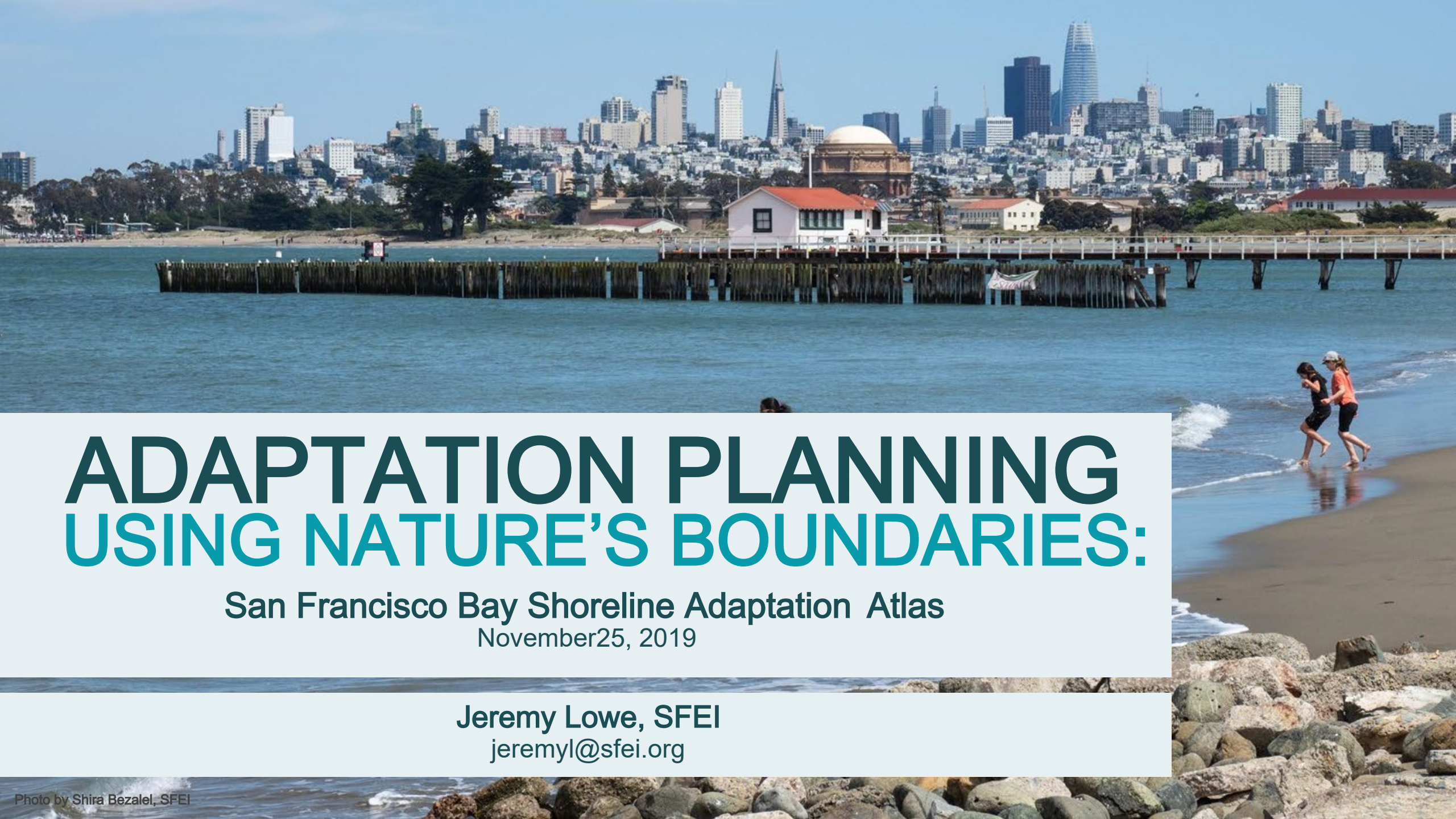

ADAPTATION PLANNING
USING NATURE'S BOUNDARIES:

San Francisco Bay Shoreline Adaptation Atlas

November25, 2019

Jeremy Lowe, SFEI
jeremyl@sfei.org

Photo by Shira Bezalel, SFEI

San Francisco Estuary Institute (SFEI)

- **Formed in 1986 out of need to monitor water quality** in SF Bay
- **Provide scientific support and tools** for decision-making and communication through collaborative efforts
- **Perform independent scientific assessments** to improve the health of the waters, wetlands, wildlife and landscape
- San Francisco Bay, California Delta, Southern California
- ~ 60 scientists and growing

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San Francisco Estuary Institute (SFEI)

