

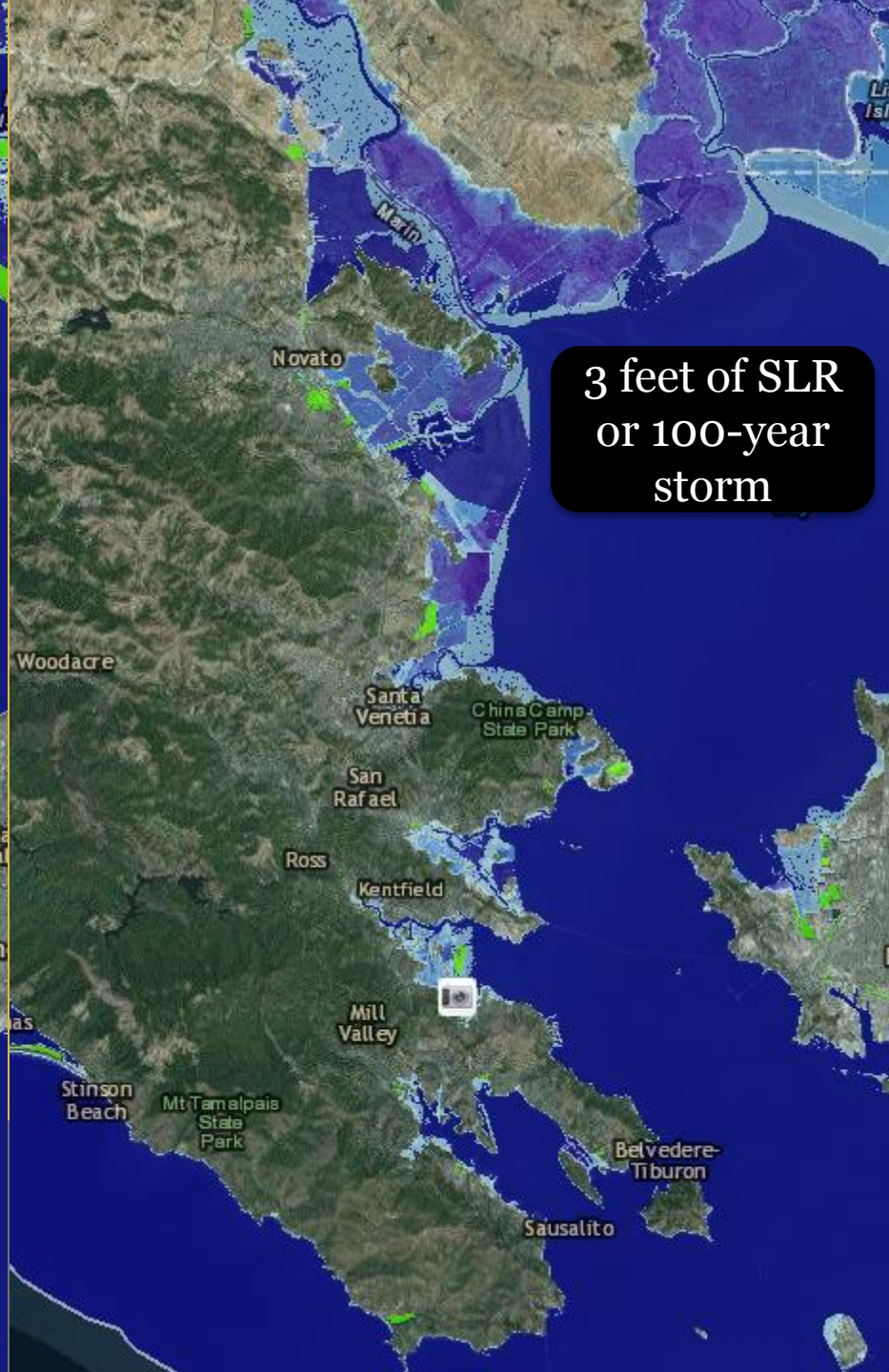


The Game of Floods

SEA LEVEL RISE IS COMING



1 foot of SLR
or King Tide



3 feet of SLR
or 100-year
storm

Major adaptation strategies

Protect

- HARD
 - Build dikes, seawalls
 - Install tide gates
 - Raise grades
 - Increase pumping
- SOFT
 - Natural beach systems
 - Tidal wetlands
 - Horizontal levees

