Sears Point Levee Adaptive Management Project

Monitoring Plan

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Monitoring Plan
Sears Point Levee Adaptive Management Project Actions

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Monitoring Plan
Sears Point Levee Adaptive Management Project Actions

1 Introduction

This Monitoring Plan covers additional monitoring to be conducted for the Sears Point Levee Adaptive Management Project (Project), constructed fall 2021 at the Sears Point Tidal Wetland Restoration Project (Restoration). This Plan fulfills regulatory requirements specified in the Project authorizations – BCDC permit amendment M2012.022.02 (Oct 21, 2020) and M2012.022.03 (June 17, 2021), RWQCB Letters of Concurrence for Order No. R2-2013-0017 (July 8, 2020, May 3, 2021), and Corps of Engineers Letters of Modification for Permit No. 2015-00152N (May 4, 2020, April 29, 2021). The purpose of this Project is to rehabilitate the excessively wave-eroded portions of the north and west levees at the Project using "nature-based strategies" to promote achievement of the intended ecological and flood protection benefits of the "habitat levee." The originally constructed "habitat levee" of the west and north levees consisted of a gentle "ecotone slope" designed to support a continuous vegetated gradient (20:1 to 10:1 slope) between tidal marsh and terrestrial grasslands on the upper levee slope. This habitat levee was constructed atop and adjacent to the core flood control levee.

Adaptive Management Project Goals and Objectives

The Adaptive Management Project goals were described in the Draft Adaptive Management Plan (Siegel Environmental 2020) and are elaborated upon here:

Goals

1) **Stabilize, recover, and restore the ecotone slope**
    a) Minimize further erosional loss of the ecotone (habitat levee) slope
    b) Accelerate vegetative stabilization of the eroded slope
    c) Promote achievement of the original ecological design objective of the ecotone levee slopes: *to establish a natural wetlands-uplands transition to the greatest extent possible and provide an upland buffer along the northern baylands boundary*[1]
2) **Avoid reaching levels of erosion that would trigger conventional engineering responses** to protect the geotechnical stability and/or flood protection functions of the levees

Objectives

1) Re-initiate development of the wetland-upland transition zone along the ecotone levee slope (continuous gradient of vegetation on substrate elevations between terrestrial and tidal marsh zones)
2) Restore and retain ecotone slopes (~5:1 or gentler if possible) along the habitat levee

[1] Performance objective from the restoration project permits

3) Halt progressive erosion of the constructed habitat levee and encourage accretion and marsh building processes
4) Utilize nature-based design strategies to the greatest extent possible

Adaptive Management Project Elements

The "living shoreline" approach to erosion control aims to restore the eroding transition zone by utilizing "nature-based strategies" – the incorporation of dynamic natural ecosystem processes and materials to the greatest extent practicable. The project includes the following design elements (Table 1), with their placement locations shown in Figure 3.

Table 1. Adaptive Management Design Elements

Design Element	Basis of Design	Locations Utilized
Utilized Across Much of North and West Levees		
Scarp grading	Interrupt the positive erosion feedback of wave-reflective scarp profiles	North and west levee
Large woody debris (LWD) placement	Act as local low-crested wave breaks and traps for coarse sediment, sheltering pioneer salt marsh seedlings; mechanism for enhancing marsh nucleation (centers of pioneer marsh establishment and accretion) and vegetative roughness to trap accreted sediment and provide complex habitat structure	North levee
Mud placement, below MHHW	Dynamic wave transport of swash bars (mud beach ridges) shoreward to interact with patchy salt marsh vegetation, maturing into natural high salt marsh berms	North and west levee
Mud placement, above MHHW	Fill depressional areas that had formed atop the ecotone levee slope and where horizontal spaces were too tight or vegetation too extensive to grade surrounding soils	Cells 1-4 of north levee
Gravel veneer, above MHHW	Resist surface erosion in the high tide zone of maximum wave exposure, and protect seedling roots during periods of high wave action, facilitating vegetative stabilization and deposition	Cells 1-4, 6 of north levee
Gravel toe berm	Establish a wave-deposited dynamic vegetated high salt marsh berm that is resilient to extreme storm wave action at high tide and inhibits re-initiation of erosional scarps, with flexibility to roll landward with higher sea level and wave runup (Aramburu Island gravel storm berm model)	North levee
Pacific cordgrass planting	Increase wave attenuation and support establishment of native tidal salt marsh habitats	North and west levee
Creeping wildrye sod transplanting	Increase soil shear strength at and below the high tide line, increasing perennial vegetative roughness to attenuate wave energy and resist erosion as sea level and maximum wave runup rise	North and west levee

Design Element	Basis of Design	Locations Utilized
Additional Treatments in Cells 6 and 7 of North Levee		
Temporary Brush fence	Temporary reduction in wave energy around new cordgrass transplants to prevent erosion from undermining them	Cells 6 and 7 of north levee
Gravel veneer, below MHHW	Resist surface erosion in gaps exposed to wave action among mud mounds, and facilitate seedling colonization and marsh stabilization	Cells 6 and 7 of north levee
Gravel toe berm	See above. July 2021 final design included this element in cells 6 and 7 only but this element was extended along much of the north levee during construction	

Sears Point Tidal Restoration Area

County Land Boundary

Sears Point Site Location Map Figure 1

San Francisco Bay National Estuarine Research Reserve

SONOMA LAND TRUST

Data: Sonoma Land Trust, watershed delineation by Camp Dresser & McKee | Aerial Imagery: (c) ESRI, i-cubed 15m eSAT | Map Date: May 2017 | Map Created by J. Kinyon, Sonoma Land Trust

