



# Collaboration: Sea-level Marin Adaptation Response Team (C-SMART)



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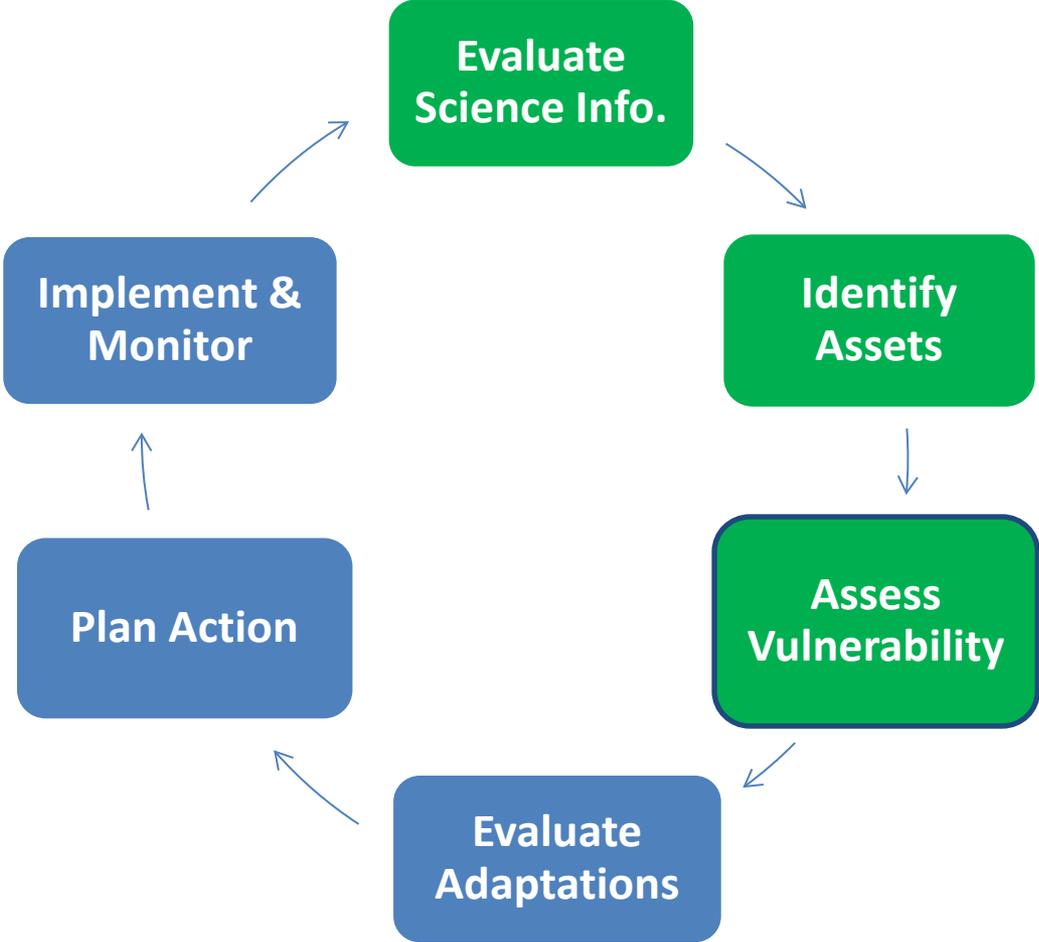
**Workshop #3 – Adaptation Strategies**  
**Point Reyes Station**  
**May 30, 2015**



# Overview

- Update on C-SMART
- Adaptation Options
- Game of Floods
- Individual Workbooks
- Next Steps

