future

- ▶ Today's "X" Zone is Tomorrow's Floodplain
- ▶ Increased erosion w/ SLR. Plan to design for coastal flood

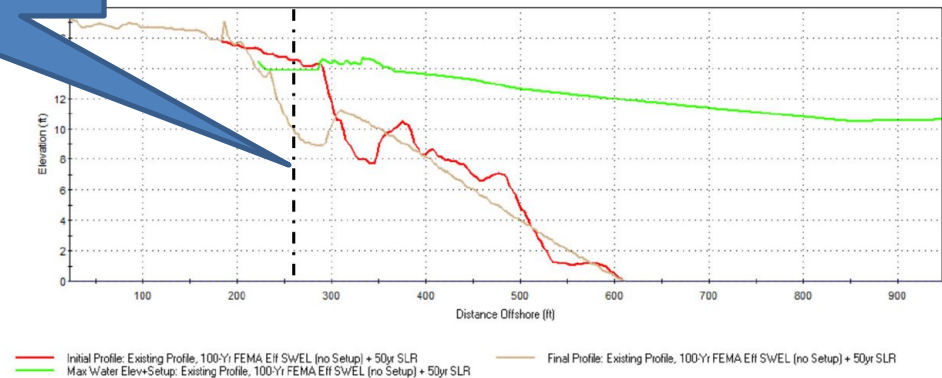
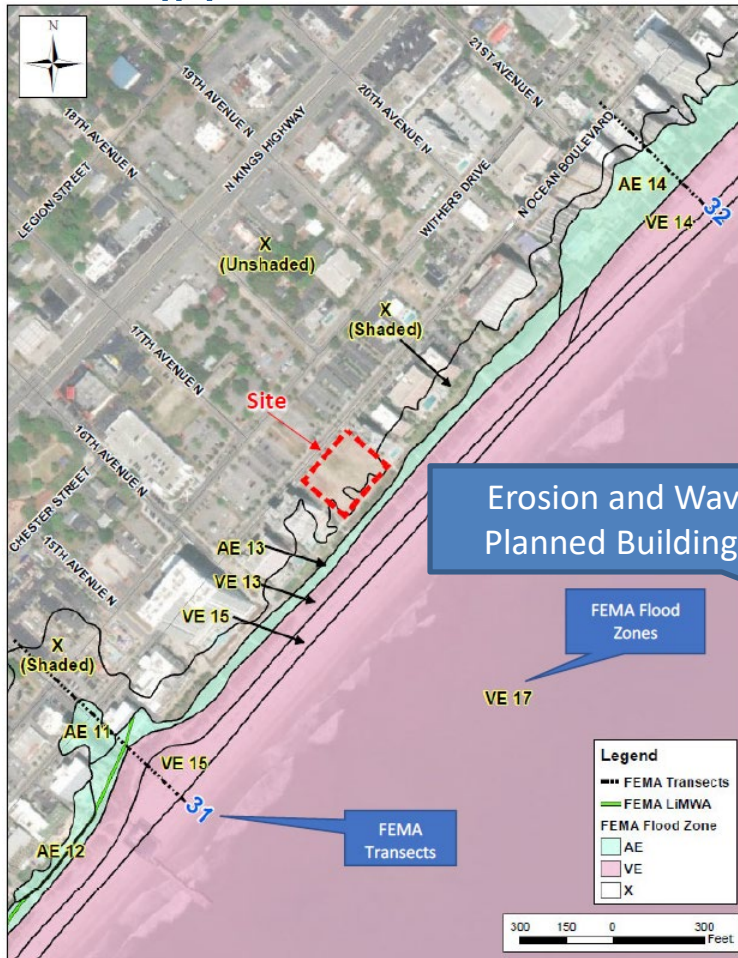


Figure 2. SBEACH input and output plot

- Elevate above Design Flood Elevation (DFE)
  - Include additional freeboard and plan for future SLR
- Flood Openings For Portions Below DFE
- Wet and Dry Floodproofing
- Structural Solutions – Trip Wall
  - Serves to reduce DFE and hydrodynamic loads (i.e., wave damage)

## Mitigation Options

No one entity is responsible for mitigation. There are several mitigation opportunities at the state, tribe, and territory and community levels and actions that individuals can implement to collectively help reduce policyholders' flood insurance rates.

