The Policies for a Rising Bay Project

Technical Workshop
May 5, 2015

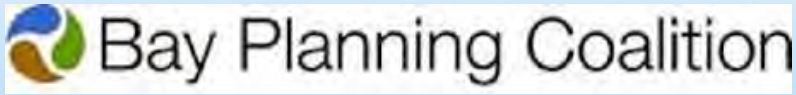
Welcome

- Introductions
- Review agenda
- Ground rules/guidelines

Project Goal

Collaboratively evaluate BCDC's fill policies in light of sea level rise and develop guidance for the Commission, staff and project proponents to promote shoreline resilience

Steering Committee Members



Case studies

- Representative, hypothetical locations
- Policies require projects be resilient to mid-century of projected sea level rise and storms and adaptable to end-of-century
- Opportunity to help develop guidance on how to evaluate and phase grey to green adaptation actions

Regional Context and Vision

Next steps to BEHGU

- Baylands Ecosystem Habitat Goals Update (Sept 2015)
- Sets recommendations for ecosystem resilience with climate change
- Guidelines for implementation, not a plan.
- Need to integrate BEHGU with other factors and constraints to create visions for a resilient bay
- Calls for integrated visions/plans for segments of shoreline

Case Study Approach: Framing

- The Bay and its shoreline are heterogenous
- No one-size-fits-all approach for SLR adaptation
- Goal is to describe a range of options that are feasible/appropriate in a given shoreline setting

Bay Settings for Case Studies

- Synthesized data to describe real Bay settings ("shoreline typology")
- Limited dataset
- Used coarse typology to create "hypothetical" settings for case studies
- Ultimately will develop more rigorous typology for Bay adaptation planning and shoreline-specific strategies

Drivers

Processes

Watershed	Tidal	Littoral/Bay
Climate | Geology | Topography & Bathymetry		
Watershed area Land Use Infrastructure	Tidal Range | Fetch Wind Speed | Water depth Headland morphology	
Q_w (surf and GW) Q_{sed} (coarse and fine) Stream power	Tidal prism Wave power Fine sediment delivery	Flow resistance Sediment trapping

Setting

Land uses

Watershed sediment supply

Shoreline Infrastructure

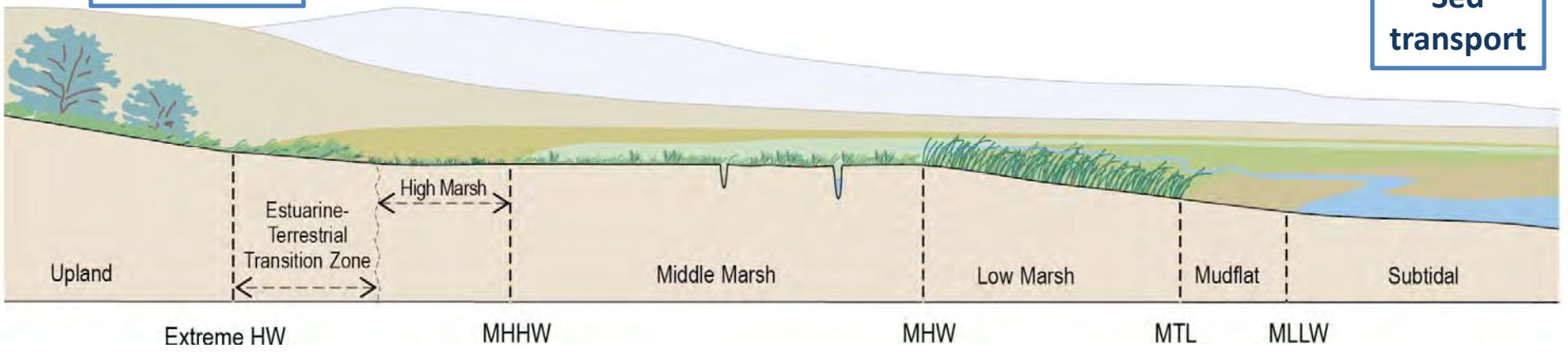
Marsh width
(elevation, evolution)
(Species)

Bathymetry (mudflat)

Wave energy

SSC

Sed transport



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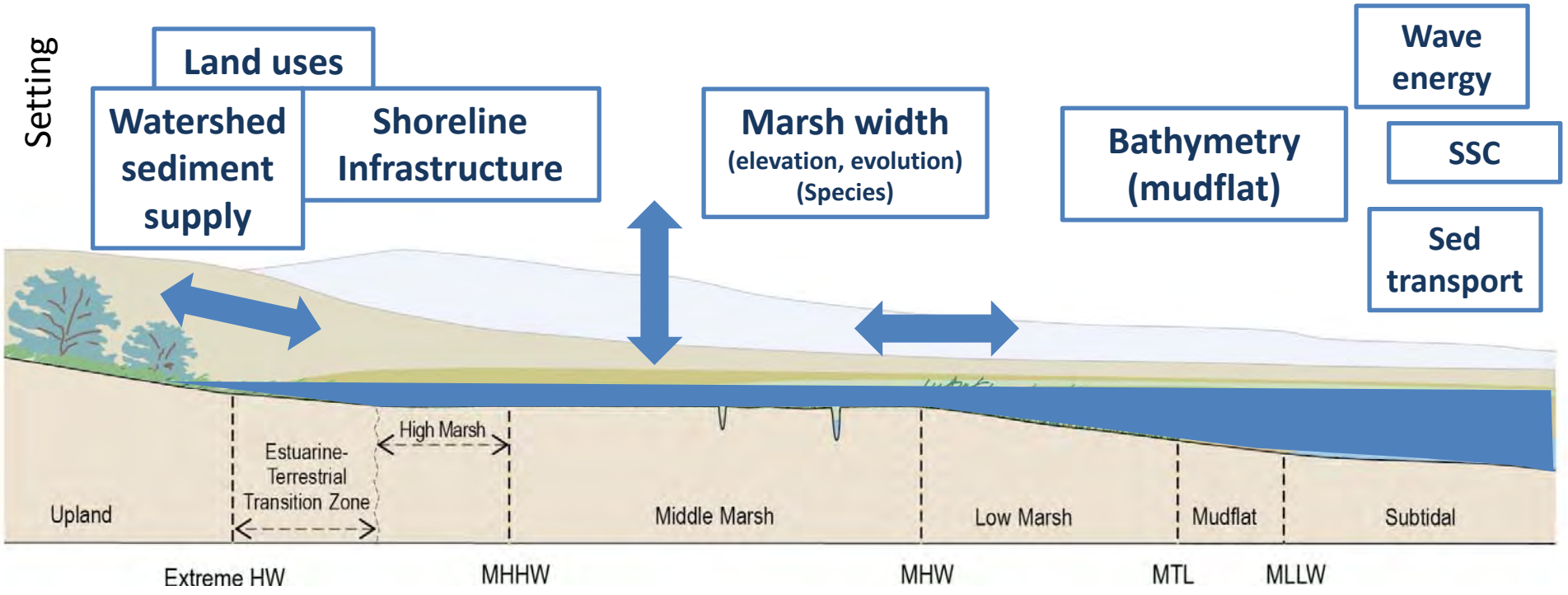
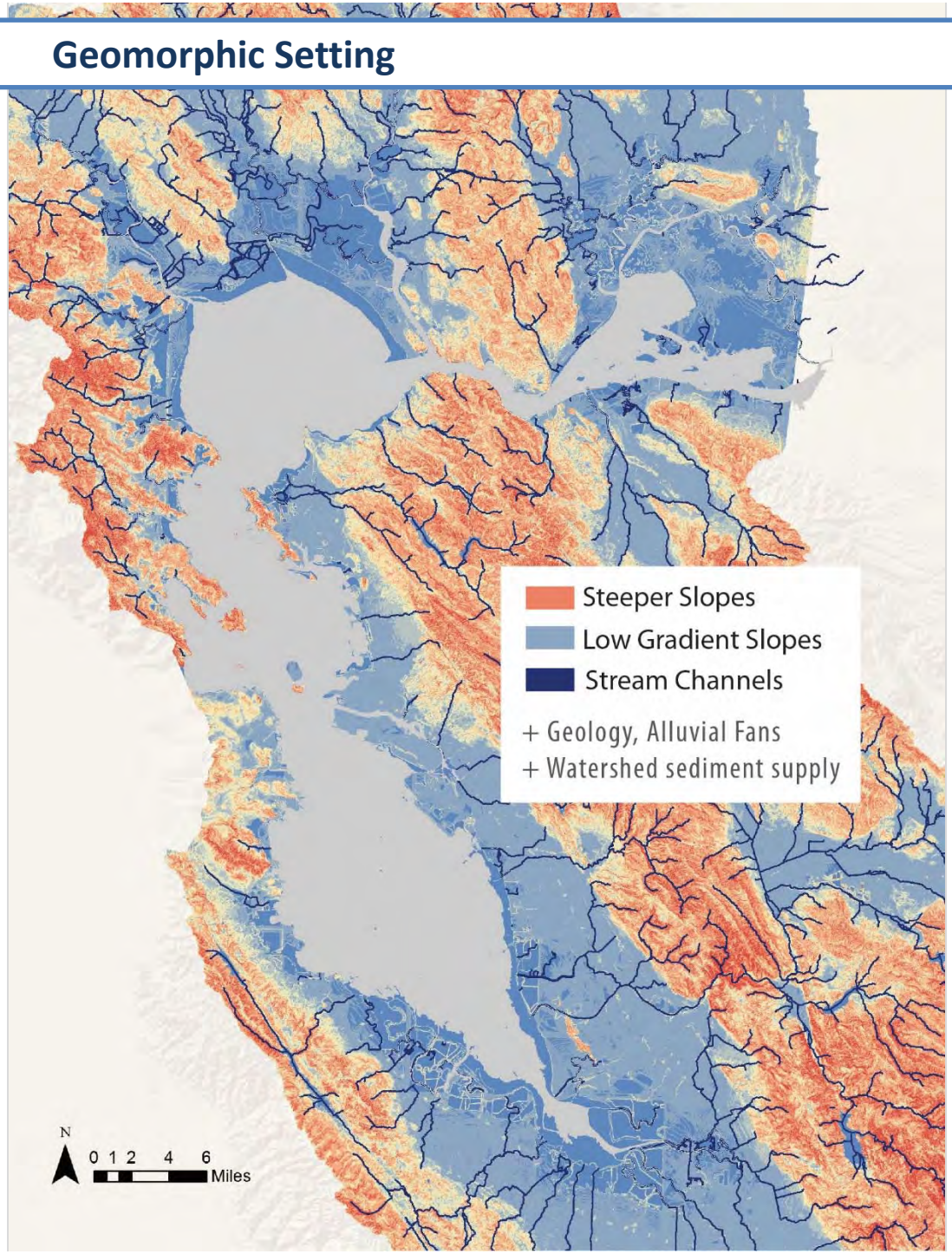
Setting

