FEMA

Open Pacific Coast Study

Santa Barbara-Ventura Region Sea Level Rise & Coastal Impacts Planning Workshop

April 14, 2015

RiskMAP
Increasing Resilience Together

California Coastal Analysis and Mapping Project

Two Companion Large-Scale Efforts:

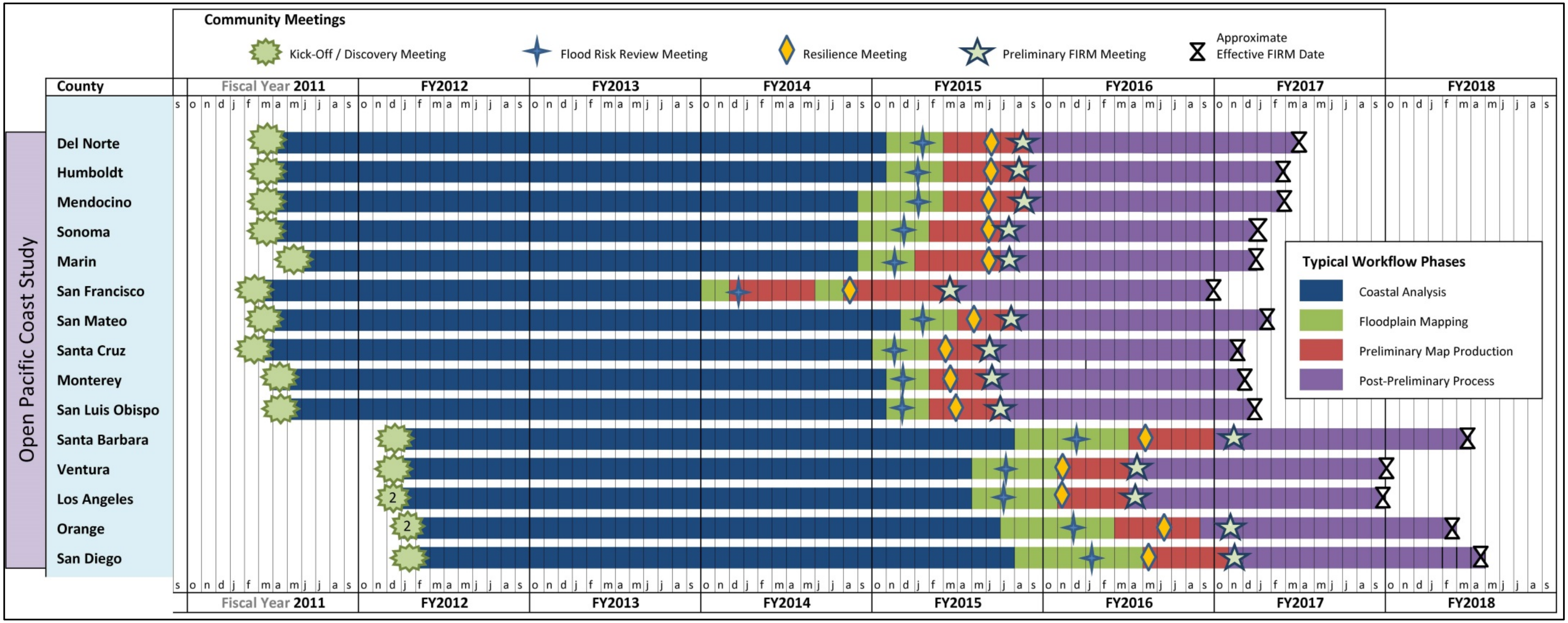
- Open Pacific Coast (OPC) Study
- San Francisco Bay Area Coastal (BAC) Study

Re-study flood risk along the open coast and inland bays of all California coastal counties

Re-map the elevation and inland extent of wave-induced coastal flooding

www.r9coastal.org

Overall OPC Study Schedule

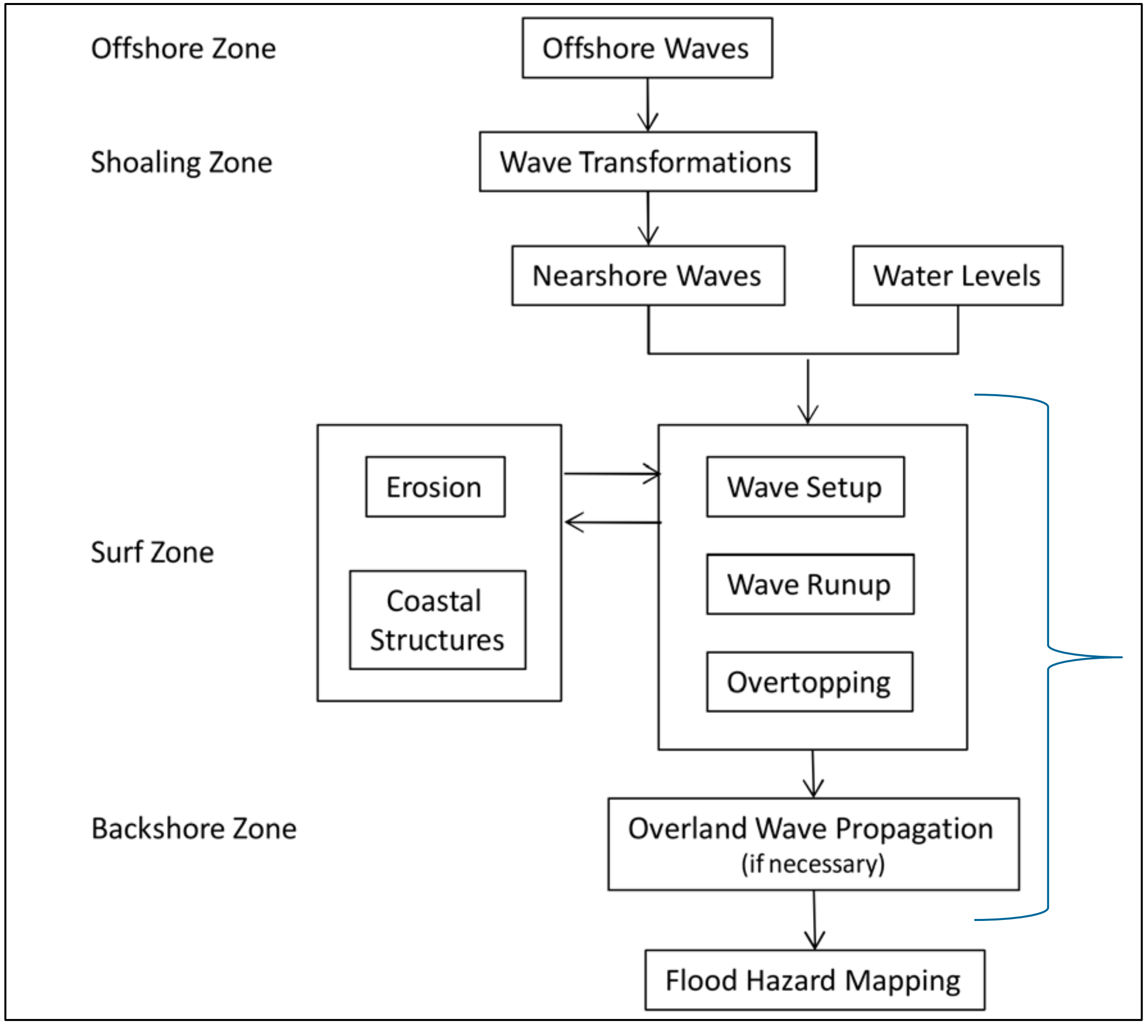


OPC Study Phase 2 includes Southern California Counties

Santa Barbara / Ventura Schedule

Task Name		Completion Date
Santa Barbara		
Kick-Off Meeting		December-11
Present Work Maps		March-16
Work Map Comment Period		May-16
Resilience Meeting		July-16
Issue Preliminary FIRM Panels		January-17
FIRM Panel Effective date		**June-18**
Ventura		
Kick-Off Meeting		December-11
Present Work Maps		August-15
Work Map Comment Period		October-15
Resilience Meeting		November-15
Issue Preliminary FIRM Panels		May-16
FIRM Panel Effective date		**September-17**

