Case Studies of Natural and Nature-Based Features in Adaptation Strategies

Sea Level Rise: Why We Need Nature-Based Adaptation
May 27, 2021

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Photo Horizon (2014)

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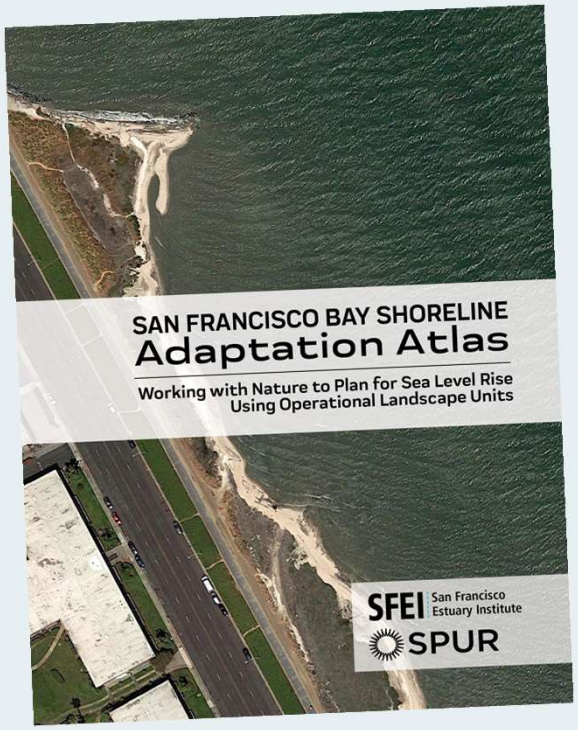
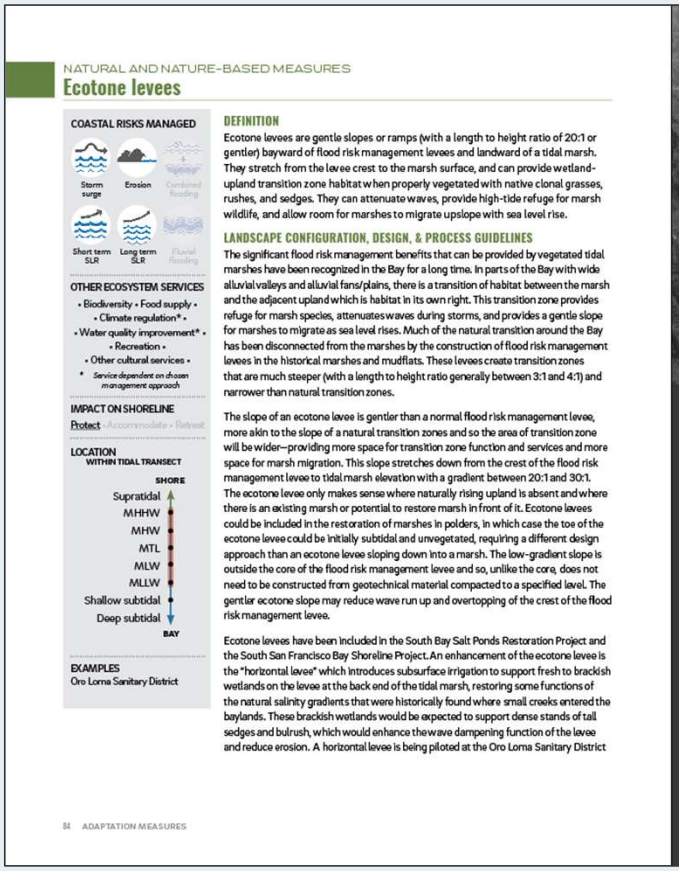
Source: USACE

Adaptation Atlas





NATURAL AND NATURE-BASED MEASURES

Ecotone levees

COASTAL RISKS MANAGED

Storm surge · Erosion · Combined flooding · Short term SLR · Long term SLR · Fluvial flooding

OTHER ECOSYSTEM SERVICES

• Biodiversity • Food supply • • Climate regulation* • • Water quality improvement* • • Recreation • • Other cultural services •

* *Service dependent on chosen management approach*

IMPACT ON SHORELINE

Protect · Accommodate · Retreat

LOCATION
WITHIN TIDAL TRANSECT

SHORE
Supratidal
MHHW
MHW
MTL
MLW
MLLW
Shallow subtidal
Deep subtidal
BAY

EXAMPLES
Oro Loma Sanitary District

DEFINITION

Ecotone levees are gentle slopes or ramps (with a length to height ratio of 20:1 or gentler) bayward of flood risk management levees and landward of a tidal marsh. They stretch from the levee crest to the marsh surface, and can provide wetland-upland transition zone habitat when properly vegetated with native clonal grasses, rushes, and sedges. They can attenuate waves, provide high-tide refuge for marsh wildlife, and allow room for marshes to migrate upslope with sea level rise.

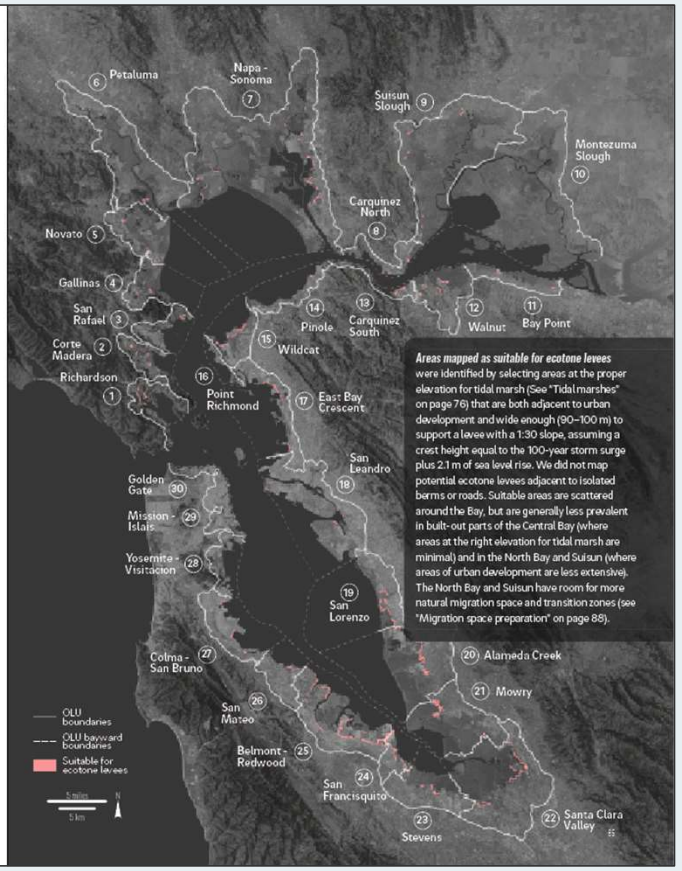
LANDSCAPE CONFIGURATION, DESIGN, & PROCESS GUIDELINES

The significant flood risk management benefits that can be provided by vegetated tidal marshes have been recognized in the Bay for a long time. In parts of the Bay with wide alluvial valleys and alluvial fans/plains, there is a transition of habitat between the marsh and the adjacent upland which is habitat in its own right. This transition zone provides refuge for marsh species, attenuates waves during storms, and provides a gentle slope for marshes to migrate as sea level rises. Much of the natural transition around the Bay has been disconnected from the marshes by the construction of flood risk management levees in the historical marshes and mudflats. These levees create transition zones that are much steeper (with a length to height ratio generally between 3:1 and 4:1) and narrower than natural transition zones.

The slope of an ecotone levee is gentler than a normal flood risk management levee, more akin to the slope of a natural transition zones and so the area of transition zone will be wider—providing more space for transition zone function and services and more space for marsh migration. This slope stretches down from the crest of the flood risk management levee to tidal marsh elevation with a gradient between 20:1 and 30:1. The ecotone levee only makes sense where naturally rising upland is absent and where there is an existing marsh or potential to restore marsh in front of it. Ecotone levees could be included in the restoration of marshes in polders, in which case the toe of the ecotone levee could be initially subtidal and unvegetated, requiring a different design approach than an ecotone levee sloping down into a marsh. The low-gradient slope is outside the core of the flood risk management levee and so, unlike the core, does not need to be constructed from geotechnical material compacted to a specified level. The gentler ecotone slope may reduce wave run up and overtopping of the crest of the flood risk management levee.

