

# *Leaning Into Adaptation*

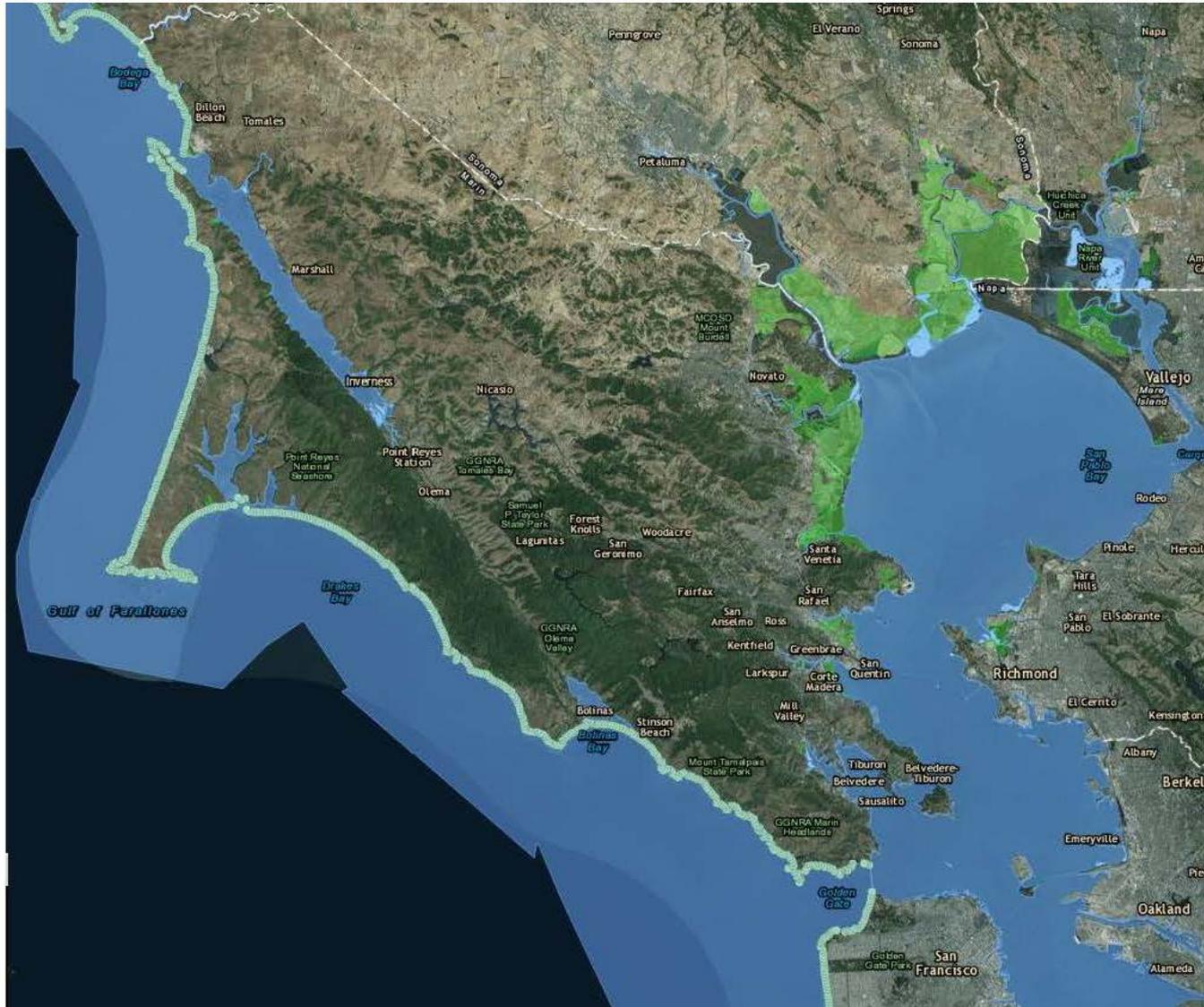
GFNMS Ocean Summit, May 17, 2016

**Jack Liebster, Planning Manager, Marin County**

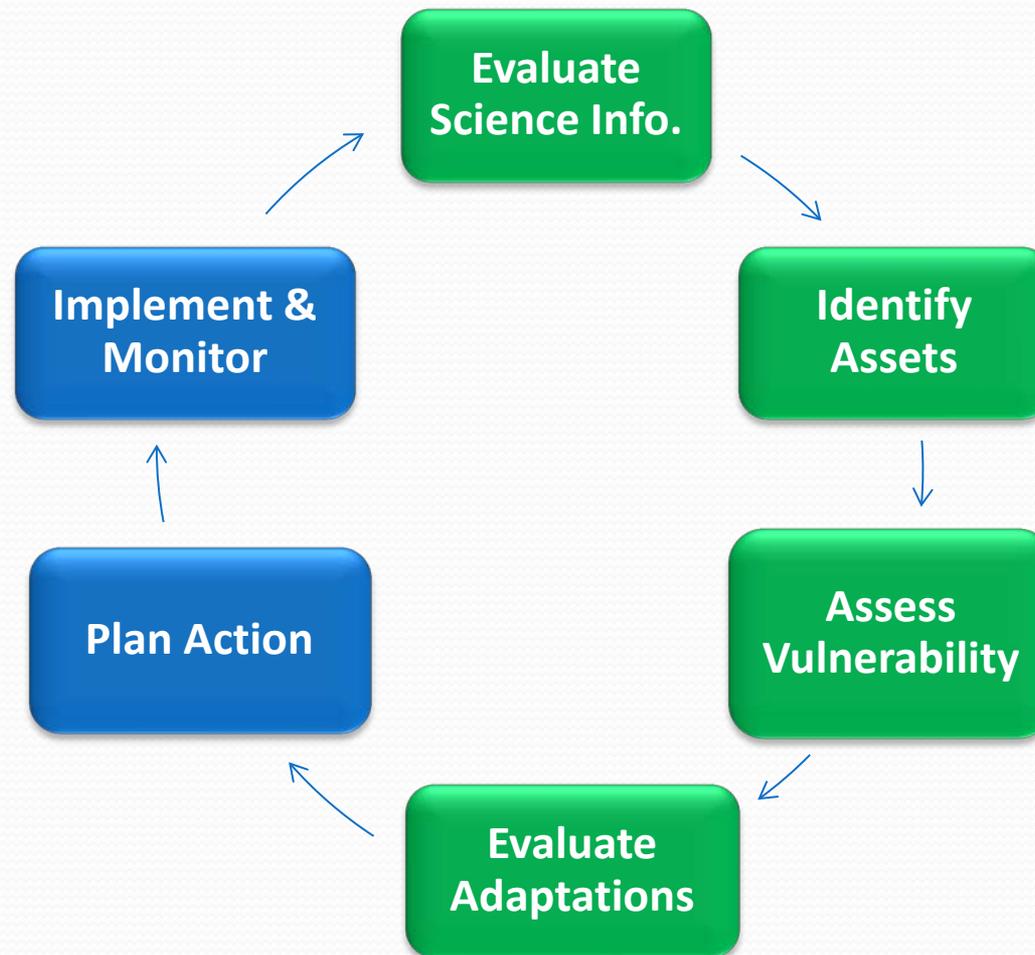


[www.MarinSLR.org](http://www.MarinSLR.org)

# Marin County C-SMART

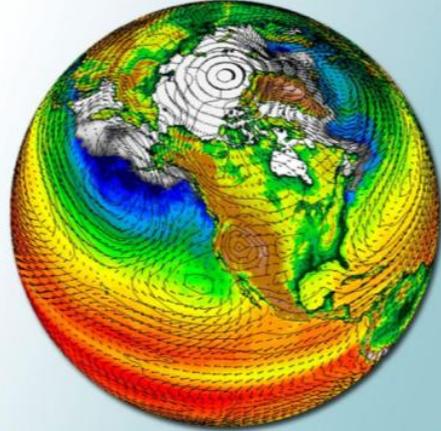


# Sea Level Rise Adaptation Process

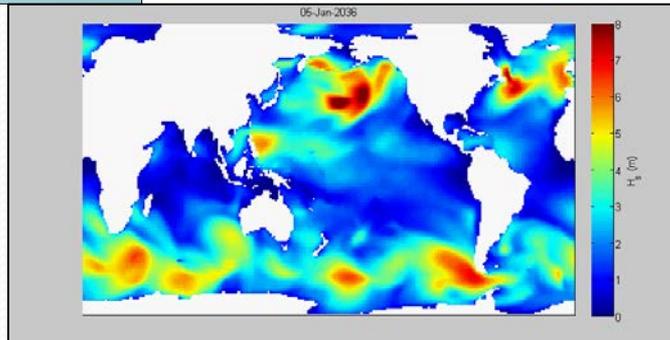


# Identifying Future Risk with CoSMoS

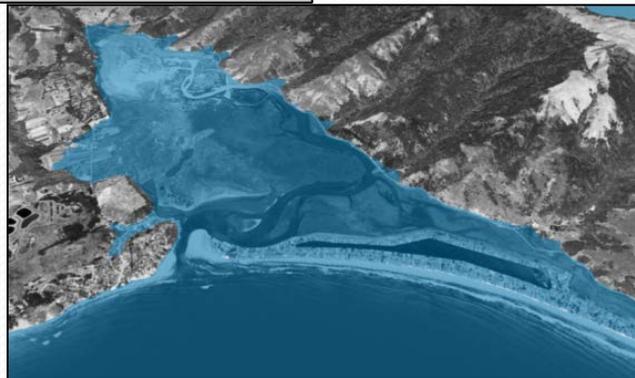
1. Global forcing using the latest climate models