# Sea Level Rise Adaptation Process



Wharf Road, Bolinas 1982 El Nino flood.  
Photo courtesy of Bolinas Museum



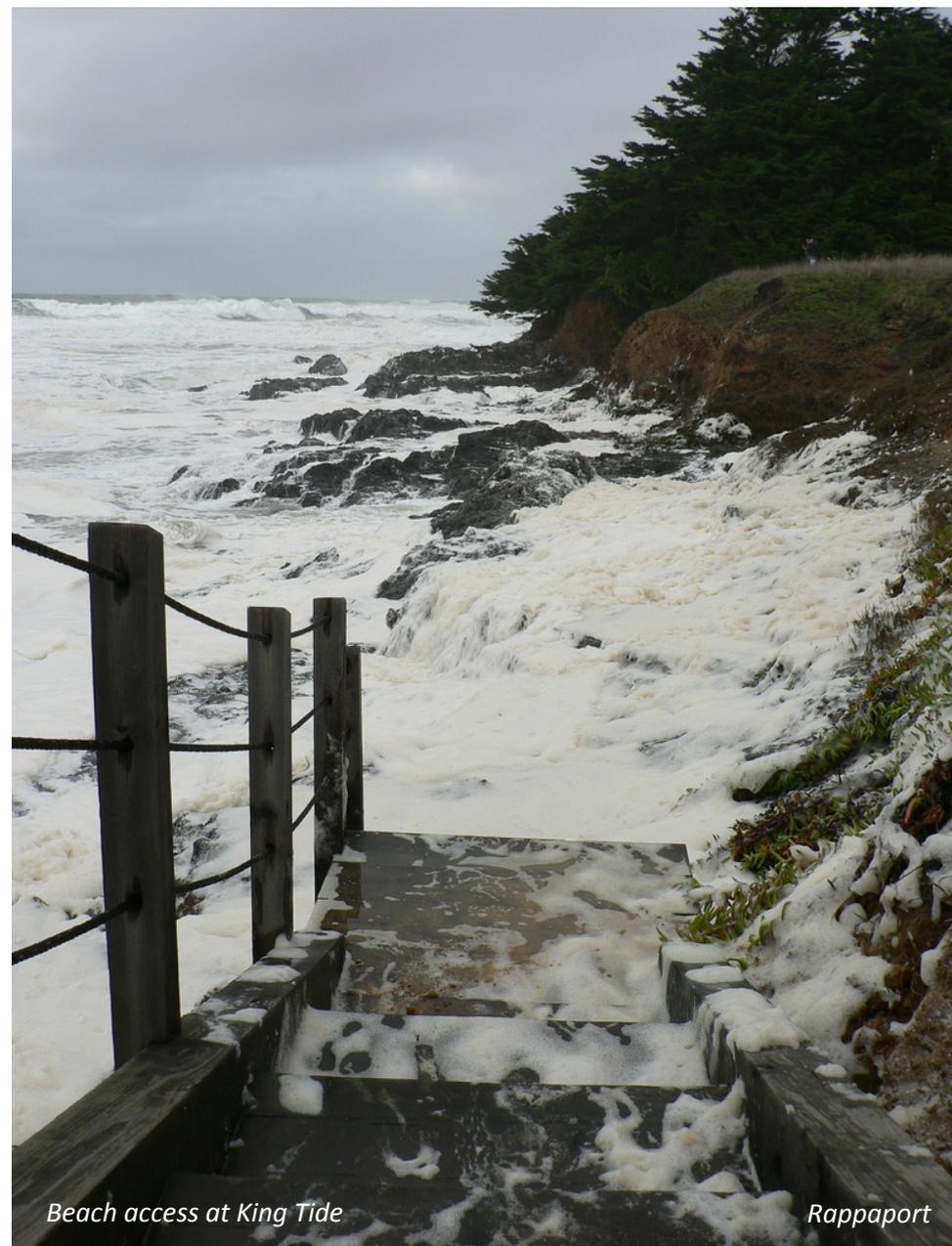


*Stinson Beach winter storm of 1997*



*Stinson Beach parking lot*

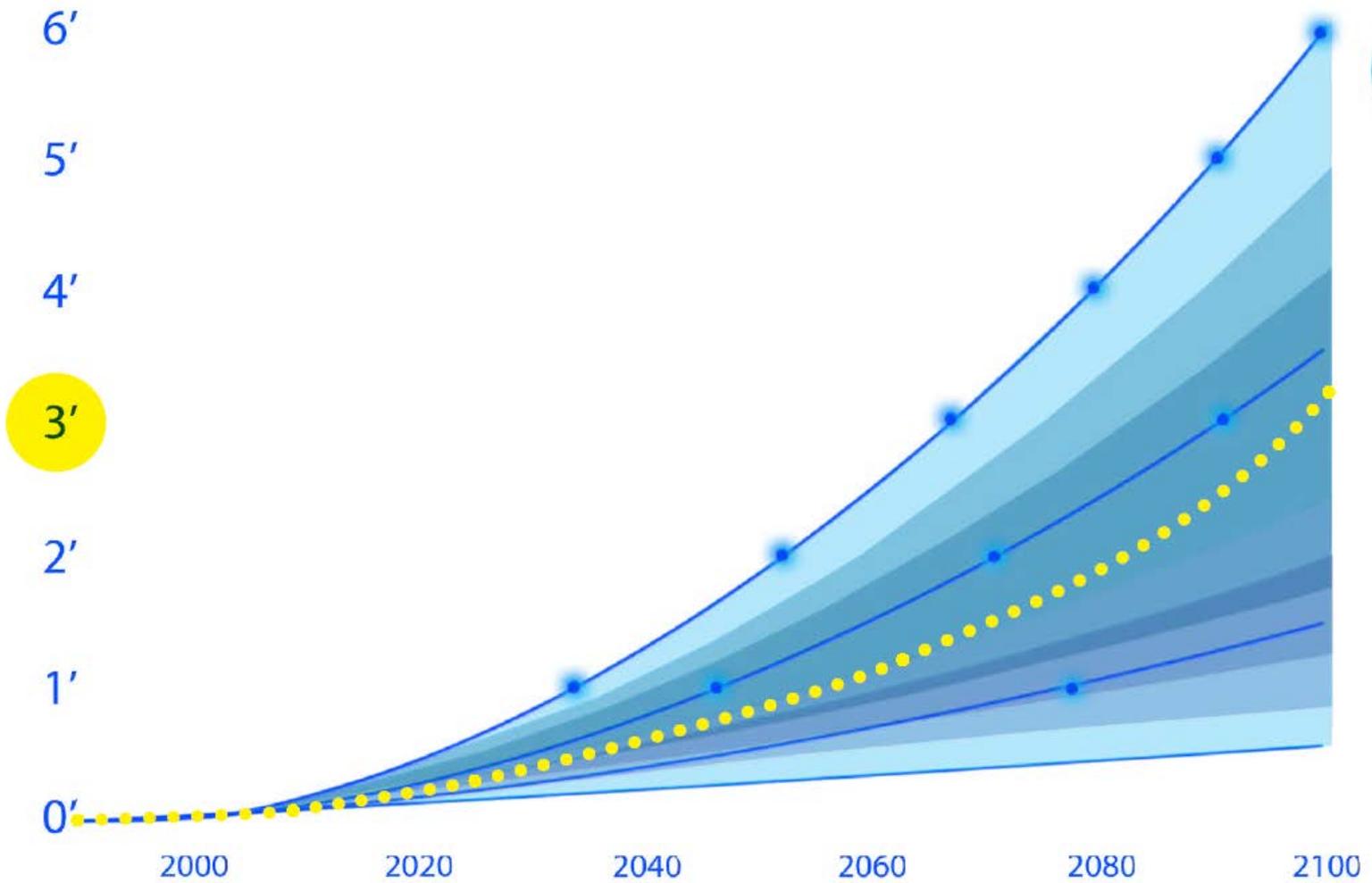
*Marin County DPW*



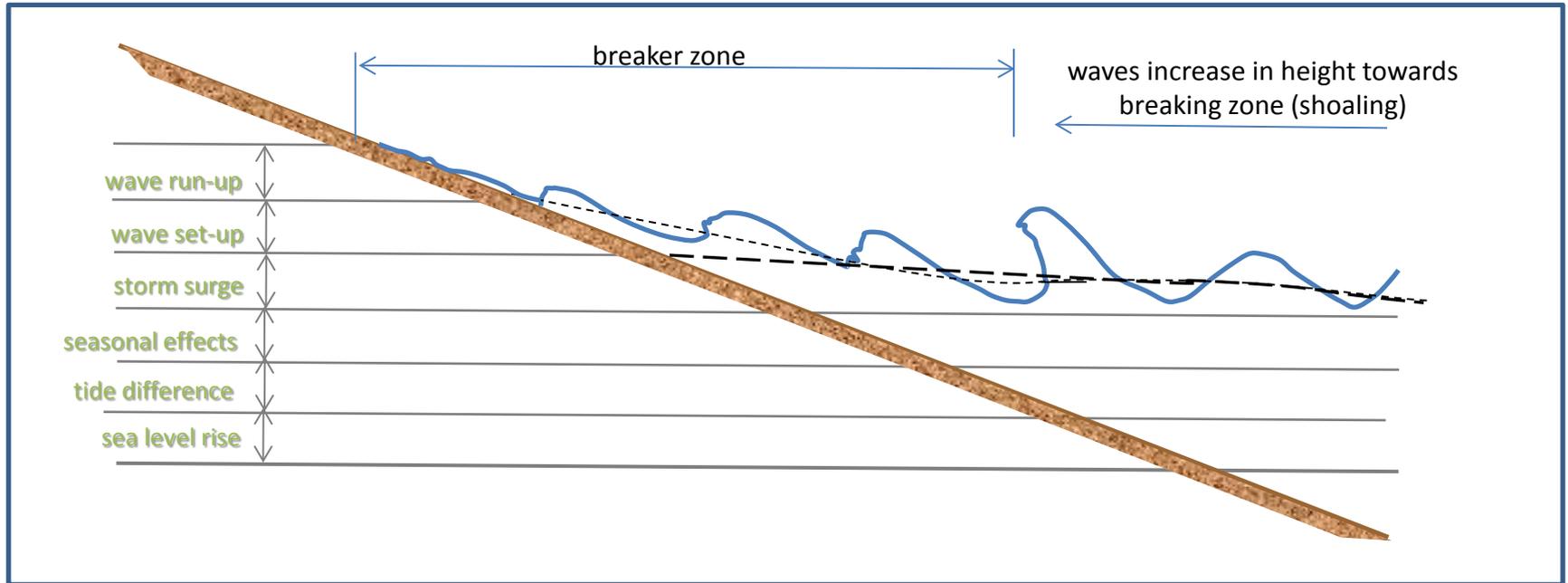
*Beach access at King Tide*

*Rappaport*

# Potential Future Sea Level Rise



# Components of Coastal Water Levels



Stinson Beach  
50 cm SLR



# Asset Mapping & Inventory

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



Hospital



Parking



School Site



Water



Grocery



Fire Station



Library



Restaurant



Roadway