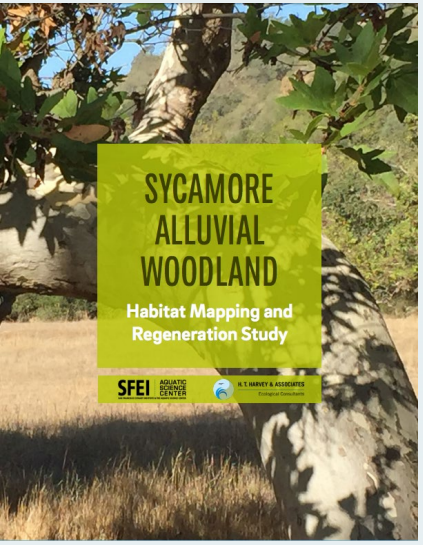
CLEAN WATER

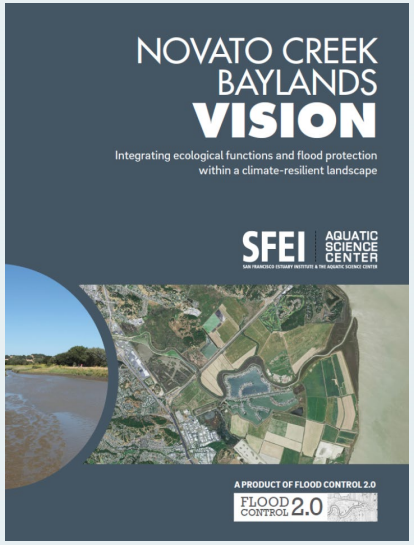
ENVIRONMENTAL INFORMATICS

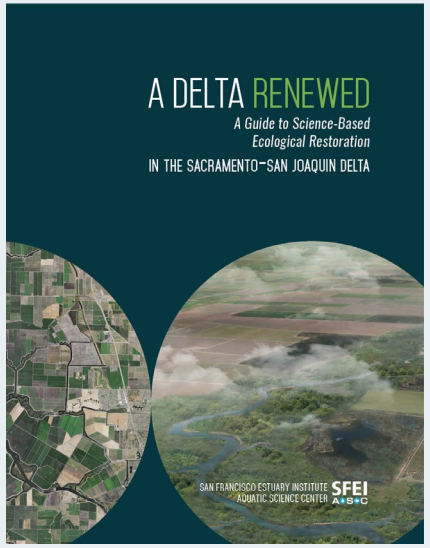
RESILIENT LANDSCAPES

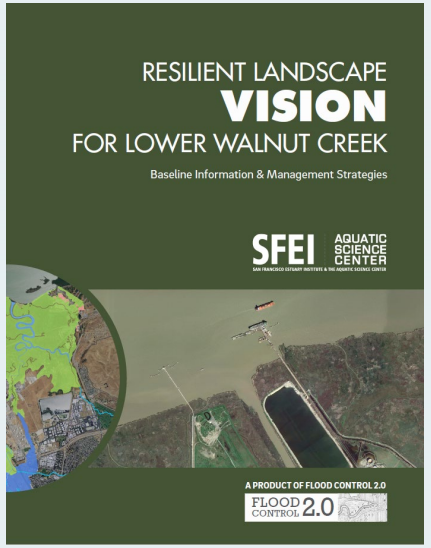
SFEI: Clients and Partners

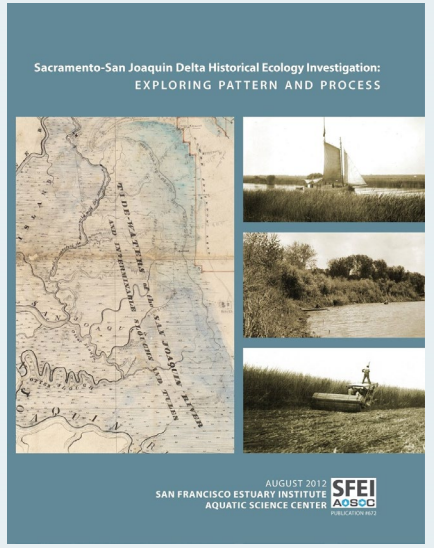
- Federal agencies *(EPA, Army Corp of Engineers, National Marine Fisheries Service)*
- State & regional regulators *(MTC, SanFrancisco Bay Regional Water Quality Control Board, CA Dept. of Fish and Wildlife)*
- *Cities and Counties (Palo Alto, Corte Madera, Hayward, Marin, San Mateo)*
- Land use and resource agencies *(Santa Clara Valley Water District, Zone 7, Santa Clara Valley Open Space Authority, Peninsula Open Space Trust, etc.)*
- Business & NGO leaders *(Google Ecology Program, San Francisco Estuary Partnership)*

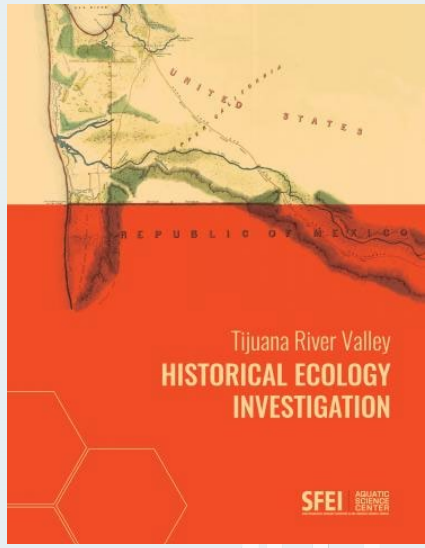












A science-based framework is essential to identify effective adaptation strategies....

...that are appropriate for their particular settings and that take advantage of natural processes.