### Individual-Level Mitigation Actions

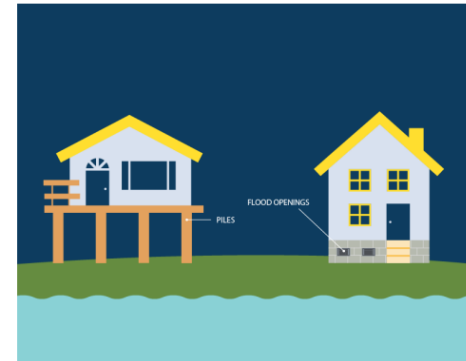


Figure 2. Two examples of individual mitigation actions to protect from future flooding

# Liberty Hill Farm Trip Wall Mt. Pleasant, SC

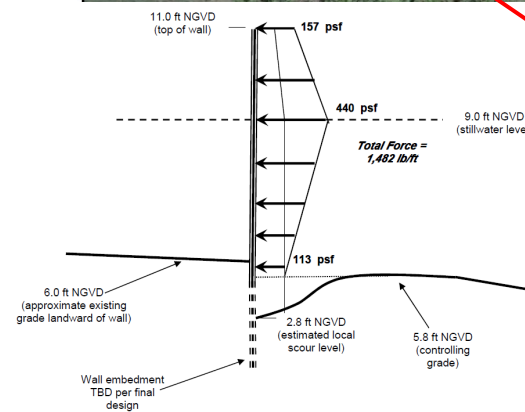
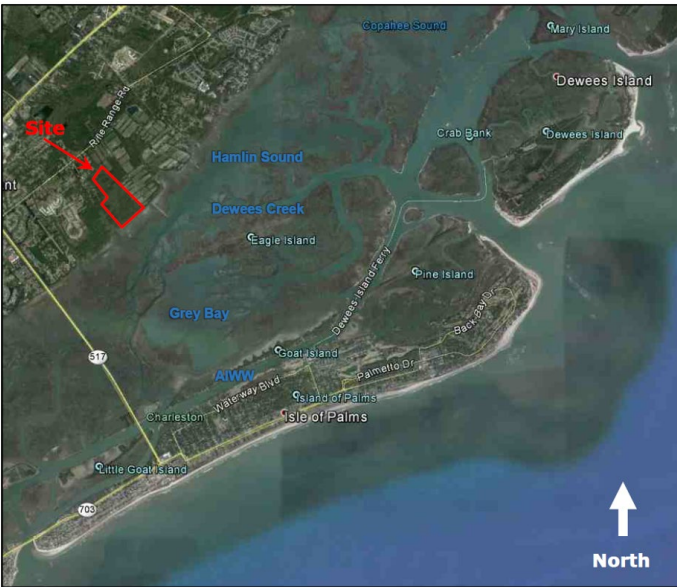


Figure 2. Critical breaking wave load distribution against trip wall (not to scale)

- 2,400 LF wall
  - Primarily aluminum sheetpile, with H-piles and concrete lag wall sections
- Designed for 100-year storm w/ SLR

# Liberty Hill Farm Trip Wall Mt. Pleasant, SC

- Design analyses – scour, wave transmission, overtopping, splash distance.
- Structural Design - Hydro & Debris Impact Loads.
- Several scenarios considered

2. The *wave overtopping splash zone* is the area landward of the crest of an overtopped barrier, in cases where the potential 2-percent wave runup exceeds the barrier crest elevation by 3.0 feet or more ( $\Delta R > 3.0$  feet). (See Subsection D.2.8.2.)
3. The *breaking wave height zone* occurs where 3-foot or greater wave heights could occur (this is the area where the wave crest profile is 2.1 feet or more above the total stillwater level).

