Agenda Item #10

Operational Landscape Units For San Francisco Bay:

Using nature's jurisdictions to plan for sea level rise

BCDC COMMISSION HEARING
July 19, 2018

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Marin Community Foundation
Moore Foundation

SPUR SFEI AQUATIC SCIENCE CENTER
SAN FRANCISCO ESTUARY INSTITUTE & THE AQUATIC SCIENCE CENTER

A new look at the Bay

- Create spatial framework to guide nature-based adaptation strategies for sea-level rise
- "Nature's jurisdictions"
- Pairing problems with adaptation measures in appropriate places

Project Rationale

1. Processes that govern the shoreline happen at the **Bay scale**. Too large and complex for individual projects.

OCEAN / BAY PROCESSES
WATERSHED PROCESSES
ESTUARINE PROCESSES

Project Rationale

1. Processes that govern the shoreline happen at the **Bay scale**. Too large and complex for individual projects.
2. Need to **divide up the Bay** into smaller manageable pieces: Sea level rise won't stop at city boundaries.

Another way of splitting the Bay?

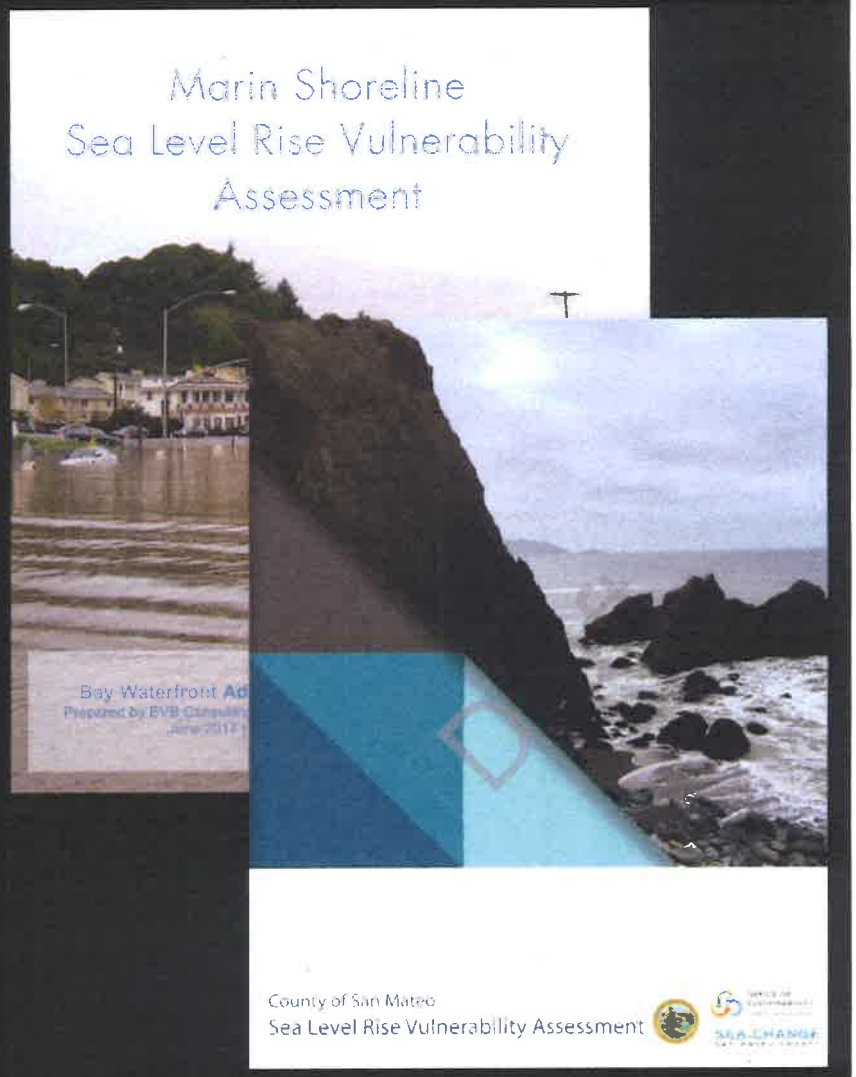
- City boundaries
  - Generally smaller than the vulnerable areas
- County boundaries
  - Often split creeks
- Watersheds
  - Poorly defined in flat Baylands
- Bayland Goals segments
  - Based on historical wetlands

Project Rationale

1. Processes that govern the shoreline happen at the **Bay scale**.
2. Need to **divide up the Bay** into smaller pieces to manage.
3. Risk of the **wrong type** of actions in the **wrong places**. Less resilience, and not all the benefits.
4. Opportunity to maximize **multi-benefit, nature-based solutions**. More resilience, most co-benefits, more adaptable over time.

How can this be used?

- Assist environmental review and permitting
  - RWQCB
- Inform local and regional vulnerability analyses and adaptation actions
  - ART Bay Area
  - BCDC's Regional Adaptation Plan
  - MTC's Horizon/Bay Plan Area
  - San Mateo SeaChange
  - Marin BayWAVE

