A Novel Approach to San Francisco Baylands and Sea Level Rise: Adaptation Using Horizontal Levees

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A new kind of levee

The Bay Institute, an environmental group, has proposed a number of "horizontal levees" for San Francisco Bay that blend a traditional earthen levee with restored tidal marshes. The marshes would be built up with sediment from local flood control channels. Marsh vegetation would be irrigated with reclaimed wastewater.

Marshes as barriers
Tidal marshes can slow down storm surges, meaning levees fronted by marshes can be built half as tall, and at half the cost, as traditional levees made of earth and clay.

WITH NO MARSH
13.5-foot-high levee

WITH MARSH
7-foot-high levee

Note: Not to scale

Planted with fast-growing plants such as the mildly seawater-tolerant alkali bulrush and tule, the brackish marsh would slow down a storm surge, absorbing it like a sponge. This dense vegetation, home to birds such as song sparrows, can reach 8 feet in height.

Clapper rails build their nests in tidal marsh cord grass, which would grow 3 to 5 feet tall alongside 1-foot pickleweed.

Covered by seawater most of the day, tidal mud flats would not be vegetated.

Source: The Bay Institute
CURRENT FRESHWATER INPUTS TO THE BAYLANDS, ca 2014

Freshwater Inputs at Tidal Marsh Interface
- Creek/Channel
- Treated Effluent Outfall
- Diffuse intermittent flow
- Diffuse perennial flow

Freshwater Input Magnitude (estimate)
- >150 cfs / 100 MGD
- 50-150 cfs / 32-100 MGD
- <50 cfs / 32 MGD
- <10 cfs / 6.5 MGD

Freshwater Input Timing
- Peak flow
- Mean annual flow
- Dry season baseflow

Contemporary Landscape Features
- Engineered Channel
- Underground Culvert, Storm Drain
- Bay
- Tidal Flat
- Tidal Marsh
- Muted Tidal Marsh
- Managed Marsh
- Salt Pond
- Storage or Treatment Basin
- Diked Former Bayland
- Artificial Fill

Question marks (?) = No data, estimate shown

1 mile
Landscape Vision - Processes

- Flood control levee
- Treated water routed through seepage slope
Irrigating a Seepage Slope - Treated Wastewater?

- Gentle slope
- Treated wastewater = freshwater input
- Plant growth, build organic soils to help keep pace w/ SLR
- Polish wastewater reducing level of tertiary treatment

![Diagram showing wave attenuation, seepage, and various marsh types](#)
Oro Loma Sanitary District
Wastewater Treatment Plant
Multi-Objective Demonstration Project

- Freshwater treatment wetland & wet weather storage
- Perimeter levee
- Secondary treated effluent
- Nitrification facility
- Pump station
- Perforated seep & collection lines
- Return line to WWTP
- Ecotone slope
- Realign stormwater channel
- Culvert with tide gate
- Weir gate
Nutrient Cycling?
Oro Loma – Ecotone Experiments

4 cell types

1) **Fine substrate** + swales & depressions

2) **Fine substrate** + wet meadow

3) **Coarse substrate** + wet meadow

4) **Coarse substrate** + riparian scrub

Source: ESA
Traditional Propagation Methods

- 70,000 plants
- $2.00 - $6.00 per container
- Plus installation = ~$425K
On Site Raised Nursery Beds
Planting with Volunteers

Began November 14, 2015
Completed Early February 2016
Ecotone Slope Cell Types

Wet meadow/Riparian scrub

Restrictive layer – compacted clay

SEEPAGE TERRACE

Brackish high marsh transition zone

Tidal salt marsh

Wet meadow/riparian scrub

• wetland grass, sedge, and rush matrix

• Baltic rush, field sedge, creeping wild rye, and other rhizomatous grasses.
Rapid Vegetation Establishment

Cell Type

Fine substrate + Wet Meadow

5/31/16

10/27/16
Cell Type

Coarse substrate + Wet Meadow
Cell Type

Coarse substrate + Riparian Scrub
Monitoring

• Amount of wastewater per acre of ecotone?
  • Monitor plant health
  • Monitor nutrient uptake/removal
• Flow rates measured at top & bottom of each cell
• Sampling Piezometers – 3 per cell
• Surveys and/or SET monitoring of organic soil elevations
• Vegetation Monitoring
• Nutrient removal rates (UC Berkeley)
Future Applications?
• Flood control levee
• Treated water routed through seepage slope
Proposed Transition Zone Restoration Areas: Bedwell Bayfront and All American Canal

Figure 1. Site-scale map
San Francisco Bay wastewater treatment plants vulnerable to a 100-year coastal flood with a 1.4-meter sea-level rise.

Data sources: USGS/SCRIPPS Institution of Oceanography, EPA PWS Database, CaSIL, ESRI.
http://www.pacinst.org/reports/sea_level_rise
No Time

Imagine

With a Little Help From My Friends

Trouble

A Little Bit Crazy

How High is the Water Momma?

Happy Together
Questions?
Benefits

• Creates upland ecotone lost from the Bay
• Nutrient loading in the Bay
• Flood risk management
• Buys time
Rapid Vegetation Establishment

Fine substrate
+ Swale/Depression
Cell Type

5/31/16

10/27/16
Habitat/Community-Based Restoration
Present

2050 - 12-14 in

2100 - 36-55 in

2100 - ?
Sample Summary of Opportunities

- Freshwater/brackish marsh
- Water recycling
- Horizontal levees
- Shoreline restoration and protection
- Discharge to marsh
- Increase instream flows
- Creek restoration
Habitat Friendly Levee