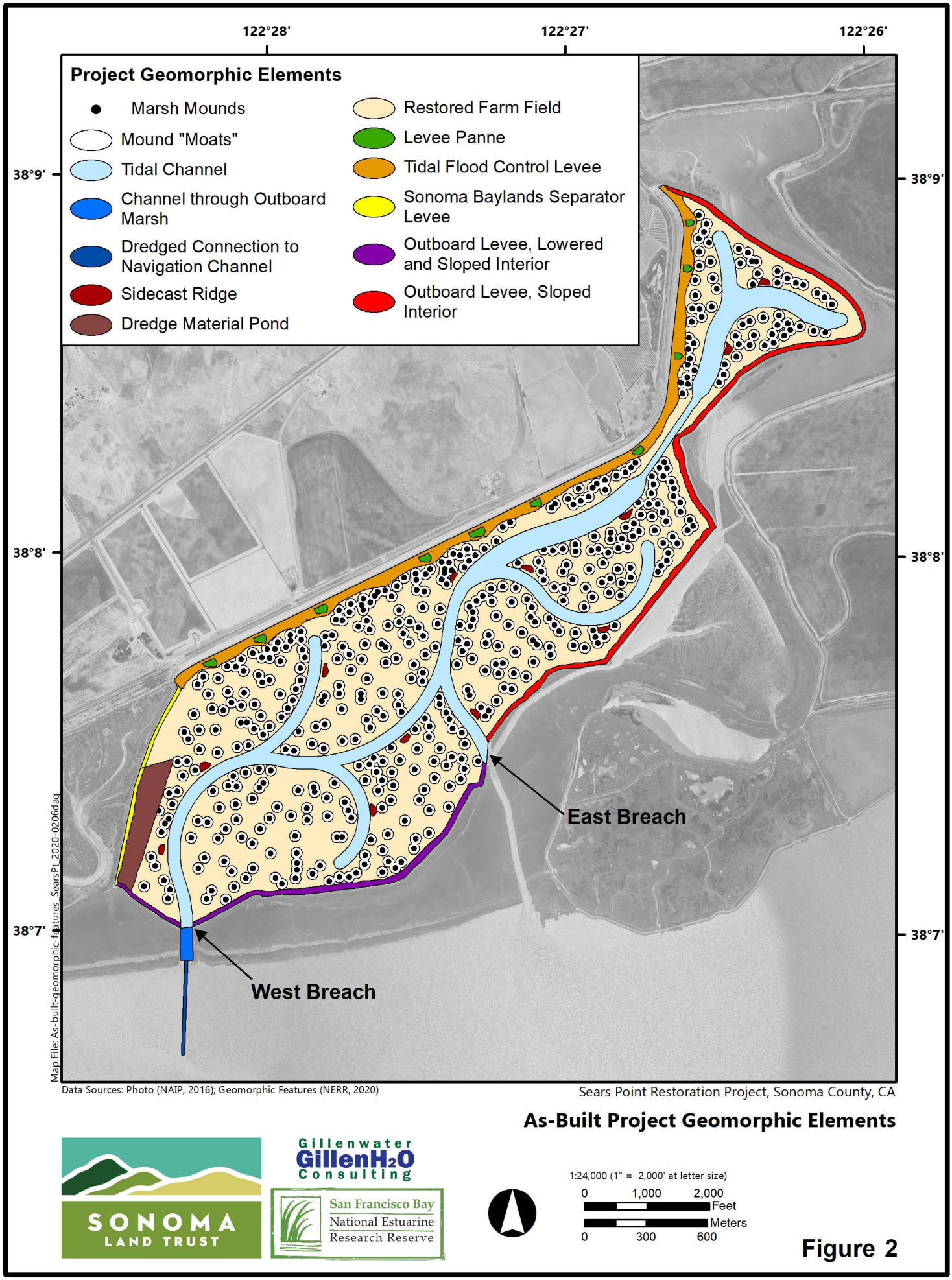
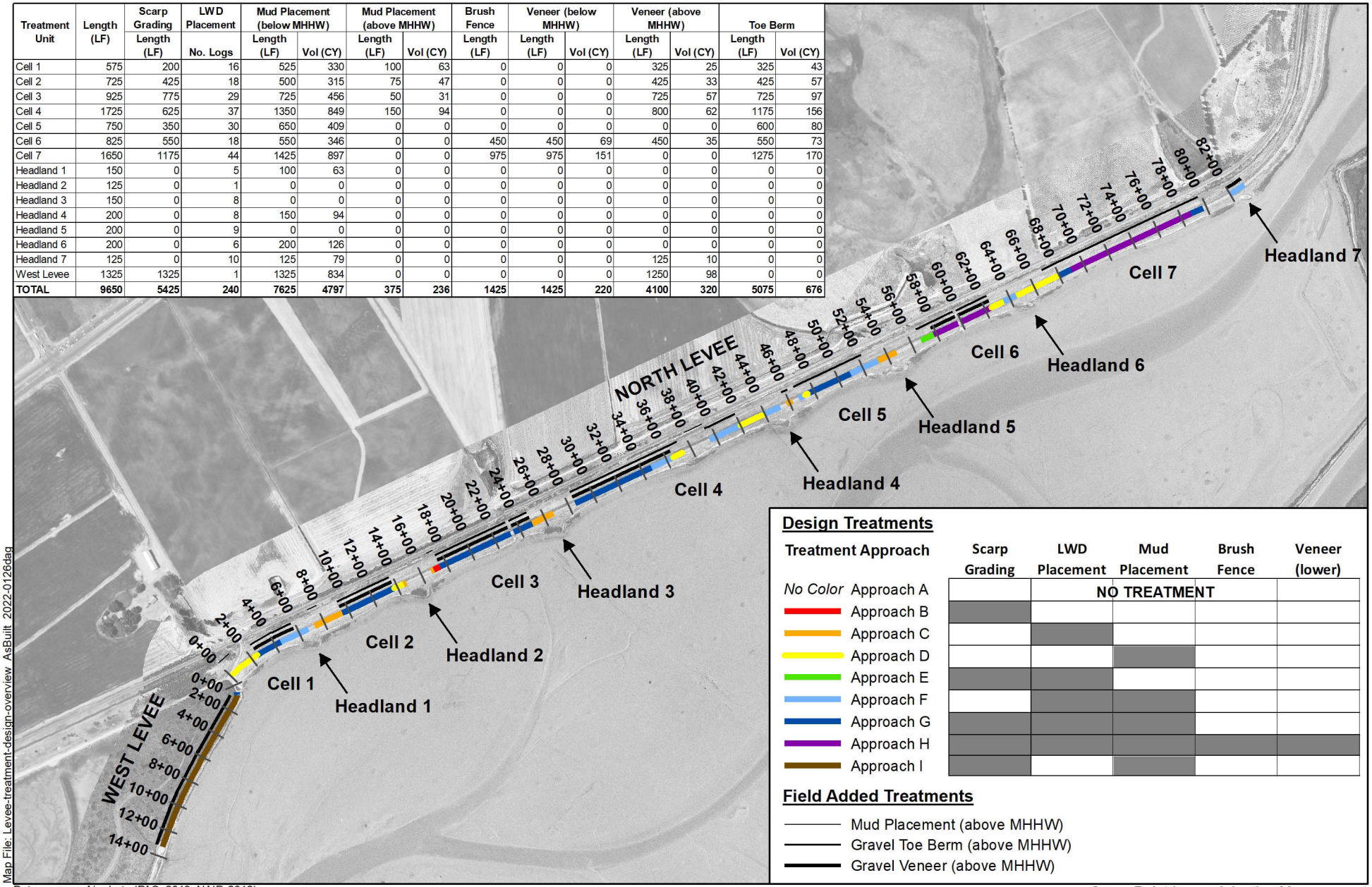