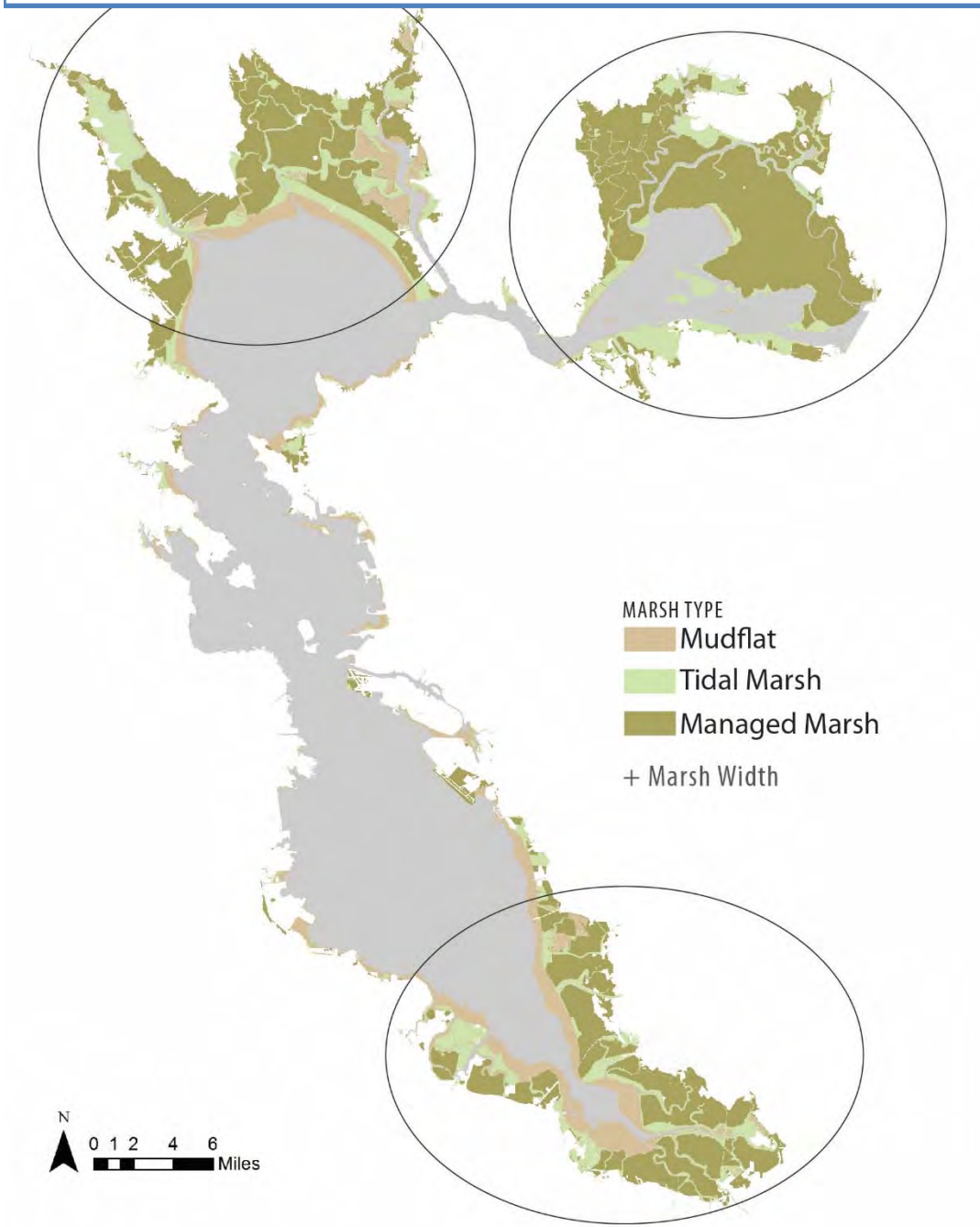


Geomorphic Setting

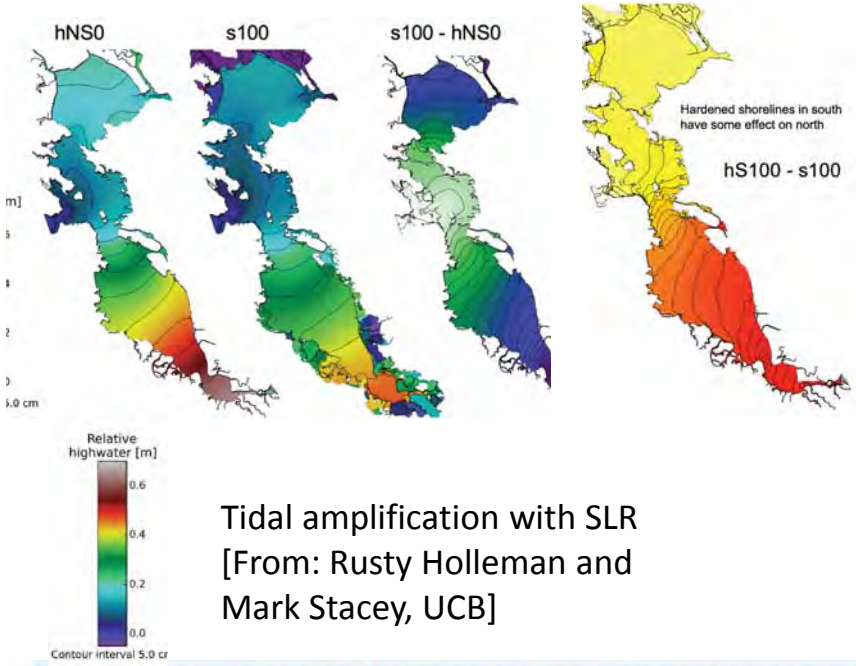
- Big wide alluvial valleys
- alluvial fans/long plains
- short steep plains
- steep headlands/small valleys
- steep no plain



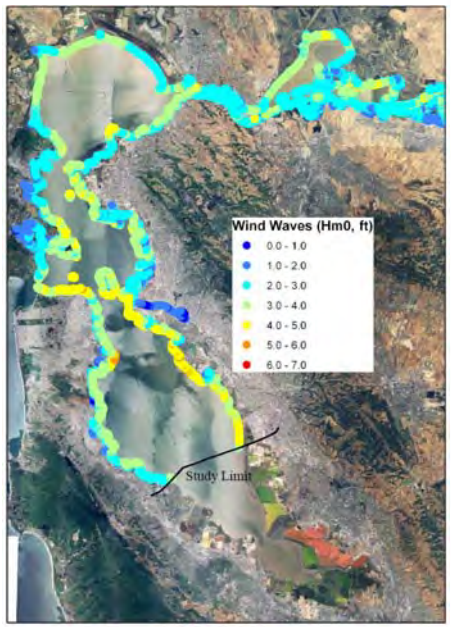
Baylands width



Wave energy: Tidal Amplification, Wave heights



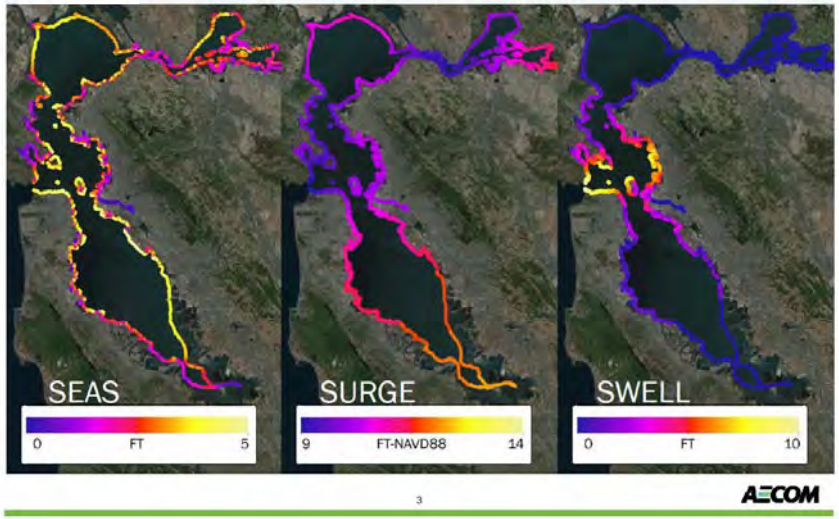
Tidal amplification with SLR
[From: Rusty Holleman and Mark Stacey, UCB]



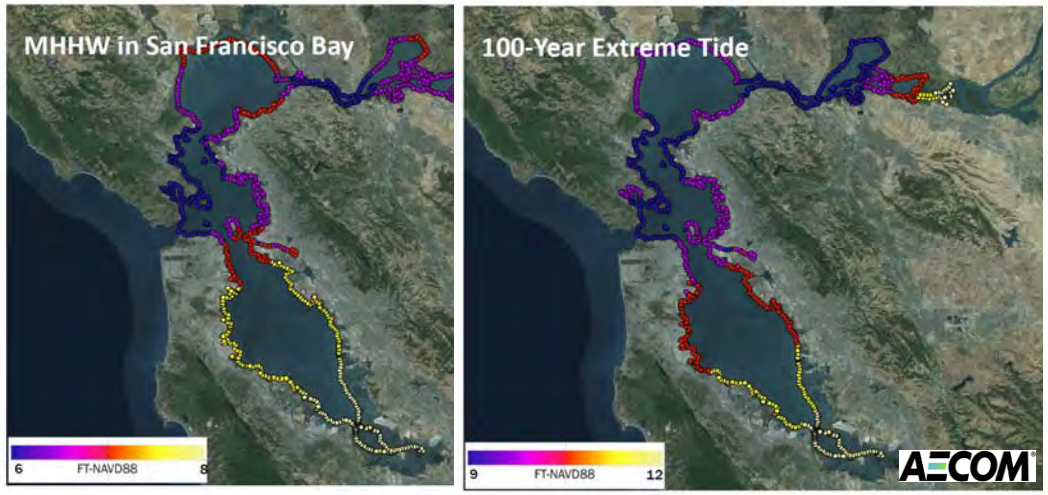
Incident wind wave heights
[from: DHI 2013]

Figure 7.8 Variation of estimated 1% Seas Significant Wave Height in the extended South Bay study area.

South_SF_Bay_Regional_Coastal_Hazard_Modeling_Study Page 161 of 167 DHI WATER AND ENVIRONMENT, INC.
Date: 1/9/2013
Rev: 01



[Coastal study from AECOM]



[Tidal datum update from AECOM]

Bathymetry

Mudflat width

Wide (> 0.25 mi) ⟷

Narrow (< 0.25 mi) ⟷

Proximity to deep water

Nearshore sediment transport

Nearshore sediment transport

Depositional

Dispersive

Gyre

-300 ft

>1700 ft

Shoreline composition

Legend

Flood Infrastructure

Class - Transportation_Type

- Engineered Levee
- Berm
- Shoreline Protection Structure
- Embankment
- Transportation Structure - Major Road
- Transportation Structure - Rail
- Natural Shoreline
- Wetland
- Channel or opening
- Tidegate


