



Menlo Park SAFER Bay

Basis of Design (60% Update)

Job # MLPK.10.25

June 5, 2026

PREPARED FOR:

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Table of Contents

Table of Contents	i
Table of Figures	v
List of Tables	vi
List of Acronyms	vii
1. Overview	1
1.1 SAFER Bay	1
1.2 SFCJPA work to date	1
1.3 City of Menlo Park Responsibilities for Further Project Development.....	1
1.4 Basis of Design Organization.....	2
1.4.1 Background (Section 2).....	2
1.4.2 Design Methodologies and Criteria (Section 3)	2
1.4.3 Levee Sub-reaches (Section 4).....	2
1.4.4 Environmental Restoration (Section 5).....	2
1.4.5 Landscape Architecture (Section 6).....	2
1.4.6 Other Design Considerations (Section 7)	2
1.4.7 Estimated Construction Value (Section 8)	2
1.4.8 Preliminary Value Engineering Concepts (Section 9)	3
1.5 Report Appendices	3
2. Background	5
2.1 City of Menlo Park Levee Sub-Reaches	6
2.1.1 Substation and Marsh Restoration Reach.....	6
2.1.2 Tech Campus Reach.....	7
2.1.3 Bayfront Expressway Reach	7
2.2 Scope of Environmental Restoration.....	7
2.2.1 Restoration	8
2.2.2 Plan-Specific Restoration.....	8
3. Design Methodologies and Criteria	11
3.1 Plan Sheet Control.....	13
3.2 Survey and Mapping Control	14
3.2.1 Horizontal Control	14
3.2.2 Vertical Control.....	15
3.3 Levee and Trail Alignments.....	15
3.4 Flood Protection Elevations	15
3.4.1 Stillwater Flood Elevations	15
3.4.2 Waves and Wave Runup.....	16
3.4.3 Freeboard	17
3.4.4 Sea Level Rise Adaptation	17
3.4.4.1 SAFER Bay Criteria.....	18
3.4.4.2 BCDC RSAP Criteria	19

3.4.5 Impact on Stillwater Elevations 19

3.4.6 Impact to Wave Elevations 19

3.5 Project Life 20

3.6 Geotechnical Hazards and Design Considerations 20

 3.6.1 Subsurface Conditions 20

 3.6.2 Seismic Hazards 22

 3.6.3 Consolidation Settlement 23

 3.6.4 Ground Subsidence 24

 3.6.5 Seepage Control 24

3.7 Landscape Design Criteria 24

 3.7.1 San Francisco Bay Trail 24

 3.7.2 Bay Trail and Levee Access 25

 3.7.3 Planting 25

 3.7.4 Landscape Soils 25

 3.7.5 Paving 25

 3.7.6 Irrigation 25

 3.7.7 Site Elements and Furnishings 25

 3.7.8 Site Signage 25

4. Levee Sub-reaches 27

 4.1 Substation and Marsh Reach 27

 4.2 Tech Campus Reach 29

 4.3 Bayfront Expressway Reach 29

5. Environmental Restoration 39

 5.1 Restoration Objectives 39

 5.2 Tidal Datums 39

 5.3 Design Criteria 40

 5.4 Revegetation Plan 42

 5.4.1 Tidal Marsh Zone 43

 5.4.2 Upland Transition Zone 45

 5.4.2.1 High-Tide Refugia Group 45

 5.4.2.2 Biodiversity Resources Group 45

 5.4.2.3 Clonal Meadow Group 46

 5.4.2.4 Annual Native Cover Crop Group 46

 5.4.3 Visual Interest Zone 47

 5.5 Non-Native Species Management 47

 5.6 Irrigation 47

 5.7 Preliminary Cost Estimate 47

 5.8 Restoration References 49

6. Landscape Architecture 51

 6.1 Levee 51

 6.2 Streetscape 52

6.3 Landscape Grading52

6.4 Tree Removal and Protection52

6.5 Landscape Drainage.....52

6.6 Landscaping Soils52

 6.6.1 Existing Soil Testing Process53

 6.6.2 Site Soil Plan and Mix Design53

 6.6.3 Assumptions for Cost Estimating.....53

6.7 Paving54

 6.7.1 General San Francisco Bay Trail Guidelines54

 6.7.2 Bay Trail at Overlooks and Rest Stops54

 6.7.3 Secondary Pedestrian Paths.....54

6.8 Irrigation54

 6.8.1 Water Quality Standards55

 6.8.1.1 High Quality (Level I)55

 6.8.1.2 Relaxed Standards (Level II)55

 6.8.2 Irrigation System Design55

6.9 Understory Planting and Trees56

 6.9.1 General Landscape Criteria56

 6.9.1.1 Inboard Levee Embankments57

 6.9.1.2 Outboard Levee Embankments57

6.10 Bioretention Areas57

6.11 Trees.....57

6.12 USACE Levee Vegetation Criteria57

6.13 Site Elements and Furnishings59

6.14 Site Signage59

7. Other Design Considerations.....61

 7.1 Earthen Levee Construction61

 7.1.1 Equipment.....61

 7.1.2 Wet Soil Conditions.....61

 7.1.3 Site Preparation61

 7.1.4 Grading.....62

 7.1.5 Fill Material62

 7.1.6 Fill Placement and Compaction.....63

 7.2 Floodwall Construction63

 7.3 Design Loading Conditions64

 7.3.1 Hydraulic Loading Conditions.....64

 7.3.1.1 Base Flood (1% Annual Chance Event).....64

 7.3.1.2 Long-Duration Storm / Steady-State Seepage.....64

 7.3.1.3 Rapid Drawdown (Post-Storm Recession).....64

 7.3.1.4 Erosion and Scour64

 7.3.1.5 Sea Level Rise (SLR) Sensitivity Case64

7.3.2 Seismic Loading Conditions	65
7.3.3 Structural and Earth Loads.....	65
7.3.4 Other Loading Conditions (Coastal-Specific Additions)	65
7.3.5 Load Combinations and Performance Criteria.....	65
7.4 Structural Modeling Approach.....	65
7.5 Summary of Governing Load Cases	66
7.6 Factors of Safety and Design Targets	66
7.6.1 Levee Stability (per EM 1110-2-1913 / EM 1110-2-6051).....	66
7.6.2 Seepage and Underseepage (EM 1110-2-6050)	66
7.6.3 Floodwall Stability (EM 1110-2-2502)	67
7.6.4 Deformation-Based Criteria.....	67
7.7 Risk-Informed Framework and Fragility Assessment	67
7.7.1 Failure Modes and Mechanisms	67
7.7.2 Fragility Curves	67
7.7.3 System Reliability.....	67
7.7.4 Uncertainty and Sensitivity Evaluation	67
7.8 Documentation for Review and Accreditation.....	68
7.9 Dewatering and Groundwater Management During Construction	68
7.10 Flood Protection during Construction.....	68
7.11 Interior Drainage	69
7.11.1 FEMA Accreditation Requirements	69
7.11.2 Interior Drainage Study Synopsis	70
8. Estimated Construction Value.....	73
9. Value Engineering	75
9.1 Levee Fill Materials.....	75
9.2 Settlement Mitigation	76
9.2.1 Cellular Concrete	76
9.2.2 Surcharge Fill.....	76
9.2.3 Ground Improvement.....	77
9.3 Seepage Control.....	78
9.4 Landscape Program	79
9.5 Alignment at Ravenswood Slough	79
9.6 Alignment Between Pond R4 and Pond R5.....	79
9.7 Alignment at PG&E Substation	79
Appendix A SAFER Bay Design Criteria.....	A
Appendix B Landscape Basis of Design	B
Appendix C Design Review Board Material.....	C
Appendix D Coastal Flood Hazard Analysis	D
Appendix E Coastal Flood Hazard Analysis.....	E
Appendix F Estimate of Construction Value	F
Appendix G Geotechnical Data.....	G

Table of Figures

Figure 2-1: SAFER Bay Program Location (ESA, 2025).....	5
Figure 2-2: Menlo SAFER Bay Project Location.....	6
Figure 2-3: Programmatic Restoration and Enhancement Actions (H.T. Harvey, 2026)	9
Figure 3-1: SAFER Bay Program Ground Control for 30% Design Plans (HDR, 2024)	14
Figure 3-2: Conflicting Horizontal Control Information on 30% Design Plans (HDR, 2024).....	14
Figure 3-3: 100-year Wind Waves Menlo Park (Beagle et al, 2019)	16
Figure 3-4: Future Sea Level Rise (California OPC, 2024) showing SAFER Bay Criterion	18
Figure 3-5: Young Bay Mud Thickness with Superimposed Project Alignment.....	21
Figure 3-6: Liquefaction Zone (shaded) at Menlo SAFER Bay (California Geological Survey) ..	22
Figure 4-1: Near East End (Start) of Menlo Park SAFER Bay	27
Figure 4-2: West of Dumbarton Bridge Approaching PG&E Substation	28
Figure 4-3: Transmission Lines at PG&E Substation	30
Figure 4-4: West of Substation near End of Substation and Marsh Restoration Reach	31
Figure 4-5: Near End of Substation and Marsh Restoration Reach Looking East.....	31
Figure 4-6: Beginning of Tech Campus Reach Looking West.....	32
Figure 4-7: Ravenswood Pump Station Discharge Outfall.....	33
Figure 4-8: View from Meta Looking to the Northwest.....	34
Figure 4-9: Bayfront Expressway Reach Looking East with Meta in Distance	34
Figure 4-10: Pedestrian Crossing from Meta's South Campus	35
Figure 4-11: View from Meta Pedestrian Crossing.....	35
Figure 4-12: Levee Alignment Looking North Toward Bedwell Park.....	36
Figure 4-13: A Water Control Structure That Interconnects Ponds.....	36
Figure 4-14: End of Menlo SAFER Bay at Bedwell Bayfront Park	37
Figure 5-1: Pond R2 Ecotone Cross Section (Expected 2031 and 2081 Conditions).....	42
Figure 6-1: USACE Vegetation-Free Zone (EP 1110-2-18).....	58
Figure 7-1: Example of Fill Failure due to Instability and Mud Wave Formation.....	63
Figure 7-3: FEMA Flood Insurance Rate Map (annotated by ESA, 2025).....	70

List of Tables

Table 3-1: Design Development Path for Menlo Park SAFER Bay	11
Table 3-2: Basis of Design Stillwater Elevation for Menlo SAFER Bay	16
Table 3-3: Design Tides for Menlo SAFER Bay	19
Table 3-4: Design Project Life	20
Table 3-5: Consolidation Settlement Estimates Based on Soil Testing	23
Table 5-1: Tidal Datums Near the Ravenswood Pond Complex	39
Table 5-2: Imported Topsoil Criteria for Upper 2 Feet of 10H:1V Transition Zone in Pond R2	41
Table 5-3: Planting Zones	43
Table 5-4: Plant Species List	44
Table 5-5: Restoration Cost Estimate	48
Table 8-1: Menlo Park SAFER Bay 60% Cost Estimate	73
Table 9-1: Estimated Import and Off Haul Quantities Based on Design Progression	75

List of Acronyms

Acronym	Description
ADA	Americans with Disabilities Act
BCDC	Bay Conservation and Development Commission
BFE	Base Flood Elevation
CDFW	California Department of Fish and Wildlife
Caltrans	California Department of Transportation
CEQA	California Environmental Quality Act
CGS	California Geological Survey
Cal OPC-SAT	California Ocean Protection Council Science Advisory Team
CalOES	California Office of Emergency Services
FEMA	Federal Emergency Management Agency
FIRM	Flood Insurance Rate Map
NAD83	North American Datum of 1983
NAVD88	North American Vertical Datum of 1988
NFIP	National Flood Insurance Program
NOAA	National Oceanic and Atmospheric Administration
PG&E	Pacific Gas and Electric Company
SFHA	Special Flood Hazard Area
SLR	Sea Level Rise
SWL	Stillwater Level
TWL	Total Water Level
USACE	United States Army Corps of Engineers
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
YBM	Young Bay Mud

1. Overview

This Basis of Design update accompanies the 60 percent submittal of plans, specifications, and estimates (PS&E). Considered a living document until the final contract documents are prepared, the Basis of Design outlines the rationale, assumptions, and criteria used in the design process for Menlo Park SAFER Bay to ensure that the design aligns with both the City's project requirements and the overall SAFER Bay program, which is under the direction of the San Francisco Creek Joint Powers Authority (SFCJPA or JPA). The Basis of Design is in essence a detailed explanation of the design approach, including performance criteria, sample products, and technical specifications, and it evolves throughout the project lifecycle.

Another important function of the Basis of Design is to facilitate communication between the City, JPA, design team, communications team, and private and public stakeholders in the project.

1.1 SAFER Bay

The SAFER Bay project, formally known as the Strategy to Advance Flood protection, Ecosystems Restoration and Recreation along San Francisco Bay, is a regional initiative focused on protecting communities and critical infrastructure along the San Francisco Bay shoreline from rising sea levels and tidal flooding. It is a multi-jurisdictional effort involving public and private partners, overseen by the SFCJPA. The total SAFER Bay project encompasses 7.5 miles of shoreline in Menlo Park and East Palo Alto.

The project aims to implement both engineered and natural solutions, such as levees, floodwalls, and habitat restoration, to protect against 100-year tidal flooding with 3.5 feet of projected sea level rise. Ecosystems will be enhanced by restoring and creating tidal marsh and other habitats along the shoreline. Recreational opportunities will be improved through better access to the shoreline for recreational activities, including the San Francisco Bay Trail.

1.2 SFCJPA work to date

The JPA has completed technical studies and engineering designs to produce an Environmental Impact Report (EIR) and inform the SAFER Bay design. The EIR is either programmatic or project-level depending on the levee reach and the proposed tidal restoration and/or managed pond enhancement of some of the former Bayland salt ponds.

1.3 City of Menlo Park Responsibilities for Further Project Development

The City of Menlo Park was awarded a FEMA Building Resilient Communities and Infrastructure (BRIC) grant with local matching funds contributed by Facebook (now Meta), PG&E and the City itself to support detailed design in Menlo Park. The City intends to leverage the work completed by the JPA and closely coordinate its levee reach and restoration designs with the JPA. The City will not author a separate EIR for its reaches. Rather, depending upon how the detailed design progresses, either an addendum or supplement to the JPA programmatic-project level EIR will be prepared. To that end, the JPA's preliminary design for SAFER Bay, which is the basis for the programmatic-project level EIR, will be followed, as modified by value engineering decisions and design detail.

1.4 Basis of Design Organization

The Basis of Design is organized in eight (8) sections as briefly described here.

1.4.1 Background (Section 2)

This section provides an abbreviated background for SAFER Bay and the scope of Menlo Park's reaches, which are known as Menlo Park SAFER Bay. Menlo Park is responsible for the design and construction of project improvements from the Ravenswood Loop Trail just west of the Dumbarton Bridge, to Bedwell Bayfront Park, which borders Redwood City.

1.4.2 Design Methodologies and Criteria (Section 3)

A guide for reviewing the 60% plan submittal is provided and methodologies for survey and mapping control, designing levee and trail alignments, establishing required flood protection elevations to include sea level rise, and setting an appropriate project design life. Geotechnical hazards and design considerations are discussed including the issue of the type of settlement endemic to the foundation soils encountered along the Bayfront. Landscape design criteria and criteria for public access are presented.

