Natural Shoreline Infrastructure in Humboldt Bay for Intertidal Coastal Marsh Restoration and Transportation Corridor Protection

Technical Working Group Meeting #4
October 12, 2021

NATIONAL FISH AND WILDLIFE FOUNDATION NFWF

COUNTY OF HUMBOLDT The Home of the Redwoods

OCEAN PROTECTION COUNCIL

Scope of Work

Tasks
Task 1: Grant Administration / Project Management
Task 2: Stakeholder Engagement and Consultation
Task 3: Site Assessment 3.1 – Topographic and bathymetric survey 3.2 – Sediment characterization 3.3 – Habitat evaluation and vegetation mapping 3.4 – Geomorphic evaluation 3.5 – Hydraulic analysis
Task 4: Preliminary Design 4.1 – Goals and objectives 4.2 – Options evaluation 4.3 – Engineering design 4.4 – Re-vegetation plan 4.5 – Access and staging plan 4.6 – Monitoring plan 4.7 – Habitat effects analysis
Task 5: Reporting

Timeline (Updated)

Date	Key Milestones
August 3, 2020	• Technical working group meeting #1 (introduction)
December 15, 2020	• Technical working group meeting #2 (update on site assessment)
May 6, 2021	• Technical working group meeting #3 (draft goals and objectives, preliminary design options)
May 31, 2021	• Due date for receiving written comments on goals/objectives and preliminary design options
September 29, 2021	• Release draft report for site assessment and design options
October 12, 2021	• Technical working group meeting #4 (discuss site assessment, design options, and apparent best alternative)
November 2021	• Site Visit (Date/Time TBD)
January 2022	• Technical working group meeting #5 (35% Design Progress Update)
Spring 2022	• Technical working group meeting #6 (50% Design Progress Update)
June 30, 2022	• Project Completion (Technical working group meeting #7?)

Presentation Overview

1. Site Assessment (Task 3)
   - ✓ Historic Condition Assessment
   - ✓ Summary of Geomorphic Assessment
   - ✓ Sediment Flux Conceptual Model
   - ✓ Summary of Marsh Disturbance and Recovery
2. Re-cap Goals & Objectives (Task 4)
3. Alternative Development
4. Recommendation of Apparent Best Alternative
5. Discussion and Next Steps

Task 3 – Site Assessment

Paper Size ANSI A

0 0.2 0.4 0.6 0.8

Miles

Map Projection: Lambert Conformal Conic
Horizontal Datum: North American 1983
Grid: NAD 1983 StatePlane California I FIPS 0401 Feet

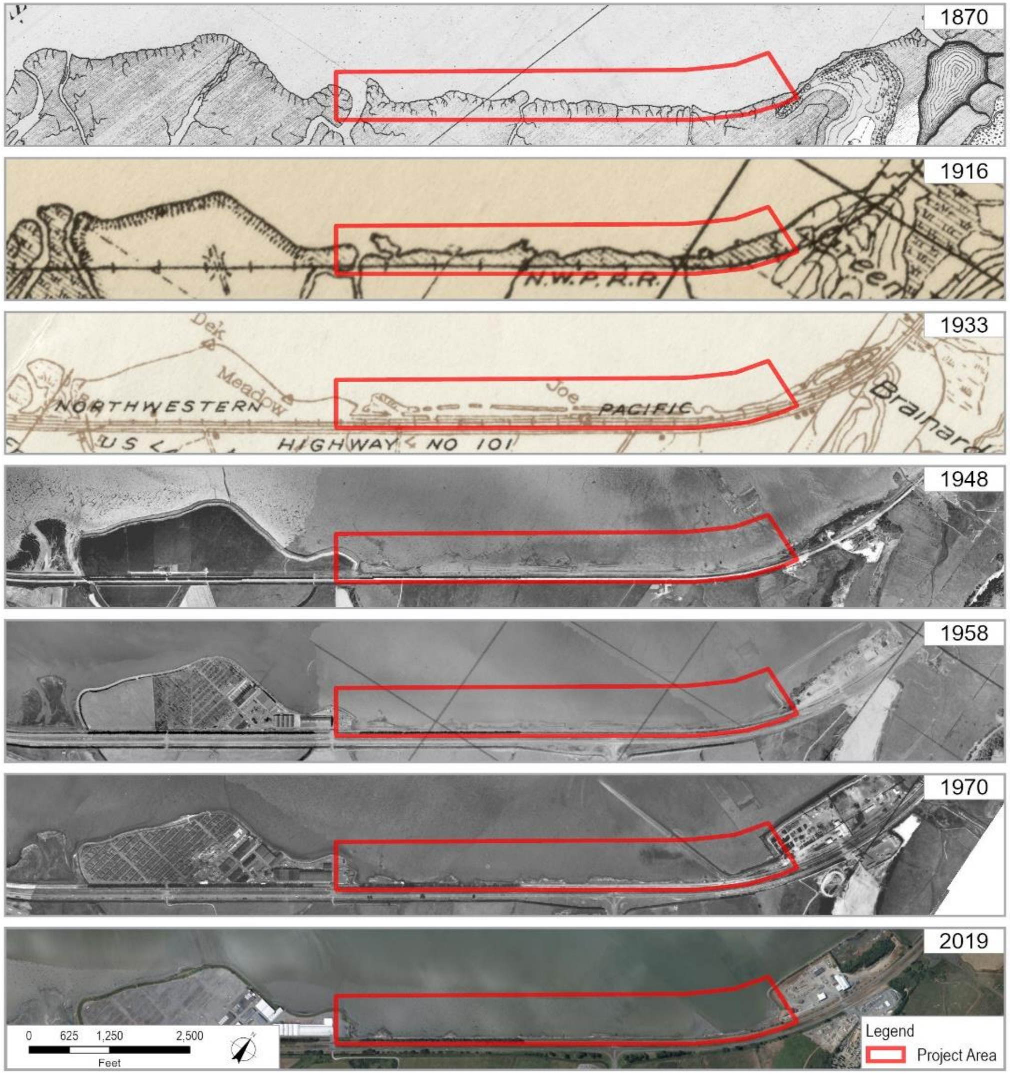
Humboldt County Department of Public Works
Humboldt Bay Natural Shoreline Infrastructure

Project and Reference Areas

Project No. **11214987**
Revision No. **-**
Date **Dec 2020**

FIGURE X

Summary of Historic Conditions



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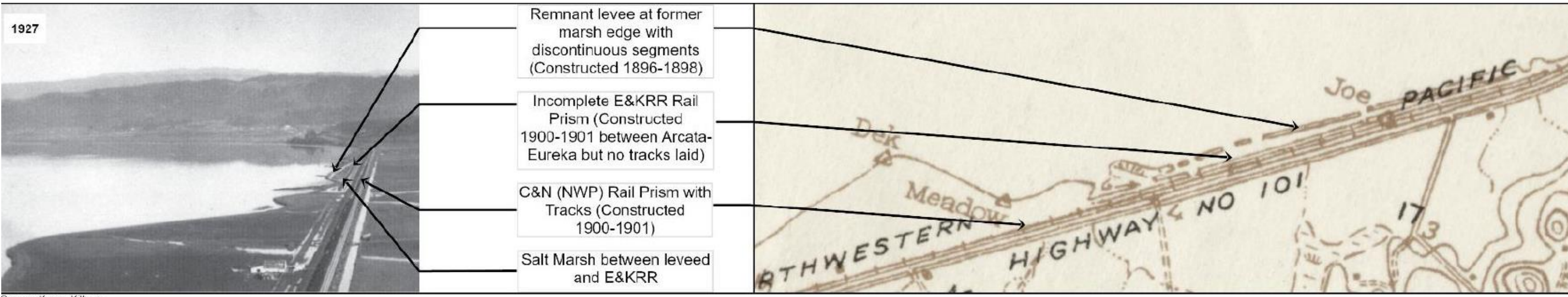
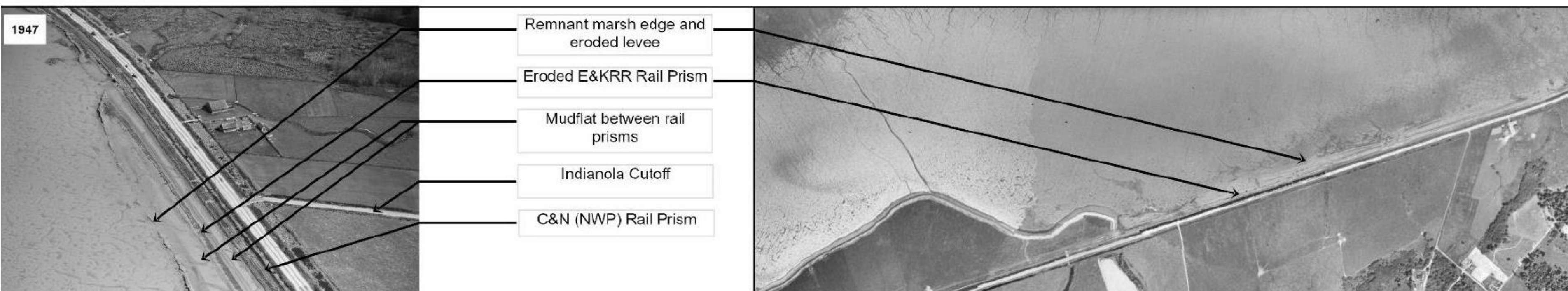
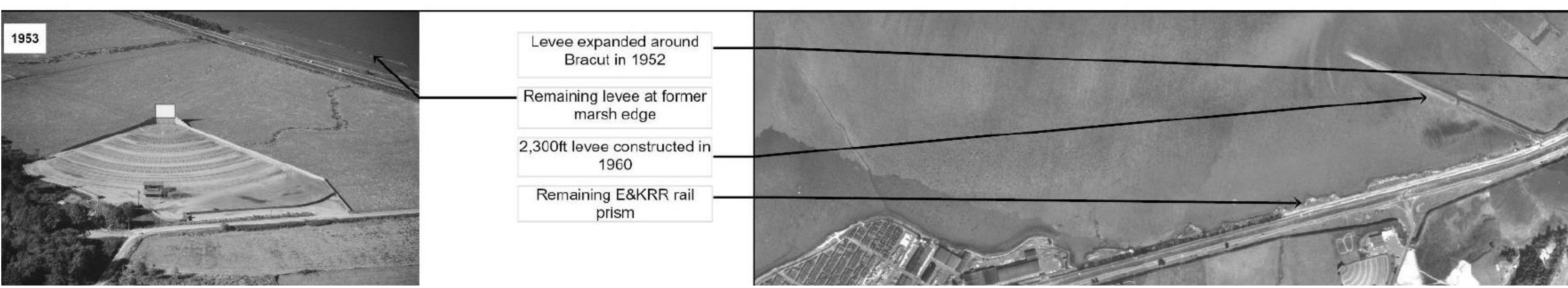


Source: Kenny Kilburn



Source: HSU Library



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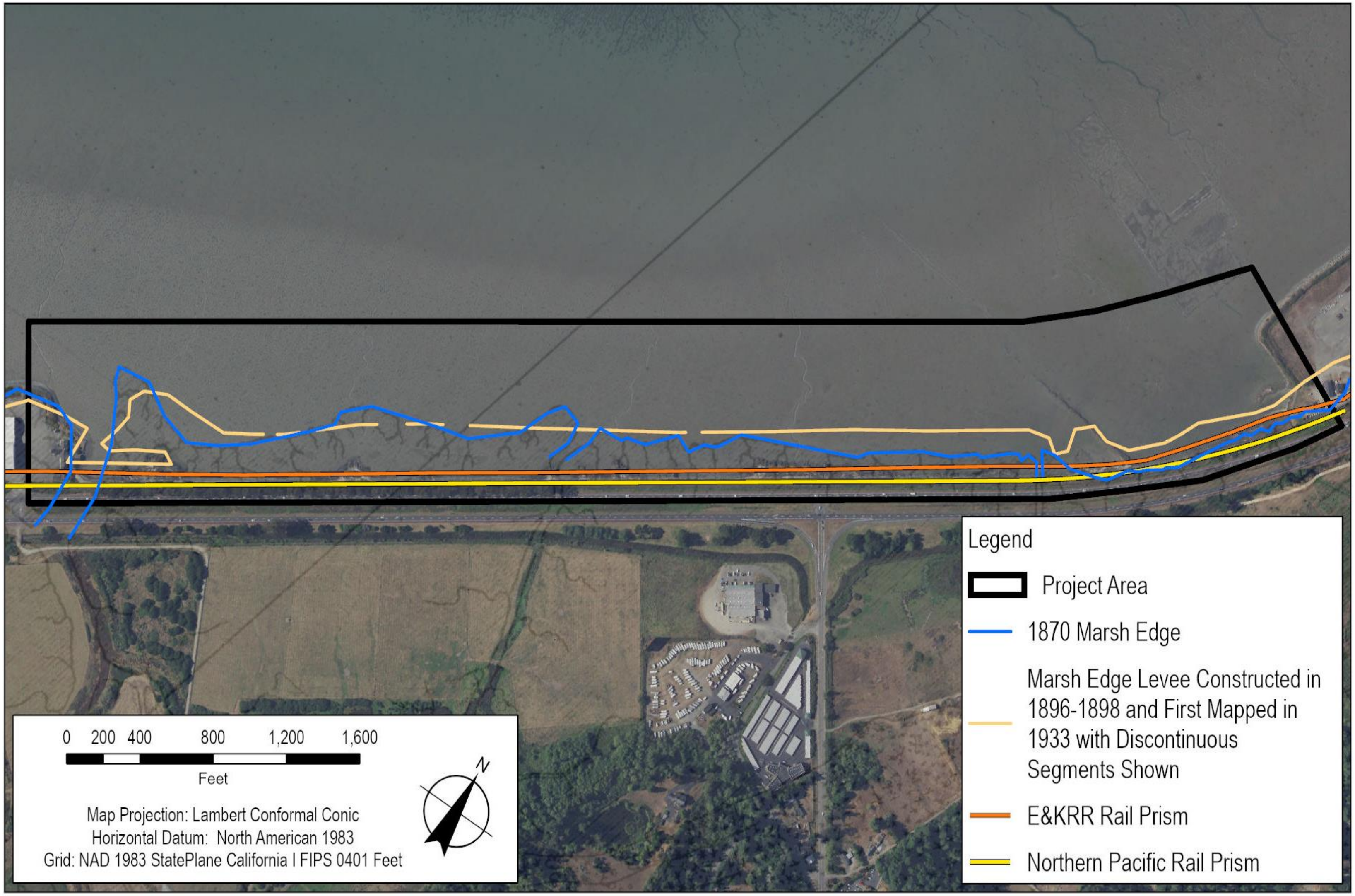