Manage Retreat

- Land and structure acquisition /relocation
- Building/Planning code and regulation changes
- Allow erosion /migration of natural areas

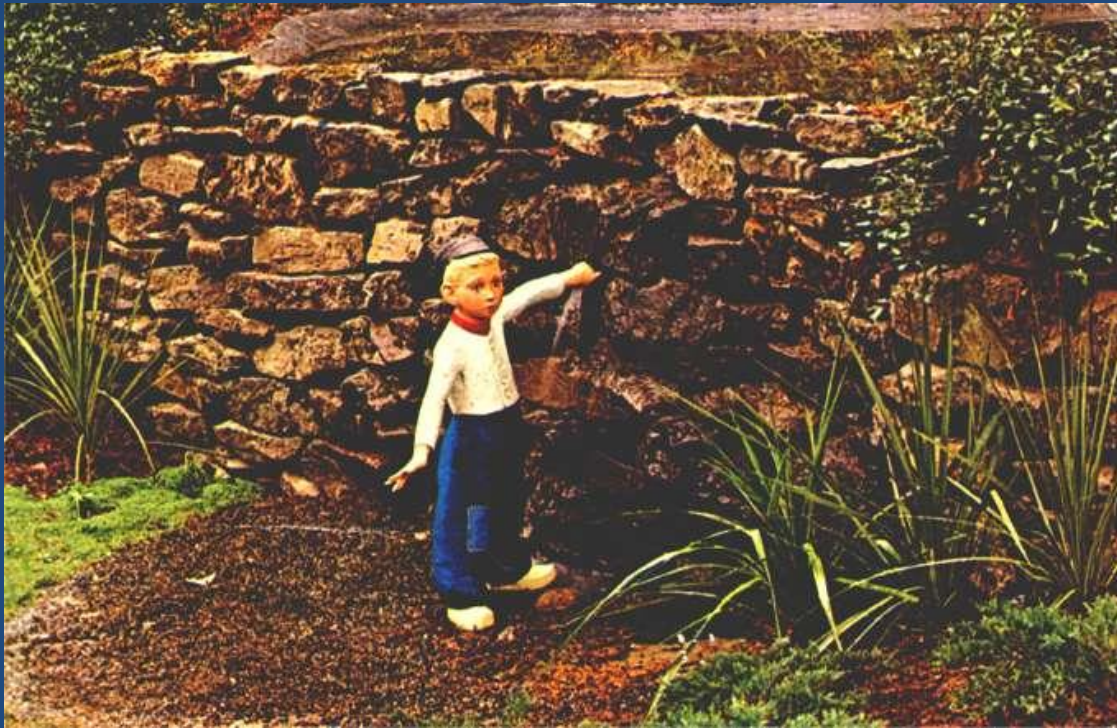
Accommodate

- Elevate buildings and infrastructure
- Floodproof critical structures
- Floodable buildings/tiered developments

...and combinations of any above

Famous adaptors throughout history...

Dutch Boy built protection



Moses implemented managed retreat



Noah went for accommodation (floodable structures)



Major adaptation strategies

Hard

- Flood/sea walls
- Levees/dikes
- High tide gates
- Rock rip-rap

Soft

- Wetlands creation/enhancement
- Engineered beaches shoreline

Infrastructure/ Lifestyle

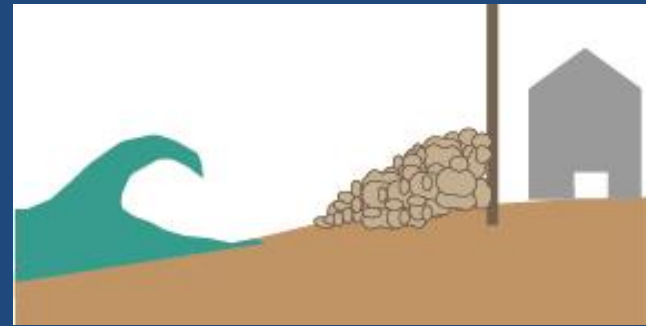
- Elevate structures
- Raise grades
- Lifestyle adaptation
- Zoning changes
- Planned retreat