Public Well



Post Office



Historic Church



Boat Launch



Beach



Home



Ranch



Mammal Habitat



Marina



Evacuation Route



Agriculture



Seabird Colony



Gas Station



Storm Shelter



Sheriff



Aquaculture



Sewage Lift Station



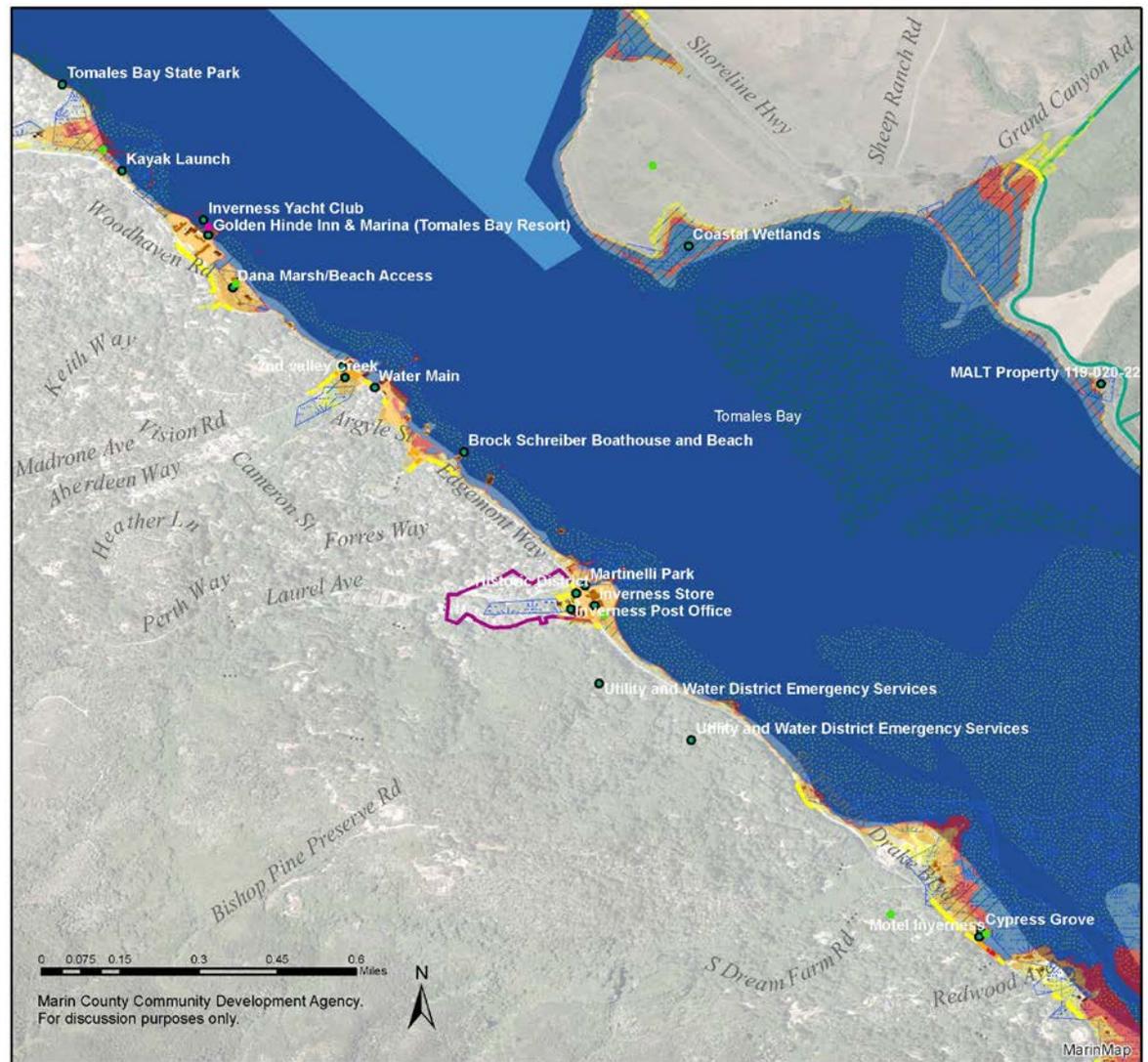
Electrical Sub-Station

- Hotels/Motels
- Trails

- Elderly/mobility limited facilities

- Harbors and marinas
- Archeological sites

# Inverness Exposed Assets



- Seabird Colonies
- Mammal Haul Out
- Surfgrass
- Eelgrass
- Coastal Marsh

- Parcels
- Buildings
- Agricultural Parcels
- Aquaculture
- Park Parcels
- Historic District
- Dike
- Bulk head
- Inlet/Outlet Pipes