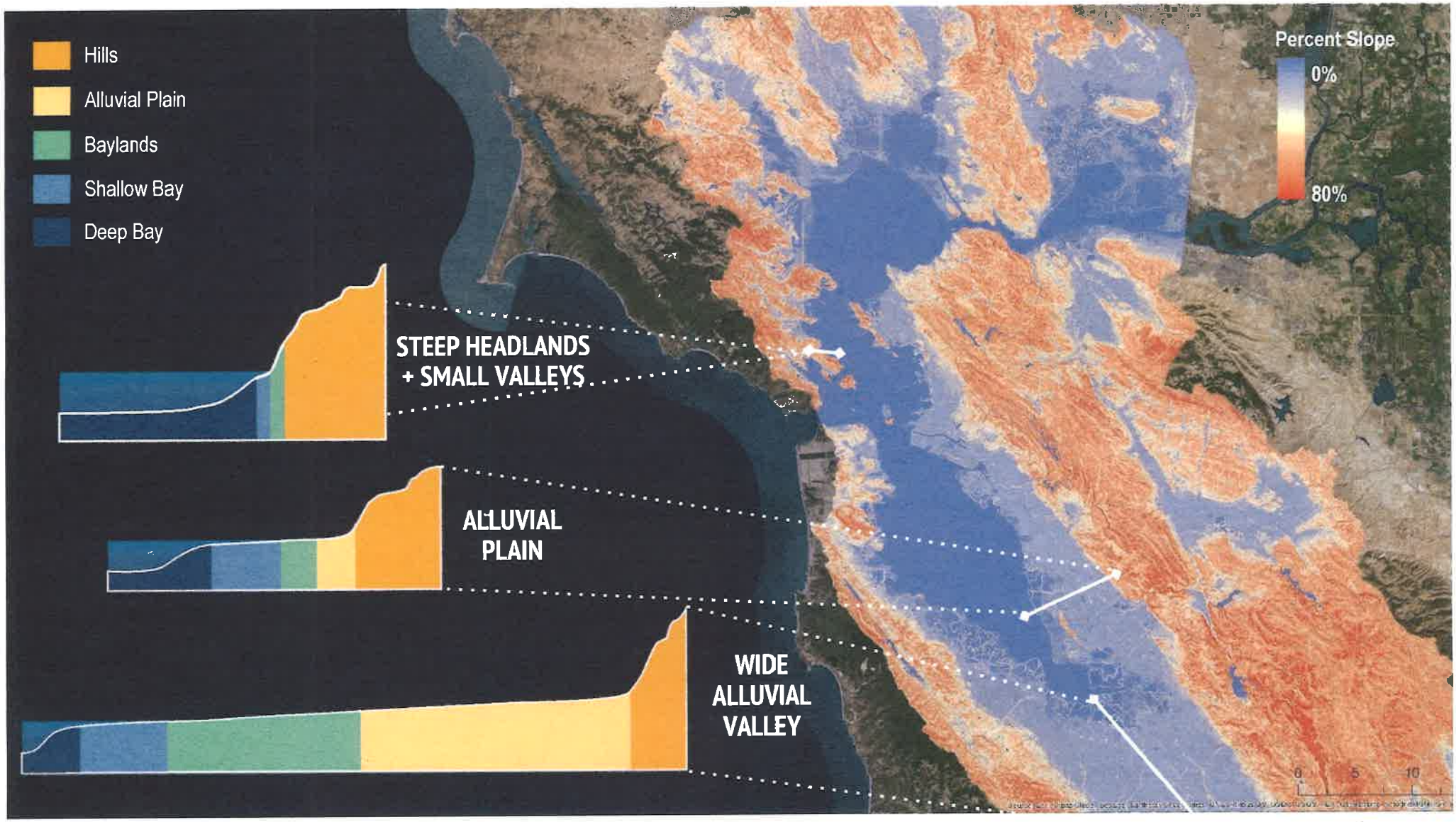


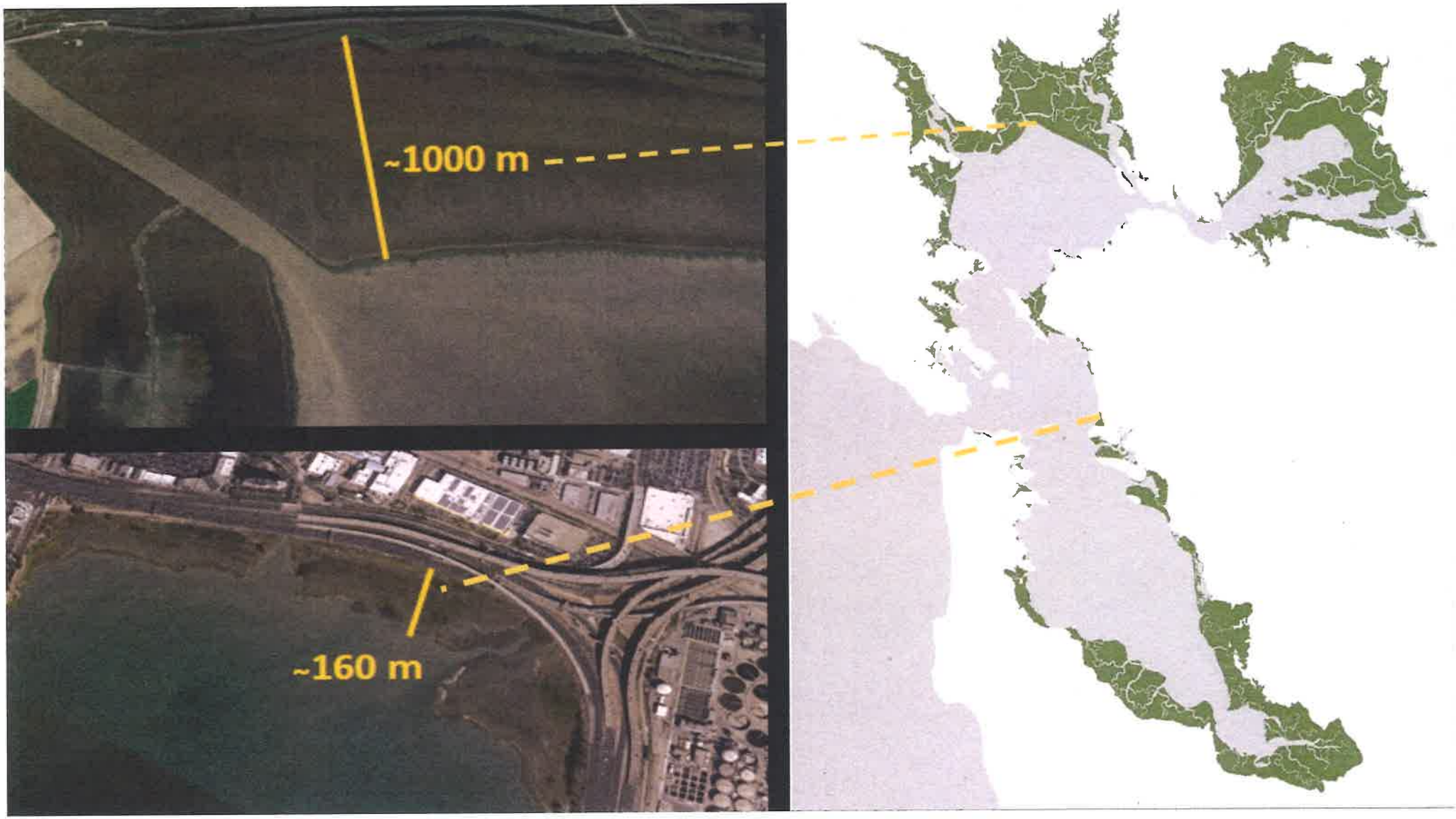
Defining OLU Boundaries

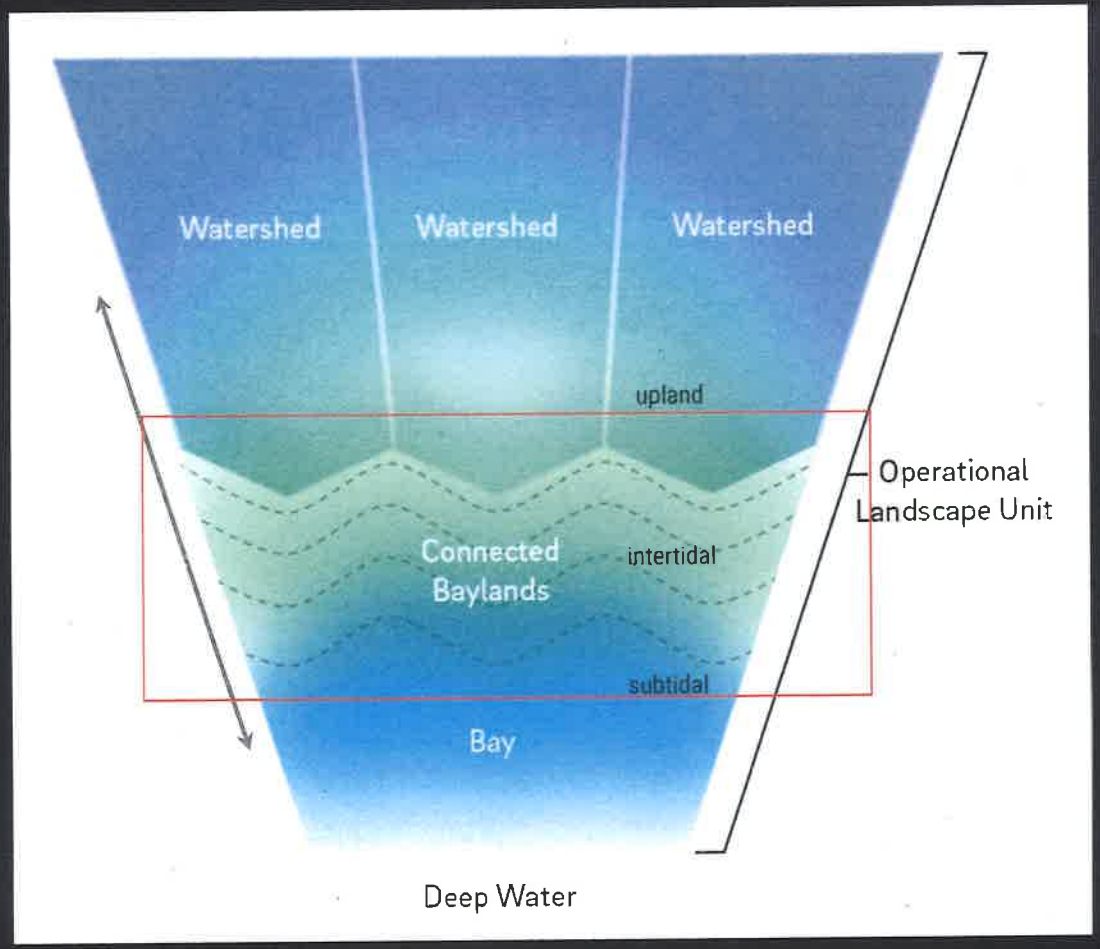
Percent Slope
0%
80%
0
5
10

Hills
Alluvial Plain
Baylands
Shallow Bay
Deep Bay
STEEP HEADLANDS
+ SMALL VALLEYS
Percent Slope
0%
80%
0
5
10

Hills
Alluvial Plain
Baylands
Shallow Bay
Deep Bay
STEEP HEADLANDS
+ SMALL VALLEYS
ALLUVIAL
PLAIN
Percent Slope
0%
80%
0
5
10


Hills
Alluvial Plain
Baylands
Shallow Bay
Deep Bay
STEEP HEADLANDS
+ SMALL VALLEYS
ALLUVIAL
PLAIN
WIDE
ALLUVIAL
VALLEY
Percent Slope
0%
80%
0
5
10