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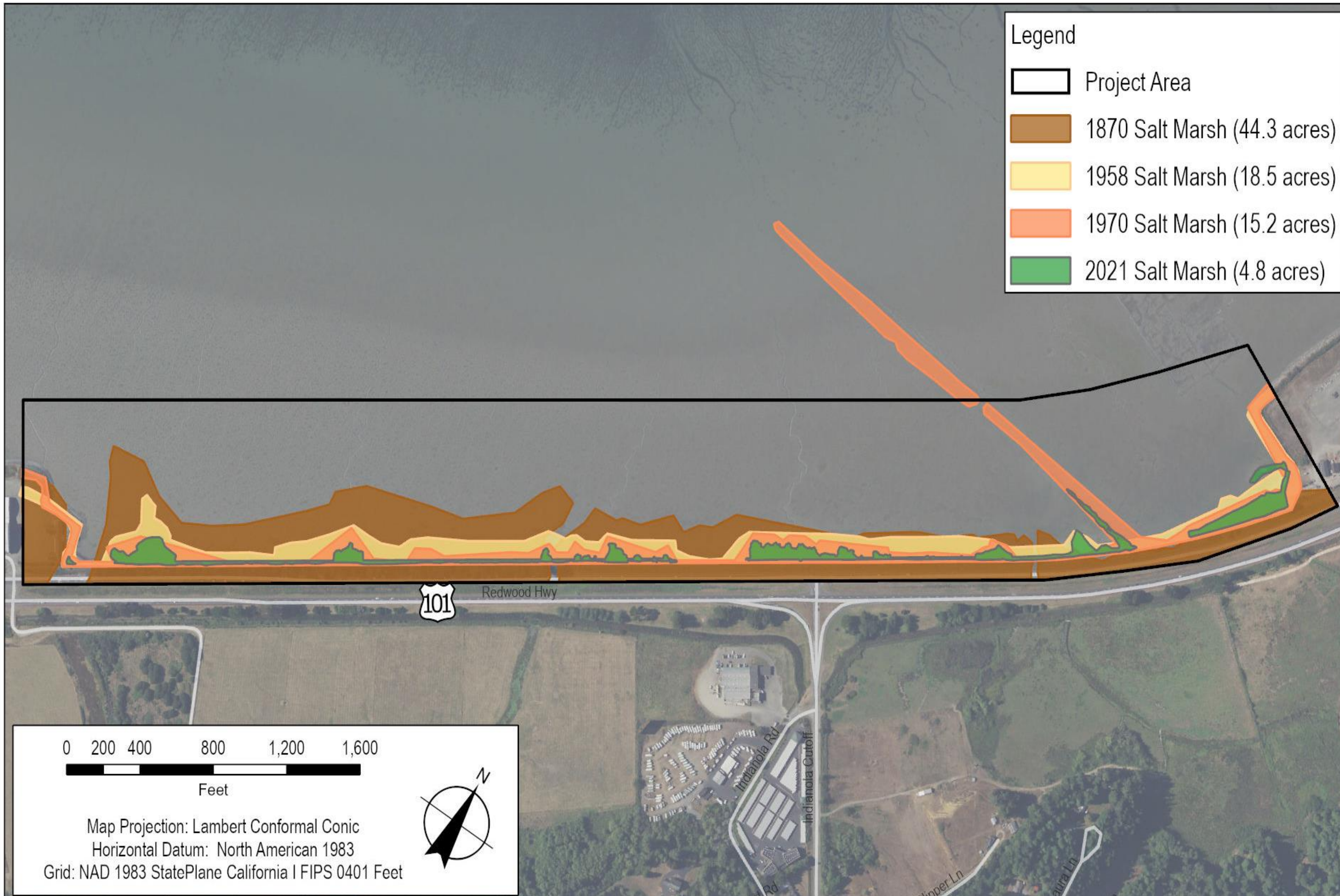
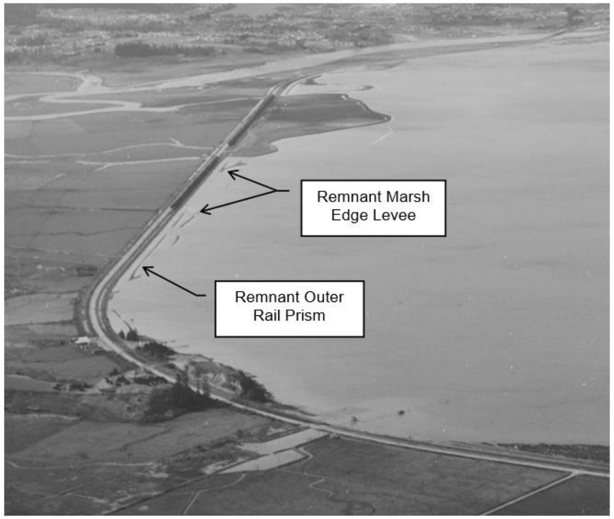


Summary of Historic Conditions

1947

Present

Circa 1940

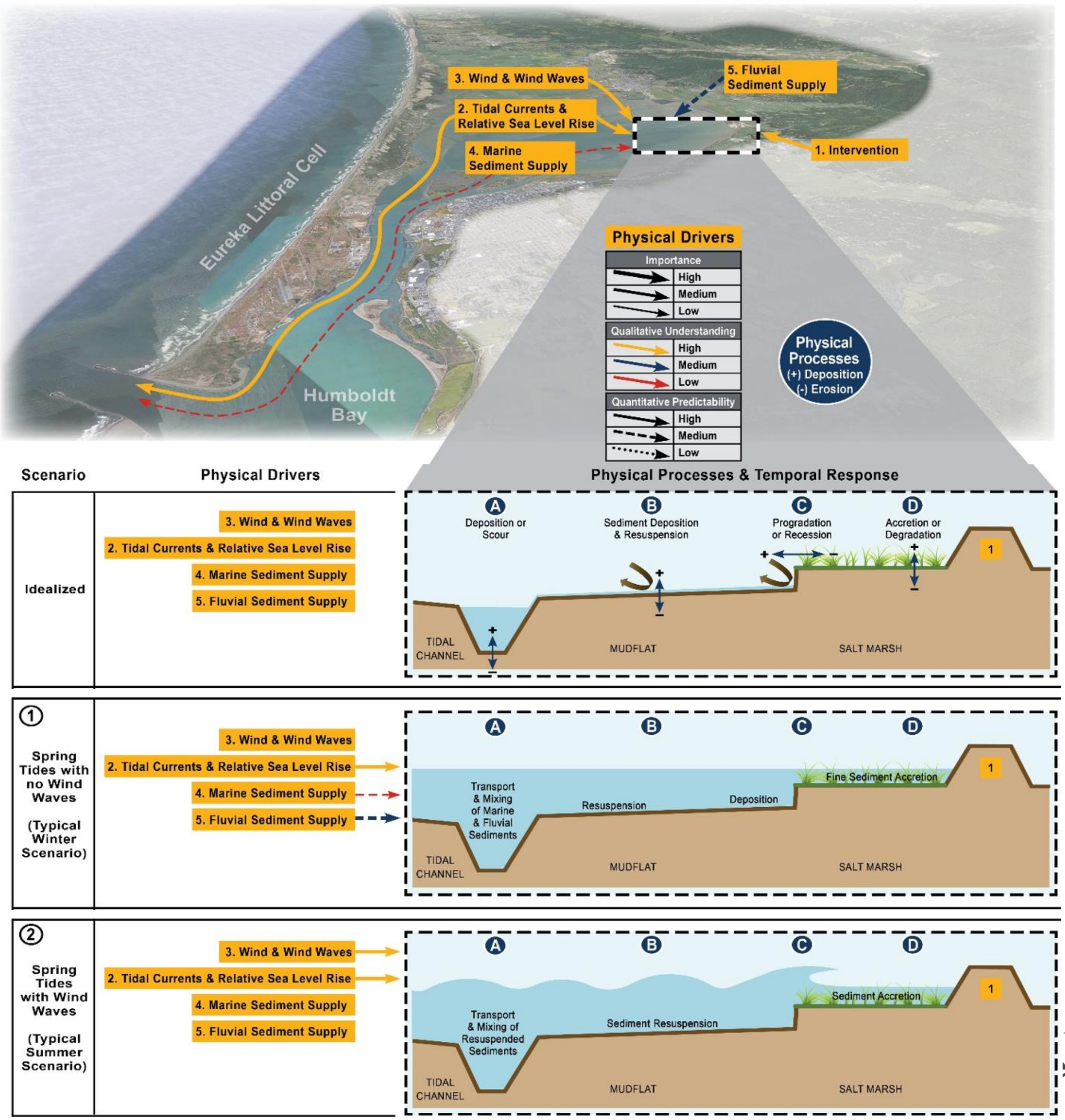


Geomorphic Assessment

- **Questions:**

1. What are the key physical drivers and anthropogenic interventions that influence physical processes along the eastern shoreline of Arcata Bay?
2. Which drivers and processes have attributed to the loss or gain of salt marsh in the project area?
3. Based on the drivers and processes, what potential natural shoreline infrastructure measures could be implemented to achieve the project goals and restore a resilient salt marsh at the project area?

Geomorphic Assessment: Sediment Flux Conceptual Model



Physical Drivers:

1. Interventions
2. Tidal Currents and Relative Sea Level Rise
3. Wind and Wind Waves
4. Marine Sediment Supply
5. Fluvial Sediment Supply

Physical Processes:

A. & B. Mudflat Deposition and Resuspension

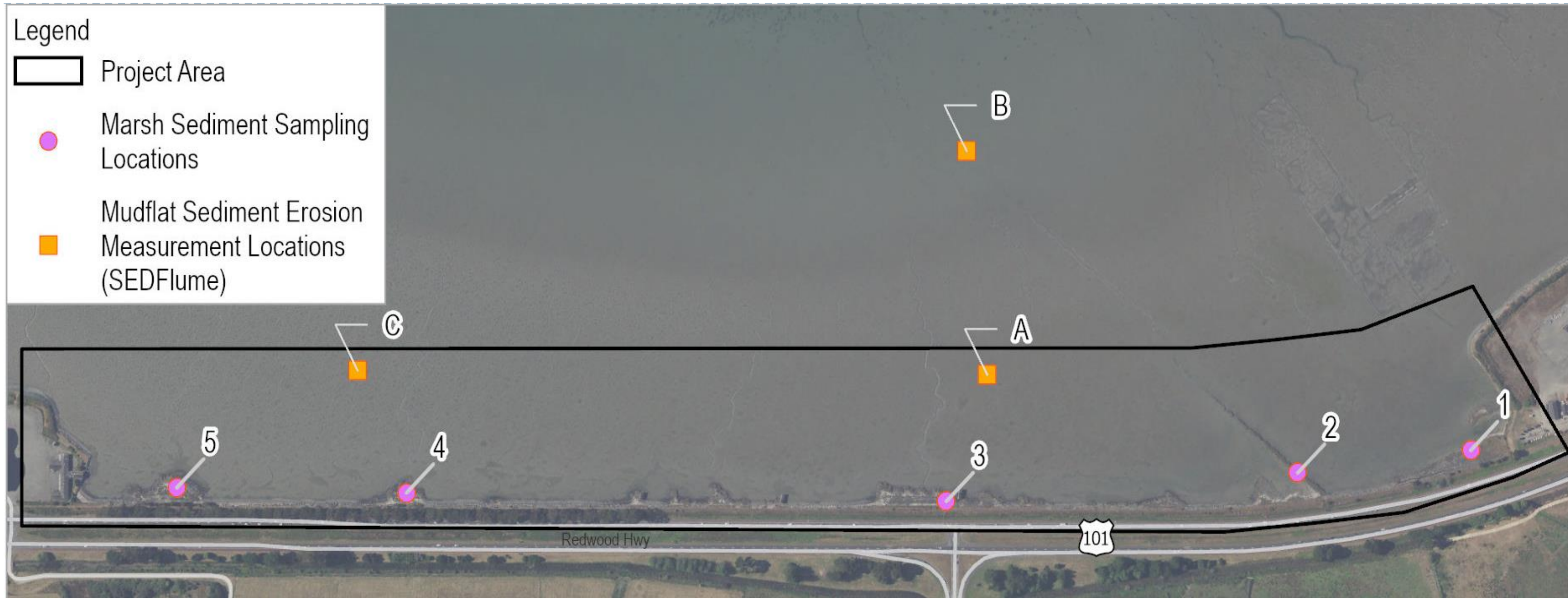
C. Salt Marsh Edge Lateral Progradation and Recession

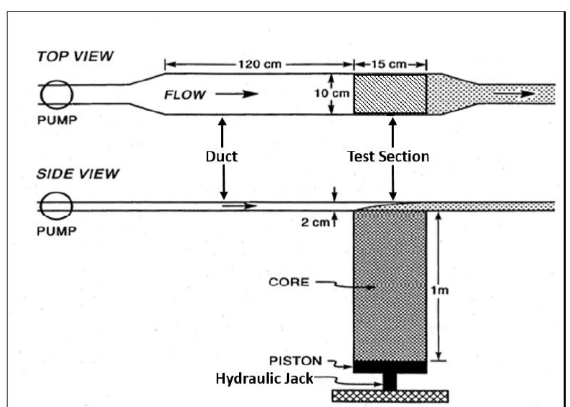
D. Salt Marsh Vertical Accretion and Degradation

① **Description:**
- Tributary flows deliver fluvial sediments to Arcata Bay
- Colloidal sediments remain in suspension and are circulated with tidal currents
- Silts and fine-sand sediments deposit on near-shore mudflats and resuspend when tidal currents shear stresses are high on off-shore mudflats
- Infrequent spring tides coincident with fine suspended sediment loads allow for marsh plain deposition

② **Description:**
- Wind generated waves increase shear stresses on mudflat and resuspend deposited sediments
- Infrequent spring tides coincident with high wind waves deliver fine-grained sediment resuspended from mudflat to marsh plain