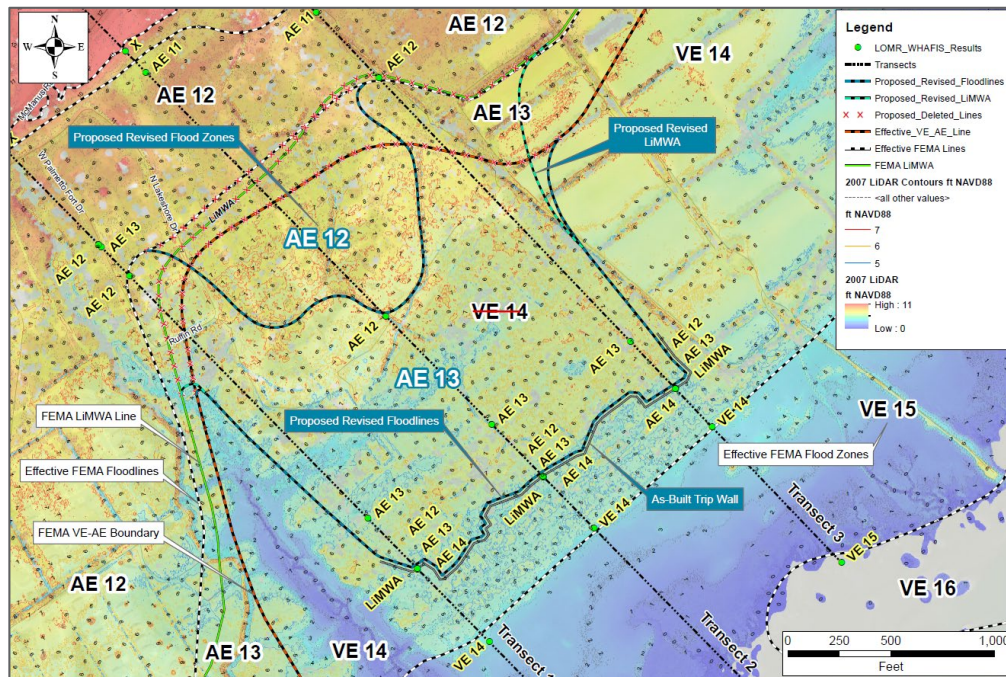
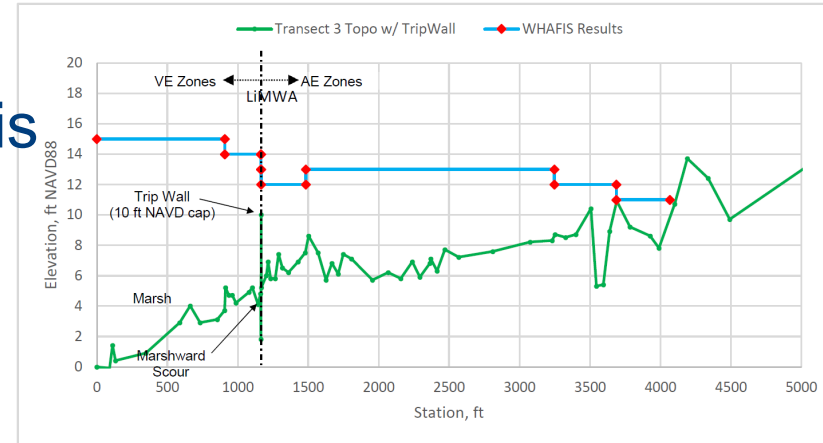


Table 5: Summary of Trip Wall Overtopping Analysis\*

Stillwater Elevation (ft NAVD)	H <sub>s</sub> (ft)	T <sub>p</sub> (sec)	Q* (cfs/ft)	Q <sub>50</sub> (cfs/ft)
7.0	0.9	3.2	5.0x10 <sup>-5</sup>	0.000
8.0	1.3	3.2	1.0x10 <sup>-3</sup>	0.008
9.0	1.7	3.2	1.0x10 <sup>-2</sup>	0.126
9.5	1.9	3.2	4.0x10 <sup>-2</sup>	0.594

\* trip wall cap elevation = 10 ft NAVD, marshward ground elevation at base of wall = 5 ft NAVD.