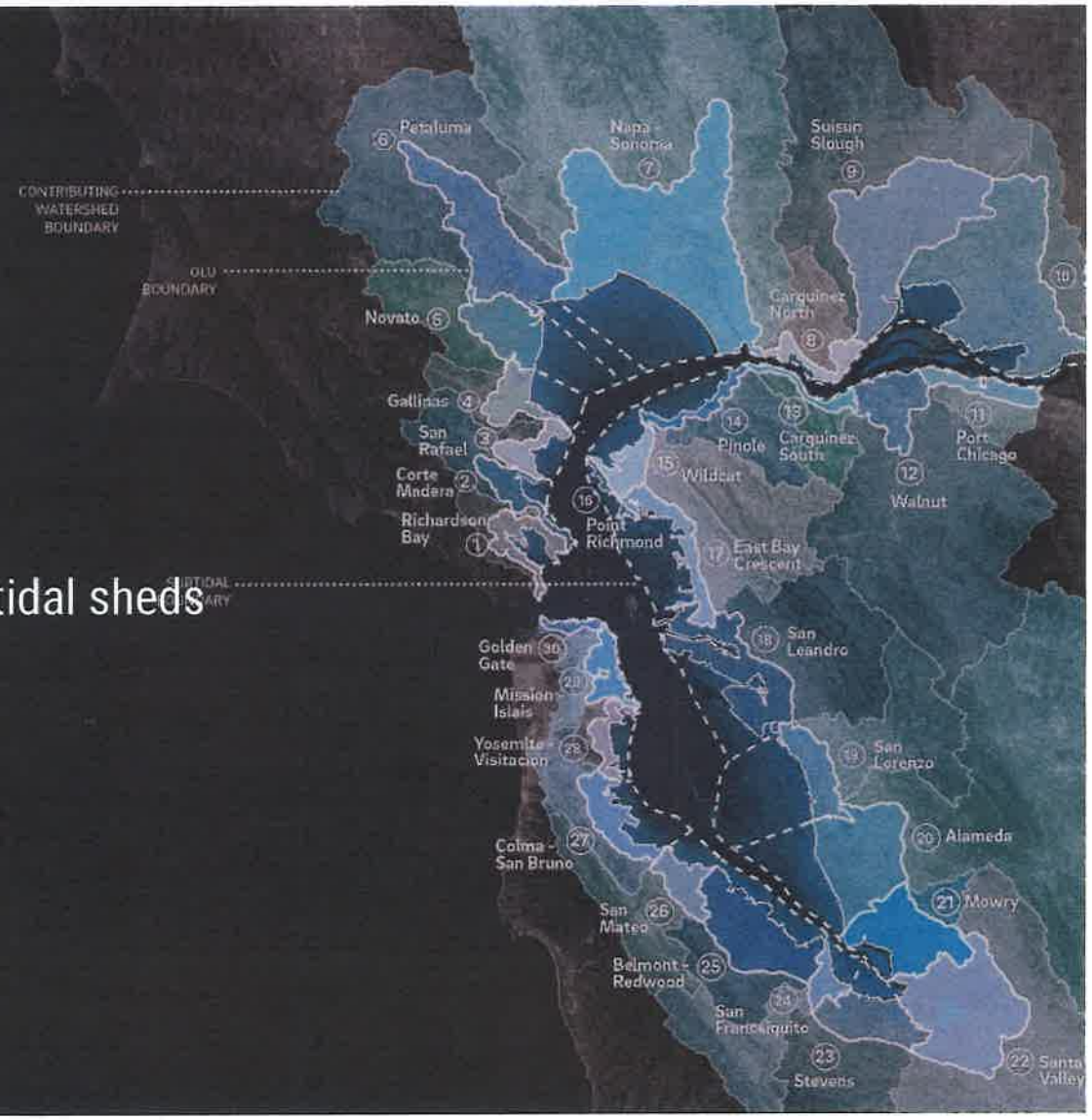

~1000 m
~160 m


Watershed
Watershed
Watershed
upland
Connected Baylands
intertidal
subtidal
Bay
Operational Landscape Unit
Deep Water

6 Petaluma
Napa - Sonoma 7
Suisun Slough 9
10 Montezuma Slough
Carquinez North 8
Novato 5
Gallinas 4
San Rafael 3
Corte Madera 2
Richardson Bay 1
14 Pinole
13 Carquinez South
11 Port Chicago
12 Walnut
15 Wildcat
16 Point Richmond
17 East Bay Crescent
18 San Leandro
Golden Gate 30
29 Mission Islais
Yosemite - Visitacion 28
19 San Lorenzo
20 Alameda
Colma - San Bruno 27
21 Mowry
San Mateo 26
Belmont - Redwood 25
24 San Francsiquito
23 Stevens
22 Santa Clara Valley

Area of analysis

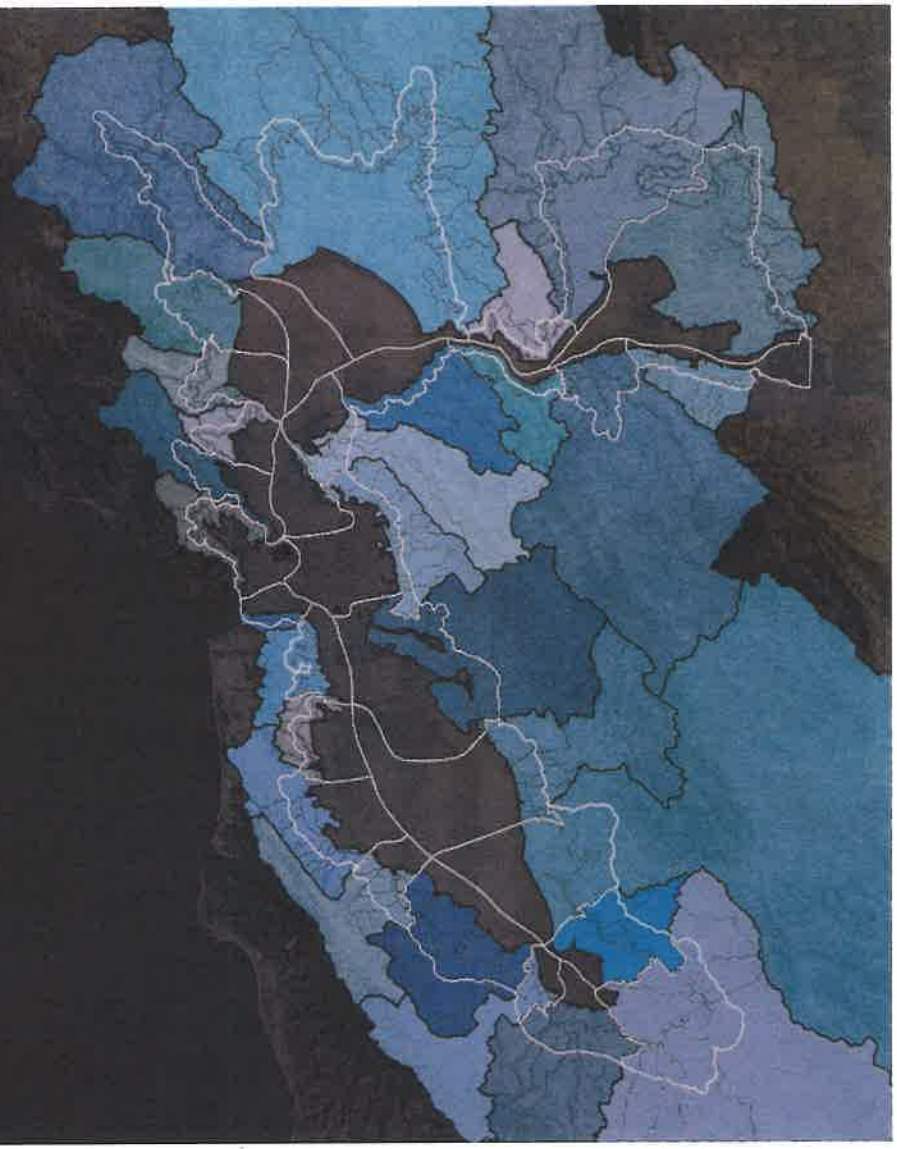
- Back boundary
  - 5 m SLR + Transition zone
- Side boundaries
  - Headlands, drainage divides, tidal sheds
- Subtidal boundary
  - Depth of closure