122°28'
122°27'
122°26'
38°9'
38°8'
38°7'
Project Geomorphic Elements
Marsh Mounds
Mound "Moats"
Tidal Channel
Channel through Outboard Marsh
Dredged Connection to Navigation Channel
Sidecast Ridge
Dredge Material Pond
Restored Farm Field
Levee Panne
Tidal Flood Control Levee
Sonoma Baylands Separator Levee
Outboard Levee, Lowered and Sloped Interior
Outboard Levee, Sloped Interior
East Breach
West Breach
Map File: As-built-geomorphic-features_SearsPt_2020-0206dag
Data Sources: Photo (NAIP, 2016); Geomorphic Features (NERR, 2020)
Sears Point Restoration Project, Sonoma County, CA
As-Built Project Geomorphic Elements
1:24,000 (1" = 2,000' at letter size)
0 1,000 2,000
Feet
0 300 600
Meters
SONOMA LAND TRUST
Gillenwater GillenH2O Consulting
San Francisco Bay National Estuarine Research Reserve

Figure 2

Treatment Unit	Length (LF)	Scarp Grading	LWD Placement	Mud Placement (below MHHW)		Mud Placement (above MHHW)		Brush Fence	Veneer (below MHHW)		Veneer (above MHHW)		Toe Berm	
		Length (LF)	No. Logs	Length (LF)	Vol (CY)	Length (LF)	Vol (CY)	Length (LF)	Length (LF)	Vol (CY)	Length (LF)	Vol (CY)	Length (LF)	Vol (CY)
Cell 1	575	200	16	525	330	100	63	0	0	0	325	25	325	43
Cell 2	725	425	18	500	315	75	47	0	0	0	425	33	425	57
Cell 3	925	775	29	725	456	50	31	0	0	0	725	57	725	97
Cell 4	1725	625	37	1350	849	150	94	0	0	0	800	62	1175	156
Cell 5	750	350	30	650	409	0	0	0	0	0	0	0	600	80
Cell 6	825	550	18	550	346	0	0	450	450	69	450	35	550	73
Cell 7	1650	1175	44	1425	897	0	0	975	975	151	0	0	1275	170
Headland 1	150	0	5	100	63	0	0	0	0	0	0	0	0	0
Headland 2	125	0	1	0	0	0	0	0	0	0	0	0	0	0
Headland 3	150	0	8	0	0	0	0	0	0	0	0	0	0	0
Headland 4	200	0	8	150	94	0	0	0	0	0	0	0	0	0
Headland 5	200	0	9	0	0	0	0	0	0	0	0	0	0	0
Headland 6	200	0	6	200	126	0	0	0	0	0	0	0	0	0
Headland 7	125	0	10	125	79	0	0	0	0	0	125	10	0	0
West Levee	1325	1325	1	1325	834	0	0	0	0	0	1250	98	0	0
TOTAL	**9650**	**5425**	**240**	**7625**	**4797**	**375**	**236**	**1425**	**1425**	**220**	**4100**	**320**	**5075**	**676**



Design Treatments

Treatment Approach	Scarp Grading	LWD Placement	Mud Placement	Brush Fence	Veneer (lower)
No Color Approach A		NO TREATMENT			
Approach B	■				
Approach C		■			
Approach D			■		
Approach E	■	■			
Approach F		■	■		
Approach G	■	■	■		
Approach H	■	■	■	■	■
Approach I	■		■		

Field Added Treatments

- Mud Placement (above MHHW)
- Gravel Toe Berm (above MHHW)
- Gravel Veneer (above MHHW)

Map File: Levee-treatment-design-overview_AsBuilt_2022-0126dag

Data sources: Air photo (PAS, 2019; NAIP, 2012);
Design data (SE, 2022)