1.4.3 Levee Sub-reaches (Section 4)

Primarily a photo-document section, conditions within each of the Menlo Park SAFER Bay reaches are described.

1.4.4 Environmental Restoration (Section 5)

Restoration objectives based on the JPA's preliminary design are summarized and design criteria, a description of the 60% revegetation plan and value engineering for restoration are discussed.

1.4.5 Landscape Architecture (Section 6)

Landscape architecture concepts compatible with environmental restoration plans, the levee, and adjacent streetscapes are introduced. More detailed design criteria for tree removal and protection, landscape drainage, horticultural soils, irrigation, trail and trail amenity design, and assumptions made to prepare the cost estimate for landscape architecture fill this section. A discussion of the U.S. Army Corps of Engineers levee vegetation policy is provided to frame the variance the JPA will seek from that policy through the Corps. Draft materials furnished for the first BCDC Design Review Board (DRB) meeting are discussed.

1.4.6 Other Design Considerations (Section 7)

Constructability is considered to inform the ongoing design process. This section raises issues that have been resolved at the 60% submittal stage and those that remain to be resolved through final design, such as: earthen levee construction techniques, floodwall construction, dewatering and groundwater management during construction, flood protection during construction, and interior drainage.

1.4.7 Estimated Construction Value (Section 8)

Detailed quantity estimates and calculations for the estimated construction value of Menlo Park SAFER Bay are summarized. In 2026 dollars, the estimated cost for construction and property acquisition is \$450 million.

1.4.8 Preliminary Value Engineering Concepts (Section 9)

A discussion of initial value engineering considerations evaluated and discarded and those that warrant further assessment at the 90% (complete) plan level is provided here, all to reduce the \$450 million price tag or provide enhanced public value for that money.

1.5 Report Appendices

Seven appendices accompany this Basis of Design update in addition to the plan set and draft project manual (specifications). Appendix A provides SAFER Bay Design Criteria prepared by HDR for the JPA, since these remain the foundational design criteria for Menlo Park SAFER Bay. Appendix B provides a link to a public message styled basis for the conceptual project landscape architecture. Appendix C provides a link to materials submitted for BCDC DRB review. Appendix D contains the coastal flood hazard analysis prepared by FlowWest. Appendix E contains the interior flood hazard and mapping analysis. Appendix F provides a link to an updated detailed cost estimating spreadsheet. Appendix G provides geotechnical data used in the design to date.

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2. Background

SAFER Bay is a multi-benefit, multi-jurisdictional collaboration to protect critical infrastructure from estuarine flood hazards on San Francisco Bay, protect and restore habitat, provide resilience to predictions of future sea level rise, and improve recreational access along a reach of the San Francisco Bay Trail. SAFER Bay is the Strategy to Advance Flood Protection, Ecosystems, and Recreation along San Francisco Bay. The program is being implemented by the San Francisquito Creek Joint Powers Authority (SFCJPA or JPA) utilizing a combination of private and public financing.

The shoreline protection area in Menlo Park is generally bound by San Francisco Bay to the north and east, California Highway 84 (Bayfront Expressway) to the south, and Flood Slough to the west. The JPA has formulated the holistic project shown in Figure 2-1. In turn as a partner in SAFER Bay, the City of Menlo Park is charged with completing the design and construction of Program elements between Bedwell Bayfront Park to the west and the Ravenswood Trail at the Mosely Tract near the west abutment of Dumbarton Bridge. It is recognized that flood protection completed by Menlo Park must dovetail with neighboring systems at Redwood City and East Palo Alto, which are also vulnerable to tidal flood hazards and future sea level rise.



SOURCES: NAIP Imagery, 2024; HDR, 2024; ESA, 2024

NOTES: Reaches to be evaluated at a project-level of detail are shown in solid lines; reaches to be evaluated at a program-level of detail are shown as dashed lines. The northern ends of the Bayfront Expressway and Bedwell Bayfront Park Reaches tie into high ground at Bedwell Bayfront Park.

SAFER Bay Project

Figure 2-1
Project Location and Components



Figure 2-1: SAFER Bay Program Location (ESA, 2025)



2.1 City of Menlo Park Levee Sub-Reaches

Menlo Park is specifically responsible for three JPA-designated SAFER Bay reaches, which are combined graphically in Figure 2-2.

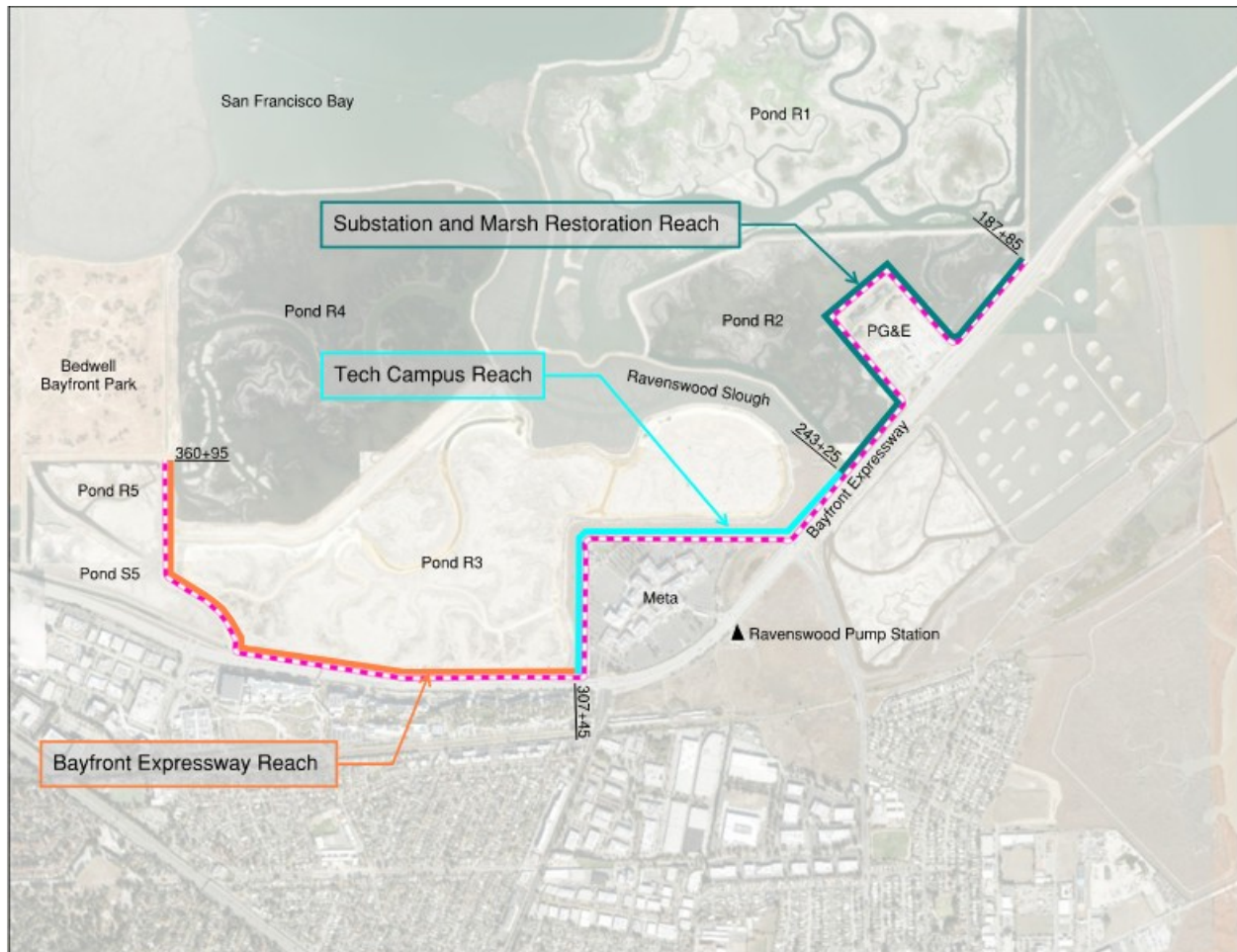


Figure 2-2: Menlo SAFER Bay Project Location

2.1.1 Substation and Marsh Restoration Reach

This sub-reach extends from Plan Station 187+85 between Ravenswood Trail and the west Dumbarton Bridge abutment to Plan Station 243+25 at Ravenswood Slough, or between each trailhead of the Ravenswood Trail loop. The length of this reach is about 5,540 feet.

Programmatic flood protection elements include an earthen levee parallel to and offset from Bayfront Expressway and offset from the substation perimeter. Bayside slopes adjacent to Pond R2 would transition from 3:1 (horizontal:vertical) to 10:1 to provide a transition zone that lets habitat adapt to future sea level rise. The programmatic plan is to decommission a portion of the looped Ravenswood Trail, leaving two spur trails. Public access on top of the new levee has been proposed to PG&E, which did not reject the concept out of hand. This public access provides viewing opportunities for the Pond R2 marsh restoration planned as part of this project. This type of public access is subject to PG&E approval and based on surveys to date, could require adjustments to overhead electrical wires to maintain the necessary vertical clearance above a public trail, for safety.

Critical infrastructure to be protected within this reach of the project includes California Highway 84, PG&E's substation, and the Menlo Park Fire Rescue Training Site adjacent to the substation. Since contiguous flood protection requires the completion of work by Redwood City and East Palo Alto and PG&E is a major private partner to the project, should the Redwood City or East Palo Alto protective reaches lag in design, permitting, or construction; an optional floodwall with passive flood barriers at substation access points from Bayshore Freeway is shown on the Plans, which would move forward to construction if it becomes clear that contiguous flood protection will be significantly delayed.

2.1.2 Tech Campus Reach

This sub-reach extends from Plan Station 243+25 at Ravenswood Slough to Plan Station 307+45 near Bayfront Expressway. The length of this reach is about 6,420 feet.

Planned shoreline protection elements include earthen levees, structural floodwalls, and a hybrid of levee and floodwall. The Bay Trail would be extended from the Substation and Marsh Restoration Reach to provide public shoreline access at the Meta Campus and existing, possibly substandard, access trails around the campus itself would be replaced by the new Bay Trail woven into the shoreline protection.

Critical infrastructure within this reach of the project includes California Highway 84 and the Meta Campus (formerly Facebook). Contiguous flood protection requires the completion of work by Redwood City and East Palo Alto and Meta is also a major private partner to the project. Unlike the PG&E substation, however, if it becomes clear that contiguous flood protection will be significantly delayed in design, permitting, or construction, an optional way to close off the campus while maintaining free access from Bayshore Freeway and local streets has not been considered to date.

2.1.3 Bayfront Expressway Reach

This sub-reach extends from Plan Station 307+45 near Bayfront Expressway to Plan Station 376+04 at high ground within Bedwell Bayfront Park. The end of this reach signifies the end of Menlo Park's work. The length of this reach is about 6,859 feet. The total length of Menlo Park's SAFER Bay reach is about 3.56 miles.

The planned shoreline protection element for this reach is an earthen levee. The Bay Trail would be extended from the Tech Campus Reach to create a levee top trail parallel to the existing Bay Trail that parallels Bayshore Expressway. The flood protection and trail alignment cross two existing and recently constructed structures that connect Pond S5 to Pond R3 and Pond R5 to Pond R4. These structures and their operational capabilities and access thereto will be preserved. Critical infrastructure within this reach of the project includes Bayfront Expressway. This levee sub-reach is an example of the type of contiguous flood protection needed to protect critical infrastructure in other sub-reaches and greater east Menlo Park.

2.2 Scope of Environmental Restoration

As part of extensive programmatic mitigation for the flood protection elements of SAFER Bay, flood protection will be combined with ecological elements such as salt marsh-upland transition zone habitat restoration. The JPA's program- and project-level objectives enable adaptation to changing climate by "implementing flood protection in ways that sustain and restore tidal marsh habitat while also enhancing and protecting habitat for western snowy plover consistent with the South Bay Salt Pond Restoration Project (SBSPRP) and other restoration efforts." (H.T. Harvey, 2026)

2.2.1 Restoration

The JPA is taking a holistic approach to the environmental restoration efforts throughout the SAFER Bay reaches, consistent with disclosures to be made in the Environmental Impact Report and jurisdictional authorizations to be made on a program level through regulatory permitting. This is consistent with an April 16, 2026 memorandum prepared by H.T. Harvey & Associates for the JPA and sent to the San Francisco Bay Regional Water Quality Control Board to provide SAFER Bay's rationale for the sufficiency of proposed on-site tidal wetland restoration and pond enhancement as compensatory mitigation for impacts to Waters of the State.

The proposed levees and other flood protection improvements will impact jurisdictional wetlands along the shoreline frontage and affect the special-status wildlife species that make the existing shoreline their home. Species habitats within the vicinity of project work include western snowy plover (*Charadrius alexandrinus nivosus*), salt marsh harvest mouse (*Reithrodontomys raviventris*), California Ridgway's rail (*Rallus obsoletus obsoletus*), California black rail (*Laterallus jamaicensis coturniculus*), black skimmer (*Rynchops niger*), elegant tern (*Thalasseus elegans*), Caspian tern (*Hydroprogne caspia*), and several fish species. To reduce temporal loss of regulated habitats and associated species impacts, project restoration will be constructed concurrently with the project's initial impacts from levee and associated construction.

SAFER Bay's proposed overall restoration and enhancement actions are shown as Figure 2-3, which is excerpted directly from H.T. Harvey & Associates *Habitat Restoration Basis of Design*. (H.T. Harvey, 2025) Programmatic restoration and enhancement actions include 568 acres of tidal salt marsh restoration in Pond R1 and Pond R2, 84 acres of pond enhancement in Pond SF2 south of California Highway 84 to create western snowy plover habitat, 352 acres of pond enhancement in Pond SF2 south of California Highway 84 and in Pond R3 adjacent to the Bayfront Expressway Reach, and creating a salt marsh to upland transition zone (T-zone) between Pond R2 and the Substation and Marsh Restoration Reach.

2.2.2 Plan-Specific Restoration

Menlo Park is responsible for advancing H.T. Harvey & Associates program-level design for the salt marsh to upland transition zone between the Substation and Marsh Restoration Reach and Pond R2. This includes final alignments, grading plans, planting plans, and irrigation plans, whether temporary or permanent based on the proposed plant species.

The basis of design for restoration (Section 6) entails following the program's lead as established by H.T. Harvey & Associates, modifying the plan as necessary to fit final design details or to obtain value engineering objectives as explained in that section of this report.



Figure 2. Restoration/Enhancement Actions Proposed in Ponds R1, R2, R3 and SF2
SAFER Bay Project - Rationale for Sufficiency of Proposed On-site Tidal Wetland Restoration and Pond Enhancement as Compensatory Mitigation for Impacts to Waters of the State
April 2026

Figure 2-3: Programmatic Restoration and Enhancement Actions (H.T. Harvey, 2026)

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3. Design Methodologies and Criteria

Design criteria established for the JPA by HDR on behalf of the SAFER Bay Project are retained as modified herein. HDR's design criteria report is included as Appendix A for reference. The intent of this Basis of Design is to provide a review and verification of the design criteria published in draft form by HDR, expanding or modifying said criteria to explain how HDR's program-level 10% design and project-level 30% design have coalesced into a project-level 35% design for further development within Menlo Park. Design development has occurred at the 60% project level and will continue to the 90% project level as outlined in Table 3-1. Plans and specifications provided with each submittal conform to this design development path unless otherwise changed during detailed design and contract document preparation. Design elements are discussed in additional detail within this report section.