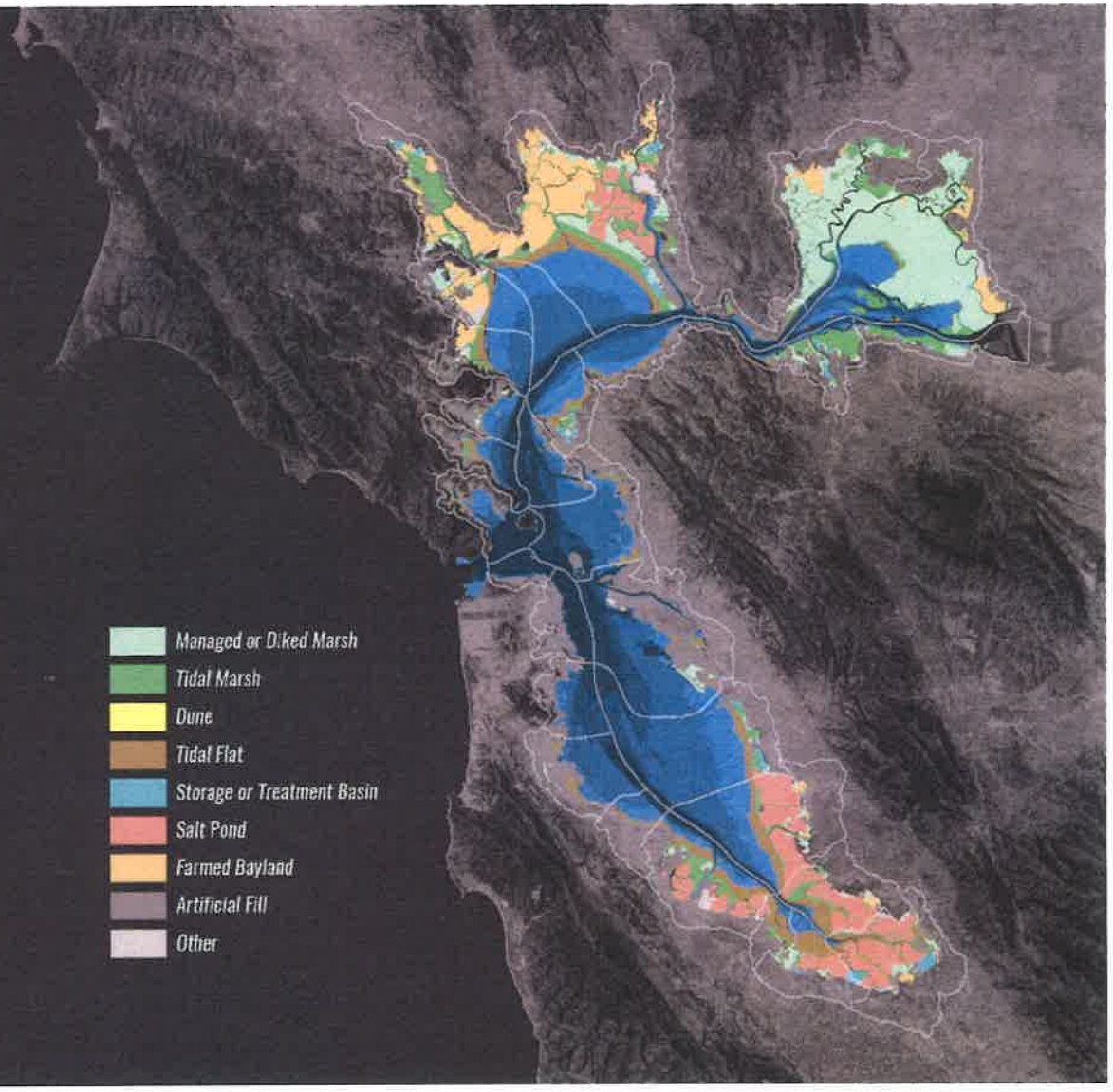
Characterizing OLUs

Watershed inputs

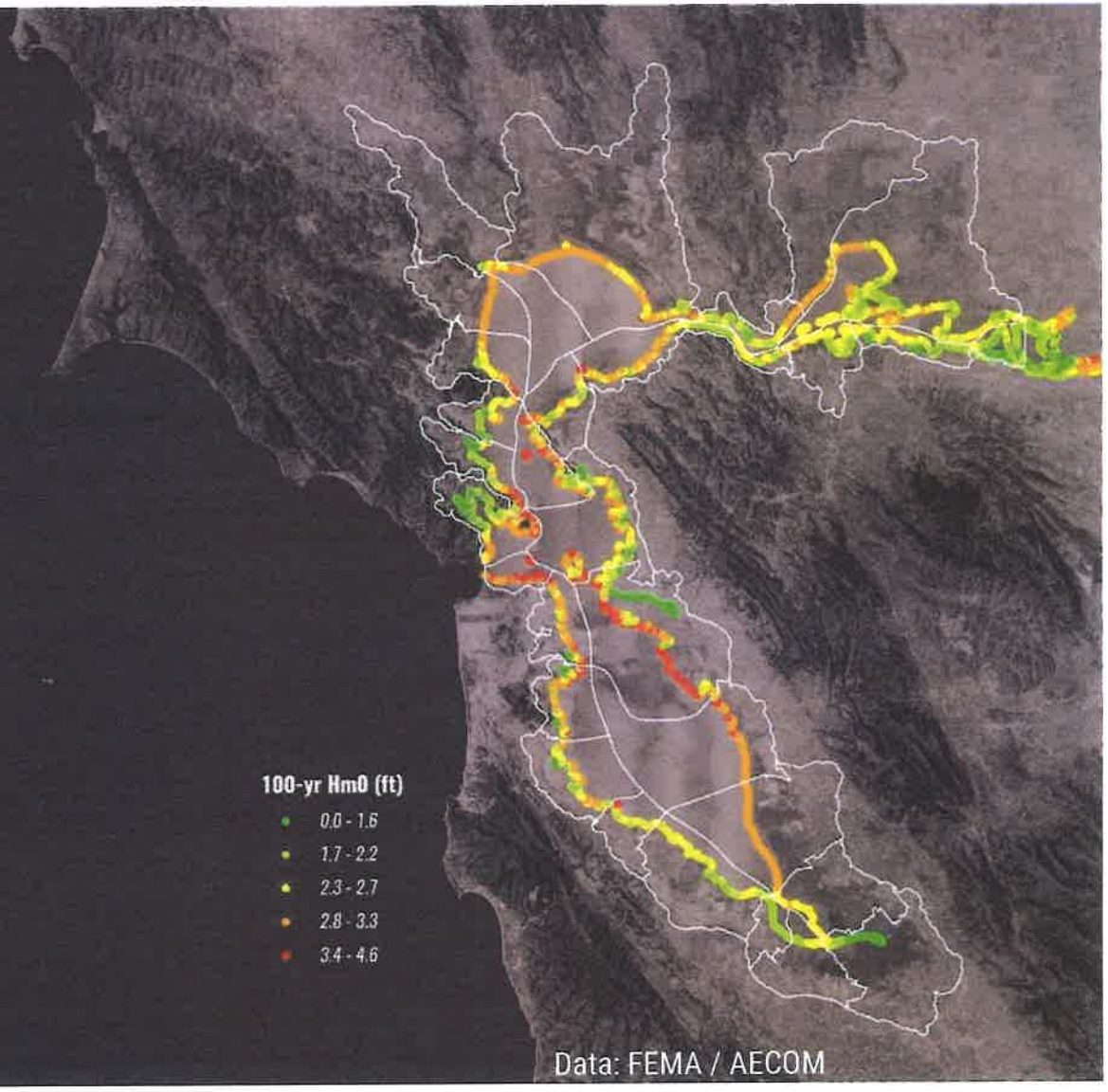
- Sediment loads
- Freshwater (Rivers and Creeks)
- Nutrients
- Creek-Bay Interfaces
- Head of Tide zones