PROTECT

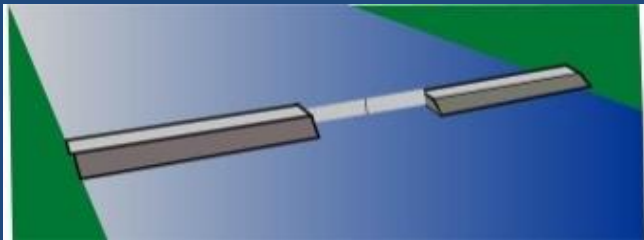
Hard (traditional) engineering



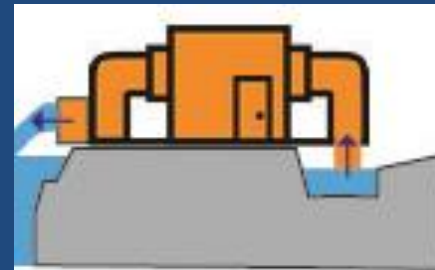
Traditional levee



Seawall/revetment



Tide gate

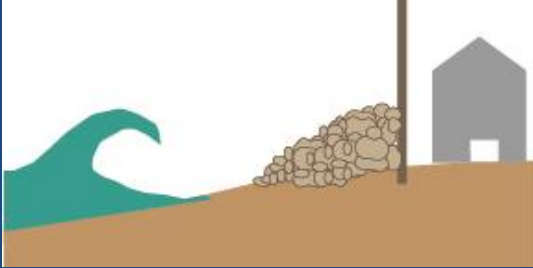


Flood wall & pump station

Sea wall

Pros: Limited ROW required

Cons: Cost, Impacts



Bulkhead seawall in Seadrift neighborhood

Westhoff

Levee

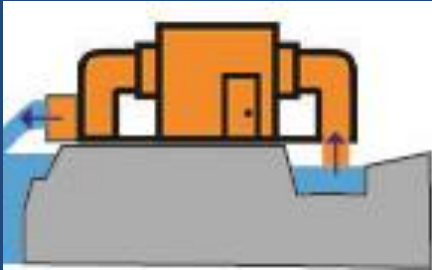


Pros: Stability if maintained,
Cost lower than wall

Cons: Large ROW required

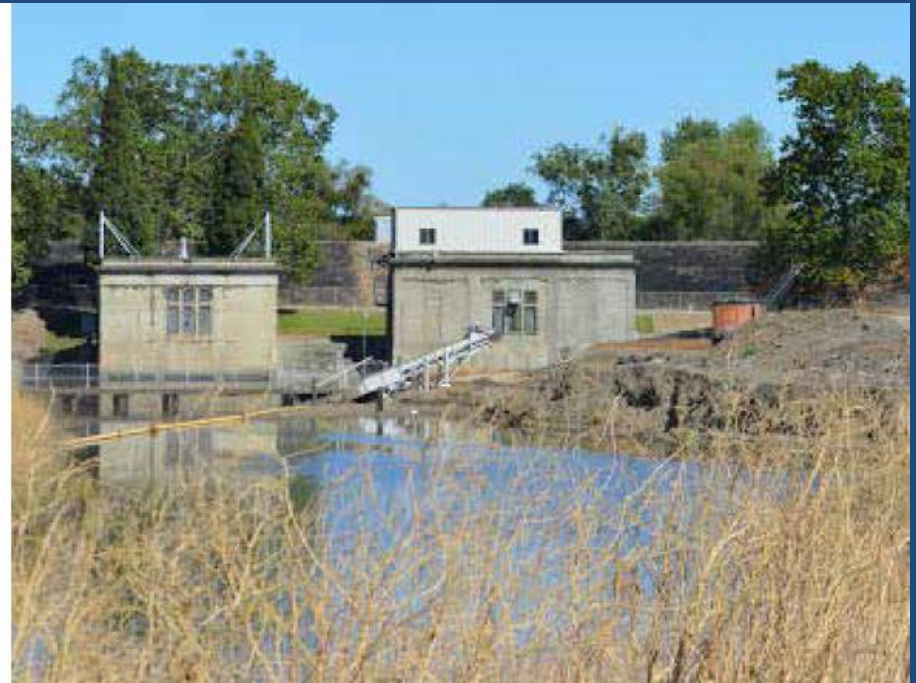


Flood wall & pump station

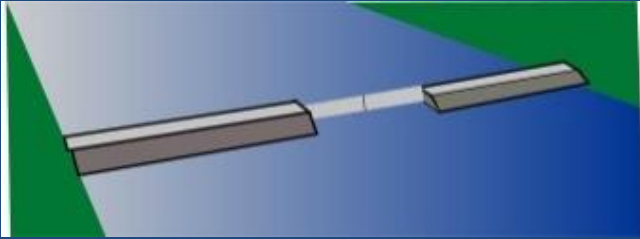