Coastal Study Process

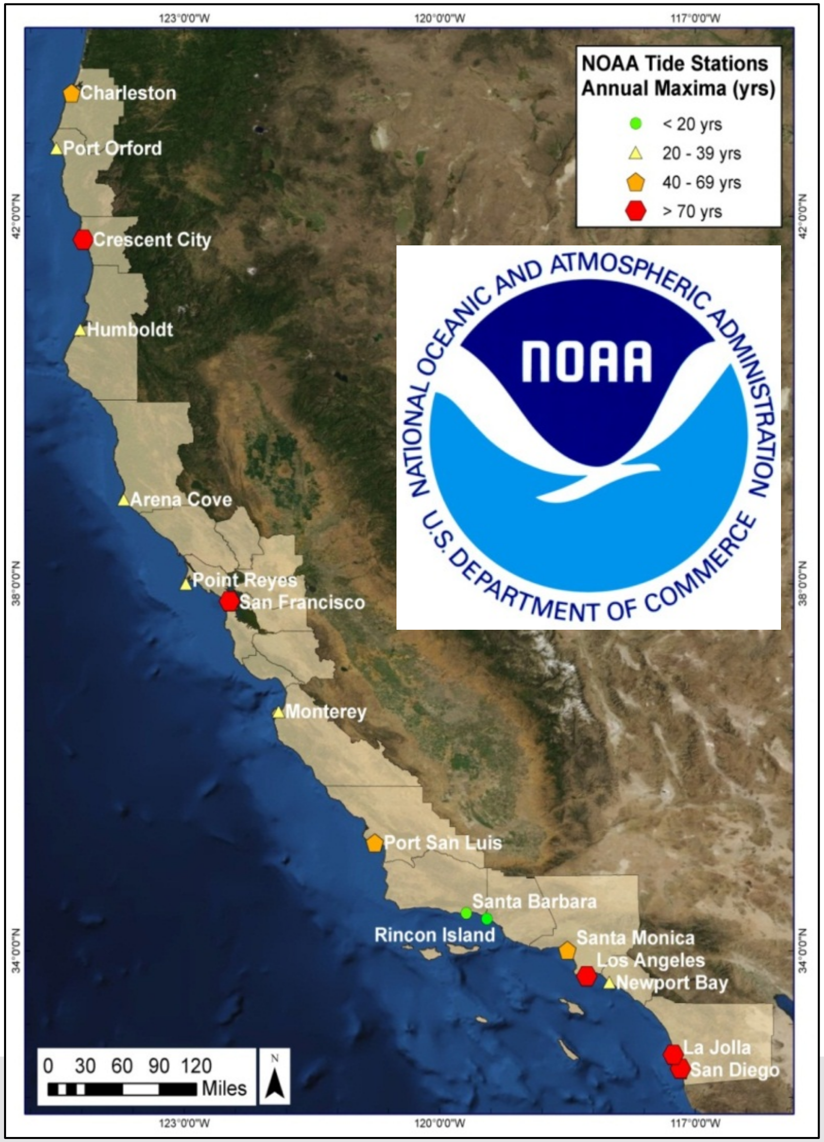


1-D Transect-based Analysis

Data Acquisition & Processing

Offshore Water Levels

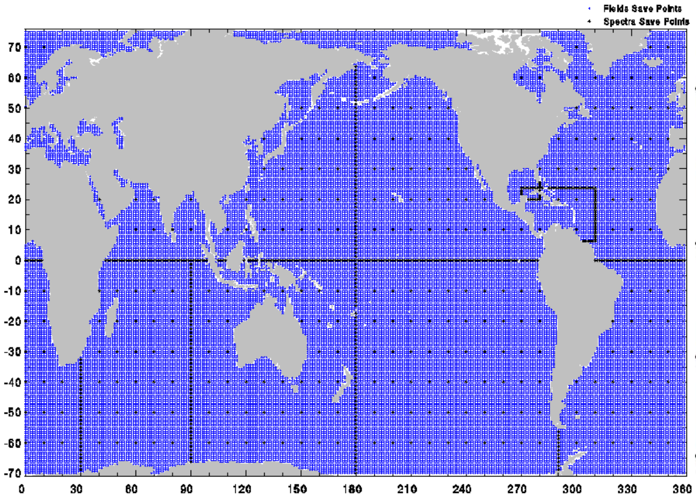
- **50-year (1960-2009) hourly stillwater level (SWL) time series**
  - Rely on long-term observed tide station records where available
  - Use predicted tide data and adjacent station data to fill gaps
- **Extreme tide frequency analysis for stillwater elevations (SWEL)**
  - Based on observed annual maxima tide data
  - 50-, 20-, 10-, 4-, 2-, 1-, and 0.2-percent annual chance SWELs



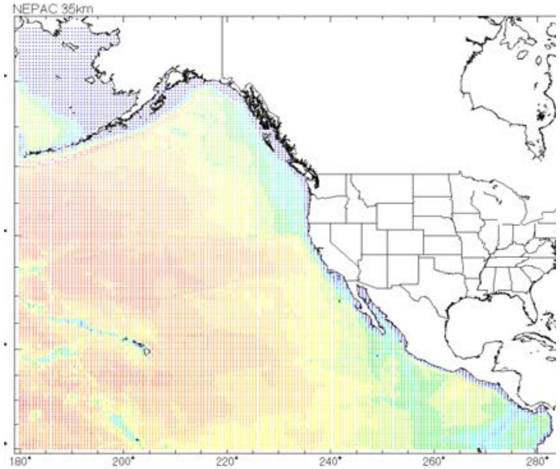
Data Acquisition & Processing

Deepwater Wave Hindcast (OWI) – Oceanweather Inc.

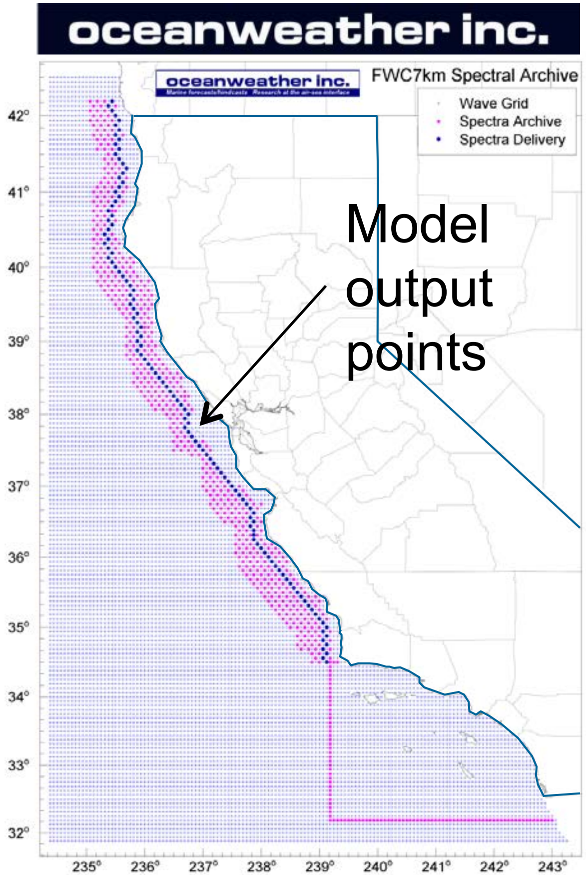
- Global Reanalysis of Ocean Waves (GROW) Model
- 50-year hourly hindcast of waves (1960-2009)
- COASTAL model provides wave spectra at 124 grid point locations
- Extensive validation with buoy data



GROW



GROWFine: NEPAC



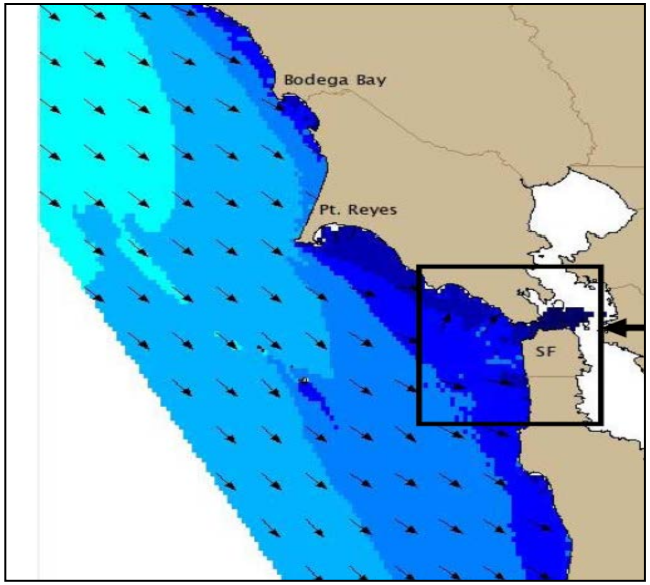
COASTAL Model

Data Acquisition & Processing

Nearshore Wave Transformation – Scripps Institution of Oceanography

- SIO SHELF linear spectral refraction and shoaling model from deepwater to surf zone (15m water depth in San Mateo at 200 m spacing)
- 50-year hourly hindcast of nearshore waves (1960-2009)
- Model validation with buoy data

Wave height and peak direction



1-D Coastal Hazard Analyses

- **Transect-based analysis**
- **59 analysis transects**
- **Transect locations and density based on:**
  - Shoreline characteristics
  - Shoreline orientation
  - Nearshore bathymetry
  - Wave climate
  - Land use and development