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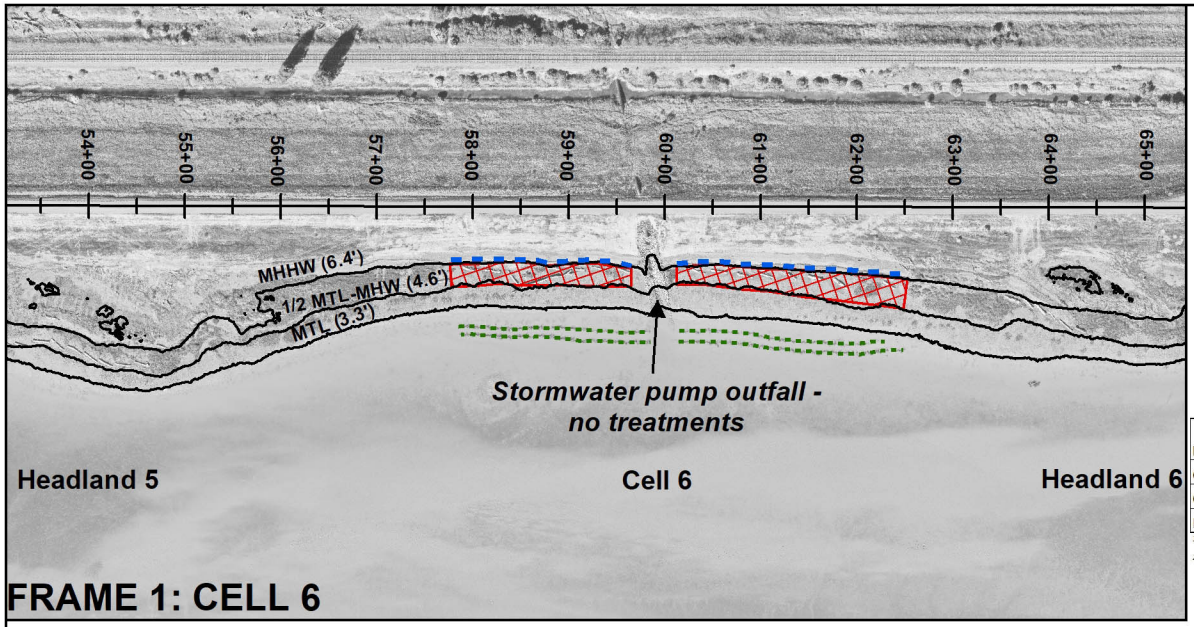
0 500 1,000 Ft

0 150 300 M

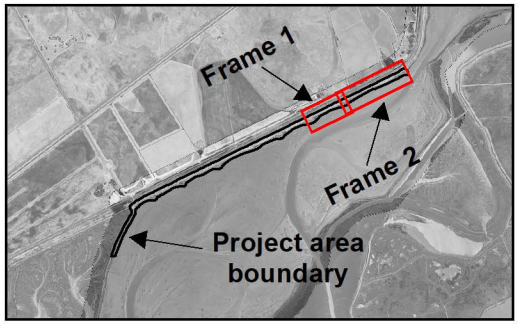
Sears Point Levee Adaptive Management

Figure 3

Adaptive Management Treatment Overview



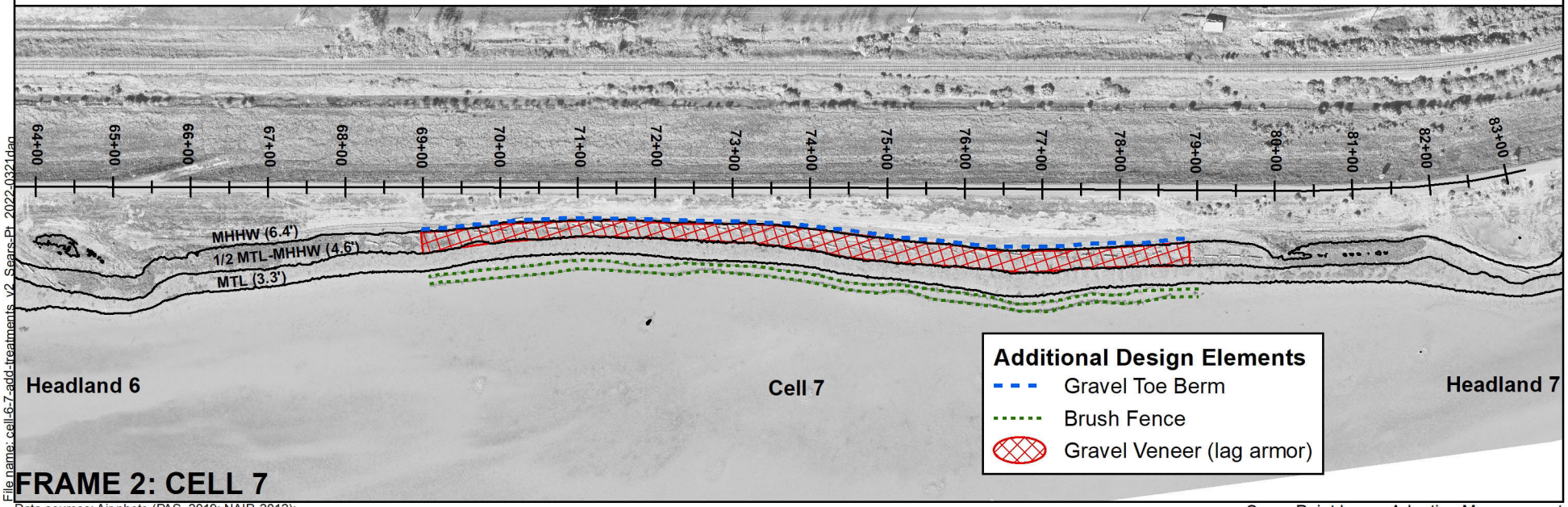
FRAME 1: CELL 6



CONSTRUCTION QUANTITIES

Design Element	Elevation Range	Length (ft)	Area (ft²)	Excavation Vol (CY)	New Fill Vol (CY)	Replaced Fill Vol (CY)
Gravel Toe Berm	MHHW - HTL[1]	1,825	10,040	-	243	-
Gravel Veneer	1/2 MTL-MHW[2] - MHHW	1,450	35,270	-	220	-
Brush Fences (2 rows)	MTL - 1/2 MTL-MHW	2,900	5,800	860	-	860

[1] *High tide line: ~8' NAVD88*
[2] *Mid point between the elevation of MTL and MHW (4.6' NAVD88)*



FRAME 2: CELL 7

File name: cell-6-7-add-treatments_v2_Sears-Pt_2022-0321dan

Data sources: Air photo (PAS, 2019; NAIP, 2012);
Design data (SE, 2021)

1:2,400 (1" = 200' at letter size)

0 100 200 Ft
0 30 60 M

Sears Point Levee Adaptive Management

Figure 4

Constructed Additional Cell 6 & 7 Treatments

2 Monitoring Activities

Monitoring activities (Table 2) are split into two broad categories – 1) the intended outcomes of the adaptive management project, and 2) the supporting conditions and processes intended by the project design to achieve those outcomes.