- berm
- bluff wall
- jetty
- revetment (rock)
- seawall
- seawall (cement)
- seawall (soldier pile)
- seawall (timber)

- mid bluff wall
- revetment
- seawall
- upper bluff wall
- Access Points
- Ports
- Marinas
- Boat Launches

- Sea Level Rise Scenarios**
- 10" SLR + Annual Storm
  - 10" SLR + 20 year Storm
  - 20" SLR + 20 year Storm
  - 40" SLR + 20 year Storm
  - 80" SLR + 100 year Storm

- Exposed Roads**
- 10" + Annual storm
  - 10" + 20-year storm
  - 20" + 20-year storm
  - 20" + 100-year storm
  - 80" + 100-year storm

# Fall 2014 Public Workshops



Stinson Beach, October 2014

Marin County CDA



# Tam High SLR Adaptation Game



# Adaptation Measures

## 1. PROTECT

**Hard Engineering**

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

**Soft Engineering**

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

## 2. ACCOMMODATE

**Accommodate Water**

- Elevate Buildings: \$\$\$ | EE | ●
- Floodable Buildings: \$\$\$\$\$\$ | EEE | ●
- Elevate/New Road: \$\$\$\$\$\$ | EEE | ●

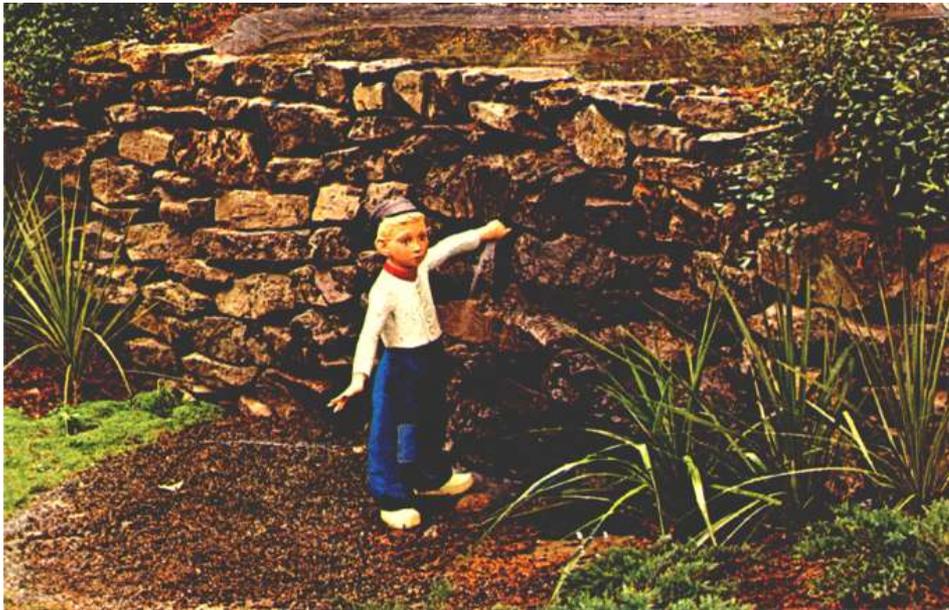
## 3. RETREAT

**Managed Retreat**

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

# Famous adaptors throughout history...

Dutch Boy built protection



Moses implemented phased managed retreat



Noah went for accommodation  
(floodable structures)

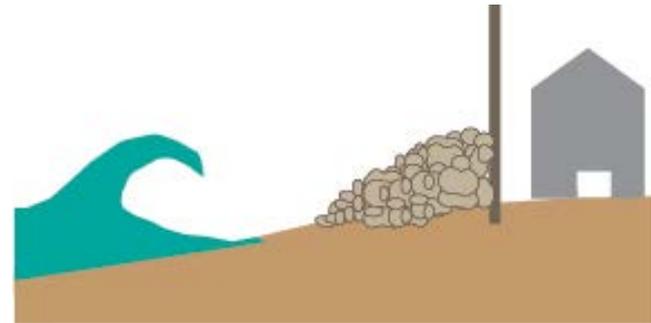


# 1. PROTECT

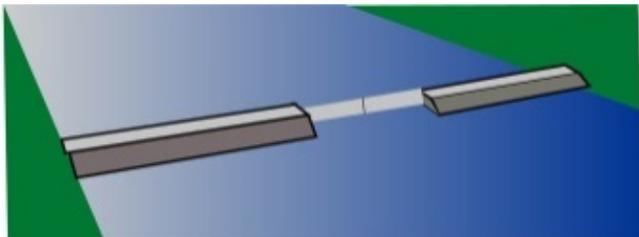
## Hard (Traditional) Engineering



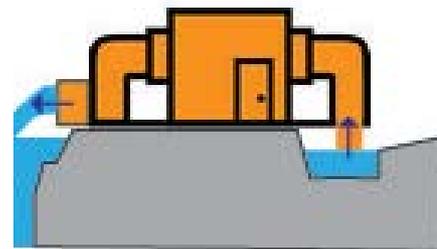
Traditional levee



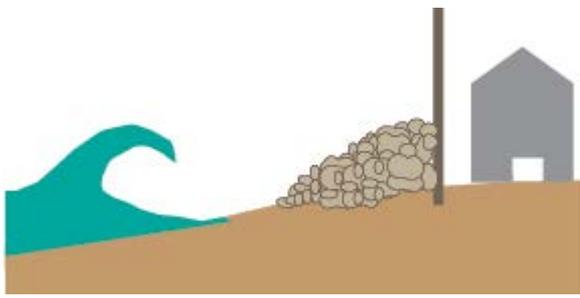
Seawall/Revetment



Tidal gate



Flood wall & Pump station



# Seawall

Pros: Limited ROW required  
Cons: Cost, Impacts



*Bulkhead seawall in Seadrift neighborhood*

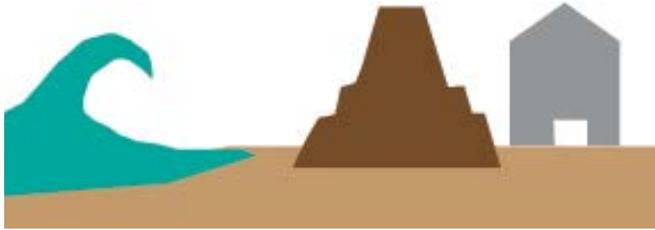
*Westhoff*



Failed “razor dike,”  
New Orleans (2005)