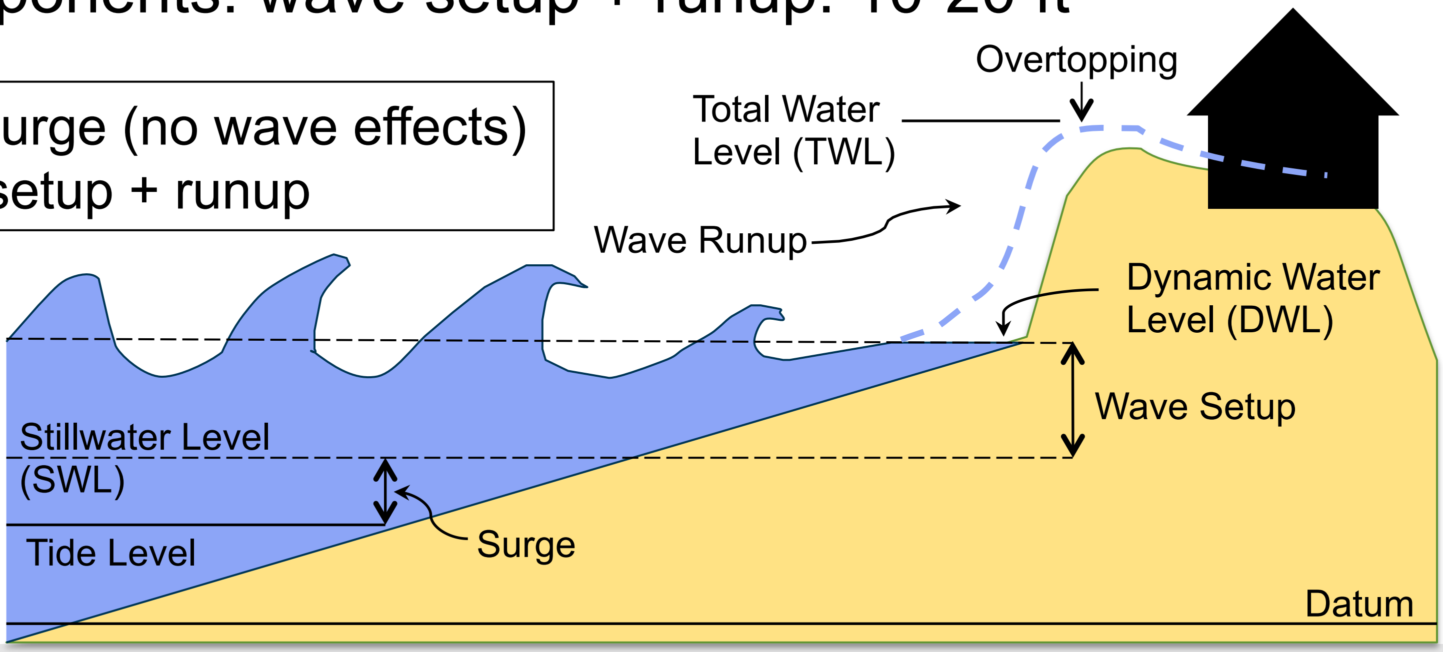
Total Water Level

Components of the total water level (TWL)

- Astronomical tide (predicted tide): 5-7 ft
- Surge components: atmospheric pressure, wind setup, El Niño sea level effects: 1-3 ft
- Wave components: wave setup + runup: 10-20 ft

SWL = Tide + surge (no wave effects)
TWL = SWL + setup + runup

No overland wave propagation analysis in San Mateo OPC Study area



Analyzing Wave Setup, Runup, and Overtopping

Setup and Runup Methods

- Stockdon (2006): sandy beaches and dunes with slope < 1:9
- DIM (*Pacific Guidelines*): rocky beaches with slope > 1:9
- DIM + TAW (van der Meer): steep barriers (bluff, seawalls, and revetments)

Overtopping Method

- Cox-Machemehl (inland extend of high velocity zone beyond crest)

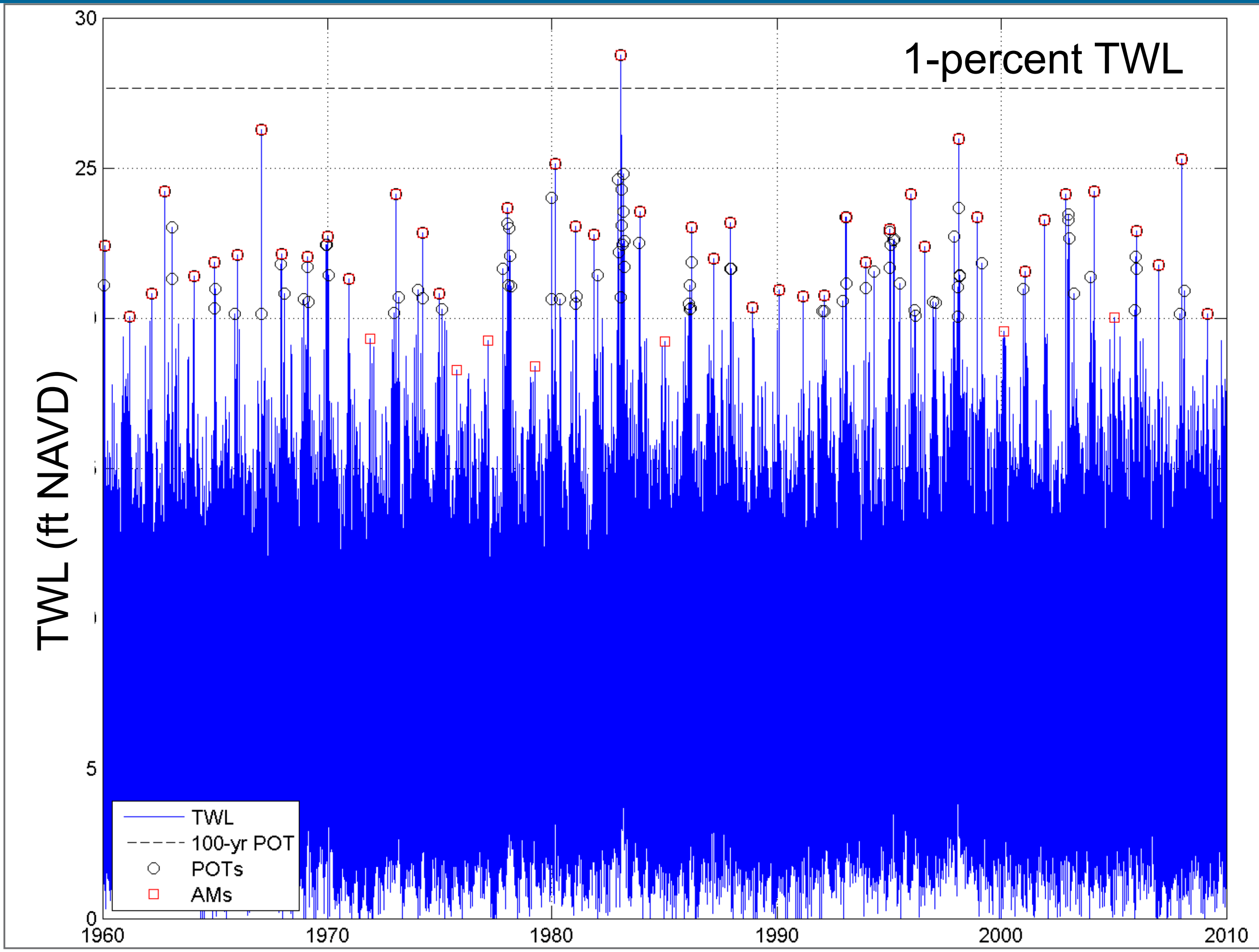
Dune Erosion Method

- MK & A geometric dune erosion model
- Kriebel and Dean time dependence adjustment

Extreme Value Statistical Analysis

- Primary: Peaks-over-threshold (POT) with Generalized Pareto Distribution (GPD)
- Secondary: Annual maxima (AM) with Generalized Extreme Value Distribution (GEV)

Estimating Extreme TWLs



- TWL time series is computed for 50-year hindcast period
- Peak TWLs values are extracted for extreme value statistical analysis
- EVA to determine: 50-, 20-, 10-, 4-, 2-, 1-, and 0.2-percent annual chance TWLs

Coastal Structures

- Wide variety of coastal structures present along CA coast
- BakerAECOM reviewed: LiDAR, as-builts from community, aerial photos, site visit notes, USACE drawings and surveys, and Coastal Commission GIS layers to identify and represent structures in profile

Coastal Structures

- BakerAECOM developed global treatments to guide decisions at each site based on FEMA's Pacific Guidelines and USACE guidance
- Consider historical performance, structure condition, as-built drawings, maintenance history, certification, permits, and engineering judgment
- Will structure withstand base flood event?
  - Yes → Conduct Intact analysis only
  - No or uncertain → Conduct Intact and Failed Analysis
- Failed Analysis = partial failure *or* removal, depending on site conditions
- Map the most hazardous Base Flood Elevation only

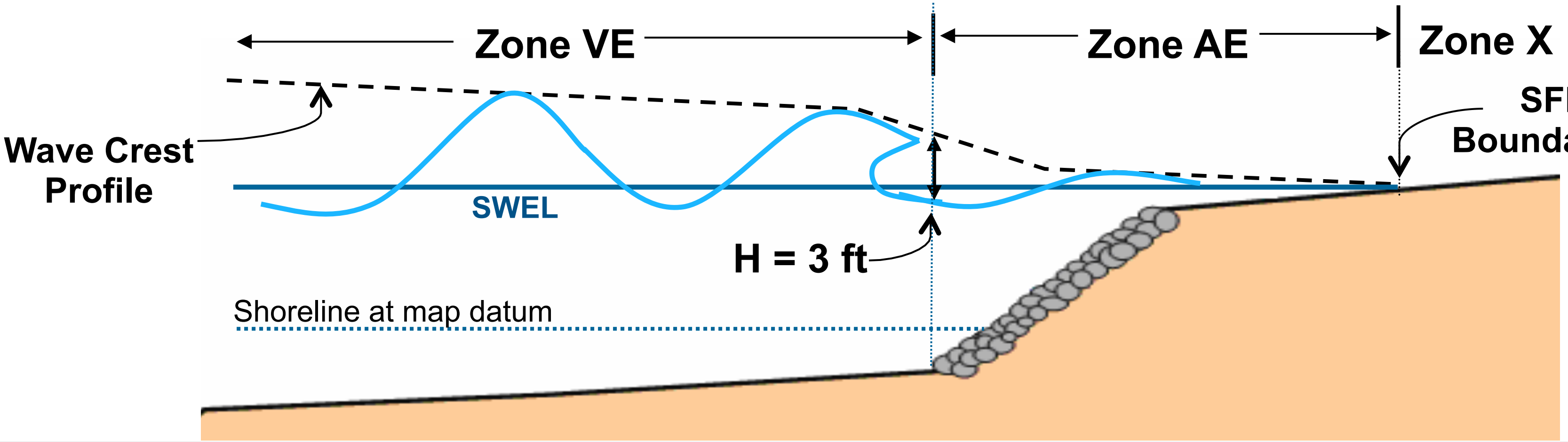
Flood Hazard Mapping

Special Flood Hazard Area (SFHA) Mapping

- Zone VE: Inundated by 1-percent annual chance flood with additional wave-induced hazards (wave runup, wave overtopping splash, high velocity, or overland wave propagation); detailed Base Flood Elevation (BFE)
- Zone AE: Inundated by 1-percent annual chance flood; detailed BFE