2. Drives global and regional wave models



3. Scaled down to local hazards projections

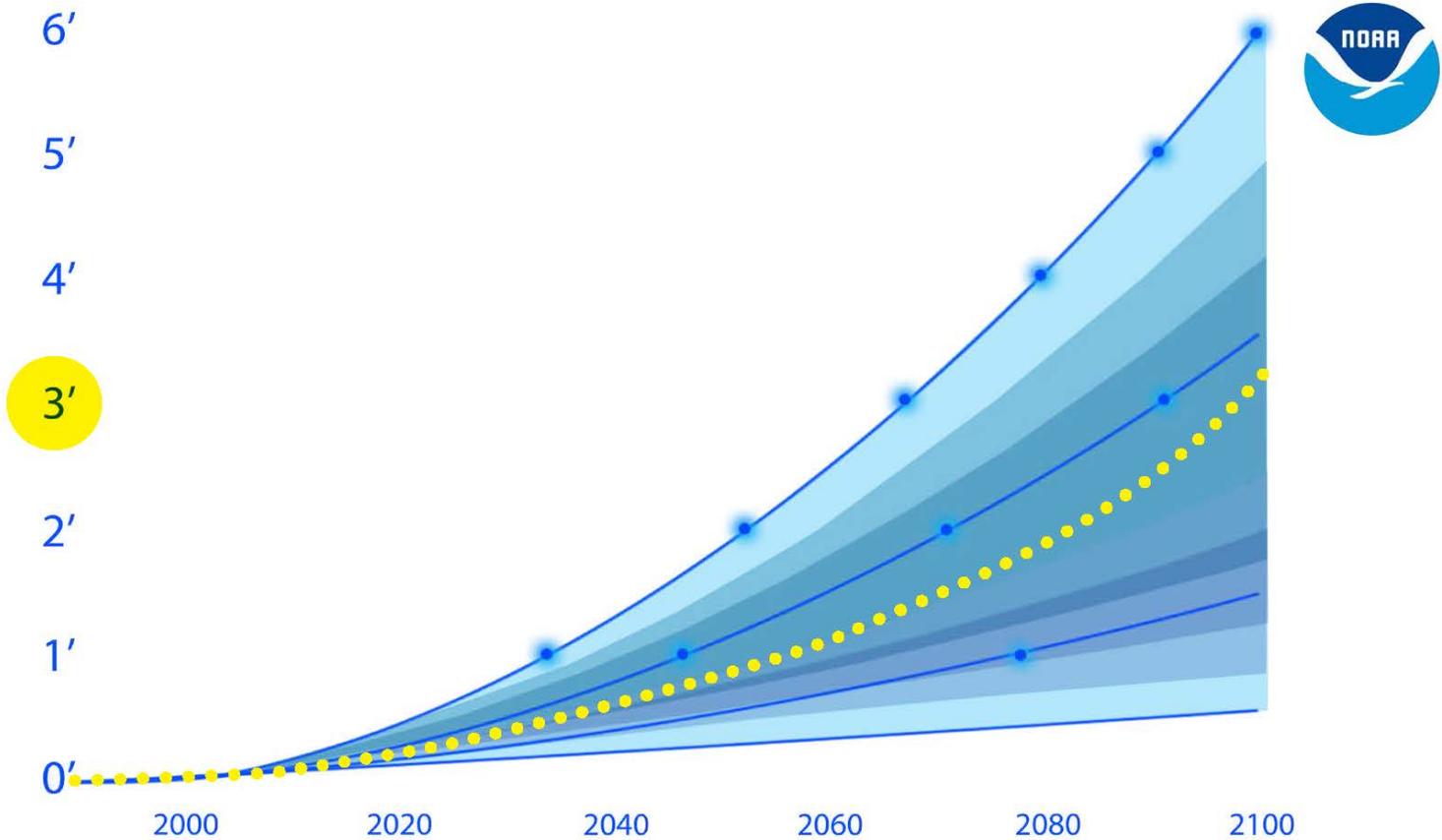


# State of California Official Guidance

<b>Period</b>	<b>Projected Range of SLR</b>
2030	<b>1.6 - 11.8 in.</b> (4 - 30 cm)
2050	<b>4.7 - 24 in.</b> (18 - 61 cm)
2100	<b>16.6 - 65.8 in.</b> (42 - 167 cm)

NRC Sea-Level Rise Projections for California (SF Region), *NAS-NRC 2012*

# Potential Future Sea Level Rise



# Methods

## C-SMART SCENARIOS

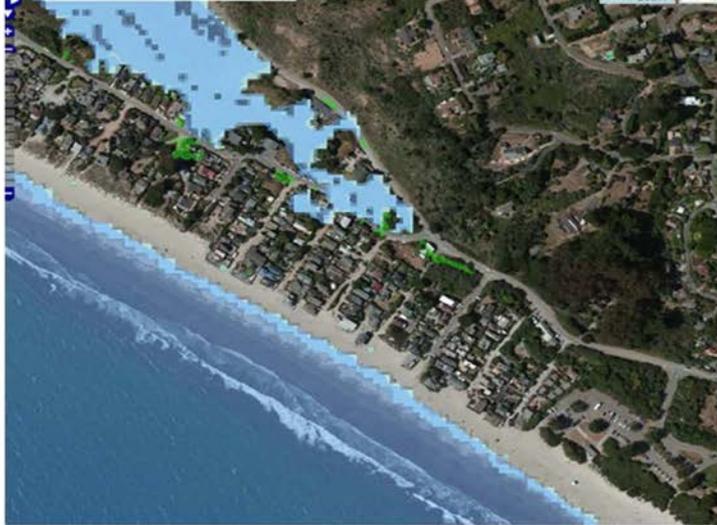
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**Table 1. Selected Sea Level Rise & Storms Scenarios**

Baseline: No new Sea Level Rise + No storm	
Scenario 1: 10 inches Sea Level Rise + Annual Storm	Near-term
Scenario 2: 10 inches Sea Level Rise + 20-year Storm	
Scenario 3: 20 inches Sea Level Rise + 20-year Storm	Medium-term
Scenario 4: 40 inches Sea Level Rise + 100-year Storm	Long-term
Scenario 5: 80 inches Sea Level Rise + 100-year Storm	

# EXPOSURE – SLR vs. ANNUAL STORM

**25 cm, 0 Storm**



**100 cm, 0 Storm**



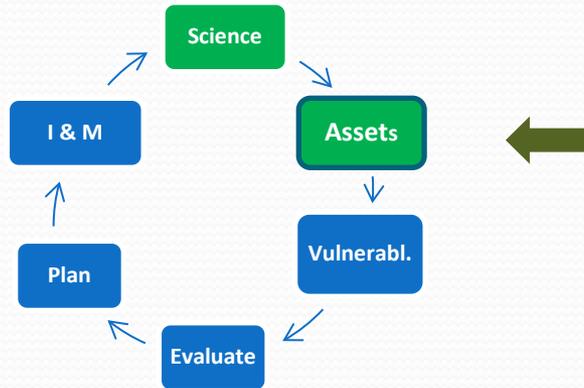
**25 cm, 1 Yr Storm**



**100 cm, 1 Yr Storm**



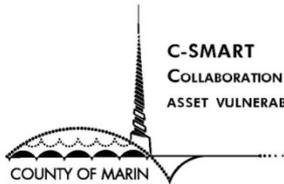
# ASSET MAPPING & INVENTORYING



**Mapping people; livelihoods; environmental services and resources; infrastructure; and economic, social, & cultural assets**

- **Agricultural land**
- **Protected areas**
- **Public beaches and parks**
- **Dunes**
- **River & streams**
- **Wetland areas**
- **Habitat areas**
- **Oyster beds**
- **Sandspits**
- **Shorebirds**
- **Roads and transportation**
- **Trails**
- **Buildings**
- **Residential development**
- **Commercial buildings**
- **Schools**
- **Elderly/mobility limited facilities**
- **Hotels/Motels**
- **Harbors and marinas**
- **Fishing, aquaculture facilities**
- **Utilities & services**
- **Septic leach fields**
- **Water Supply wells**
- **Archeological/ Paleontological sites**
- **Historic sites**

# Asset Manager Interview Tool



**C-SMART**  
**COLLABORATION SEA-LEVEL MARIN ADAPTATION RESPONSE TEAM**  
**ASSET VULNERABILITY ASSESSMENT TOOL AND SCRIPT**

**INTERVIEWER:** \_\_\_\_\_  
**INTERVIEWEE:** \_\_\_\_\_  
**ASSET:** \_\_\_\_\_

**DATE:** \_\_\_\_\_  
**PHONE:** \_\_\_\_\_

*Instructions to CDA: Use this script to conduct interviews (in-person or on the phone) with identified asset managers. Read the instructions to the asset manager and provide an overview of the process. Be sure to ask the questions as they are written to ensure consistency across interviews.*

CDA: Hello, my name is \_\_\_\_\_ from Marin County Community Development Agency and I am calling/here for our appointment to discuss how sea level rise can impact public assets on Marin's Coast. *[Allow response]*

CDA: Thank you for agreeing to this interview. We hope that this process is useful for you and the future management of coastal assets. In particular, we have one/a few/several public assets relating to your area of expertise we would like to go over with you (and your team). These assets are:

1. \_\_\_\_\_
2. \_\_\_\_\_
3. \_\_\_\_\_

At most this process could take 30 minutes per asset, and answers about 35 questions. For each asset, I will ask several yes or no and short answer questions, followed by ranking degrees of sensitivity, adaptive capacity, and risk factors associated with Sea Level Rise and storm surges. Completing this for each asset will enable us to complete a vulnerability assessment and facilitate adaptation planning if needed.

Before I get started, do you have any questions? *[Allow Q&A]*

CDA: We will begin with the *[insert asset]* *[if needed]*. The first set of questions may be useful in the planning process and will help get us thinking about sea level rise and storm surge preparation.

1. Are there efforts underway to address SLR/SS (emergency or climate change efforts) impacts for the asset?  
 No  Yes, \_\_\_\_\_
2. What is your level awareness of sea level rise?  
 None  Low, heard/read of SLR  Moderate, involved in training/project  High, expert
3. What is your general workplace's awareness of sea level rise?  
 None  Low, heard/read of SLR  Moderate, involved in training/project  High, expert

What is the current physical condition of the asset. Are there existing stresses, are they likely to improve/worsen?

Has the asset been disrupted in the past due to an unplanned stress e.g., weather-related closure, emergency repair, strike?

Yes. How long did disruption last? \_\_\_\_\_  
 7a. Was the asset able to continue functioning?  No  Partially  Yes

When was the last repair or update? \_\_\_\_\_  
 Is maintenance or repair planned?  No  Yes, when \_\_\_\_\_

Consider how the following sea level rise and storm surge exposures could impact *[insert asset]*. The

- 1. High water table
- 2. Water intrusion
- 3. Permanent flooding
- 4. Temporary flooding
- 5. Storm impacts
- 6. High winds impacts
- 7. Beach/cliff erosion
- 8. Habitat shifts

How sensitive about what any of these exposures are? *[Allow response, and clarify if needed]*

How sensitive to activity, then adaptive capacity, adaptation ideas, and risk for each. For the sensitivity assessment,

what degree an asset could be damaged or the service it provides disrupted. Please indicate if

\_\_\_\_\_ will be sensitive for each exposure according to these levels:

- 1. Slightly impaired, damaged, or disrupted. The asset may require minor repairs or suffer minimal disruption.
- 2. Somewhat impaired, damaged, or disrupted. The asset may require repairs and able to maintain most
- 3. Moderately impaired, damaged, or disrupted with complete loss or shut-down. The asset will require significant
- 4. Severely impaired, damaged, or disrupted with complete loss or shut-down. The asset will require significant

How sensitive to activity, then adaptive capacity, adaptation ideas, and risk for each. For the sensitivity assessment, what degree an asset could be damaged or the service it provides disrupted. Please indicate if \_\_\_\_\_ will be sensitive for each exposure according to these levels:

How sensitive to activity, then adaptive capacity, adaptation ideas, and risk for each. For the sensitivity assessment, what degree an asset could be damaged or the service it provides disrupted. Please indicate if \_\_\_\_\_ will be sensitive for each exposure according to these levels:

- Sensitivity? Do you have any questions about sensitivity? *[Allow response, and clarify if needed]*
- Asset to: \_\_\_\_\_
- |                     | No                    | Low                   | Med                   | High                  | Max                   |
|---------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|
| Temporary flooding? | <input type="radio"/> |
| Permanent flooding? | <input type="radio"/> |
| Beach erosion?      | <input type="radio"/> |
| Sea level rising?   | <input type="radio"/> |
| Water intrusion?    | <input type="radio"/> |
| Storm surge?        | <input type="radio"/> |
| High winds?         | <input type="radio"/> |
| Habitat shifts?     | <input type="radio"/> |

When you find that *[insert asset(s)]* is/are moderately, highly, or maximally sensitive to *[name]* is sensitive to any of these exposures, ask the asset manager what the impact of the exposure could be, hours of system shutdown; what is the NATURE of the sensitivity).