Process: Mudflat Deposition and Resuspension SEDflume Analysis





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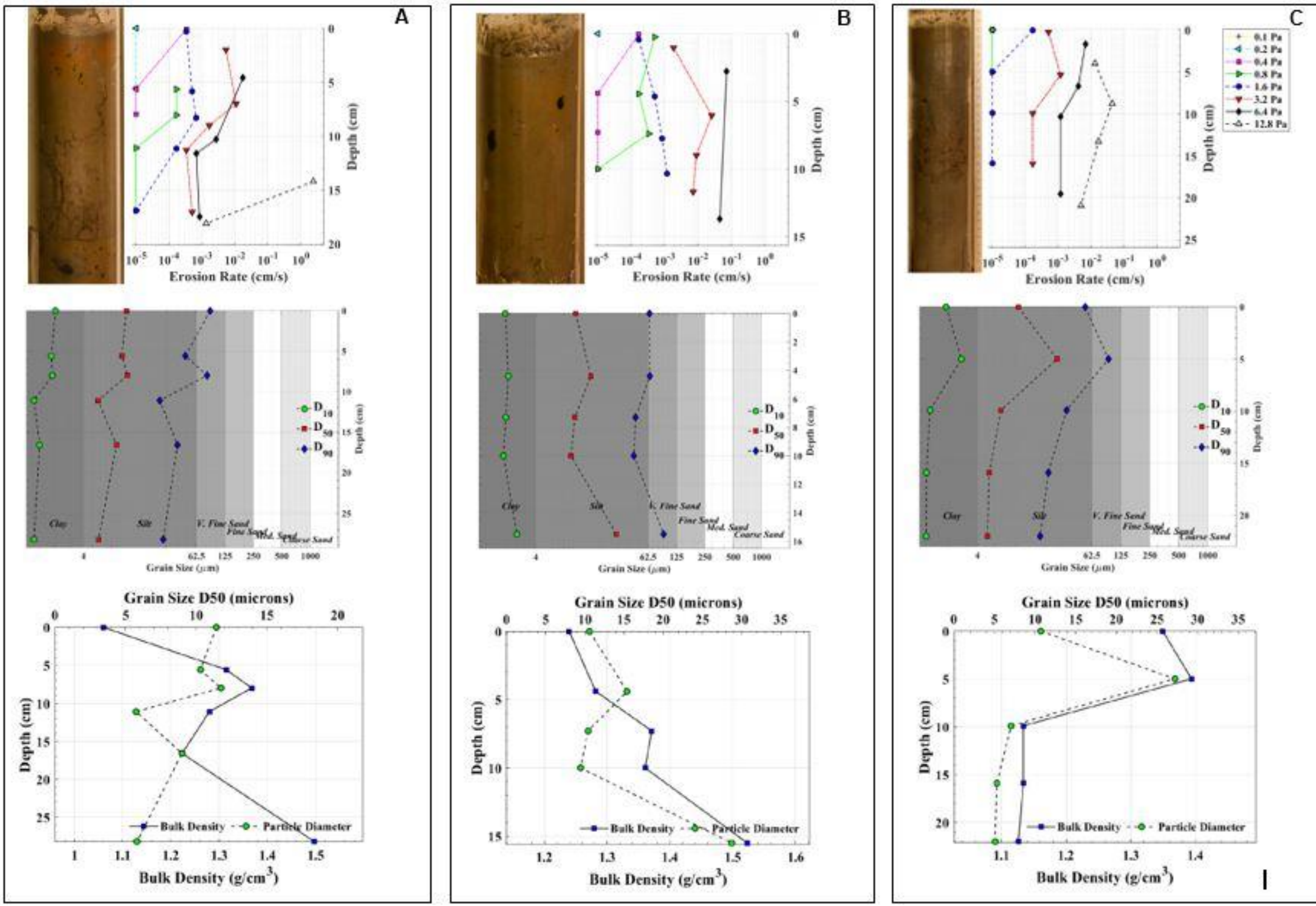
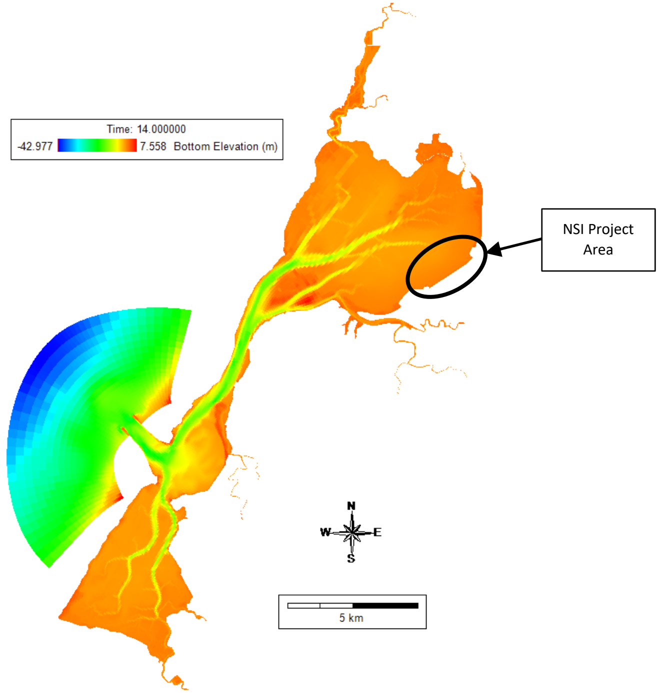
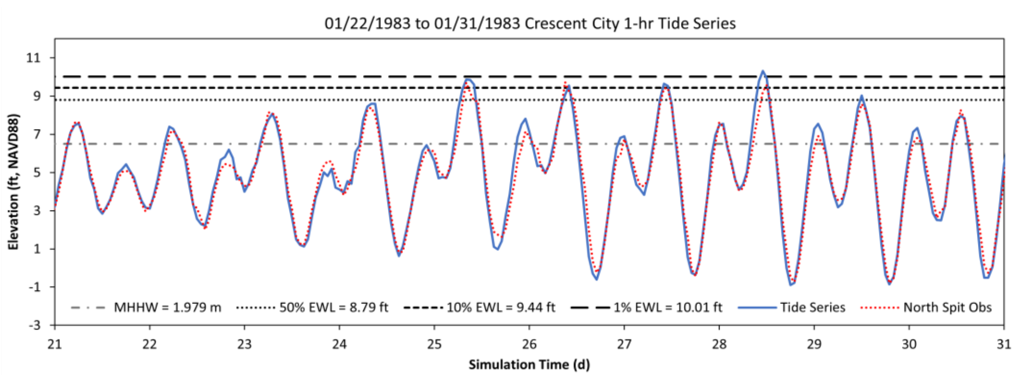


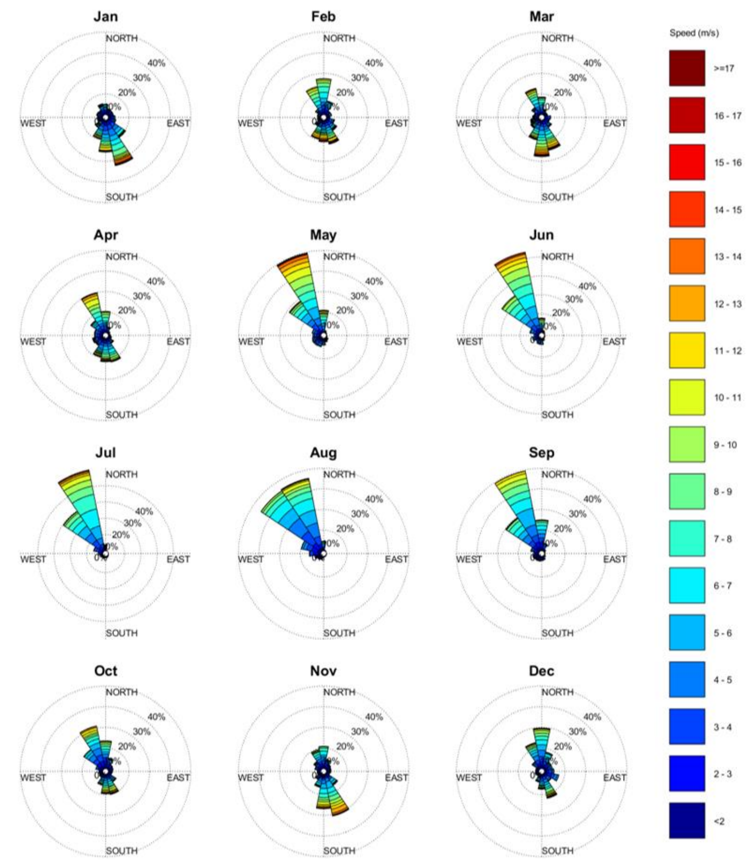
Process: Mudflat Deposition and Resuspension Hydrodynamic Analysis



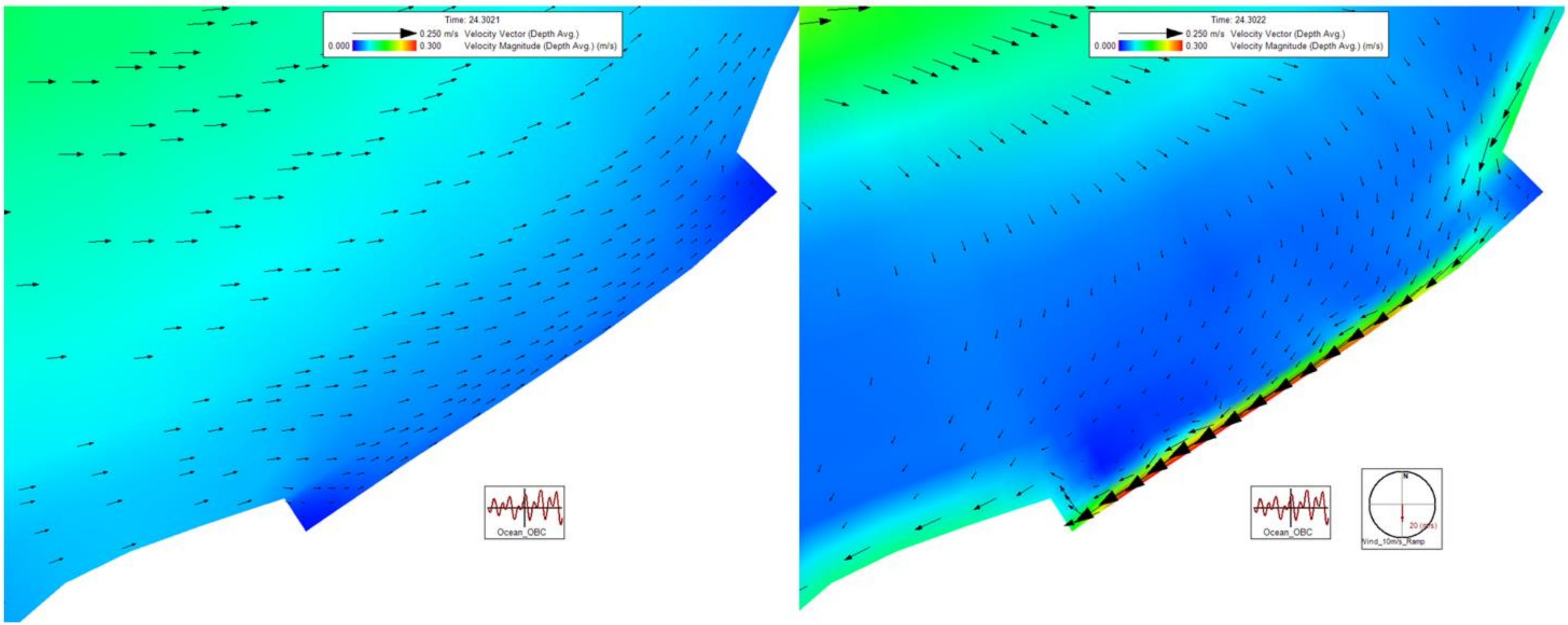


Boundary Conditions:

- 10-day tidal series during 1982-83 El Niño
- Wind at 11, 22, 34, 45 mph from NNW and S

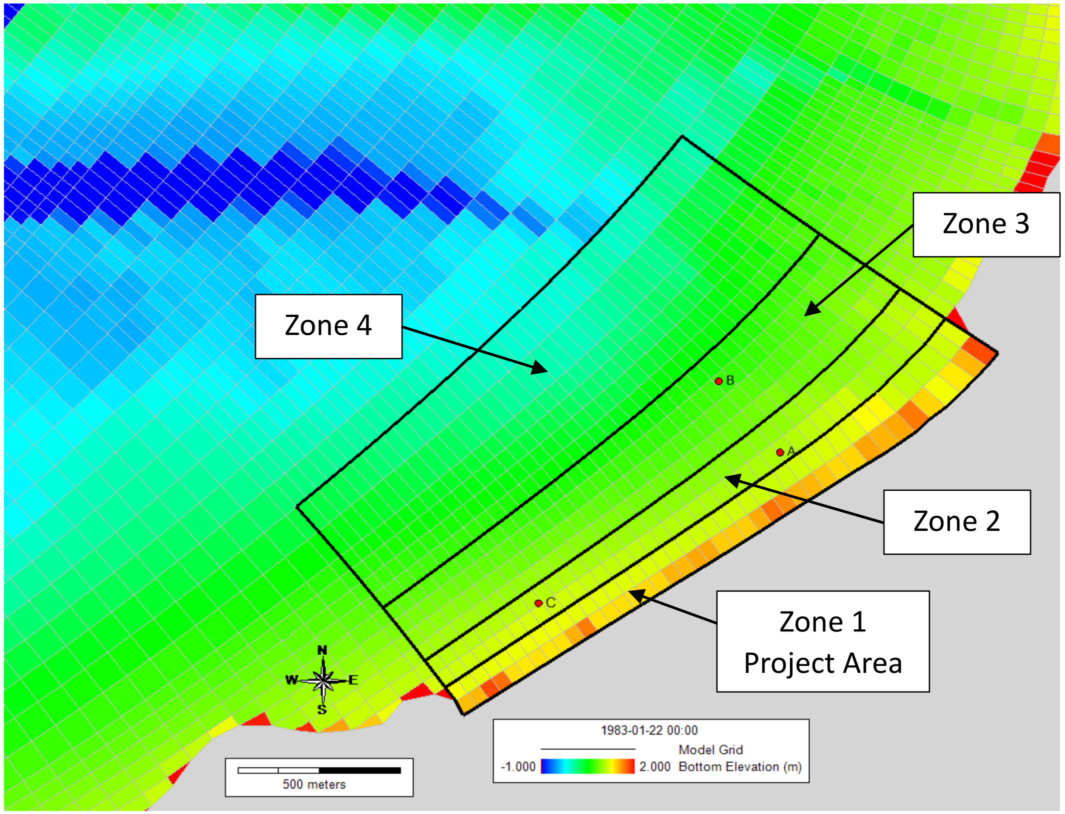


Process: Mudflat Deposition and Resuspension Hydrodynamic Analysis



Velocity vectors (magnitude and direction) of tidal currents predicted during a 2-year flood tide along the project shoreline without wind (left), and tidal and wave induced currents from a 22-mph northwest wind (right)

Process: Mudflat Deposition and Resuspension Hydrodynamic Analysis



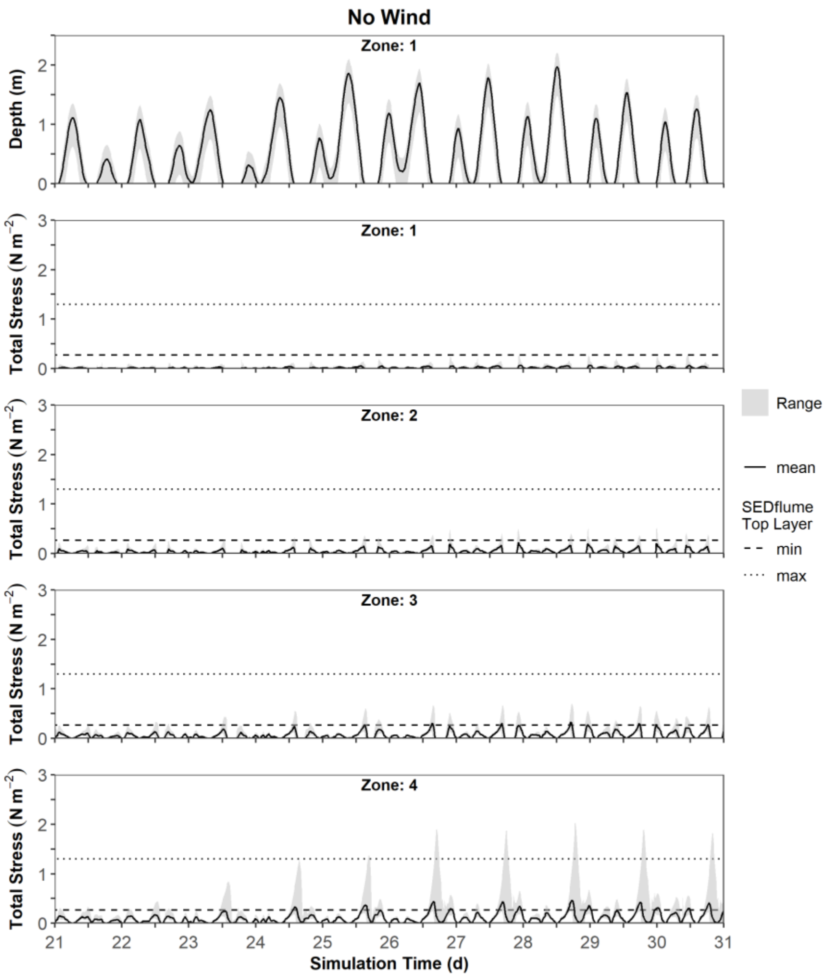
Erosion/Deposition Potential Analysis:

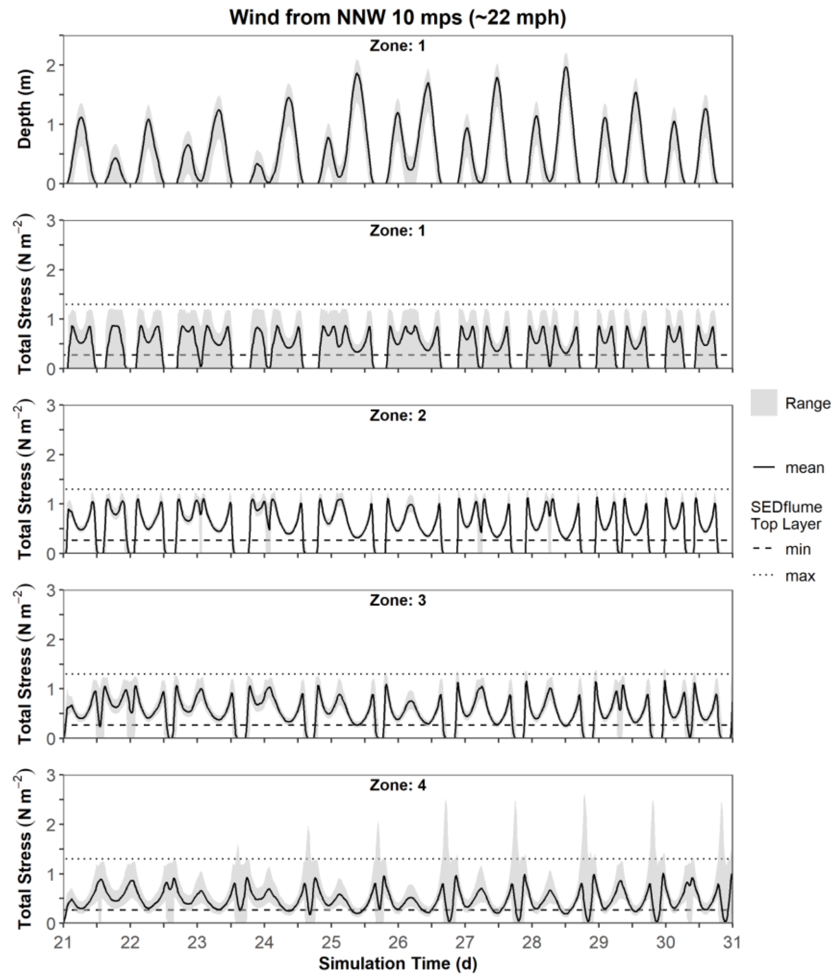
- Better understand the potential for erosion/deposition from tidal and wind-wave induced currents
- Compared predicted total bed shear stress to SEDflume critical shear stresses for top 5 cm of bed material
- Potential for erosion occurs when total stress exceeds 0.27 to 1.3 N/m^2
- Potential for deposition occurs when total stress is below 0.27 N/m^2

- NSI project and offshore mudflat areas were delineated into 4 zones
  - Zone 1 – Project Area (avg bed elev = 4.3 ft)
  - Zone 2 (avg bed elev = 3.3 ft)
  - Zone 3 (avg bed elev = 2.5 ft)
  - Zone 4 (avg bed elev = 1.1 ft)

Process: Mudflat Deposition and Resuspension Hydrodynamic Analysis

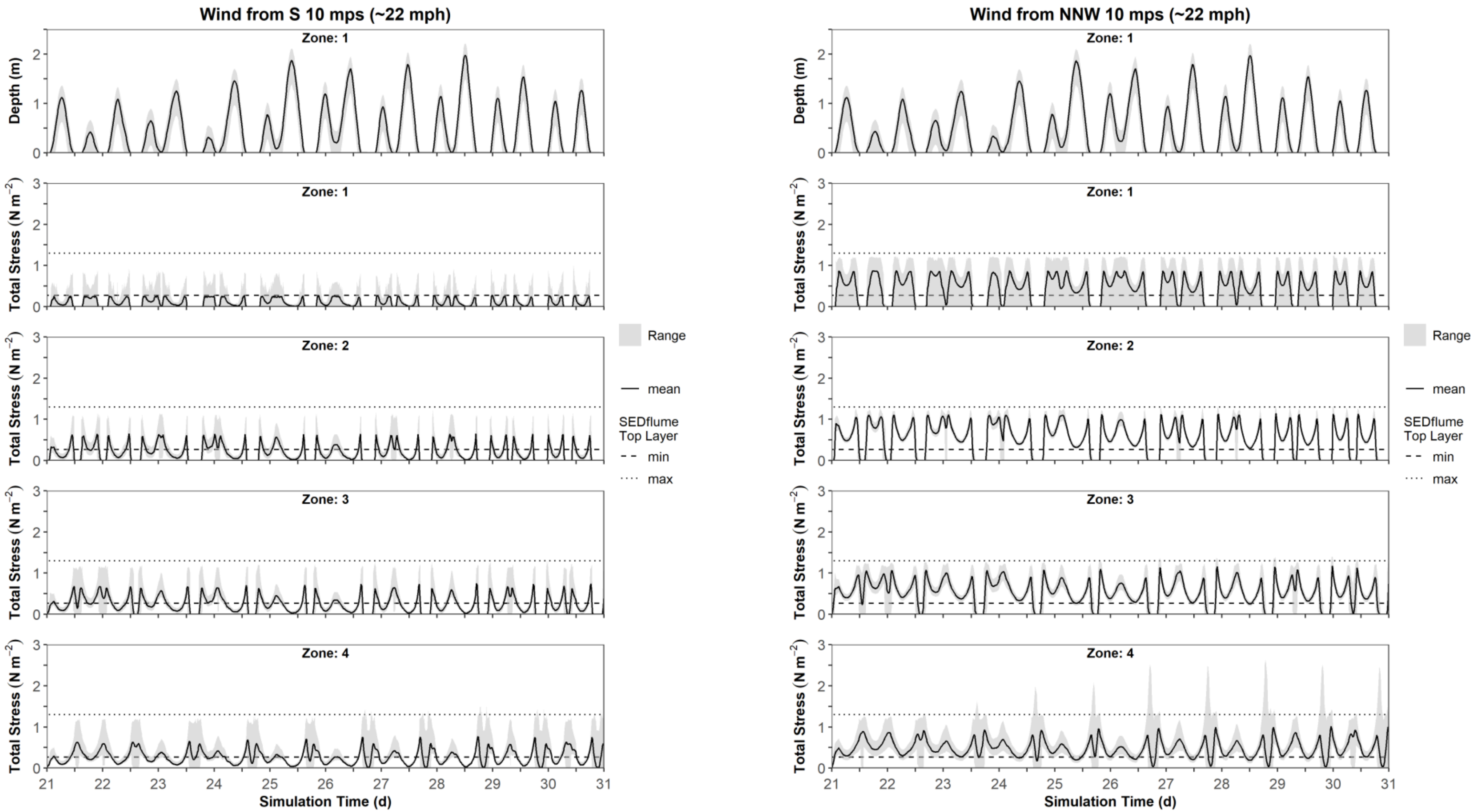
Results for No Wind (left) and 22 mph Wind from NNW (right)





Process: Mudflat Deposition and Resuspension Hydrodynamic Analysis

Results for 22 mph Wind from S (left) and 22 mph Wind from NNW (right)

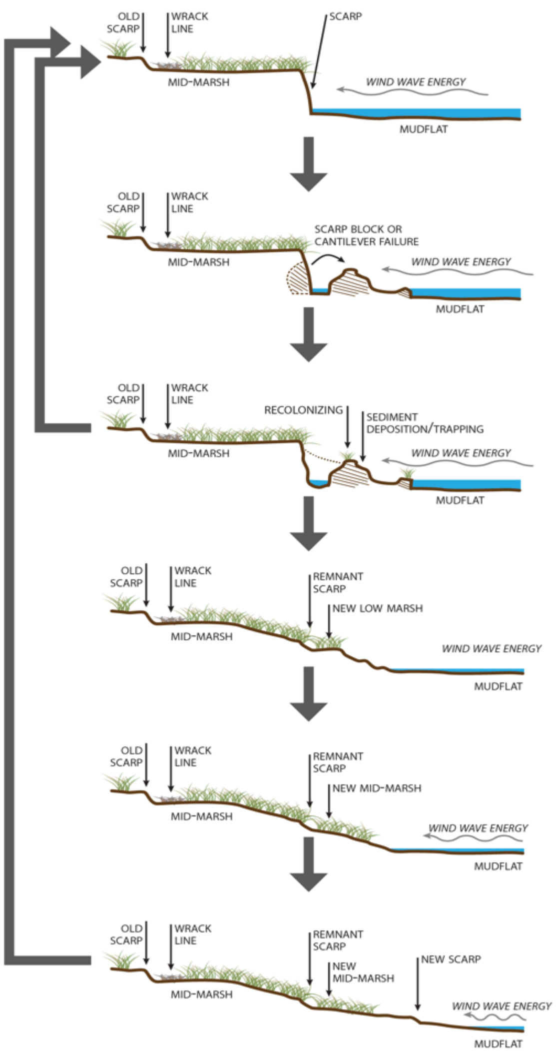


Process: Mudflat Deposition and Resuspension

- <u>Summary:</u>

- Wind-generated waves can alter circulation patterns, tidal currents, and increase velocity along the project shoreline.
- Depositional patterns of gravels and the gravel shoreline corroborate the model results indicating an increase in velocity and shear stresses along the shoreline.
- The erosion/deposition potential analysis demonstrates that tidal-induced currents alone can erode sediment from deeper water areas (Zones 3 and 4), but in general the total stresses and the potential for erosion is low.
- Wave-induced stresses from NNW and S winds generate total stresses high enough to erode sediment from all zones, demonstrating that wind-waves are the likely dominate driver for mudflat erosion and deposition in the project area.
- Model results indicate that the nearshore zone (Zone 1) has the largest range of total stresses. During wind-wave events the potential exists for sediment to be eroded from offshore mudflat areas and transported to the NSI project area where deposition could occur due to a wider range and lower total stresses.

Process: Salt Marsh Edge Lateral Progradation and Recession



Scarp without bayward vegetation (SN)
Fails under pressure from wind wave energy or wave run-up, and undercut blocks fail or cantilever, depositing sediment (with or without vegetation) in front of the scarp.

Scarp without bayward vegetation (SN)
The failed block dissipates wave energy until deposit is secured away and redistributed on the mudflat or marsh plain, thus creating an erosional environment as the wave energy is then directed back to the scarp.

1

Scarp with bayward vegetation (SV)
If the failure is large enough to redirect wave energy for longer periods of time, the failed blocks may create an environment for sediment deposition and trapping between the old scarp and the failed block.

2

Ramp with inflection point (RI)
A ramped profile begins to form as sediment fills in behind the failed block, building elevation, creating new low marsh and leaving behind a remnant scarp.

3

Ramp without inflection point (RN)
As the ramping continues, wave energy is dissipated such that the low marsh vegetation traps sediment, building up to mid marsh habitat.

Ramp with new bluff forming (RI)
When the new mid marsh levels, the ramped profile steepens and wind wave energy begins to erode the new mid marsh, creating a new scarp. And the cycle continues....