(Zone VE and Zone AE: Coastal High Hazard Areas)

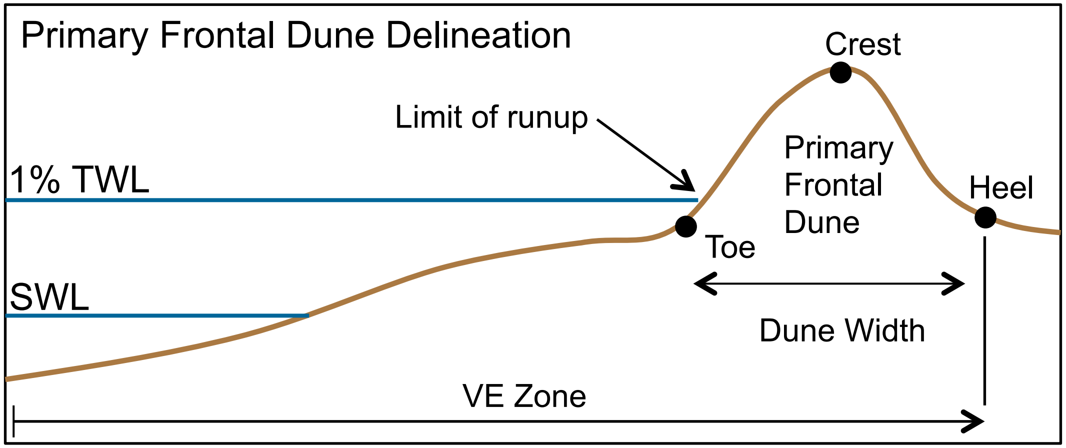
- Both high hazard zones carry mandatory flood insurance purchase requirements
- Zone X (shaded): Inundated by 0.2-percent annual chance flood (or inundated by <1 ft for 1-percent flood)



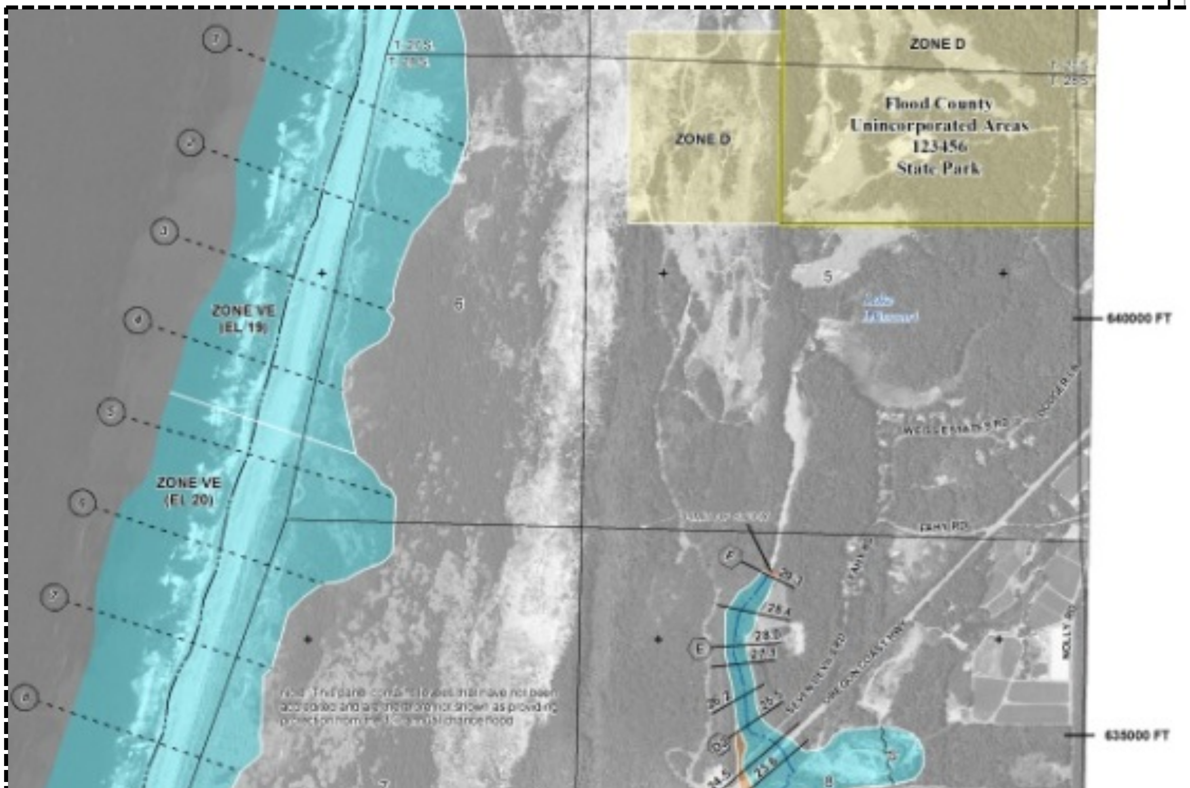
Primary Frontal Dune V Zone Mapping

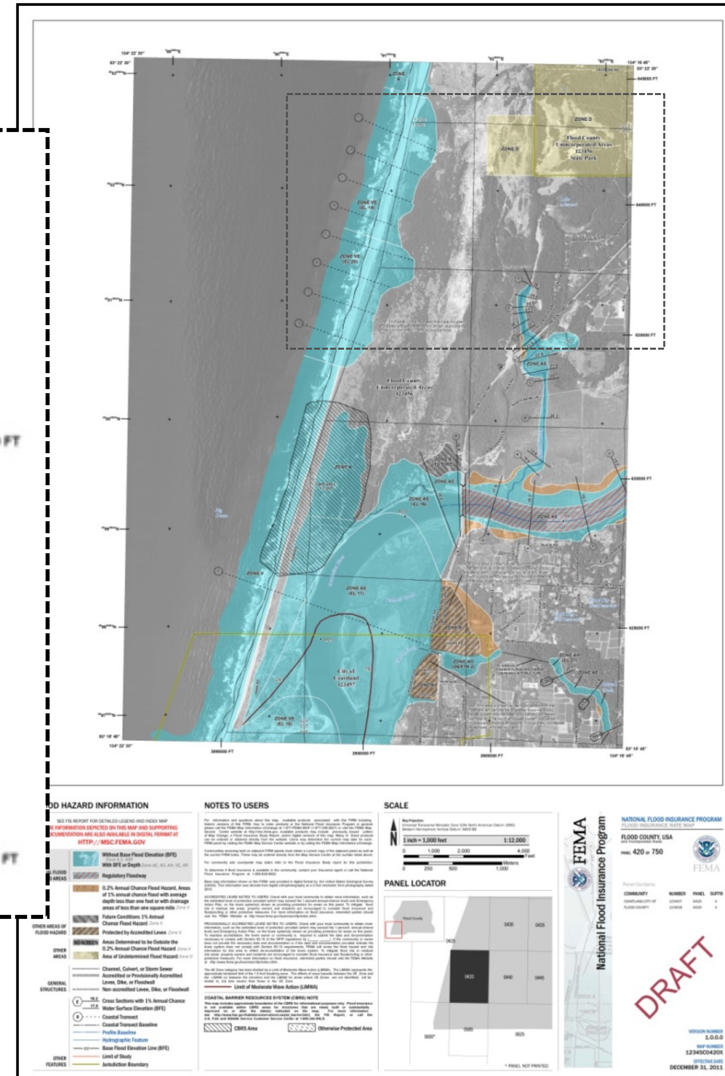
Primary Frontal Dune (PFD) V Zone Mapping

- Definition: "a continuous or nearly continuous mound or ridge of sand with relatively steep seaward and landward slopes immediately landward and adjacent to the beach and subject to erosion and overtopping from high tides and waves during major coastal storms…"
- Landward extent: "a point where there is a distinct chance from a relatively steep slope to a relatively mild slope" (i.e., the *dune heel*)
- Implications: The PFD represents the landward extension of the VE Zone
- Purpose: Floodplain management tool to protect dunes and regulate coastal construction practices and building standards
- Delineation of the PFD is mandated by FEMA regulations