Legend
Flood Infrastructure
Class - Transportation_Type
Engineered Levee
Berm
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Natural Shoreline
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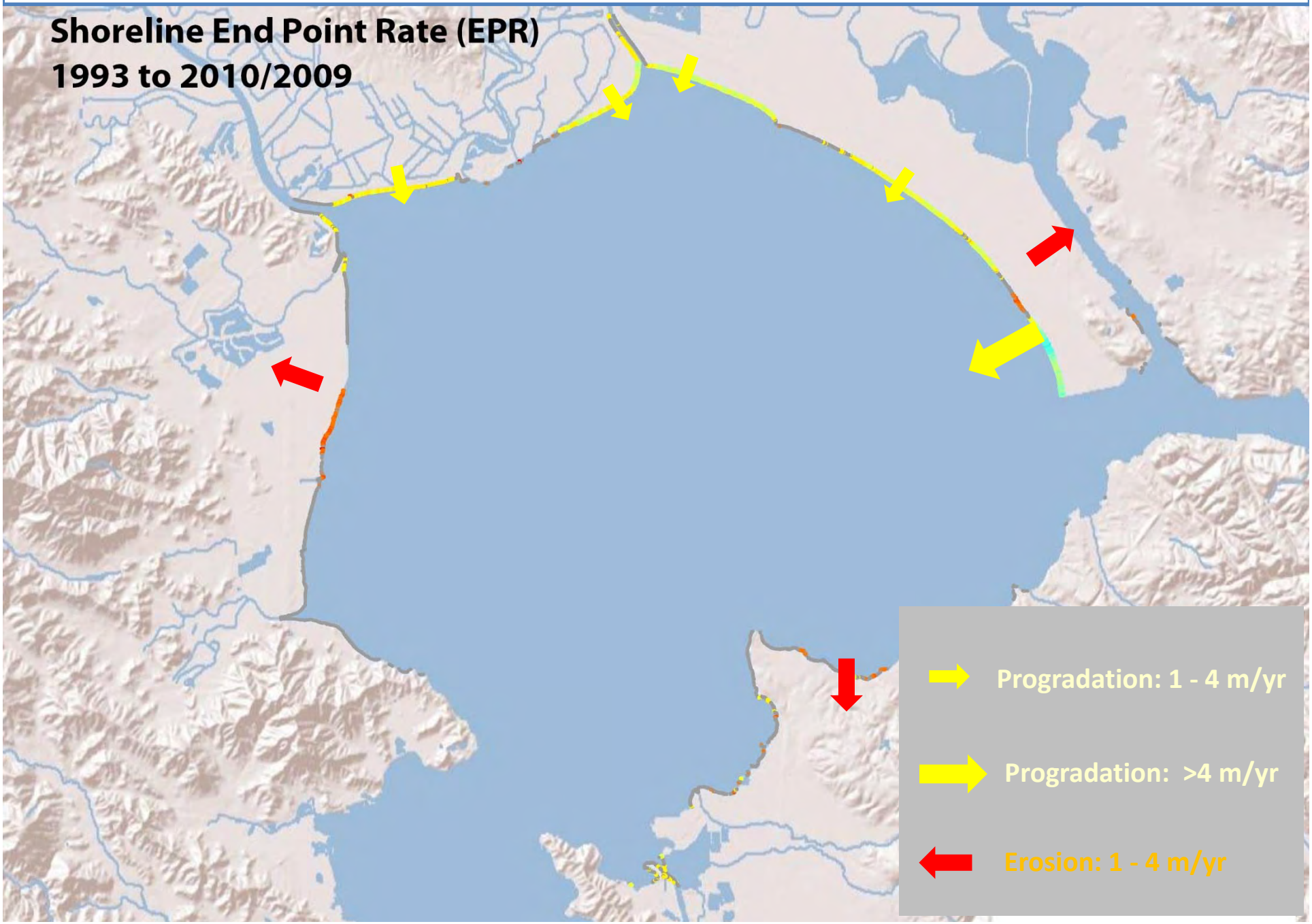
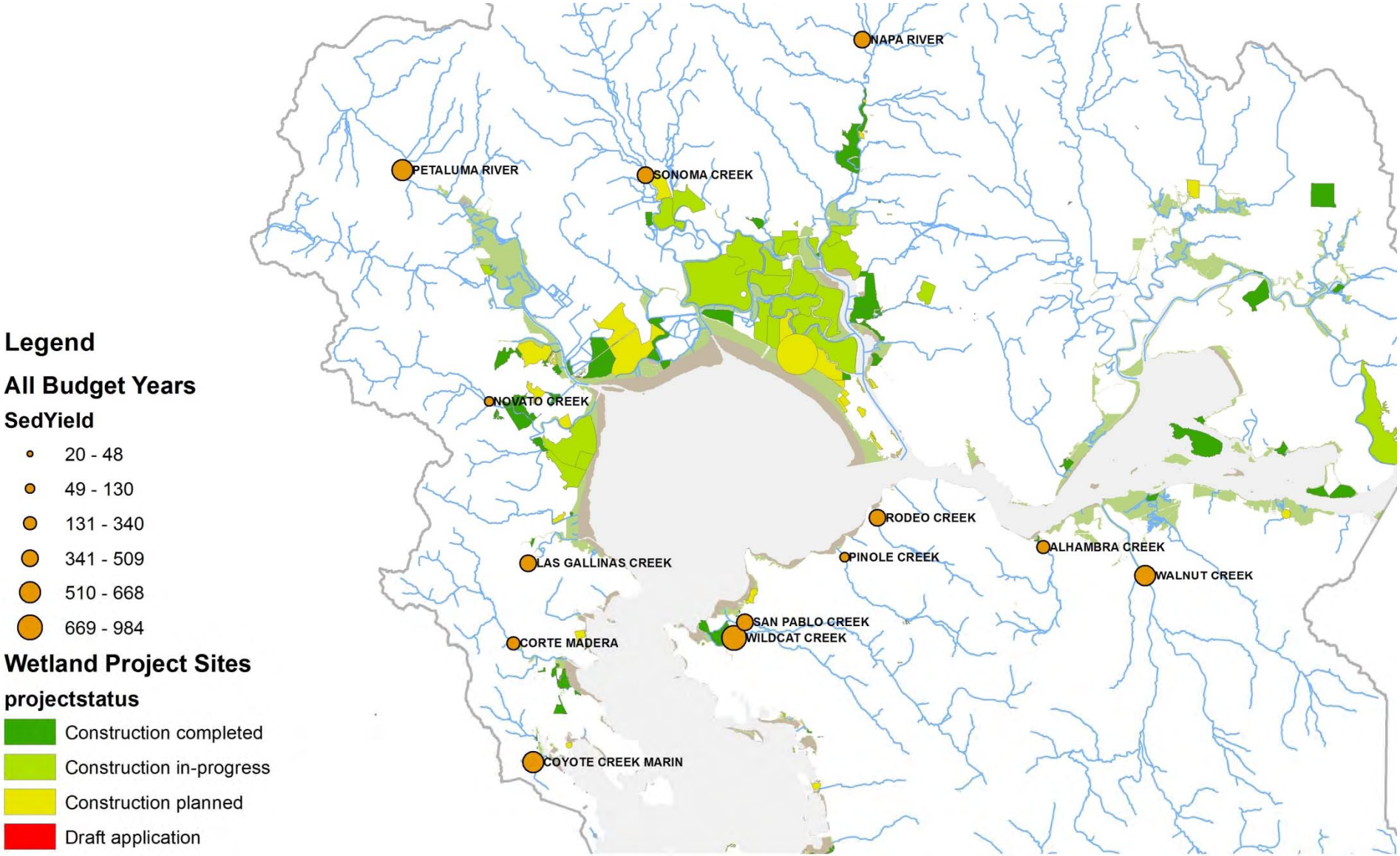
SHORELINE DELINEATION 2010