Table 3-1: Design Development Path for Menlo Park SAFER Bay

Design Element	Submittal	Characteristics of Design Submittal
General Plan (G Sheets)	35%	An organizational structure for the plan set submitted that indicates the type of design elements that are furnished as plans to complete the project. This includes a drawing list, sheet index, general notes, abbreviations and legend.
	60%	A complete set of organizational and general construction subject matter ready for bid.
	90%	Initial thoughts on potential construction access locations and stockpile and staging areas. No negotiation with agencies or property owners.
Site Access, Staging, and Haul Routes (ASH sheets)	35%	A Bay Trail detour plan and specified requirements for pedestrian and traffic detours. A thorough plan for construction access and stockpile/staging areas based on a construction schedule, areas of project impact disclosed in the EIR, and the volumes of material to store. The plan submitted at 60% shows haul routes and staging areas located on public rights-of-way and within the construction limits. Construction staging on private property is only allowed with written permission from the property owners (Specification Section 01 14 19).
	60%	A fully vetted plan providing a Bay Trail detour plan, allowable haul routes, staging areas, and stockpile areas by contract.
	90%	Generally premature, included as a placeholder.
SWPPP and Details (SWP sheets)	35%	Proposed stormwater pollution prevention plan and details, noting that the Contractor will be required to submit overall and location-specific plans for review and approval per the relevant specification sections.
	60%	Not included.
	90%	Diagrammatic plans for temporary cofferdams to control exposure to San Francisco Bay tides during construction to allow dewatering of work sites. The plan is to inform the contractor's own means and methods.
Temporary Flood Protection and Dewatering (FPD sheets)	35%	Accept ownership of HDR's programmatic control, as modified for 35% design. See Report Section 3.2.
	60%	Final horizontal and vertical control for levee and trail alignments and ancillary features.
	90%	Final horizontal and vertical control for construction staking.
Survey Control and Layout (SCL sheets)	35%	Final horizontal and vertical control for levee and trail alignments and ancillary features.
	60%	Final horizontal and vertical control for construction staking.
	90%	

Design Element	Submittal	Characteristics of Design Submittal
Rights of Way (ROW sheets)	35%	Property lines from County of San Mateo GIS. Provides guidance on upcoming boundary surveys.
	60%	Property lines, easements, and other right-of-way information from boundary surveys and title searches.
	90%	
Demolition and Utilities (DU sheets)	35%	Preliminary limits of work, limits of grading, areas to be demolished, areas of clear and grub. Existing utility locations based on preliminary research and GIS.
	60%	Final limits of work, limits of grading, demolition instructions, utility preservation and relocation instructions based on detailed utility research, mapping, and potholing.
	90%	The above plus further details regarding utility preservation and relocation pending review of franchise agreements and correspondence with the affected utilities.
Plan and Profiles (PP sheets)	35%	HDR's program- and project-level alignment and flood protection profiles, modified as described herein. See Sections 3.3 and 3.4 for further discussion.
	60%	Final plan and profiles for flood protection elements, public access facilities, and secondary trails.
	90%	Final plan and profiles that incorporate regulatory review comments and BCDC DRB comments.
Trail and Shoreline Access Points (AP sheets)	35%	See Appendix B (separately bound) for trail and shoreline access conceptual design.
	60%	Trail and shoreline access alignments including trail plans, wall plans, and grading plans.
	90%	60% plan elements plus additional details to fully describe the construction of trail and shoreline access, suitable for bid.
Construction Details (C sheets)	35%	Generally premature, included as a placeholder.
	60%	City standard details that could be used during the Work and other construction details referenced from within the plan set.
	90%	Full set of construction details cross referenced to the set of plans.
Traffic Detour Plans (TD sheets)	35%	Generally premature, included as a placeholder.
	60%	Preliminary traffic and pedestrian detour plans, for vetting with City, Caltrans, and regulatory agencies. Note that the need for permanent traffic detours appears to be minimal.
	90%	Final traffic and pedestrian detour plans incorporating review comments from City, Caltrans, and regulatory agencies. Note that Contractor will be required to submit full traffic detour plans for review and approval.
Paving and Striping Plans (PS sheets)	35%	Generally premature, included as a placeholder. Trail paving is shown on the PP sheets.
	60%	Increasingly detailed instructions on how to pave and stripe the Bay Trail, secondary trails, fire lanes, and other project elements. May include the addition of crosswalks if necessary for improved public access safety and emergency access.
	90%	
Typical Sections (TCX sheets)	35%	Typical cross sections showing flood protection elements from the HDR plans as modified. Typical cross sections are annotated to provide the most detailed information about levee and floodwall construction including elevations, bank slopes, zones of fill, seepage control, and geotechnical details.
	60%	Further developed typical cross sections.
	90%	Final typical cross sections for construction.

Design Element	Submittal	Characteristics of Design Submittal
Cross Sections (CX sheets)	35%	Cross sections every 100 feet along the project alignment. In contrast to typical sections these show how the project conforms to existing grade but does not provide a level of annotative detail.
	60%	Cross sections updated to reflect alignment and grading design development.
	90%	Cross sections updated to reflect construction plans.
Structural Plans and Details (S sheets)	35%	Not included.
	60%	Project elements requiring structural design are isolated. These elements include floodwalls, retaining walls, pedestrian and vehicular bridges, and water control structures.
	90%	Full set of structural plans and details for construction to accompany the final project elements.
Restoration Plans (R sheets)	35%	Take ownership of the Program-level Basis of Design prepared by H.T. Harvey & Associates and incorporate those elements that are part of Menlo Park's Project-level scope.
	60%	Restoration plans that include general notes, abbreviations, and legend, planting palette, contour grading, sections, planting plans, and ancillary features.
	90%	Construction-ready restoration plans for the salt marsh to upland transition zone between Pond R2 and the Substation and Marsh Restoration Reach.
Restoration Details (RD sheets)	35%	Not included.
	60%	Not included.
	90%	Construction-ready restoration details to support the R sheets.
Irrigation Plans and Details (IRR sheets)	35%	Not included.
	60%	Not included.
	90%	Construction-ready irrigation plans and details pending approval of landscape plans and details.
Landscape Plans and Details (L sheets)	35%	Conceptual landscaping plans show general planting areas and trail amenities. See also the conceptual design process of Appendix B.
	60%	Further developed landscaping plans with landscape materials, planting schedule, planting plan, landscape sections, landscape details, trail amenities, site furnishings, and signage.
	90%	Construction-ready landscape plans and details.
Geotechnical Investigation Logs (GEO sheets)	35%	Collection of subsurface boring and piezometer logs obtained in support of design and contract drawing development. Boring log locations are shown on the PP sheets.
	60%	
	90%	
	90%	

3.1 Plan Sheet Control

Sheets have been reoriented from the HDR plans sets so that north is page up where possible and sheet order is from left to right (generally west to east) so by flipping sheets, one moves along the project alignment in order of decreasing stations. While somewhat unconventional this is not an unusual sheet orientation.

Sheets are managed to preserve consistent viewport locations and "layer" different types of design information to avoid plan clutter. For example, Sheet PP10 shows grading, trail improvements, and elevation profiles at an identical station-to-station reach of the levee as does Sheet DU10, the latter showing demolition activities and utility information.

3.2 Survey and Mapping Control

Horizontal and vertical control networks created by Towill, Inc. for HDR and the JPA are preserved. Cinquini & Passarino completed a quality control survey of Towill's control network and concluded in a May 14, 2025 report that Towill's project control meets the standard of care and the mapping furnished by Towill to HDR for the JPA's use in created 10% and 30% plans is suitable for further design and construction document development. **All design work for the 60% submittal is based on the Towill mapping and their control networks with supplemental field surveys provided by Cinquini & Passarino using that verified control network.**

3.2.1 Horizontal Control

Figure 3-1 shows the horizontal control listed by HDR on its 10% and 30% plan set Survey Control Maps. The presumed horizontal datum is NAD83 (2011), which means the North American Datum of 1983 with data that was adjusted and published in 2011.

GROUND CONTROL FOR SAFER LEVEES

LOCATION: MENLO PARK, EAST PALO ALTO
 PREPARED BY: TOWILL, INC.
 PREPARED FOR: HDR ENGINEERING HORIZONTAL DATUM: NAD
 83 (2011) 2017.50 VERTICAL DATUM: NAVD 88
 GEOID USED: 18
 COORDINATE SYSTEM: CALIFORNIA COORDINATE SYSTEM
 ZONE 3 LINEAR UNIT: US SURVEY FEET (GRID)
 COMBINED SCALE FACTOR: 0.99994298

Figure 3-1: SAFER Bay Program Ground Control for 30% Design Plans (HDR, 2024)

HDR's General Notes for the 10% plan set reflect these same horizontal and vertical datums with an unknown date of photography but HDR's 30% plan set General Notes reference photography taken on March 4, 2010 and a different horizontal datum, with adjusted data published in 2007. This is captured in Figure 3-2.

GENERAL NOTES

1. ALL EXISTING FACILITIES, STRUCTURES, TREES, FENCES, LANDSCAPING, ETC., DESIGNATED "EXIST". OR SHOWN EXISTING (DASHED LINES) ARE TO REMAIN. ONLY THOSE SPECIFICALLY DESIGNATED FOR REMOVAL AS SHOWN ON THE DRAWINGS, OR AS DIRECTED BY THE ENGINEER SHALL BE REMOVED.
2. ALL REFERENCES MADE TO RIGHT OR LEFT AND ALL CROSS-SECTIONS SHOWN ON THE PLANS ARE VIEWED LOOKING UPSTREAM.
3. DATE OF PHOTOGRAPHY: MARCH 4, 2010
 HORIZONTAL DATUM:
 CALIFORNIA COORDINATE SYSTEM, ZONE 3
 NORTH AMERICAN DATUM OF 1983
 (NAD83, NSR 2007)
 VERTICAL DATUM:
 NORTH AMERICAN VERTICAL
 DATUM OF 1988 (NAVD88)
 PROJECT CONVERSION: EL. 0.0 NAVD 88=EL. -2.75 NAVD 29
 GROUND CONTROL SURVEY BY: TOWILL, INC.

Figure 3-2: Conflicting Horizontal Control Information on 30% Design Plans (HDR, 2024)

Aerial photography for the entire SAFER Bay reach was flown at the same time, so the most likely horizontal datum is NAD83 (NSR2007). The positional difference between NAD83 (2011) and NAD83 (2007) is minimal. All project work is done on whatever control Towill furnished to HDR. A survey control report from Towill has not been provided, so the year of the horizontal datum adjustment has been affirmatively determined and is reflected by the 60% plans.

3.2.2 Vertical Control

There is no question that Towill's mapping is based on the North American Vertical Datum of 1988 or NAVD88. This is the same vertical datum used by FEMA to prepare the Flood Insurance Rate Maps. The NAVD88 datum will be carried through to contract documents and construction. Cinquini & Passarino ran level circuits and completed a benchmark analysis to verify the project's vertical control.

NAVD88 and NAVD are often used synonymously because the North American Vertical Datum has not changed since 1988. The previous national vertical datum was the National Geodetic Vertical Datum of 1929 or NGVD29. Menlo SAFER Bay does not use NGVD29 nor provide conversions to NAVD. It is noted that an adjustment to or replacement of the NAVD is scheduled to occur no sooner than 2026. There will be no adjustment in SAFER Bay plans to the upcoming national vertical datum although construction may occur after the official datum change. Design development plans and contract documents will continue to reference NAVD88 or NAVD to provide that distinction. The new vertical datum will be titled North American-Pacific Geopotential Datum of 2022 (NAPGD2022), so there is little chance for confusion.

3.3 Levee and Trail Alignments

The JPA's programmatic levee alignment is generally followed, with stationing increasing from east to west. That is, the lowest station on the "Levee Control 1" Alignment within the Menlo Park reach is 187+85, just east of the Ravenswood Trail. It is recognized that maintaining a contiguous programmatic alignment without interruption from East Palo Alto to Redwood City is neither feasible nor worth the effort involved. Furthermore, alignment control stationing may be broken during subsequent design development or particularly during construction if full control realignment proves to be confusing or unmanageable. While desiring to avoid this, station equations at alignment breaks may be used. As secondary trails and other public access alignments have been developed, additional named control lines have been assigned.

3.4 Flood Protection Elevations

Levee and floodwall elevations presented in the 60% plan set reflect the coastal flood hazard study prepared by FlowWest as described in Appendix D and summarized in this report subsection.

3.4.1 Stillwater Flood Elevations

As described in Appendix A (Page 20), the Code of Federal Regulations – 44 CFR 65.10 – requires the crown elevations of certified levees be built at least two feet above the 100-year stillwater level, often also referred to as the one-percent storm surge. The one-percent storm surge, with an assumed baseline year of 2000, is also the baseline for applying predictive models for future sea level rise.

The published FIRM establishes the total water level (TWL) at a one-percent annual exceedance frequency, which includes waves and wave runup, so the San Francisco Bay Tidal Datums and Extreme Tides Study (AECOM, 2016) is referenced to establish a project 100-year stillwater elevation of 11 feet NAVD, based on the tidal extremes referenced in Table 3-2.

Table 3-2: Basis of Design Stillwater Elevation for Menlo SAFER Bay

Reach Description	2016 Tidal Extreme Study Location ID	2016 Tidal Extreme Study 100-year Tide Elevation	Adopted Design Stillwater Elevation
Substation and Marsh Restoration	741 - 744	10.88 – 10.80 feet NAVD	10.9 feet NAVD
Tech Campus	744 - 745	10.80 – 10.79 feet NAVD	10.9 feet NAVD
Bayfront Expressway	745 - 747	10.79 – 10.77 feet	10.9 feet NAVD

3.4.2 Waves and Wave Runup

As described in Appendix D, with existing bathymetric conditions, pond levee status, and sea levels; wave runup is not problematic along the Menlo Park Bayfront and is not anticipated to become a problem even with future breaches in the non-accredited outboard berms contemplated for tidal marsh restoration. FlowWest based their determination of wave heights for a 100-year event on a wave study of South San Francisco Bay conducted by DHI (2011, 2013) as retrieved from the SFEI Adaptation Atlas (Beagle et al, 2019). For Menlo Park, a 100-year significant wave height of 2.6 feet is adopted for flood protection. FlowWest notes that this is probably a conservative estimate of the wave height at the toe of the proposed levee because the value from the SFEI Atlas lists this as the wave height in the open Bay. More likely there is a reduction in height as waves propagate across shallow water or vegetated areas between the open Bay and the toe of the Project levee. Figure 3-3 provides 100-year significant wind wave heights (in meters) from the SFEI Atlas.