FEMA Regulatory Flood Insurance Rate Map



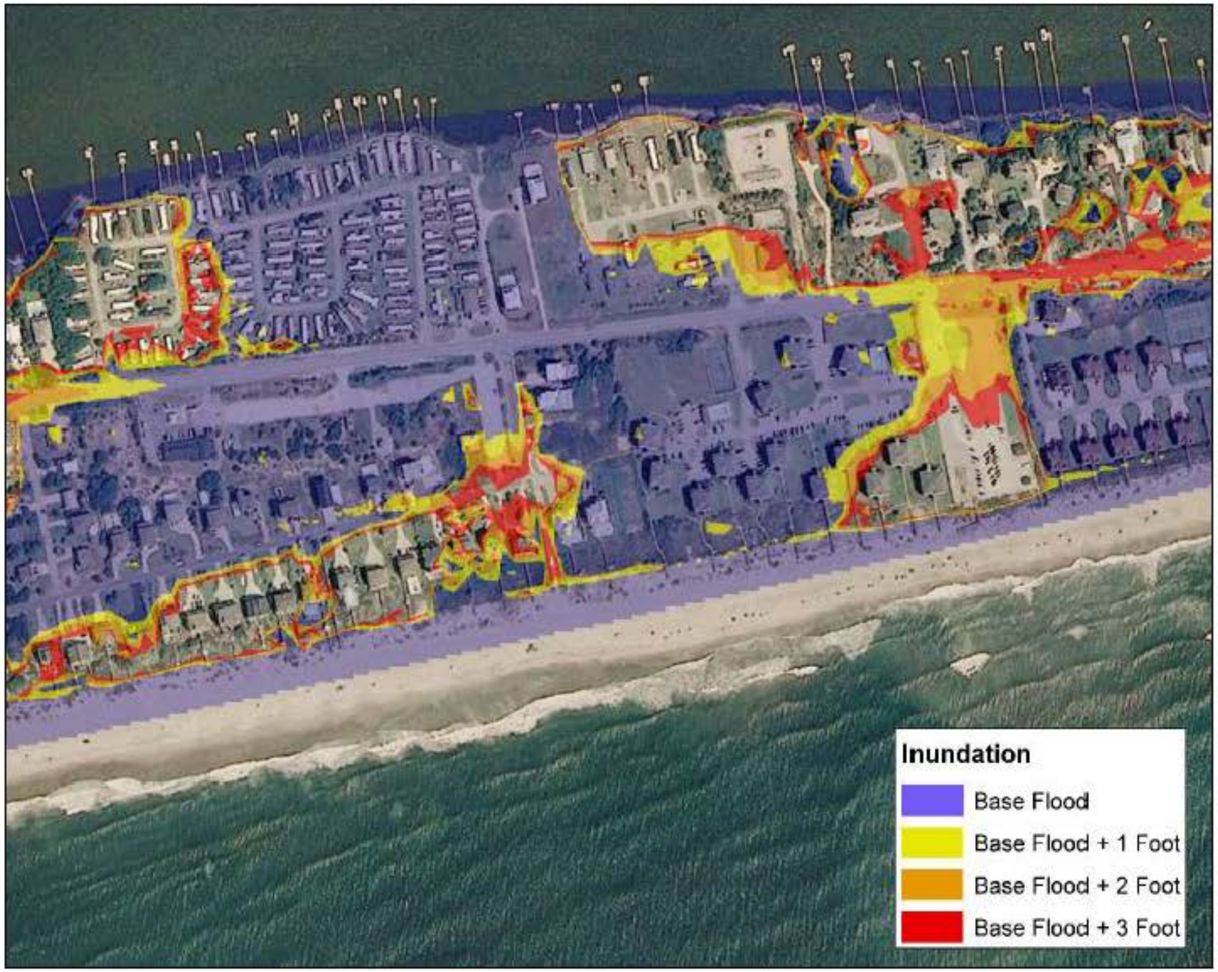


Coastal Non-Regulatory Products

- **Changes Since Last FIRM**
- **Flood Depth Grids**
- **Flood Risk Analysis Grids**
  - 50-, 20-, 10-, 4-, 2-, 1-, and 0.2-percent annual chance
- **Primary Frontal Dune Location**
- **Increased Flooding Scenarios (BFE + 1 ft, BFE + 2 ft, BFE + 3ft)**

Coastal Non-Regulatory Products

Figure 2: Example of the Increased Flooding Scenarios Dataset



FEMA

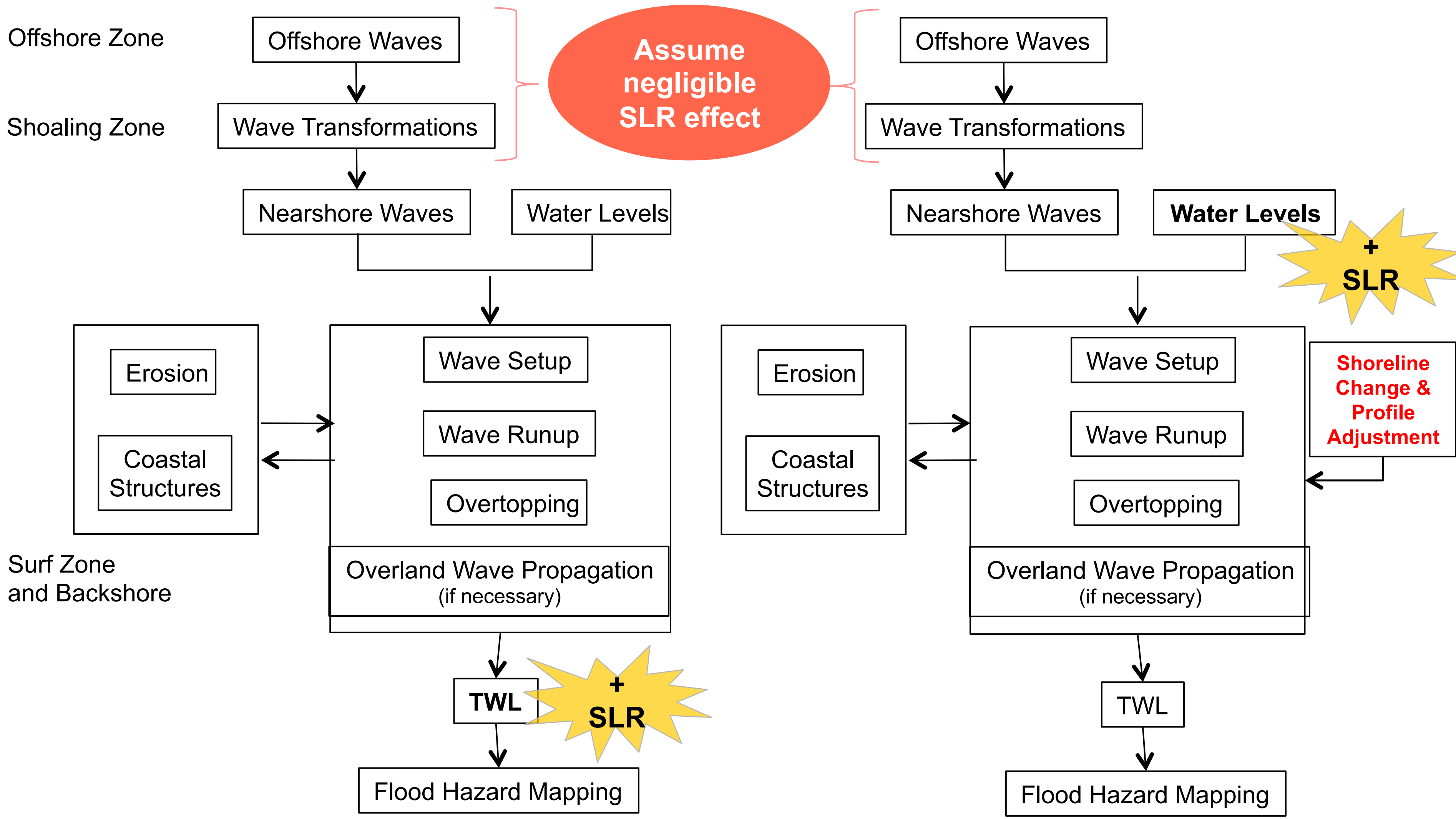
FEMA West Coast Sea Level Rise Pilot Study