Table 2. Indicators, Performance Objectives, and Monitoring Methods, Frequency, and Duration

No.	Indicator	Performance Metric	Monitoring Methods	Frequency	Timing	Monitoring Year				
						0[1]	1	2	3	4
						2021	2022	2023	2024	2025
Intended Outcomes										
1	Erosion scarps at levee	No new scarp formation >1ft tall within four years in treated areas	a. Topographic survey transects[2] b. Visual inspections and photo monitoring at fixed locations established ahead of construction c. Aerial topo[2,3] d. Erosion pins	a. 1x/yr[4] b. 2x/yr c. 1x/yr[4] d. 2x/yr	a. Summer b. Winter, summer c. Summer d. Winter, summer	✓	✓	✓	Visual	✓
2	Rate of habitat levee erosion above MTL	Treated reaches exhibit <25% annual horizontal erosion rates through 2021[2] vs. pretreatment conditions	a. Topographic survey transects[2] b. Aerial topo[2,3]	1x/yr[4]	Summer	✓	✓	✓	If funds	✓
3	Establishment of marsh vegetation	Increasing percent cover trend with time of native tidal marsh vegetation at toe of ecotone levee and >2x spatial extent in treated vs. untreated areas with stable colonies	a. Area and shoreline length of perennial salt marsh vegetation in each cell and headland measured from aerial photo[2,3] b. Percent cover and plant species composition surveys at ground truthing polygons, field photographs	1x/yr	End Summer/ Fall		✓	✓	If funds	✓

No.	Indicator	Performance Metric	Monitoring Methods	Frequency	Timing	Monitoring Year				
						0[1]	1	2	3	4
						2021	2022	2023	2024	2025
Supporting Processes and Conditions										
4	Installed log position stability	Within two years following construction: 1. No more than 20% logs detach from anchored position. 2. No more than 50% of detached logs move more than one log length. 3. No more than 10% of detached, moved logs escape their original shoreline cells	a. UAV ortho photo for as-built b. UAV ortho photos years 1, 2 c. Field inspection	1x/yr	Flexible, align with other activities	✓	✓	✓		
5	Redistribution and vegetative stabilization of placed bay mud in swash zone[5]	1. Combined placed bay mud and redeposited mud grain swash bars- are present along 50% of treated shoreline length one year post construction	Field inspection of shoreline bed materials (redistributed placed mud vs deposited bay mud vs eroded upper levee soils), topographic change detection data analysis[3], assess topographic change at fixed transects if feasible, air photo analysis	1x	Fall		✓			
		2. Combined placed bay mud and redeposited mud grain swash bars are vegetated by perennial native salt marsh plant cover along at least 30%	a. Vegetation delineation from aerial imagery (3a above) b. Field ground truthing to align swash bars with vegetation	2x	Summer		✓	✓		

No.	Indicator	Performance Metric	Monitoring Methods	Frequency	Timing	Monitoring Year				
						0[1]	1	2	3	4
						2021	2022	2023	2024	2025
		of treated shoreline three years post construction								
6	Redistribution of placed toe berm gravel in swash zone, northern levee	Redistributed gravel from placed toe berm present along 75% of treated shoreline length	Field inspection of shoreline bed materials (redistributed placed gravel vs. constructed levee vs eroded upper levee soils), topographic change detection data analysis[2], assess topographic change at fixed transects, collect sediment samples at half the topographic transects and field estimate percent gravel by volume, within some cells place wood stakes at center of toe berm and track movement above and below, field photographs	1x/yr	Flexible, align with other activities		✓	✓		✓
7	Retention of lag gravel in cells 6 & 7	Lag gravel layer is present below MHW within original placement extent	Detection by probing with survey rod/boots during topo surveys	1x/yr	Flexible, align with other activities		✓	✓		✓
8	Integrity of mudflat brush fence sheltering	One growing season (short-term) wave shelter zone for seedlings or transplants of marsh vegetation to establish and anchor roots enough to support high survival rate	Direct photo monitoring (fixed perspective, position) of gap sizes, branch density class (rank into 3-4 groups of branch density/meter); digitize and compare as-built to year-1 UAV imagery	1x	Late summer or fall		✓			

Notes:

1. *Year-0 (2021) "as-built" data collection included levee topographic transects, UAV aerial imagery and aerial photogrammetry (Siegel Environmental 2022).*
2. *Pre-construction levee topographic transects (reoccupying prior transects) and aerial-based elevation mapping of the west and north levees completed prior to construction.*
3. *Aerial topographic mapping and photography will be conducted as follows: Years 1 and 2 will be flown with a UAV of the north and west levee only. Year 4 (restoration project Year 10) will be flown from fixed wing aircraft for full site LiDAR and ortho photo. Funds availability may reduce these efforts.*
4. *If funds available, add immediate post-storm monitoring (adaptive, contingent) of sediment pins before post-storm sedimentation masks maxima.*
5. *Placed mud intended to be distributed by wave action and colonized by vegetation. Anticipate that once vegetated, will be more difficult to distinguish this as substrate.*