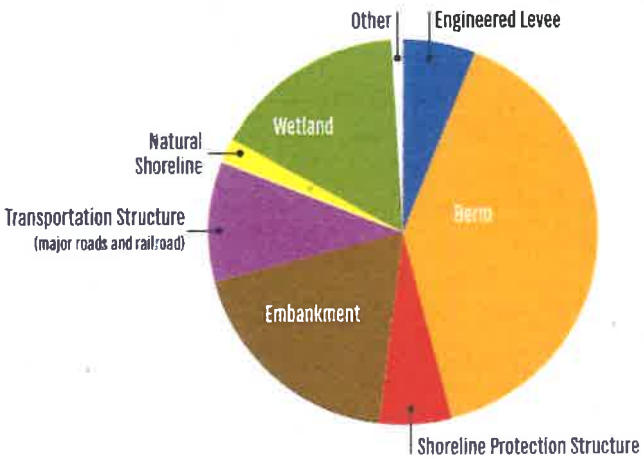
Marshes & tidal flats



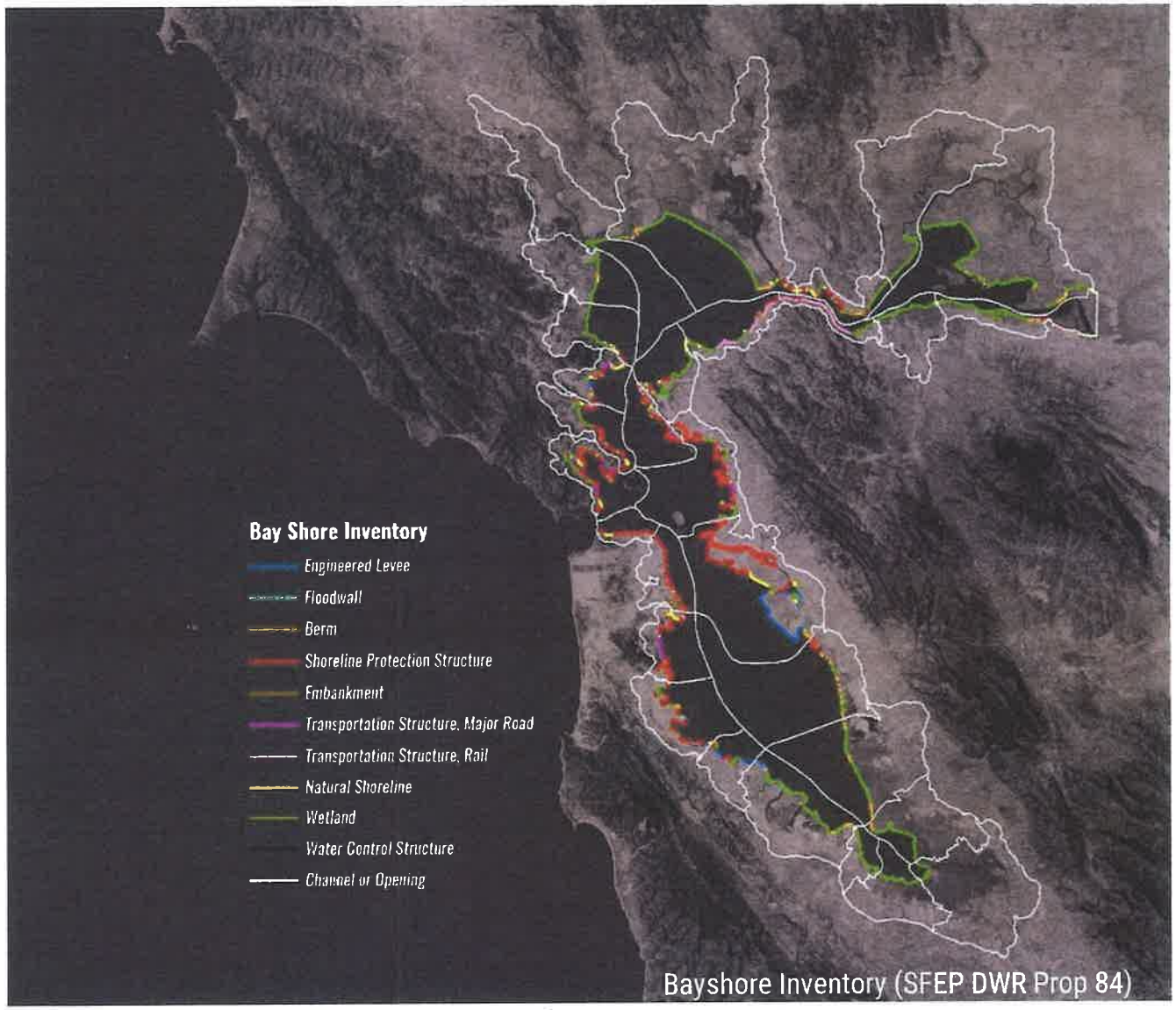
Wave heights



Shoreline Inventory



Class	Percent	Miles
Engineered Levee	6%	170
Berm	40%	1,215
Shoreline Protection Structure	6%	175
Embankment	19%	558
Transportation Structure (major roads, railroad)	10%	313
Natural Shoreline	2%	66
Wetland	16%	486
Other	1%	29
TOTAL	**100%**	**3,012**



Bayshore Inventory (SFEP DWR Prop 84)