Shoreline evolution

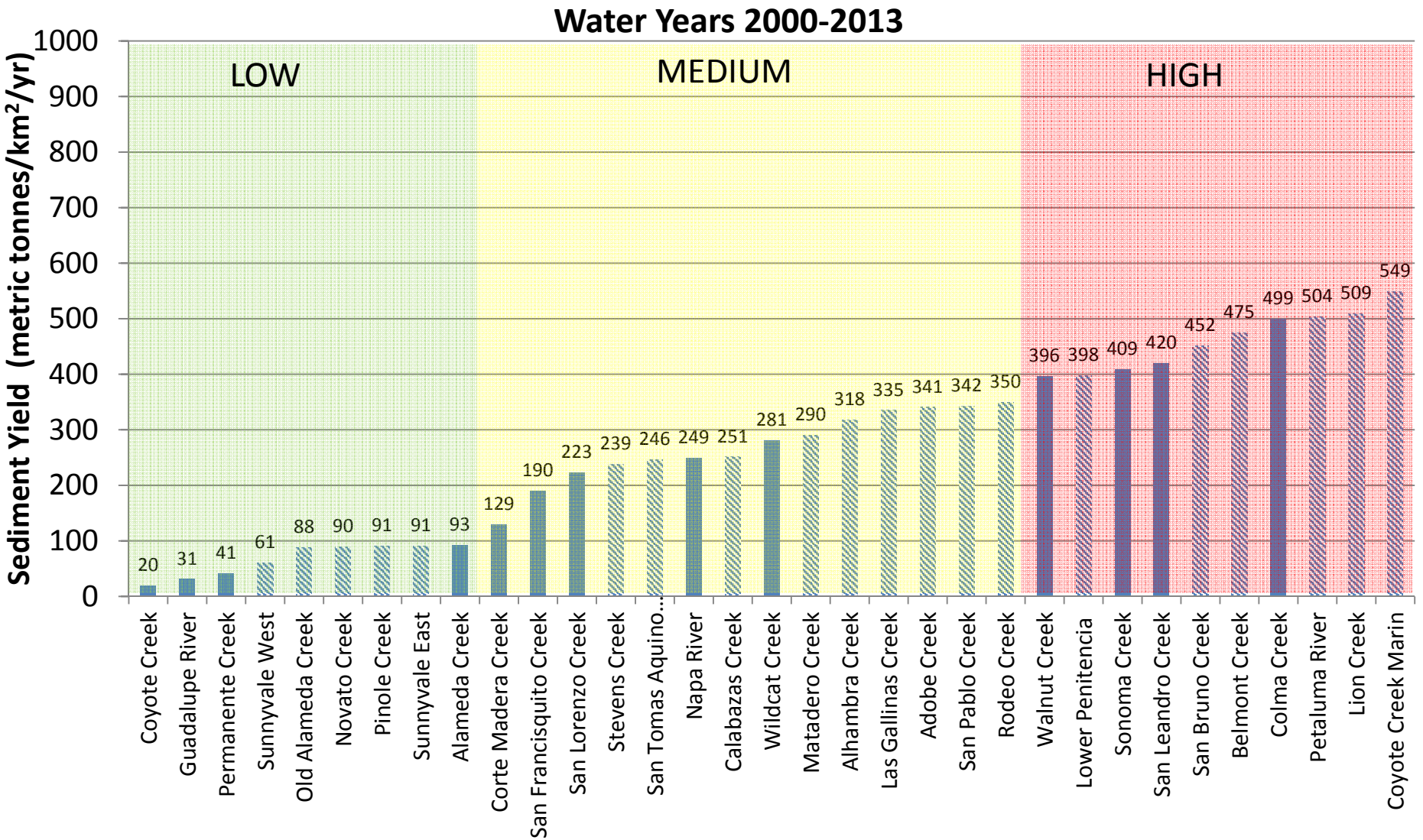


Watershed processes

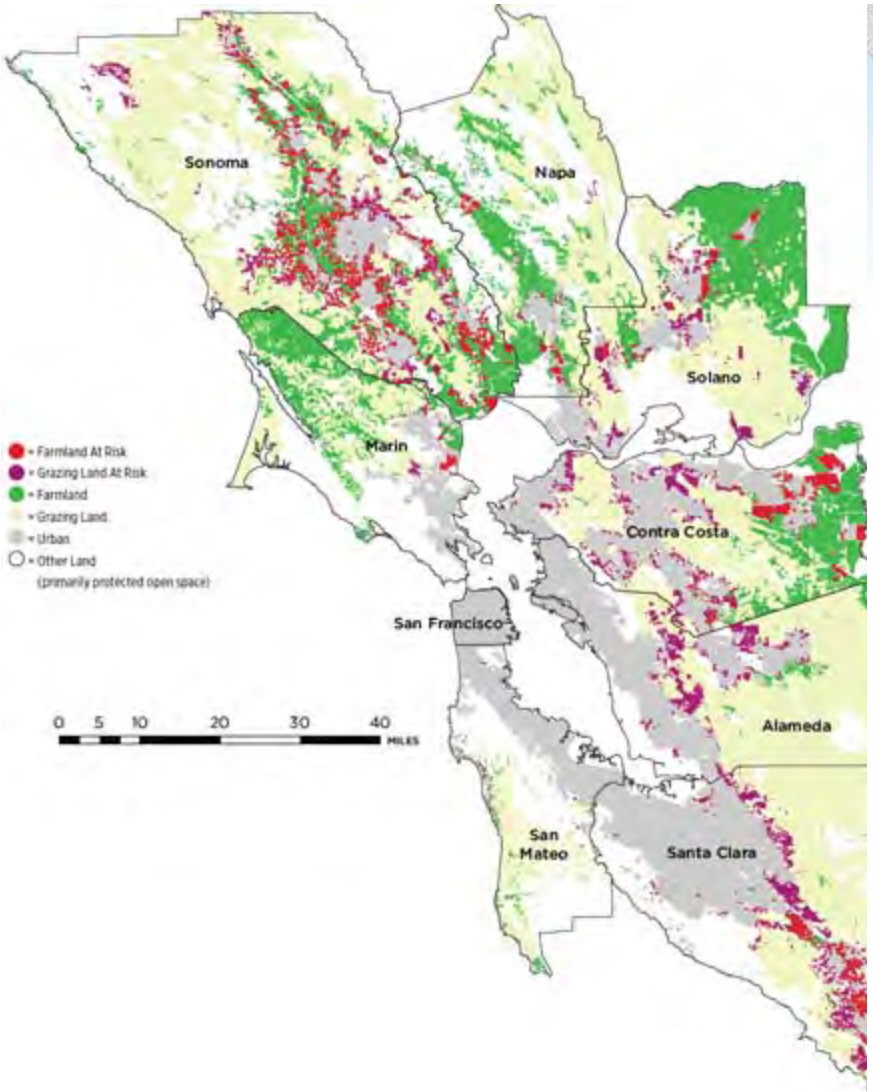


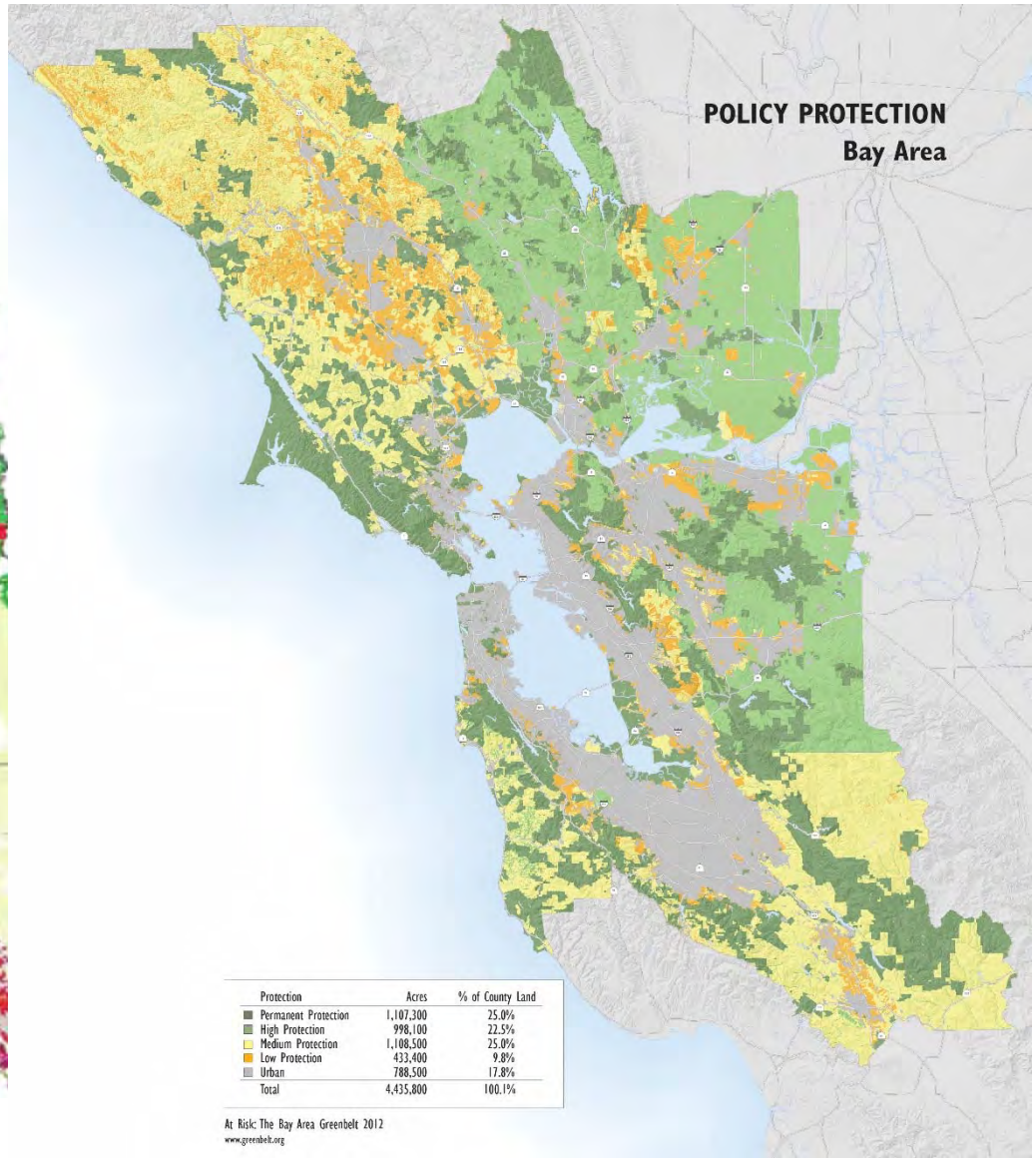
Watershed processes: Sediment inputs

Marin Co. Channels

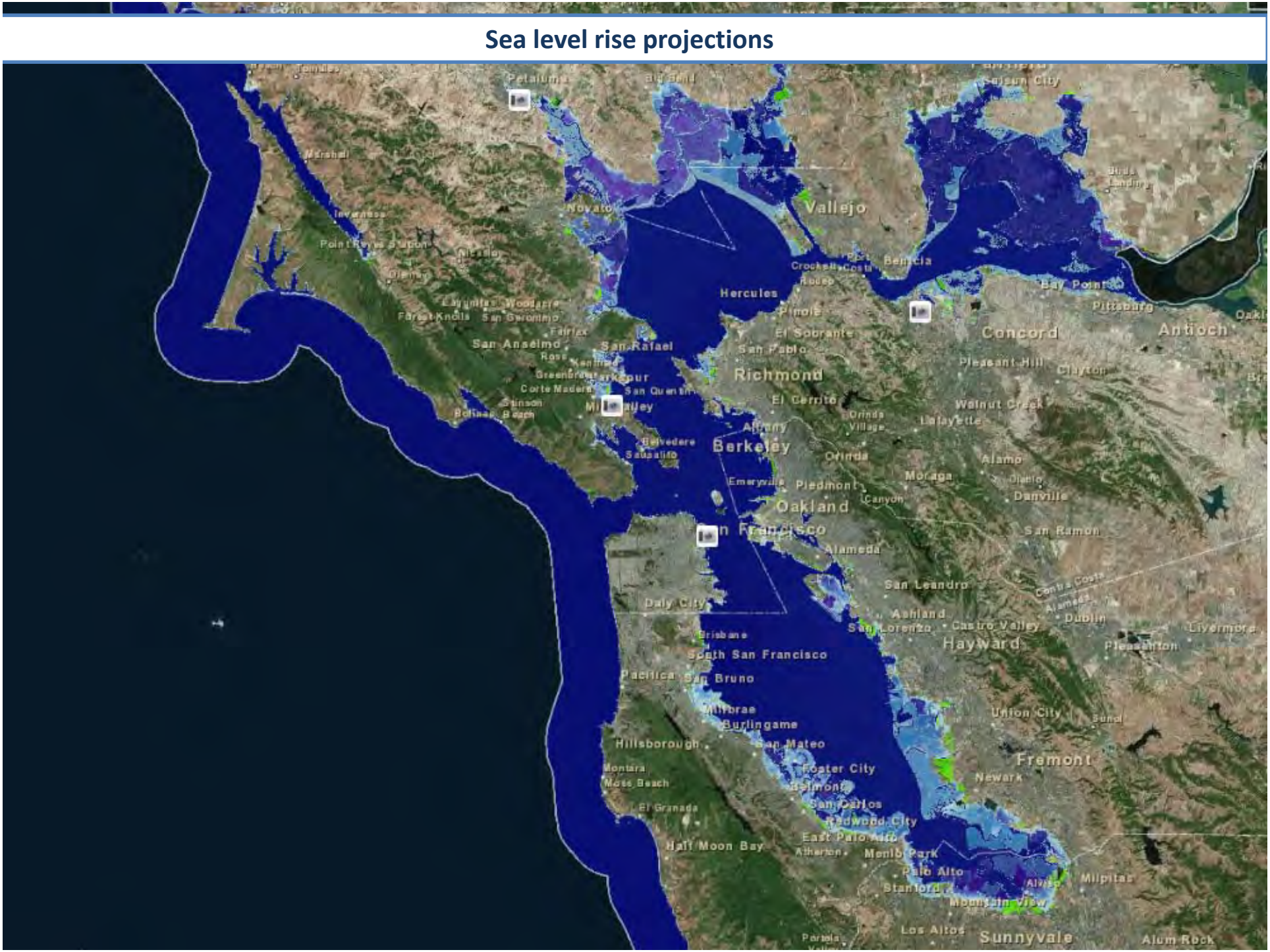


Land use adjacent to Baylands





Sea level rise projections



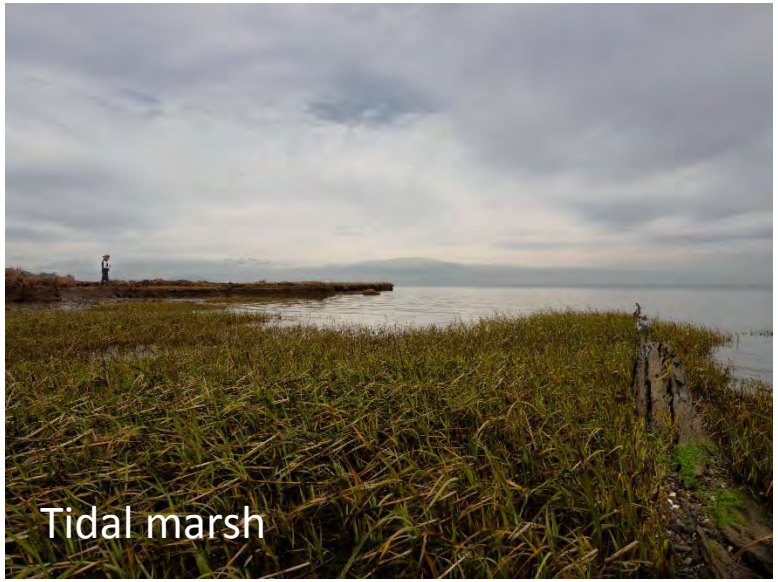
Case studies

- 5 Hypothetical locations (You may recognize them)
- Drawn from a “setting” or shoreline “type”
- Issues that BCDC deals with regularly

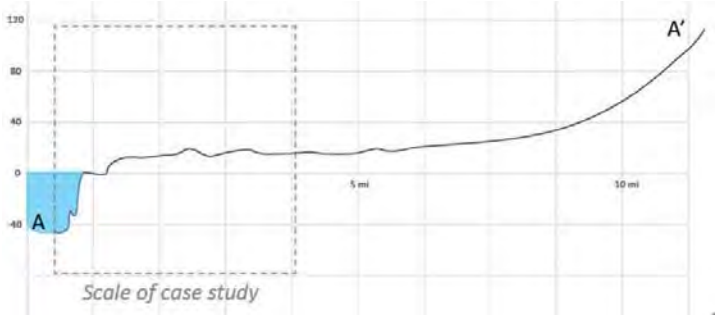
	Case Studies
1	Marsh enhancement
2	Shoreline protection (Transportation)
3	Shoreline protection (Residential)
4	Shoreline protection (Airport)
5	Flood protection (Fluvial-tidal flooding)

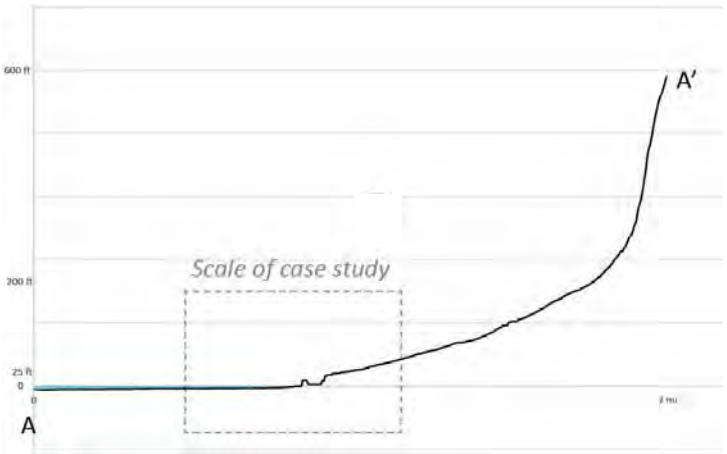
Characteristics
Geomorphic Setting
Bay SSC
Wave impact (fetch, wind direction, water depth, wave height)
Nearshore sediment transport
Bathymetry **(mudflat width)**
Shoreline composition
Shoreline evolution
Species considerations
Marsh/Salt pond width
Land use (mixed)
Watershed sediment supply
SLR Scenarios