Adaptive capacity: First, we will ask you to rate the adaptive capacity of the asset for each exposure you rated you may know, adaptive capacity is defined as the ability of an asset to recover from the damage or prevention. Before we continue, do you have any questions about adaptive capacity? *[Allow for Q & A]*

Adaptive capacity for the asset according to these categories:

- 1. Asset is able to tolerate [Impact], no need for intervention.
- 2. Asset is able to tolerate [Impact] and cope with the consequences without the need for significant intervention (e.g. alternate infrastructure routes, elevated structure). Could be easily replaced, repaired.
- 3. Asset is somewhat able to tolerate [Impact], and cope with the consequences with significant intervention (repair, replacement are possible)
- 4. Asset has limited ability to tolerate [Impact], and cope with the consequences (no alternative routes, could require replacement or very costly repairs.
- 5. Asset is not able to tolerate [Impact]. Not repairable or replaceable in current location

Adaptive capacity for each of the moderate, high, and maximum sensitivity exposures. *[insert asset]*

Rank below	No	Low	Med	High	Max
_____	<input type="radio"/>				
_____	<input type="radio"/>				
_____	<input type="radio"/>				
_____	<input type="radio"/>				
_____	<input type="radio"/>				

Questions to get us thinking about adaptation planning, the next phase of analysis and exploration.

Adaptation or preparation actions have you or your agency incorporated into managing the asset in times

Adaptation or preparation actions have you or your agency have for new adaptation or preparation actions that will ensure the asset/ maintained in future sea level rise and storm scenarios?

Physical:

# THE GAME OF FLOODS *Marin Island*

START

Sea levels are rising worldwide at an average of 3mm per year and it is expected that by 2100, sea levels will rise by 1 to 6 feet. This is the level of these threats you are tasked with collaboratively developing a risk level for. Adaptation Plans using the strategies (game pieces).

- To begin, one player reads the risk level and declares their preferred level of risk. The first player to reach the risk level is the winner.

- It is your turn to draw pieces in order to accommodate, defend, or retreat from the costs of higher sea levels. Use the strategies provided to record your choice, costs, and how you intend to manage the risk. Collaborative strategies are allowed.
- Use the remaining time to reduce the impact of the rising sea levels. Environmental impacts, if they occur, are published by the host.



**LEGEND**

	Evacuation Route		Marina		Mammal Habitat		Storm Shelter		Elevated Sub-Station
	Municipal Water Plant		Goat Station		Seabird Colony		Agriculture		Swing Lift
	Beach		Shed		Aquaculture		Home		Public Well
	Ranch		Agriculture		Home		Public Well		Beach Launch
	Grocery		Beach		Restaurant		Library		Post Office
	Water		Beach		Hospital		Fire Station		Church
	School Site		Hospital		Fire Station		Church		
	Restaurant		Church						
	Beach Launch								

	Retreat		Post-storm prohibitions		Elevate Buildings		Elevate New Road		Revetment/Seawall		Tide Gate		Horizontal Levee		Offshore Structure
	Managed Retreat		Stricter land use zoning		Floodable Buildings		Accommodate Water		Traditional Levee		Wall & Pump Station		Wetland/shoreline vegetation		Beach Maintenance

**GAME PIECES**

# Community Meetings



# Staking out Sea Level Rise



# Join in Promoting Awareness?



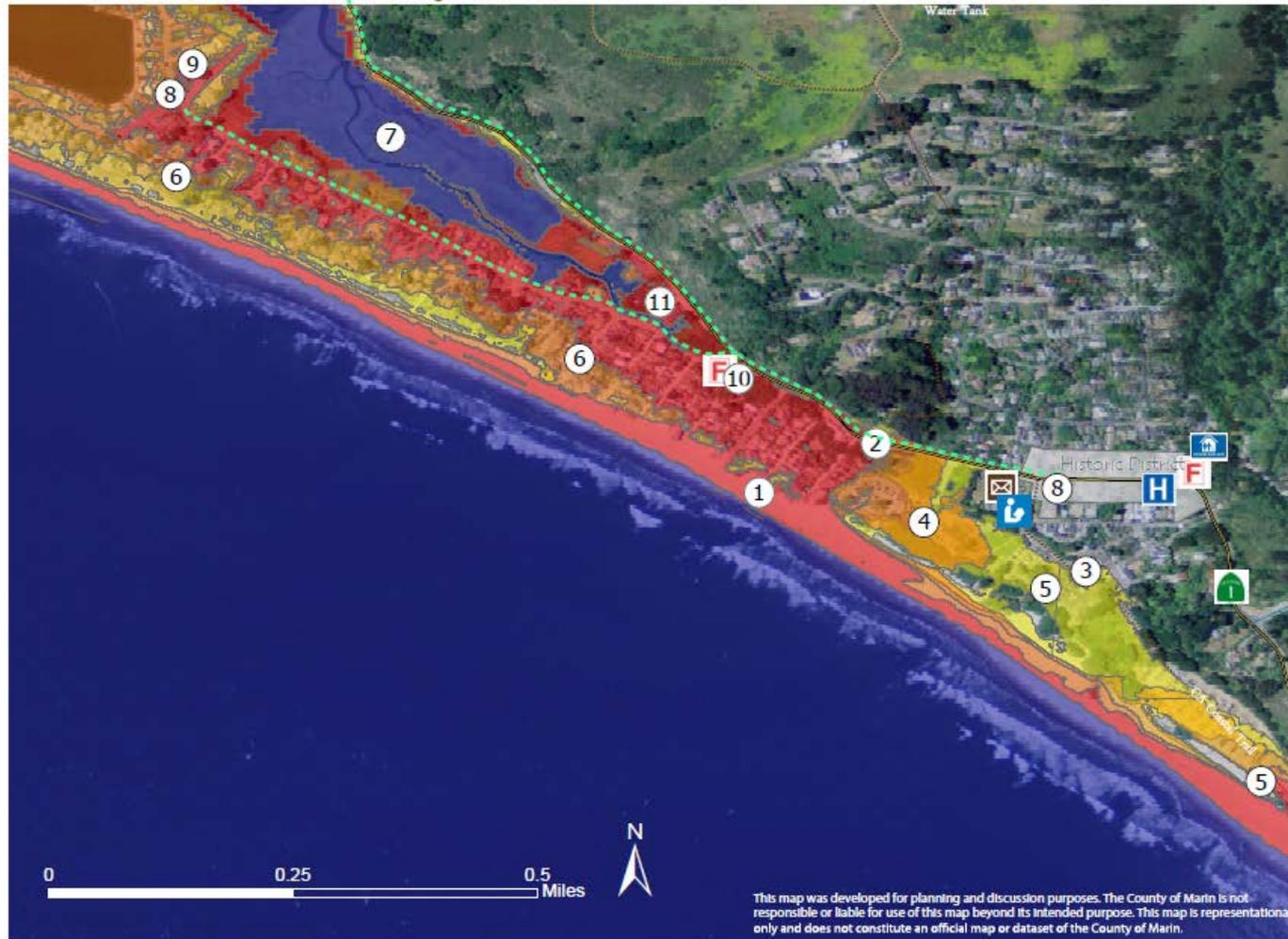
# Coming to your door...



Apr 15 - J

[BUY TICKETS](#)

# Stinson Beach



## Exposed Assets

- ① Stinson Beach
- ② State Highway 1
- ③ California Coastal Trail
- ④ Picnic Area
- ⑤ Stinson Beach Parking Lots
- ⑥ Commercial/Residential Development
- ⑦ Bolinas Lagoon
- ⑧ Tsunami Evacuation Route
- ⑨ Emergency Generator
- ⑩ Fire Station
- ⑪ Water District Office

*Additional Natural Resources include Steelhead Trout habitat, Harbor Seal Haul Outs, Brown Pelican Roosting Sites, Wetlands*

## Sea Level Rise (SLR) Scenarios

- Baseline No SLR/ No Storm
- 25 cm (0'10") SLR w/ Annual Storm
- 25 cm (0'10") SLR w/ 20 year Storm
- 50 cm (1'8") SLR w/ 20 year Storm
- 100 cm (3'3") SLR w/ 100 year Storm
- 200 cm (6'6") SLR w/ 100 year Storm

## Properties Exposed

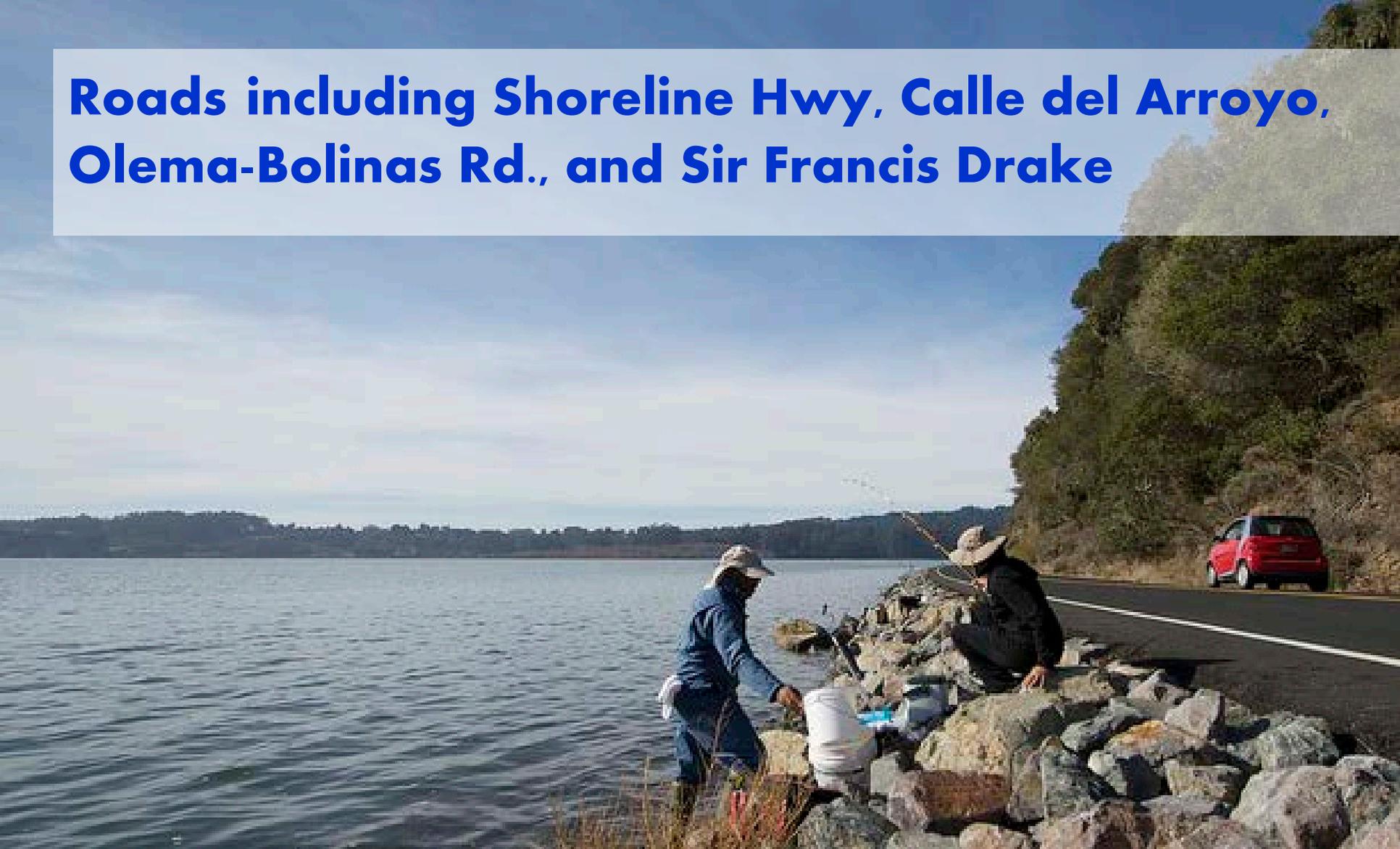
- |       |       |
|-------|-------|
| ■ 2   | ■ 398 |
| ■ 120 | ■ 490 |
| ■ 250 |       |