# Levee

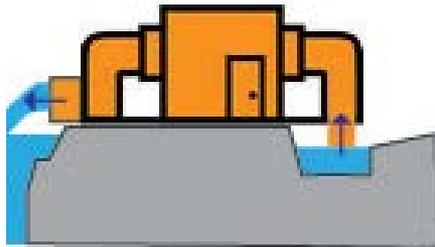


**Pros:** Stability if maintained,  
Cost lower than wall

**Cons:** Large ROW required

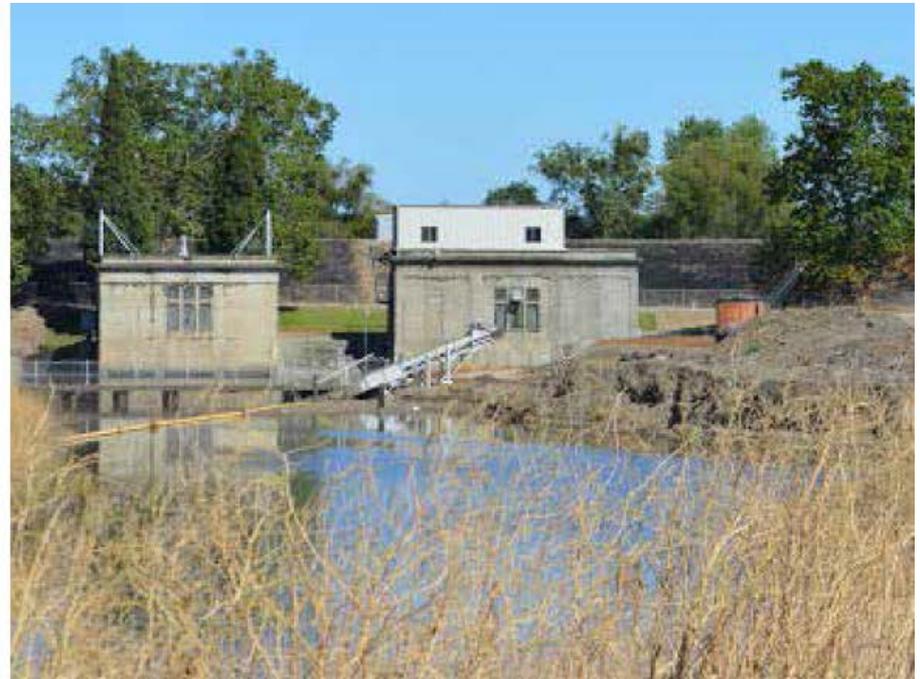


# Flood wall & Pump station

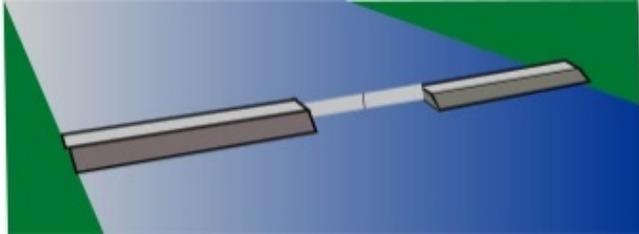


**Pros:** Lower ROW than levees

**Cons:** Capital and maintenance costs

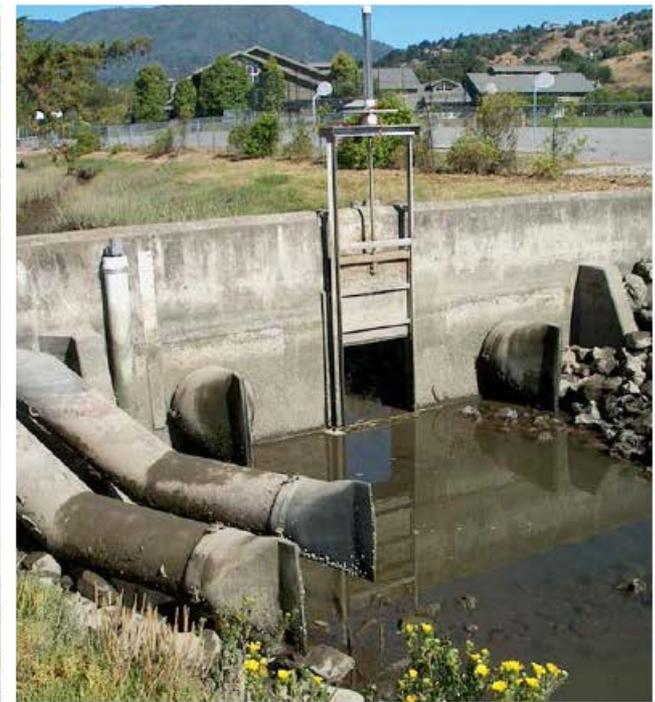


# Tidal gate



**Pros:** Temp solution to tidal riverine flooding

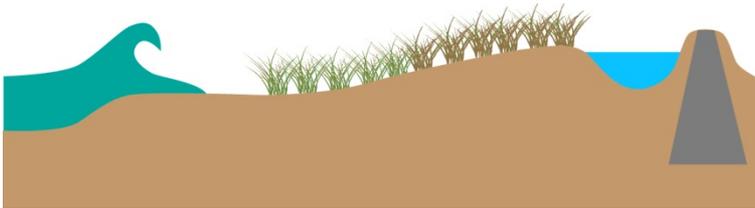
**Cons:** Cost, limited effectiveness over time