3 Monitoring Methods

Aerial orthophotos and topography

- **UAV imaging of levees:** Baseline (June 2021), as-built (December 2021), and years 1 and 2 (2022 and 2023) capture the levees and adjacent marsh/mudflat only (Figure 5). The UAV uses a higher density of ground control points to stitch together images into an orthophoto and from that software derives photogrammetry-based topography.
- **Fixed wing imaging of entire site:** Year 4 (2025) would capture the entire Sears Point site. The fixed wing use fewer GCPs, captures two-four photos that combine into an orthophoto, and it separately flies multiple passes with LiDAR to develop topography. Note that this full-site imagery also corresponds to Year-10 monitoring of the restoration project.
- Three- or four-band imagery depending on platform and cost.
- Geodetic elevations tied to the nearby NGS geodetic benchmark JT9545 at a minimum.
- Change detection comparisons to prior elevation data.
- Extract ground features manually or automated depending on features

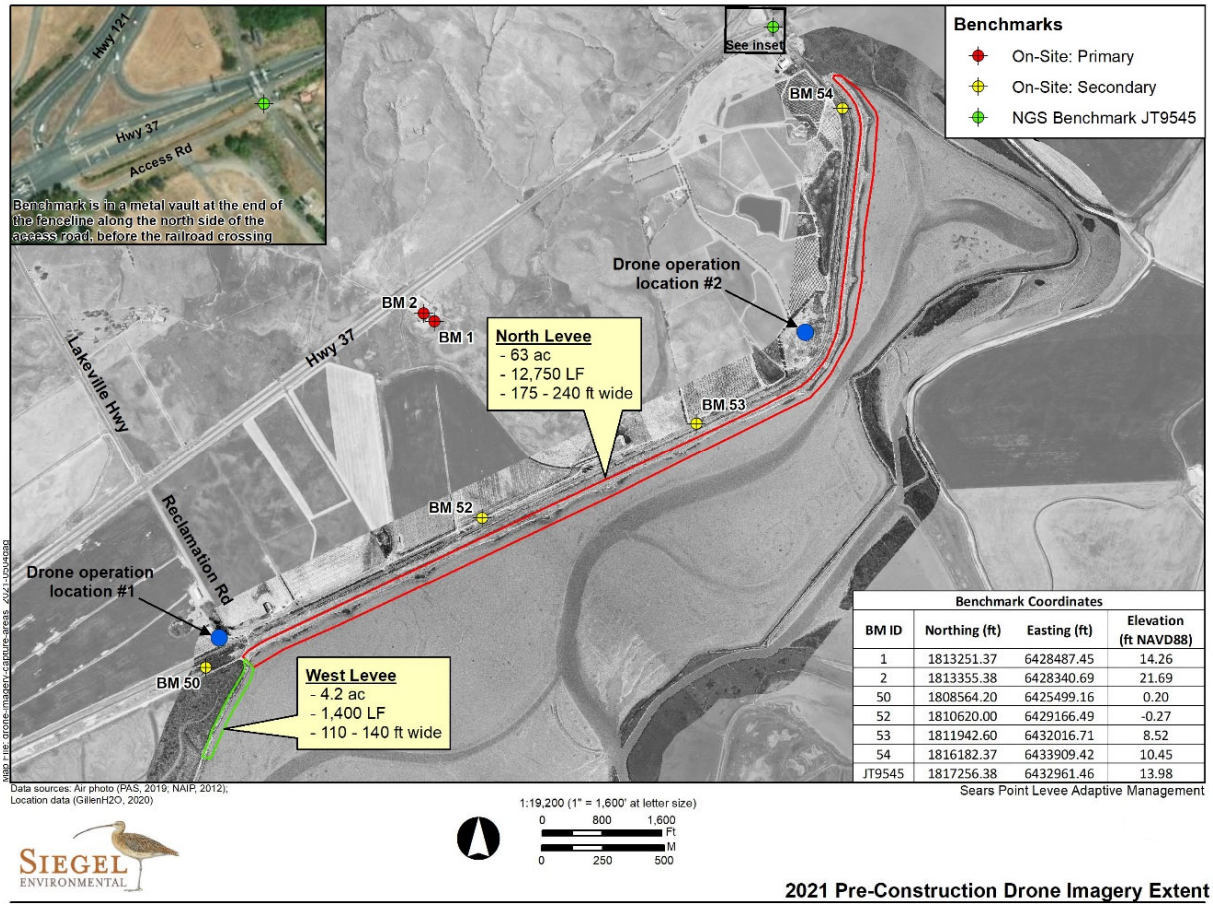


Figure 5. UAV Imaging Extent

Northeast segment of levee not necessary for adaptive management monitoring but captured as has minimal effect on cost and serves as reference conditions.

Topographic survey transects

- Reoccupy a minimum of 26 transects established by Ducks Unlimited with 2017 and 2018 surveys and an additional 22 transects surveyed as part of the as-built survey (Figure 6)
- RTK or total station surveys of these transects
- Geodetic elevations tied to nearby NGS geodetic benchmark JT9545 at a minimum
- Data plotted alongside prior transect data
- As vegetation establishes and obscures the ground surface, this method will be increasingly important