Ecotone levees have been included in the South Bay Salt Ponds Restoration Project and the South San Francisco Bay Shoreline Project. An enhancement of the ecotone levee is the "horizontal levee" which introduces subsurface irrigation to support fresh to brackish wetlands on the levee at the back end of the tidal marsh, restoring some functions of the natural salinity gradients that were historically found where small creeks entered the baylands. These brackish wetlands would be expected to support dense stands of tall sedges and bulrush, which would enhance the wave dampening function of the levee and reduce erosion. A horizontal levee is being piloted at the Oro Loma Sanitary District

84 ADAPTATION MEASURES



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Adaptation Measures

Nature-based measures

- Nearshore reefs
- Submerged aquatic vegetation (eelgrass)
- Beaches (sand, cobble, shell)
- Tidal marshes
- Polder management
- Ecotone levees
- Migration space preparation
- Creek-to-bayland reconnections
- Green stormwater infrastructure

Regulatory, financial, policy tools

- Zoning and overlay zones
- Setbacks, buffers, and clustering
- Building codes and building retrofits
- Rebuilding and redevelopment restrictions
- Conservation easements
- Tax incentives and special assessments
- Geologic Hazard Abatement District
- Transfer of Development Rights
- Buyouts

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Operational Landscape Units

Areas with shared geophysical and land use characteristics ***suited for a particular suite of nature-based measures***

- ***Bigger than a project***
- ***Bigger than a City***
- ***Smaller than a County***

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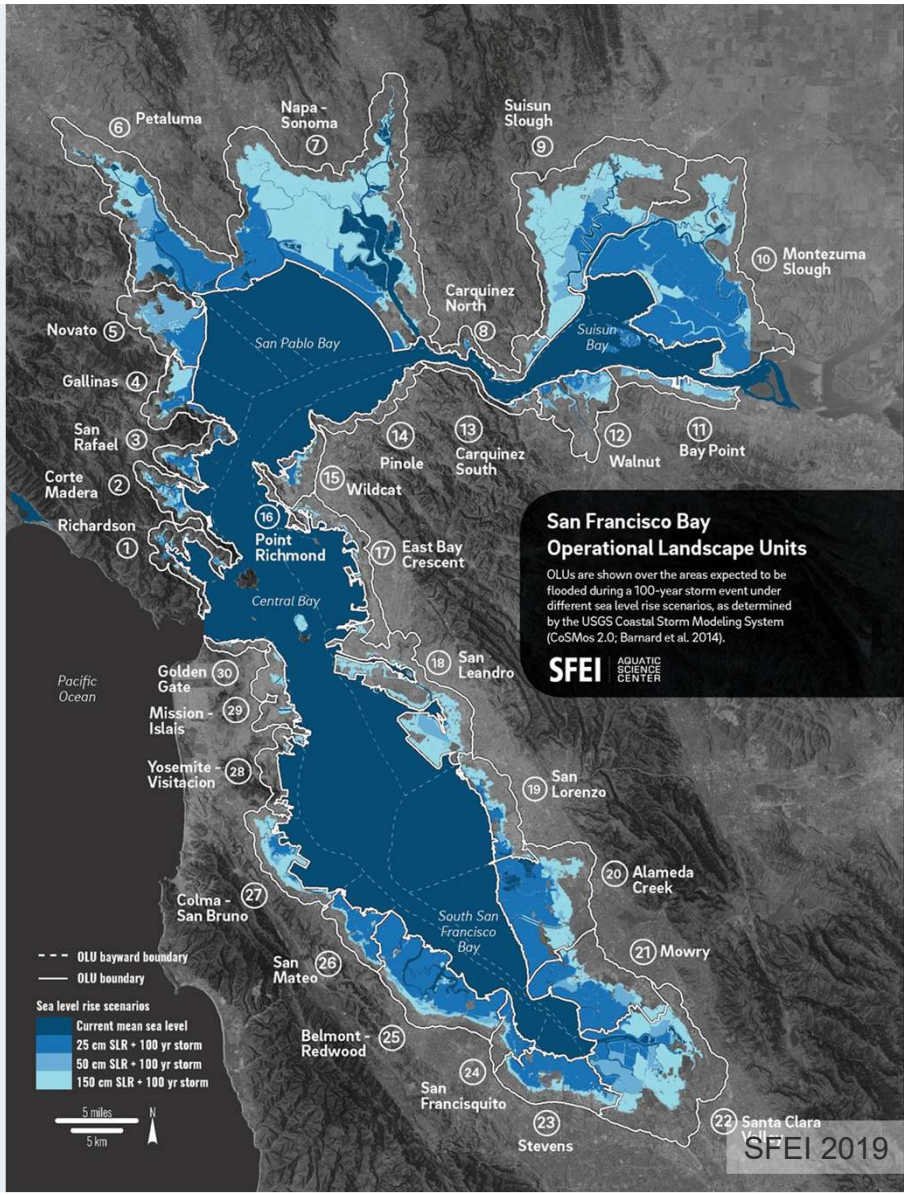

Questions to Ask

1. **What are we trying to achieve?**
   - What are the restoration opportunities?
   - What is the hazard, what is at risk, and how valuable is it?
2. **Where do marshes, beaches, reefs, etc make sense?**
   - What is appropriate to the natural setting? What is the elevation?
   - How much space do you have? What is in front, behind, and to the sides?
3. **How effective, how expensive, and how long will it last?**
   - How do you prioritize the use of resources?
   - How do natural features combine with traditional levee approaches?

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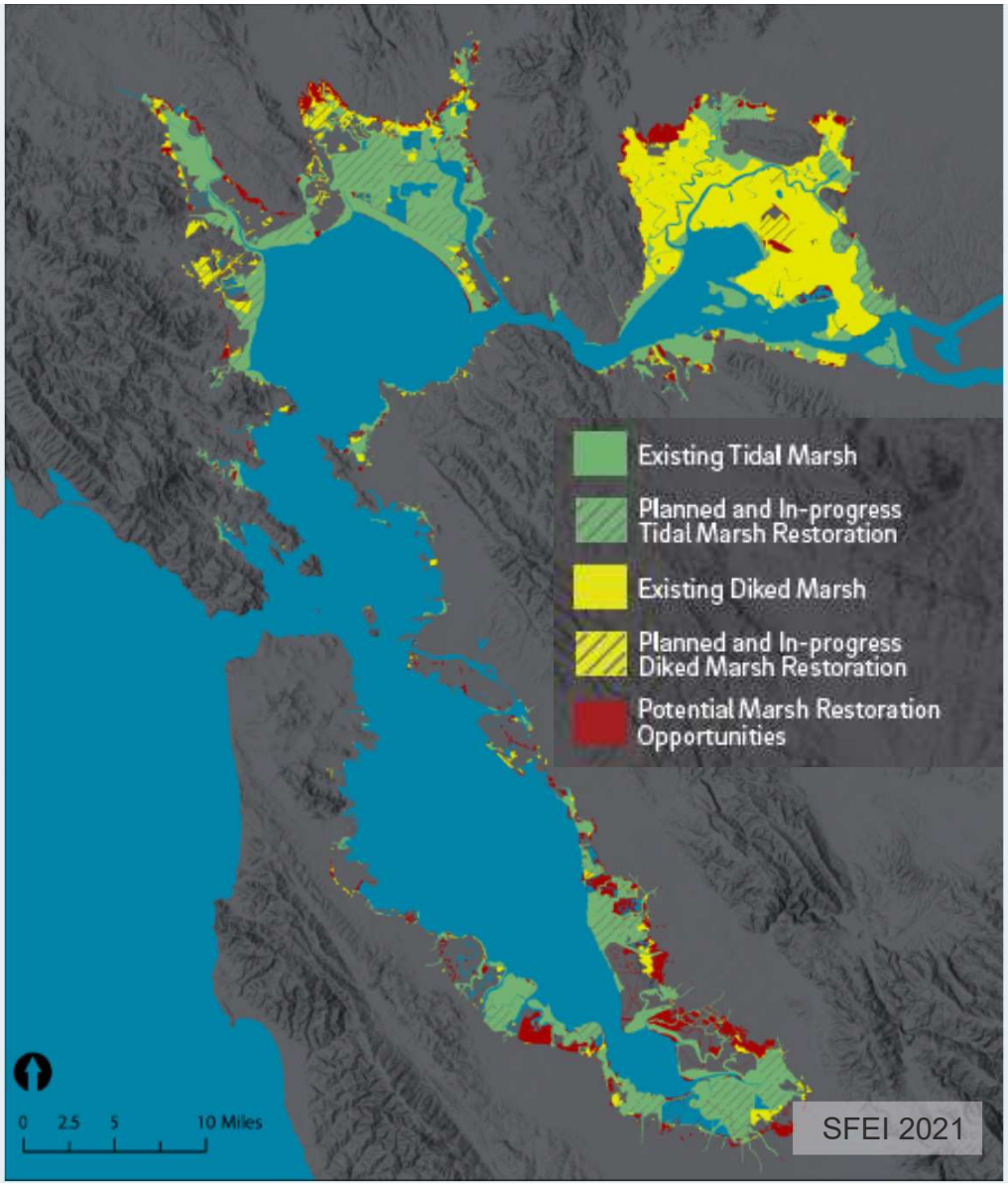
Tidal Marshes

Distribution of existing tidal and diked marshes, planned and in-progress restoration projects, and potential restoration opportunities.