4

Adapted from SFEI 2015

Process: Salt Marsh Edge Lateral Progradation and Recession

Paper Size ANSI B
0 125 250 375 500
Feet
N

Humboldt County
Humboldt Bay Natural Shoreline Infrastructure

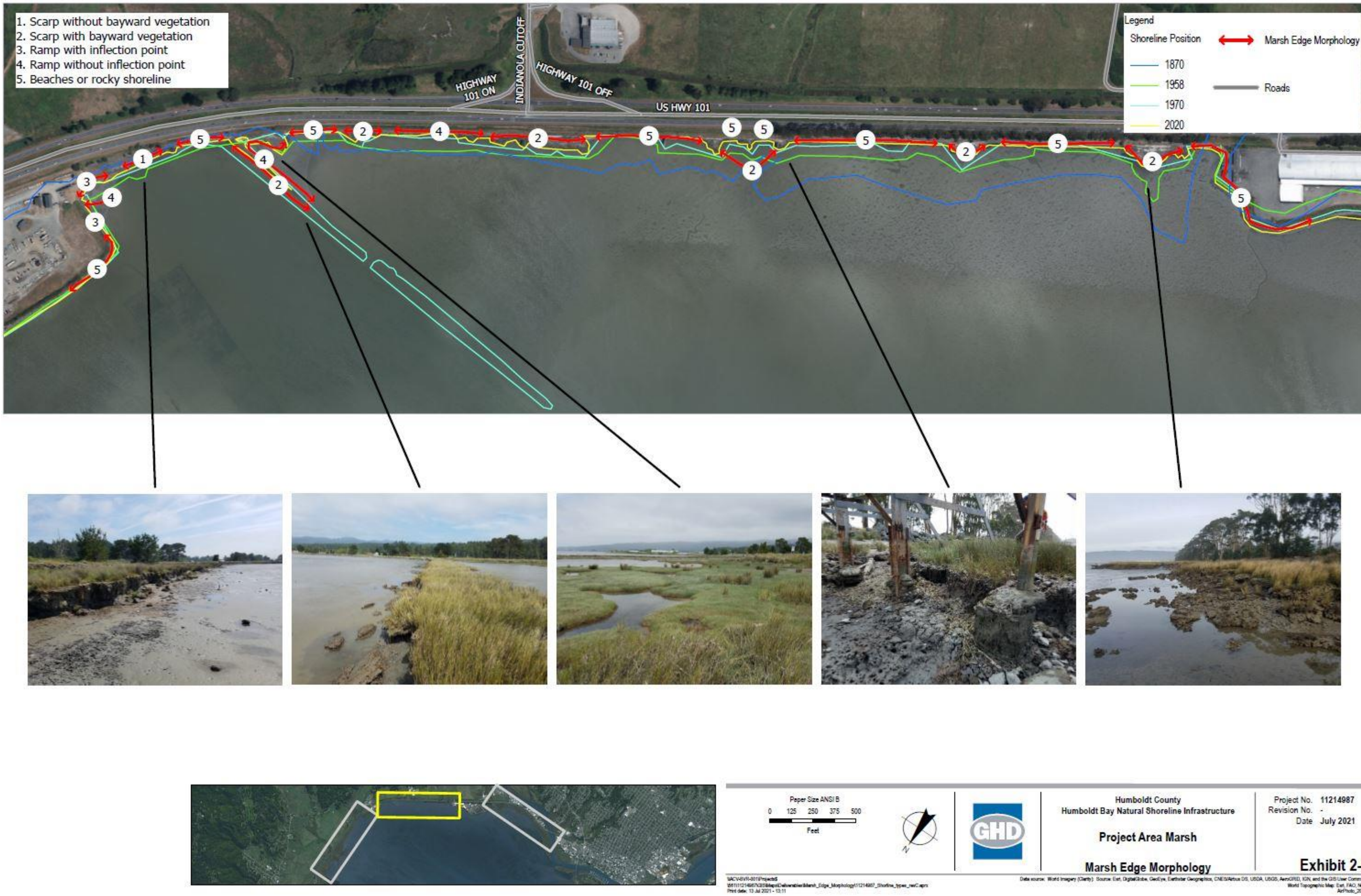
Eureka Slough Marsh

Marsh Edge Morphology

Project No. 11214987
Revision No. -
Date July 2021

Exhibit 2-8

Process: Salt Marsh Edge Lateral Progradation and Recession



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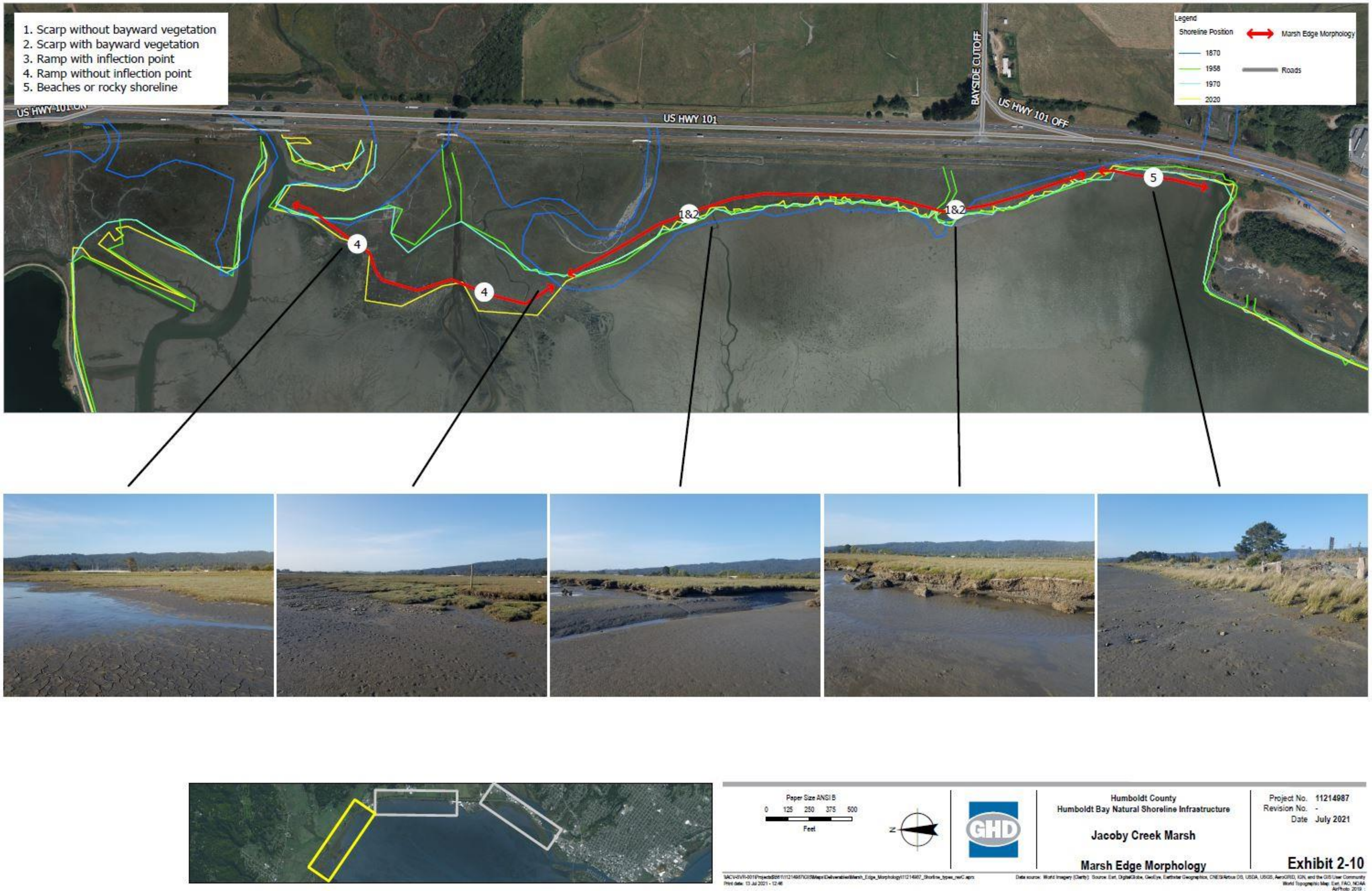

Process: Salt Marsh Edge Lateral Progradation and Recession

1947

Present

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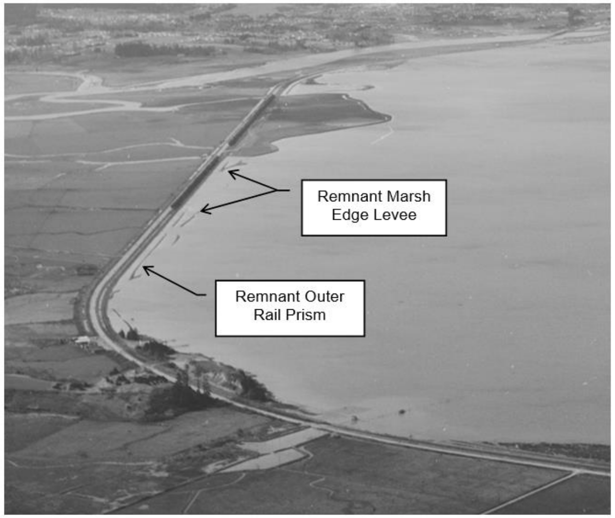


Process: Salt Marsh Edge Lateral Progradation and Recession

- <u>Summary:</u>

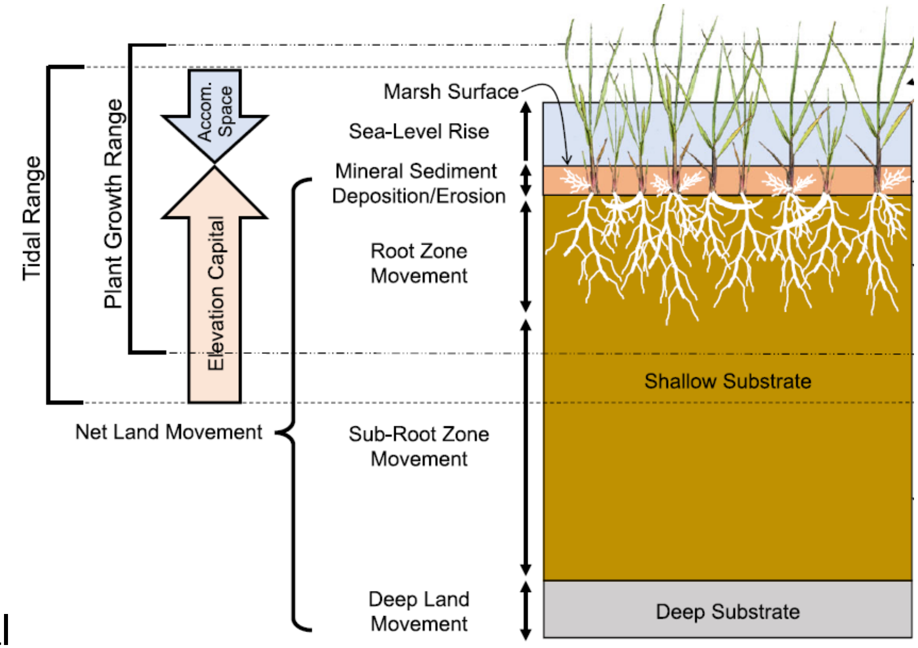
1. The marsh edge morphology in the project area primarily consists of scarps indicating a marsh edge subjected to wave driven erosion.
2. Scarping was also observed at Eureka Slough and Jacoby Creek marshes, but also with ramping. The marsh edge positions on the adjacent marshes are fairly static indicating an ongoing process of scarp block failure followed with sediment trapping behind the block and accretion for recolonization of vegetation.
3. The general marsh edge morphology appears to be primarily a function of shoreline orientation.
4. Ramping morphology is strongly correlated to edges that are prograding, observed at both Eureka Slough and Jacoby Creek marshes. Ramping edge morphology is most prevalent at the Jacoby Creek deltaic fan, however short segments of ramping and progradation are also present throughout the Eureka Slough marsh in areas exposed to long north-northwest wind fetch. Ramping in these areas suggest ample sediment supply from adjacent mudflats.

Process: Salt Marsh Vertical Accretion and Degradation

- <u>Summary:</u>

1. Salt marsh vertical accretion is driven by mineral suspended sediment delivered to the marsh surface during high tides, accumulation of organic matter supplied from marsh vegetation, subsurface expansion driven by root growth, and local rates of land movement driven by tectonic processes (Cahoon et al. 2021).

2. Accretion rates need to maintain pace with relative sea level rise rates (combination of sea level rise and local tectonic subsidence) of 5 mm/year



Process: Salt Marsh Vertical Accretion and Degradation

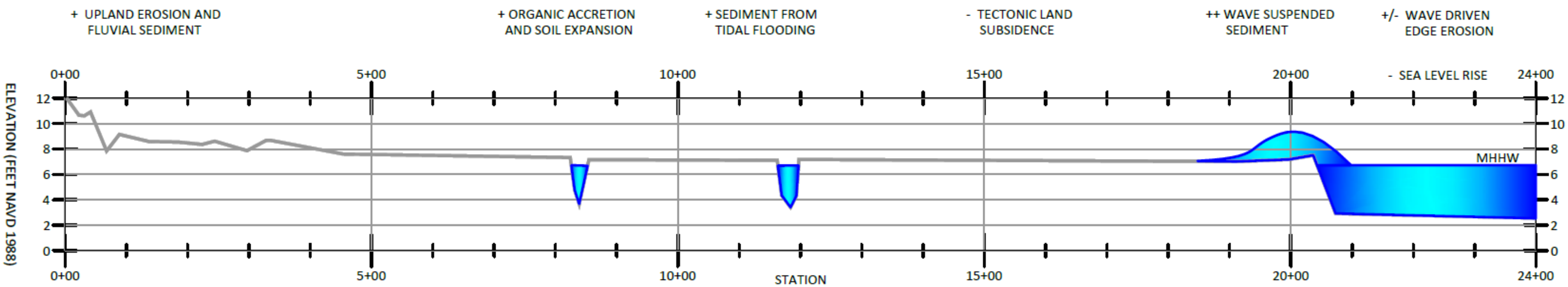
- **Summary:**

1. Historic accretions rates using chronological and carbon dating techniques for sediment cores obtained from Mad River Slough and Jacoby Creek marshes and ranged from approximately 2.9 mm/year to 8.4 mm/year of accretion (UCLA and Gerwein, 2019).

2. Current accretion rates were measured using surface elevation tables (SETs) and feldspar marker horizon (MH) on North Bay marshes for three years and ranged between 0.71 mm/year and 0.98 mm/year of accretion (Curtis, 2019).

3. Accretion rates and chronological dating have not been measured in the project area, however visual observations identified areas of deposited sediment located between the former rail prisms near Indianola Cut-off. These depositional characteristics in sheltered areas indicate a sediment supply/availability that could support a net onshore sediment flux if the sediment can be trapped and retained.

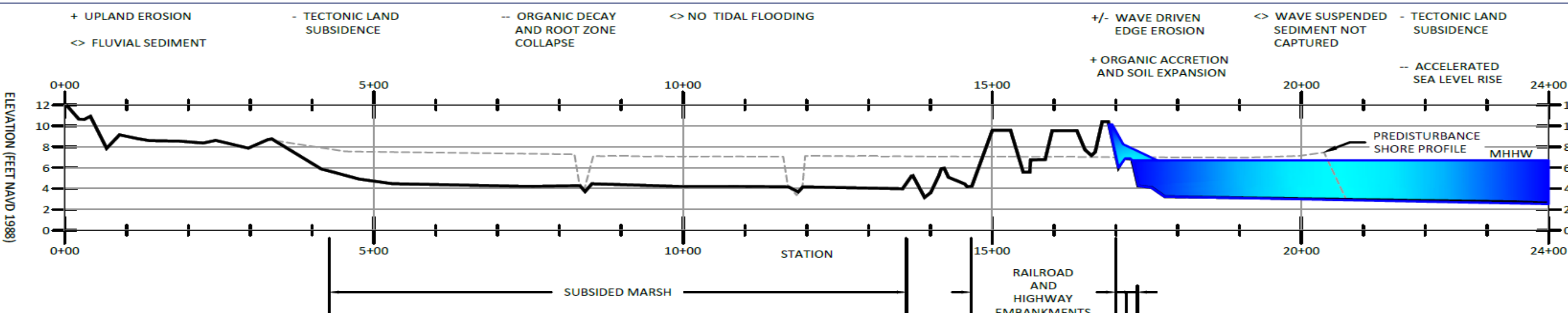
Marsh Disturbance and Recovery



PRE-DISTURBANCE CONDITION - MARSH IN QUASI-EQUILIBRIUM WITH SEA LEVEL RISE:

VERTICAL MOTION:
UPLAND EROSION + FLUVIAL SEDIMENT + ORGANIC ACCRETION + TIDAL SEDIMENT + WAVE SEDIMENT ≈ TECTONIC SUBSIDENCE + SEA LEVEL RISE

EDGE POSITION:
STABLE OR PROGRADING



PRESENT DAY CONDITION: SUBSIDED INLAND MARSH AND REMNANT OUTER MARSH:

- SUBSIDED INLAND MARSH SINKING RELATIVE TO SEA LEVEL AND AT RISK:
  UPLAND EROSION < ORGANIC DECAY + TECTONIC SUBSIDENCE + SEA LEVEL RISE
- REMNANT MARSH VERTICAL ACCRETION QUASI-STABLE (BUT NOT RESILIENT TO RAPID SEA LEVEL RISE:
  ORGANIC ACCRETION + MINOR SEDIMENT TRAPPING ≈ TECTONIC SUBSIDENCE + SEA LEVEL RISE
- REMNANT MARSH EDGE STABLE OR MINOR PROGRADING:
  SEDIMENT SUPPLY AVAILABLE, BUT WAVE ENVIRONMENT TRANSPORTS SEDIMENT ALONGSHORE OR ONTO MUDFLATS

Summary of Geomorphic Assessment

- <u>Summary:</u>

1. Marsh expansion and accretion through natural processes has occurred in isolated areas following 1950's suggesting availability of suspended sediment delivered to depositional areas.
2. Sediment deposition on existing marsh surfaces is evident from high marsh elevations and emphasizes important role of wind waves for transporting sediment to marsh surface.
3. Ability for marsh to trap sediment is hindered by narrow width and exposure to harsh wind wave environment.
4. Sediment delivery to Humboldt Bay is estimated to increase over time with climate change (Curtis, 2021), and while sediment distribution patterns in Arcata Bay are not well studied, depositional areas may accrete in conjunction with sea level rise.

Task 4 – Goals & Objectives

Goals and Objectives

The fundamental concept of the project is to integrate the natural flood-risk reduction properties of salt marsh into the shoreline management strategy for the Eureka-Arcata Highway 101 transportation corridor in an area where salt marsh was historically abundant but currently exists only in small, isolated patches.

Goal 1: Restore and enhance intertidal coastal marsh habitat

Goal 2: Protect transportation infrastructure

Goal 3: Create opportunities for innovation and learning

Goal 1: Restore and enhance intertidal coastal marsh habitat

- **Objectives:**

1. Provide a tidal ecotone extending from intertidal mudflat through low, middle, and high marsh to the upland transition zone.
2. Increase salt marsh area.
3. Increase habitat for native salt marsh plant communities and rare plant species.
4. Avoid infestation by the invasive dense-flowered chordgrass (*Spartina densiflora*).
5. Create landforms that are in dynamic equilibrium with hydraulic and geomorphic processes under current conditions and projected future conditions.
6. Create conditions where vertical accretion of sediment keeps pace with relative sea level rise.
7. Provide elevation gradients that allow upward migration of salt marsh in response to sea level rise.
8. Provide a diversity of habitat forms that emulate natural systems.

Goal 2: Protect transportation infrastructure

- **Objectives:**

1. Prevent substantial erosion of the shoreline by reducing wave height and energy.
2. Reduce wave runup and overtopping onto the railroad, Humboldt Bay Trail, and Highway 101.

Goal 3: Create opportunities for innovation and learning

- **Objectives:**

1. Serve as a demonstration project for natural shoreline infrastructure and nature-based sea level rise adaptation strategies within Humboldt Bay.
2. Explore the feasibility of beneficial reuse of dredged sediment.
3. Collect and publish monitoring data.