# **4,700** acres exposed at mean higher high water

**Mean higher high water: The average high tide, thus some sites could be dry during lower tides.**

# Roads including Shoreline Hwy, Calle del Arroyo, Olema-Bolinas Rd., and Sir Francis Drake





A photograph of a white, single-story house built on wooden stilts over a body of water. The house has a brown roof and several windows. In the foreground, there are large, grey rocks and some green grass. In the background, there are more houses, a dock with several sailboats, and a green hillside under a clear blue sky.

**\$300 million losses in assessed value -  
market value is much higher**

**\$7 million in lost property tax**

**\$700,000 lost Transient Occupancy Tax**



**Every exposed building would face waste and/or drinking water impacts**



# Beaches could flood and erode

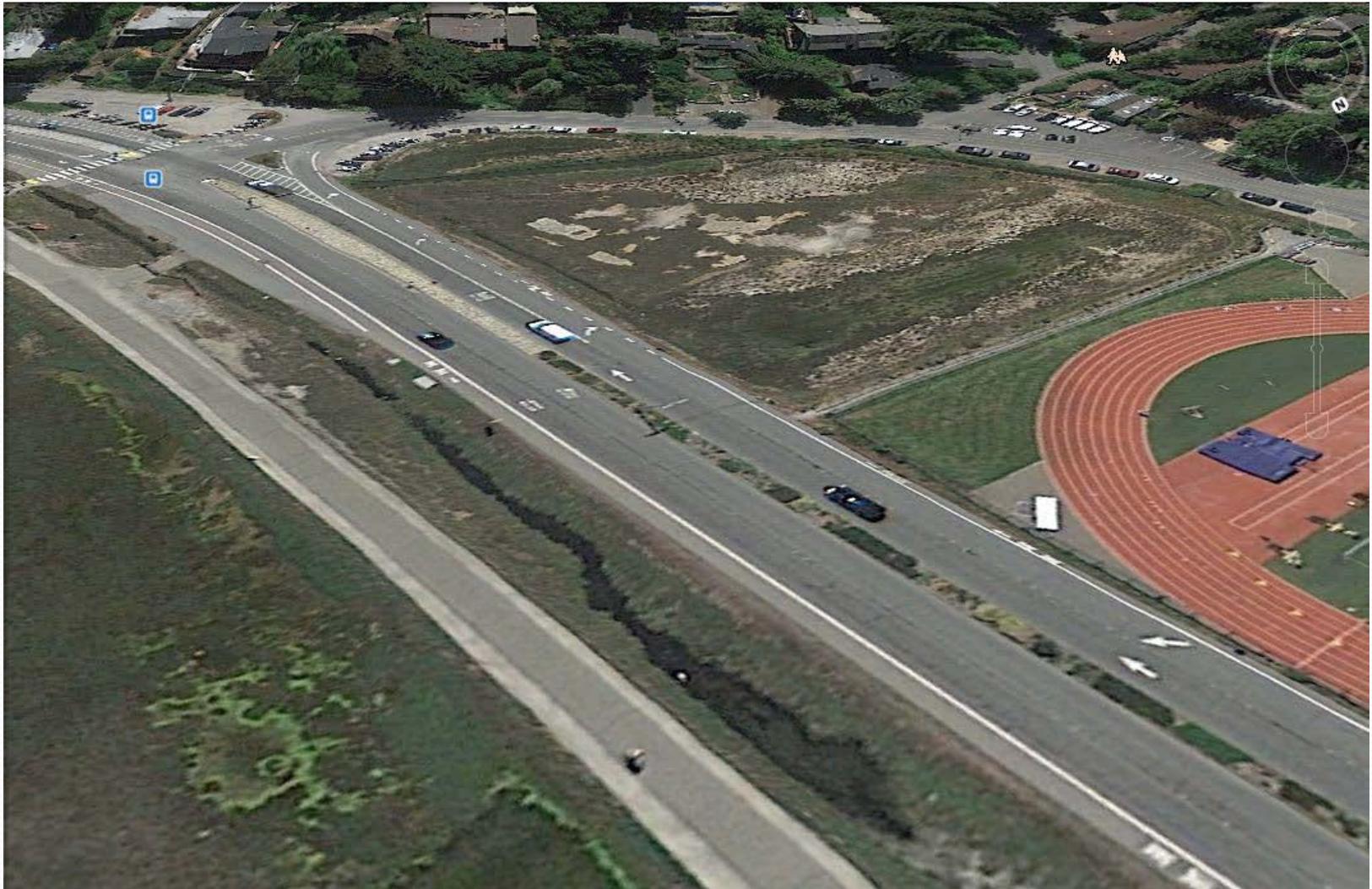
Community Development Agency  
Marin Coast Sea Level Rise Vulnerability Assessment  
Nov. 9, 2015 | [www.marinslr.org](http://www.marinslr.org)



# Marshes could convert to mud flats, and may move upland

Community Development Agency  
Marin Coast Sea Level Rise Vulnerability Assessment  
Nov. 9, 2015 | [www.marinslr.org](http://www.marinslr.org)