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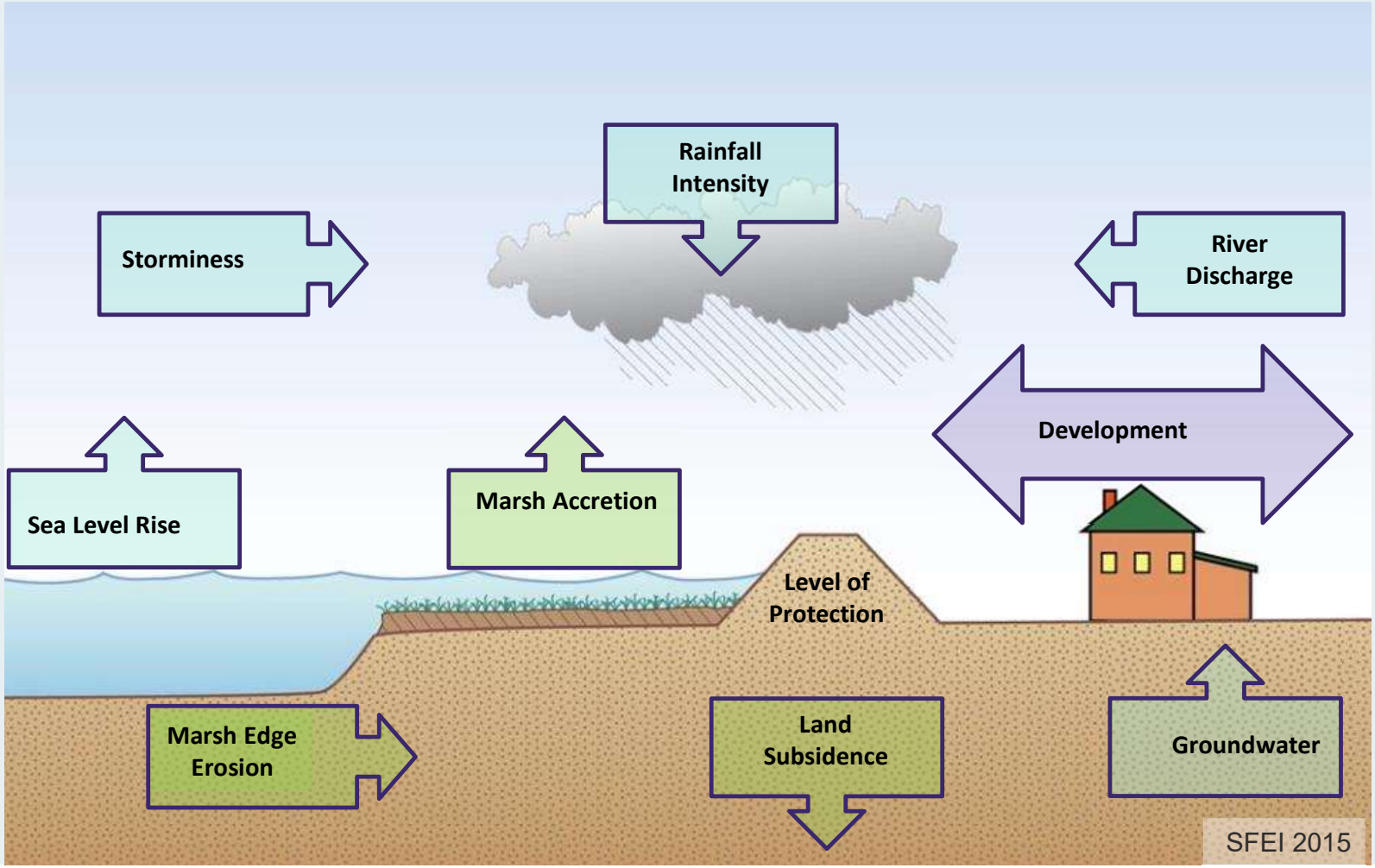
Drivers for Future Flood Risks



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Pairing Problems with Measures

EXAMPLE PROBLEM	CAUSE	EXAMPLE MEASURE
Wave overtopping or erosion of levee with wide foreshore	Large waves reach levee	Marsh, fine beach, horizontal levee
Combined flooding	Loss of floodplain	Retention basins, setback levee
Loss of marsh area	Wave erosion of scarp	Coarse beach, oyster reef
Subsided areas behind levee	Diking and draining of marshes	Reconnect to creeks, placement of sediment

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Natural and Nature-Based Features