Task 4 – Alternatives Development and Evaluation

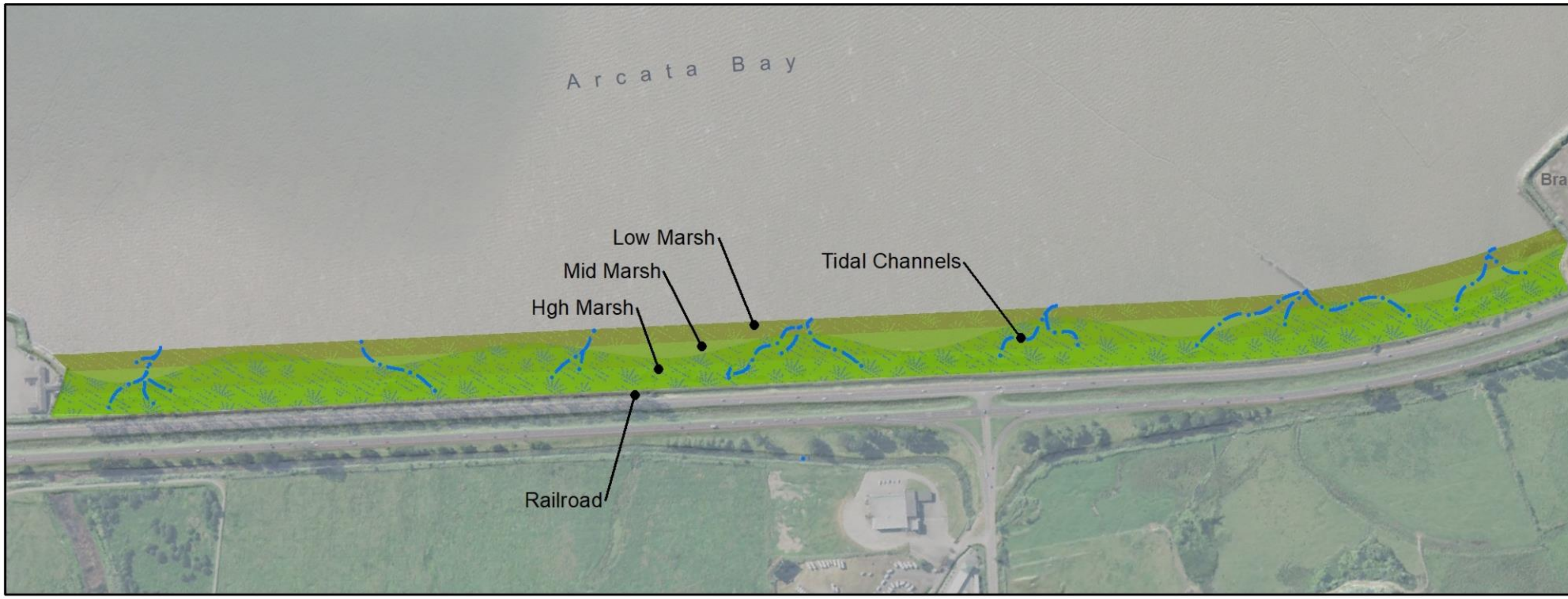
Alternative Development and Evaluation- Concept Design Criteria for a Resilient Marsh

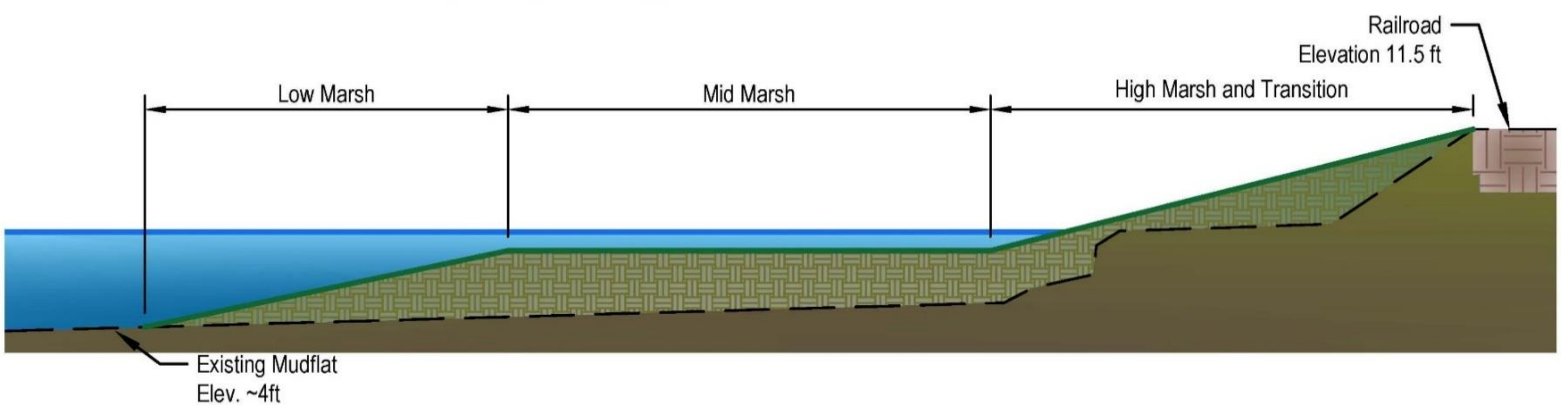
1. **Marsh Geometry**
   - Sufficient width and elevation to dissipate wave energy and promote colonization of native marsh species.
   - Sufficient width and transitional zone that enhance sediment trapping and promotes deposition.
2. **Stability**
   - Provide initial stabilization of marsh edge until marsh vegetation is established.
   - Reduce susceptibility of long-term marsh edge erosion to wave energy.
   - Minimize lateral marsh edge erosion tidal and wind generated currents at the interface with existing Bracut (north) and Brainard (south) levee rock slope protection.
3. **Tidal Channel Network**
   - Restore tidal exchange, sediment delivery and improve marsh drainage.

Alternative Development and Evaluation Preliminary Screening

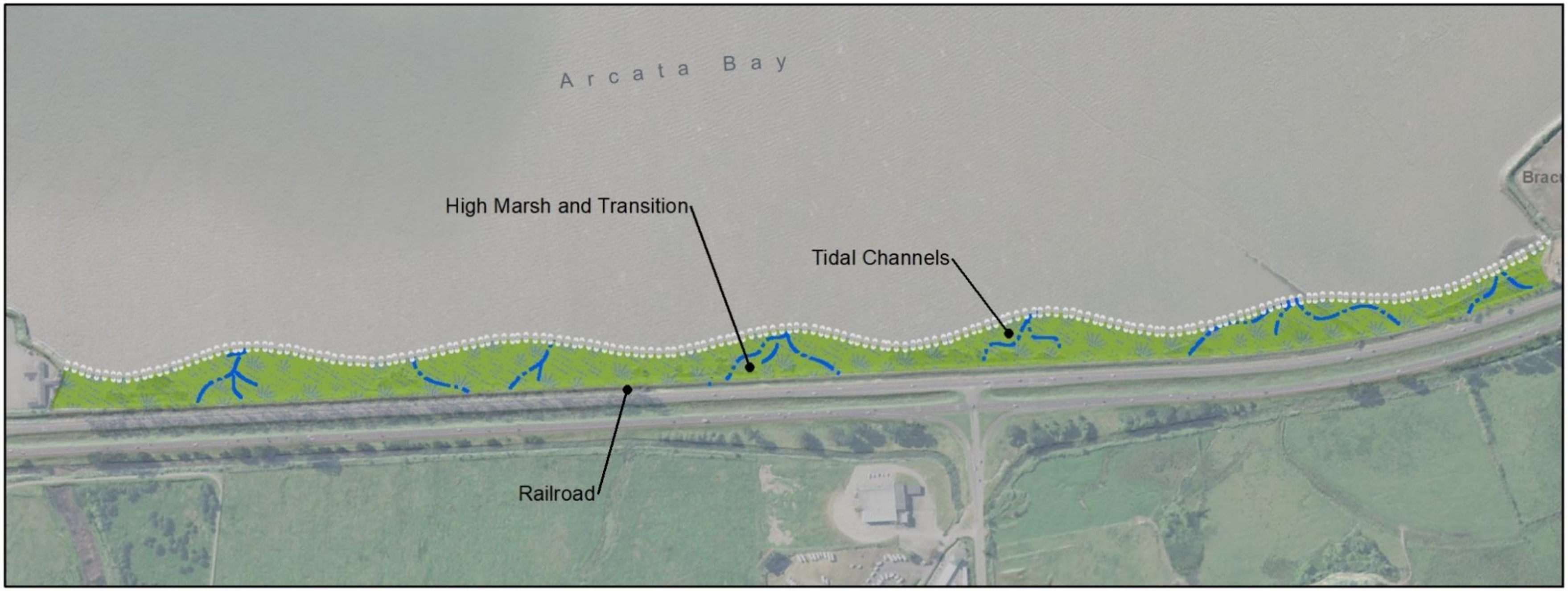
1. Horizontal Levee: Low, Mid, and High Salt Marsh Creation
2. Horizontal Levee: High Salt Marsh Creation with and without Armored Toe
3. Breakwater Reef with Passive and Active Salt Marsh Creation
4. Barrier Island Breakwater with Passive and Active Salt Marsh Creation
5. Groins with Passive and Active Salt Marsh Creation
6. Coarse Sediment Shore (sand/gravel/oyster hash)

1. Horizontal Levee: Low, Mid, and High Salt Marsh Creation

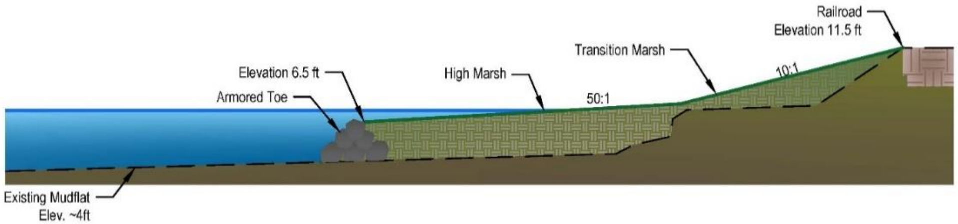




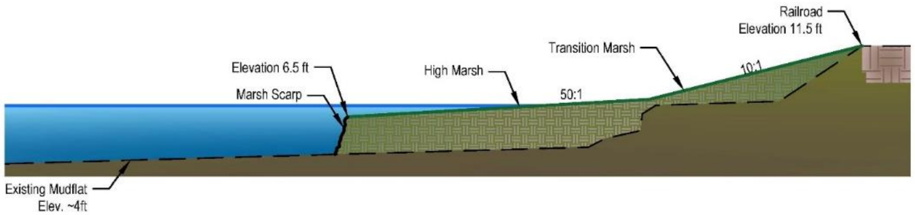
2. Horizontal Levee: High Salt Marsh Creation with and without Armored Toe



Armored Toe



Unarmored Toe



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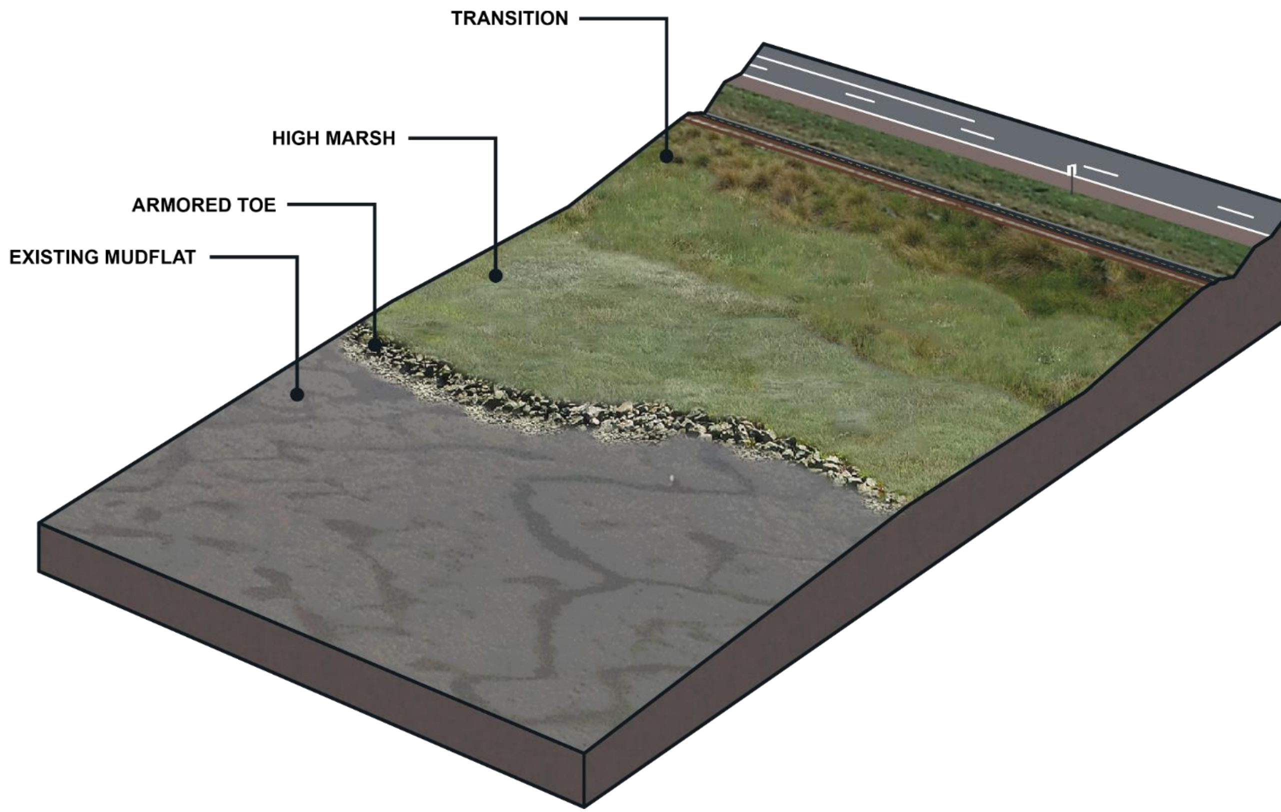
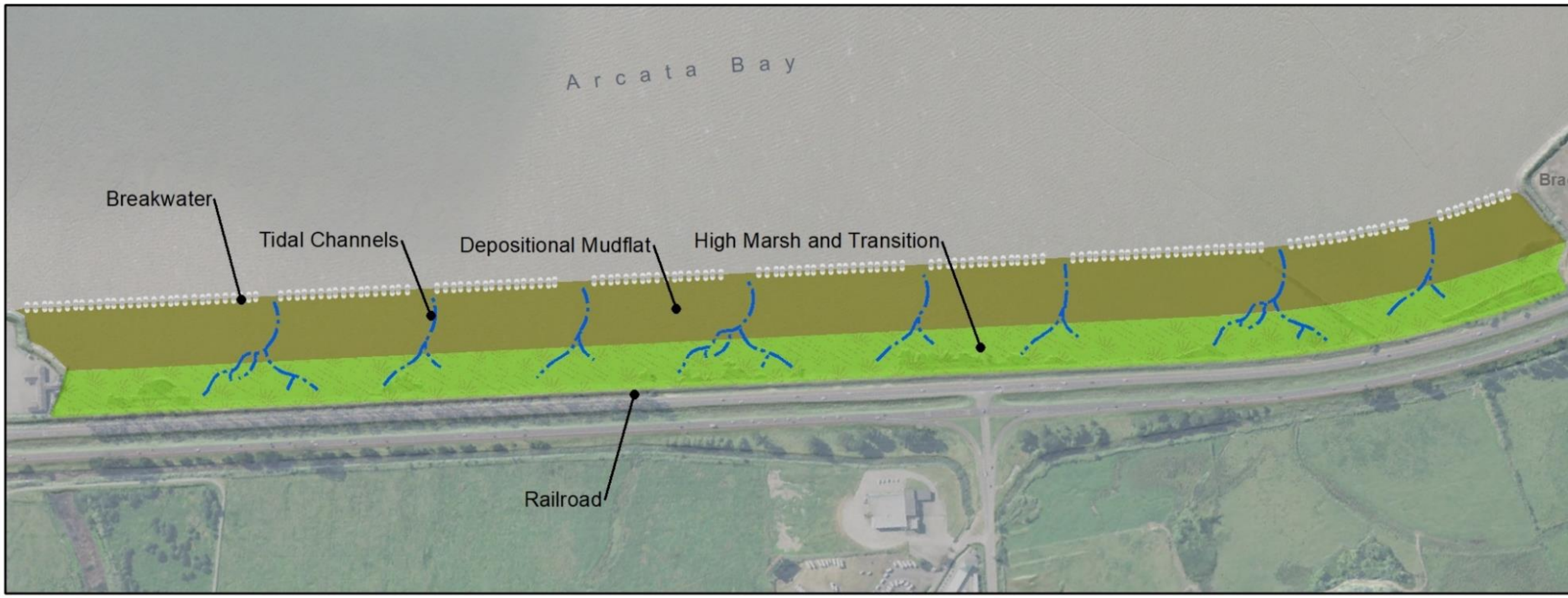
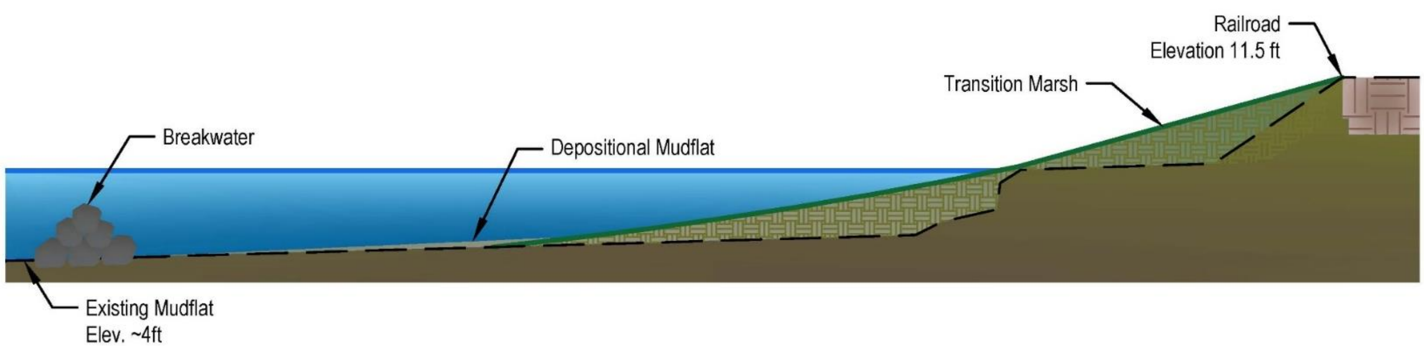