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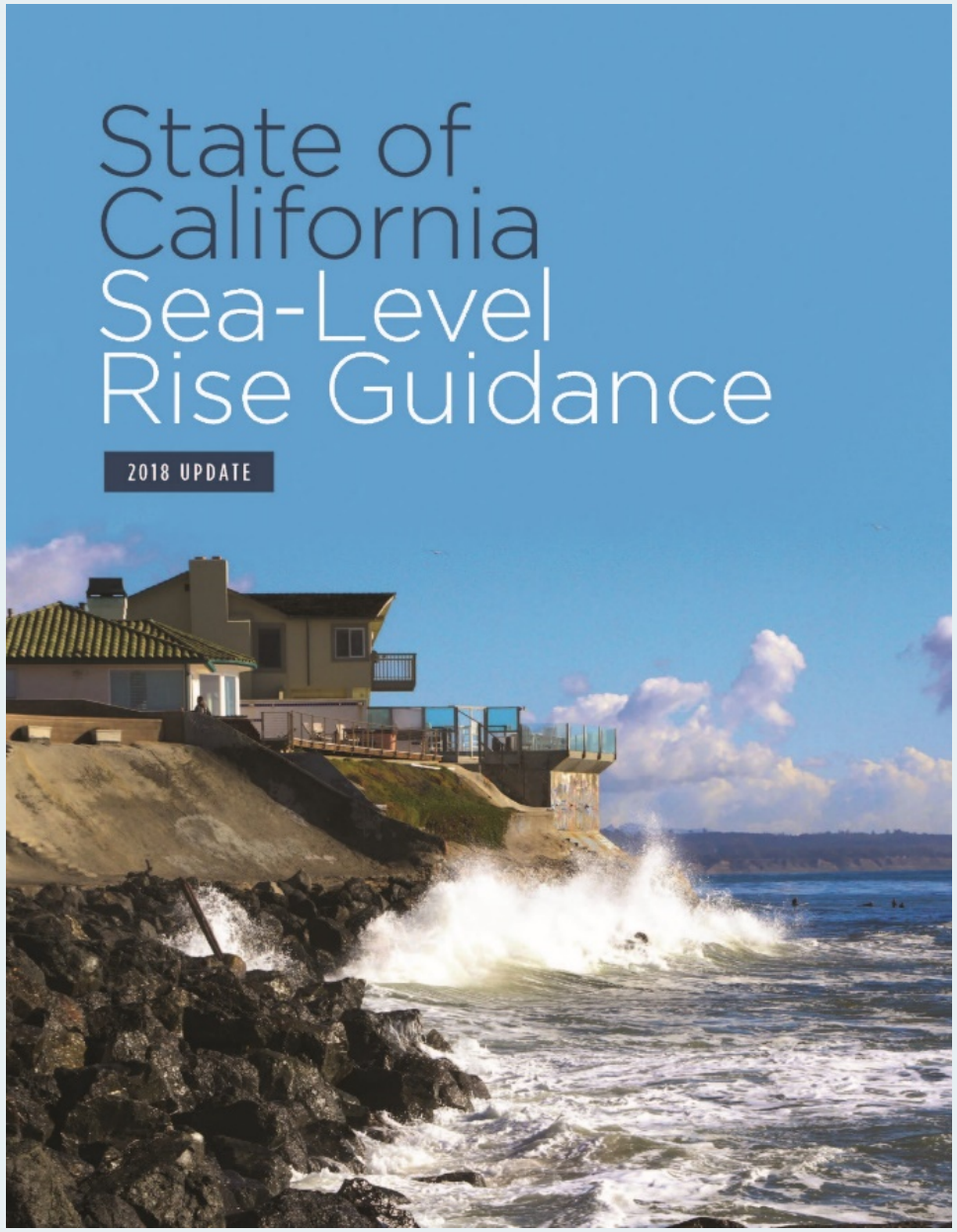
Sea-Level Rise

- Sea level in the Bay Area has risen over 0.6 feet in the last 100 years.
- Projection of sea level rise **up to 2 feet by 2050** , and between **5 and 7 feet by 2100** .
- Extremely high sea level rise by 2100 (as high as 10 feet) is plausible but with very low probability.
- **At least 6 feet of sea level rise is inevitable** over the next several centuries.



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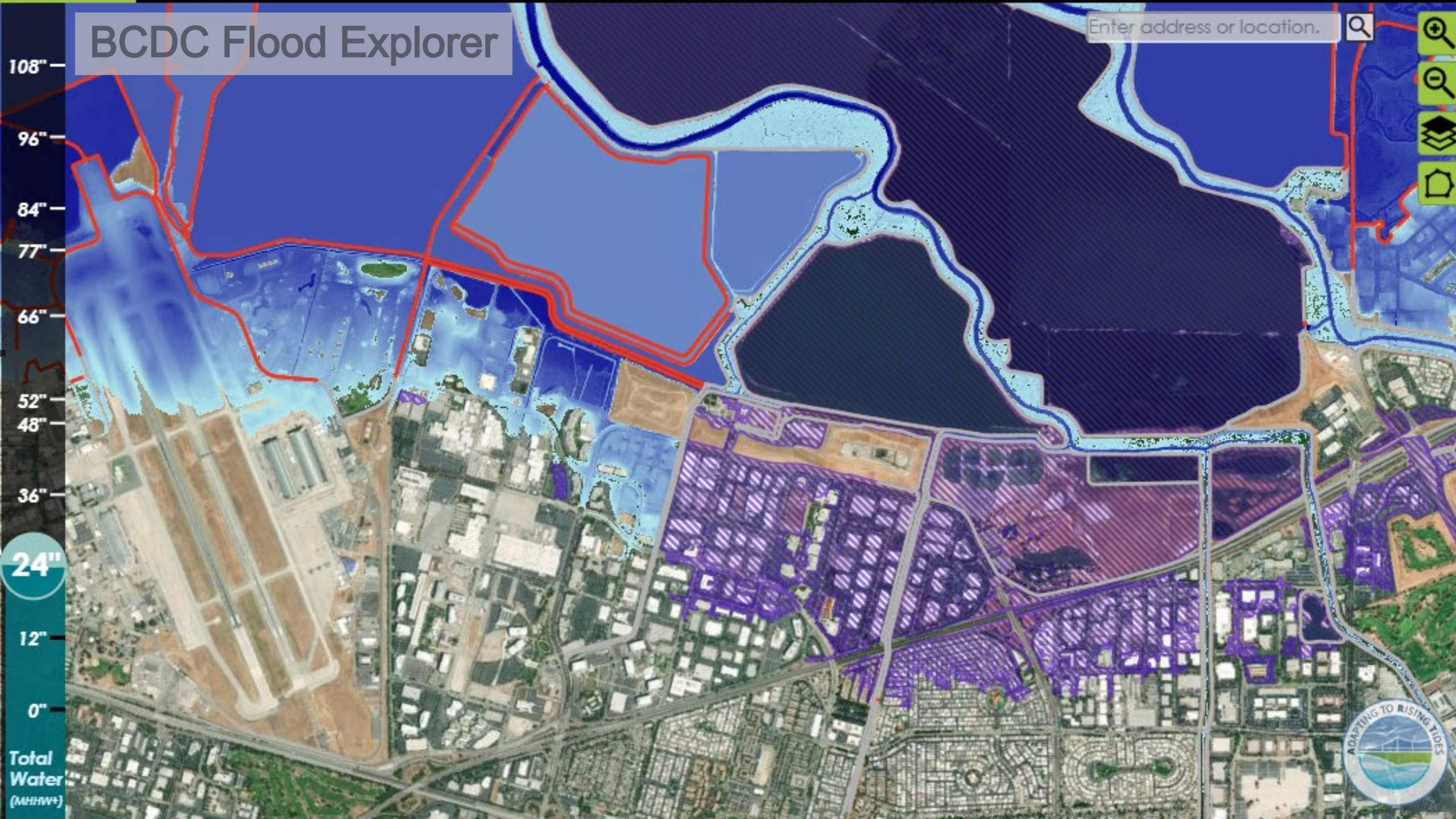
BCDC Flood Explorer
Enter address or location.
108"
96"
84"
77"
66"
52"
48"
36"
24"
12"
0"
Total Water (MHHW+)
ADAPTING TO RISING TIDES