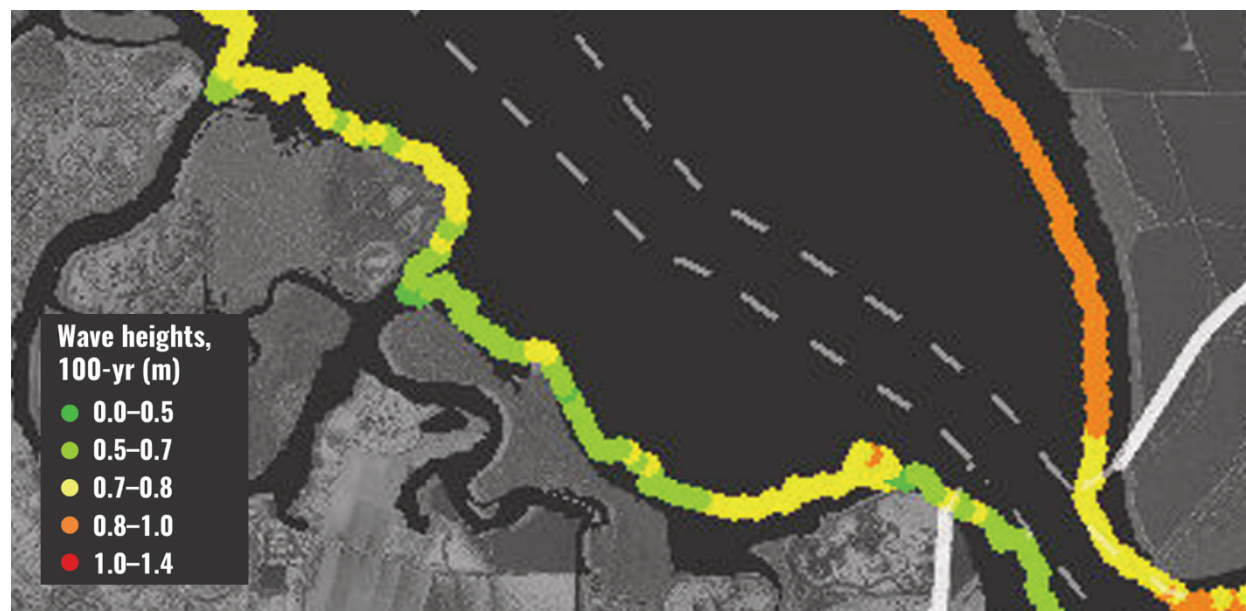


Figure 3-3: 100-year Wind Waves Menlo Park (Beagle et al, 2019)

Wave height for calculating the crest elevation associated with the one-percent stillwater elevation is calculated as 70 percent of the controlling wave height, which itself is 1.6 times the significant wave height. For Menlo SAFER Bay, the wave crest height is therefore 2.9 feet.

3.4.3 Freeboard

To certify that a coastal levee system meets NFIP standards for levee accreditation – a primary goal of the Project – freeboard measured as the height of the protective flood barrier above the base flood (one percent annual exceedance) elevation must be at least:

- 2 feet above the stillwater elevation, or
- 1 foot above the wave crest elevation, whichever is higher.

From the information presented in Section 3.4.2 and a design stillwater elevation of 10.9 feet NAVD, the minimum flood protection elevation to certify the levee system under existing conditions without sea level rise is 13.8 feet NAVD plus one foot, rounded to 15 feet NAVD.

3.4.4 Sea Level Rise Adaptation

SAFER Bay is intended to provide resilience against one percent stillwater, wave, and maximum wave runup hazards with future sea level rise after the restoration of the outboard ponds including targeted breaching.

A historic rate of sea level rise (SLR) of 1.3 mm per year (0.4 foot per century), has been estimated for San Francisco Bay.¹ In April 2017 a working group of the California Ocean Protection Council Science Advisory Team (OPC-SAT), supported and convened by the California Ocean Science Trust, published *Rising Seas in California: An Update on Sea-Level Rise Science* to “provide guidance to state agencies for incorporating sea-level rise projections into planning, design, permitting, construction, investment and other decisions.”² This document “reflect[s] recent advances in ice loss science and projections of sea-level rise...[and] provides a synthesis of the state of the science on sea-level rise.” This document was further updated based on review comments and finalized in March 2018.

OPC provided the State of California Sea Level Rise Guidance 2024 Science and Policy Update in January 2024. California has largely adopted the global and regional sea level rise scenarios for the United States spearheaded by NOAA.³ Key takeaways from the 2022 NOAA reference document include:

- There is more confidence in a narrower range of projected global, national, and regional sea level rise by 2050 than previously reported.

¹ National Oceanographic and Atmospheric Administration (NOAA), 2001.

² Griggs, G, Arvai, J, Cayan, D, DeConto, R, Fox, J, Fricker, HA, Kopp, RE, Tebaldi, C, Whiteman, EA (California Ocean Protection Council Science Advisory Team Working Group). “Rising Seas in California: An Update on Sea-Level Rise Science.” California Ocean Science Trust, April 2017.

³ Kris May, Pathways Climate Institute, Personal Communication. Document Citation: Sweet, W.V., B.D. Hamlington, R.E. Kopp, C.P. Weaver, P.L. Barnard, D. Bekaert, W. Brooks, M. Craghan, G. Dusek, T. Frederikse, G. Garner, A.S. Genz, J.P. Krasting, E. Larour, D. Marcy, J.J. Marra, J. Obeysekera, M. Osler, M. Pendleton, D. Roman, L. Schmied, W. Veatch, K.D. White, and C. Zuzak, 2022: Global and Regional Sea Level Rise Scenarios for the United States: Updated Mean Projections and Extreme Water Level Probabilities Along U.S. Coastlines. NOAA Technical Report NOS 01. National Oceanic and Atmospheric Administration, National Ocean Service, Silver Spring, MD, 111 pp.
<https://oceanservice.noaa.gov/hazards/sealevelrise/noaa-nostechrpt01-global-regional-SLR-scenarios-US.pdf>

- By 2050, tide and storm surge heights will increase with major and moderate high tide flood events occurring as frequently as moderate and minor high tide flood events occur today.

Future sea level rise projections have been evaluated within the context of SAFER Bay criteria as presented in Appendix A and BCDC’s recent draft Regional Shoreline Adaptation Plan (RSAP), which BCDC will use to evaluate permit applications.

3.4.4.1 SAFER Bay Criteria

SAFER Bay adopted California’s strategy to ensure resilience against 3.5 feet of future sea level rise. The Ocean Protection Council projects there to be about a one percent chance of this amount of sea level rise being exceeded by 2100. Even with the highest projected sea level rise scenario, this amount of sea level rise is not expected before 2075. For context, the most recent California Ocean Protection Council projections are presented as Figure 3-4.

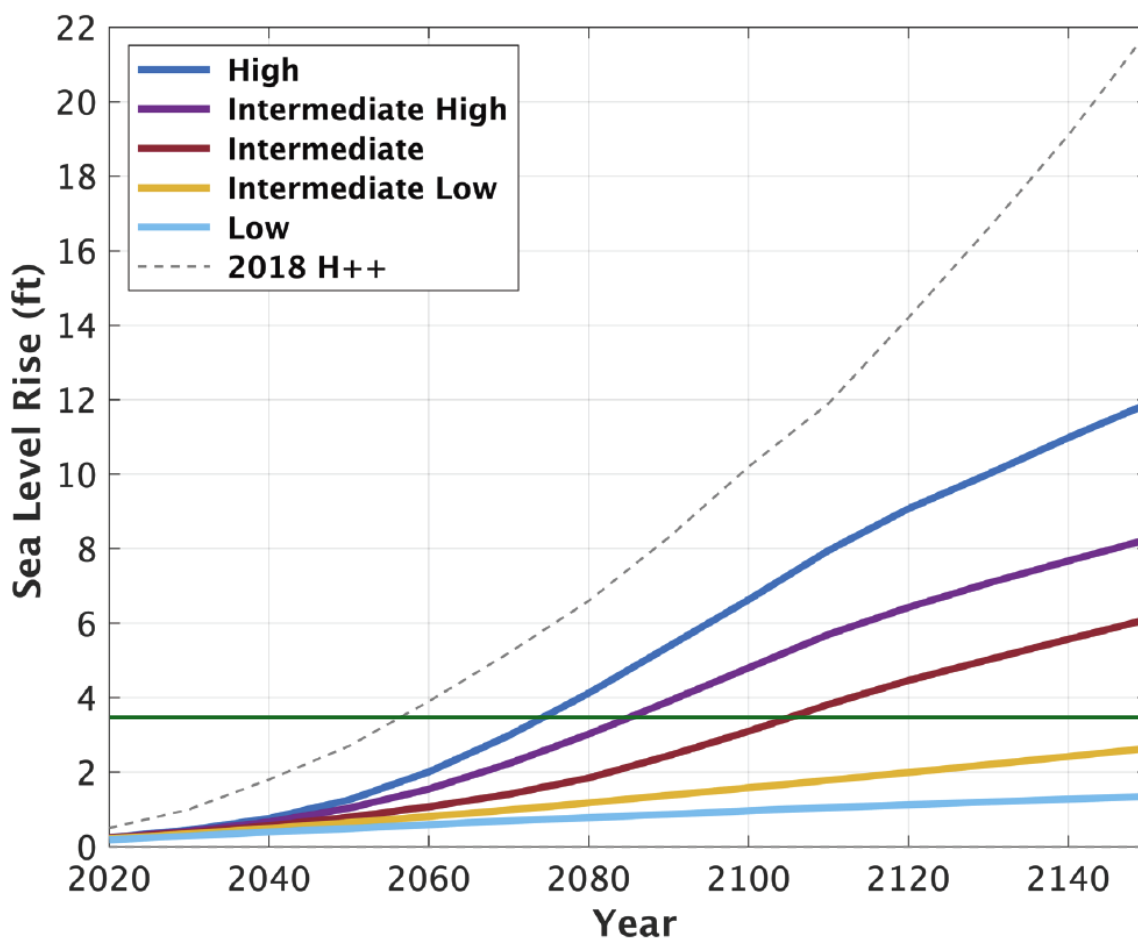


Figure 3-4: Future Sea Level Rise (California OPC, 2024) showing SAFER Bay Criterion

3.4.4.2 BCDC RSAP Criteria

The Bay Conservation and Development Commission (BCDC) published a draft Regional Shoreline Adaptation Plan (RSAP) in December 2024. The RSAP provides guidelines and standards for use in Subregional Shoreline Adaptation Plans as required by SB 272. BCDC expects projects that come to them for regulatory approval will present adaptation within the context of their RSAP in addition to other current Bay Plan policies.

Fortunately, the RSAP uses the same California Sea Level Rise Guidance (2024) and Menlo SAFER Bay's 3.5 feet SLR criterion is fully consistent with the RSAP. The RSAP does not require one sea level rise standard; rather, asks for project proponents to assess their flood risk as a product of the hazard, exposure, and vulnerability. Target sea level rise values for assessment include 0.8 foot (2050), 3.1 feet (2100 intermediate), 4.9 feet (2100 intermediate-high), and 6.6 feet (2100 high). BCDC will likely ask for an adaptive pathway to be identified.

3.4.5 Impact on Stillwater Elevations

SAFER Bay's methodology of adding 3.5 feet of sea level rise to the current stillwater elevation of 10.9 feet NAVD has been followed for the detailed design of flood protection elevations. The addition of future sea level rise estimates equally across various tidal datums, and extreme tide values is widely accepted practice. Table 3-3 provides adopted tidal datums and extreme tide values for Menlo SAFER Bay design based on the 2016 Tidal Datums Study.

Table 3-3: Design Tides for Menlo SAFER Bay

Tidal Datum or Extreme Value	Elevation (feet MLLW)	Elevation (feet NAVD)	Design Elevation with 3.5 feet SLR (feet NAVD)
500-year	13.6	12.4	15.9
100-year	12.1	10.9	14.4
50-year	11.6	10.4	13.9
10-year	10.8	9.6	13.1
2-year	10.1	8.9	12.4
King Tide	9.7	8.5	12.0
Mean Higher High Water (MHHW)	8.4	7.2	10.7
Mean High Water (MHW)	7.8	6.6	10.1
Mean Sea Level (MSL)	4.6	3.4	6.9
Mean Tide Level (MTL)	4.5	3.3	6.8
Mean Low Water (MLW)	1.3	0.1	3.6
Mean Lower Low Water (MLLW)	0.0	-1.2	2.3

3.4.6 Impact to Wave Elevations

Sea level rise ultimately has the potential to cause changes to wave development and characteristics relevant to run-up calculation (wave height, period, and run-up slope). While the changes result in a non-linear relationship between sea level rise and maximum run-up, FlowWest has found that simply adding the sea level rise value to the 100-year wave crest elevation is an only slightly conservative method for accounting for the sea level rise impact to wave elevations for flood protection and resilience. This sets the protective elevation at 18.3 feet NAVD to include sea level rise and freeboard, which is rounded to 19 feet NAVD.

This is likely a conservative estimate because it pairs the one-percent stillwater elevation with the one-percent wave height, even though these may not occur at the same time. Furthermore, wave heights predicted at the Bayward margin of the Project area are used in this calculation rather than wave heights that are attenuated across the shallow areas or marshes between the open Bay and the toe of the protective new levees.

3.5 Project Life

SAFER Bay's project objectives are to protect communities and infrastructure from coastal flooding and sea level rise, while also enhancing ecosystems and recreational opportunities. The cessation of the project's ability to meet those objectives indicates the end of project life. Project life is therefore a function of the durability of materials used in construction, constructed and settled flood protection elevations, the accuracy of future sea level rise estimates, and the ability for future generations to adapt the constructed project to changes in those conditions. Table 3-4 provides estimates of project life for these components. For this exercise, the baseline construction year is assumed to be 2030.

Table 3-4: Design Project Life

Project Component	Lifecycle (years)	Notes
Earthen levee fill	indefinite	Assumes periodic repairs of slumping and bank erosion as required
Concrete floodwalls and retaining walls	100	
Recreational trails	100	With ongoing maintenance, periodic repair, and periodic replacement
Environmental restoration	indefinite	Designed to be dynamically self-sustaining
Landscape planting	indefinite	Designed to be self-sustaining with plant care, periodic plant replacement, irrigation system maintenance and replacement
Cal OPC-SAT SLR estimates	120	Caution is exercised in the use of estimates beyond 2100 (70 years)

A design project life of 100 years seems reasonable. The most volatile project component may be the estimate of future sea level rise noting that the variance in values among emissions scenarios is greater than any other consideration.

3.6 Geotechnical Hazards and Design Considerations

Shoreline evolution based on prior urbanization has present-day project ramifications regarding the geotechnical feasibility of implementing a levee project. Generally, development within shoreline protection areas is built on often undocumented artificial fills placed over former Baylands and open water. Geotechnical hazards include flooding, shallow groundwater, fills, expansive soils, consolidation settlement, corrosive soils, seepage, slope stability.

3.6.1 Subsurface Conditions

Artificial fill adjacent to San Francisco Bay on which developed areas like east Menlo Park are built often contains man-made debris like asphalt, brick, wood, and concrete fragments. Below the artificial fill, Young Bay Mud (YBM) deposits will be encountered. Young Bay Mud is a marine deposit containing high plasticity clays with organics. Within the project area this deposit varies in depth below the ground surface and in thickness from 5 feet to about 35 feet.⁴ The YBM deposits typically overlie older and stiffer Pleistocene-aged alluvial deposits. Depth to bedrock is most likely more than 100 feet below ground surface. Figure 3-5 presents an excerpted regional map showing YBM thickness contours with an approximate project alignment superimposed. Haley & Aldrich has reviewed previously completed subsurface explorations along the existing shoreline/proposed alignment and has completed preliminary geotechnical analyses based on the borings and laboratory tests of the material.