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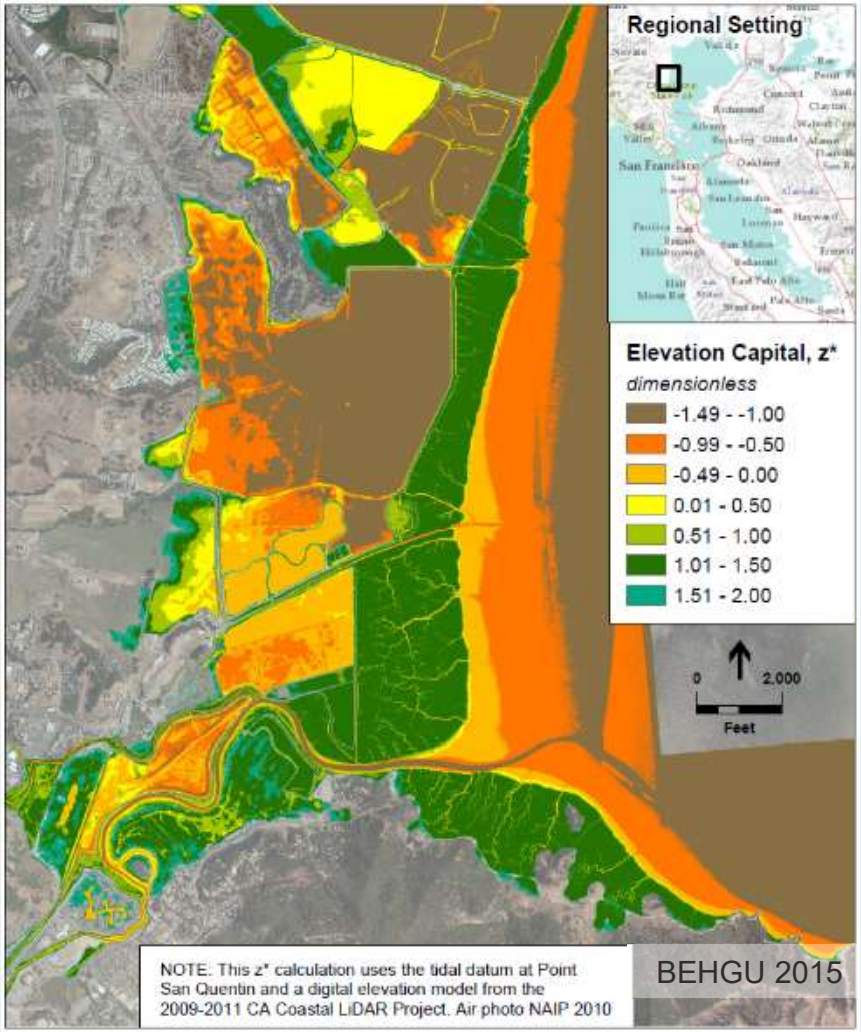
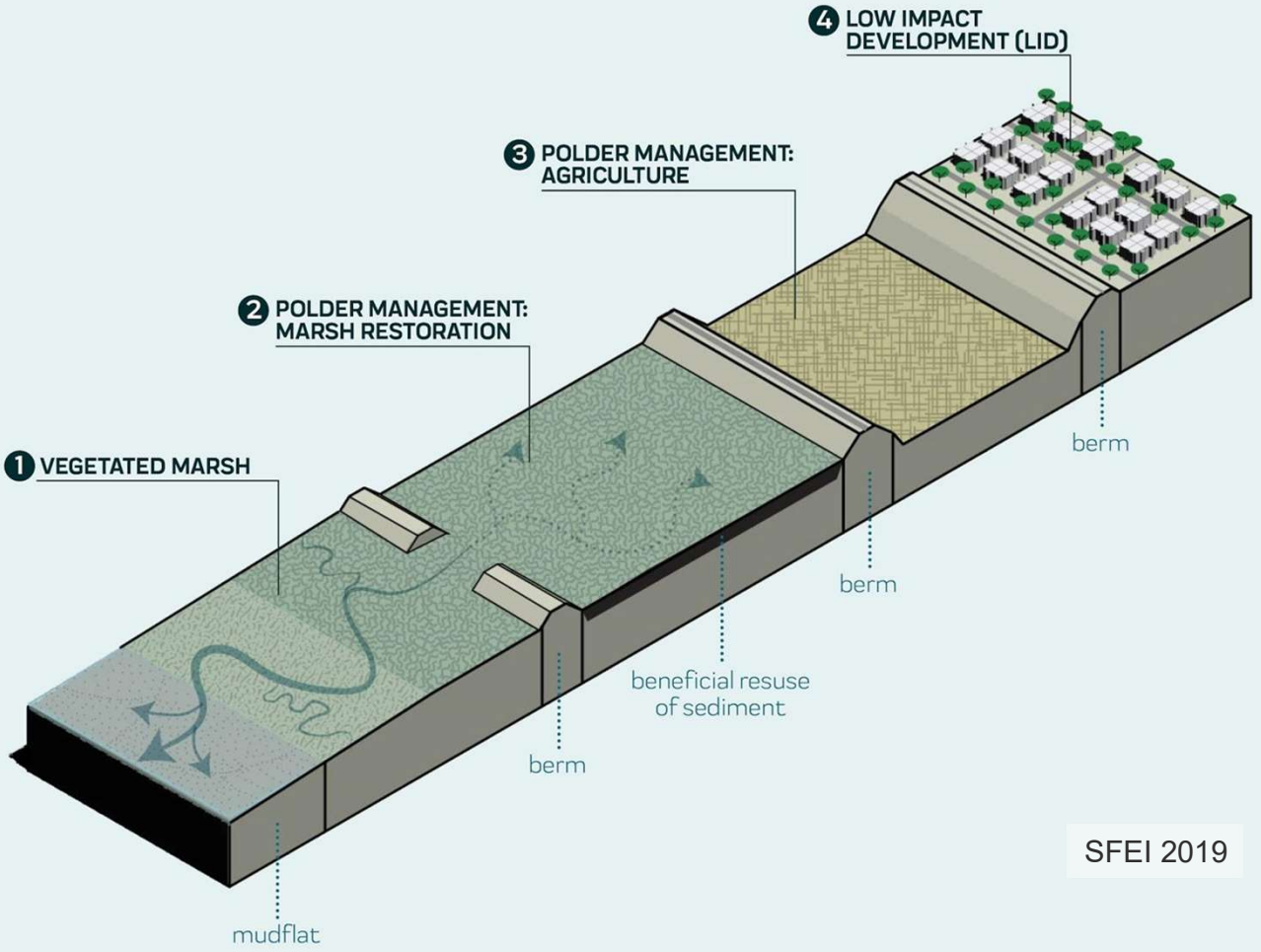
Las Gallinas and Hamilton



Polders



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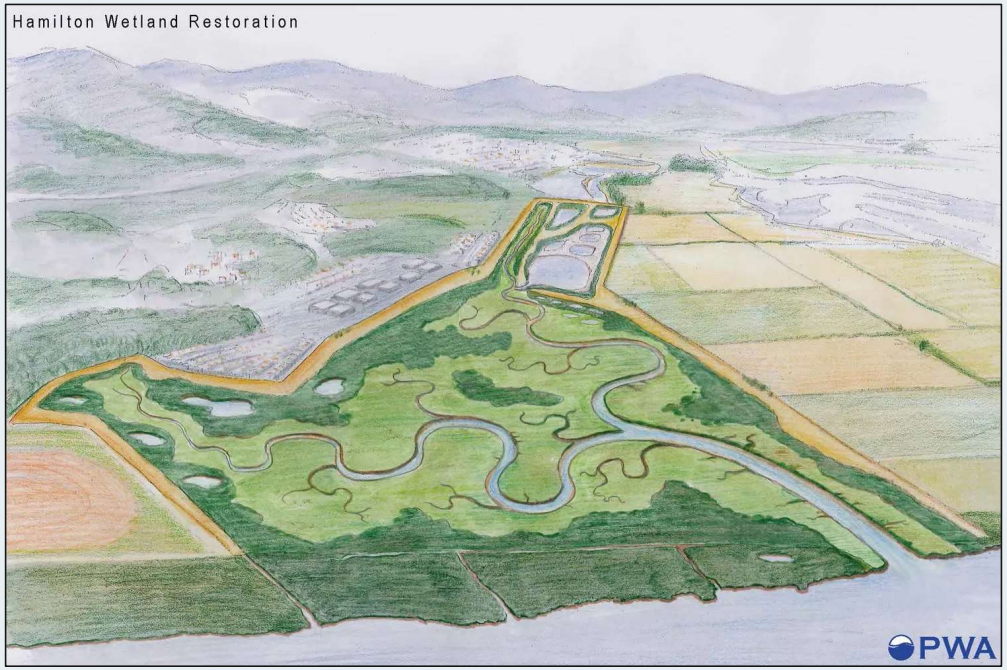
Hamilton Airfield Marsh Restoration



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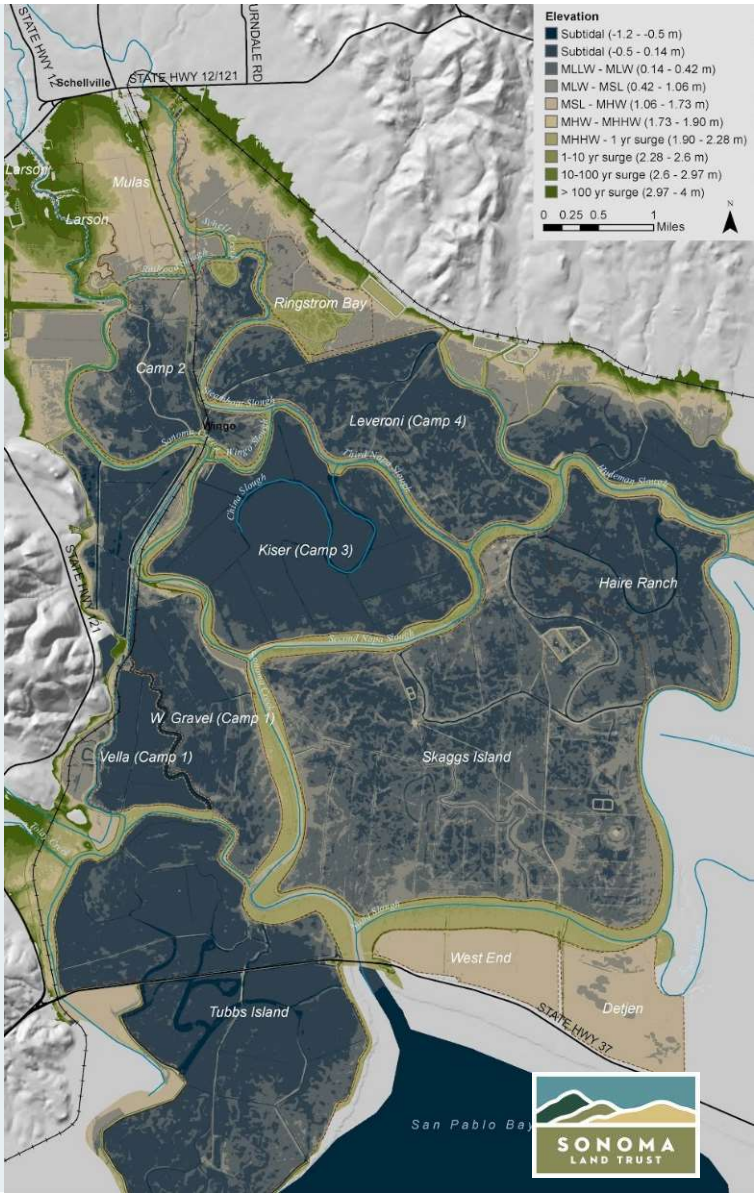
Sonoma Creek Baylands