# Miller Avenue Entry to Mill Valley



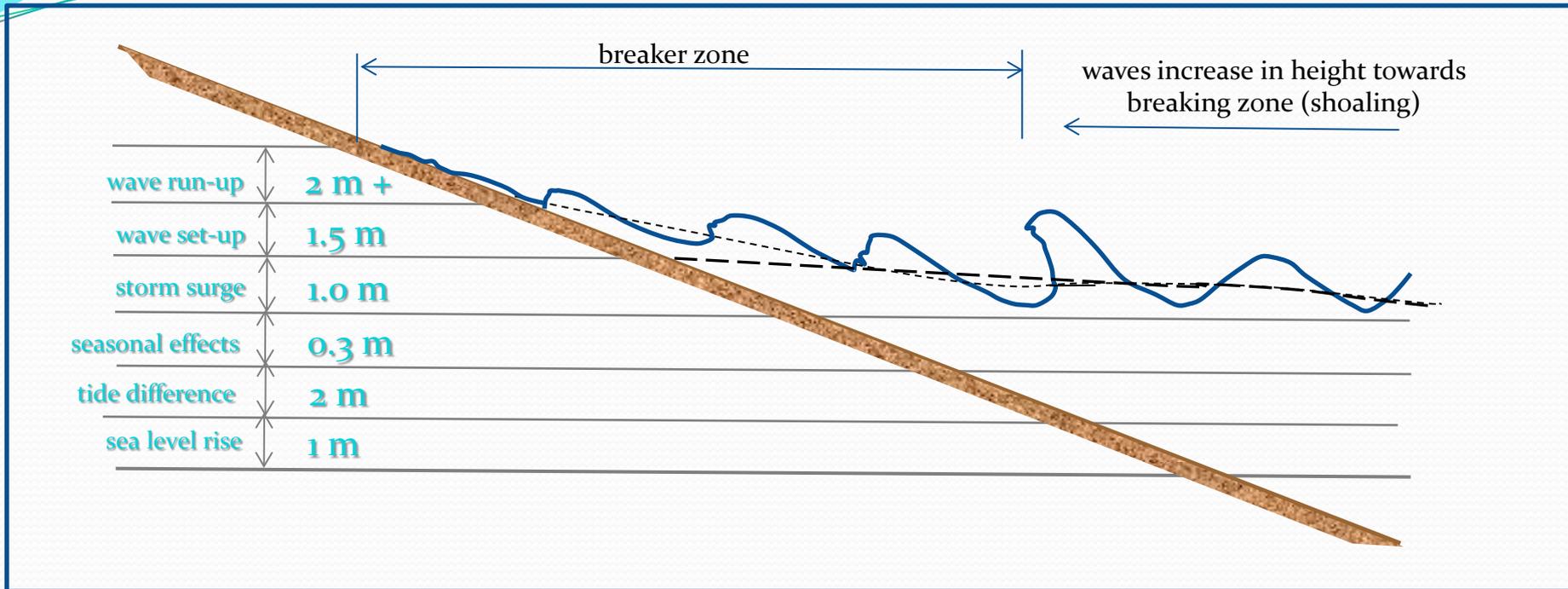
# December 3, 2014 - Mill Valley



# December 3, 2014 - Mill Valley



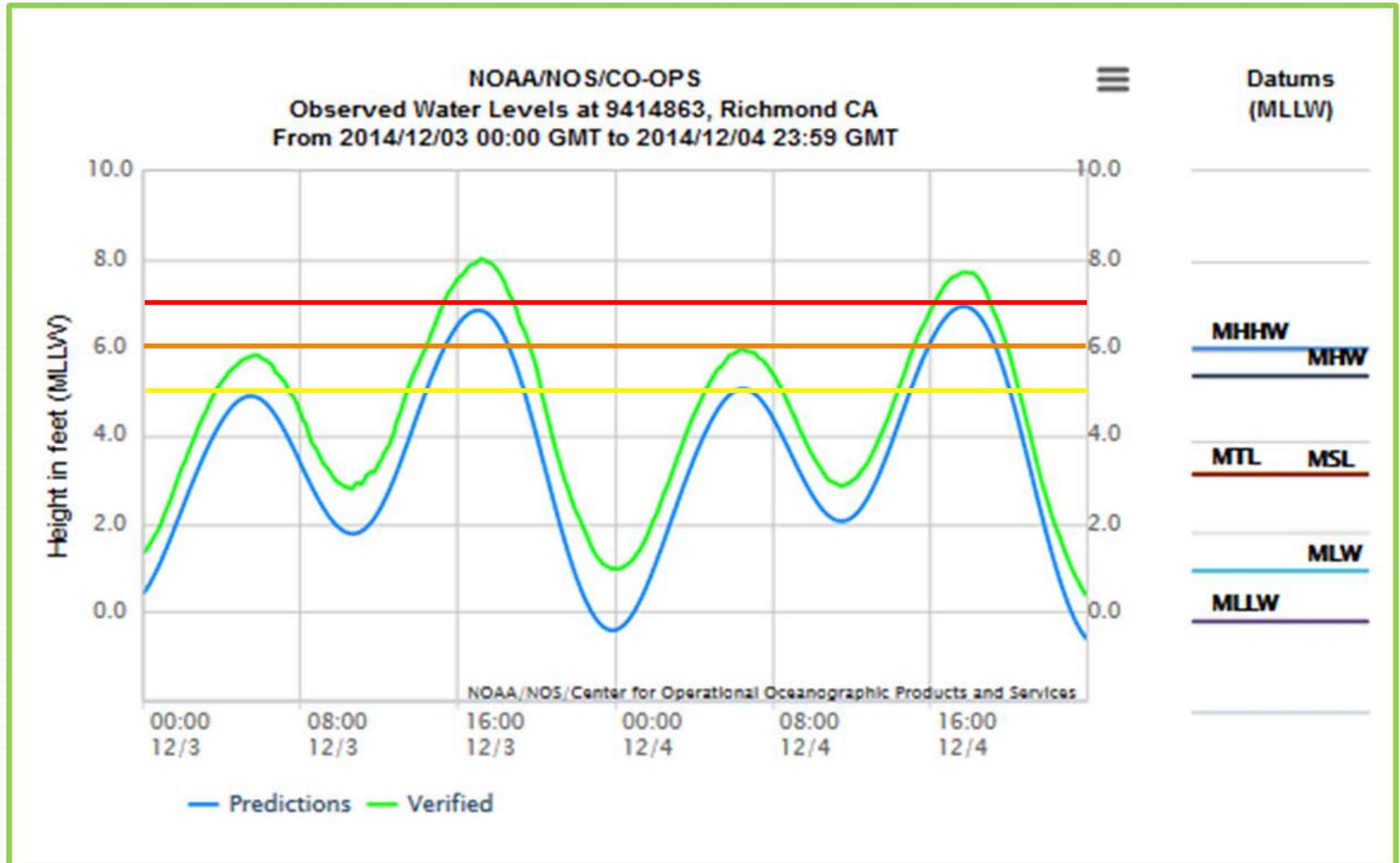
# Components of Coastal Water Levels



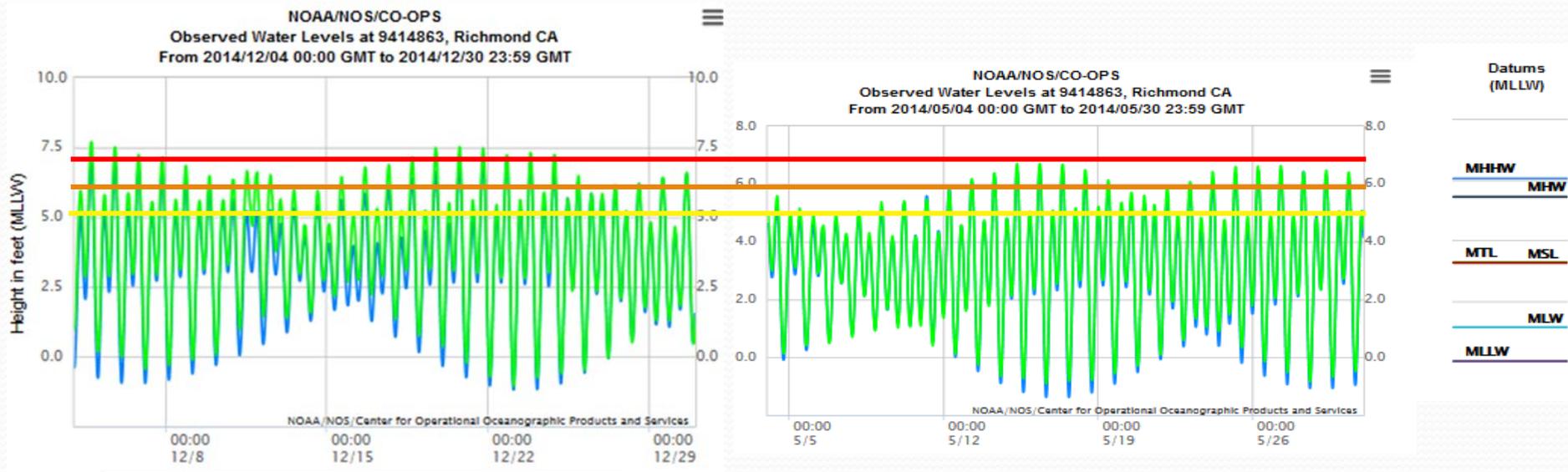
Stinson Beach  
50 cm SLR



# Periodicity of Inundation



# Annual Range

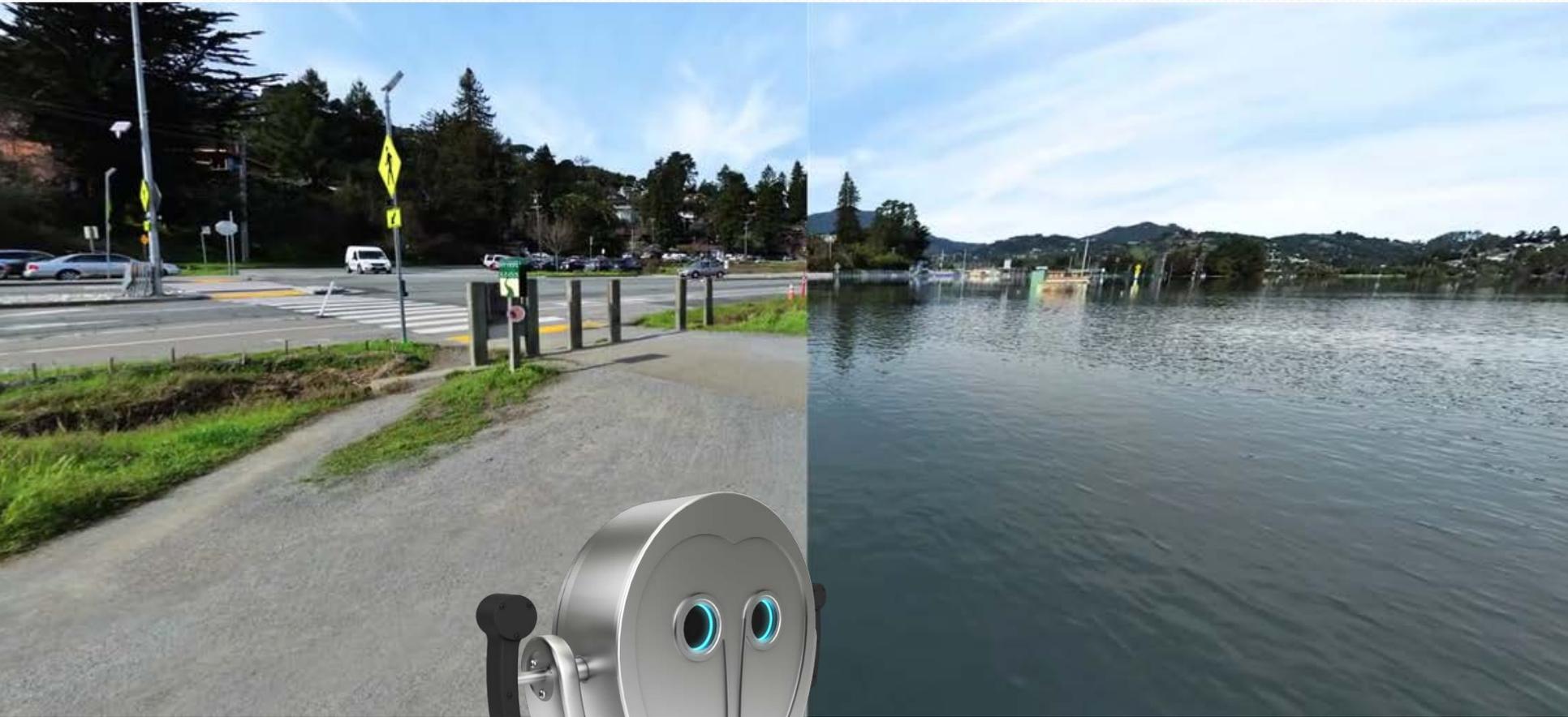


# Nov. 14, 2015 Adaptation Workshop



Community Development Agency  
Marin Coast Sea Level Rise Vulnerability Assessment  
Nov. 9, 2015 | [www.marinslr.org](http://www.marinslr.org)

# OWLize Show the Future. Bothin Marsh



# OWLize Shows the Options: Bothin Marsh

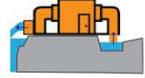




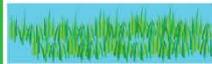
# Adaptation Measures

## 1. PROTECT

**Hard Engineering**

 Revetment/Seawall \$\$\$ EEE ●	 Tide Gate \$\$\$\$\$ EEE ●
 Traditional Levee \$\$\$\$ EEE ●	 Wall & Pump Station \$\$\$ EEE ○

**Soft Engineering**

 Horizontal Levee \$\$\$\$\$ E ●	 Artificial Reef \$\$ EE ●
 Wetland/shoreline vegetation \$\$\$\$ E ●	 Beach Maintenance \$\$\$ EE ○

## 2. ACCOMMODATE

**Accomodate Water**

 Elevate Buildings \$\$\$ EE ●	 Elevate/New Road \$\$\$\$\$ EEE ●
 Floodable Buildings \$\$\$\$\$ EEE ●	

## 3. RETREAT

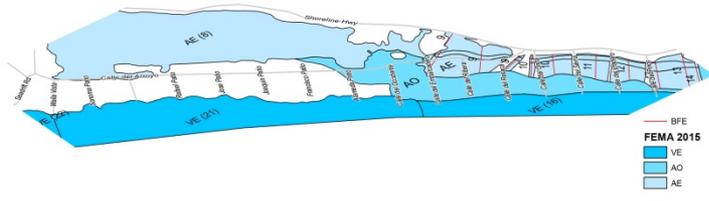
**Managed Retreat**

 Retreat \$\$\$\$ E ●	 Post-storm prohibitions \$ EE ●
 Move here \$\$\$ EEE ●	 Stricter land use zoning \$ EE ●