⁴ Sandra D. McDonald, Donald R. Nichols, Nancy A. Wright, and Brian Atwater, "Map Showing Thickness of Young Bay Mud, Southern San Francisco Bay, California," United States Geological Survey, 1978.

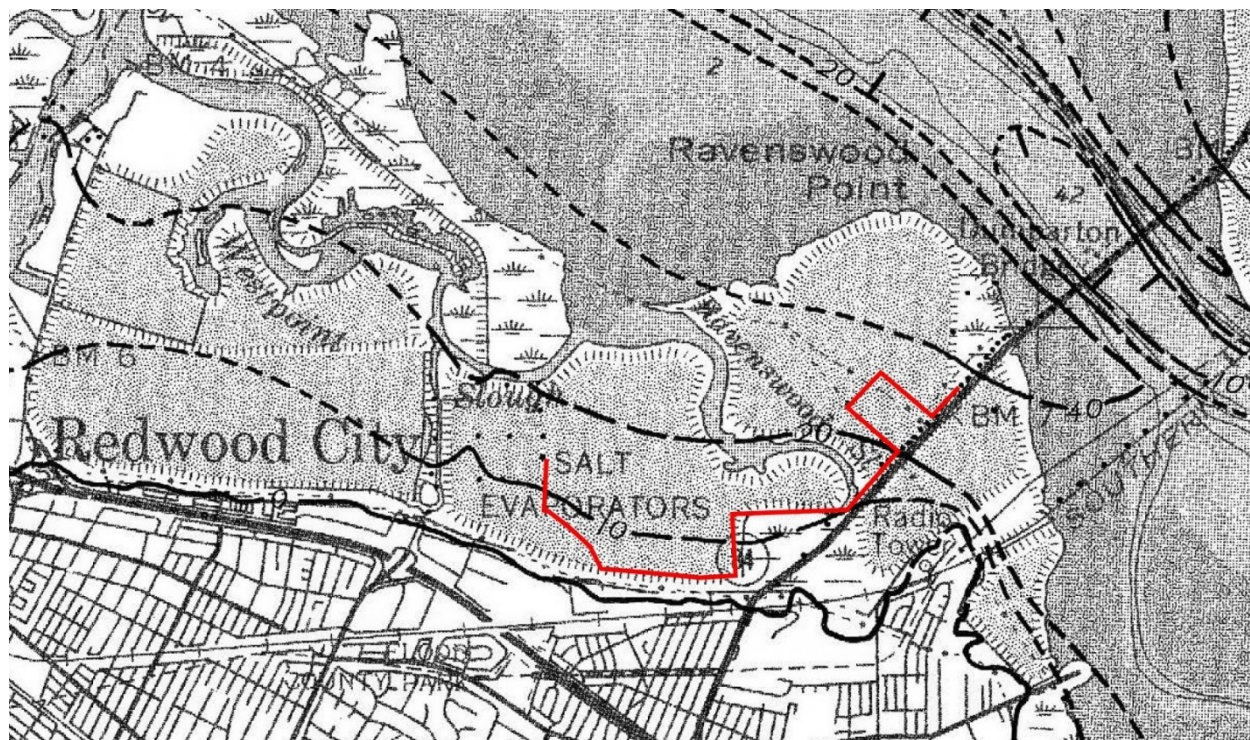


Figure 3-5: Young Bay Mud Thickness with Superimposed Project Alignment

Given the proximity of the project alignment to a variable-head boundary to the flow of groundwater, shallow groundwater is expected. Haley & Aldrich plans to complete five piezometers along the alignment to begin the monitoring of groundwater levels during winter and summer construction seasons. In general, groundwater is expected to be at or near the top of the Bay Mud and is influenced by tidal fluctuations at the shoreline and nearby tributary creeks. Shallow groundwater levels will rise with future increases in sea level.

Non-engineered fills could undergo vertical settlement under loading from new fill, and this is not easily predicted. Removing non-engineered fill as part of project improvement construction remains a value engineering alternative, but it may not be feasible due to the depths of existing fills, limited site rights-of-way, and shallow groundwater conditions. Often due to the density of near surface fill, the vertical settlement of previously placed artificial fill resulting from the placement of new engineered fill is relatively limited and most of this settlement would occur during or shortly after grading is concluded.

Placement methods for earthen fill, compaction methods, benching, and reinforcement are defined in Specification Section 31 00 00 and further detailed on the plan set. For final design, the primary aspects of fill placement to consider are consolidation settlement and slope stability and site-specific seismic analysis as described herein.

Expansive soil may be present along the project alignment and could be encountered during construction even if not indicated in subsurface exploration. Expansive soils change in volume as moisture conditions change. This type of soil can shrink or swell, causing the heaving and cracking of slabs-on-grade, pavements, and structures founded on shallow foundations. These types of soils will be identified based on further subsurface exploration and surface observation. Mitigation during construction may be required in the form of moisture conditioning, excavation, replacement, and/or re-compaction.

Representative soil samples have been collected to catalog soil parameters relative to corrosivity including redox potential, pH, resistivity, sulfide concentration, chloride concentration, and sulfate concentration. High clay content soils tend to be corrosive, particularly in a marine environment.

3.6.2 Seismic Hazards

There are many active earthquake faults in the Bay Area. An active fault is defined by the California Geological Survey (CGS) as one that has had surface displacement within Holocene times (the last 11,000 years). Numerous small earthquakes occur every year in the San Francisco Bay Region, and larger earthquakes have been recorded and can be expected to occur in the future. Potential seismic hazards that could result from a nearby moderate to major earthquake are primary and secondary hazards.

A primary effect would be ground rupture or surface faulting. The project is not located within a currently designated Alquist-Priolo Earthquake Fault Zone and no known surface expression of active faults is believed to exist within the project area. Major active faults in the area include the San Andreas and San Gregorio to the west of the Bay, and the Hayward and Calaveras to the east of the Bay. Project improvements will be designed to meet seismic codes for ground shaking.

The project area is located within a CGS designated Liquefaction Zone (Figure 3-6). Liquefaction can occur when loose water saturated sediments lose their strength in response to strong ground shaking and increase in pore pressure as occurs during a seismic event. Preliminary analysis indicates that with an Operating Basis Earthquake (OBE or 475-year return period), liquefaction settlement due to sand layers below the YBM might be as much as 5¼ inches. The OBE is paired with the one-percent flood hazard to evaluate the feasibility of sufficiently quick restoration prior to the next extreme flood event. Here, the post-slump flood protection elevation would be 18.5 feet NAVD, leaving 1.2 feet of freeboard, leaving sufficient time for levee repair and restoration.

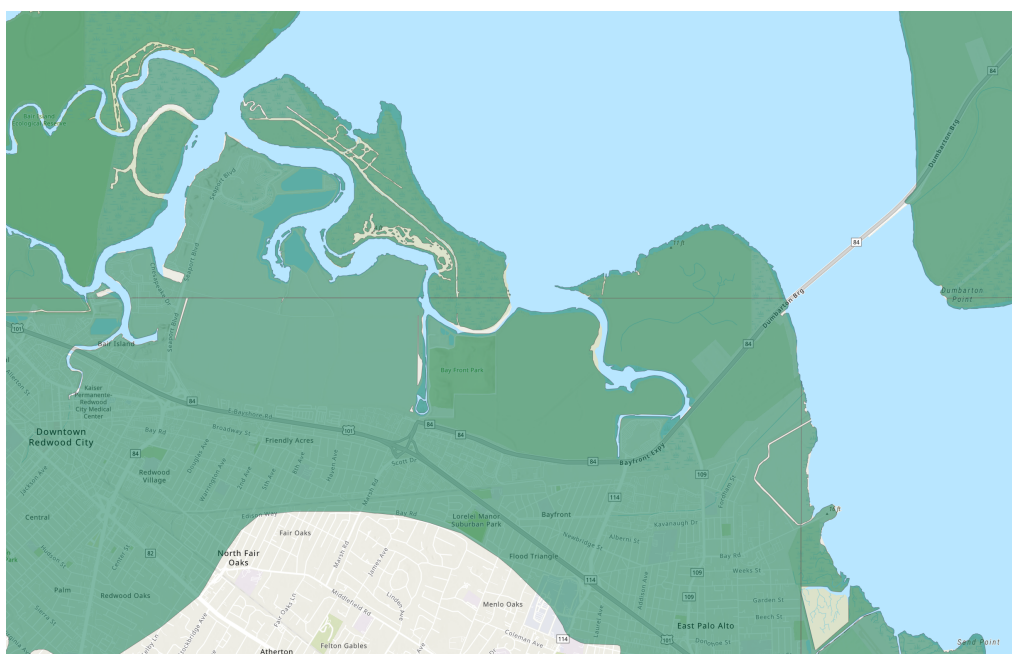


Figure 3-6: Liquefaction Zone (shaded) at Menlo SAFER Bay (California Geological Survey)

SAFER Bay is taking a uniform and consistent approach to site specific seismic analysis rather than simplified methods for final design. The approach, which will be shared by Menlo Park and East Palo Alto, is to use advanced methods of nonlinear site response analysis and time history selection that are driven by USACE ER 1806 requirements for critical structures in high seismic zones and the presence of liquefiable soils along the alignment. Since the East Palo Alto design team is ahead in terms of their design, they will develop the common ground motion inputs that both project reaches will use, while each team conducts their own soil-structure analysis based on site-specific conditions.

The SAFER Bay seismic deformation criteria are:

- OBE (475-year event): Maximum one foot of vertical displacement, maintaining protection against the 100-year flood hazard with sea level rise.
- MDE (2,475-year event): Deformation no lower than the 10-year water elevation with sea level rise, requiring repair but providing interim protection.

The maximum allowable deformation is 3 feet based on 60% plan top of levee elevations and the 10-year water elevation with sea level rise. Since there are no readily available results for 10-year wave heights, the 100-year wave height paired with 10-year stillwater level and is considered conservative, defensible, and an accepted practice for interim risk assessment. Anticipated deformation from the maximum design earthquake (MDE), will be analyzed once the ground motion inputs are established using the Fast Lagrangian Analysis of Continua (FLAC) program, which will also be used to evaluate deformation under normal loads and consolidation settlement based on proposed levee improvement sections.

3.6.3 Consolidation Settlement

Project improvements will be constructed over fills above previously consolidated (stressed) YBM and directly over YBM that has never been consolidated. FLAC modeling will be used to evaluate deformation under load, but preliminary settlement estimates have been made for the grading plan and profile shown on the 60% plans using available consolidation test curves for the Project alignment. (See Appendix G) Table 3-5 summarizes these estimates and the additional fill height that must be placed at various Plan Stations for the constructed levee to settle at no less than 19 feet NAVD, assuming normal weight fill at 125 pounds per cubic foot.

Table 3-5: Consolidation Settlement Estimates Based on Soil Testing

Plan Station	Boring Number	YBM	Initial Fill Elevation	Fill Height	Consolidation
188+00	B24-05	4 to 34 feet bgs (30 feet thick)	24.5 feet NAVD	21.5 feet	63.0"
201+00	B24-06	11 to 36 feet (25 feet thick)	21.5 feet NAVD	17.5 feet	27.0"
220+00	B24-07	14 to 34 ft bgs (20 feet thick)	21.5 feet NAVD	16.5 feet	29.3"
243+00	B24-08	4 to 24 ft bgs (20 feet thick)	21.0 feet NAVD	12.0 feet	18.5"
276+00	B24-09	14 to 23 ft bgs (9 feet thick)	n/a	n/a	No Curve
336+00	B24-10	9 to 16 ft bgs (7 feet thick)	19.5 feet NAVD	17.5 feet	2.1"
366+50	B24-11	8 to 18 ft bgs (10 feet thick)	20.0 feet NAVD	8.0 feet	9.2"

This major variability in YBM thickness across the levee alignment, which is not entirely open to subsurface exploration along the Project control line, could be problematic in terms of differential design settlement mitigation. The foundation soils are not of uniform compressibility, ranging from thin, near pinch-out zones to thick basin deposits. This indicates irregular Bay Mud basin geometry due to paleochannels, marsh variability, and alluvial deposits. This informs the value engineering for settlement mitigation described in Section 9.2 based on construction time and ultimate San Francisco Bay Trail performance and long-term maintenance.

3.6.4 Ground Subsidence

Portions of the San Francisco Bay shoreline experience long-term ground subsidence, which could cause further flood protection elevation degradation in addition to the previously discussed primary consolidation and secondary consolidation, which is the slow, long-term compression of soil that occurs after the initial expulsion of pore water pressure has largely ceased.

Absent long-term benchmark monitoring, this is difficult to quantify for design. Over Young Bay Mud, secondary compression without pore pressure change can persist for decades to centuries and be a dominant long-term settlement mechanism. This will only be partially offset by increased groundwater levels due to future sea level rise, which will reduce effective stress at the compressive soil layers.

Mitigation can be addressed at the time of Project construction as described in Section 9.2 or the top of constructed levee elevations can be monitored over the long-term with periodic capital improvements to restore elevations to combat the long-term subsidence.

3.6.5 Seepage Control

Levee, embankment, and floodwall stability can be compromised by the flow of water through porous materials. Excessive hydraulic gradients can result in the formation of sand boils, piping, and levee failure if embankment fill is mobilized by the flow of water. Preliminary analysis indicates that under seepage will not be a significant design factor, leaving levee material selection as the primary mechanism for thru-seepage control. Section 9 provides value engineering evaluation for seepage control.

3.7 Landscape Design Criteria

Landscape design is integral to the 3.75-mile SAFER Bay levee along the Menlo Park Bay shoreline. A re-aligned Bay Trail segment will run the length of the SAFER Bay levee and connect to existing Bay Trail segments east and west of the project area. Public access to the new Bay trail will occur at key intersections, public parking areas, and connections to adjacent open space and corporate campuses. Levee slopes will be planted and irrigated. Seating areas and overlooks will occur at regular intervals and provide public seating.

3.7.1 San Francisco Bay Trail

Bay Trail design and layout will adhere to Bay Trail Standards as defined in the San Francisco Bay Trail Design Guidelines and Toolkit. Version 2.0 of the Toolkit is expected to be published before the end of 2025. Bay Trail improvements made as part of the project will comply with ADA accessibility standards.

3.7.2 Bay Trail and Levee Access

Pedestrian and bicycle access to the levee-top Bay Trail will be provided at both ends of the Menlo SAFER Bay levee reach and at important intersections, parking areas, and locations where current access exists. Stairs, ramps, and sloped walkways to the Bay Trail will comply with ADA accessibility requirements.

3.7.3 Planting

Earthen slopes at the levee will be planted with native California grasses, annuals, and perennials. Inland levee embankment planting will be a base of hydroseeded grasses, annuals, and perennials, with addition of groundcover, perennial, shrubs, and bunch grasses installed as container plants. Bayside levee embankment will be planted with bay edge species appropriate to the adjacent ecological conditions. All planting will consist of low water use plants.