3. Breakwater Reef with Passive and Active Salt Marsh Creation





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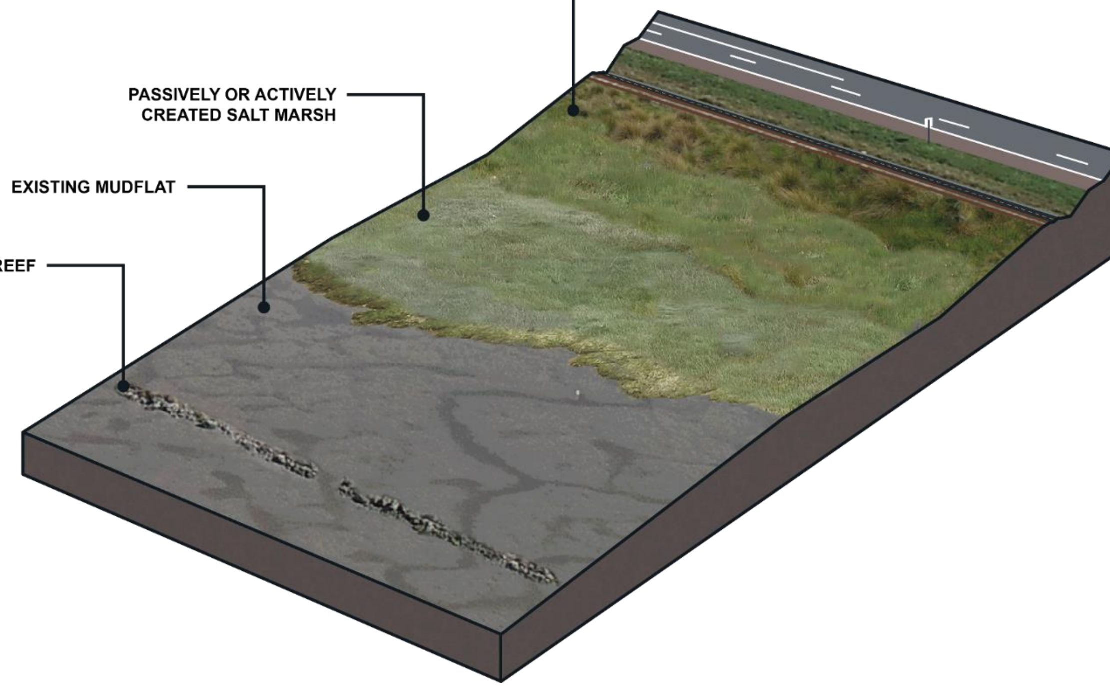
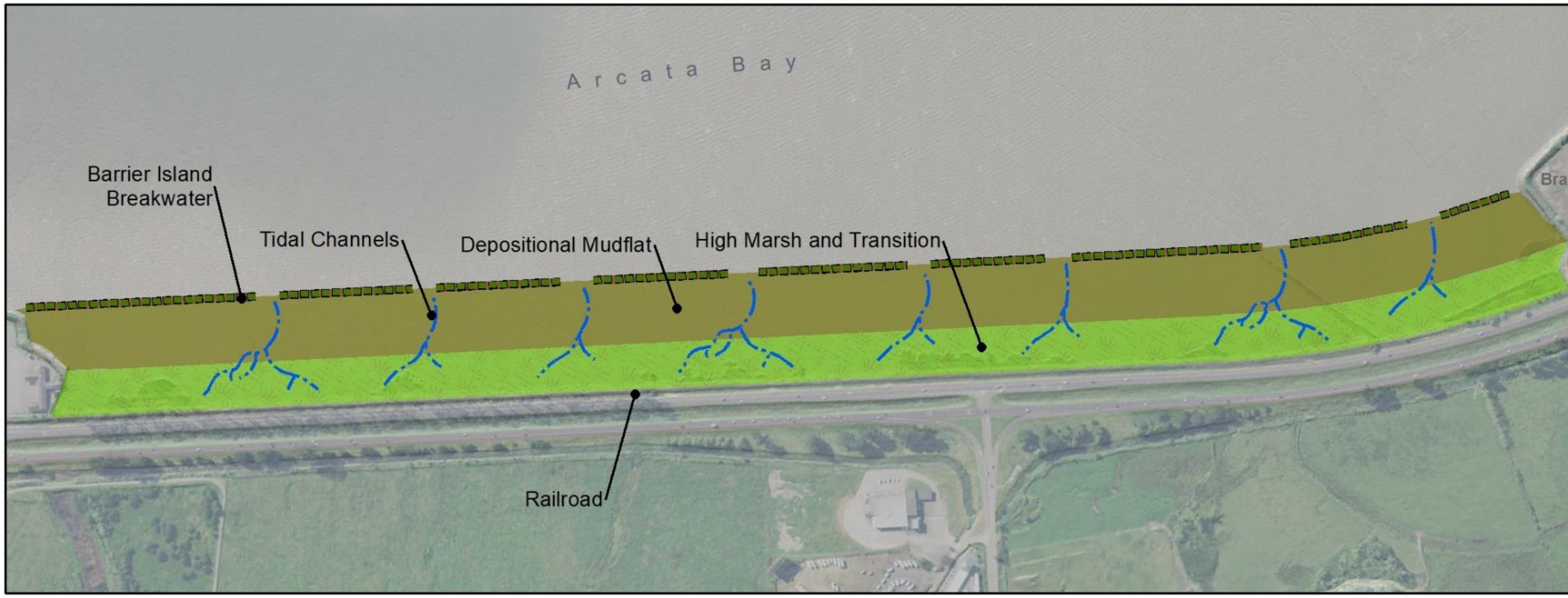
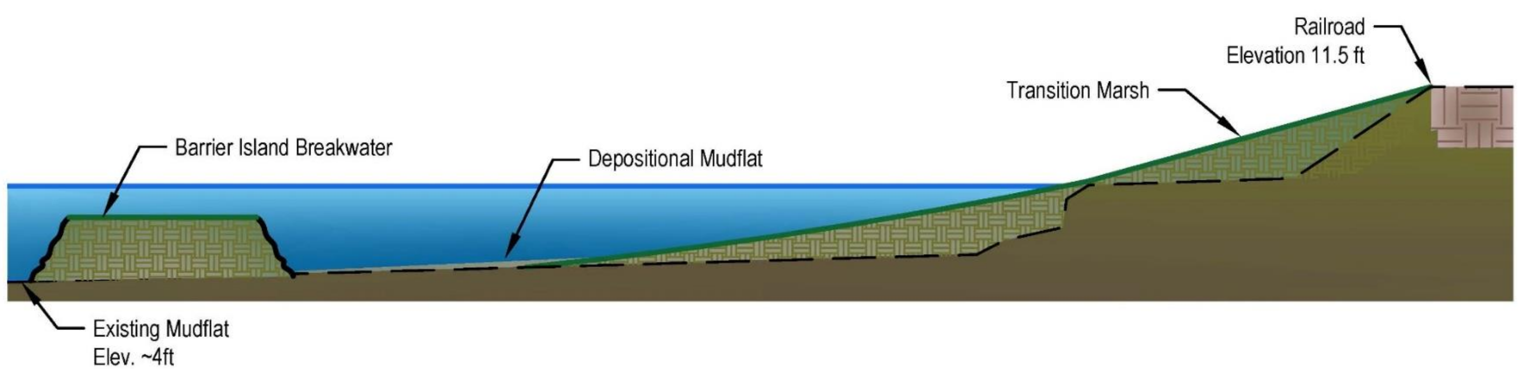


4. Barrier Island Breakwater with Passive and Active Salt Marsh Creation





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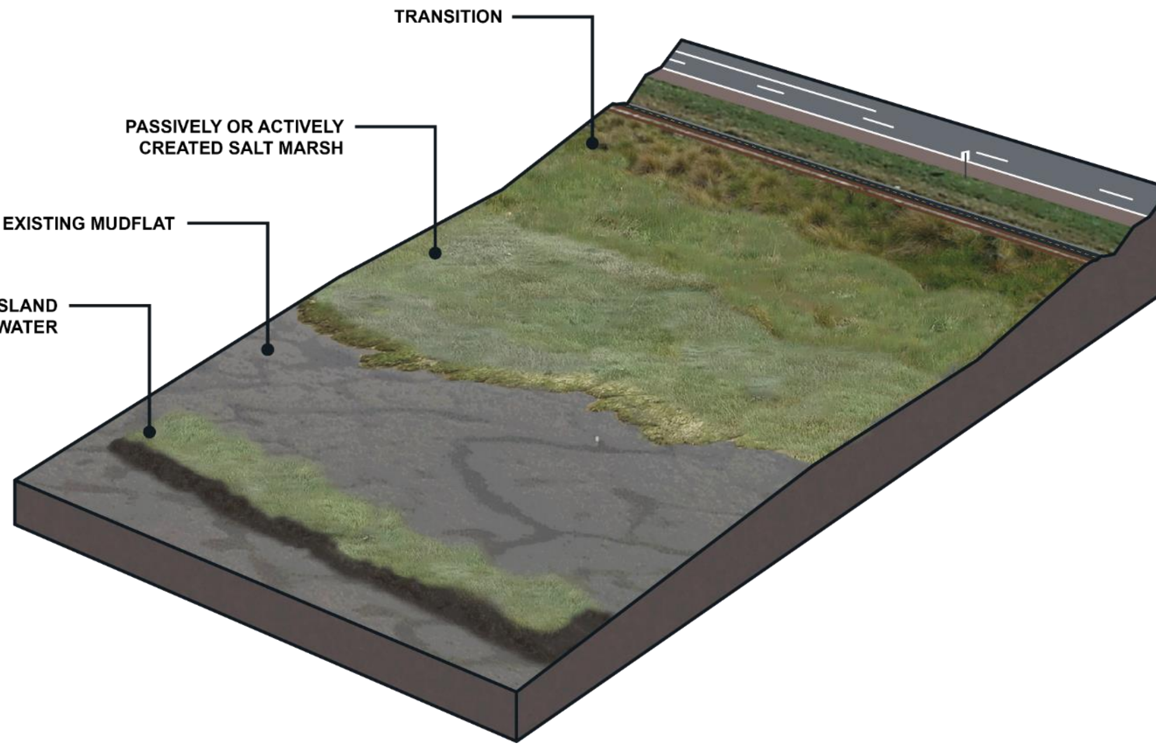
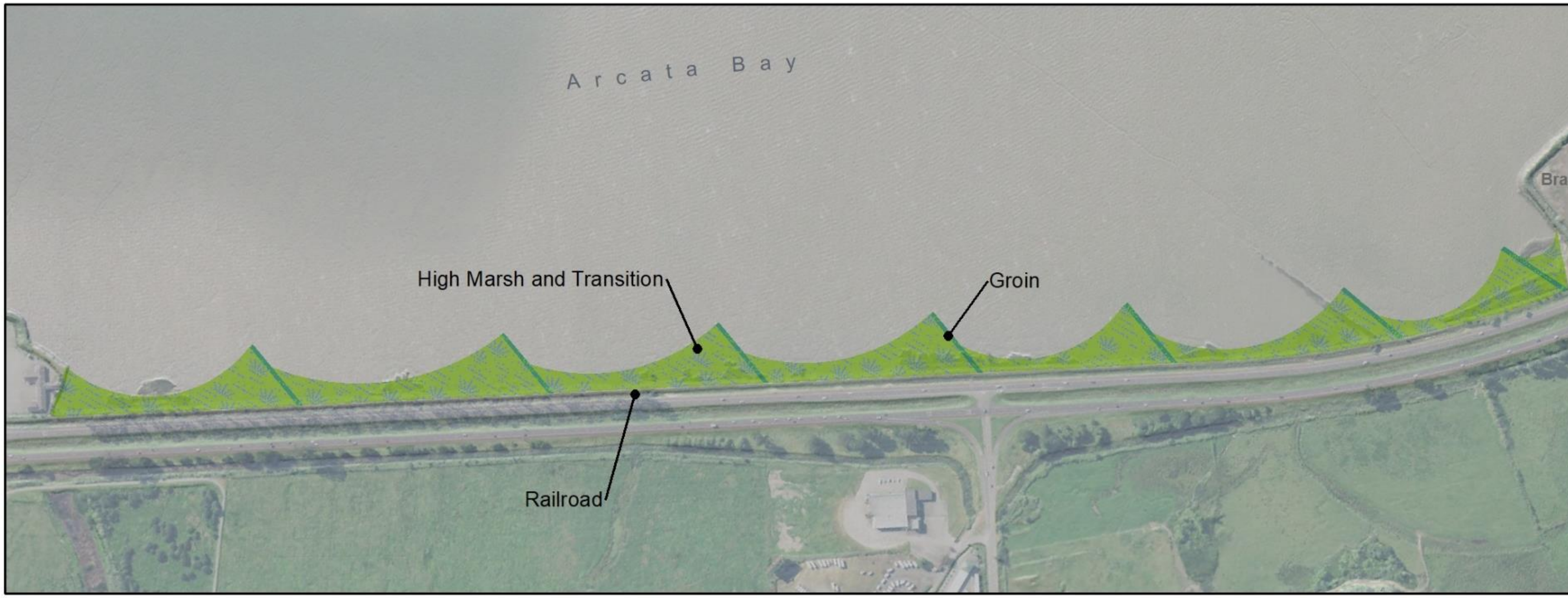
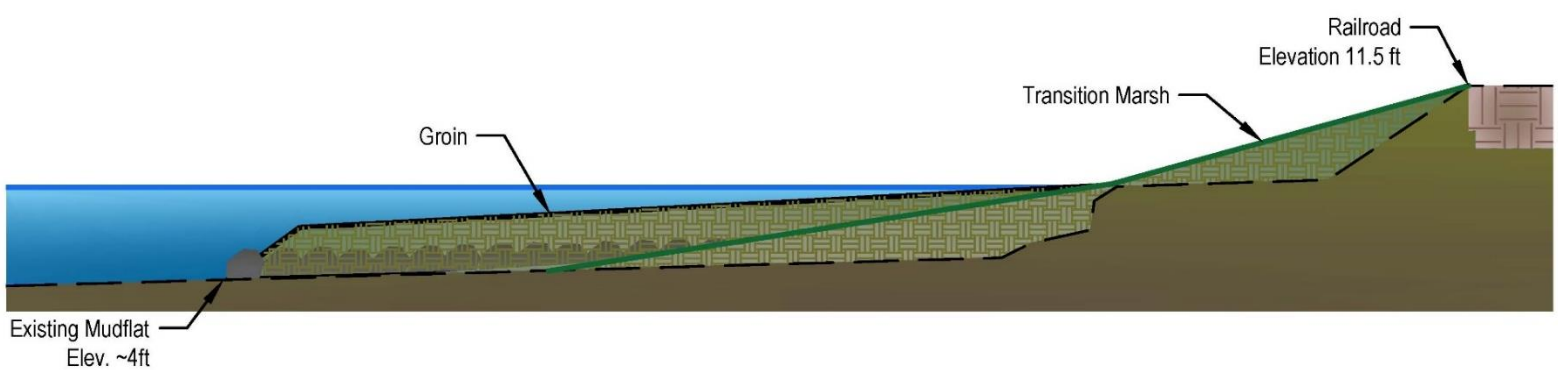