Photo: Sonoma Land Trust

Sonoma Land Trust

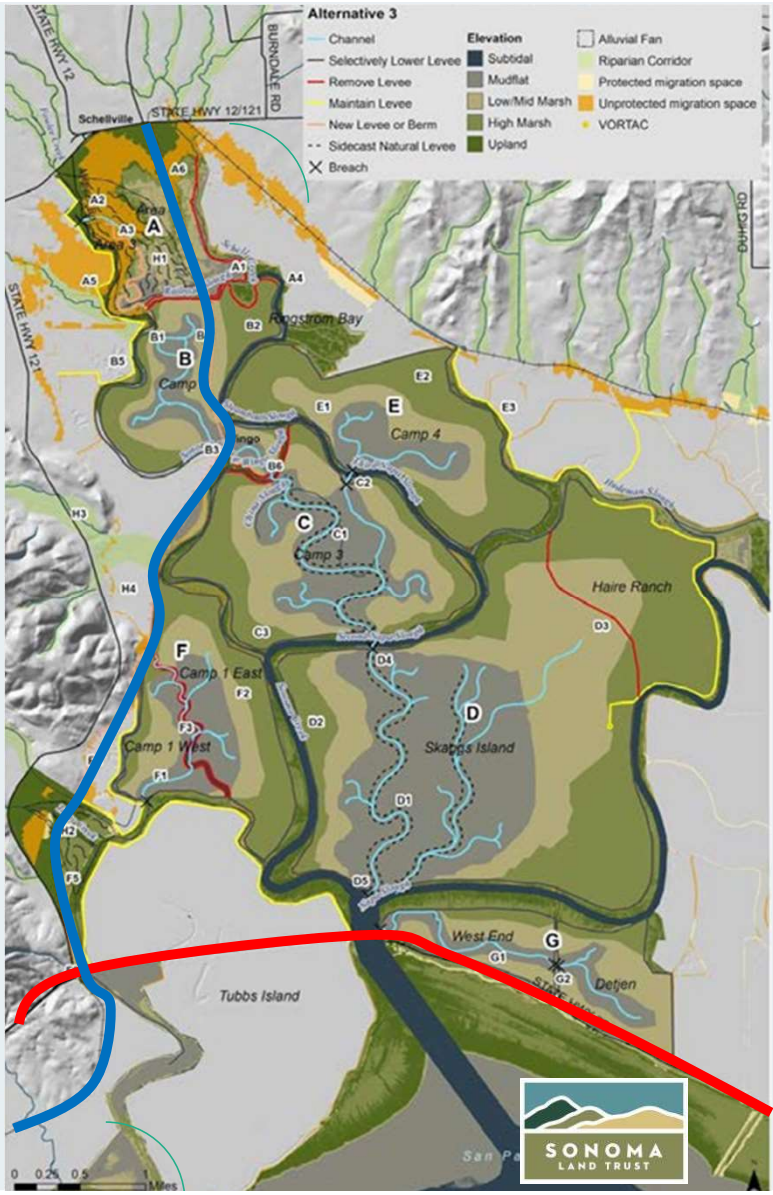
Sonoma Creek Baylands Strategy

- **Support acquisition and design of restorations**
- **Recommendations for infrastructure**
- **Goals:**
  - Habitat: Mixes of subtidal, tidal, freshwater, transitional, and upland habitats
  - Planning Horizon: 100 years (2100) assuming sea level rise up to 6.9ft
  - Urgency: Implement early more likely to succeed
  - Cost: Consider whole-life



“Integrate, Not Mitigate”

1. **Present bridge crossings and embankments** disrupt hydrologic and habitat connectivity.
2. **Habitat restoration** can help manage extreme flows.
3. **Road and rail need to be raised** to accommodate sea-level rise and modified to increase connectivity.
4. **Bridges need to be lengthened** to accommodate future flows.



Natural and Nature-Based Features

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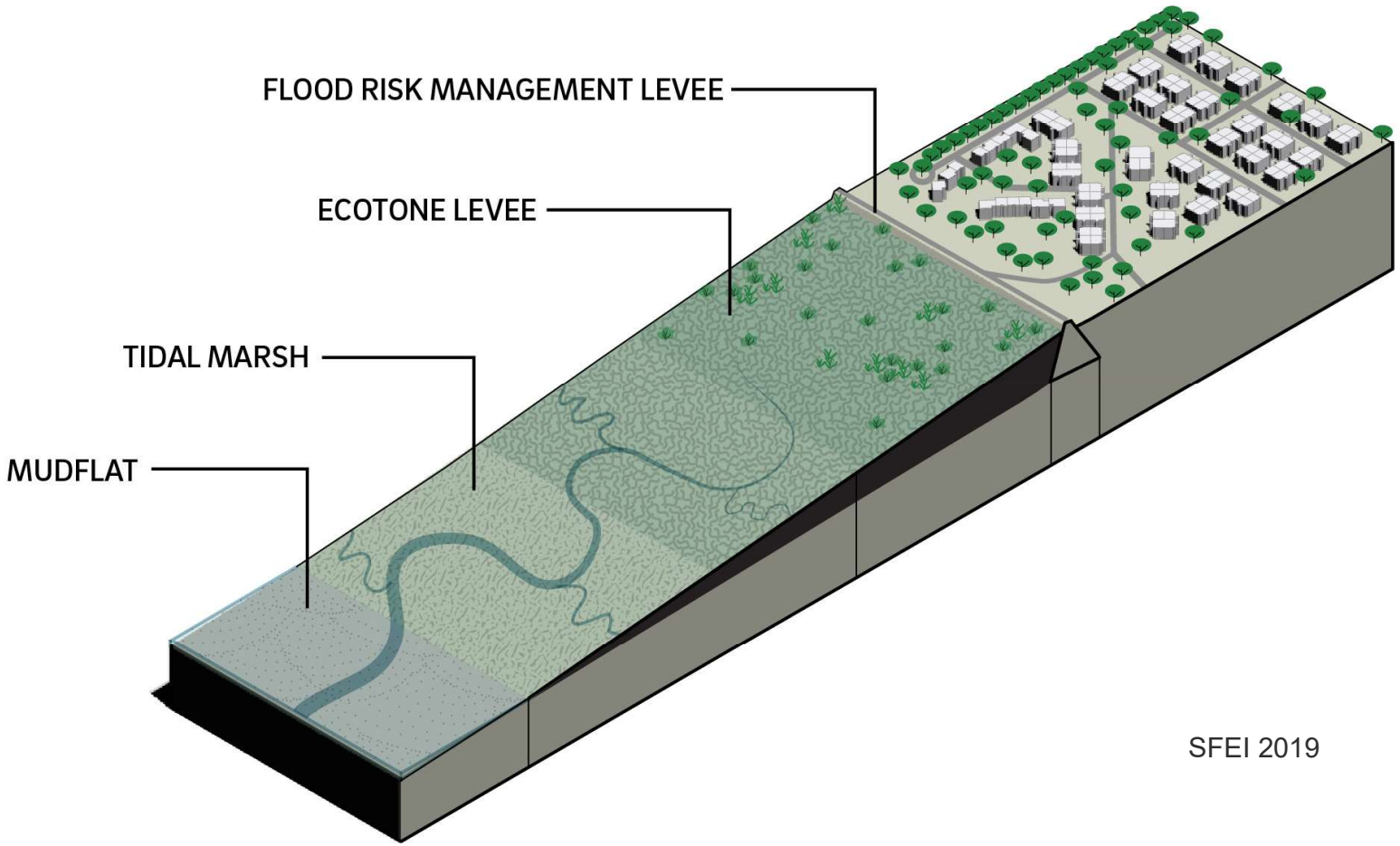
Hybrid Strategies