Addressing this challenge by:

- Dividing up the Bay into manageable units that respond to the **physical and ecological processes**
- Mapping **suitability for nature - based adaptation measures**
- **Integrating across the land -water divide,** and connecting bayside measures with landside measures

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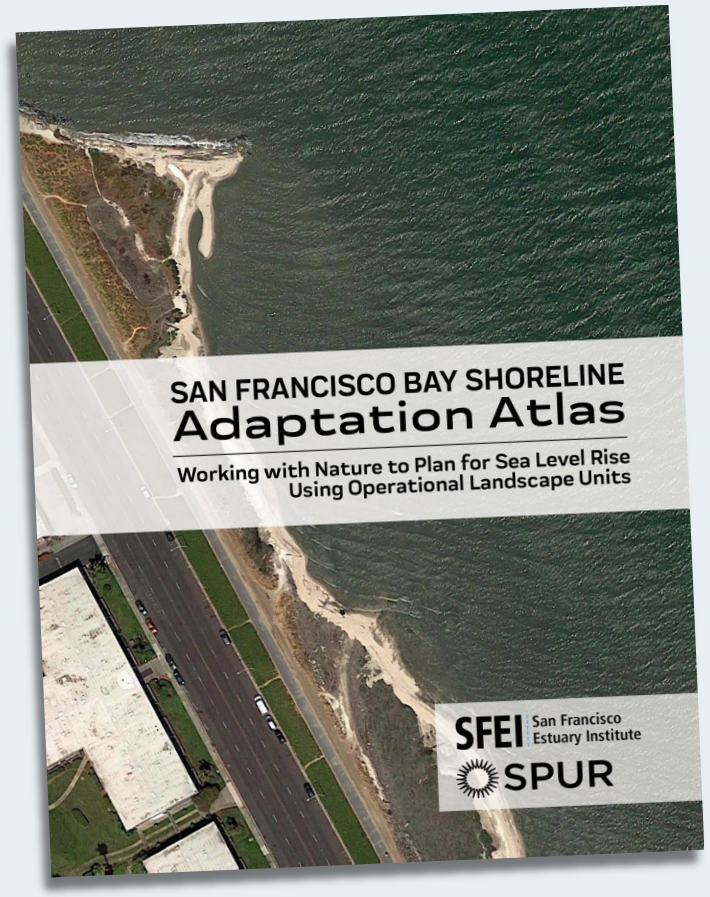
Adaptation Atlas



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

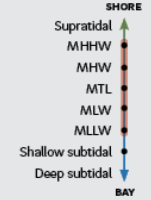
• Biodiversity • Food supply • • Climate regulation* • • Water quality improvement* • • Recreation • • Other cultural services •

* *Service dependent on chosen management approach*

IMPACT ON SHORELINE

Protect · Accommodate · Retreat

LOCATION
WITHIN TIDAL TRANSECT



EXAMPLES
Oro Loma Sanitary District

DEFINITION

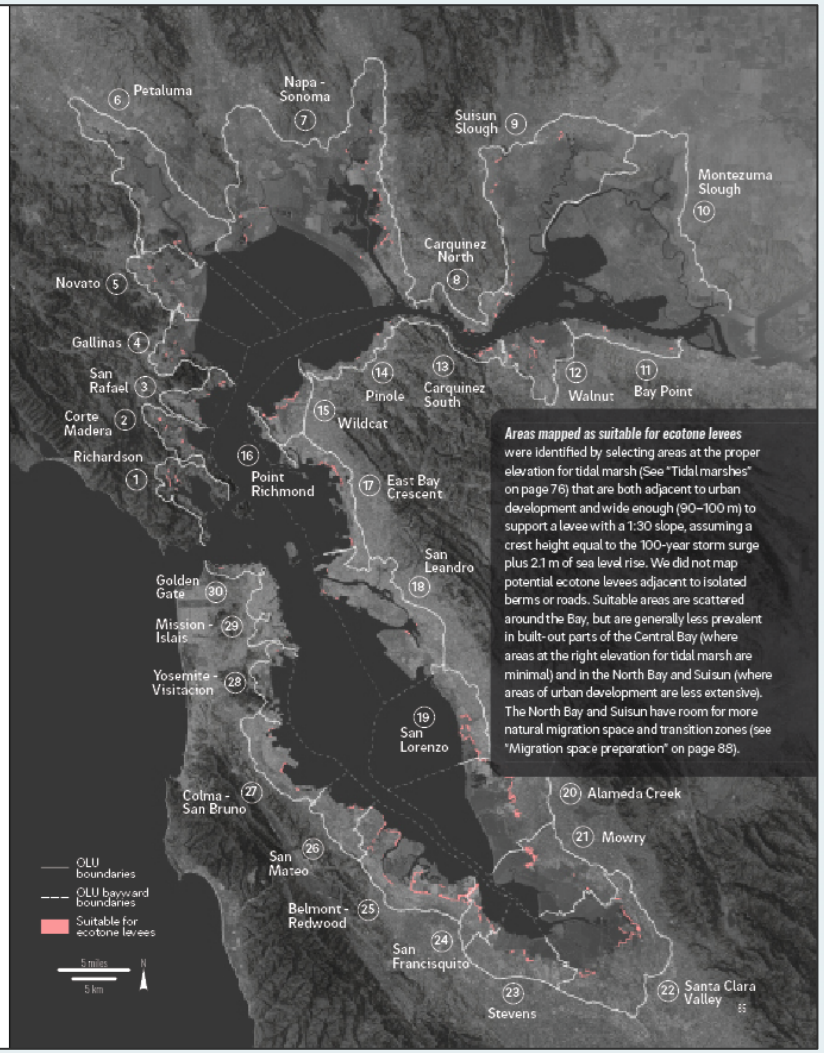
Ecotone levees are gentle slopes or ramps (with a length to height ratio of 20:1 or gentler) bayward of flood risk management levees and landward of a tidal marsh. They stretch from the levee crest to the marsh surface, and can provide wetland-upland transition zone habitat when properly vegetated with 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