Pros: Lower ROW than levees

Cons: Capital and maintenance costs

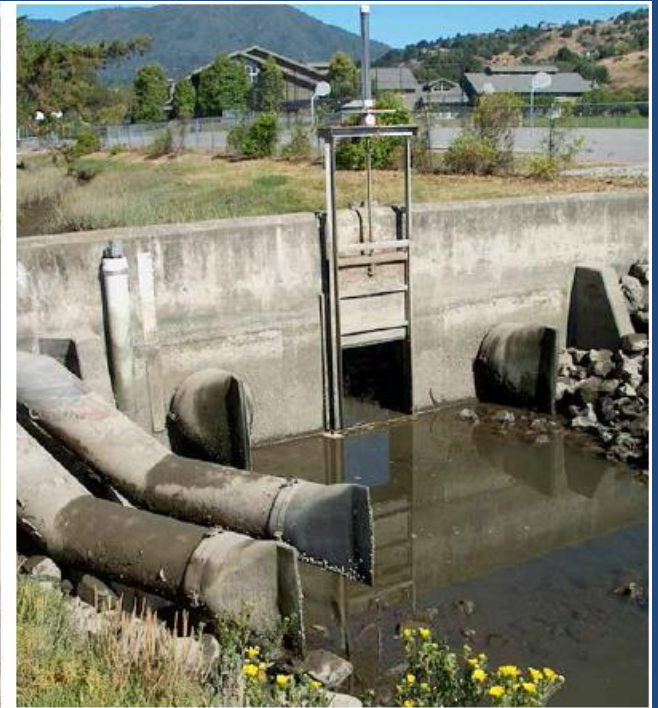


Tide gate



Pros: Temp solution to tidal riverine flooding

Cons: Cost, limited effectiveness over time



Major adaptation strategies

Hard

- Flood/sea walls
- Levees/dikes
- High tide gates
- Rock rip-rap

Soft

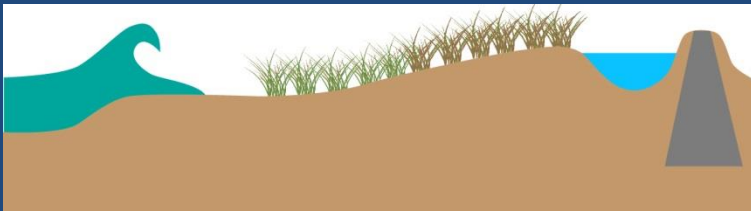
- Ecotone Levees
- Wetlands creation/enhancement
- Engineered beaches shoreline

Infrastructure/ Lifestyle

- Elevate structures
- Raise grades
- Lifestyle adaptation
- Zoning changes
- Planned retreat