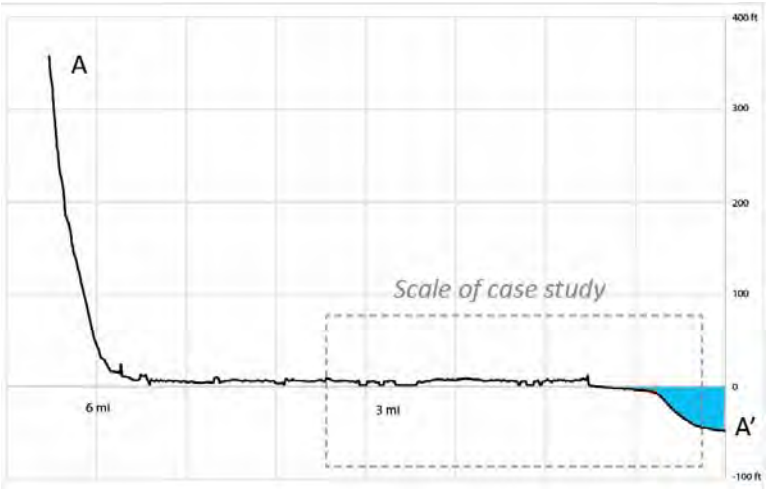
A diversity of vulnerable assets

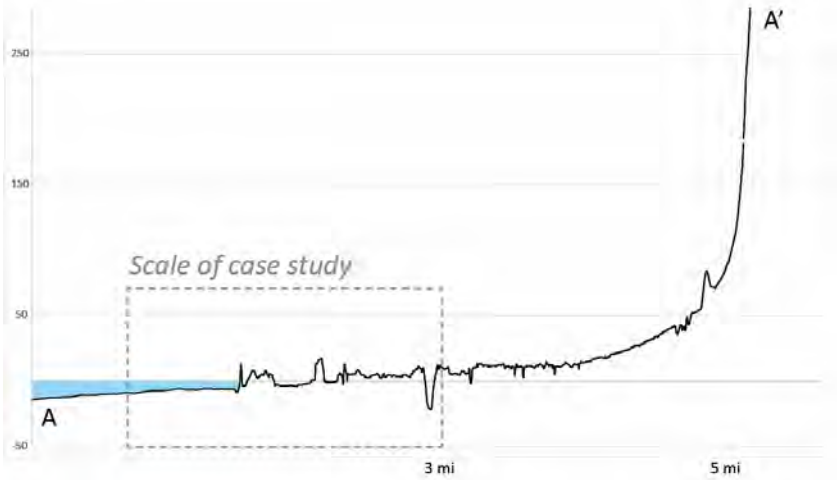


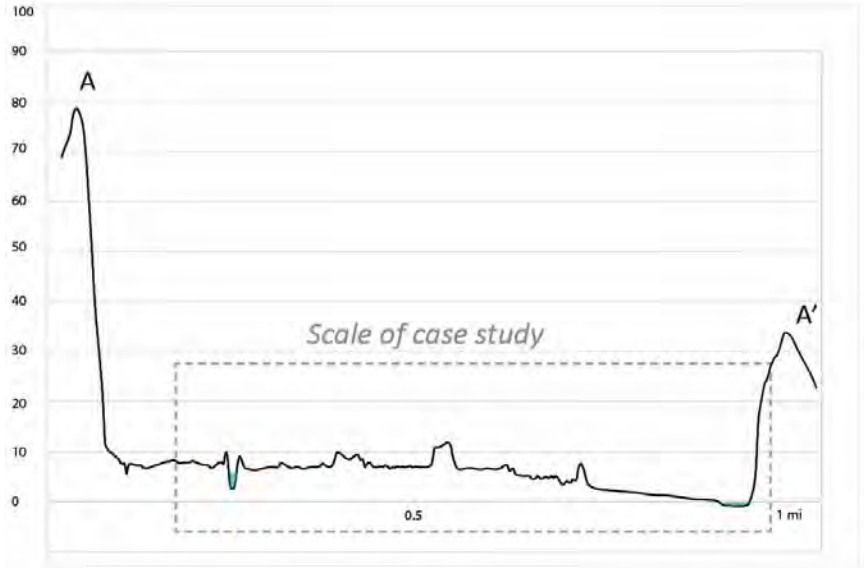
A diversity of settings…











A diversity of land uses

A diversity of possible actions and strategies

Area of focus	Actions to protect Bay resources and development
Subtidal	Living breakwaters/sill
	Tidal barriers (regional)
Shoreline	Barrier beach creation/nourishment
	Riprap/revetments
	Flood/seawalls
	Dikes/levees
	Stormwater management
	Elevate transportation
Marsh Restoration / Enhancement	Marsh restoration - mudflat recharge
	Marsh restoration - thin sediment layer placement
	Marsh restoration - transition zone slope/horizontal levee
	Marsh restoration - reconnect creek and baylands
	Modify pond management

- Drawn from BEHGU recommendations
- BCDC permit analysts
- Other reports (Leventhal, BCDC etc.)

Does not include:

- Upland land acquisition for T-zone
- Strategic retreat
- Many others…

- Not a complete list!
- Feel free to add/combine/phase

Adaptation Actions "Cheat Sheet"

All of these measures require further analysis before being pursued for a given reach to investigate feasibility and more precisely evaluate opportunities and constraints. These considerations are intended to give a broad overview of the geomorphic and land use factors that affect their applicability.

This list is considered neither complete nor final. Please feel free to add "actions" and add to or edit the applicability considerations.

Area of focus	Actions to protect Bay resources and development[1]	Description	Applicability Considerations
Subtidal	Sills or living breakwaters	Offshore breakwaters that provide wave attenuation at low water levels and possibly habitat (e.g., eelgrass beds/oyster reefs)	--High: Wide mudflats, historic populations, low-med wave energy --Low: Narrow mudflats, high wave energy, high Bay SSC
	Tidal barriers	Controllable tide gate structures across creeks, rivers and even major waterways to limit the impact of high tides; gates have to closed more and more as sea level rises	--Medium: Narrow channels, low wave energy/currents, backwater flooding from watershed runoff against rising tides causes a public safety issue and long-term planning underway --Low: Wide channels, high wave energy/currents, local efforts can be better spent on small-scale actions, there are not people/critical assets in areas at risk that would justify large investment
	Barrier beach creation/nourishment	Coarse beach (gravels/cobbles) to prevent shoreline erosion; habitat-friendly, cost-competitive alternative to riprap; may require periodic replenishment of sediment	--High: Historical/current beaches, high wave energy, depositional nearshore sediment transport, coarse sediment supply to provide ongoing replenishment, space to retreat back as sea level rises --Medium: Fronting fringing marshes even if no historical/current beaches --Low: No historical/current beaches, dispersive nearshore sediment transport (high erosion rates = high maintenance/nourishment costs)
	Riprap/revetments	Small/large rocks to prevent shoreline erosion	--High: Steep slope, narrow marsh, critical land uses (limited space for nature-based solutions), existing hardened shoreline (2:1 slope) --Low: Gentle slope, current beaches (20:1 foreshore 5:1 storm berm),

Worksheet

Evaluation of Adaptation Actions

No.	Actions to protect Bay resources and development	Applicability Considerations	Timing and Adaptability	Other Notes
		• *Why is this action applicable in this case study?* • *What other information would you need?*	• *What is the life span of the action?* • *When should the strategy be implemented and how much lead time is required?* • *Is the strategy adaptable over time and can it be combined with other actions over the long and short term?*	• *Constructable with existing understanding?* • *Cost-effective?* • *Impacts to the economy, environment and society and equity?*
1				
2				
3				
4				

Example case study: Marsh Enhancement

- Walk through one example (brief)
- After the break, we will split into our groups and repeat this process for the 4 other case studies
- Then we'll report back

MARSH ENHANCEMENT

SETTING SUMMARY:

This case study focuses on a wide alluvial valley with a medium/large sized brackish marsh along the shoreline. The marsh edge experiences erosion due to high/medium wave energy. The marsh is bisected by a major creek with coarse sediment stored in the flood control channel. Significant transportation routes, industrial land uses and open space are located in-land of the marsh. Sea level rise is expected to reach 12" by 2050 and 36" by 2100.

WHAT'S AT RISK FROM SEA LEVEL RISE?

- Tidal marsh, and marsh-dependent wildlife
- Railroads
- Landfills
- Industrial land uses

ASSIGNMENT:

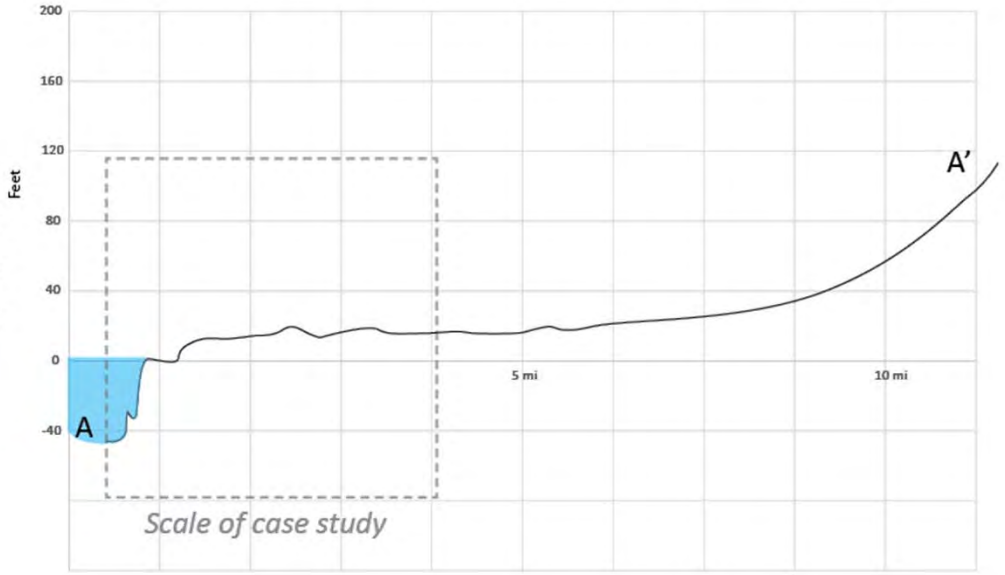
Evaluate at least three adaptation actions that will preserve and protect existing naturalresources/development to mid-century and that are adaptable to end of century.

To the maximum practicable extent, strategies should:

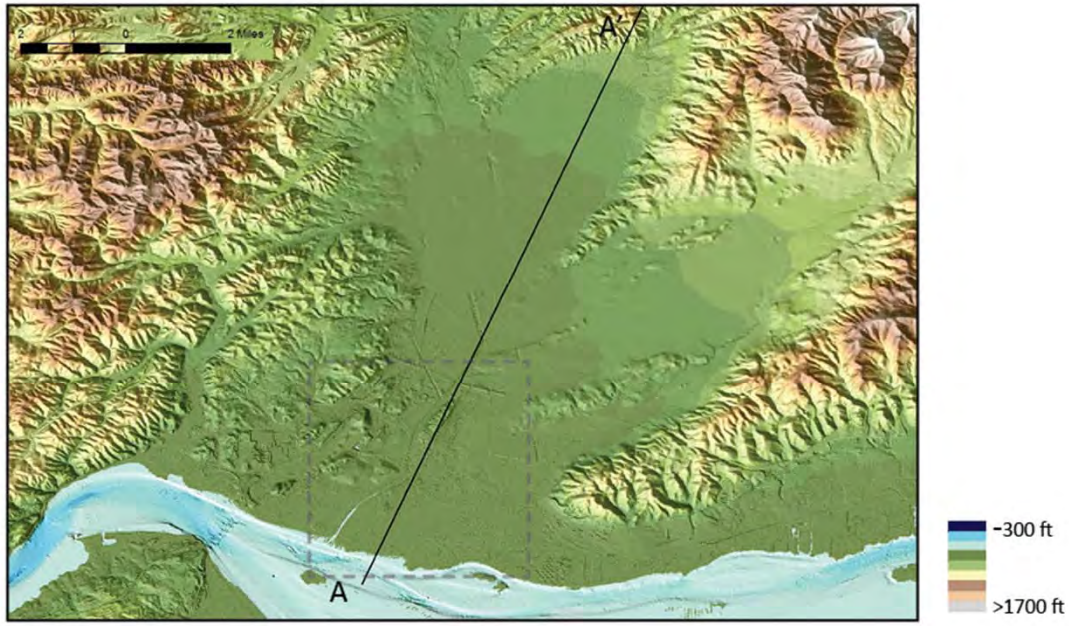
- Maximize nature-based adaptation solutions where appropriate;
- Promote equitable solutions that increase resilience in communities, especially those that are most vulnerable;
- Restore and enhance diversity of Bay ecosystems and wildlife; and
- Support sustainable development, economic health, and quality of life of the Bay Area.