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Nature's Boundaries

Operational Landscape Units

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

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

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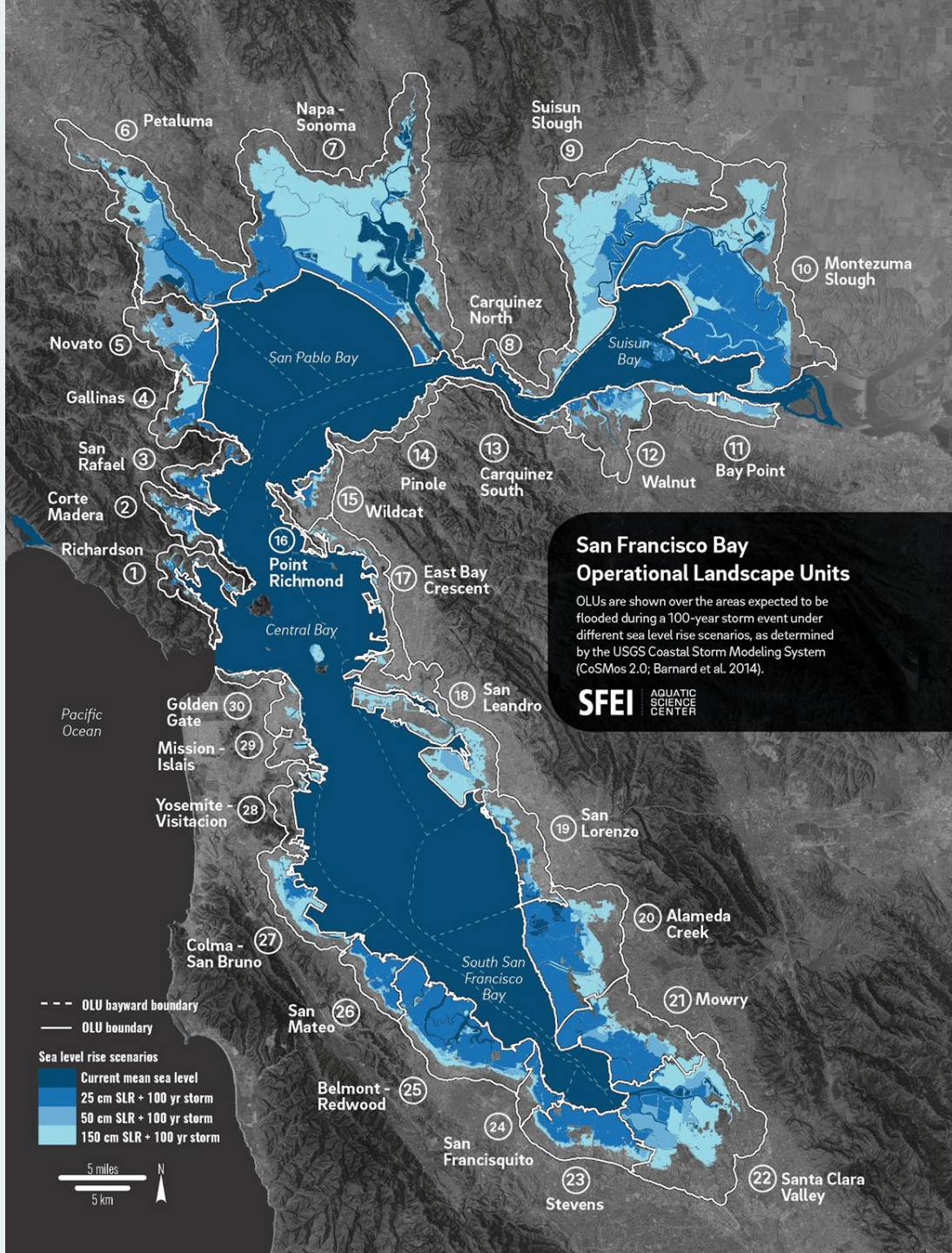