PROTECT

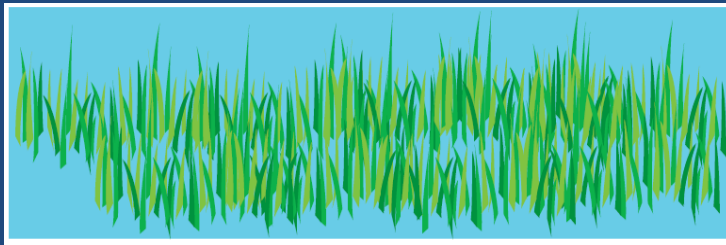
Soft (nature-based) engineering



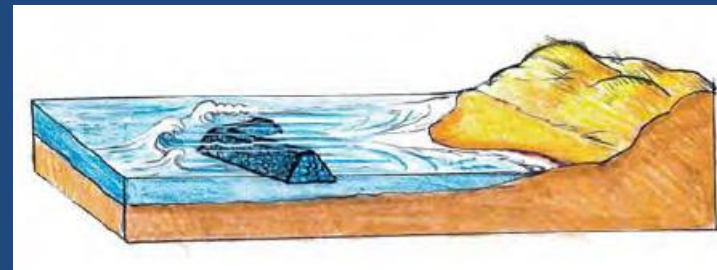
Horizontal levee



Dune restoration &
Beach maintenance

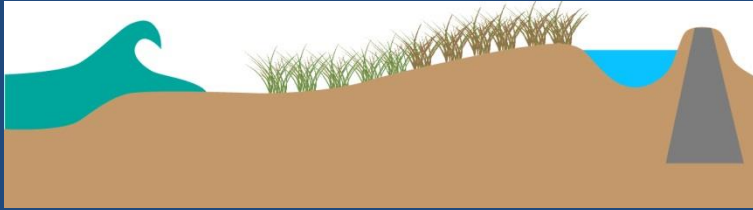


Wetland/ shoreline vegetation



Offshore structure

Horizontal levee

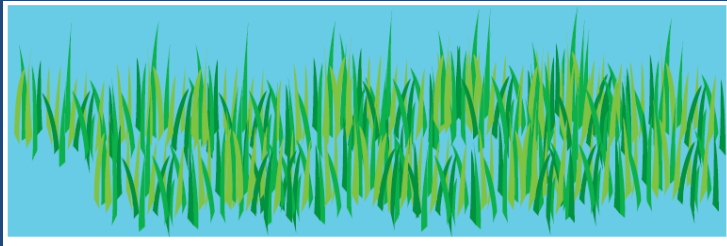


Pros: Uses landscape to attenuate waves, provides habitat

Cons: Cost for earthwork, larger ROW



Wetland/ shoreline vegetation



Pros: Habitat improvement and flood reduction

Cons: Large ROW required



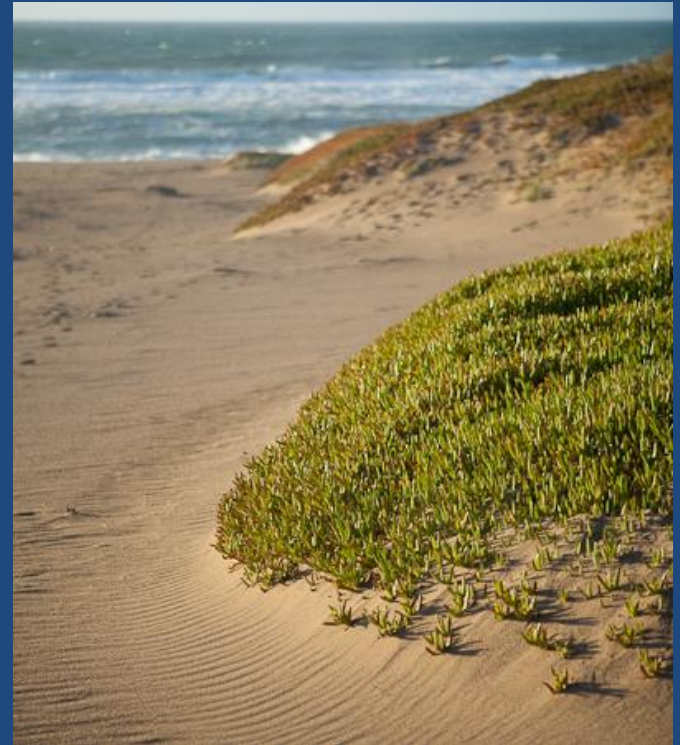
Giacomini Wetland Restoration, 2008

Dune restoration & beach maintenance



Pros: Recreation and flood reduction benefits

Cons: Costs for replenishment



Aramburu sandy foreshore construction 2012



Placing larger wood groins – eucalyptus logs



Aramburu engineered bay beach spring-summer 2013

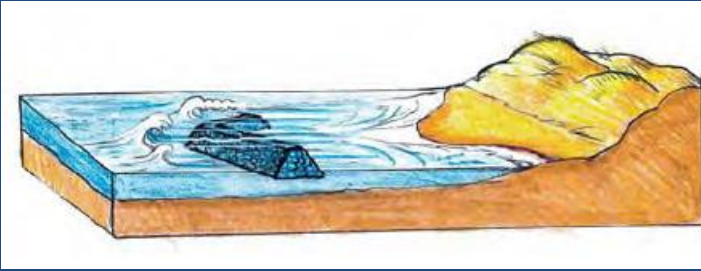
Winter storm gravel and shell
berm persists