City and County of San Francisco

RiskMAP
Increasing Resilience Together

SLR Pilot Study and FEMA *Pacific Guidelines*

Linear Superposition | Direct Analysis



$TWL_{SLR} = TWL + SLR$

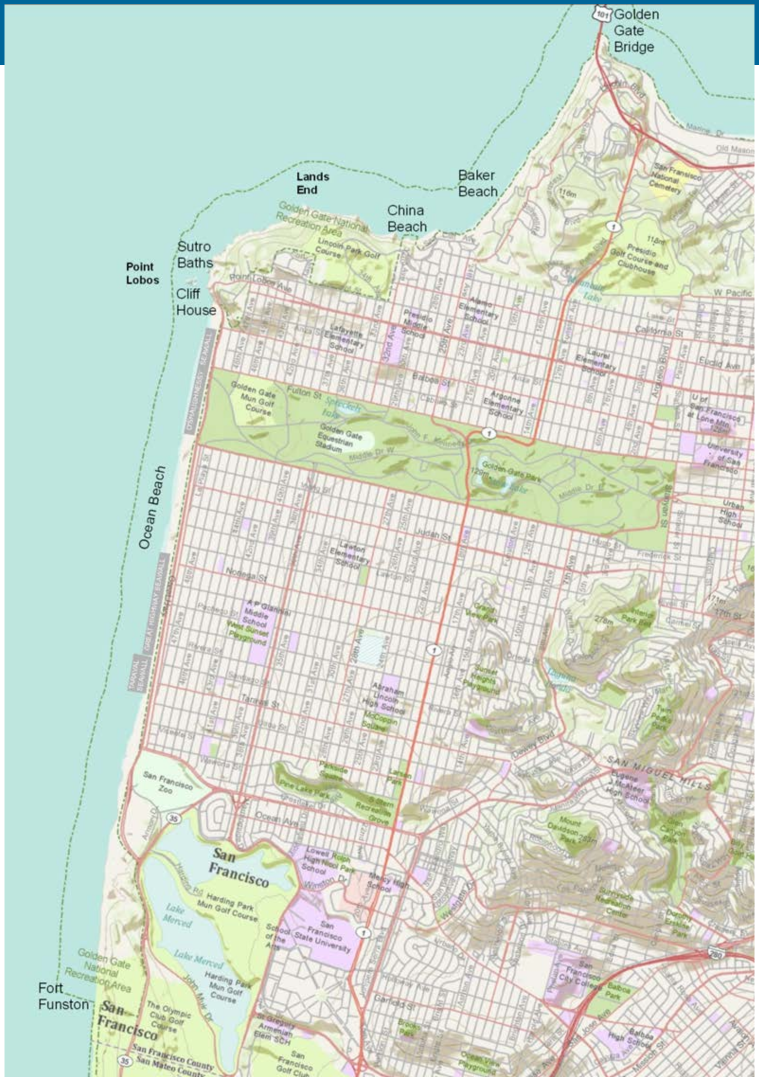
$TWL_{SLR} > TWL + SLR$

Pilot Study SLR Scenarios *

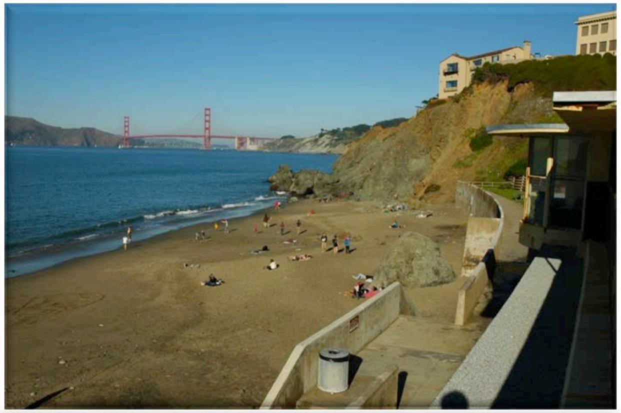
- **Mid-range values for 2050 and 2100**
  - **+12” and + 36”**
- **High end of range for 2050 and 2100**
  - **+24” and +66”**

* *Sea-Level Rise for the Coasts of California, Oregon, and Washington*, National Research Council, 2012

San Francisco County

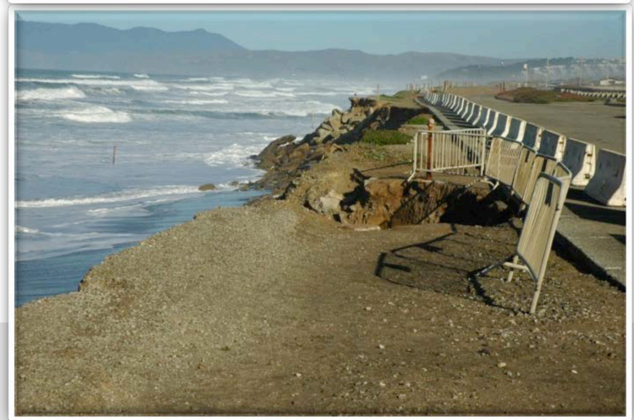


San Francisco County Shoreline



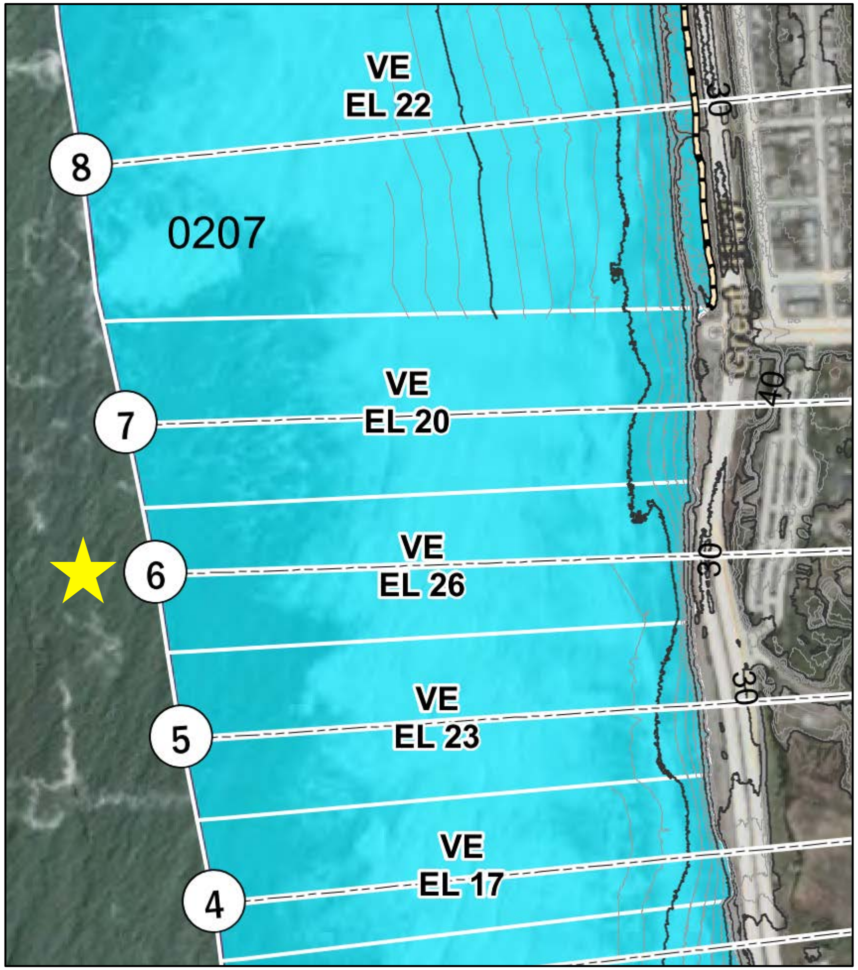
China Beach (Narrow beach + seawall+ rocky bluffs)

Ocean Beach (Wide beach + seawall)

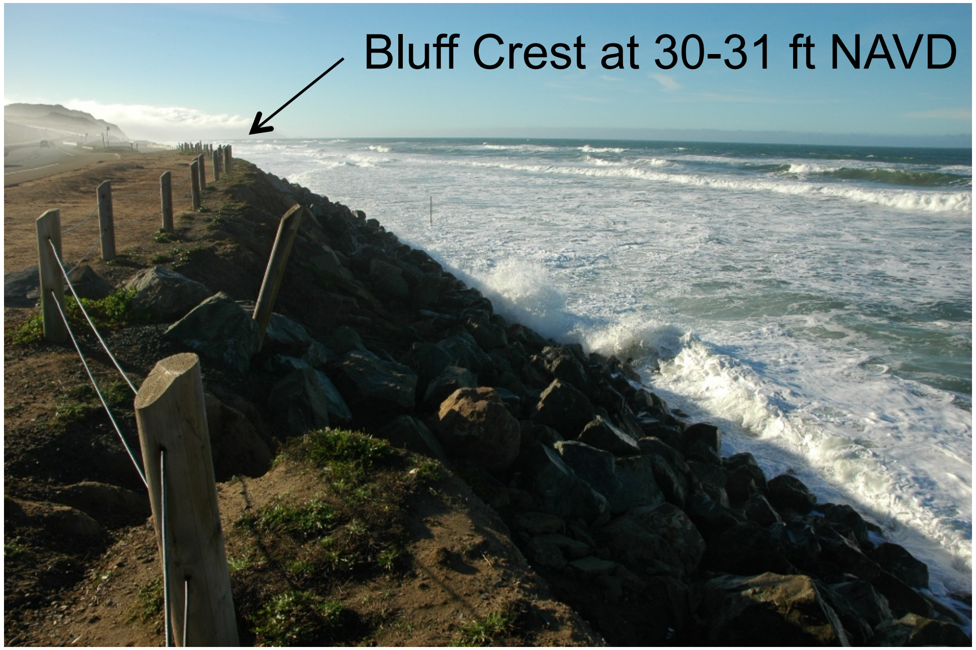


Ocean Beach (Narrow beach + eroding bluff)