# 1. PROTECT

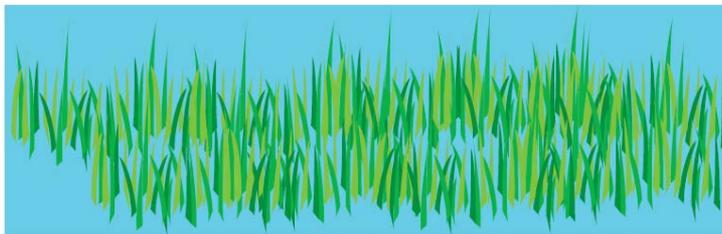
## Soft (Nature-based) Engineering



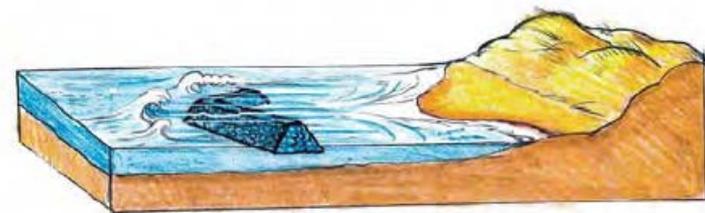
Horizontal levee



Dune restoration & Beach maintenance

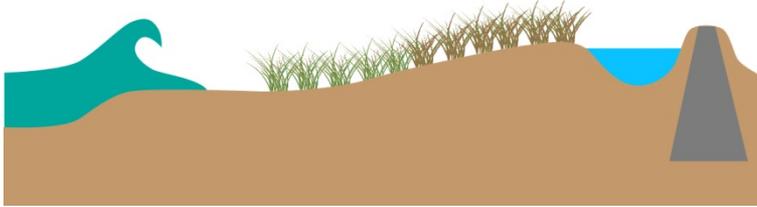


Wetland/ shoreline vegetation



Offshore structure

# Horizontal levee

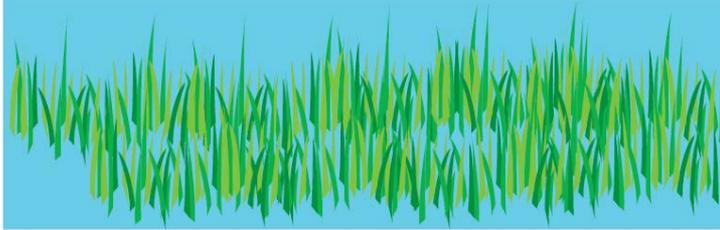


**Pros:** Uses landscape to attenuate waves, provides habitat

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



# Wetland/ shoreline vegetation



**Pros:** Habitat improvement and flood reduction

**Cons:** Large ROW required



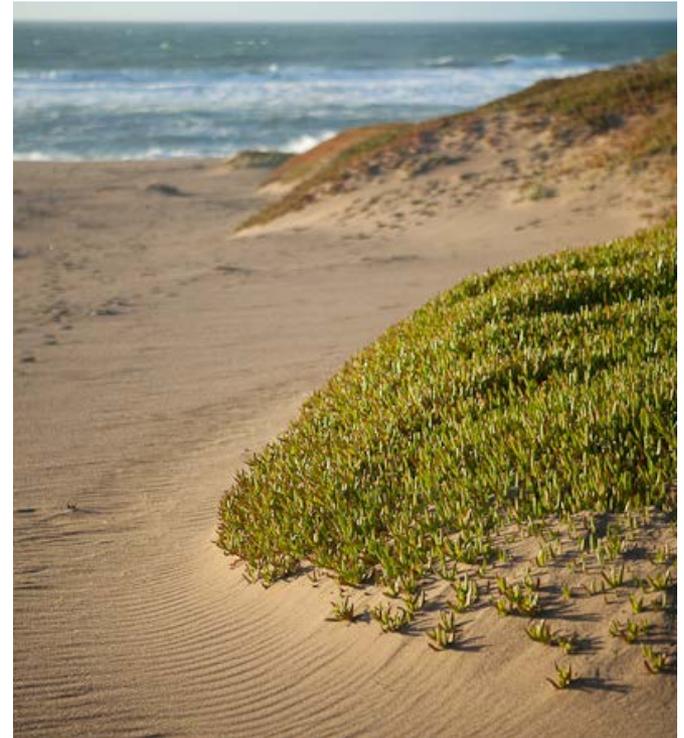
Giacomini Wetland Restoration, 2008

# Dune Restoration & Beach Maintenance



**Pros:** Recreation and flood reduction benefits

**Cons:** Costs for replenishment





Building the “Zandmotor” using a side-caster, in addition to slurry pipes : 2011



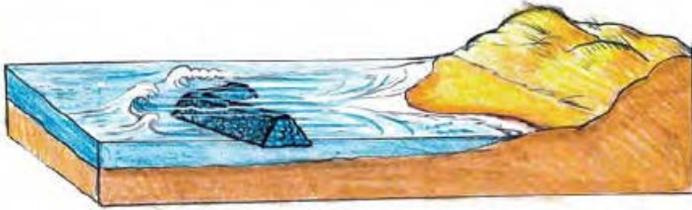
## Rotterdam, The Netherlands

The “sand engine,” hard at work widening beaches/dunes to the north and south.