Open Space

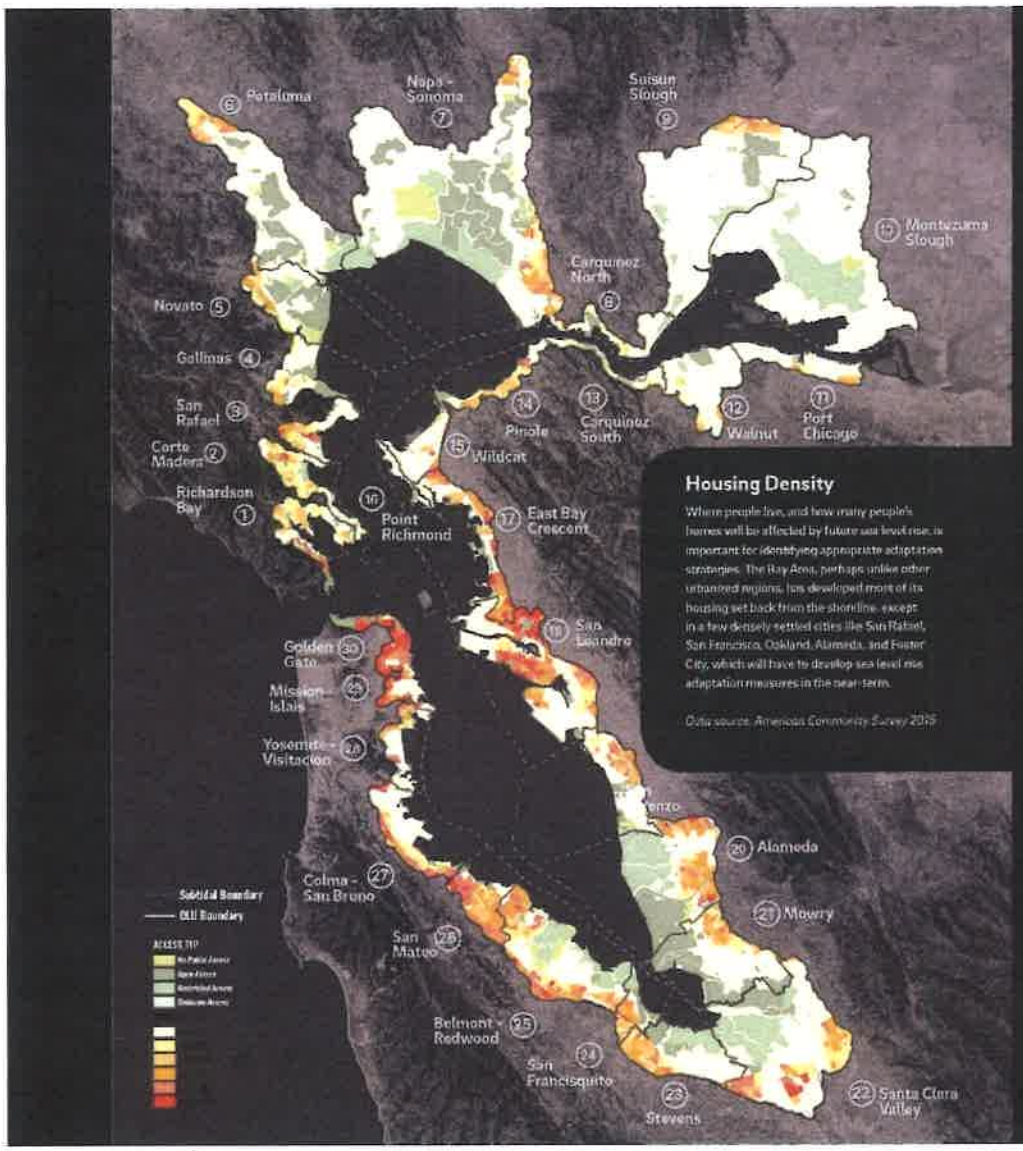
Small-lot residential with mixed use

Job-dense suburban centers

Low-density residential

Low-density commercial and industrial

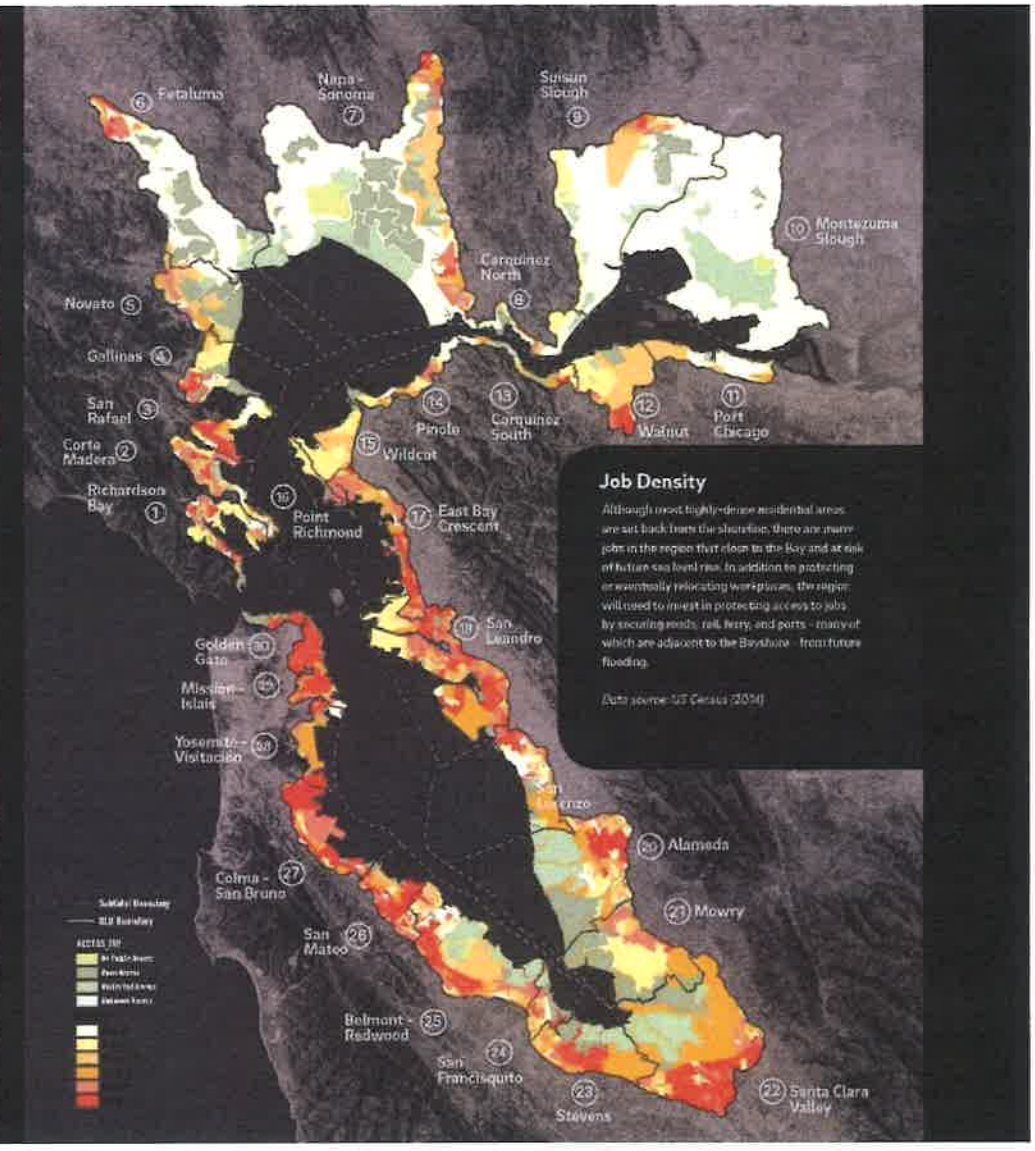
High-density downtowns



Housing Density

Where people live, and how many people's homes will be affected by future sea level rise, is important for identifying appropriate adaptation strategies. The Bay Area, perhaps unlike other urbanized regions, has developed most of its housing set back from the shoreline, except in a few densely settled cities like San Rafael, San Francisco, Oakland, Alameda, and Foster City, which will have to develop sea level rise adaptation measures in the near-term.

Data source: American Community Survey 2010



Job Density

Although most highly-dense residential areas are set back from the shoreline, there are many jobs in the region that cluster to the Bay and at risk of future sea level rise. In addition to protecting or eventually relocating workplaces, the region will need to invest in protecting access to jobs by securing roads, rail, ferry, and ports – many of which are adjacent to the Bayshore – from future flooding.

Data source: US Census (2014)

Vulnerability

LEGEND

Vulnerable buildings

- 25 cm SLR + 100 year storm
- 50 cm SLR + 100 year storm
- 150 cm SLR + 100 year storm

Flood hazard

- existing (0 cm SLR, no storm)
- 25 cm SLR + 100 year storm
- 50 cm SLR + 100 year storm
- 150 cm SLR + 100 year storm

Shoreline infrastructure

lower ← → higher

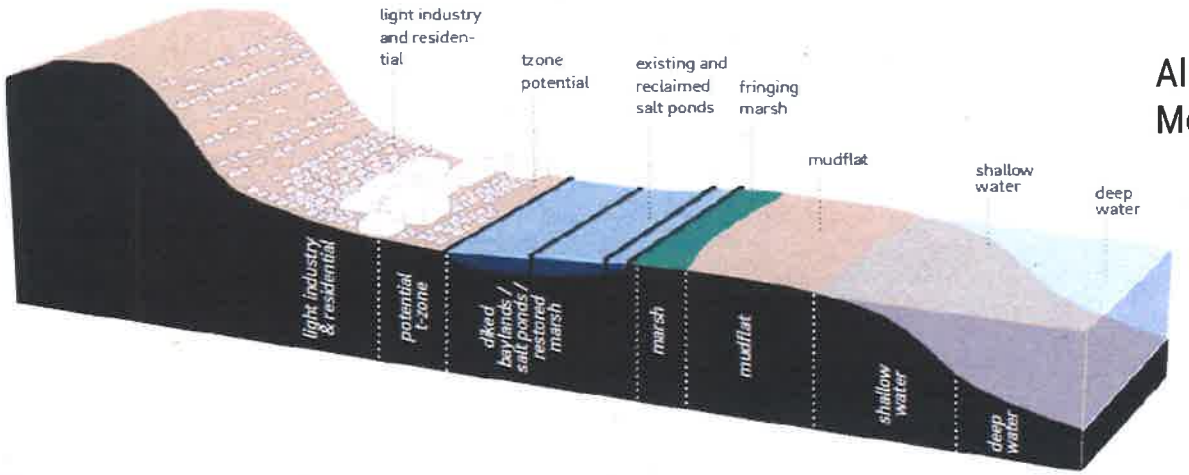
natural

built

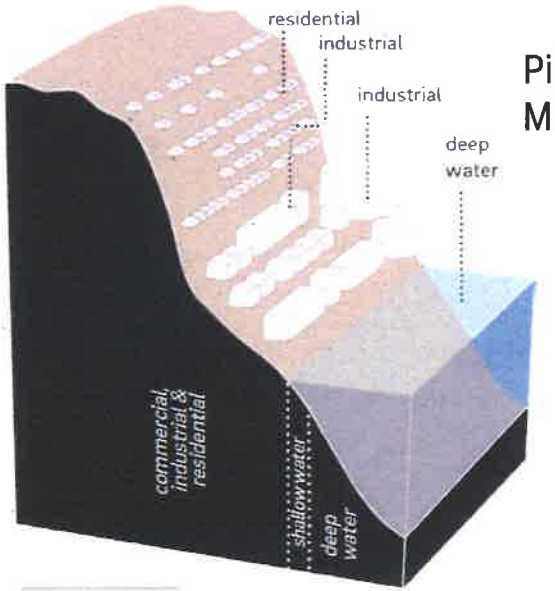
0.5 2.7 3.9 6.0 10.4 29.3

infrastructure elevation (m. NAVD88)

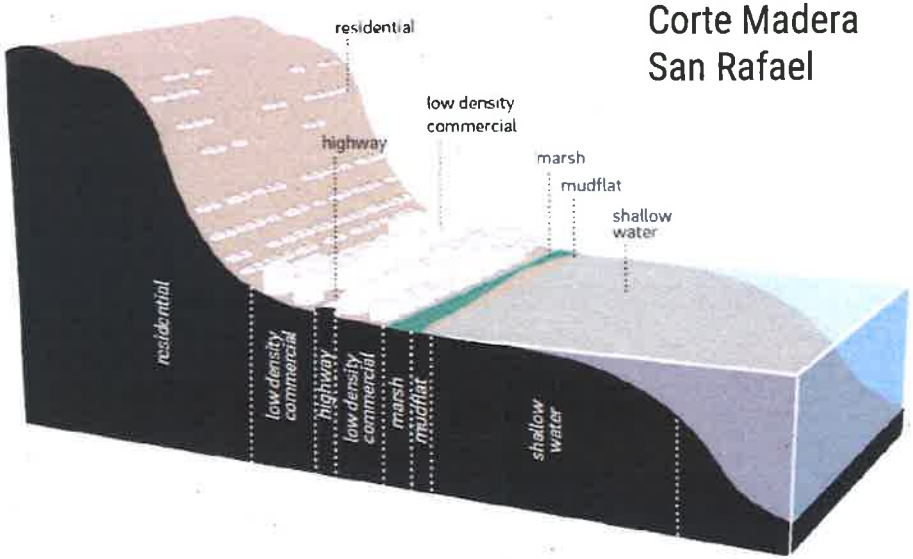
Data from BayWave



Alameda
Mowry



Pinole
Mission-Islais



Corte Madera
San Rafael

Pairing OLUs with Adaptation Measures

Adaptation measures

Nature based measures (examples)

- Oyster reef creation
- Submerged vegetation restoration
- Mudflat augmentation
- Beach creation (sand, cobble, shell)
- Marsh restoration (various)
- Polder management
- Horizontal levee creation
- Migration zone preparation

Regulatory, Financial, Policy tools

- Easements
- Building restrictions
- Policy changes
- Zoning changes or overlays
- Buyouts
- Transfer of Development Rights
- Temporary use?