Hard Measures

Nature-Based Measures

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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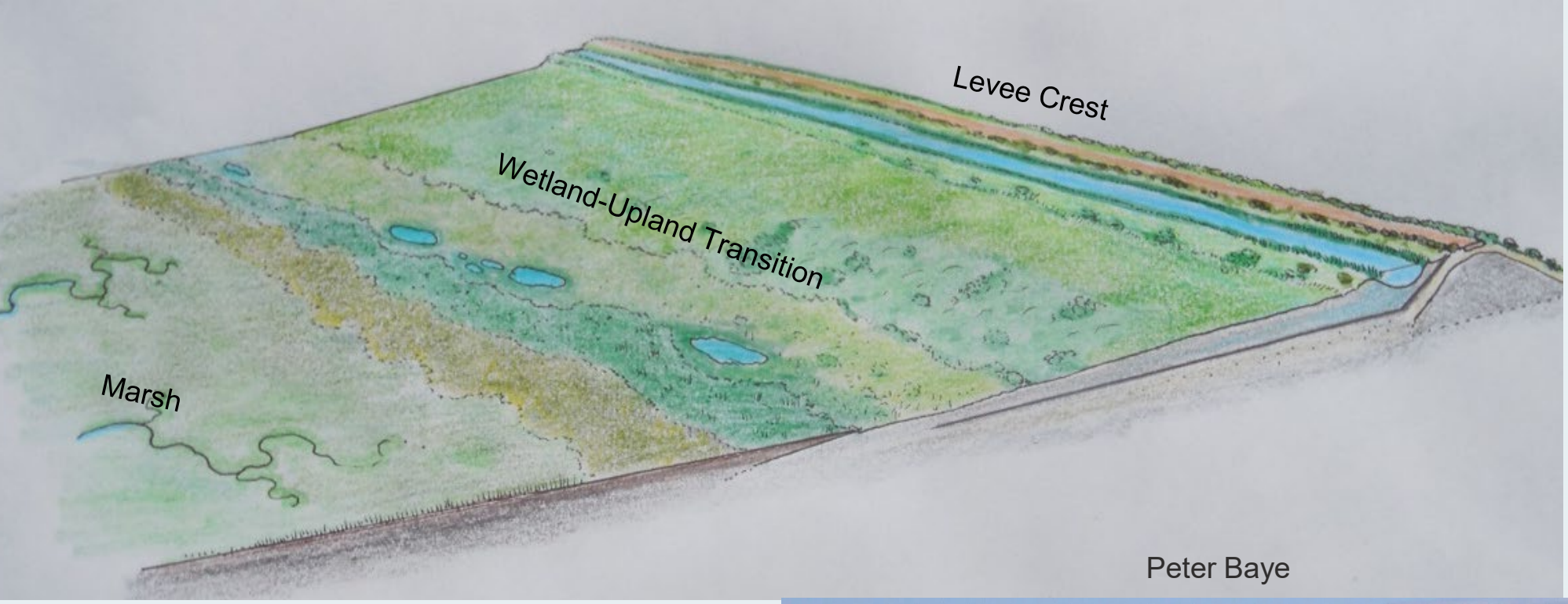
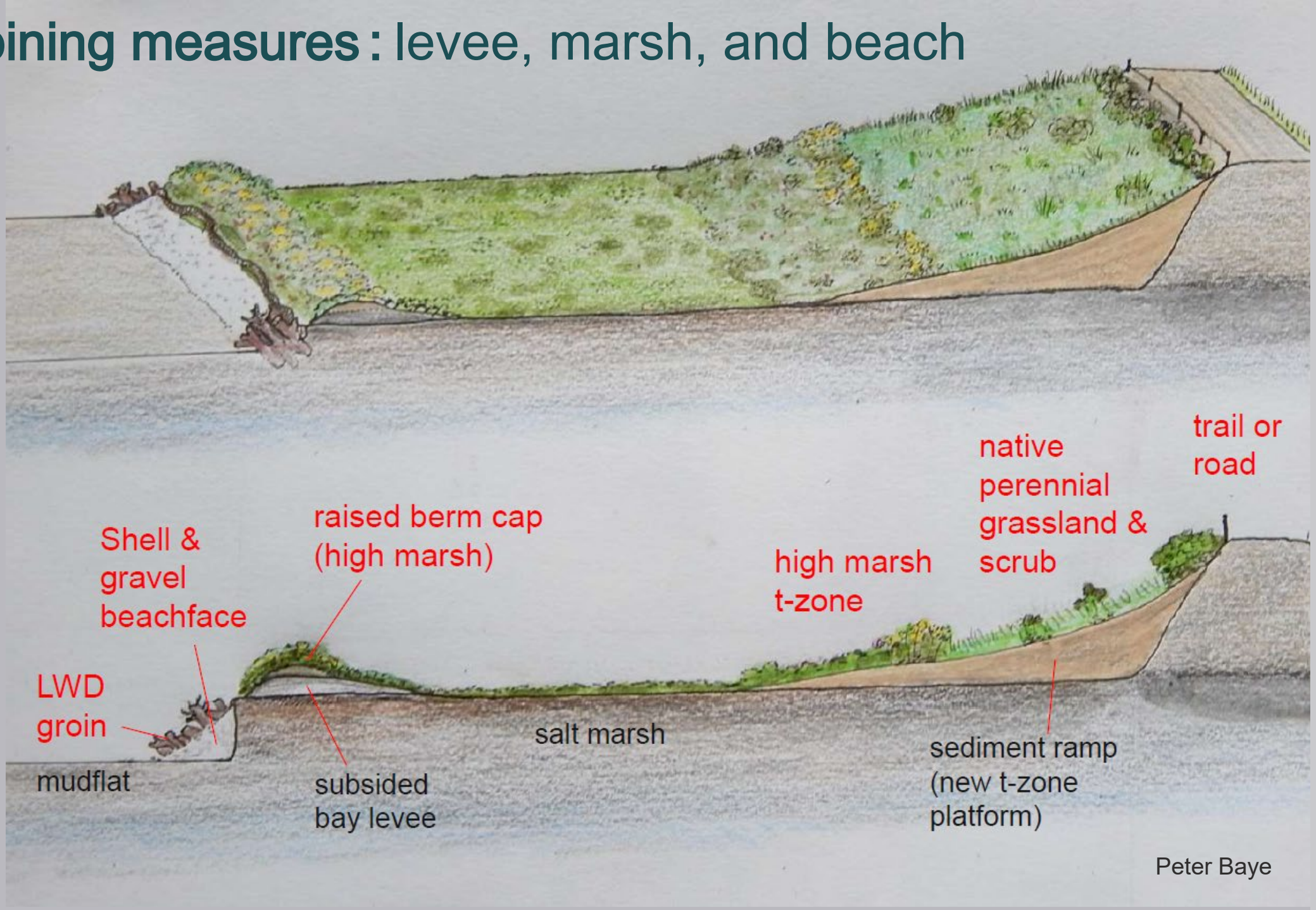