Current Condition Mapping
Sloat Blvd – Armored Low Bluff



- 1% Runup (TWL) = 26 ft NAVD
- 0.2% Runup (TWL) = 27 ft NAVD
- No overtopping

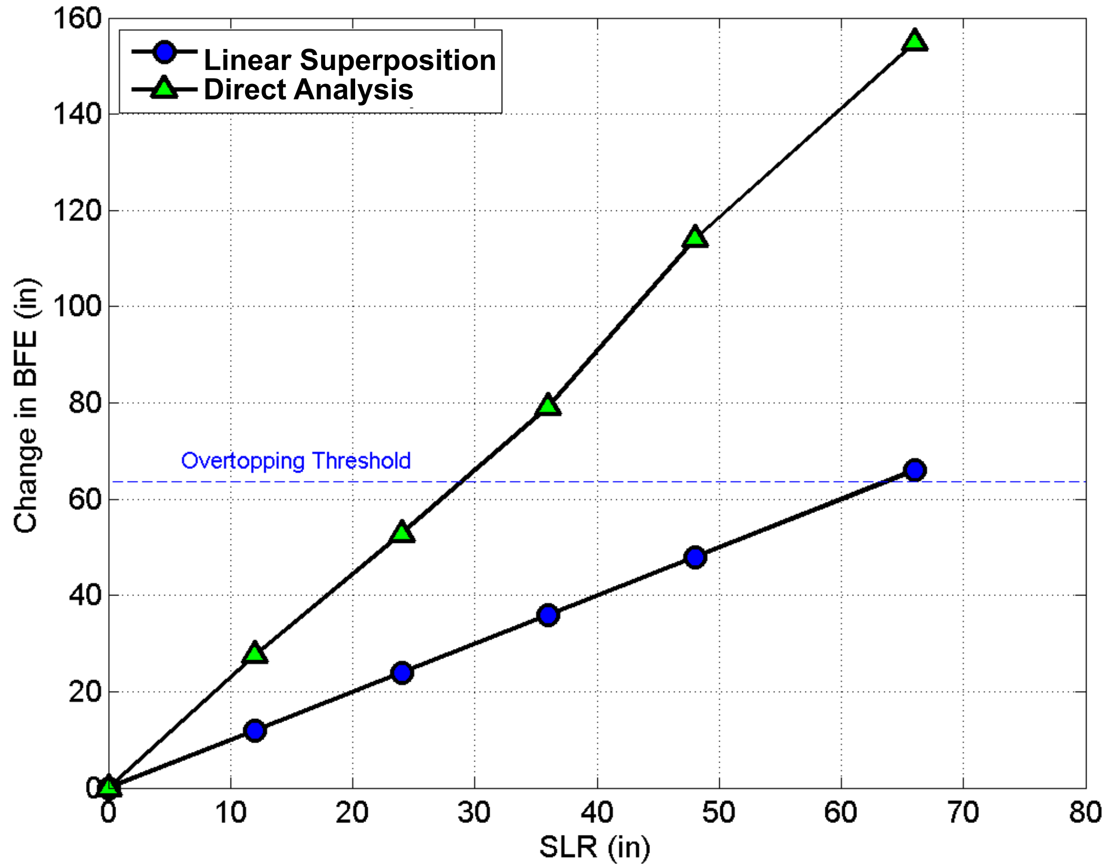


Linear Superposition vs. Direct Analysis

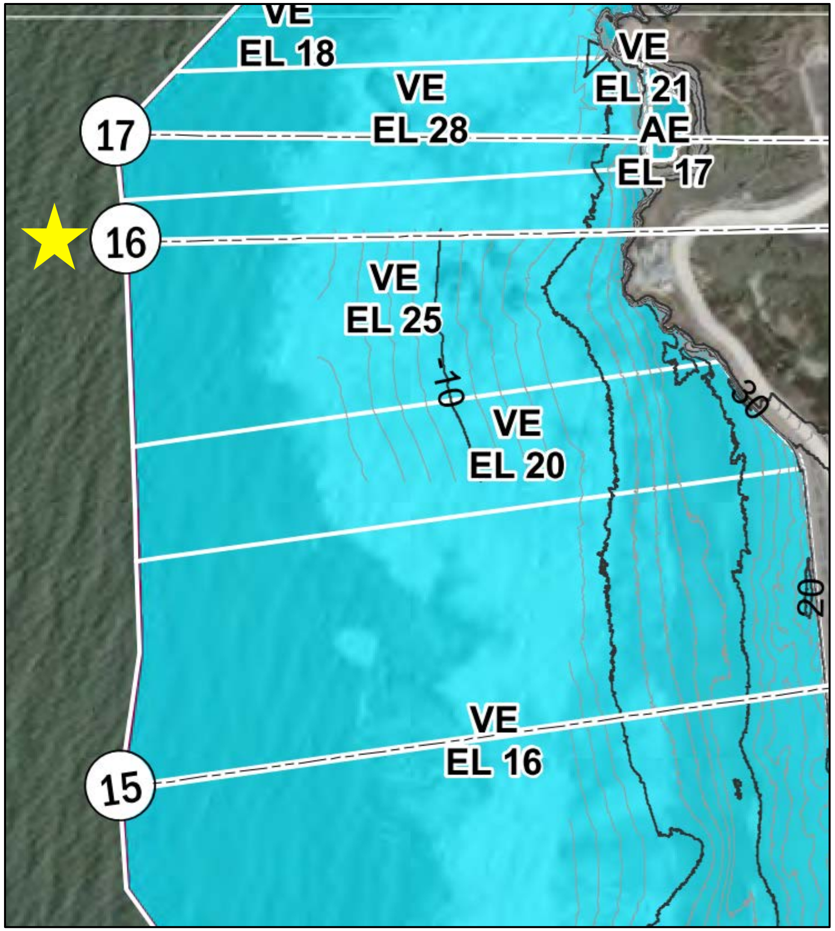
Sloat Blvd – Armored Low Bluff

- **BFE increase exceeds the SLR increase by a factor of ~2**
- **Overtopping occurs at much lower SLR under direct analysis vs. linear superposition method**

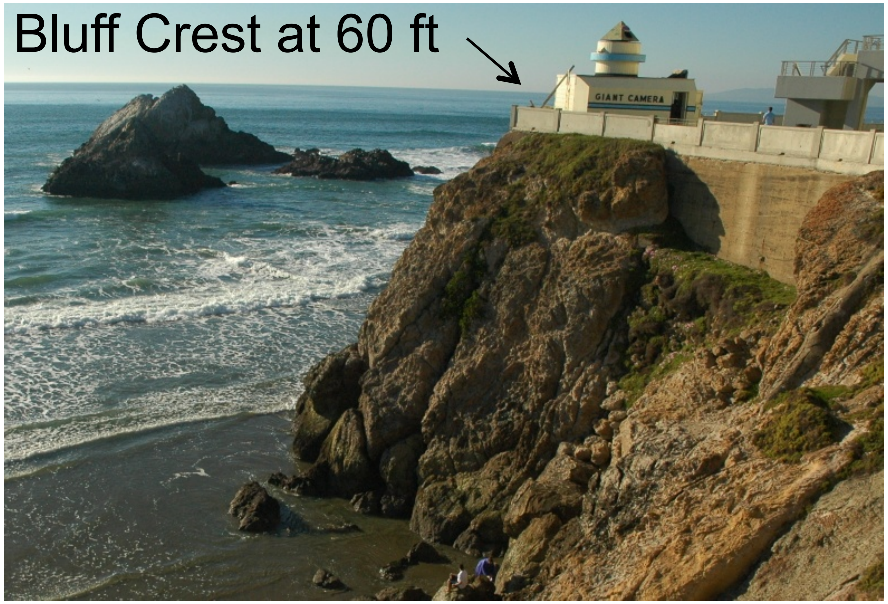
SLR (ft)	ΔBFE (ft)
0	-
1.0	2.2
2.0	4.3
3.0	6.3
4.0	9.6
5.5	12.9



Current Condition Mapping
Cliff House – Natural High Bluff



- **1% Runup (TWL) = 25 ft NAVD**
- **0.2% Runup (TWL) = 26 ft NAVD**
- **No overtopping**