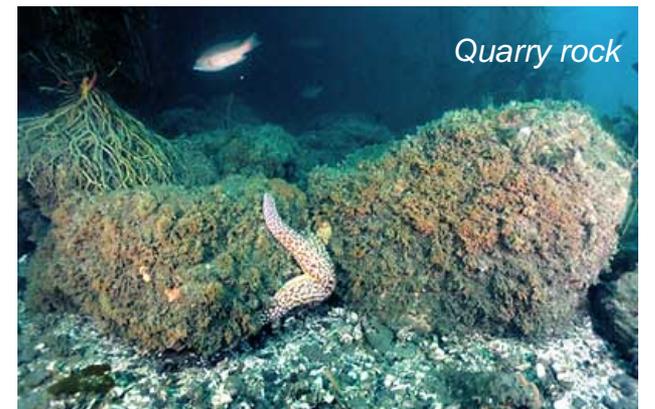
# Offshore structures

**Pros:** Reduces waves impacts – more when structure is higher

**Cons:** Costs to construct, maintain and limited effectiveness for SLR



*San Clemente artificial reef experiment*



## 2. ACCOMMODATE



New floodable  
development



Elevate buildings



New/elevate road



# Elevate buildings

**Pros:** Effective for storm flooding

**Cons:** Costs, not effective for permanent tidal flooding

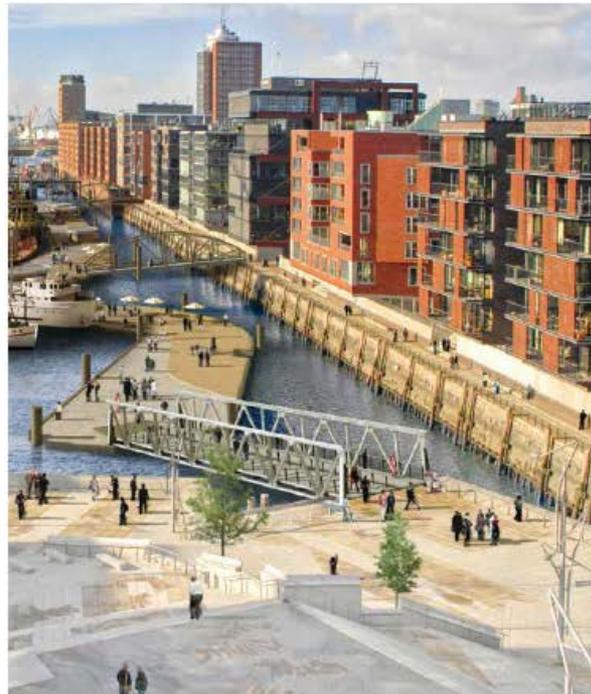




# Floodable development

**Pros:** Potential solution that generates revenue

**Cons:** Impacts from more development – higher density to pay for costs



# New/elevate road

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**Pros:** Protects roads when designed correctly

**Cons:** Very high cost, ROW



# New/elevate road

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**Pros:** Protects roads when designed correctly

**Cons:** Very high cost, ROW





# 3. RETREAT



Retreat



Rebuild here



Post-storm prohibitions



Stricter land use zoning

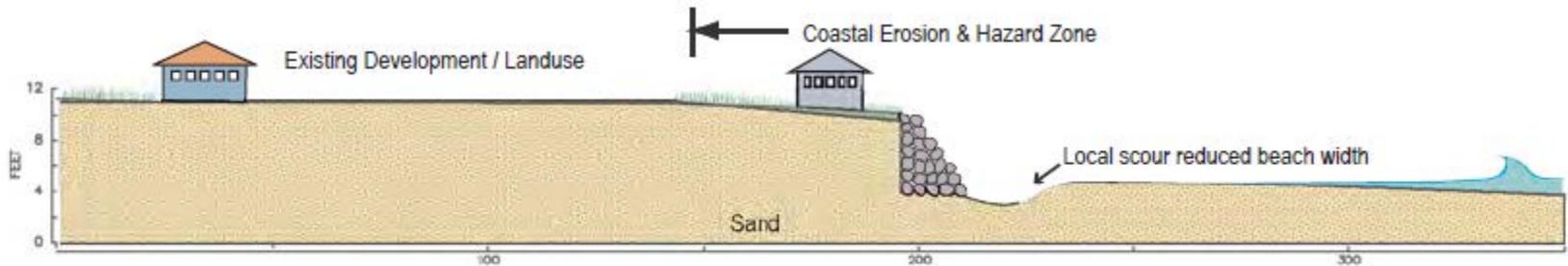


# Managed Retreat

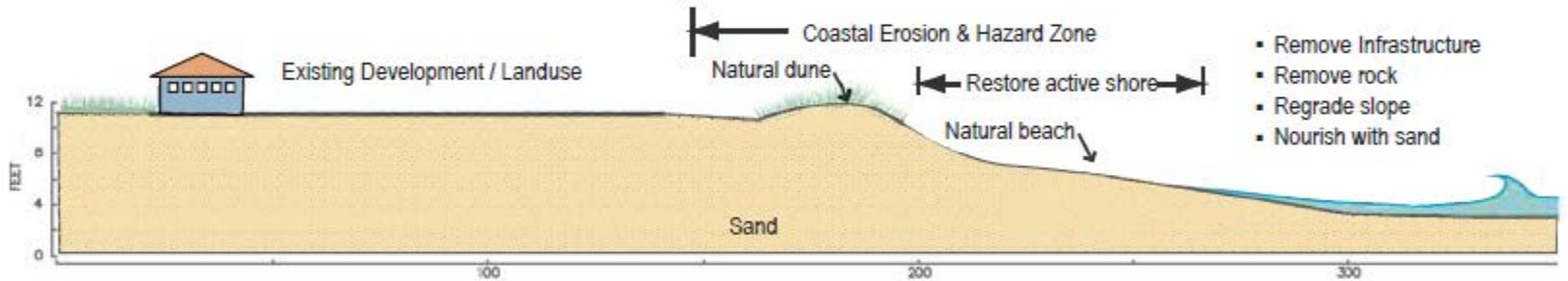
Pros: Lower costs if no buyout

Cons: Costs for buy-out and community impacts, new infrastructure

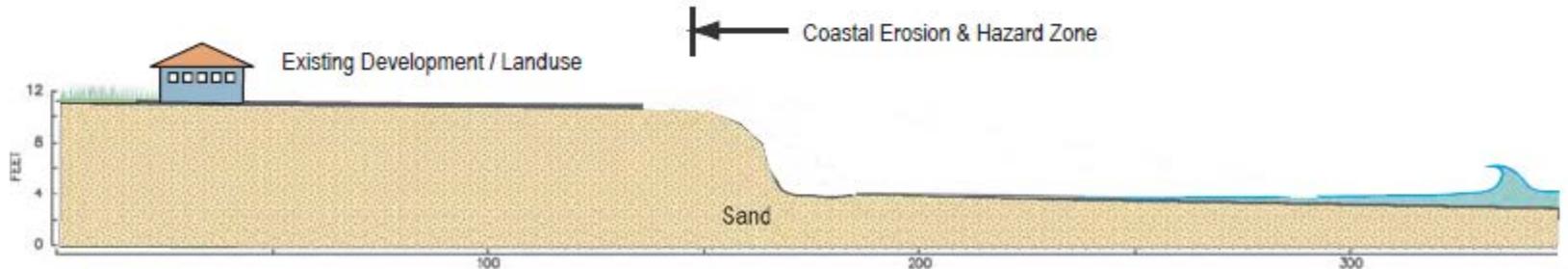
Current



Post



Eroded



# Post Storm Restrictions and Stricter Land Use Zoning



- No or restricted rebuilding after storms?
- Rolling easements
- Extra technical studies
- Use of stricter codes (FEMA V)