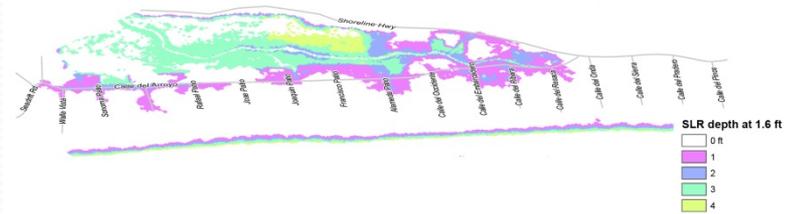
# Strategy Options

	Ref #	Approach	Potential Management Action	Example Location(s)	Impacts Addressed*	Key Partners	Required Resources	Other Assets
Near	44	Protect	Maintain existing seawalls and revetments throughout communities	Stinson Beach, Bolinas	I, TF, E, WS, HW	CDA, Local Assessment District	Staff time, financial resources, materials/supplies	All
	45	Protect	Implement floodwalls and gates in feasible locations 	Stinson Beach, other locations	TF, WS, HW	CDA, Homeowners	Financial resources, homeowner buy-in	All
	46	Monitor	Marin Littoral Cell / Regional Sediment Movements to inform beach nourishment efforts	West Marin				
Medium	47	Protect	Restore and enhance dunes	Stinson Beach, Dillon Beach, Lawson's Landing	TF, E, WS, HW	CDA, State/National Park System, Local Assessment District, Property Owners, Department of Fish and Wildlife, CCC	Staff time, financial resources, sand, plant material, permitting/environmental impact report	All
	48	Protect	Place sand on beaches	Muir Beach, Stinson Beach, Bolinas, Dillon Beach	TF, E, WS, HW	CDA, State/National Park System, Local Assessment District, Property Owners, Department of Fish and Wildlife, CCC	Staff time, financial resources, sand, permitting/environmental impact report	All
	49	Protect	Enhance living shorelines in sheltered bays	Bolinas Lagoon, Tomales Bay	I, TF, E, WS, HW	CDA, National Park Service, Local Assessment District, Coastal Conservancy, Department of Fish and Wildlife	Staff time, financial resources (e.g., grants), fill material, plant material, permitting/environmental impact report	All

# Potential Increase to Building Elevations



FEMA Base Flood Elevation



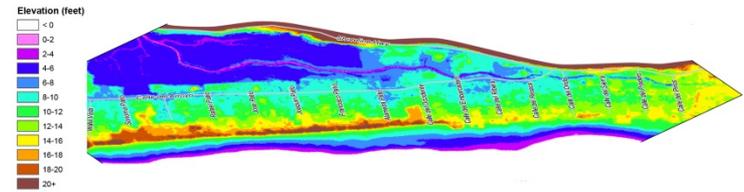
Sea Level Rise Depth -

+

-



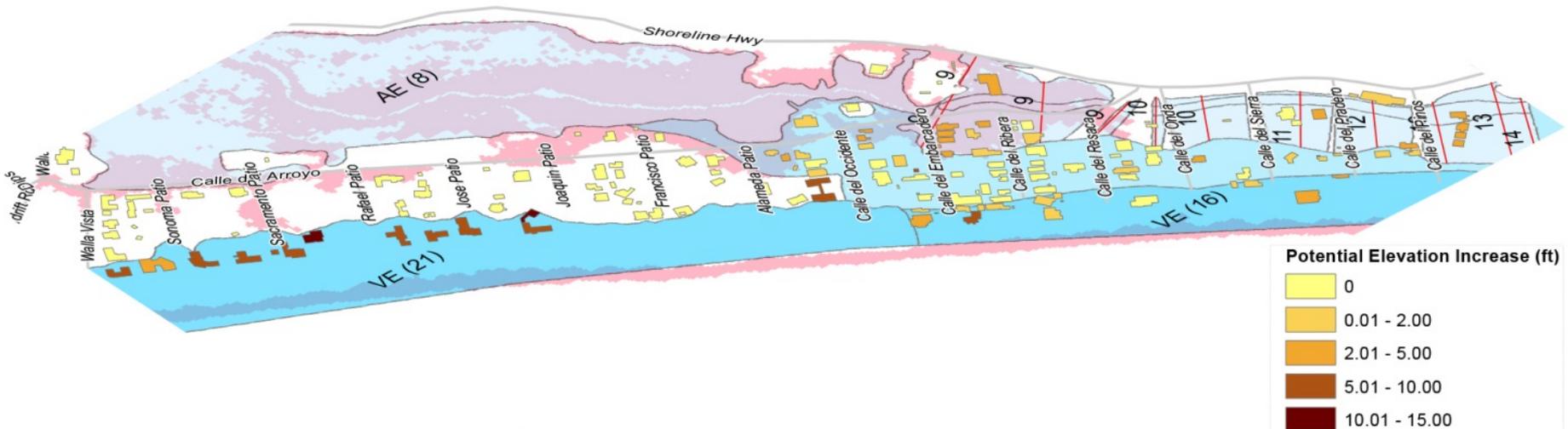
Finished Floor Elevations



Topography

or

=

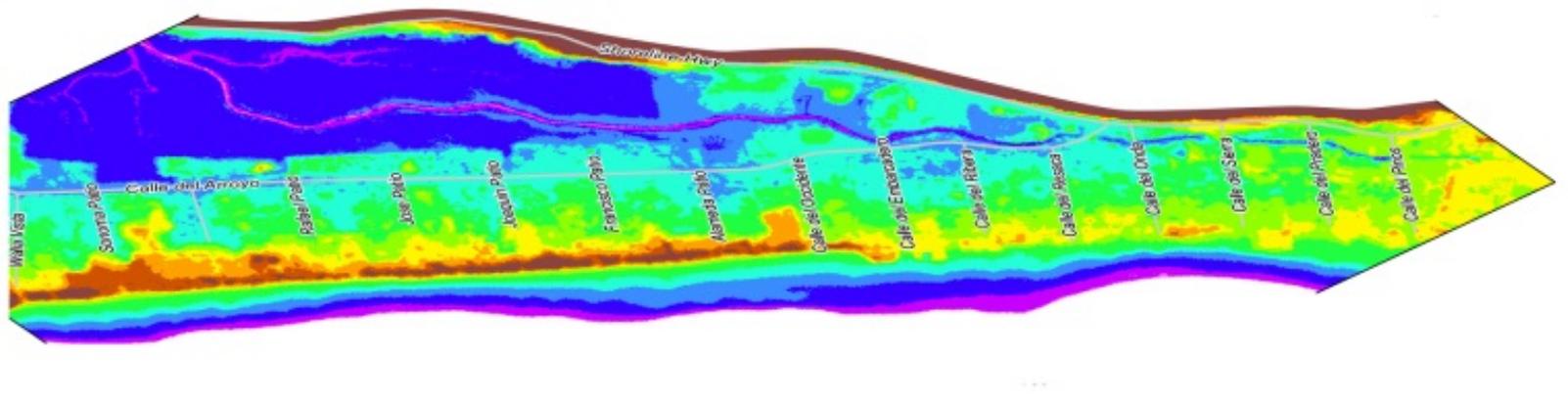
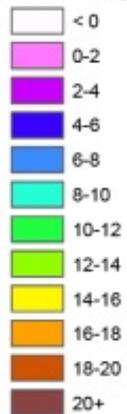


Potential Elevation Increase (ft)