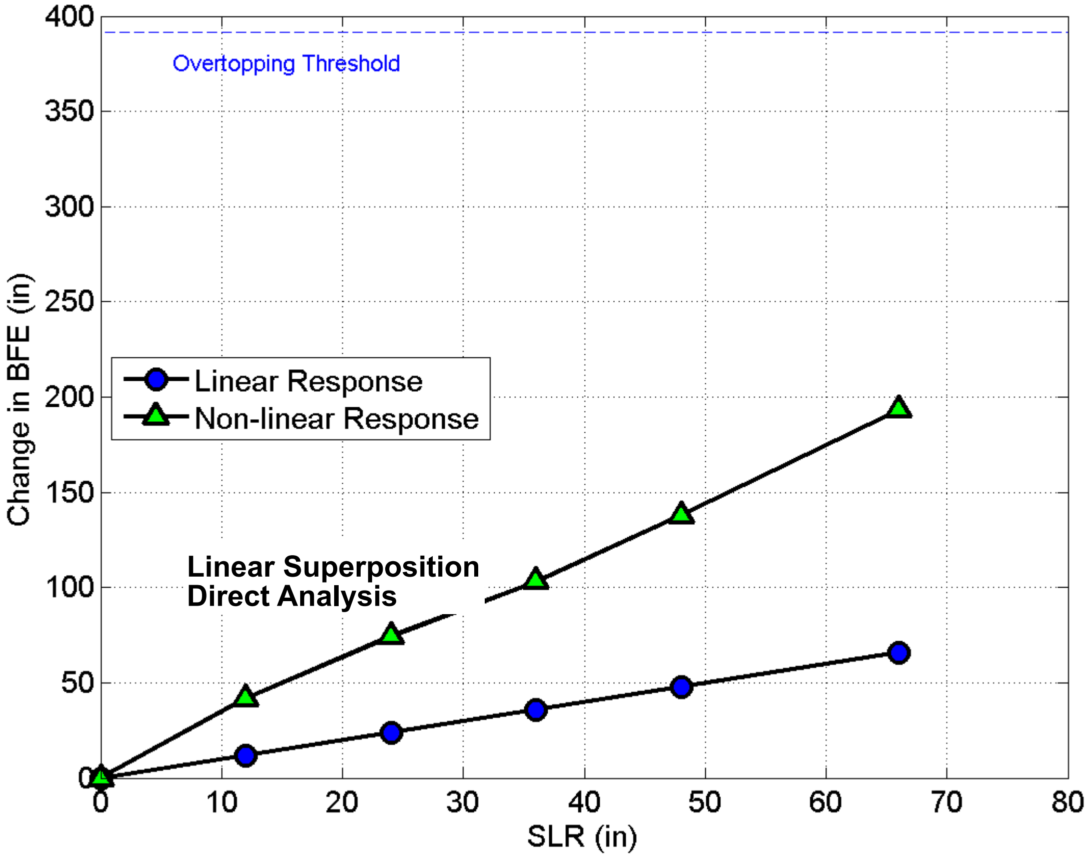


Linear Superposition vs. Direct Analysis

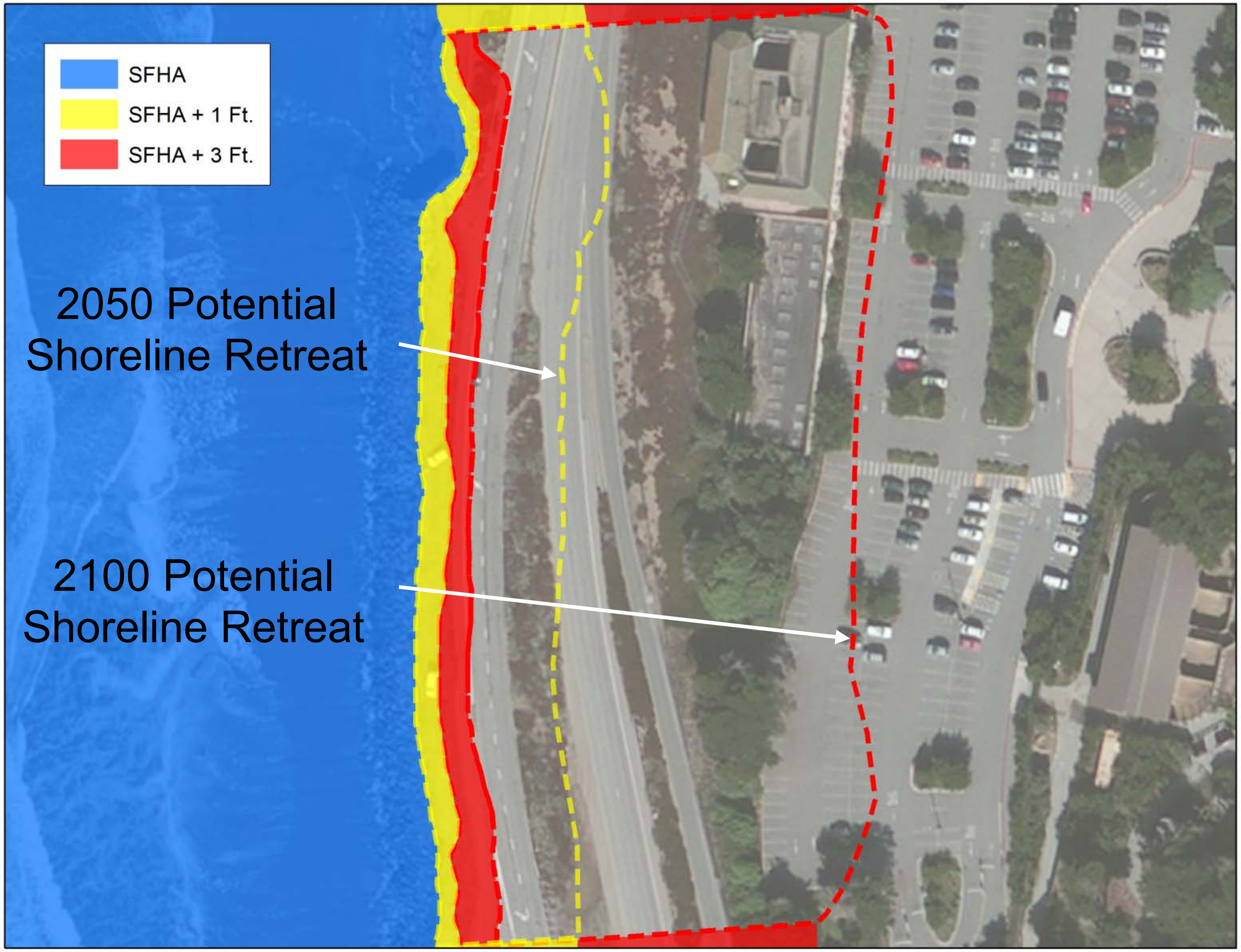
Cliff House – Natural High Bluff

- **BFE increase exceeds the SLR increase by a factor of ~3**

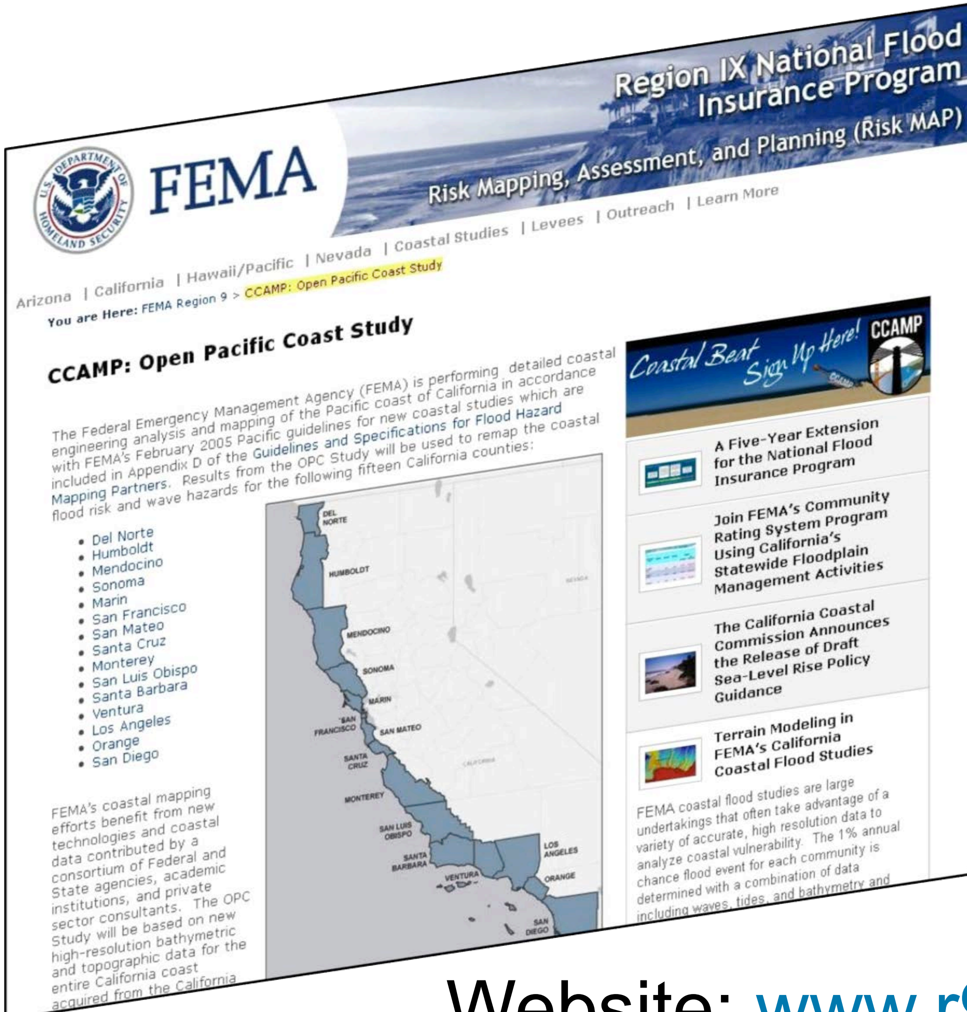
SLR (ft)	ΔBFE (ft)
0	-
1.0	3.5
2.0	6.2
3.0	8.6
4.0	11.5
5.5	16.1



Armored Shoreline – Potential Shoreline Retreat



Stay Informed Throughout the Study



- Meetings
- Materials
- Study Updates

Website: www.r9coastal.org

FEMA Resources

- **Follow FEMA R9 via Twitter @femaregion9**
- **Sign up for the CCAMP E-newsletter at** www.r9map.org/SiteAssets/signUPNewsletter.html

- **Flood Map Center**: https://msc.fema.gov/portal - Print a FREE flood map

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Questions & Answers

RiskMAP
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