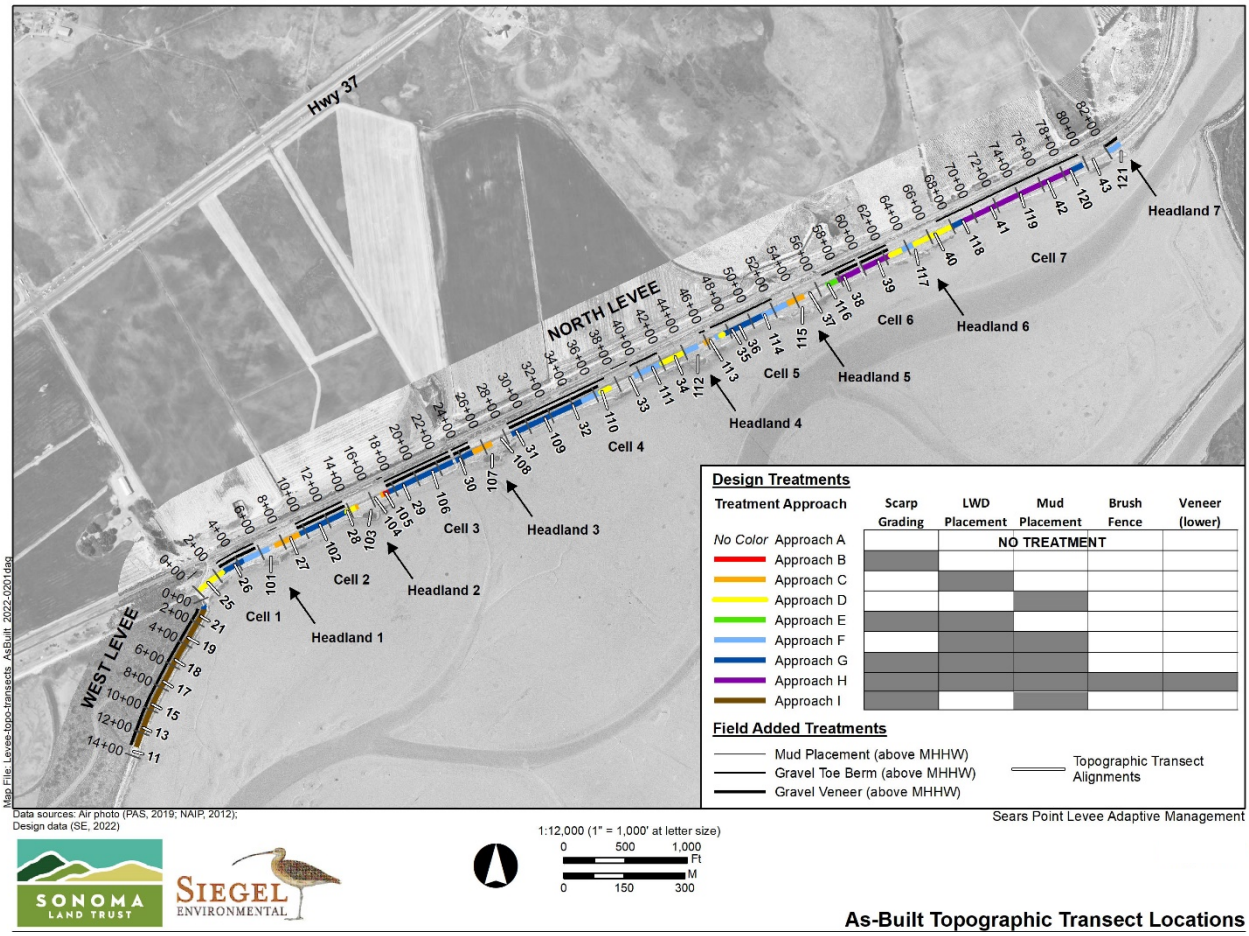


Figure 6. Topographic Survey Transects to Be Reoccupied

Double-digit transect numbers correspond to original numbers established by Ducks Unlimited in its post-construction surveys. Triple-digit transect numbers added for the as-built survey. For this monitoring plan, all identified transects will be surveyed. Primary reference benchmark is JT9545 shown in Figure 5.

Shoreline inspections

- Walk entire length of treatment area and inspect:
    - Log stability
    - Distribution of placed toe berm gravel
    - Distribution of bay mud swash bars
    - Shoreline scarp reactivation
    - General shoreline conditions including new or unanticipated patterns or processes of sediment transport and vegetation
- GPS mapping of shoreline design elements of interest

Salt marsh vegetation

- **Remote sensing data extraction of vegetation polygons** from aerial ortho photos for total absolute vegetation cover measurement.
- **Early-stage marsh vegetation establishment – *core* ground-truth salt marsh patch areas**
    - Classify by plant species dominance type (*e.g.*, annual vs. perennial pickleweed-dominated assemblages, cordgrass, alkali-bulrush) to 1 m scale (minimum patch size)
    - Shoreline length of patch
    - Plant species composition (sub-dominant to infrequent species)
    - Percent cover of vegetation dominant species within patches (subjective rank abundance (cover-class) estimates)
    - Vegetation height average by species
    - Elevation zone (from aerial topographic data) of below scarp (near HTL) to mid-intertidal zone (MTL)
- **Early-stage marsh vegetation establishment – *recommended* ground-truth salt marsh patch areas**
    - Shoot density (stems/m via line-intercept)
- **Late-stage marsh vegetation establishment – ground-truth continuous, extensive vegetation belts within cells**.
    - Characterize marsh vegetation of continuous belts (fringing marsh) within relatively homogeneous segments, or systematic sampling intervals, along shore within cells, measuring vegetation sampling variables as for discrete patches. Sampling intensity will be adjusted to heterogeneity of vegetation within segments (higher heterogeneity, higher sampling intensity).
- Compile shoreline length and total areal extent by vegetation patch type (vegetation stands), assign to elevation ranges, summarize species composition and relative cover by patch type

Erosion pins, horizontal

- Purpose is to measure horizontal retreat (erosion) of the regraded habitat levee slopes, finer scale data compared to topographic transects
- Rebar pounded horizontally into the levee face at lower elevations closer to the wetland-upland transition where erosion has been observed previously
- Measure distance from rebar tip back to levee face, track over time. No change means no erosion, increasing distance means erosion has taken place, decreasing distance means accretion has taken place
- Focus placement at selected locations that previously exhibited the greatest erosion (west levee, north levee cells 1, 3, 4, 6, 7). Estimate about 15 locations based on the baseline and as-built topographic transect data (Siegel Environmental 2022)

Erosion pins, vertical

- Used as backstop in case severe erosion destabilizes horizontal erosion pins
- Rebar pounded vertical into the levee in slope above placed logs (roughly along MHHW)
- Distance from pin downslope to scarp (if present), track over time. No change means no erosion, decreasing distance means erosion has taken place

Gravel lag presence below LWD (Cells 6 & 7 only)

- The project used a 3” minus gravel mixture for this lag layer placed atop the eroding levee surface and then buried with placement of coarse dried bay mud.
- If the bay mud remains in place, then the lag gravel will be detectable by probing (soil core, survey rod, piece of rebar, or shallow excavation) through the overlaying bay mud.
- If the bay mud is scoured away and the lag gravel remains, it will be visible on the surface (though maybe mud encrusted).
- If the bay mud is scoured away and the lag gravel also is scoured away, then there will be no detectable lag gravel through probing or visual assessment.
- Inspect (probe and/or visually assess) during topographic transect surveys. Take field photographs.
- Record location of lag along transect – survey start and end points.