# Digital Elevation Model

MARIN COUNTY 2013

## Elevation (feet)



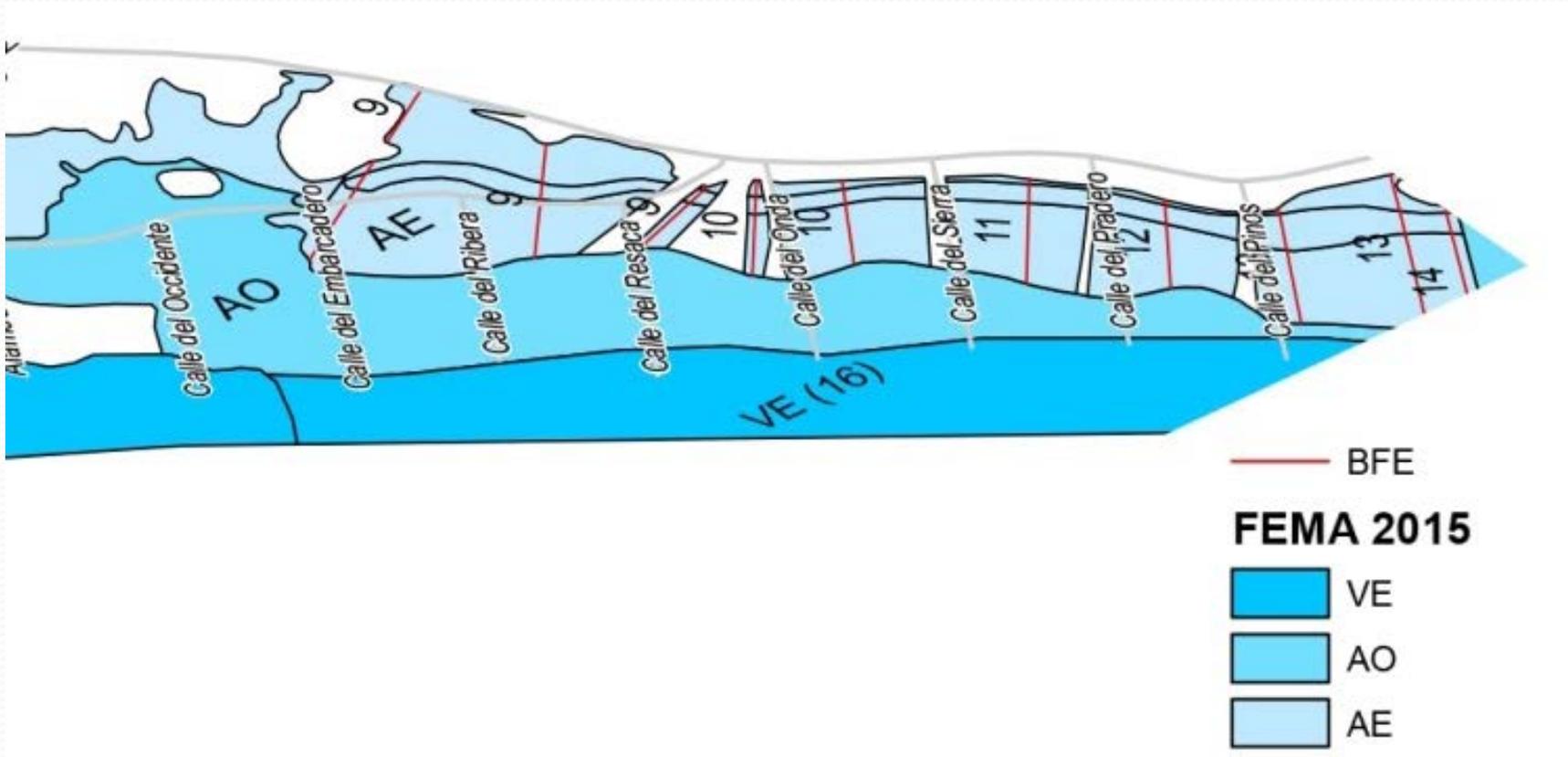
# Floor Elevation

MARIN COUNTY 2012



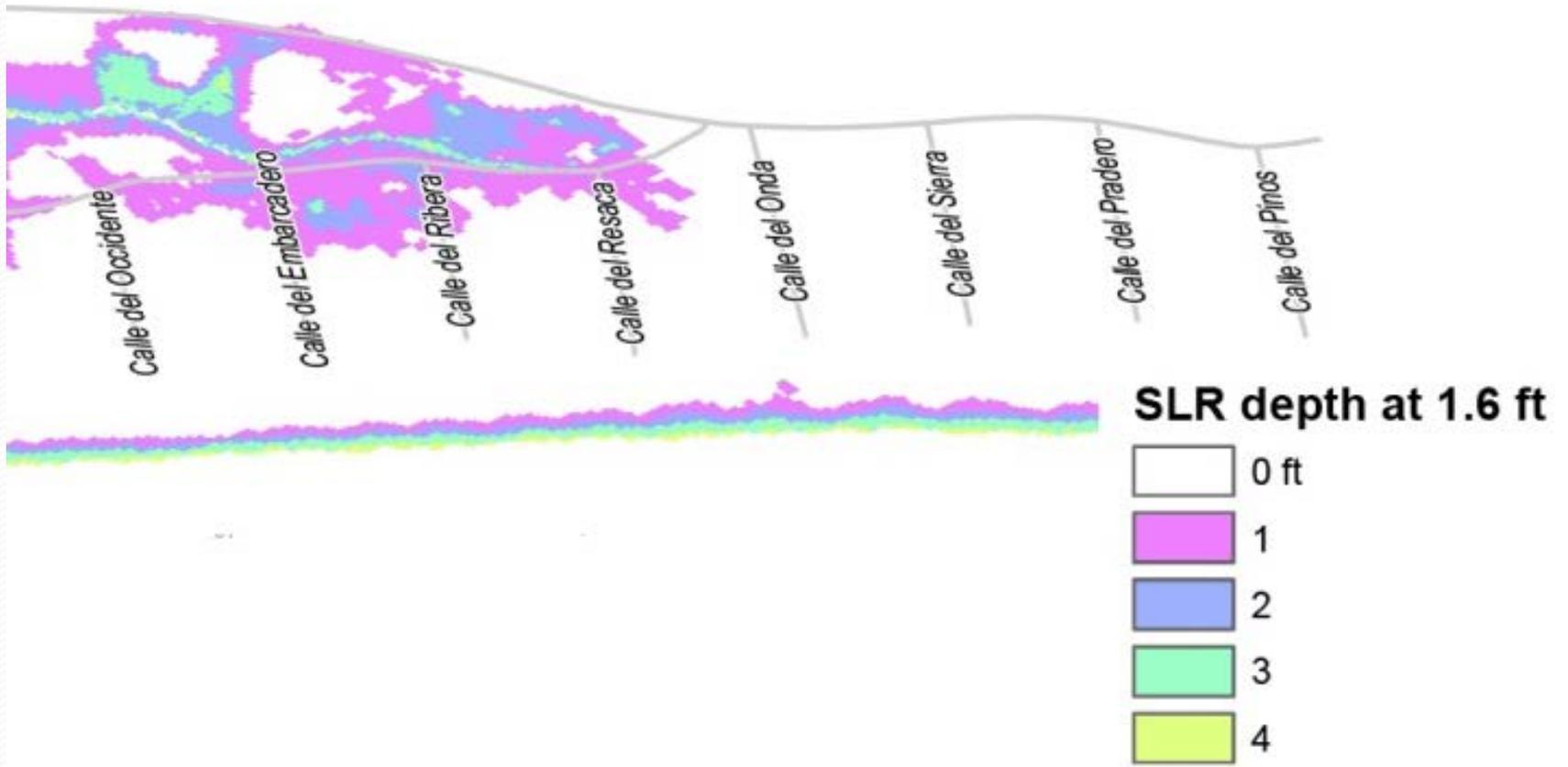
# Base Flood Elevations (BFE)