Peter Baye

Coastal storm-surge barriers: tidal marsh & horizontal levee

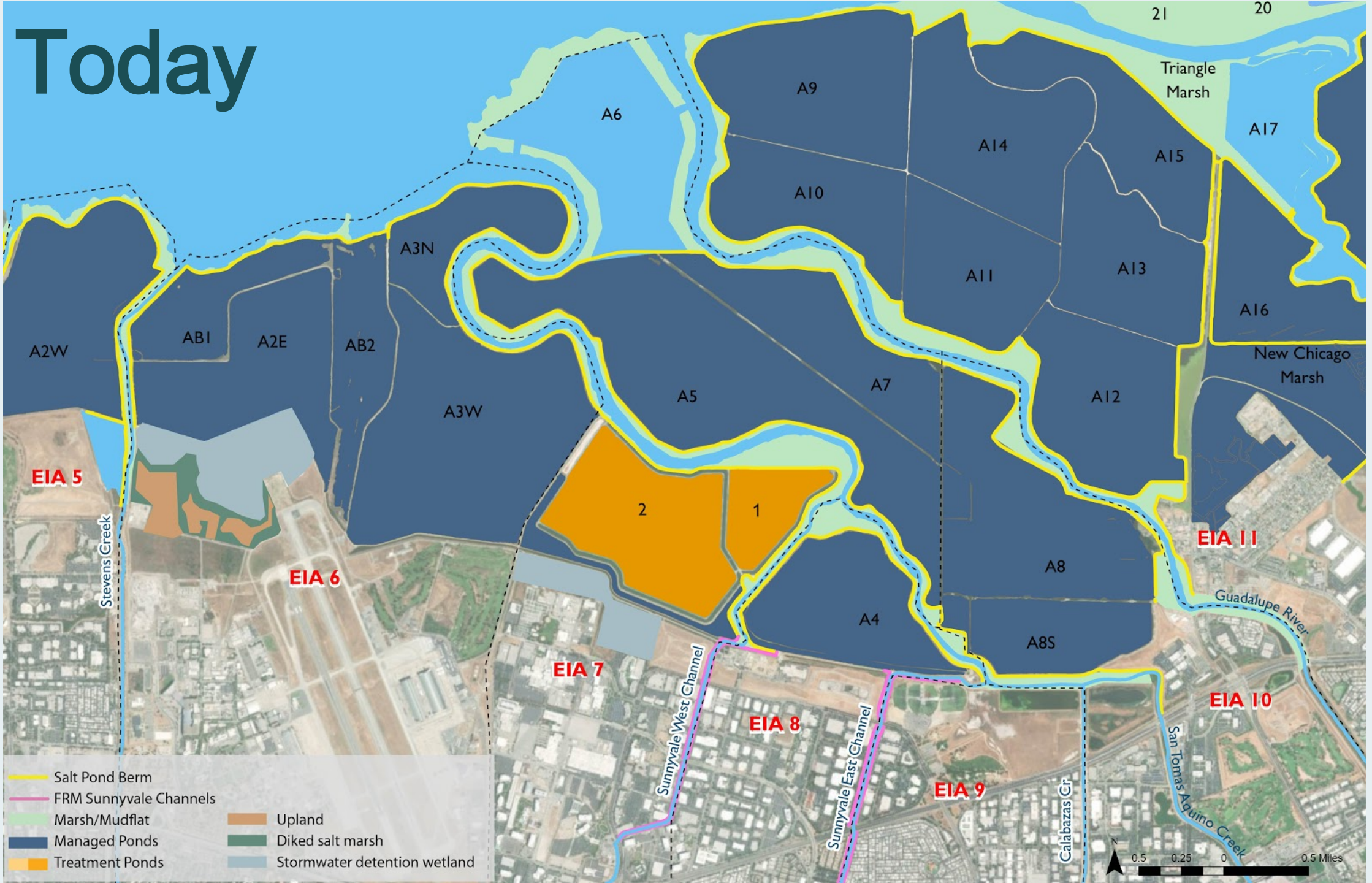
Wave barriers: beaches

Combining measures : levee, marsh, and beach



How can this be used?

- As a toolkit to bring together stakeholders around a given shoreline unit (BCDC)
- A resource to assist environmental review and permitting (BCDC, RB2)
- Guidance for developers and project applicants
- Local, regional planners, and communities creating adaptation plans and policies