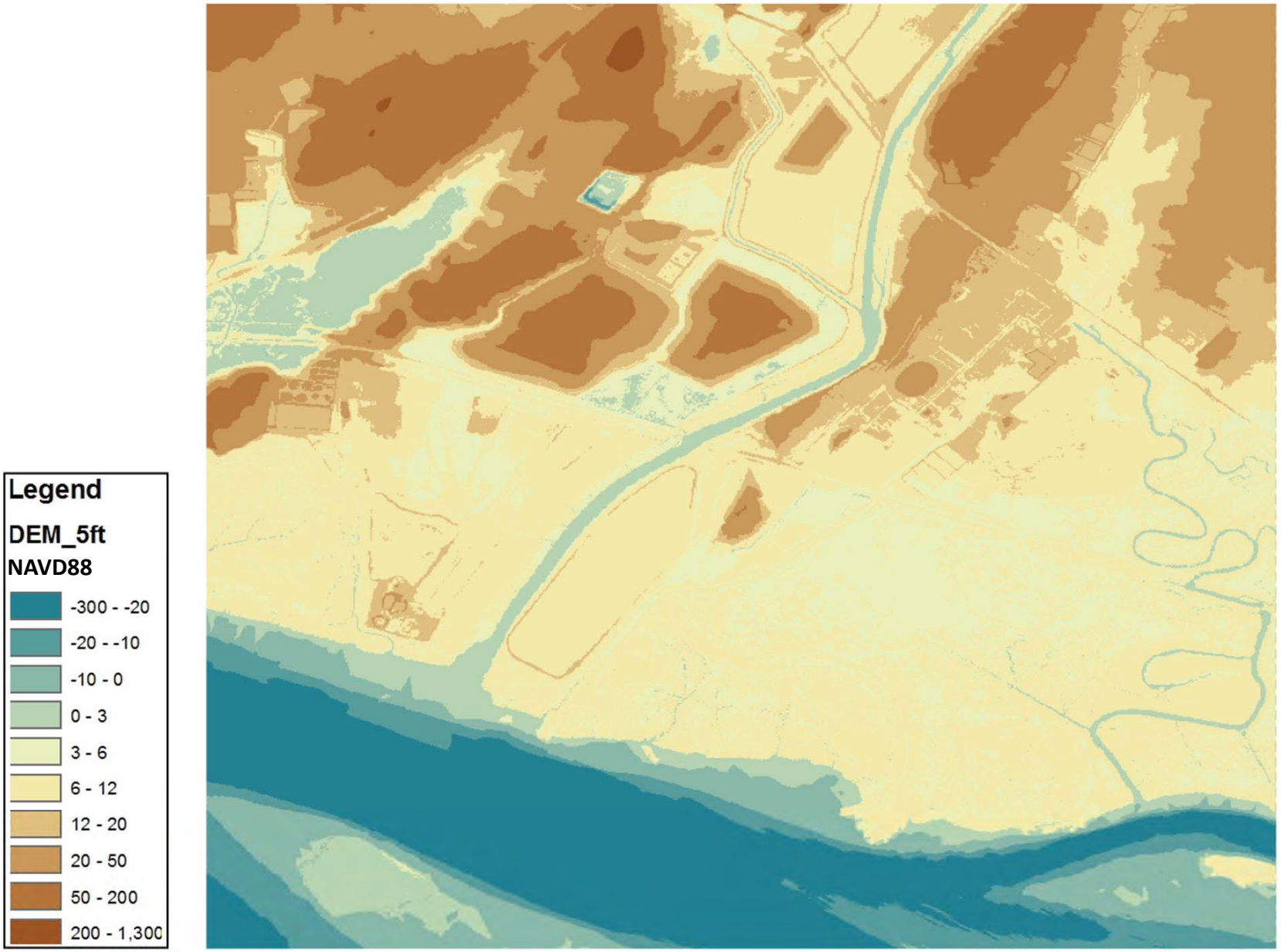
CASE STUDY 1: Marsh Enhancement

CONCEPTUALIZED CROSS SECTION

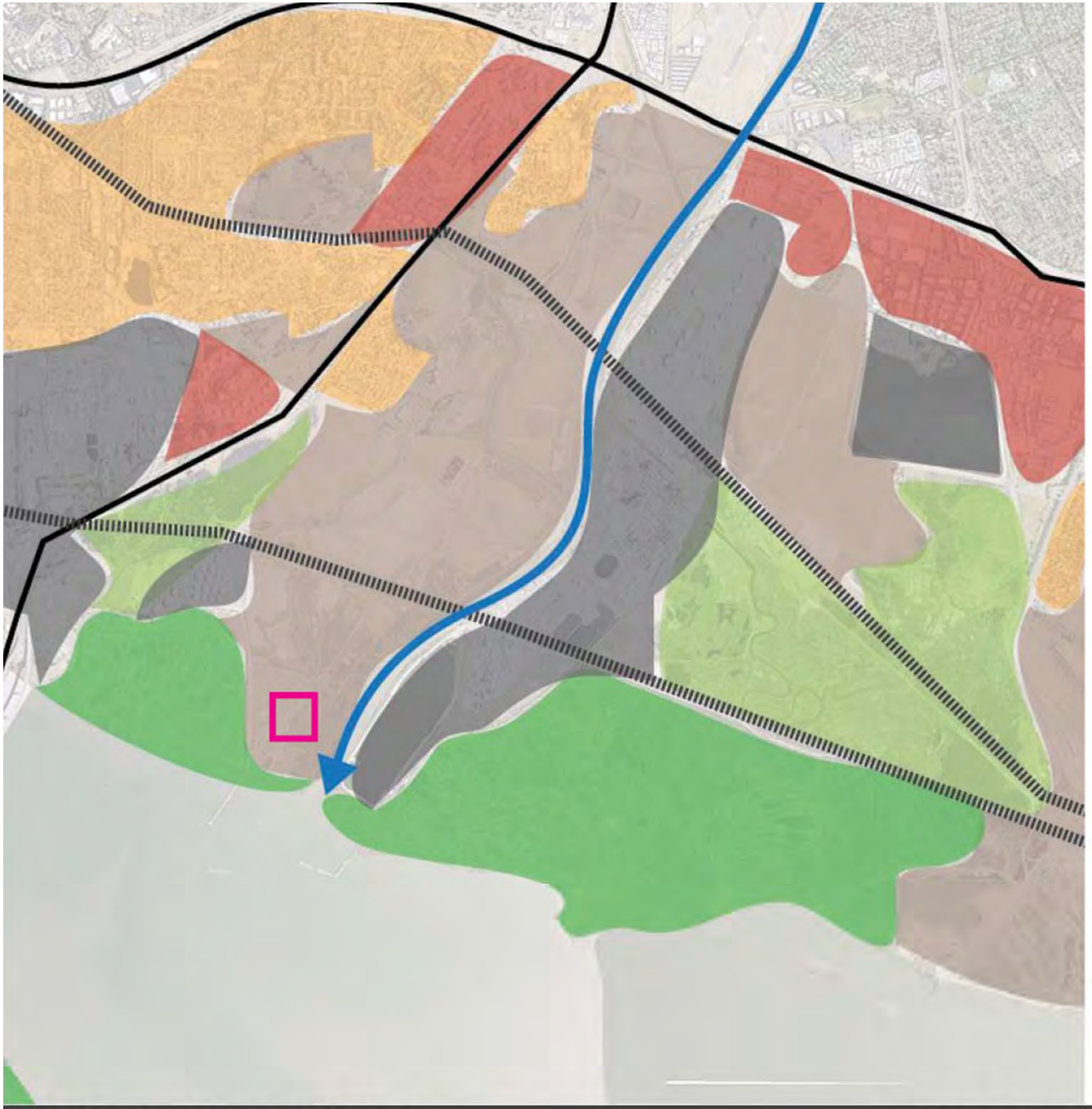


CONCEPTUALIZED LANDSCAPE SETTING





Source: OPC LiDAR 2010

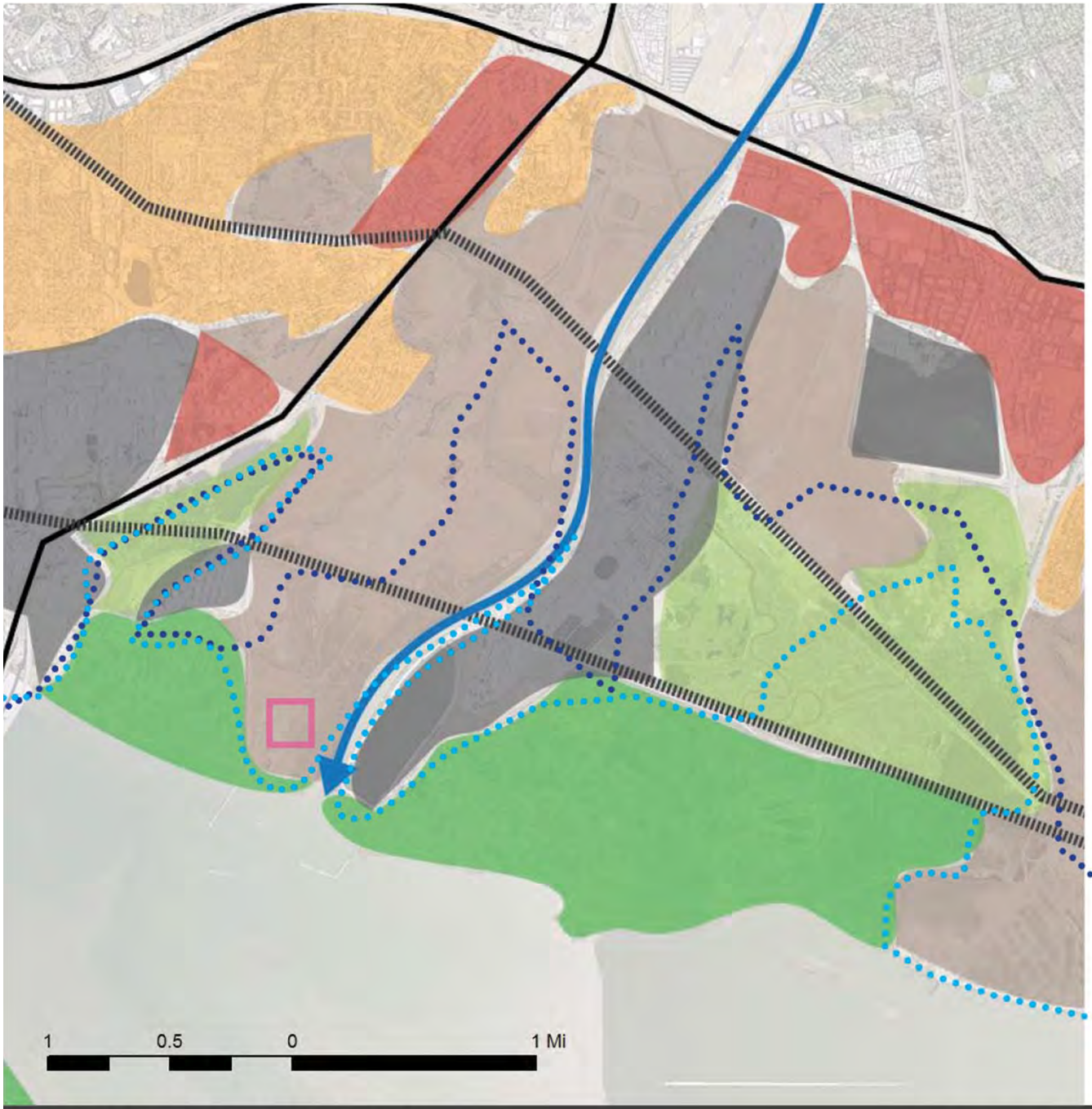


CONCEPTUAL LAND USES

- Tidal marsh
- Muted tidal marsh
- Open space/landfills etc.
- Heavy industrial
- Light industrial/commercial
- Residential (near baylands)
- Railroad
- Major road
- Major creek
- Historic contaminated landfill

CONCEPTUAL LANDSCAPE SETTING CHARACTERISTICS	
Geomorphic setting	Wide alluvial valley
Bay SSC	Low
Wave energy	Medium
Nearshore sediment transport	Dispersive
Proximity to deep water	High
Mudflat width	Narrow
Shoreline composition	Marsh (brackish)
Shoreline evolution	Eroding
Species consideration	Ridgeway rails
Marsh width	Wide
Watershed sed yield	High

CASE STUDY 1 MARSH ENHANCEMENT



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- 1 ft SLR + MHHW (NOAA)
- 3 ft SLR + MHHW (NOAA)

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Which to explore further?