FEMA FIRM MAPS, 2015



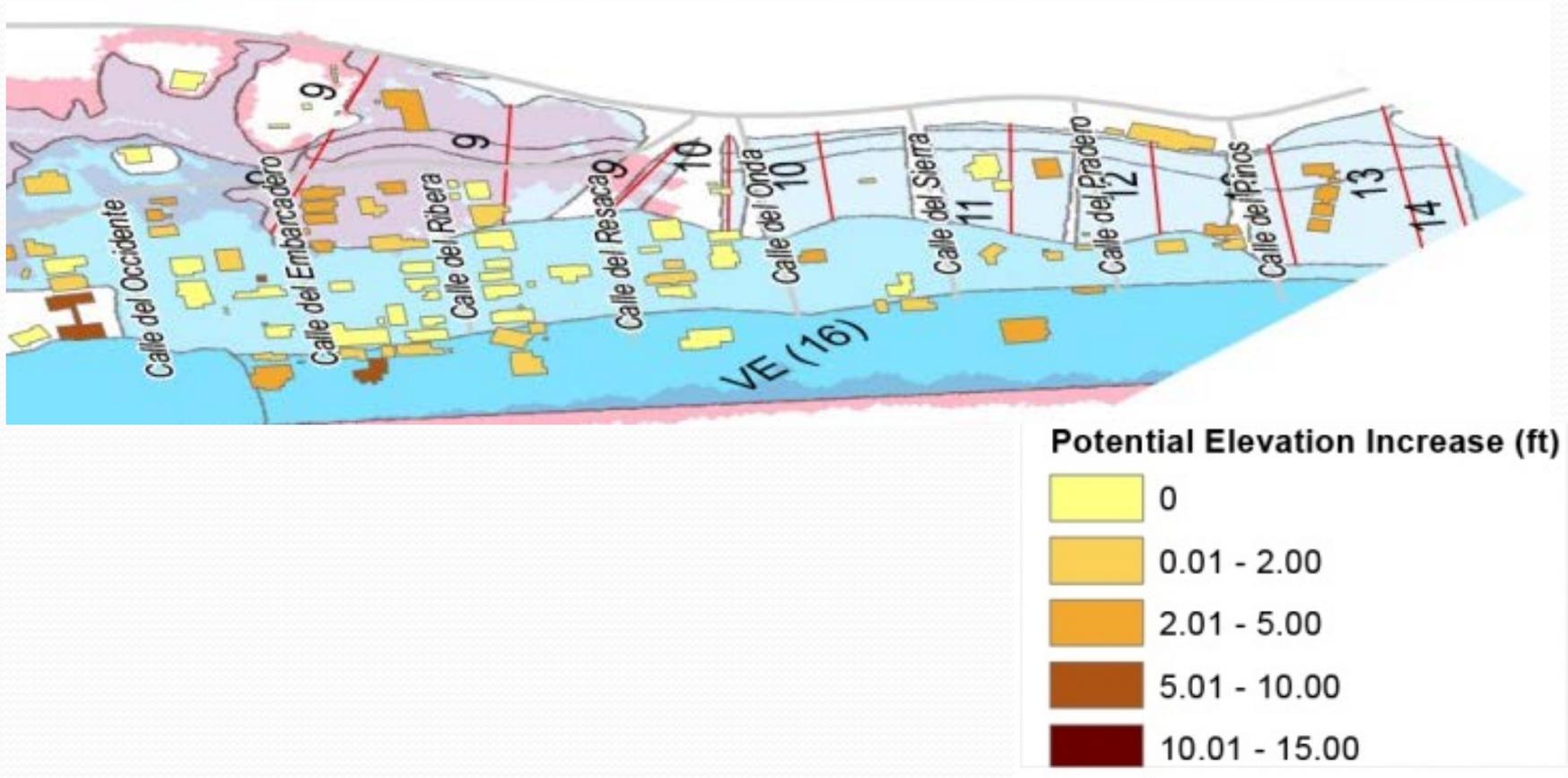
# Sea Level Rise depths

USGS COASTAL STORM MODELING SYSTEM

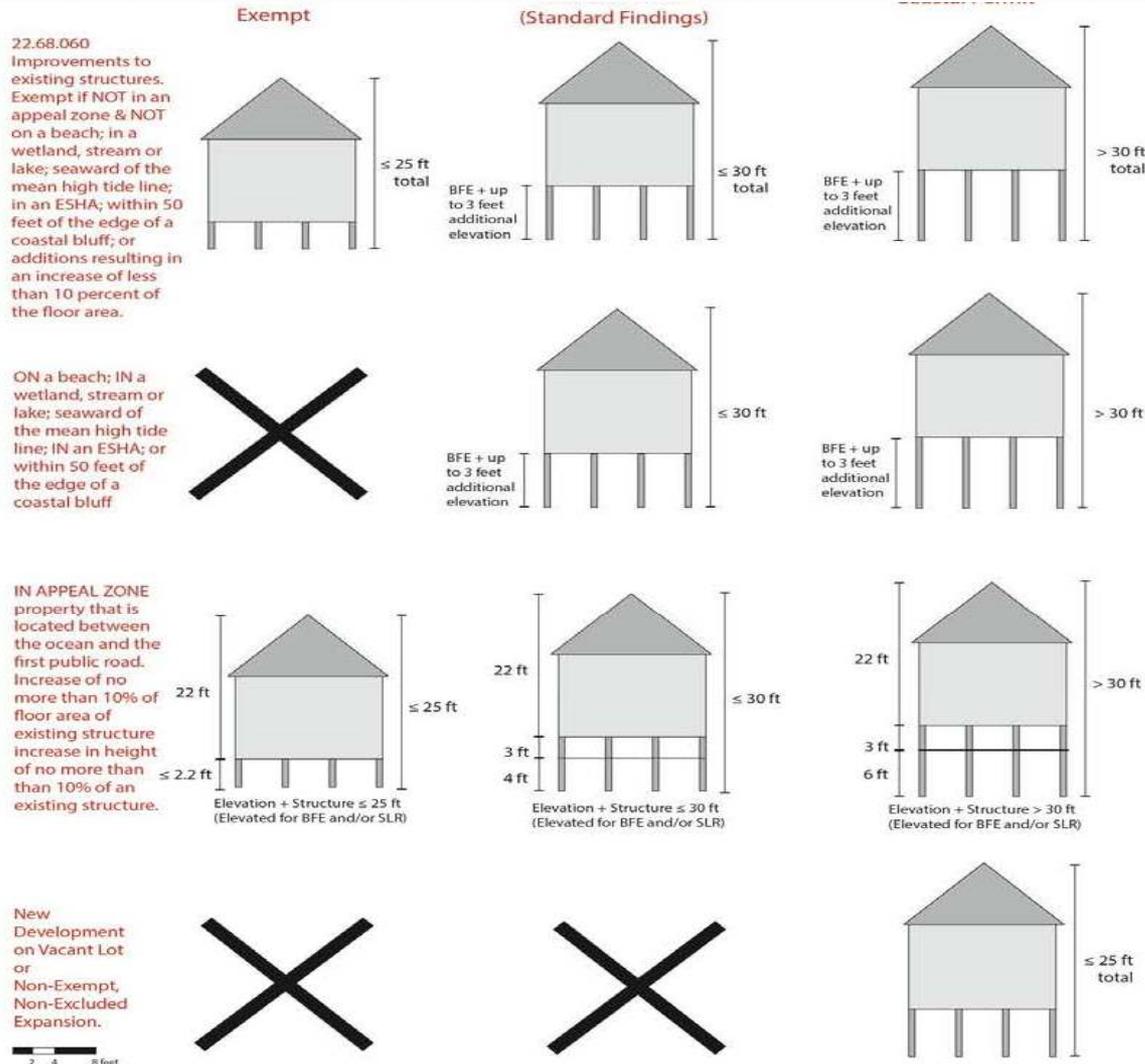


# Potential Elevation Increase

BFE + SLR - FFE/DEM



# Development Requirements: FEMA+LCP



C  
M  
N

# a·dapt·ive man·age·ment

*/ə' daptiv/ man-ij-muh nt (Noun)*

An iterative method of decision making in the face of uncertainty that reduces uncertainty by continuous monitoring; used especially in the management of ecosystems etc.



**Living with Water**  
*Rotterdam, The Netherlands*  
High-end modern housing in a stormwater pond

# Horizontal Levees & Tidal Marshes

**Pros:** Uses landscape to attenuate waves, provides habitat

**Cons:** Cost for earthwork, larger ROW

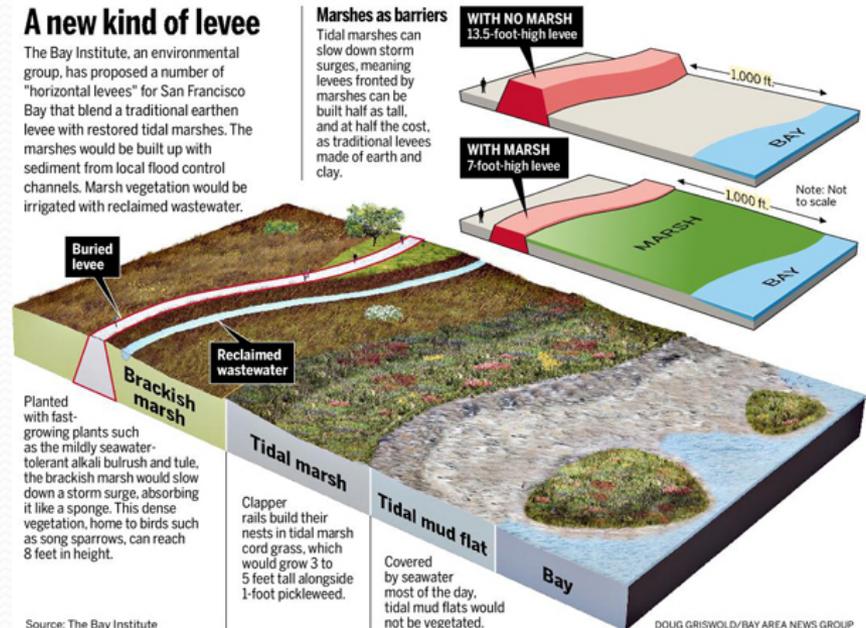


## A new kind of levee

The Bay Institute, an environmental group, has proposed a number of "horizontal levees" for San Francisco Bay that blend a traditional earthen levee with restored tidal marshes. The marshes would be built up with sediment from local flood control channels. Marsh vegetation would be irrigated with reclaimed wastewater.

## Marshes as barriers

Tidal marshes can slow down storm surges, meaning levees fronted by marshes can be built half as tall, and at half the cost, as traditional levees made of earth and clay.



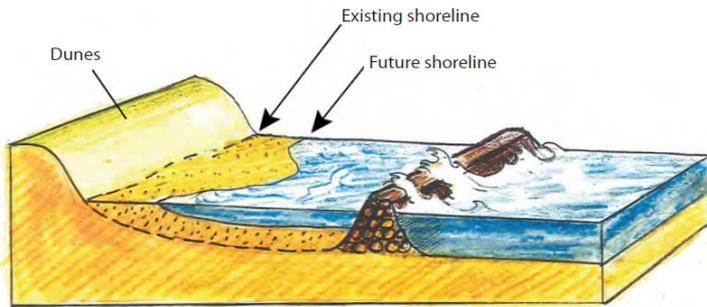
# Restore Native Dune Vegetation



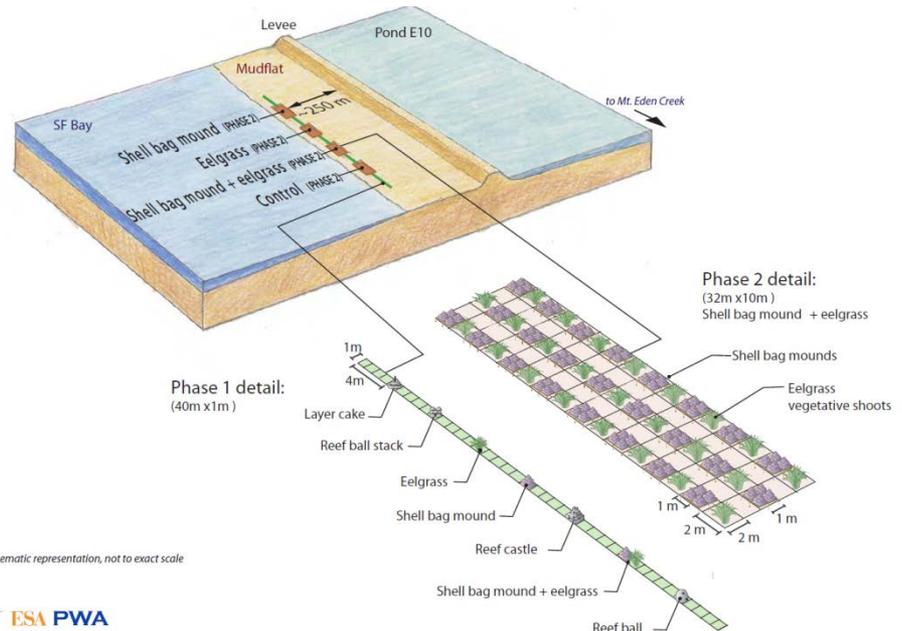
# Offshore Structures

**Pros:** Uses landscape to attenuate waves, provides habitat  
**Cons:** Cost for earthwork, larger ROW

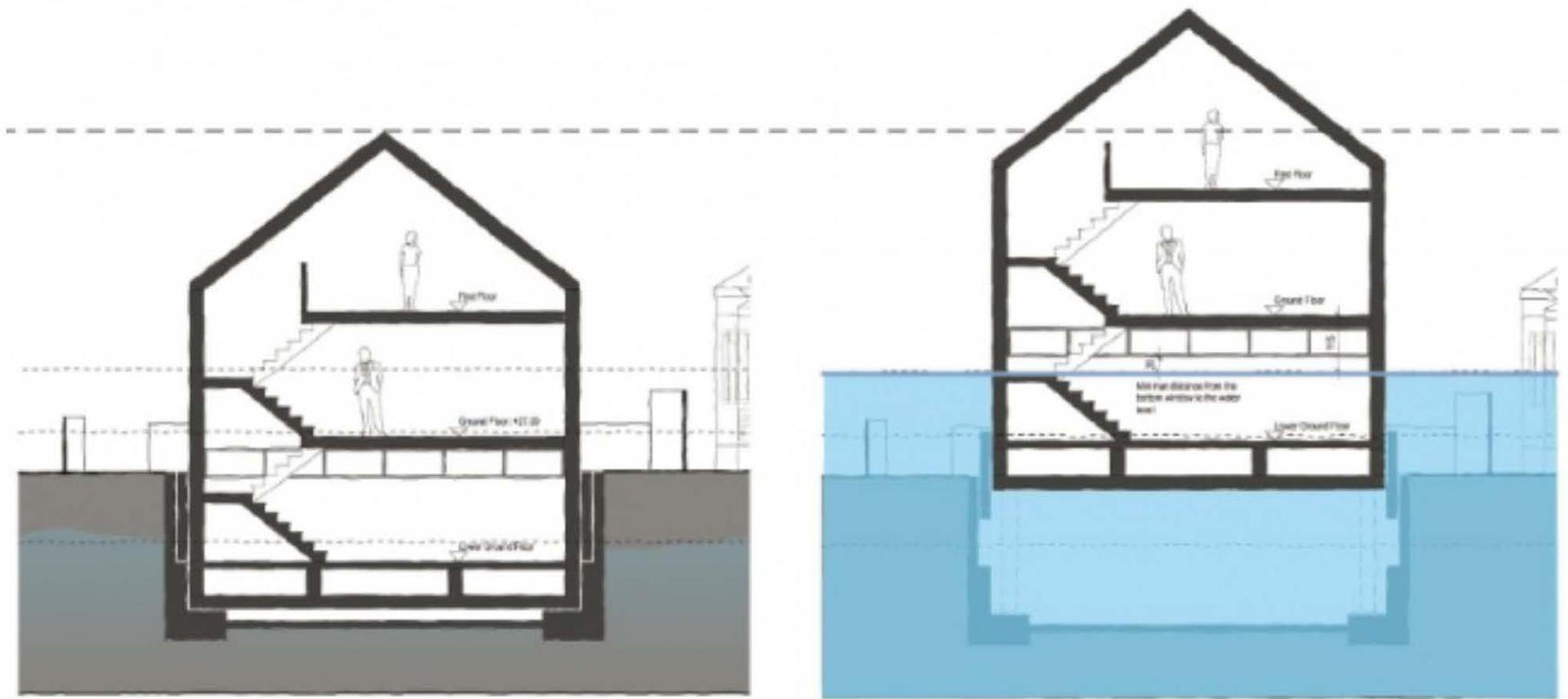
## Breakwaters



## Oyster Reefs



# Amphibious Architecture



Before a flood

During a flood

Sausalito



*SF Guardian*

## Floating Homes

Community Development Agency  
Black Point/Green Point Communities Plan  
March 8, 2016  
[marincounty.org/blackpoint](http://marincounty.org/blackpoint)



Thank You

QUESTIONS & ANSWERS

Caden at the Beach September 2013. Credit: Rendel

Community Development Agency  
3501 Civic Center Drive, Rm. 308  
San Rafael, CA 94903  
415 4736269 T  
[www.marinslr.org](http://www.marinslr.org)