Sand beachface slope
accretes, steepens

Sand partially buries winter
storm berm



Offshore structures



Pros: Reduces waves impacts – more when structure is higher

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



Major adaptation strategies

Hard

- Flood/sea walls
- Levees/dikes
- High tide gates
- Rock rip-rap

Soft

- Wetlands creation/enhancement
- Engineered beaches shoreline
- T-zone creation

Infrastructure/ Lifestyle

- Elevate structures
- Raise grades
- Lifestyle adaptation
- Zoning changes
- Planned retreat

ACCOMMODATE



New floodable
development



Elevate buildings



New/ elevated 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/elevated road

Pros: Protects roads when designed correctly

Cons: Very high cost, ROW



RETREAT



Retreat



Rebuild here



Post-storm
prohibitions



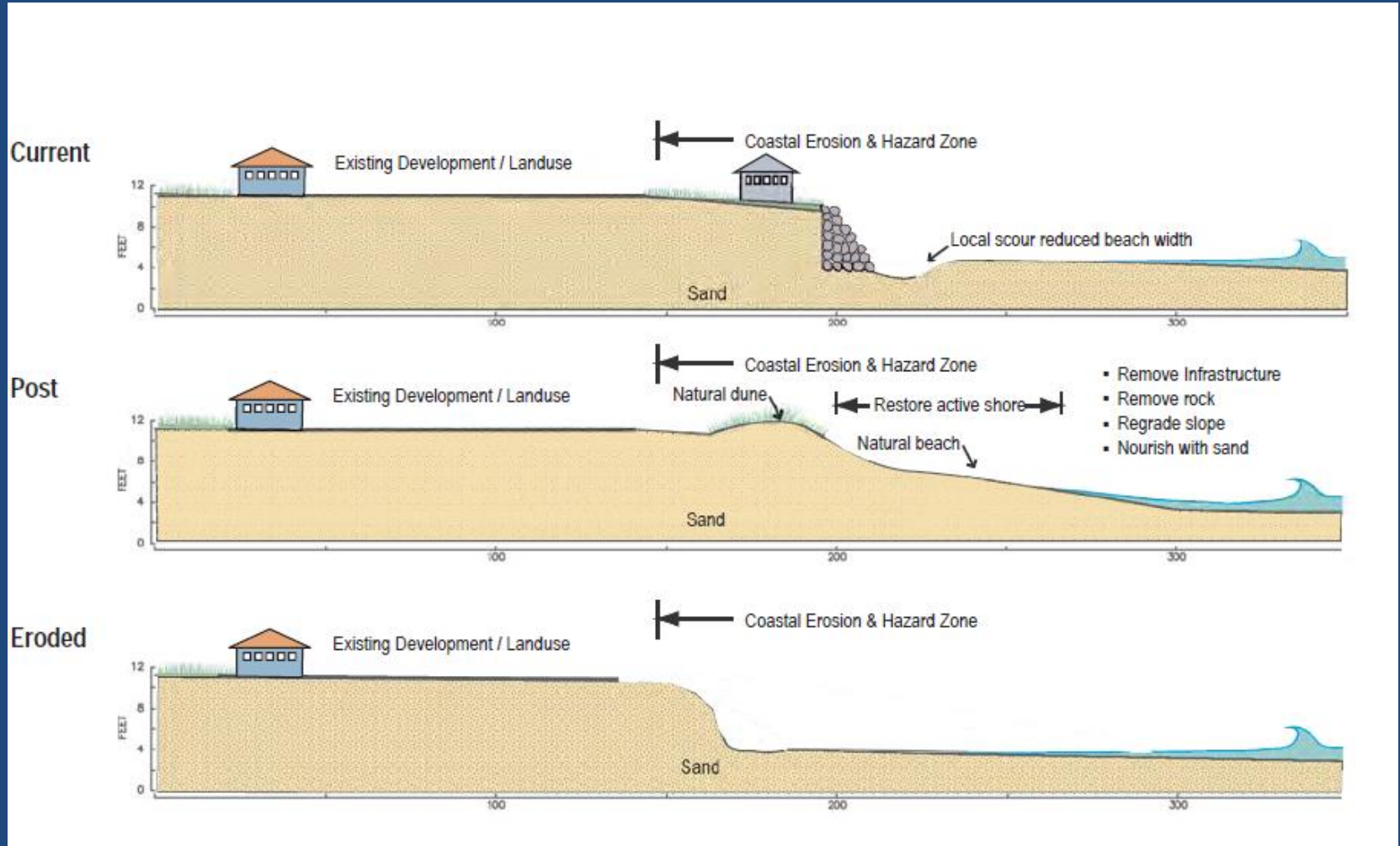
Stricter land use zoning



Managed Retreat

Pros: Lower costs if no buyout

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



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)





THE GAME OF FLOODS

Your 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. Adaptation plans using the strategies in this game are critical to help us better understand and plan for the risks we face.

1. To begin, each player needs the sea level that corresponds to their role. The highest roll goes first. If tie occur, the tied players must re-roll. Players take turns in clockwise order.
2. 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.
3. Next, in turn each player places and states aloud their preferred adaptation strategies to avoid the island. Conflicting strategies are allowed.