3.7.4 Landscape Soils

Plant areas will include a minimum of 18 inches of horticultural soil suitable for native bayshore planting.

3.7.5 Paving

Asphalt paving, cast-in-place concrete paving, and stabilized crushed stone paving are proposed for pedestrian environments. In locations where emergency vehicle access is required, paving profiles shall have a minimum loading capacity that complies City of Menlo Park guidelines for emergency vehicles.

3.7.6 Irrigation

The landscape irrigation system will be a fully automated water efficient system and designed to comply with the San Mateo County Water Efficient Landscape Ordinance. The system will be installed to be compatible with the City's recycled water supply should it eventually come online near the project alignment.

3.7.7 Site Elements and Furnishings

A consistent family of contemporary site furnishings supports the continuity of the project's pedestrian character. These elements include benches, signage, trash, recycling and compost receptacles, bicycle racks, and bollards.

3.7.8 Site Signage

The landscape design will be coordinated with a wayfinding and signage program consistent with BCDC guidelines and include:

- Monument Signage
- Standard San Francisco Bay Trail Signage
- Pedestrian Wayfinding and Directional Signage

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4. Levee Sub-reaches

Menlo Park SAFER Bay levee sub-reaches are described with on-ground photographs to point out interesting design features.

4.1 Substation and Marsh Reach

Figure 4-1 shows the eastern end of this reach near the Ravenswood Trail. The specific nature of the tie-in or end of levee needs to be coordinated with the JPA and East Palo Alto's design team. At least in the interim, some use can be made of the existing sheet pile flood wall to provide some level of contiguous flood protection. Maintaining PG&E boardwalk access to their transmission towers is also a design necessity within this reach.



Figure 4-1: Near East End (Start) of Menlo Park SAFER Bay

The need to maintain highway drainage across the new levee alignment (See Section 7.5) is highlighted by Figure 4-2, which shows the westbound approach toward the PG&E substation. Design will also consider stormwater treatment and bio-retention requirements and opportunities.



Figure 4-2: West of Dumbarton Bridge Approaching PG&E Substation

Figure 4-3 shows how PG&E transmission lines and the drops to the substation facility affected SAFER Bay's levee alignment around the substation and why it is offset as shown on the 60% plans. Again, maintenance access to the boardwalks will need to be preserved both on the inboard and outboard sides of the new levee. The substation is securely fenced, and this will be considered in concert with PG&E and CDFW to establish whether pedestrian access adjacent to the T-zone ecotone is allowed or desirable.

Figure 4-4 provides perspective near the end of this sub-reach, within what will be part of the new freshwater/brackish water pond between the levee and substation, noting both older and newer transmission tower foundations. One fundamental design assumption is that no PG&E tower or tower foundation will be relocated or modified as part of Menlo Park SAFER Bay due to the liability and expense. Rather, grading and ancillary structures will be designed to maintain PG&E required clearance from their transmission facilities, which is generally ten feet horizontal in any direction.

Figure 4-5 looks east toward the substation at the end of this sub-reach. Highway 84 drainage appears not to positively drain across the existing levee but may evaporate in the pond located between levee and highway. The interior drainage study (Section 7.11) needs to provide a solution for this roadway drainage.

4.2 Tech Campus Reach

The beginning of the Tech Campus Reach, parallel to Highway 84, is shown looking west in Figure 4-6. An interior pond is located between the highway and a levee that contains Ravenswood Slough. Figure 4-7 is a photograph taken further west that shows the Ravenswood Pump Station outfall at the head of Ravenswood Slough. The gravity outfall from the open space next to Ravenswood Pump Station is also visible with slide gate control. The separation levee is at the center of the photograph toward the left.

A view from Meta toward the northwest and the Santa Cruz Mountains is provided by Figure 4-8. The campus already has programmed recreation, which needs to be considered in landscape design for this reach.

4.3 Bayfront Expressway Reach

An eastbound view of the existing San Francisco Bay Trail, with Meta visible in the distance, is shown by Figure 4-9. The proposed levee and a new levee-top trail would largely block the view of Meta for people on the lower trail at the roadway elevation.

The existing pedestrian crossing/art piece at "Meta south" (Figure 4-10) and the views it affords (Figure 4-11) will be preserved and met by newly designed pedestrian access from the levee-top trail as described in Appendix B.

The existing levee alignment between the expressway and Bedwell Bayfront Park to the north is shown in Figure 4-12 and one of the water control structures that interconnect ponds is pictured in Figure 4-13. Alignment adjustments have been made from the JPA plans to preserve these relatively new structures rather than demolish and replace them. See also the value engineering discussion in Section 9.

Figure 4-14 finishes the virtual levee alignment tour at high ground within Bedwell Bayfront Park. At the end of Menlo Park SAFER Bay, the levee trail will conform to the lower park trail in the background at no greater than a 5 percent grade, to meet ADA requirements.



Figure 4-3: Transmission Lines at PG&E Substation



Figure 4-4: West of Substation near End of Substation and Marsh Restoration Reach



Figure 4-5: Near End of Substation and Marsh Restoration Reach Looking East



Figure 4-6: Beginning of Tech Campus Reach Looking West



Figure 4-7: Ravenswood Pump Station Discharge Outfall



Figure 4-8: View from Meta Looking to the Northwest



Figure 4-9: Bayfront Expressway Reach Looking East with Meta in Distance



Figure 4-10: Pedestrian Crossing from Meta's South Campus



Figure 4-11: View from Meta Pedestrian Crossing



Figure 4-12: Levee Alignment Looking North Toward Bedwell Park



Figure 4-13: A Water Control Structure That Interconnects Ponds



Figure 4-14: End of Menlo SAFER Bay at Bedwell Bayfront Park

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5. Environmental Restoration

Phase 1 of the Menlo Park SAFER BAY Project includes the construction of an ecotone along approximately 5,000 linear feet of levee (see Sheet R2) to create a salt marsh-upland transition zone (T-zone) habitat between the existing PG&E substation and Pond R2 in the Ravenswood Pond Complex. This section of the 60% Basis of Design Document update describes the approach and assumptions used to develop the ecotone component of Phase 1 of the Menlo Park SAFER Bay Project, which are included in the 60% Design package as Sheets R1 to R6.

5.1 Restoration Objectives

Salt marsh-upland transition zone habitat was historically abundant along tidal marshes adjacent to lowlands in the San Francisco Bay (HT Harvey, 2025; Beller et al. 2013).⁵ The primary restoration objective of the ecotone is to create salt marsh-upland transition zone habitat between the existing PG&E substation and Pond R2 in the Ravenswood Pond Complex. For the SAFER Bay project, salt marsh-upland transition zone habitat is defined as salt marsh and adjacent upland habitat between mean higher high water (MHHW) and the top of the levee. Salt marsh-upland transition zone habitat provides space for refugia habitat and marsh transgression with sea level rise (HT Harvey 2025).

5.2 Tidal Datums

Tidal datums at the project site were used in the design of the ecotone to determine inflection points in the design slopes and to develop the revegetation planting design. The current National Oceanic and Atmospheric Administration (NOAA) tidal datums at Dumbarton Bridge (NOAA Station 9414509) near the Ravenswood Pond Complex were used for project construction year (2031) conditions. NOAA tidal datums in mean lower low water were converted to NAVD88 based on Foxgrover et al. (2007). The intermediate-high scenario for San Francisco from the California Ocean Protection Council (OPC 2024) guidance was then used to estimate sea level rise (SLR) to Year 50 (2081). The OPC guidance projects 3.08 feet of SLR for 2081. The resulting tidal datums are provided in Table 5-1.

Table 5-1: Tidal Datums Near the Ravenswood Pond Complex

Tidal Datum	2031 (feet NAVD)	2081 (feet NAVD)
Highest Astronomical Tide (HAT)	8.94	12.02
High Tide Level (HTL)	8.41	11.49
Mean Higher High Water (MHHW)	7.41	10.49
Mean High Water (MHW)	6.80	9.88
Mean Sea Level (MSL)	3.48	6.56
Mean Lower Low Water (MLW)	0.06	3.14
Mean Lower Low Water (MLLW)	-1.20	1.88

⁵ Beller, EE; Salomnon, M; Grossinger, RM. 2013. An Assessment of the South Bay Historical Tidal-Terrestrial Transition Zone. SFEI Contribution No. 693. San Francisco Estuary Institute: Richmond, CA.

5.3 Design Criteria

The 60% design of the T-zone builds upon the 35% design, with a key revision to the underlying assumption regarding settlement of the flood protection levee (levee). The 60% design assumes ground improvement to render future settlement of the levee negligible. As a result, T-zone design elevations and inflection points have been updated accordingly. All other project goals and design criteria remain consistent with the 35% design, which was based on H.T. Harvey's 30% design concept (H.T. Harvey, 2025) for the Pond R2 T-zone.

The T-zone design is intended to achieve the following objectives:

- 1) Minimize conversion of R2 to upland while providing an adequately sized T-zone with suitable high tide refugia cover to benefit Salt-Marsh Harvest Mouse (SMHM) and California Ridgway's Rail (CRR), provide a modest upslope area for marsh transgression with SLR, increase habitat diversity, and resist wind wave scour.
- 2) Design a cost-effective T-zone of adequate width and height to provide suitable high tide refugia habitat through the project's design life (to accommodate three feet of SLR); given the volume of fill needed for T-zones, this restoration feature is a high-cost item and should be designed to be both ecologically function and cost-effective.
- 3) Establish a diverse assemblage of flowering plants with varying phenology to benefit pollinators and provide food web support for birds.

To meet these goals, the following design criteria were established:

- 1) Construct a 10H:1V T-zone slope to provide at least 30 feet of high-quality T-zone vegetation above the HTL after three feet of SLR.
- 2) Establish dense, native vegetation that includes both substantial area of vegetation patches with vertical canopy between two to four feet tall for high tide refugia cover and areas of grassland at least one foot tall.
- 3) No shrubs or trees over five feet tall to minimize creation of avian predator perches
- 4) Control invasive plants on the T-zone where vegetation structure is necessary to achieve the habitat high-tide refuge goal.

The 35% design was based on H.T. Harvey's 30% design (H.T. Harvey, 2025) which assumed settlement of the levee and established T-zone design elevations and inflection points relative to tidal datums under that assumption. Ground improvements used to construct the levee minimize future consolidation settlement (See Section 9.2) and therefore adjustments to the design elevations and inflection points for the T-zone have been made. (Figure 5-1)

- 1) From the crest of the levee down to the HAT (elevation 12.0 feet NAVD88), the transition zone habitat uses the same 3H:1V slope that is used on the portions of the levee which do not include the construction of the ecotone habitat.
- 2) The T-zone slope will be constructed starting at the HAT (elevation 12.0 feet NAVD) descending at a 10H:1V slope down to approximately five feet NAVD or to a depth of one foot of fill (if this depth of fill occurs above five feet NAVD). From that point, the slope of the fill then steepens to a 3H:1V slope until it meets the existing grade.

The soil design criteria for the two feet of topsoil fill and environmental fill (fill at depths below the upper 2 feet of topsoil on the T-zone) are consistent with H.T. Harvey’s 30% design and remain unchanged for the 60% design. Due to the high salinity, high boron, and potential for very low pH, reuse of any salvaged bay mud is not permitted. The upper two feet of topsoil fill for the T-zone and levee slope above the HAT (elevation 12.0 feet NAVD) will require imported fill to support dense grassland and alkali meadow habitats. The imported fill must meet the broad range of physical and chemical horticultural properties for imported topsoil criteria presented in Table 5-2, which is reproduced from Table 5 in H.T. Harvey’s 30% design (H.T. Harvey, 2025).

Below the two-foot depth of topsoil where environmental fill is proposed, no horticultural criteria are required as T-zone plant are not expected to root below this depth. Additionally, all imported soil will be required to meet contaminant screening criteria to protect sensitive ecological receptors. The Refuge’s Master Quality Assurance Project Plan (Master QAPP; USFWS and H.T. Harvey 2024b) provides screening methods for soil contaminants in imported upland soil used in the Refuge’s wetland environments, including levee slopes and T-zones. Imported topsoil in Pond R2 (which is within the Refuge) will be required to meet the Wetland Surface Criteria in the Master QAPP. Environmental fill soil below the topsoil layer will be required to meet the Wetland Surface Criteria in the Master QAPP or Wetland Foundation Criteria with approval from the RWQCB and BCDC.

Table 5-2: Imported Topsoil Criteria for Upper 2 Feet of 10H:1V Transition Zone in Pond R2

Physical Properties	
Particle Size Range	Percent
Coarse sand .5-2.0 millimeters	0-85
Silt 0.002-0.05 millimeters	0-85
Clay 0-0.002 millimeters	0-80
Gravel 2-12 millimeters	0-25
Rock 12mm - <3 inches	0-10 by volume
Organic matter	2-5 by dry weight basis
Chemistry*	
Salinity	Less than 5.0 deciSiemens per meter
Sodium adsorption	Less than 6.0
Boron	Less than 1.5 ppm
pH of saturated paste	5.5-8
Calcium to Magnesium ratio	Greater than 1:1
*Additionally, all imported soil (topsoil and subsoil) used to construct this T-zone must meet the Wetland Surface Criteria in the Master Quality Assurance Project Plan (USFWS and H.T. Harvey 2024)	

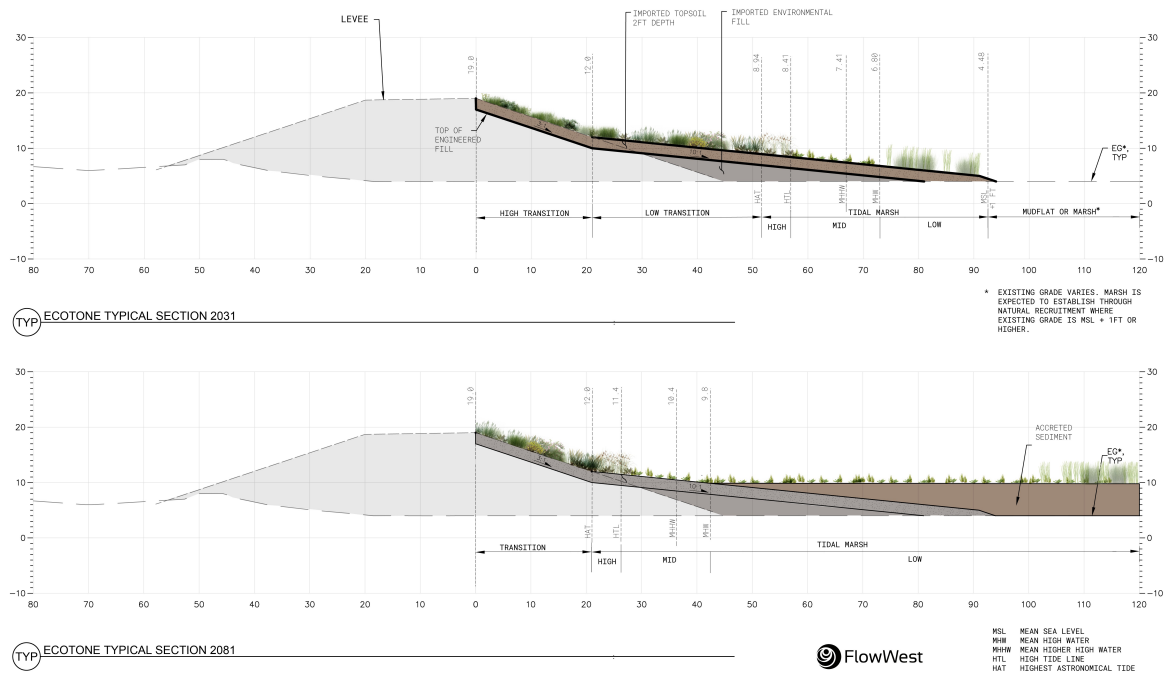


Figure 5-1: Pond R2 Ecotone Cross Section (Expected 2031 and 2081 Conditions)

5.4 Revegetation Plan

The planting design for the SAFER Bay Ecotone supports three primary goals:

- Develop native tidal marsh ecotone with an upland transition zone
- Support tidal marsh species and pollinators through diversity and refugia patches
- Deter invasive species through annual cover crops and rhizomatous perennials

Ecotone planting zones are delineated based on tidal elevation, slope geometry, and proximity to the levee crest (Table 5-3). All proposed species are native to California, and most are native to the San Francisco Bay. All species are suited to the site's tidal hydrology and soils, with the intent to promote long-term habitat function and self-sustainability. The project includes three planting zones:

- *Tidal marsh zone*, falling between high astronomical tide (HAT) and mean sea level (MSL). This forms the lower elevation portion of the ecotone profile.
- *Upland transition zone*, falling between the levee crest and HAT. This forms the higher elevation portion of the ecotone profile.
- *Trail-adjacent visual interest zone*, between the levee crest and the levee inflection point.