Area of focus	Actions to protect Bay resources and development
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	Dikes/levees
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	Modify pond management

Adaptation Actions "Cheat Sheet"

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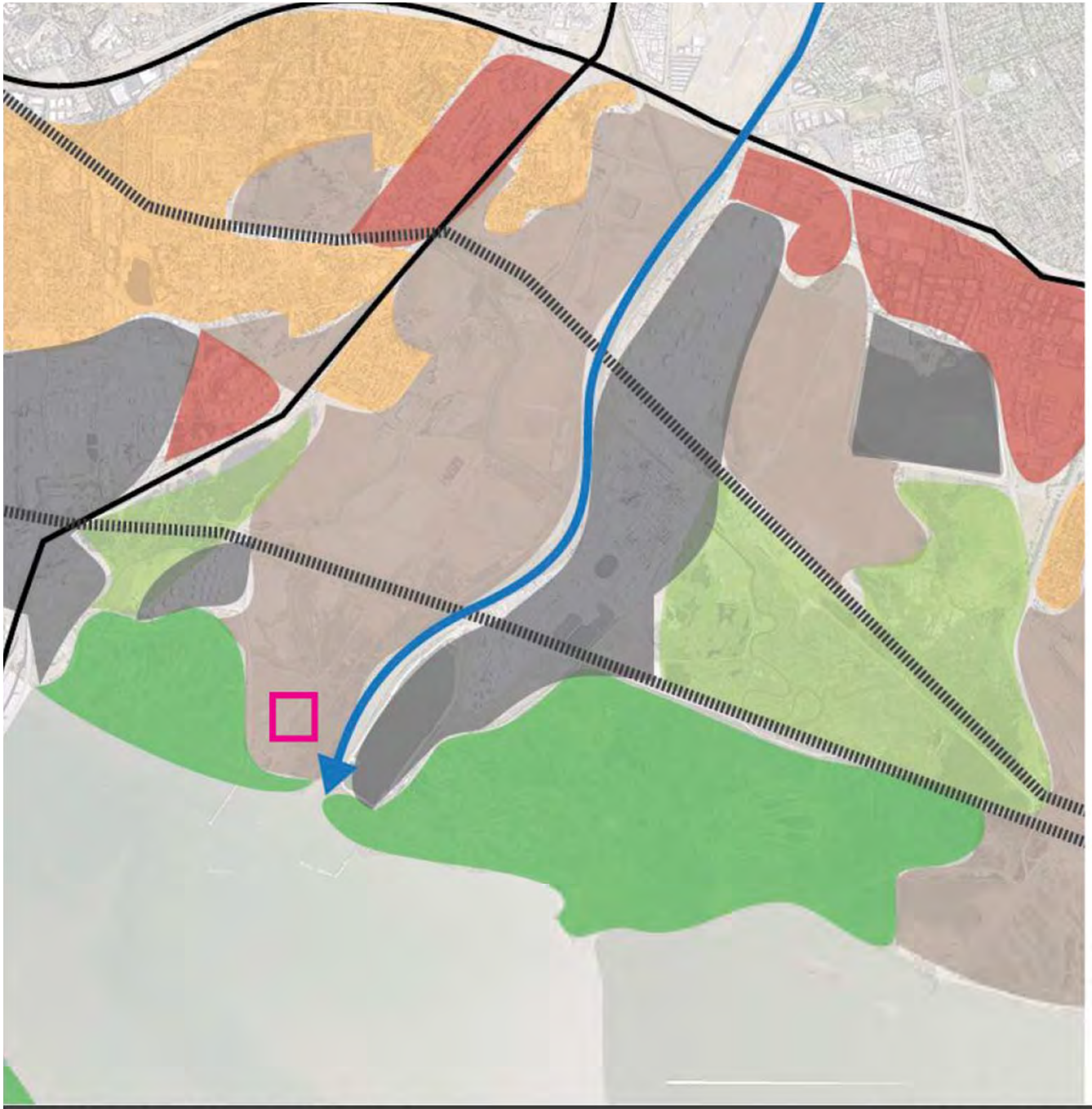
	Flood/seawalls	Walls constructed in narrow right-of-way to prevent inland flooding; can be constructed on the ground or on the top of existing dikes/levees and ability to raise walls as sea level rises depends on foundation, e.g., soft bay muds require deeper foundation may require rebuilding to stay effective; often require pump stations if wall impedes gravity drainage	--High: No natural area/space for nature-based solutions between the Bay and development, sheltered from wave energy --Low: Wide tidal marsh, no people/critical assets at risk, high wave energy
		Earthen structures built to prevent inland flooding; top width needs to be wide enough to allow for equipment to raise the elevation as sea level rises; levee tops can be used for roads/trails; FEMA certification requirements	--High: No natural area/space for nature-based solutions between the Bay and development, high wave energy --Low: Wide tidal marsh and no people/critical assets at risk



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CASE STUDY 1 MARSH ENHANCEMENT

Worksheet

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1	Riprap	**Low applicability**: wide marsh, critical resources not near shoreline, wider area for natural solutions.	**NA**	**NA**
2				

Which to explore further?

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	Tidal barriers (regional)
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	~~Riprap/revetments~~
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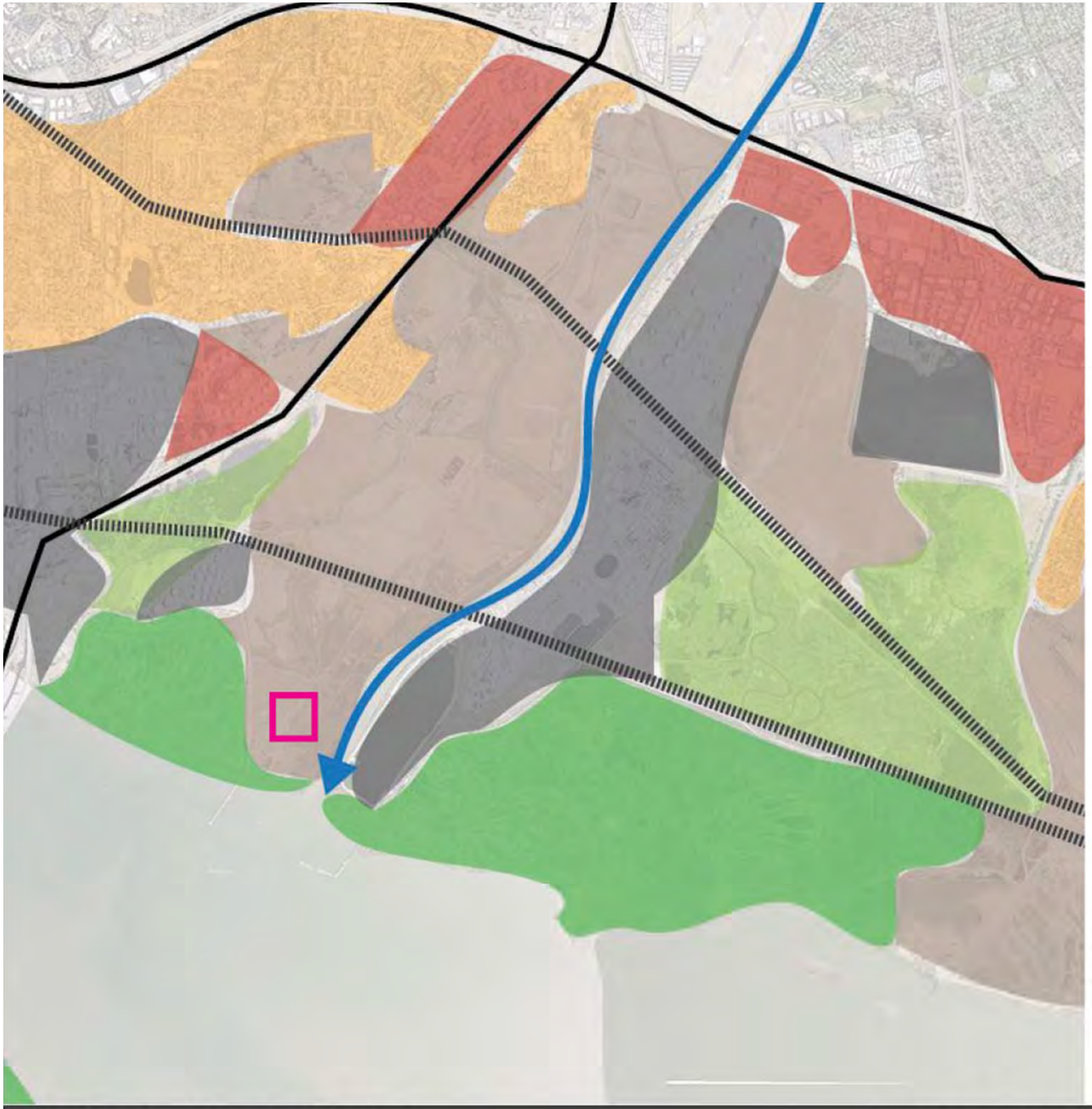
	Flood/seawalls	Walls constructed in narrow right-of-way to prevent inland flooding; can be constructed on the ground or on the top of existing dikes/levees and ability to raise walls as sea level rises depends on foundation, e.g., soft bay muds require deeper foundation may require rebuilding to stay effective; often require pump stations if wall impedes gravity drainage	--High: No natural area/space for nature-based solutions between the Bay and development, sheltered from wave energy --Low: Wide tidal marsh, no people/critical assets at risk, high wave energy
		Earthen structures built to prevent inland flooding; top width needs to be wide enough to allow for equipment to raise the elevation as sea level rises; levee tops can be used for roads/trails; FEMA certification requirements	--High: No natural area/space for nature-based solutions between the Bay and development, high wave energy --Low: Wide tidal marsh and no people/critical assets at risk

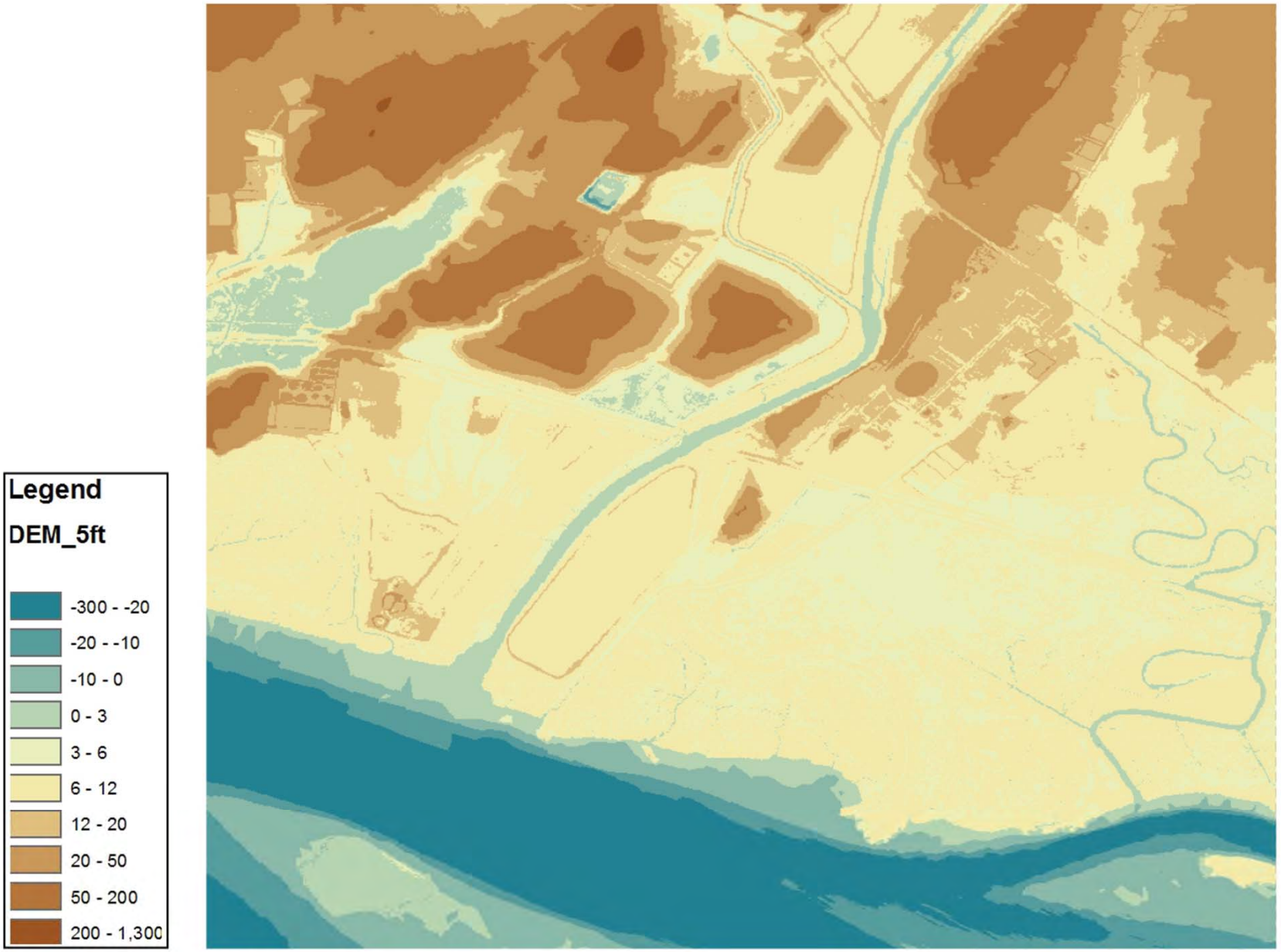


CONCEPTUAL LAND USES

- Tidal marsh
- Muted tidal marsh
- Open space/landfills etc.
- Heavy industrial
- Light industrial/commercial
- Residential (near baylands)
- Railroad
- Major road
- Major creek
- Historic contaminated landfill

CONCEPTUAL LANDSCAPE SETTING CHARACTERISTICS	
Geomorphic setting	Wide alluvial valley
Bay SSC	Low
Wave energy	Medium
Nearshore sediment transport	Dispersive
Proximity to deep water	High
Mudflat width	Narrow
Shoreline composition	Marsh (brackish)
Shoreline evolution	Eroding
Species consideration	Ridgway's rails
Marsh width	Wide
Watershed sed yield	High

CASE STUDY 1 MARSH ENHANCEMENT



Source: OPC LiDAR 2010

Adaptation Actions "Cheat Sheet"

All of these measures require further analysis before being pursued for a given reach to investigate feasibility and more precisely evaluate opportunities and constraints. These considerations are intended to give a broad overview of the geomorphic and land use factors that affect their applicability.