4. Consider the following factors to inform the proposal: (1) cost/benefit, (2) Private property impacts, (3) Environmental impacts, (4) Equity/social justice/economic, (5) Other. Use your worksheet to take notes.
5. Repeat steps 2-4 until all assets are accommodated, defended, or retreated from.

Sea Level Rise 2050 Scenario Key

RED AREA = Permanent Sea Level Rise Flooding

ORANGE AREA = Temporary 100-Year Storm Flooding

YELLOW AREA = Temporary 100-Year Storm Flooding

	Evacuation Route		Mamma Habitat		Storm Shelter
	Gas Station		Seabird Colony		Sewage Lift Station
	Hospital		Agriculture		Aquaculture
	Fire Station		Ranch		Sheep
	Post Office		Grocery		Home
	Library		Water		Roadway
	Historic Church		Restaurant		Beach
	Public Well		School Site		Boat Launch
	Home		Parking		Public Well
	Public Well		Roadway		Beach
	Beach		Boat Launch		Public Well
	Public Well		Roadway		Beach
	Beach		Boat Launch		Public Well

LEGEND

GAME PIECES

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

Communities of North Bay Island

- Downtown Norbay
- Eroding Cliff Heights
- Mudflat Manors
- Desolation Court
- Shoreline Marina
- Twig Cove
- Seaspray Homes

Downtown Norbay

- Commercial hub of the island
- Protected by undersize levees and vulnerable to both riverine and tidal flooding



Eroding Cliff Heights

- Residential community threatened by cliff erosion
- Zoning and shoreline protection challenges



Mudflat Manor

- Large residential community threatened by SLR
- Vocal community of property owners demanding protection



Desolation Court

- Small poor isolated community threatened by SLR
- In danger of being cut-off from services