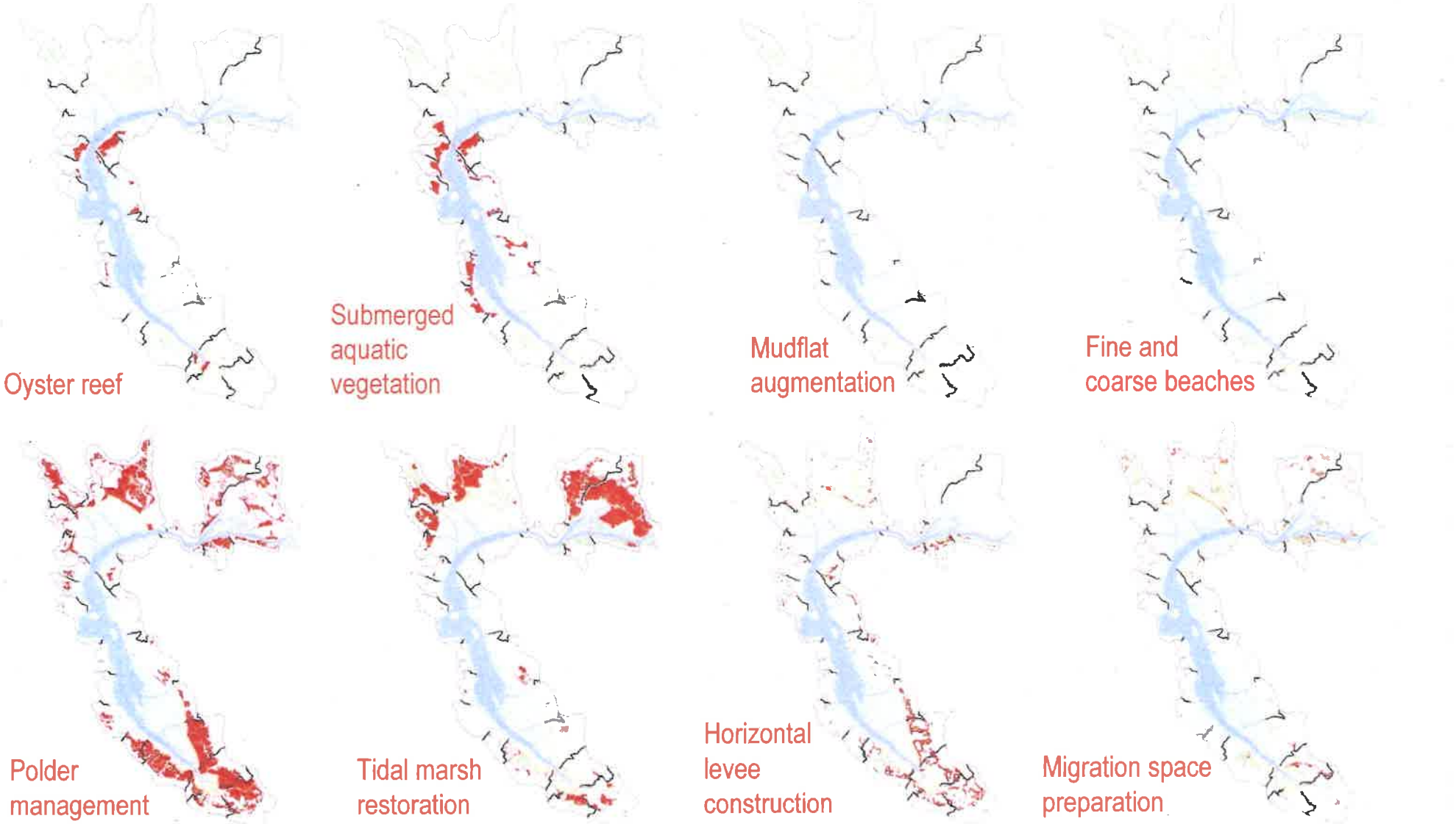
Pairing Problems with Measures

Problem	Cause	Example measure
Wave overtopping or erosion of levee with wide foreshore	Large waves reach levee	Marsh, fine beach, horizontal levee
Waves overtopping or erosion with narrow foreshore	Close to deep water	Coarse beach
Combined flooding	Loss of floodplain	Retention basins, setback levee
Combined flooding	Channel conveyance	Tidal restoration, geomorphic channels
Loss of marsh area	Wave erosion of scarp	Coarse beach, oyster reef
Loss of elevation capital	Low accretion rate	Strategic placement
No space to migrate marsh	Development up to levee	Horizontal levee
Subsided areas behind levee	Diking and draining of marshes	Reconnect to creeks, warping

Horizontal levees

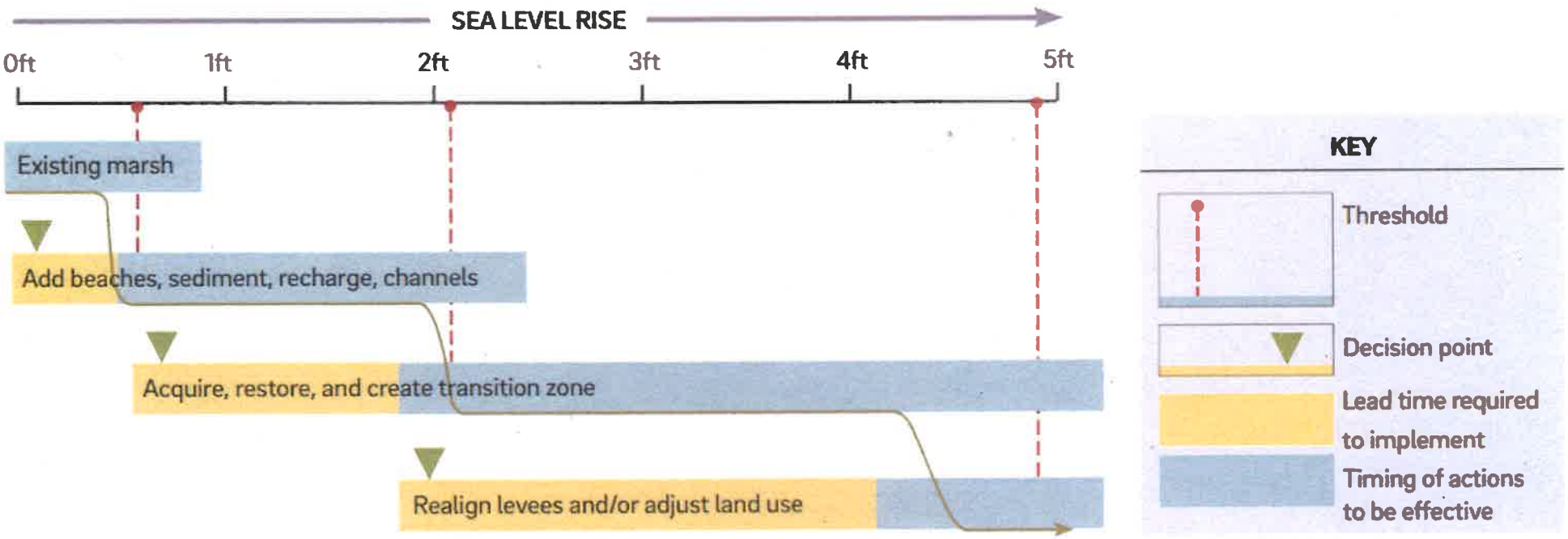
Method:

- For each OLU, determine crest elevation based on total water level:
  = *storm surge height* + *swell height* + *SLR*
- Based on crest elevation, determined levee width assuming slope of 1:30
- Map horizontal levee opportunities


Oyster reef
Submerged aquatic vegetation
Mudflat augmentation
Fine and coarse beaches
Polder management
Tidal marsh restoration
Horizontal levee construction
Migration space preparation

Measures by type of OLU

TYPOLOGY		STRATEGIES												
		Oysters	Mudflat Augmentation	Beaches	Marsh Resteration	Horizontal Levees	Transition Zone Aquisition	Warping of Polders	Densify Urban Development Away from SLR Zone	Creek Reconnection	Sediment Management	Combined Flooding Abatement	Levees	Super Levees
A	*Wide baylands with more space: Coves with dense urban settlements*	●	●	●	●	●	●	●	●					
	Wide baylands with more space: Mixed urban and agricultural creek mouths		●		●	●	●	●		●				
B	*Narrow baylands with less space: Urban waterfronts beside deep water*	●		●			●							
	Narrow baylands with less space: Pocket marshes with shallow water	●		●	●	●								
C	*Wide baylands with more space: Urban centers*			●	●		●	●						
	Wide baylands with less space: Urban centers			●	●									
D	*Narrow baylands with more space: Urban centers*			○	●	●								
	Narrow baylands with less space: Urban centers	●		●									●	●
E	*Wide baylands with more space: Agricultural fringing, big marshes*				●		●	●		●				
	Wide baylands with less space: Urban fringing, big marshes				●	●	●	●		●				
	Wide baylands with less space: Big marshes along a river				●						●	●		



Conceptual phasing of measures triggered by sea-level rise, rather than a chronological timeline (adapted from Goals Project 2015).

Technical feedback

- **Technical Advisory Committee**
  - *Peter Baye, Coastal Ecologist*
  - *Mark Stacey, UC Berkeley*
  - *Roger Leventhal, Marin County Flood*
  - *Kristina Hill, UC Berkeley*
  - *Andy Gunther*

- **Regional Advisory Committee**
  - *Luisa Valiela, EPA*
  - *Naomi Feger, RB2*
  - *Lindy Lowe, formerly BCDC*
  - *Matt Gerhart, SCC*
  - *Caitlin Sweeney, SFEP*
  - *David Lewis, Save the Bay*

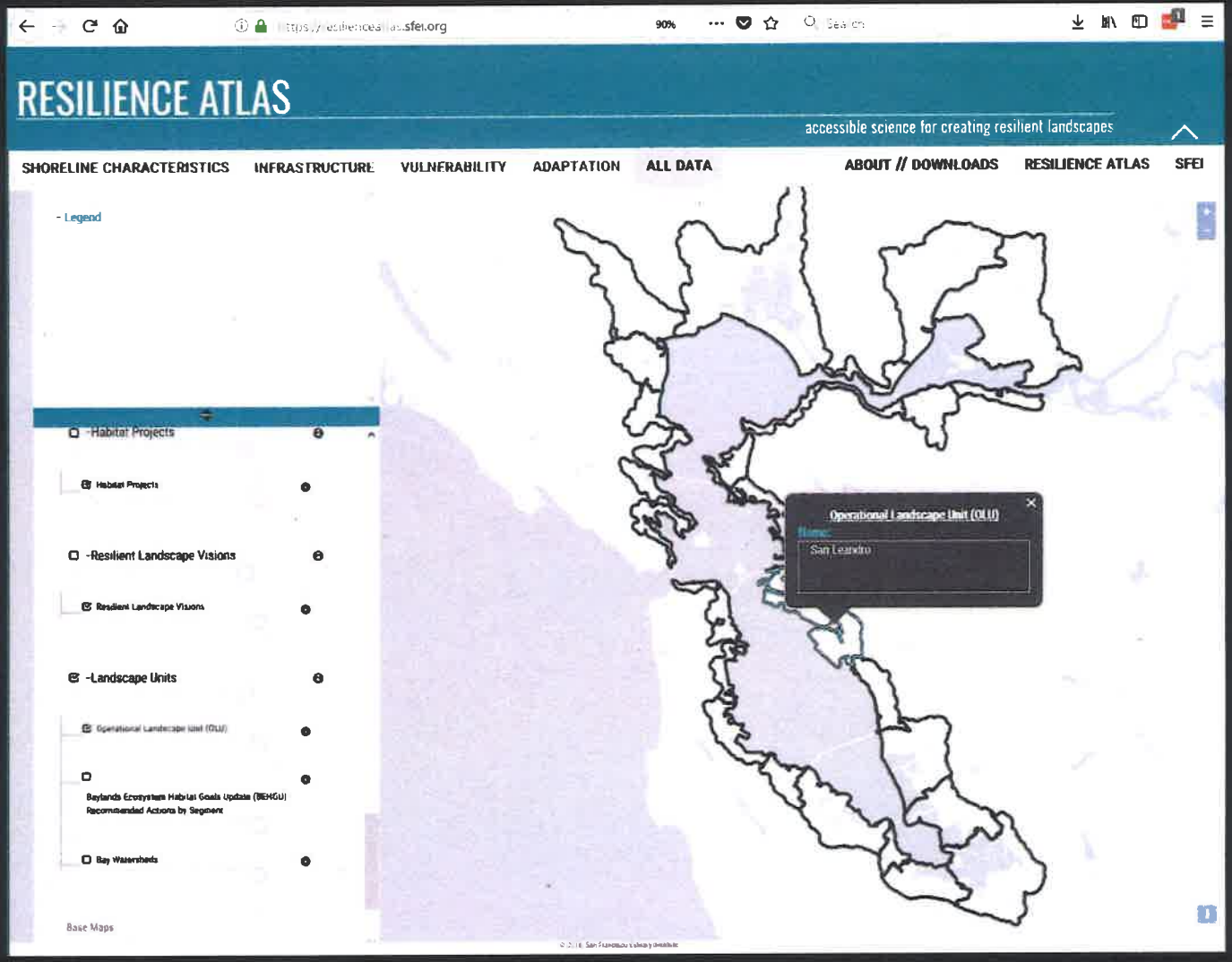
For More Info

Check out the "All Data" tab of the Resilience Atlas:

Resilienceatlas.sfei.org

or

sfei.org/projects/OLUs



THANK YOU

Contact Us: Julieb@sfei.org Jeremyl@sfei.org

Thanks to our team: Katie McKnight, Sam Safran, Letitia Grenier
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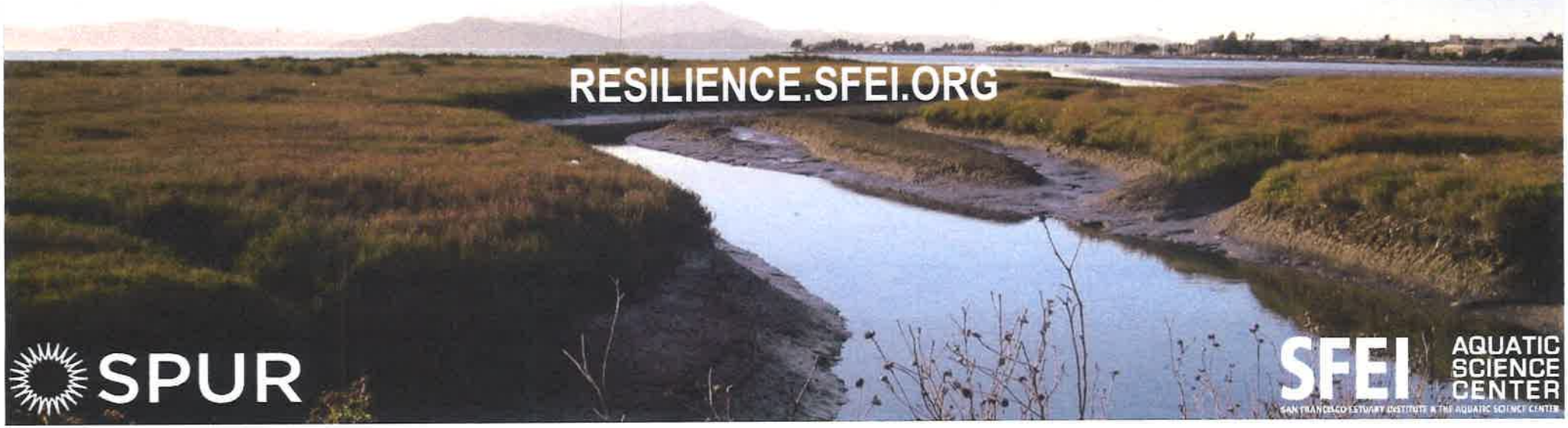

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