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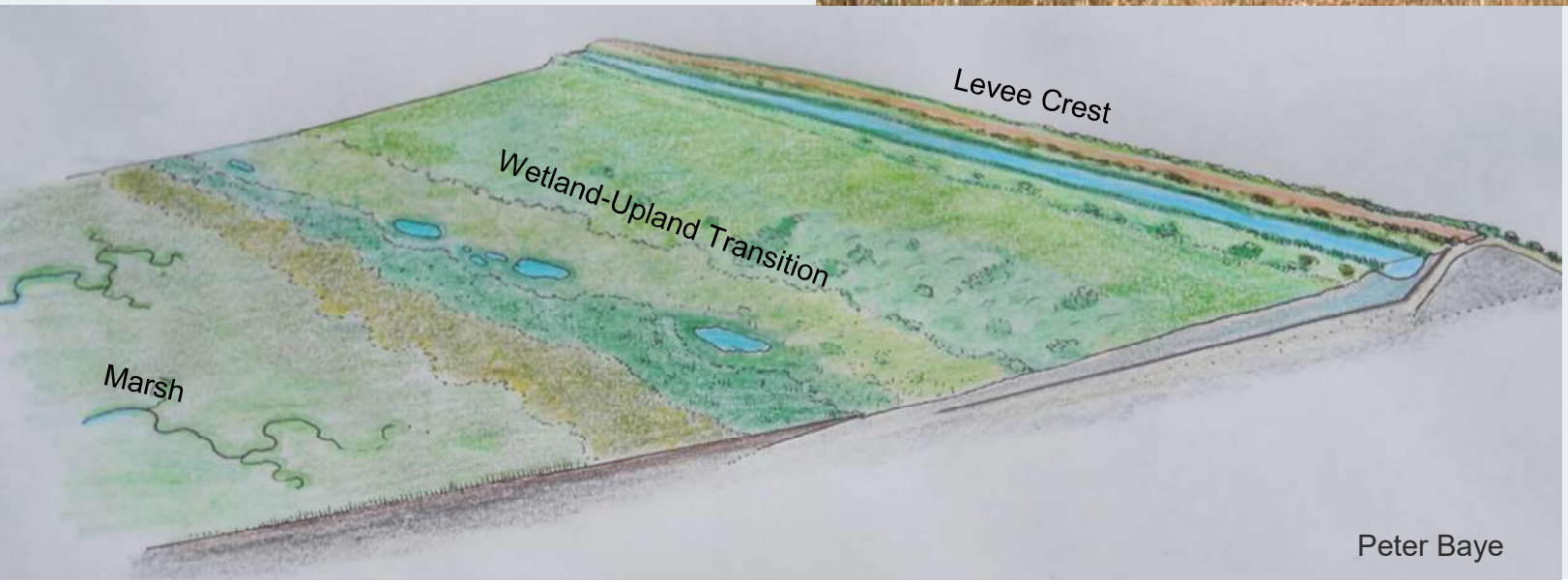
Upland

Wetland-Upland Transition



Horizontal Levee

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Ecotone Levee

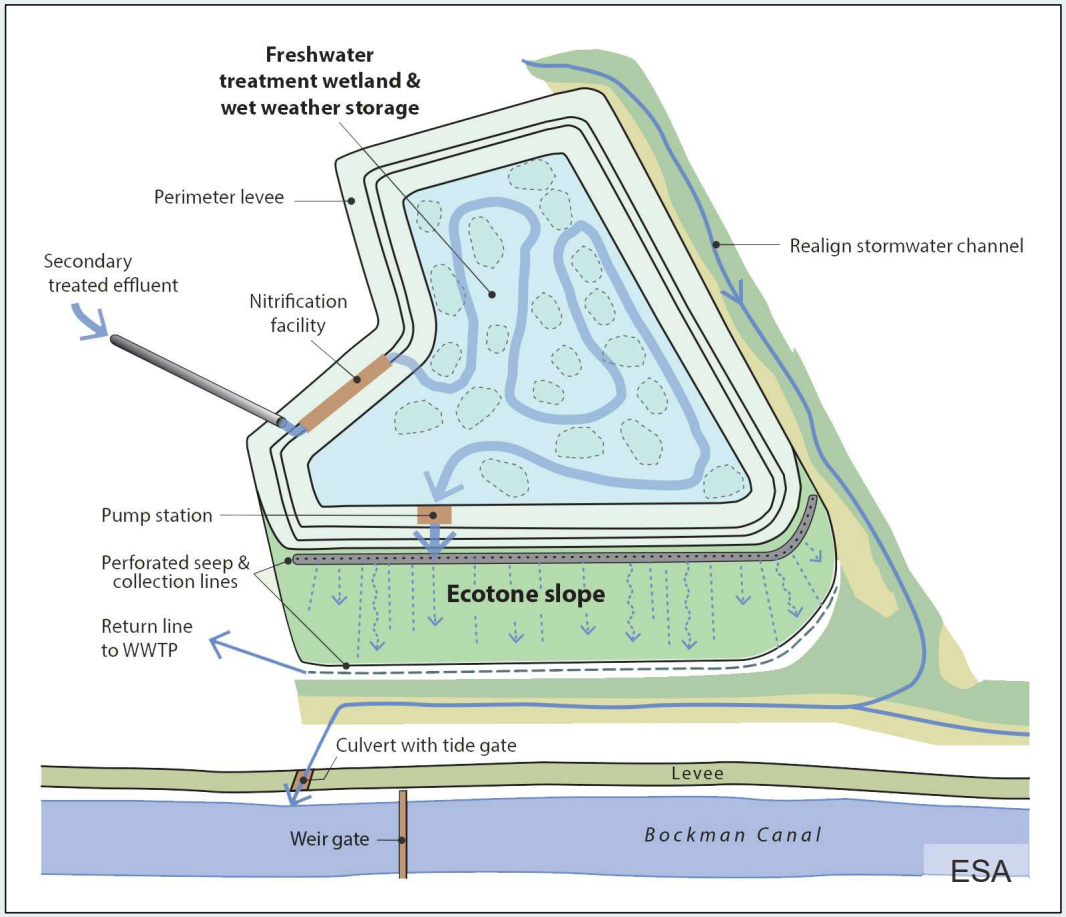
Alviso, South Bay
Traditional Levee
3:1 (V:H)


Photo: Valley Water


Photo: Sonoma Land Trust

Sears Point, North Bay
Ecotone Levee
10:1 to 20:1 (V:H)

Oro Loma Horizontal Levee and 'First Mile'



Natural and Nature-Based Features …and Processes

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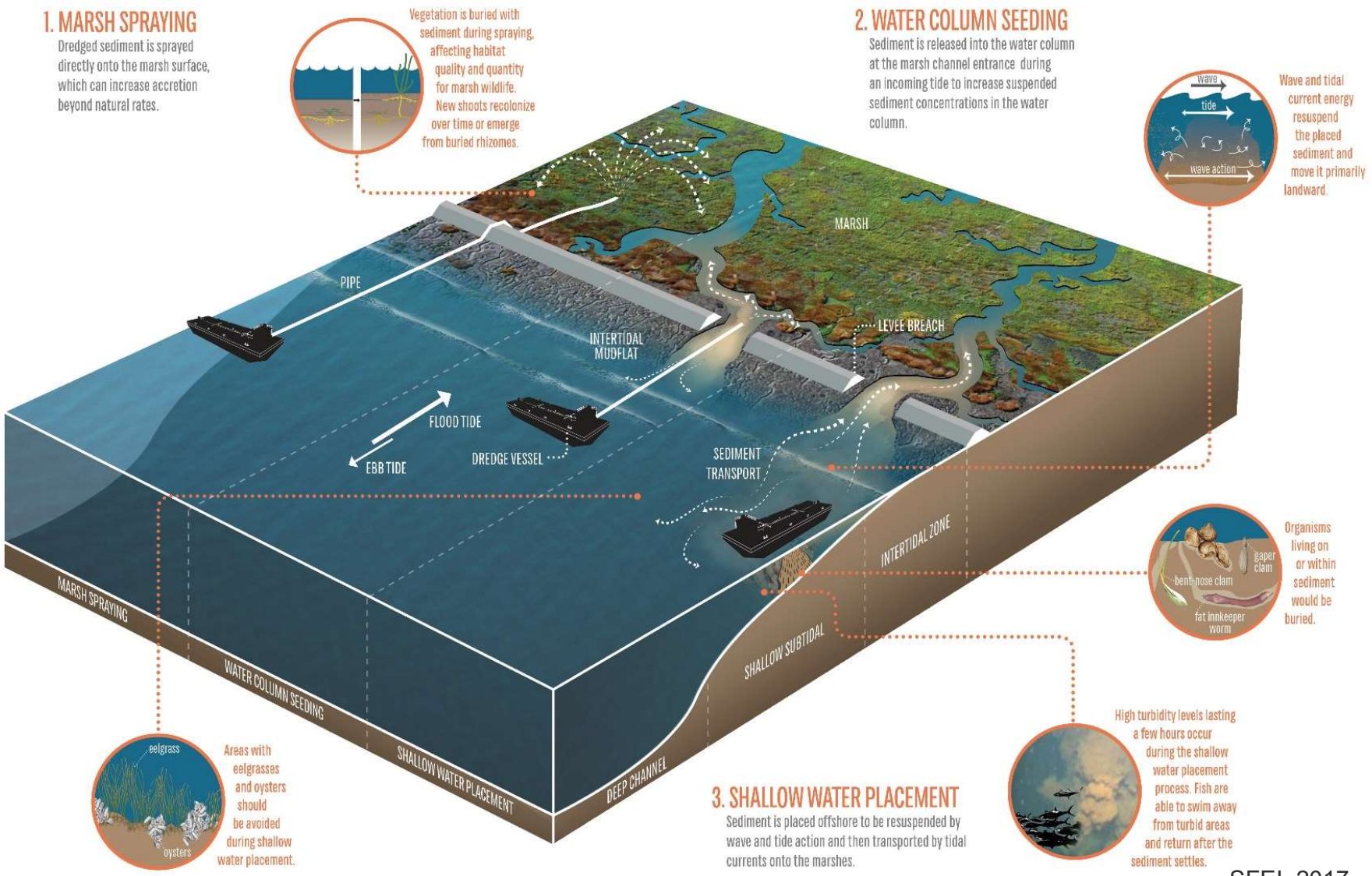
Thin-Layer Placement