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Area of focus	Actions to protect Bay resources and development[1]	Description	Applicability Considerations
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Worksheet

Evaluation of Adaptation Actions

No.	Actions to protect Bay resources and development	Applicability Considerations	Timing and Adaptability	Other Notes
		• *Why is this action applicable in this case study?* • *What other information would you need?*	• *What is the life span of the action?* • *When should the strategy be implemented and how much lead time is required?* • *Is the strategy adaptable over time and can it be combined with other actions over the long and short term?*	• *Constructable with existing understanding?* • *Cost-effective?* • *Impacts to the economy, environment and society and equity?*
1	Riprap	**Low applicability**: wide marsh, critical resources not near shoreline, wider area for natural solutions.	**NA**	**NA**
2	Beach	**Medium applicability**: eroding marsh, med wave energy with endangered spp., with high local sed supply. BUT dispersive, because of narrow mudflats, deep water		

- What is the life span of the strategy?
- When should the strategy be implemented and how much lead time is required?
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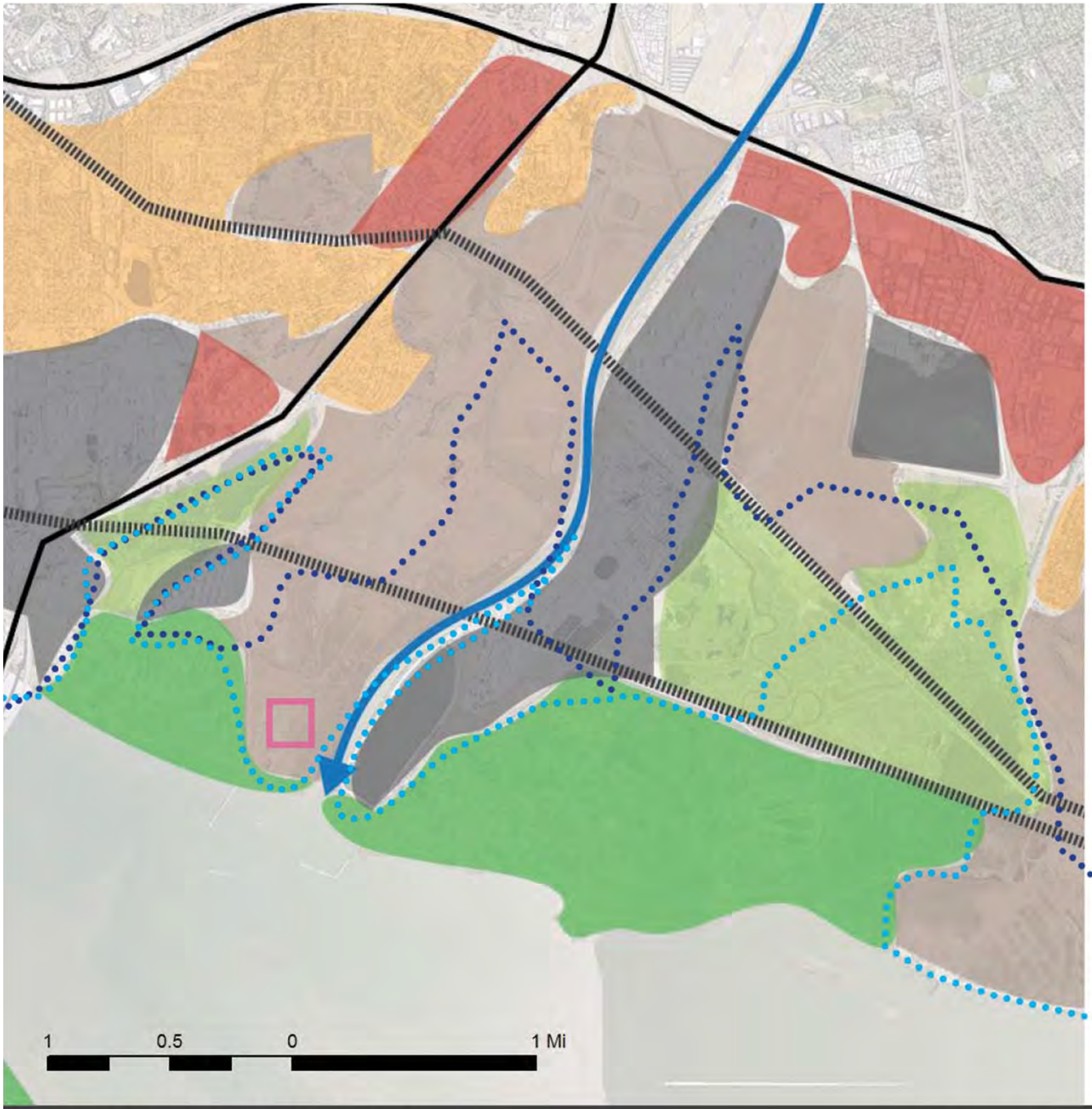

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- 1 ft SLR + MHHW (NOAA)
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Species consideration	Ridgeway rails
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Watershed sed yield	High

Worksheet

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- Is it constructable with existing understanding?
- Cost-effective?
- Can it be permitted?
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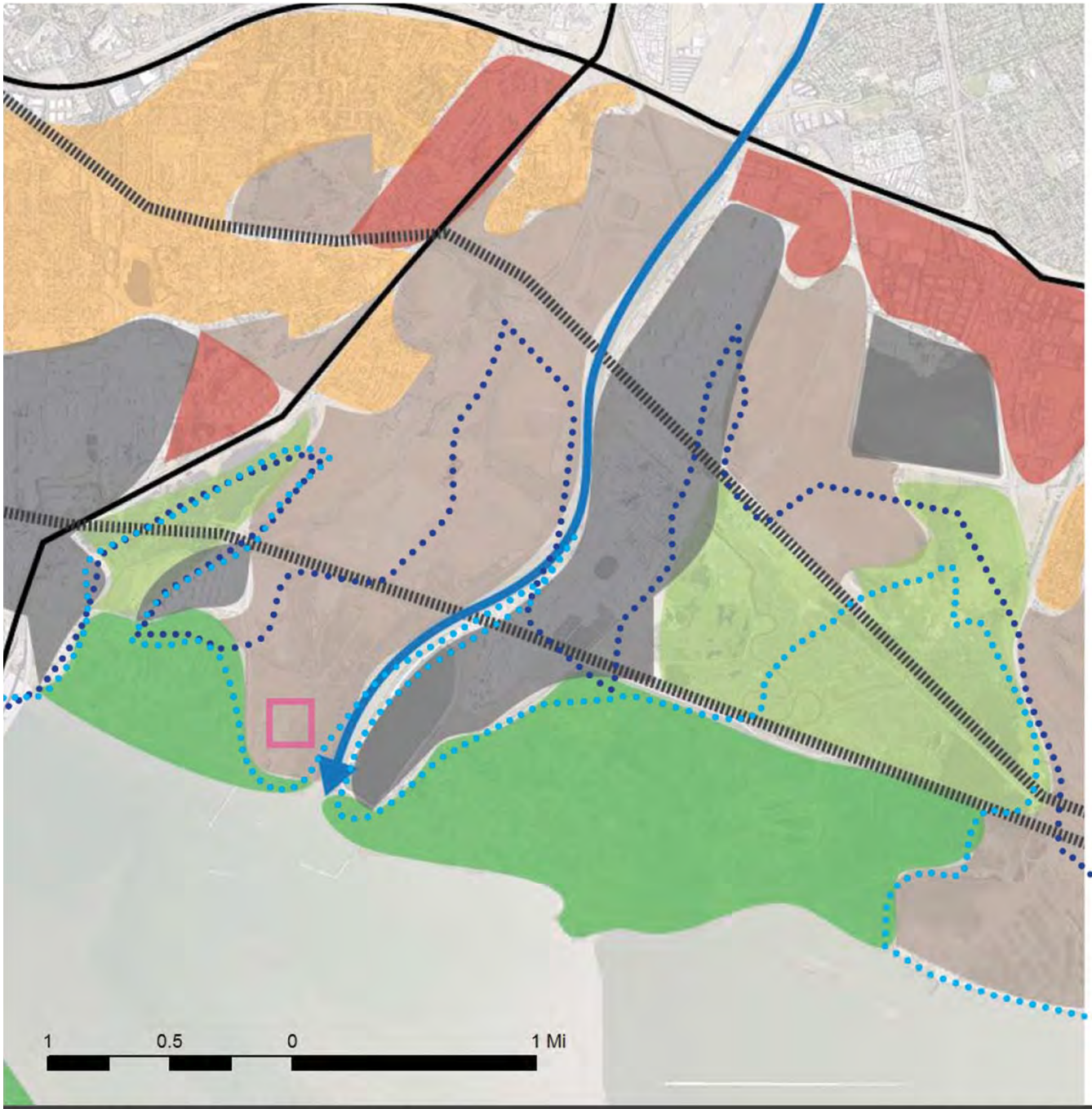
Marsh Enhancement[2]	Thin sediment layer placement	Direct approach to increase marsh plain elevation by introducing sediment in thin layers via spray dredging; potential for beneficial reuse	--High: Wide, high marsh/salt pond (elevation capital), fine sediment supply (from watershed/flood control channels), minimal impacts to endangered species --Low: Narrow marsh
	Transition zone slope/horizontal levee	Construct gentle slope (30:1 to 50:1) through placement of fill to enhance marsh and integrate with flood protection levee ("horizontal levees"); potential for decentralized wastewater treatment/disposal	--High: Wide marsh/salt pond and adjacent development --Medium: Long-term land use plan involves land acquisition/strategic retreat --Low: Narrow marsh/natural area between the Bay and development; insufficient fill supply/constructability constraints
	Reconnect creek and baylands	Restore sediment and freshwater connections (e.g., allow creek to enter a marsh through a slough, place dredged sediment from a flood channel near marsh) to build up marsh plain elevation/create brackish conditions	--High: Wide marsh, proximal creeks (freshwater and sediment input), high sediment availability --Low: Narrow marsh, no proximal creeks
	Modify pond management	Factor sea level rise into pond management and consider how higher water levels/more ponding and worse drainage affect wildlife goals	--High: Large ponds supporting significant wildlife --Low: No large ponds



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CASE STUDY 1 MARSH ENHANCEMENT

Worksheet

Evaluation of Adaptation Actions

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3	**Reconnect creek to baylands**	**High applicability**: Wide marsh, proximal creek, high sed supply, Nearby open space	**Short and long term:** Begin planning now, to build up marsh plain	+ Reuse of local sediment + Restores natural process + Marsh keeps pace with SLR? - Difficult to permit [Flood control etc] - Species considerations - Contamination considerations

Case study 1: Marsh Enhancement

Area of focus	Actions to protect Bay resources and development	Is this applicable in this case study? Why or why not?	What is the time frame for this action?	What are the tradeoffs to consider?
Subtidal	1. Living breakwaters/sill			
	2. Tidal barriers (regional)			
Shoreline	3. Barrier beach creation/nourishment	M	**short**	...
	4. Riprap/revetments			
	5. Flood/seawalls			
	6. Dikes/levees	M	**short/long**	...
	7. Stormwater management	M	**short/long**	...
Marsh Restoration / Enhancement	8. Marsh restoration - mudflat recharge			
	9. Marsh restoration - thin sediment layer placement	H	**short**	...
	10. Marsh restoration - transition zone slope/horizontal levee	H	**long**	...
	11. Marsh restoration - reconnect creek and baylands	H	**long**	...
	12. Modify pond management			

Other ideas? Regional implications? Phased approach? Timing? Contingencies etc?

- Questions?
- Time for a break. Then it’s your turn.
- Thank you.