Fixed Field Photographic Monitoring

- Fixed locations for field photographs were established prior to project construction (Figure 7)
- Pre-construction, during-construction, and post-construction photos have been collected
- Photographs are minimum of three per location – east, south, and west along the levee
- Maintain perspective and position over time
- Utilize clear system for tracking photograph location

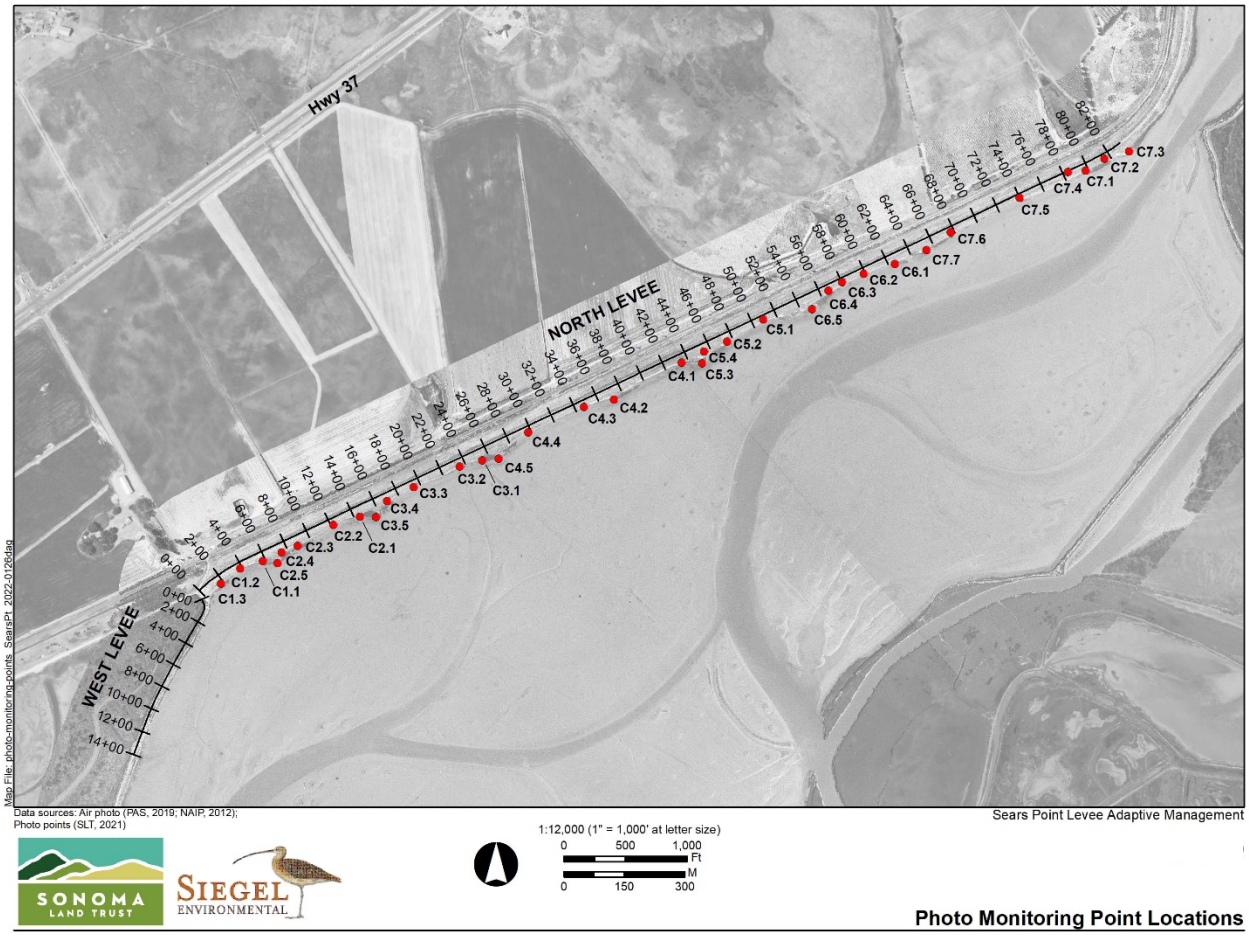


Figure 7. Field Photograph Locations

Brush Fence Monitoring

- Monitored 1 year after construction
- Visually inspect to estimate branch density and rank into ~3 density classes, with density assessed as number of embedded branches per unit length
- Direct photo monitoring (fixed perspective, position) of gap sizes
- Compare the summer 2022 UAV imagery to the December 2021 as-built UAV imagery
- Cordgrass transplant variables associated with brush fencing: patch diameter (size classes expected within 3 yr, < 15 cm, 15-30 cm, 30-50 cm, 50-80 cm, 80-120 cm, > 120 cm); erosional scour indicators (numerical ranking of surface exposure of basal buds, tiller bases, or roots above marsh surface).

4 Reporting

The “annual monitoring period” will be the calendar year. Monitoring reports will be prepared after years 1, 2, and 4 and completed by March 31 of each following year.

References

Siegel Environmental. 2020a. Sears Point Levee Adaptive Management Project Description for Regulatory Authorization Request. Prepared for the Sonoma Land Trust. February.

_____. 2020b. Draft Sears Point Levee Adaptive Management Project Plan. Prepared for the Sonoma Land Trust. August.

_____. 2022. As-Built Report, Sears Point Levee Adaptive Management Project Plan. Prepared for the Sonoma Land Trust. February.