Spraying at Seal Beach, CA

Alluvial Fan at Sonoma Baylands



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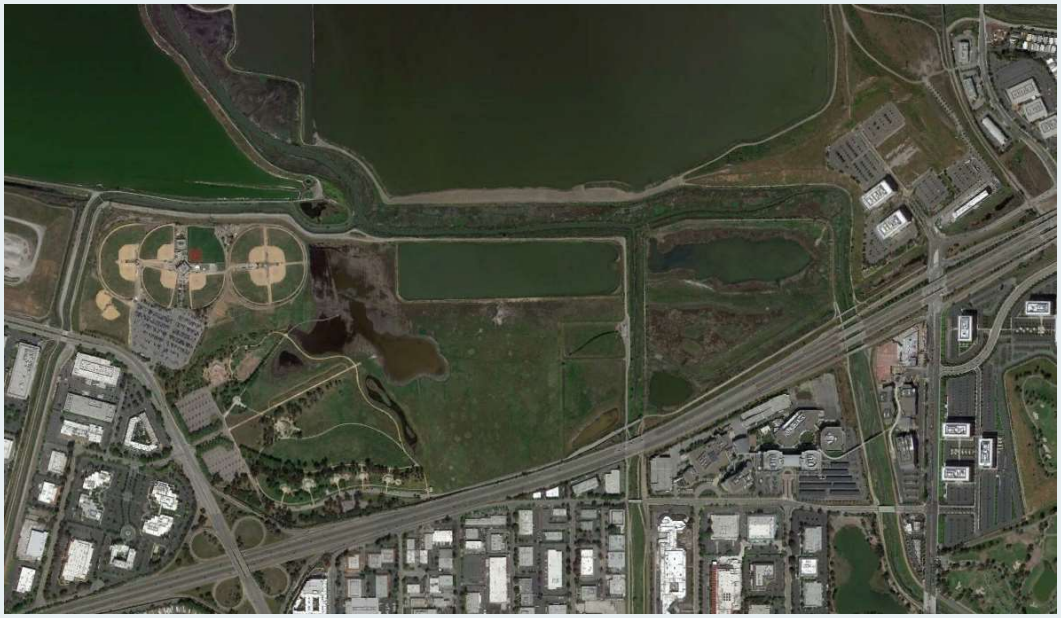
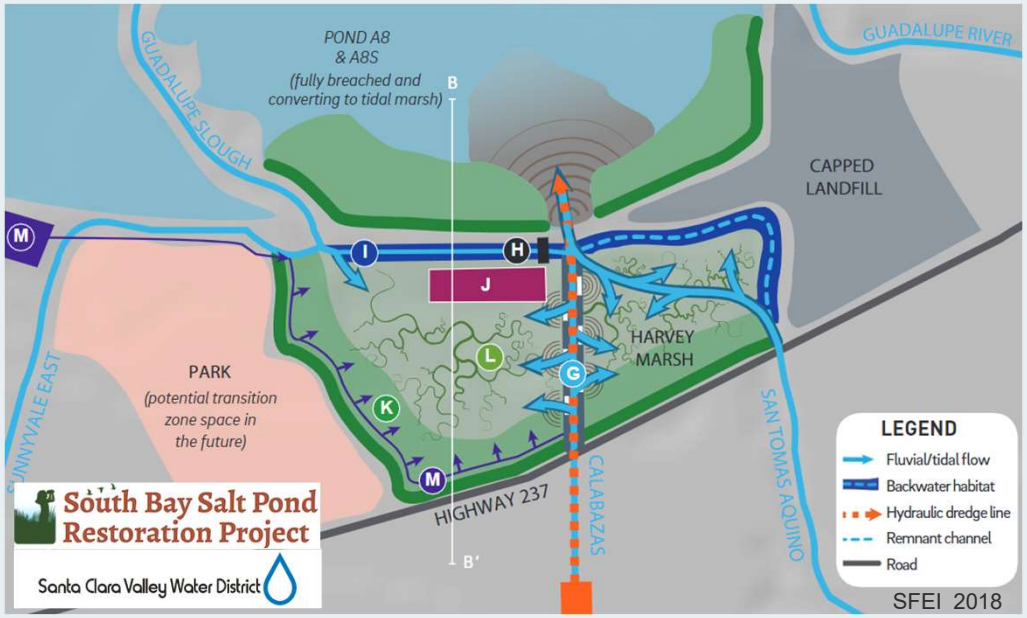
Reconnecting Creeks to Marshes





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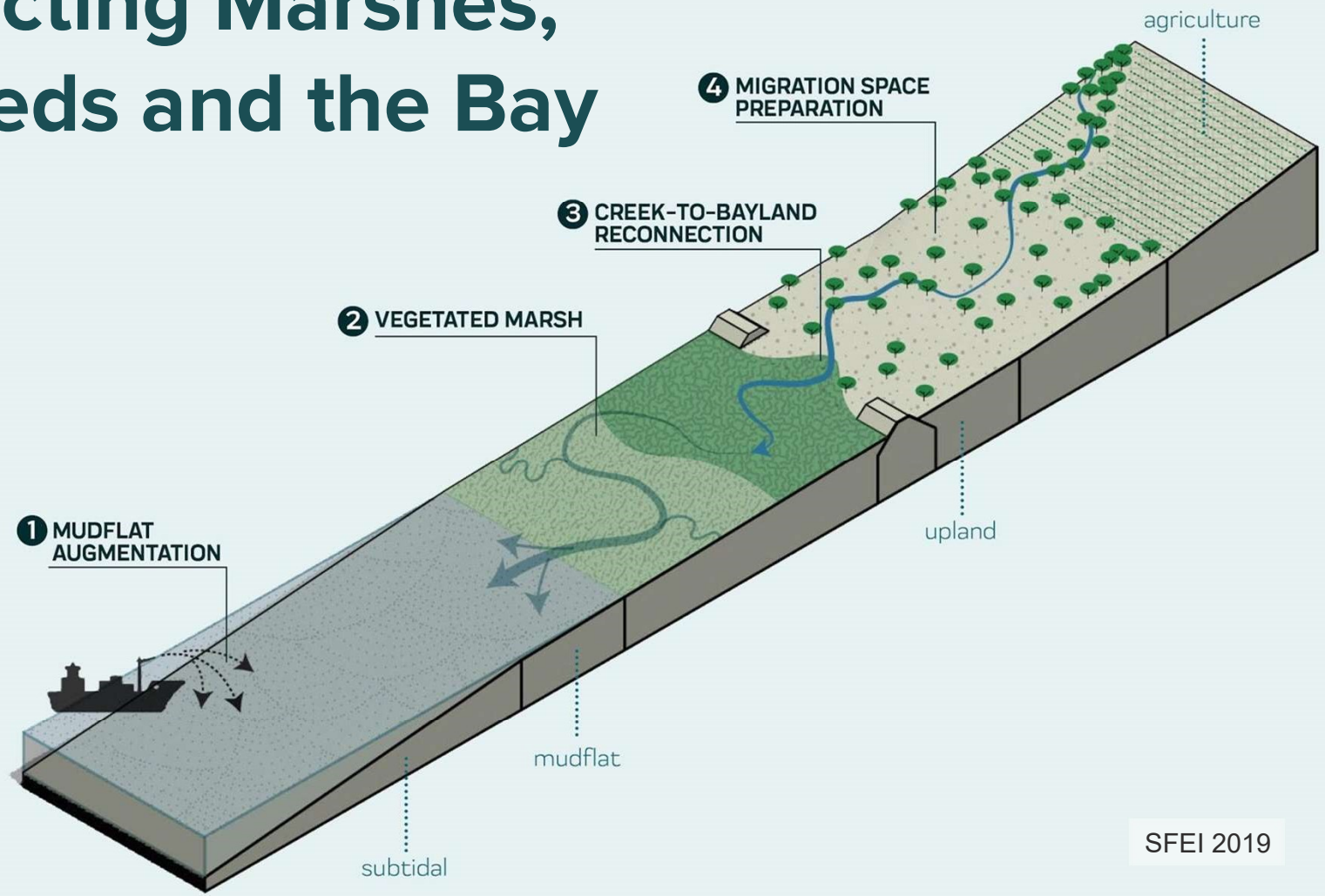
Reconnecting Marshes, Watersheds and the Bay