Table 5-3: Planting Zones

Zone	Sub Zone	Elevation Low	Elevation High	Notes
Tidal Marsh	Low Tidal Marsh	3.5 (~MSL)	7 (~MHW)	
Tidal Marsh	Mid Tidal Marsh	7 (~MHW)	8.5 (~HTL)	
Tidal Marsh	High Tidal Marsh	8.5 (~HTL)	9 (~HAT)	
Transition	Low Upland Transition	9 (~HAT)	12 (Inflection Point)	Clonal meadow and annual cover species with high tide refugia zones
Transition	High Upland Transition	12 (Inflection Point)	19 (top of levee)	Clonal meadow and annual cover species with biodiversity resource patches
Interest	Visual Interest	12 (Inflection Point)	19 (top of levee)	Adjacent to trail seating areas. High diversity zone.

5.4.1 Tidal Marsh Zone

The tidal marsh zone spans from approximately MSL (~3.5 feet NAVD) to HAT (~9 feet NAVD) and is subdivided into three planting bands: low, middle, and high, corresponding to the three natural tidal marsh communities identified in Atwater & Hedel (1976) for the San Francisco Estuary.

Planting in the intertidal zone is proposed to encourage the establishment of a regionally appropriate native salt marsh ecosystem. Much of the San Francisco Estuary's historic salt marshes have been destroyed by anthropogenic activities. In remnant tidal marshes native species are being replaced by invasive species and hybrids, like pacific cordgrass which is being replaced by Atlantic cordgrass (Goals Project, 2000). Additionally, healthy native marsh ecosystems support the reintroduction of rare tidal marsh plants (Goals Project, 2000). Planting a native salt marsh ecosystem on the Project site supports the restoration of the San Francisco Estuary.

The other primary reason for planting in the intertidal zone is to protect against erosion of the ecotone. The Sears Point Tidal Marsh Restoration Project in Sonoma County has had serious issues with ecotone erosion (Siegal, 2022). In the first five years post project implementation the 20:1 and 10:1 H:V sloped ecotones experienced significant tidal erosion that ate away at intended tidal marsh habitat and negatively impacted the natural vegetation colonization. The ecotones were not vegetated prior to the site being opened to tides. Getting a tidal marsh plant population established as soon as possible will help stabilize the ecotone and prevent erosion.

The species chosen for each tidal marsh subzone can be found in Table 5-4. Species are distributed across planting bands according to their known tidal elevation tolerances. Tidal marsh plantings will typically be installed as sod clumps or plugs.

Table 5-4: Plant Species List

Planting Zone	Sub Zone	Common Name	Scientific Name	Elevation (ft NAVD)	Functional Group
Tidal Marsh	Low Marsh	Pacific cordgrass	<i>Spartina foliosa</i>	4.5 - 7	N/A
Tidal Marsh	Middle Marsh	Fleshy Jaumea	<i>Jaumea carnosa</i>	7 - 8.5	N/A
Tidal Marsh	Middle Marsh	Annual pickleweed	<i>Salicornia depressa</i>	7 - 8.5	N/A
Tidal Marsh	Middle Marsh	Red Pickleweed	<i>Salicornia rubra</i>	7 - 8.5	N/A
Tidal Marsh	Middle Marsh	Common pickleweed	<i>Salicornia virginica</i>	7 - 8.5	N/A
Tidal Marsh	Middle and High Marsh	Alkali Bulrush	<i>Bolboschoenus maritimus</i>	8.5 - 9	N/A
Tidal Marsh	Middle and High Marsh	Alkali Heath	<i>Frankenia salina</i>	8.5 - 9	N/A
Tidal Marsh	High Marsh	Johnny-nip	<i>Castilleja ambigua</i>	8.5 - 9	N/A
Transition	Low Transition	San Francisco Gumplant	<i>Grindelia stricta</i> <i>var. angustifolia</i>	8.5 +	High-Tide Refugia
Transition	Low Transition	California Rose	<i>Rosa californica</i>	9 +	High-Tide Refugia
Transition	Low Transition	California Blackberry	<i>Rubus ursinus</i>	9 +	High-Tide Refugia
Transition	Both	Western Ragweed	<i>Ambrosia psilostachya</i>	9 +	Clonal
Transition	Both	Menzies' Fiddleneck	<i>Amsinckia menziesii</i>	9 +	Annual Native Cover
Transition	Both	Saltgrass	<i>Distichlis spicata</i>	9 +	Clonal
Transition	Both	Creeping Wildrye	<i>Elymus triticoides</i>	9 +	Clonal
Transition	Both	Alkali Heath	<i>Frankenia salina</i>	9 +	Clonal
Transition	Both	Hayfield Tarweed	<i>Hemizonia congesta</i>	9 +	Annual Native Cover
Transition	Both	Coast Tarweed	<i>Madia sativa</i>	9 +	Annual Native Cover
Transition	High Transition	Common Yarrow	<i>Achillea millefolium</i>	9 +	Biodiversity Resources
Transition	High Transition	California Sagebrush	<i>Artemisia californica</i>	9 +	Biodiversity Resources
Transition	High Transition	Mugwort	<i>Artemisia douglasiana</i>	9 +	Biodiversity Resources
Transition	High Transition	Salt Marsh Baccharis	<i>Baccharis glutinosa</i>	9 +	Biodiversity Resources
Interest	N/A	Manzanita	<i>Arctostaphylos uva-ursi</i> 'Point Reyes'	12 +	N/A
Interest	N/A	Coyote Bush	<i>Baccharis pilularis</i>	12 +	N/A
Interest	N/A	Seaside Daisy	<i>Erigeron glaucus</i>	12 +	N/A
Interest	N/A	Coastal Buckwheat	<i>Eriogonum latifolium</i>	12 +	N/A
Interest	N/A	Bush Lupine	<i>Lupinus arboreus</i>	12 +	N/A

5.4.2 Upland Transition Zone

The upland transition zone spans from approximately HAT (~9 feet NAVD) to the levee crest (19 feet NAVD) and is subdivided into two planting bands: low and high, demarcated by the levee inflection point from a 10:1 H:V to 3:1 H:V slope (at 12 feet NAVD88). The low and high bands will be planted with the same base clonal meadow and annual cover crop species. The zones differ slightly in their patches of taller, shrubby plants. The low band will have a greater emphasis on patches of high tide refugia species, while the high band will have a greater emphasis on patches of plants that support native biodiversity (described further below).

A healthy upland transition zone is essential for a resilient tidal marsh ecosystem through its support of tidal marsh bird species and small mammal species (Point Blue Conservation Science, 2017). Our planting palette for the upland transition zone is divided into four “functional groups” based on the approach used by Save The Bay on the Ravenswood Ponds restoration site (Olson, 2025), which was in turn based on the work of Peter Baye (Baye, 2008). Each functional group provides a different essential ecosystem function and supports the establishment of a healthy, native tidal marsh. The Ravenswood Ponds restoration project has been used as a model, as it has been successful and is extremely close to the Project site. The following information on each functional group is based on Baye (2008) and Olson (2025).

5.4.2.1 High Tide Refugia Group

This functional group provides high tide flood refuge habitat for small marsh mammals such as the salt marsh harvest mouse (*Reithrodontomys raviventris*) and birds like the threatened California black rail (*Laterallus jamaicensis coturniculus*) (Spautz, 2005). During storm surges, spring tides, and other high-water events, refugia patches help mammals avoid predation and prevent drowning. High tide refugia species are tall (>30 cm) woody perennials that provide dense cover at elevations that remain partially dry during high-water events, allowing mammals to escape inundation without leaving the marsh plain.

Refugia plants should be abundant enough to be easily accessible to marsh mammals. However, too much tall woody shrub creates travel corridors and denning opportunities for terrestrial predators and attractive perch habitat for avian predators. All high tide refugia species will be planted in patches, rather than bands, to avoid creating cover that is excessive and dense. Refugia species will be planted around high-tide level to be within the home range of intertidal plain mammal species.

The three species in the high tide refugia group: gumplant (*Grindelia stricta* var. *angustifolia*), California rose (*Rosa californica*), and California blackberry (*Rubus ursinus*) are woody perennials exceeding 30 cm that provide sufficient cover for mammal refuge without developing the extensive structure that facilitates predator activity. These species were all used successfully by Save The Bay in the Ravenswood Ponds restoration project. High tide refugia patches will be planted using nursery container stock in the fall after the first major rain event when soil is moist.

5.4.2.2 Biodiversity Resources Group

This functional group supports biodiversity in the upland transition zones. Biodiversity resource group species provide pollinator resources and forage for native bird and mammal species. Like high tide refugia species, some biodiversity resource species are taller and can potentially be exploited by predators. To account for this, biodiversity resource species should also be planted in patches throughout the upland transition zone.

The four biodiversity resource species selected: common yarrow (*Achillea millefolium*), California sage (*Artemisia californica*), mugwort (*Artemisia douglasiana*), and salt marsh baccharis (*Baccharis glutinosa*) were used in the Ravenswood Ponds restoration project. Biodiversity resource group patches will be planted using nursery container stock in the fall after the first major rain event when soils are moist.

5.4.2.3 Clonal Meadow Group

One of the greatest challenges of establishing a healthy upland transition zone is keeping out invasive, non-native weeds. Anticipated weeds at this site include wild mustard (*Rhaphospermum arvense*), Russian thistle (*Salsola* spp.), and stinkwort (*Dittrichia graveolens*). These invasive weeds are extremely problematic as they thrive in disturbed environments and outcompete young stands of native species, creating habitat that lacks biodiversity and native ecosystem services.

Mature stands of native vegetation - particularly creeping, rhizomatous, sod-forming perennial grasses and sedges - can be highly competitive against invasive weeds. These clonal perennials capture and retain available seedling space and create natural mulch layers that inhibit the establishment of weed seedlings. Therefore, the clonal meadow functional group is essential to the long-term exclusion of invasive weeds from the upland transition zone. Clonal meadow species will be planted throughout the upland transition zone.

Young transplants of these same native species, however, have very limited competitive ability. Mature, extensive populations of these clonal perennials take a long time without disturbance to establish. They reproduce primarily through slow lateral vegetative spread. They infrequently establish from seed and are typically not strong pioneer colonizing species.

For these reasons clonal meadow species should not be sown by seed. Hand planting nursery-grown individuals is possible, but unlikely to yield an extensive-enough mature stand to keep out invasive weeds. On larger sites, the most viable approach is to incorporate large vegetative divisions or sod propagules into the soil. Save the Bay used this approach with much success in the Ravenswood Ponds restoration project, growing clonal meadow sod in raised beds at a temporary on-site nursery and mixing it into the levee soil with a tractor.

The clonal meadow functional group is made up of saltgrass (*Distichlis spicata*), creeping wildrye (*Elymus triticoides*), alkali heath (*Frankenia salina*), and western ragweed (*Ambrosia psilostachya*). Planting of clonal meadow species should take place in the mid-to-late fall, when the clonal meadow species are dormant.

5.4.2.4 Annual Native Cover Crop Group

While clonal meadow species are an excellent long-term weed exclusion strategy, they will not be established enough in the first season to keep out invasives, even with a sod propagule planting strategy. Annual native cover crops address this gap by providing first-year competition against fast-establishing invasive annuals such as wild mustard and stinkwort.

Annual native cover crop species are fast-growing natives that can be broadcast-seeded prior to germinating rains and establish quickly enough to compete against invasive annuals during the critical first season. As clonal perennials mature and expand, the need for annual cover crops will diminish.

The cover crop mix includes Menzies' fiddleneck (*Amsinckia menziesii*), hayfield tarweed (*Hemizonia congesta*), and coast tarweed (*Madia sativa*). These species are selected based on their alignment with the life cycles of the invasive species present on site. These species will be broadcast-seeded across both upland transition bands prior to the first significant rains of the first project year.

5.4.3 Visual Interest Zone

The visual interest zone is located at and adjacent to the levee crest, around seating areas and the pedestrian trail corridor. Planting in this zone is designed to provide seasonal color, textural diversity, and pollinator habitat for trail users, while reinforcing native coastal scrub character consistent with the broader restoration context.

Species in this zone include point Reyes manzanita (*Arctostaphylos uva-ursi* 'Point Reyes'), coyote bush (*Baccharis pilularis*), seaside daisy (*Erigeron glaucus*), coastal buckwheat (*Eriogonum latifolium*), and coastal bush lupine (*Lupinus arboreus*). These species are well-suited to the well-drained, wind-exposed conditions at the levee crest and provide continuous bloom from late winter through fall. Visual interest zone plantings will be installed from nursery containers in the fall after the first major rain event when soil is moist.

5.5 Non-Native Species Management

The upland transition zone has been designed to create persistent native habitat that self-sustains and excludes invasive non-native species. However, additional management interventions to keep out non-native species are recommended.

The levee should be cleared of all invasive species prior to the beginning of the planting process. The upland transition zone will establish much more successfully if sown into a “blank slate” of thoroughly weeded soil.

Additionally, after planting, ongoing removal of particularly invasive non-native species should be regularly conducted. This includes annual ruderal herbs like wild mustard (*Rhaphospermum arvense*), Russian thistle (*Salsola* spp.), stinkwort (*Dittrichia graveolens*), and any other invasive species observed during site surveys that are not appropriate for the restoration context. These plants should be manually removed by hand, to not disturb the maturing native habitat.

5.6 Irrigation

The 60% design assumes that a sprinkler irrigation system or similar method will be used to keep ecotone soils moist during the first winter after seeding and that irrigation will also be used to supplement rainfall and establish plants in the transition and interest zones during the first three years after planting or seeding.