# Costs \$\$\$

*Real World* – costs are messy and depend on many factors

+ planning & engineering

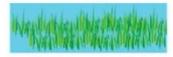
+ permitting

+ maintenance & repair

*Game World* – costs are simpler one-time costs and given to you per unit (i.e. mile or # of buildings)

## Game of Floods of Martin Island

Adaptation Game Piece Reference Sheet

Name	Piece	Units	Cost (\$)	Env. Impact EEE or EE or E	Flood Protection Short, med, or long-term	Uses and Notes
<b>Hard (Traditional) Engineering</b>						
Traditional Levee		Mile	\$\$\$\$	EEE	med	Protects against temporary flooding, storm surge and some sea level rise. <ul style="list-style-type: none"> <li>• Can increase wave run-up and overtopping.</li> <li>• In high wave energy environment on coast, need to armor levee slope.</li> </ul>
Seawall/Revetment		Mile	\$\$\$	EEE	med	Protects against erosion. <ul style="list-style-type: none"> <li>• Can increase wave run-up and overtopping.</li> <li>• Increase erosion in adjacent areas.</li> </ul>
Tidal Gate		Feet	\$\$\$\$\$	EEE	med	Protects against temporary flooding, storm surge and some sea level rise. <ul style="list-style-type: none"> <li>• High environmental impacts to hydrology.</li> <li>• Viable in sheltered estuaries and lagoons.</li> </ul>
Flood wall & pump station		Mile	\$\$\$	EEE	short	Protects against temporary flooding, storm surge and some sea level rise. <ul style="list-style-type: none"> <li>• Can increase wave run-up and overtopping.</li> <li>• Require electricity and maintenance.</li> </ul>
<b>Soft Engineering</b>						
"Horizontal" Levee		Mile	\$\$\$\$	E	med/long	Protects against temporary flooding, storm surge, some sea level rise, and wave impacts. <ul style="list-style-type: none"> <li>• Viable in sheltered estuaries and lagoons.</li> </ul>
Wetland/shoreline vegetation		Acre	\$\$\$	E	short-med	Protects against temporary flooding, storm surge, and wave impacts. <ul style="list-style-type: none"> <li>• Viable in sheltered estuaries and lagoons.</li> </ul>
Dune Restoration and Beach Maintenance (nourishment & groins)		Mile	\$\$\$	EE	short/med	Protects against temporary flooding and storm surge. <ul style="list-style-type: none"> <li>• Even nourished beaches can erode and expose infrastructure to wave damage.</li> </ul>

# THE GAME OF FLOODS

## Marin Island

START

Sea levels are rising worldwide as warming oceans expand and melt glaciers and ice sheets. Stronger storms coupled with rising seas can significantly damage—even destroy—property, infrastructure, public facilities, natural habitats, and other resources we depend on. We need to take action now to reduce our vulnerability to sea level rise. Adaptation Plan shows the strategies game pieces.

1. People and property needs the sea level rise scenario about.
2. Roles, also to the sea level rise. The highest of sea level rise, if it occurs, the tide players must re-roll. Players take turns in clockwise order.

3. In turn, each player selects an asset to accommodate, defend, or retreat from. No need to duplicate assets. Use the worksheet provided to record your choice, costs, and pros and cons.
4. Next, in turn, each player places and stakes about their preferred adaptation strategies or around the island. Conflicting strategies are allowed.
5. Consider the following factors to inform the proposal: (1) cost/benefit, (2) Private property impacts, (3) Environmental impacts, (4) Equity/Social Justice concerns, (5) Others. Use your worksheet to take notes.

Sea Level Rise 2050 Scenario Key

**RED AREA** = Permanent Sea Level Rise Flooding  
**ORANGE AREA** = Temporary Sea Level Rise Flooding  
**YELLOW AREA** = Temporary 100 Year Storm Flooding



- Evacuation Route
- Marina
- Mammal Habitat
- Ranch
- Grocery
- School Site
- Parking
- Hospital
- Gas Station
- Storm Shelter
- Public Well
- Library
- Fire Station
- Electrical Sub Station
- Sewage Lift Station
- Storm Shelter
- Home
- Historic Church
- Post Office
- Acquaculture
- Sheep
- Home
- Beach
- Boat Launch
- Beach Maintenance
- Offshore Structure
- Wetland/shoreline vegetation

### LEGEND

### GAME PIECES

<p><b>Managed Retreat</b></p> <ul style="list-style-type: none"> <li>Retreat SSS   [Icon]</li> <li>Move here SSS   [Icon]</li> <li>Post-storm prohibitions [Icon]</li> <li>Stricter land use zoning [Icon]</li> </ul>	<p><b>Accommodate Water</b></p> <ul style="list-style-type: none"> <li>Elevate Buildings SSS   [Icon]</li> <li>Floodable Buildings SSS   [Icon]</li> <li>Elevate/New Road SSS   [Icon]</li> </ul>	<p><b>Hard Engineering</b></p> <ul style="list-style-type: none"> <li>Revetment/Seawall SSS   [Icon]</li> <li>Traditional Levee SSS   [Icon]</li> <li>Tide Gate SSS   [Icon]</li> <li>Wall &amp; Pump Station SSS   [Icon]</li> </ul>	<p><b>Soft Engineering</b></p> <ul style="list-style-type: none"> <li>Horizontal Levee SS   [Icon]</li> <li>Wetland/shoreline vegetation SSS   [Icon]</li> <li>Offshore Structure SS   [Icon]</li> <li>Beach Maintenance SSS   [Icon]</li> </ul>
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# Next Steps

- Host a Game Night!
- Publish Vulnerability Assessment
- Next workshops in Fall 2015
- Draft Adaptation Plan and Local Coastal Program (LCP) Amendment



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