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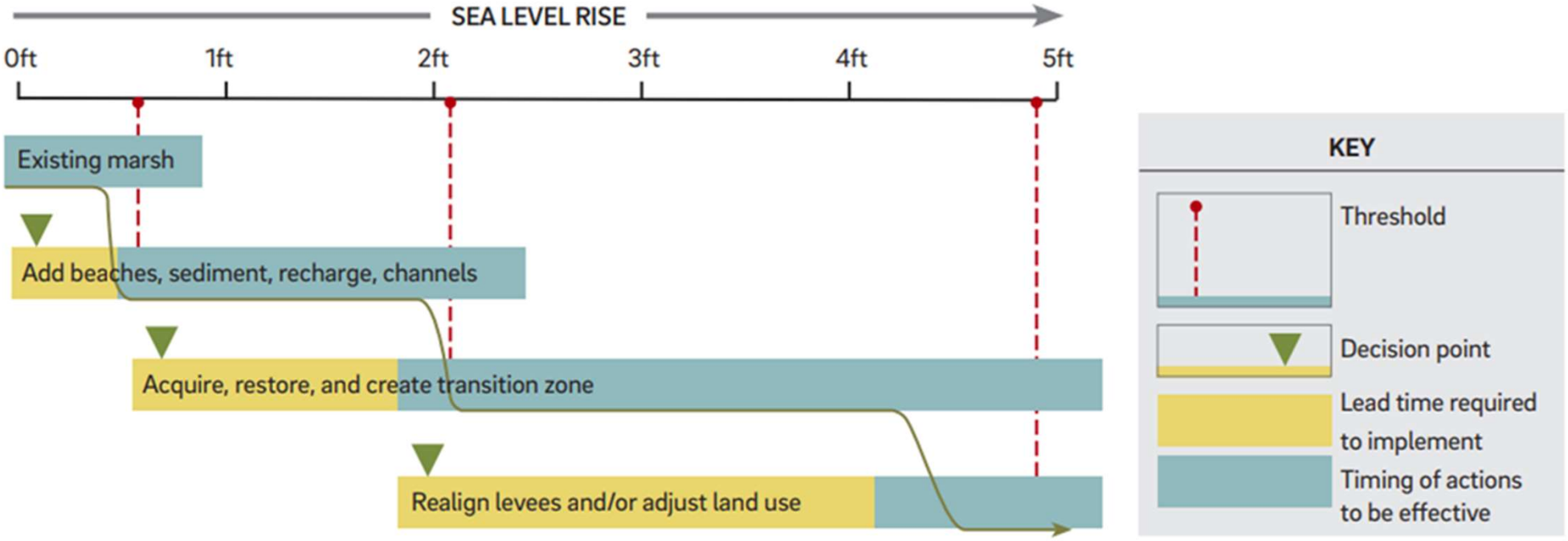
Adaptation Pathways



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

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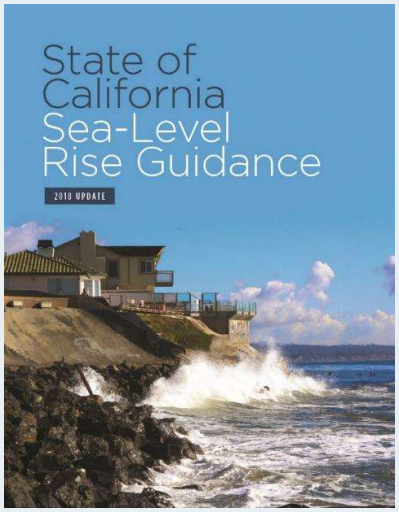
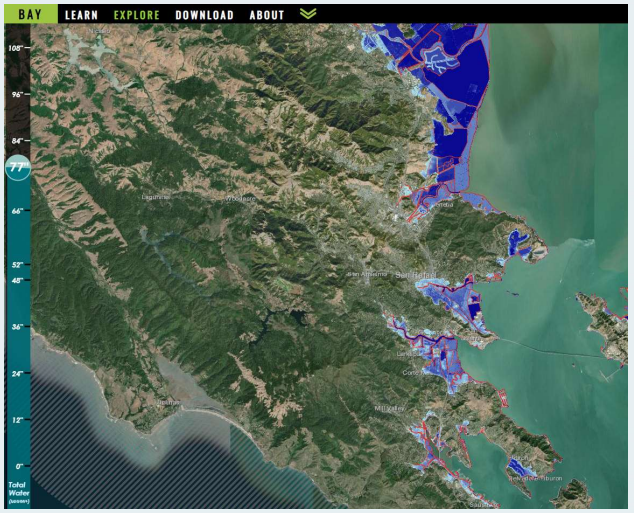
Cost

1. **Fill to change elevation** usually represents the largest impact and most costly part of any restoration project.
2. **Moving fill** around is large cost and highest potential impacts to the environment.
3. **Fill may be in short supply** and thus a finite resource.
4. **Competition for resources** between projects responding simultaneously to sea-level rise.



California Sea-Level Rise Guidance

opc.ca.gov



BCDC Flood Explorer

explorer.adaptingtorisingtides.org

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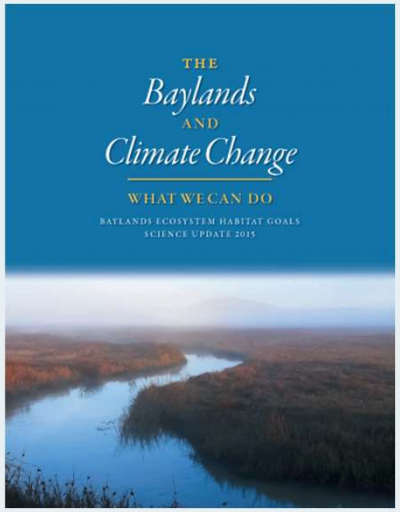
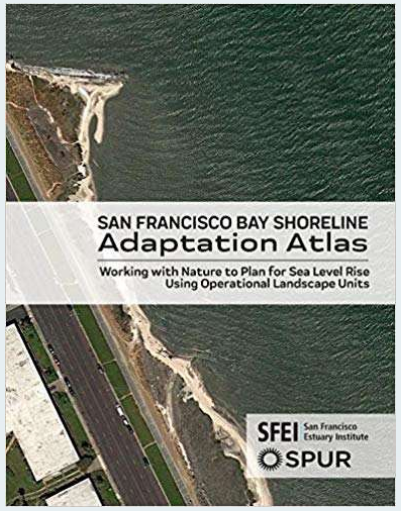


Habitat Goals Update

baylandsgoals.org



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