4. Barrier Island Breakwater with Passive and Active Salt Marsh Creation

Example Photo: White Slough, HBNWR (Laird)

5. Groins with Passive and Active Salt Marsh Creation

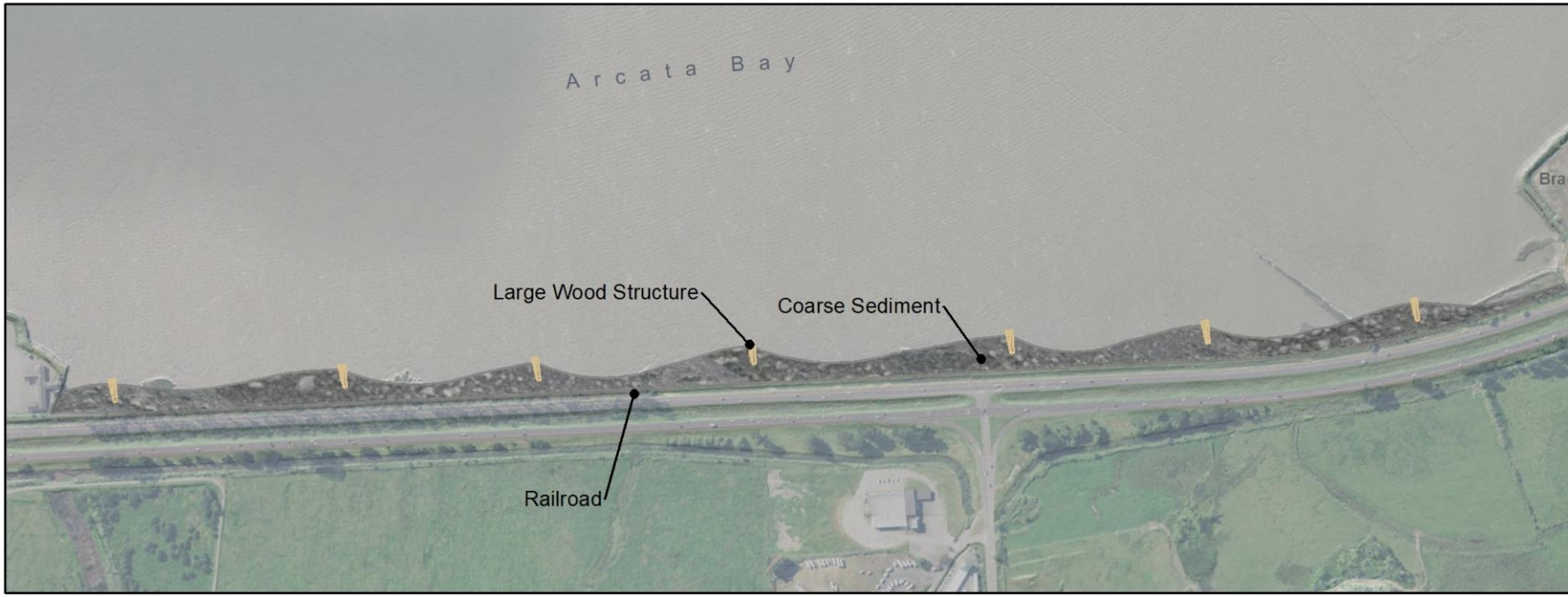


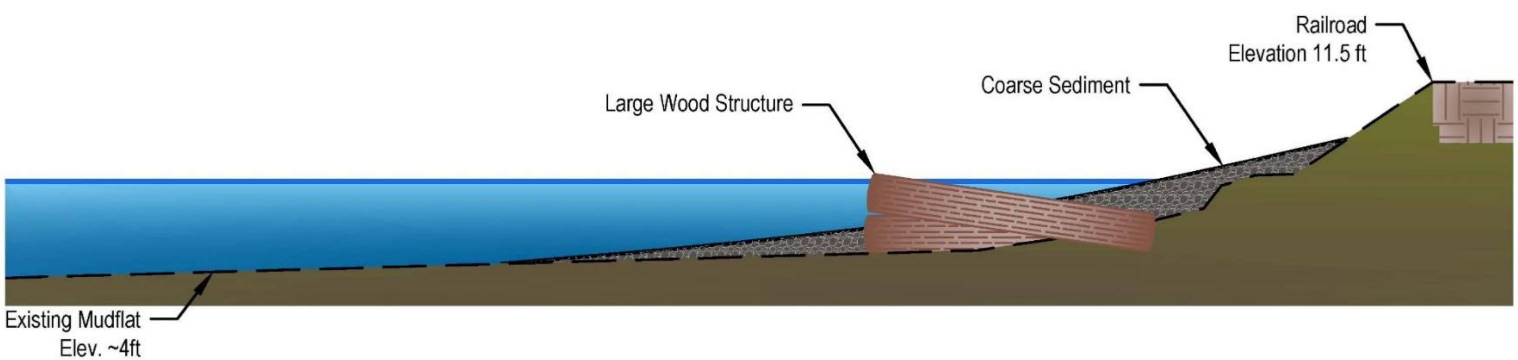


5. Groins with Passive and Active Salt Marsh Creation

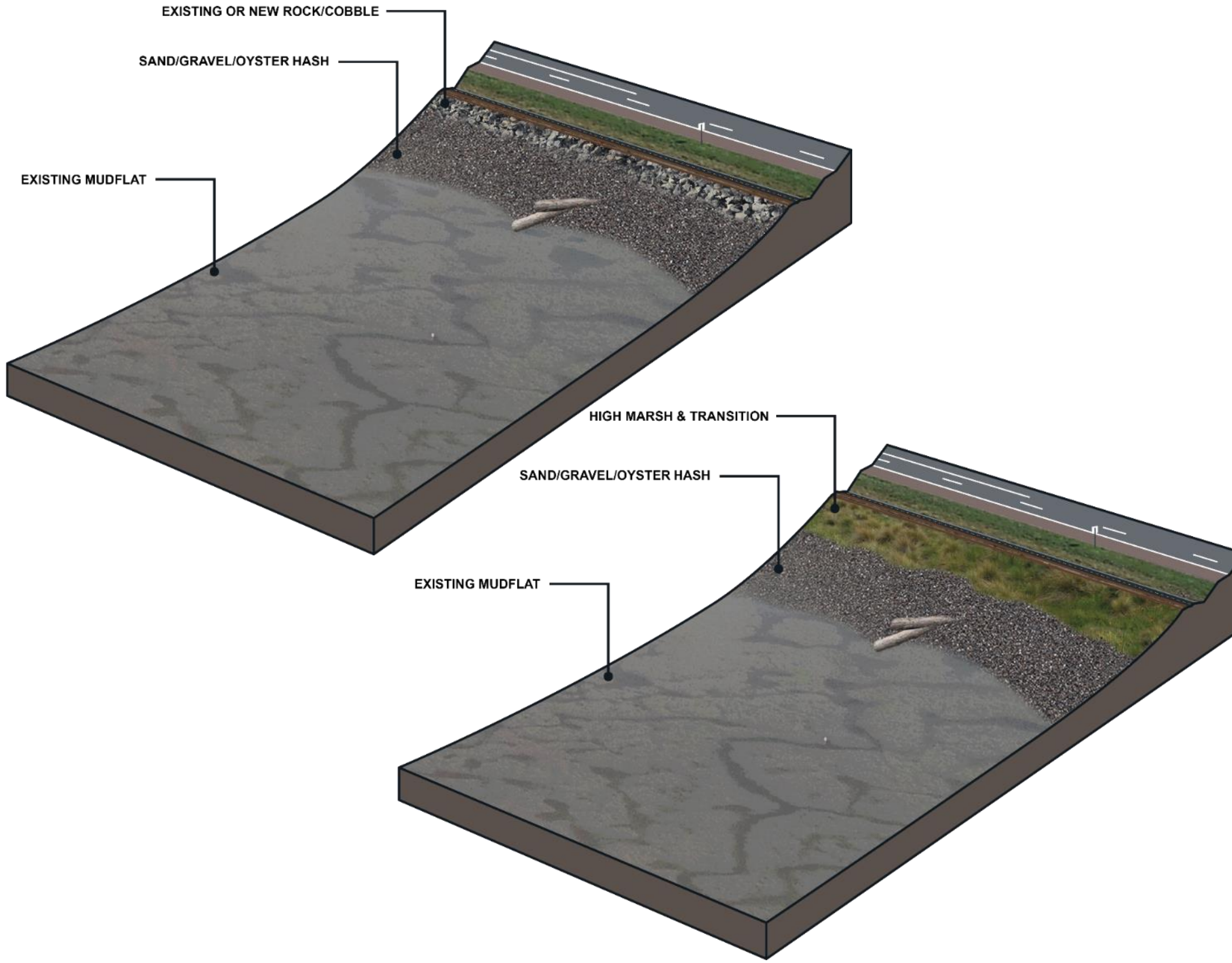
Example Photo: Project Area Shoreline (25mph north wind, ~6ft tide NAVD 88, April 2021)

6. Coarse Sediment Shore (Sand/Gravel/Oyster Hash)





6. Coarse Sediment Shore (Sand/Gravel/Oyster Hash)



6. Coarse Sediment Shore (Sand/Gravel/Oyster Hash)

Example Photo: Brainard Shoreline (January 2021)

Example Photo: San Francisco Bay

Alternative Development and Evaluation- Apparent Best Alternative Considerations

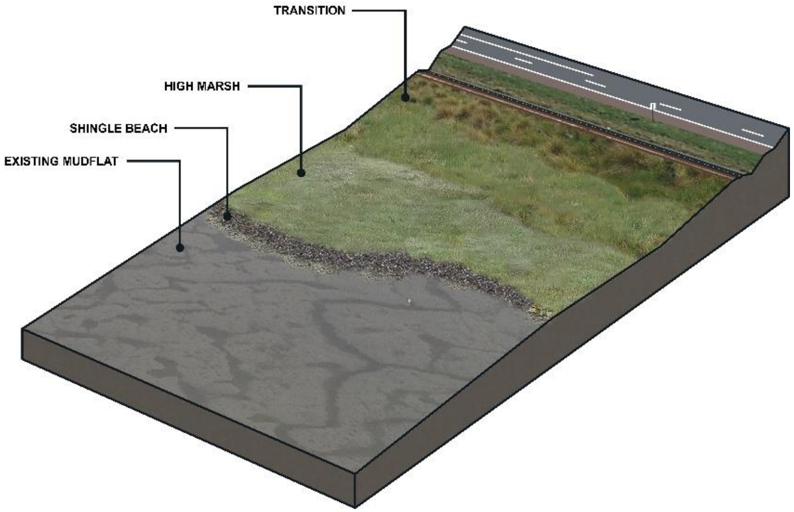
- <u>Considerations:</u>

1. Goal of restoring/enhancing intertidal marsh habitat resilient to sea level rise and in equilibrium with hydraulic and geomorphic processes.
2. Goal of protecting infrastructure (Humboldt Bay Trail and Highway 101) from wind-wave runup and overtopping.
3. Input from Technical Working Group (TWG) about minimizing the use of shoreline hardening, particularly from rock slope protection.
4. Results and findings from the Geomorphic Assessment and Conceptual Model
5. Desire for beneficial re-use of dredge spoils
6. Ease of Permitting, Cost, Constructability, Phasing/Scalability
7. Others?

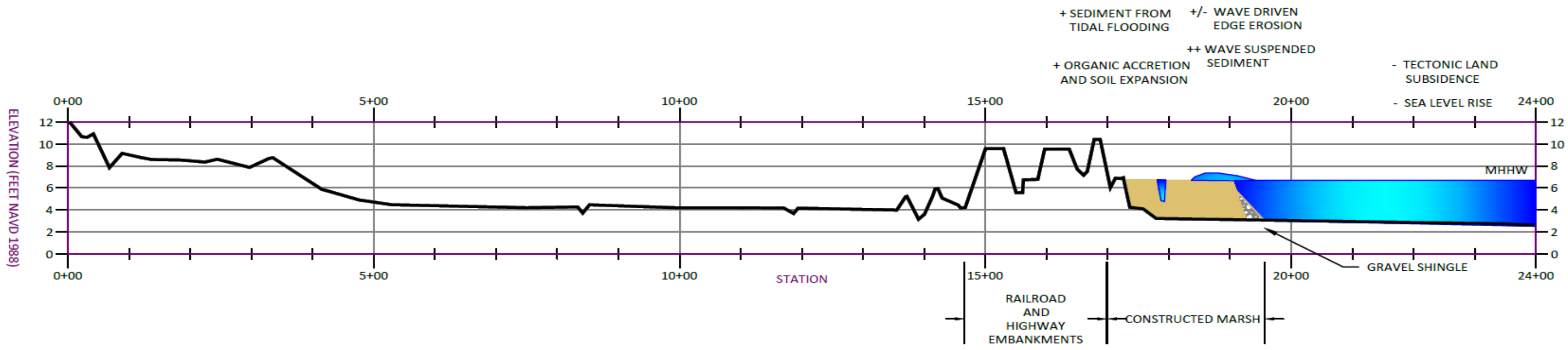
Alternative Development and Evaluation- Apparent Best Alternative Components

- **Hybrid of Alternative 2 and 6**

1. Salt Marsh with High Marsh Transition Zone
   - Promotes Sediment Trapping and Vertical Accretion
   - Early Vegetation Colonization
2. Coarse Gravel Shingle Beach
   - Gradual Slope from Mudflat to Salt Marsh
   - Dissipates Wave Energy to Accommodate Marsh Development
3. Reference Shoreline (north of Brainard Slough)



Apparent Best Alternative: Salt Marsh with Coarse Gravel Shingle Beach



SHORELINE MARSH ENHANCEMENT: RESTORE CONDITIONS TO SUPPORT PROCESSES THAT MAINTAIN MARSH IN QUASI-EQUILIBRIUM WITH RELATIVE SEA LEVEL RISE:

VERTICAL MOTION: ORGANIC ACCRETION + TIDAL SEDIMENT + WAVE SEDIMENT ≈ TECTONIC SUBSIDENCE + SEA LEVEL RISE

EDGE POSITION: STABLE OR PROGRADING

Discussion

- Seek Concurrence on Apparent Best Alternative

- Next Steps
  1. Advance Design (Shore Profile, Marsh Geometry, Channel Network)
  2. Select Site Visit Date: Nov. 2nd, 3rd or 4th (3pm)
  3. TWG Meeting #5: Tentative January 2022