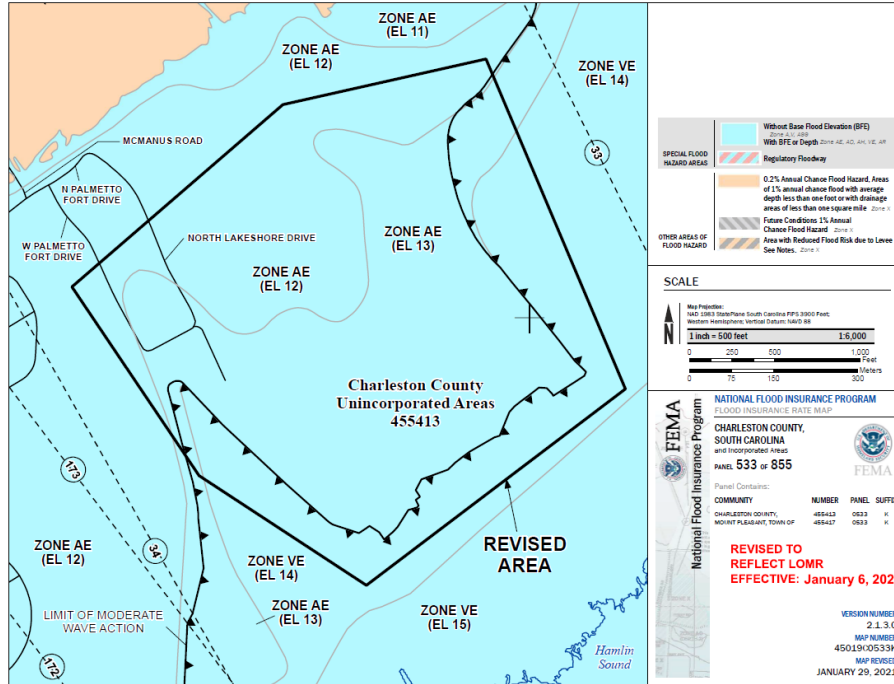
Table 4: Breaker Plunge Distance X<sub>p</sub> Landward of Trip Wall

Incident H <sub>b</sub> (ft)	m	X <sub>p</sub> (ft)*
5.1	0.01	19.8

\* measured from waterward face of wall



- Reduced vulnerability reflected through a FEMA Letter of Map Revision (LOMR)
- Annual inspections required to maintain FEMA certified structure status





# Seawall Reinforcement

Now in an AE zone

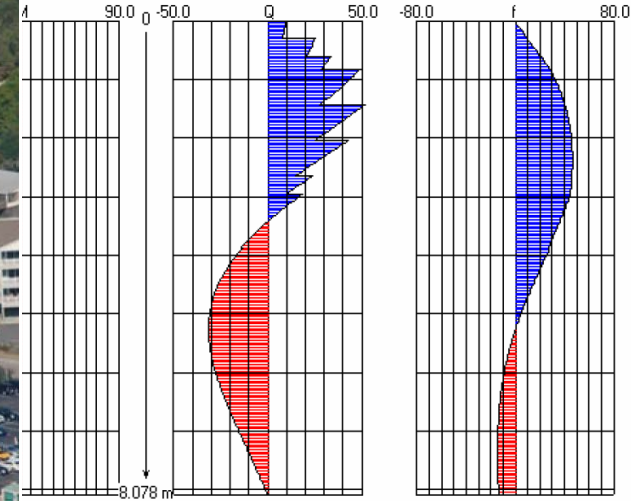


Figure 15. Finite element model for DC1-A.



NEW DEADMAN RODS TO TORSION ANCHORS

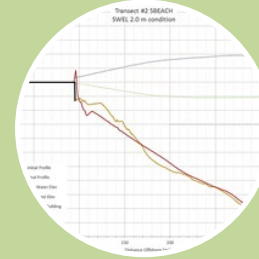




**Plan Better**  
Embed Climate  
Adaptation



**EXTREME  
EVENT**



**Rebuild Better**  
Include Climate  
Adaptation



**BOUNCE  
FORWARD**