Today
21
20
Triangle Marsh
A9
A6
A14
A15
A17
A10
A11
A13
A16
A2W
AB1
A2E
AB2
A3N
A3W
A5
A7
A12
New Chicago Marsh
EIA 5
2
1
EIA 11
Stevens Creek
EIA 6
A8
Guadalupe River
A4
A8S
EIA 7
Sunnyvale West Channel
EIA 8
Sunnyvale East Channel
EIA 10
EIA 9
Calabazas Cr
San Tomas Aquino Creek
Salt Pond Berm
FRM Sunnyvale Channels
Marsh/Mudflat
Managed Ponds
Treatment Ponds
Upland
Diked salt marsh
Stormwater detention wetland
N
0.5
0.25
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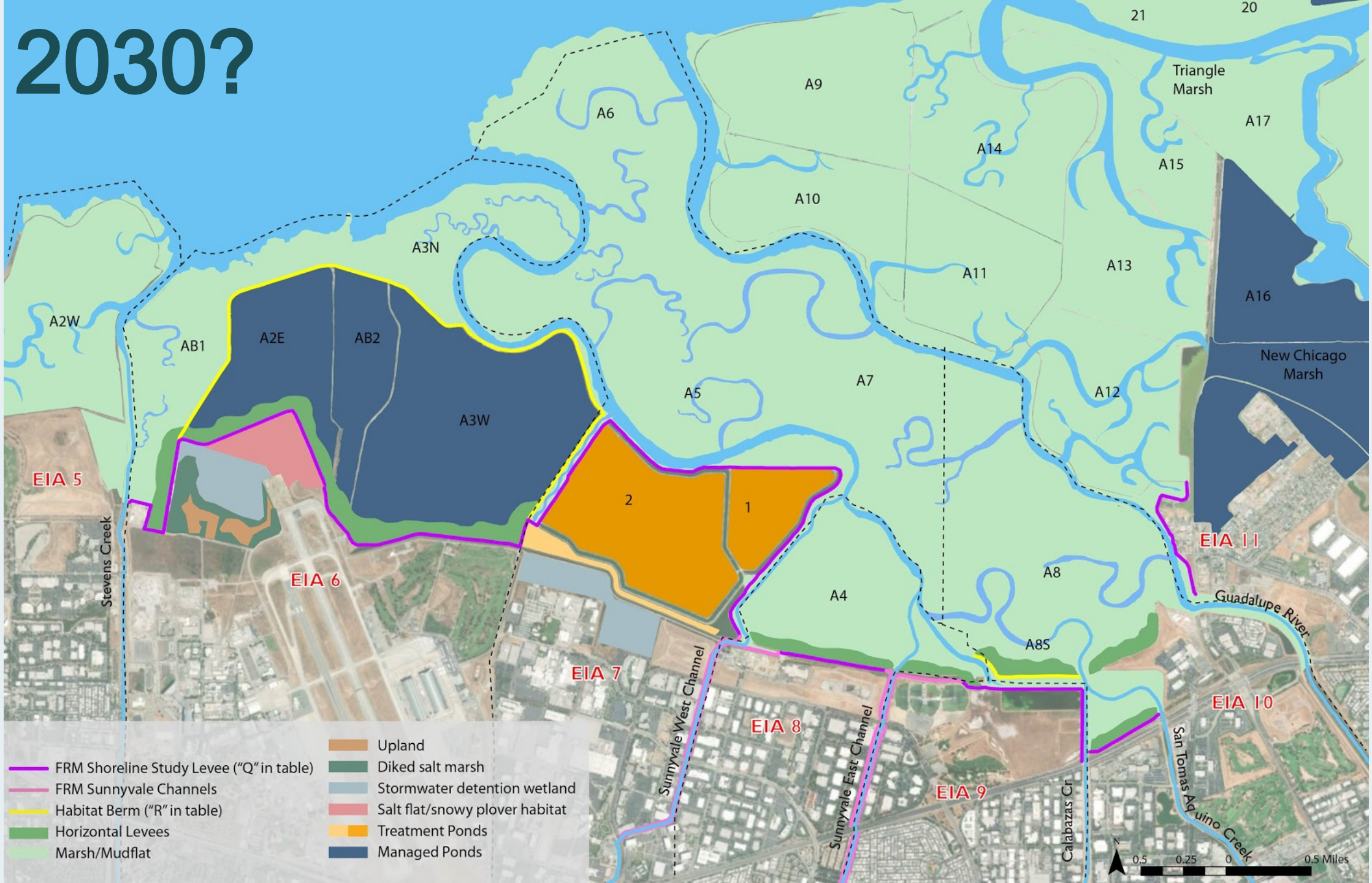
0.5 Miles


2030?
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Triangle Marsh
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A17
A15
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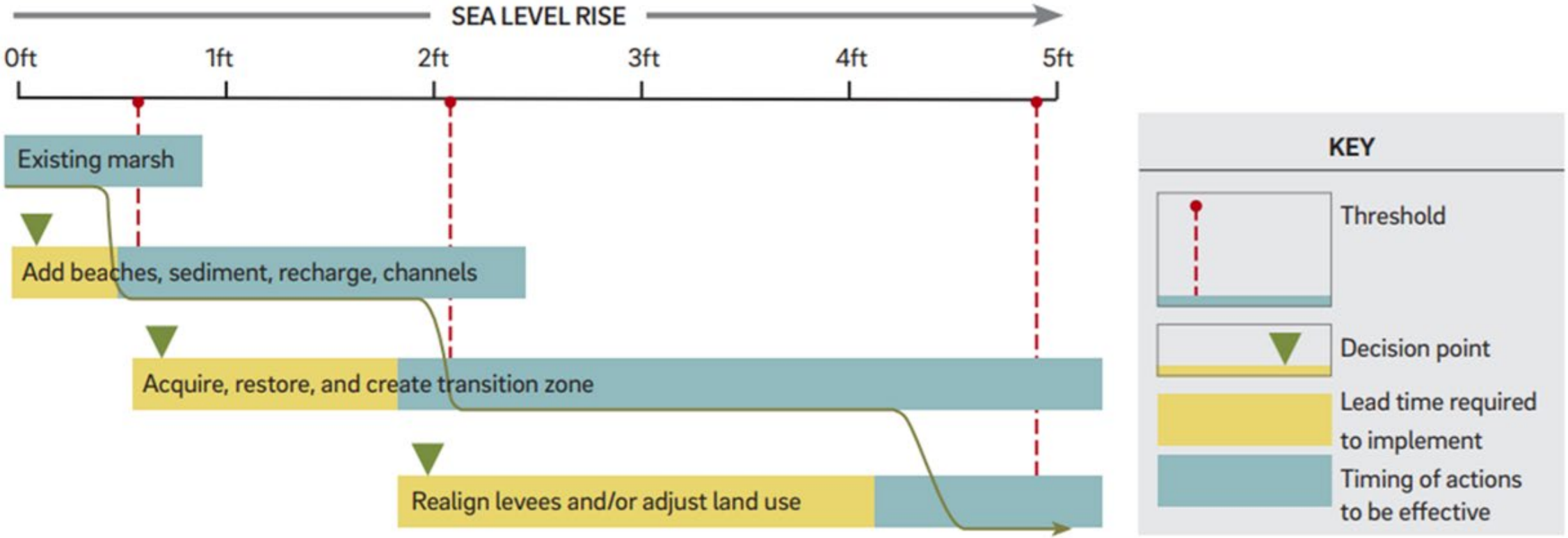
A3N
A11
A13
A16
A2W
AB1
A2E
AB2
A3W
A5
A7
A12
New Chicago Marsh
EIA 5
2
1
EIA 11
Stevens Creek
EIA 6
A8
A4
Guadalupe River
A8S
EIA 7
Sunnyvale West Channel
EIA 8
EIA 10
Sunnyvale East Channel
EIA 9
Calabazas Cr
San Tomas Aquino Creek
FRM Shoreline Study Levee ("Q" in table)
FRM Sunnyvale Channels
Habitat Berm ("R" in table)
Horizontal Levees
Marsh/Mudflat
Upland
Diked salt marsh
Stormwater detention wetland
Salt flat/snowy plover habitat
Treatment Ponds
Managed Ponds
N
0.5
0.25
0
0.5 Miles

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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Thank you

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