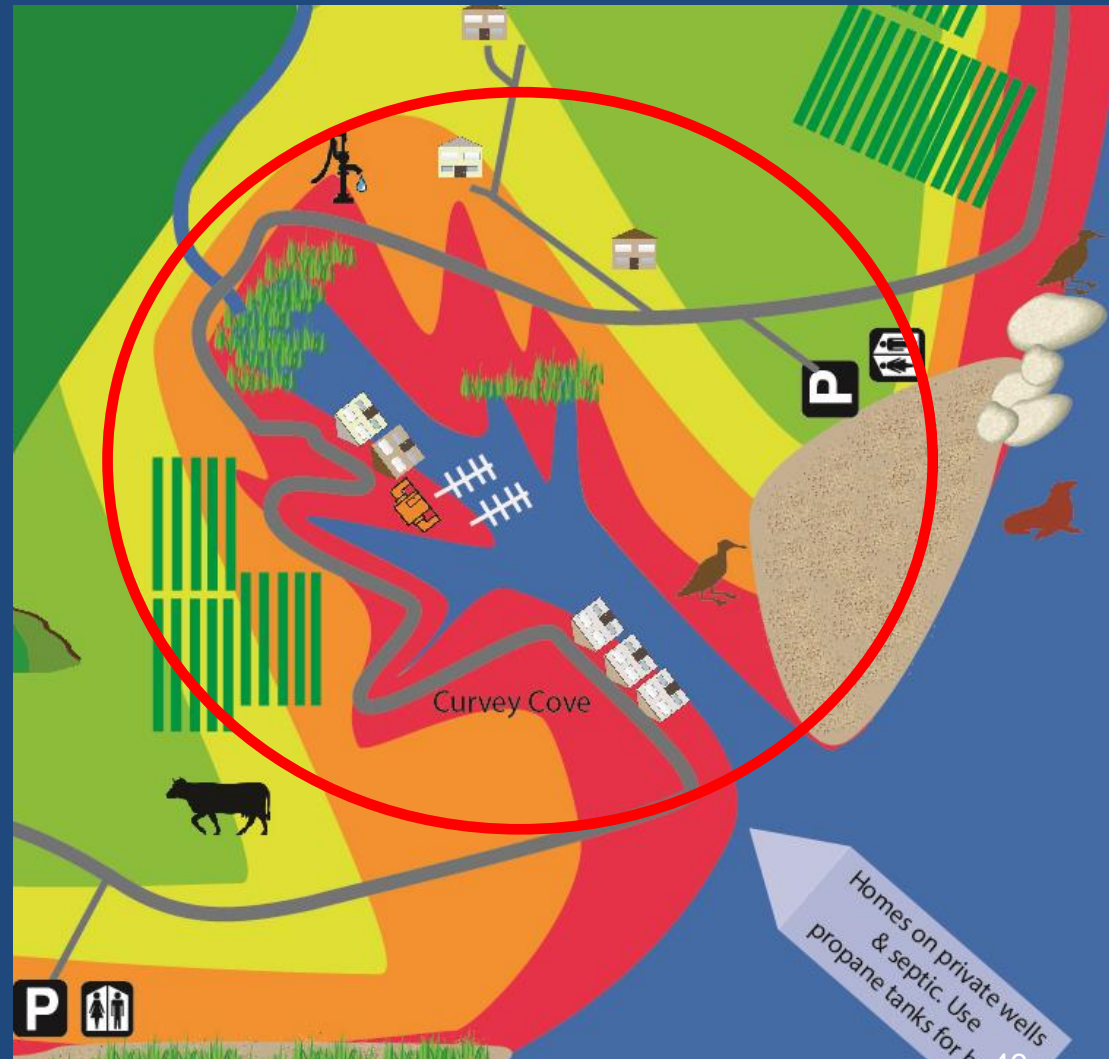
Shoreline Marina

- Water-based commercial business and associated businesses threatened by SLR
- In danger of being cut-off from road access at high tides



Curvey Cove

- Historic Ag based community with access and crops threatened by SLR
- In danger of being cut-off from road access at high tides



Seaspray Estates

- Large vacation and second home community with access and homes threatened by SLR
- In danger of being cut-off from road access at high tides



Costs \$\$\$



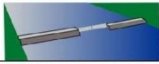




Real World – costs are messy and depend on many factors

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

Suggestions for the game

- Start with one community: what's at risk and what infrastructure is essential?
- What must be protected to allow the community to function. What other options exist?
- Adaptation options: discuss pros and cons of measures alone and combined - phasing
- Consider: mitigation, permits, and funding; options that span more than one community
- Add up the costs and stick your group's measures on the board

Game over?

- 1) Who in your organization is planning/strategizing around sea level rise?
- 2) What other organizations are also planning/strategizing that you may need to coordinate with?
- 3) What are the benefits or drawbacks of interagency discussion/planning/strategizing?
- 4) Any improvements or suggestions?

Thank You

Visit www.MarinSLR.org for more information

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Novato Creek at Highway 101. Credit: Marin County staff



Environmental Protection Agency
Game of Floods
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