5.7 Preliminary Cost Estimate

The primary cost driver for the ecotone element of the Menlo Park SAFER Bay Project is the total volume of imported environmental fill and topsoil that will be required to construct the ecotone. Based on the calculated volumes from the 60% design of the ecotone, the ecotone will require a total of 11,500 cubic yards of environmental fill and 34,120 cubic yards of topsoil. Costs for material and placement of imported soil can vary significantly, with current expected price ranges for the fill and topsoil between \$60 and \$100 per cubic yard. For the 60% design cost estimate, a cost of \$100 per cubic yard is assumed for both the environmental fill and the topsoil.

For the 60% design cost estimate, revegetation of each zone is considered separately given different revegetation techniques. Published estimates for the cost of revegetation and planting for restoration projects vary widely depending on the site conditions and the type of plantings.

- The Low Tidal Marsh Zone assumes 2 rows of Cordgrass (*Spartina foliosa*) planted along the bay margin of the ecotone at 1' on center (O.C.) spacing. *Spartina foliosa* will likely need to be harvested locally, specially sourced, or grown in an onsite nursery for this project, as commercial availability is limited. This sourcing requirement is a primary driver of the relatively higher unit cost of \$40,000/acre for this zone.
- The Mid and High Tidal Marsh Zones will be planted at mid to high density with Pickleweed (*Salicornia* spp. (mid marsh)), Jaumea (*Jaumea carnosa* (mid marsh)), Alkali Bulrush (*Bolboschoenus maritimus* (mid & high marsh)), and Alkali Heath (*Frankenia salina* (mid and high marsh)) plugs at approximately 3' - 5' O.C. spacing. Both zones share a unit cost of \$50,000/acre, reflecting the higher plug density relative to the transition zone and the sourcing requirements for native tidal marsh species. The slightly higher unit cost compared to the Low Tidal Marsh Zone reflects the broader species palette and plug-based installation across the full zone area, rather than a two-row linear planting.
- Revegetation of the Transition Zone includes a base layer of hydroseeding application, augmented by container plantings in patches of approximately 3 square feet, covering an estimated 15% of the zone area. Where site conditions and sourcing allow, sod installation should be substituted for hydroseeding to accelerate establishment. The \$35,000/acre unit cost reflects a blended assumption across these approaches.

Unit costs are summarized by acre depending on the planting zone. Approximately two thirds of the revegetation cost is related to labor and equipment. Labor costs are primarily attributed to higher density of plantings, which have been shown to improve outcomes in other projects. Higher density planting increases cost but reduces the area where invasive plants can colonize and increases the competitive advantage of planted species. (Table 5-5) Total restoration cost in 2026 dollars is estimated to be \$5 million.

Table 5-5: Restoration Cost Estimate

Ecotone Component	Volume or Area	Unit Cost	Total Cost
Environmental Fill	11,500 cubic yards	\$100/cubic yard	\$1,150,000
Topsoil	34,120 cubic yards	\$100/cubic yard	\$3,412,000
Revegetation: Tidal Marsh (Low)	2.66 acres	\$40,000/acre	\$106,400
Revegetation: Tidal Marsh (Mid)	1.68 acres	\$50,000/acre	\$84,000
Revegetation: Tidal Marsh (High)	0.55 acre	\$50,000/acre	\$27,500
Revegetation: Transition (Low)	3.34 acres	\$35,000/acre	\$116,900
Revegetation: Transition (High)	2.19 acres	\$35,000/acre	\$76,650
Revegetation: Interest	0.16 acre	\$35,000/acre	\$5,600
Total Restoration Cost			\$4,979,050

5.8 Restoration References

1. Atwater, B; Hedel, C. 1976. Distribution of Seed Plants with Respect to Tide Levels and Water Salinity in the Natural Marshes of the Northern San Francisco Bay Estuary, California. United States Department of the Interior Geological Survey.
2. Baye, PR. 2008. Vegetation Management in Terrestrial Edges of Tidal Marshes, Western San Francisco Estuary, California. Prepared for Marin Audubon Society, Mill Valley, California. www.marinaudubon.org/pdf/MAS%20tidemarsh%20ecotone%20veg%20mgmt%20final%202008-3.pdf
3. Beller, EE; Salomon, M; Grossinger, RM. 2013. An Assessment of the South Bay Historical Tidal-Terrestrial Transition Zone. SFEI Contribution No. 693. San Francisco Estuary Institute: Richmond, CA.
4. Foxgrover, A.C., B.E. Jaffe, G.T. Hovis, C.A. Martin, J.R. Hubbard, M.R. Samant, and S.M. Sullivan. 2007. 2005 Hydrographic Survey of South San Francisco Bay, California. USGS Open File Report 2007-1169.
5. Goals Project. 2000. Baylands Ecosystem Species and Community Profiles: Life histories and environmental requirements of key plants, fish and wildlife. Prepared by the San Francisco Bay Area Wetlands Ecosystem Goals Project. P.R. Olofson, editor. San Francisco Bay Regional Water Quality Control Board, Oakland, Calif.
6. H.T. Harvey, 2025. SAFER Bay Project Habitat Restoration Basis of Design, 2nd Draft, Prepared for San Francisquito Creek Joint Powers Authority, April 2025
7. Olson, J. 2025. Trial and Tractor: Large-scale Habitat Transition Zone Revegetation in the Ravenswood Complex [webinar]. Save the Bay and South Bay Salt Pond Restoration Project. www.southbayrestoration.org/media/lunch-and-learn-science-trial-and-tractor-large-scale-habitat-transition-zone-revegetation
8. California Ocean Protection Council, 2024. State of California Sea Level Rise Guidance 2024 Science and Policy Update. Available at: <https://opc.ca.gov/wp-content/uploads/2024/05/California-Sea-Level-Rise-Guidance-2024-508.pdf>
9. Point Blue Conservation Sciences. 2017. Ensuring a Resilient Tidal Marsh Ecosystem Through Healthy Upland Transition Zones: Assessment and Recommendations. www.pointblue.org/wp-content/uploads/2019/02/TBirds_LandingPage_final_nofooterlink.pdf
10. Siegal, S. 2022. Sears Point Tidal March Restoration Project Monitoring Report, Years 1 through 5. Prepared by Siegal Environmental LLC. Prepared for Sonoma Land Trust. sonomalandtrust.org/wp-content/uploads/2022/05/Sears-Point-Restoration-Project-Year-5-Monitoring-Report.pdf
11. Spautz, Hildie; Nur, Nadav; Stralberg, Diana. 2005. California Black Rail (*Laterallus jamaicensis coturniculus*) Distribution and Abundance in Relation to Habitat and Landscape Features in the San Francisco Bay Estuary. In: Ralph, C. John; Rich, Terrell D., editors 2005. Bird Conservation Implementation and Integration in the Americas: Proceedings of the Third International Partners in Flight Conference. 2002 March 20-24; Asilomar, California, Volume 1 Gen. Tech. Rep. PSW-GTR-191. Albany, CA: U.S. Dept. of Agriculture, Forest Service, Pacific Southwest Research Station: p. 465-468

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6. Landscape Architecture

SAFER Bay landscape design is integral to the 3.6-mile levee along the Menlo Park Bay shoreline ensuring a vibrant, accessible, and resilient environment where people and nature can thrive. Graphic documentation for the concepts described in this report section are linked in Appendix B and Appendix C.

The existing shoreline public access experience within the project area is varied. Stretches of public path close to Bayfront Expressway have little separation from the road and are noisy and exposed. The separation from the road around the Meta Campus and the path to Bedwell Bayfront Park affords a more peaceful environment to enjoy Bay views to the east. Notably the proposed levee will provide the needed separation of visitors from the adjacent busy roads and in already quiet stretches it will improve visual access to the bay by elevating visitors.

The new San Francisco Bay Trail (Bay Trail) will run along the top of the levee with regular points of access and moments to pause to improve public access to the Bay and its ecology. Integral to the levee is access for pedestrians and cyclists, natural areas, and public spaces large and small that allow different experiences and views of the Bay; the variety of seating and spaces on top of the levee will encourage the public to stop, linger, or gather. The banks of the levee will be enhanced with native planting, with a focus on Bay edge ecology on the bayside and durable, predominantly native planting on the landward side.

New Bay Trail access around the PG&E facility will significantly improve visitor experience of the Don Edwards San Francisco Bay National Wildlife Refuge (that will be restored as a part of this project) and complete the Ravenswood Trail. The proposed levee will improve the Bay Trail and visitor experience, as well as enhance the existing positive attributes of the remarkable landscape and the public's access to them.

Site landscape opportunities and constraints are afforded by the new levee, adjacent streetscape, and the connection between the two.

6.1 Levee

The basis of the landscape design for the levee focuses on the following elements:

1. Sea-level rise and flood protection, including earth berms, flood walls, slopes, settlement mitigation, and geotechnical provisions for seismic stability of the shoreline. See shoreline engineering and Geotechnical drawings/BOD for more information.
2. Extension of the Bay Trail through the site, including transitions to existing segments of the Bay Trail at the east and west ends of the site.
3. Segments of “soft” or “living” shoreline where feasible, including shoreline grading and planting that allows tidal influence in both current and future sea level conditions.
4. Predominantly native plants on both the bayside and landward sides of the levee.
5. Bridge at Bay Trail over Ravenswood Slough.
6. Shoreline seating areas, overlooks, and shoreline access paths (In addition to primary Bay Trail pathway).
7. Enhanced existing tidal marsh.
8. Wayfinding and Bay Trail Signage.

6.2 Streetscape

The basis of landscape design for the adjacent streetscape and interaction with the new levee focuses on the following elements:

1. Sidewalk, street trees, planting.
2. New pedestrian crossing at existing traffic control lights at the East Meta Way and Bayfront Expressway intersection.

6.3 Landscape Grading

Several design concepts are and will be incorporated into grading for landscaping elements:

1. Existing grades in the project area are relatively flat, except for where it is elevated around the META campus and at Bedwell Bayfront Park. Elevation drop to sea level at the shoreline generally occurs at or beyond the proposed limit of work.
2. All proposed onsite grading will conform to existing conditions along project edges.
3. The intent of grading design is to minimize soils off-haul in relation to cut and fill quantities, as further discussed in Section 9 of this Basis of Design.
4. Proposed grading meets existing elevations at Bedwell Bayfront Park, around the Meta campus, and at California Highway 84. Elsewhere the levee will raise elevations as required for sea-level rise protection.
5. Minor grading added to the levee will be done to define public spaces and provide sloped access to the Bay Trail.
6. Finish grading in all areas shall:
 - a. Provide erosion control during plant establishment.
 - b. Provide structural conforms to existing and proposed new infrastructure.

6.4 Tree Removal and Protection

Existing trees within the limits of the work will be retained if healthy and as practicable.

6.5 Landscape Drainage

Part of the detailed landscape design will be to determine whether the site needs to be sub-drained. Are there underlying conditions that prevent free drainage below tree pits and plant areas in the project area? For the purposes of pricing, the following is assumed:

- Provide an underdrainage system for all trees. Tie-in the underdrainage system to storm drains or other outlets (details to be determined).
- Provide landscape area drainage. Tie the landscape drainage into a storm drain or another positive outlet.

6.6 Landscaping Soils

Testing the existing sub-grade and topsoil conditions for horticultural suitability will help to determine preferred design approaches to either the stockpiling and amendment of existing soil; or importing topsoil for landscape planting. Up to 15 samples will be taken from design landscape footprints for horticultural suitability testing.

Soil is a key component to long-term plant health. Testing will help guide and develop an approach to the site soils plan. Primary objectives include:

- Balancing cut/fill and reducing import per grading design
- Determining whether any existing on-site soils are horticulturally suitable for reuse (reduces import material cost)

6.6.1 Existing Soil Testing Process

The existing site consists of imported fill over bay mud. The properties of this fill are variable and much of the existing soils may not be appropriate for horticultural uses. In addition, substantial new fill will be required to build the levee to required Sea Level Rise protection elevations.

- Determine whether there are suitable soils on site in the locations of future excavations.
- Sample starting below existing elevations.
- Sample at the following depths in a single location; one per acre:
 - upper 2 feet
 - 2-6 feet
 - 6-10 feet
 - 10-13 feet
- Exclude soil within 2 feet of pavements, roads, parking lots or buildings. They are likely to have high alkalinity, gravel and perhaps soil sterilant.
- Stockpiling:
 - Determine feasibility of on-site stockpiling with Client/Contractor
 - Determine how to stockpile and protect future planting soils
- Soils compacted to 95% are likely to have impaired drainage.

6.6.2 Site Soil Plan and Mix Design

During detailed design development, a soil quality control program for testing and verification of amended and/or import soils will be developed and incorporated into the specifications. Planting soil mix specifications shall be met by amendment, conditioning, importation of topsoil or a combination of these.

6.6.3 Assumptions for Cost Estimating

The following assumptions commensurate with 60% plan development are made for landscape cost estimating, which is included in Section 9.

- Sub Soil Preparation: Excavate and remove 2 feet in all general planting areas and 4 feet in all tree planting areas. Remove all base rock, debris and lime-treated soils. Rip and prepare subgrade. (Note: this soil can be used onsite to make rough grade; it does not require off-haul.)
- General Landscape Areas: 24 inches of import soil mix per soils engineer.
- Tree Backfill Mix: 14' x 14' x 4', each tree with import soil mix per soils engineer.
- Mulch: 3 inches of bark mulch shall be provided in all planting areas.

6.7 Paving

Paving materiality brings identity to distinct open spaces and binds the project ground-plane together. Asphalt paving, CIP concrete, and stabilized crushed stone Paving are proposed for all pedestrian environments. In locations where emergency vehicle access is required, paving profiles shall have a minimum loading capacity that complies City of Menlo Park guidelines for emergency vehicles.

6.7.1 General San Francisco Bay Trail Guidelines

The default Bay Trail section is 18 feet in width, with 12 feet of asphalt concrete pavement and 3-foot shoulders on each side of the paved trail section. It is assumed that the Bay Trail will also host maintenance and emergency vehicles.

- VEHICULAR ASPHALT over compacted aggregate subgrade, capable of supporting fire truck loading, minimum 65,000 lbs.
- STABILIZED CRUSHED STONE PAVING (SCSP) on aggregate base for pedestrian use: pavement thickness to match adjacent asphalt concrete thickness. Minimum 3-inch SCSP over 4-inch aggregate base in for pedestrian use and 6-inch aggregate base for fire access lanes. Basis of Design supplier: Granitecrete.

6.7.2 Bay Trail at Overlooks and Rest Stops

- CAST-IN-PLACE CONCRETE on compacted aggregate base for pedestrian use. Standard grey concrete. Top-cast exposed sand/aggregate finish with tooled joints.
- CAST-IN-PLACE CONCRETE on compacted aggregate base for vehicular use. Standard grey concrete. Top-cast exposed sand/aggregate finish with tooled joints. Provide 12-foot width at fire access lanes.
- CAST-IN-PLACE CONCRETE at stairs and ramps on compacted aggregate base for pedestrian use. Standard grey concrete. Top-cast exposed sand/aggregate finish with tooled joints. Provide 12-foot width at fire access lanes. Marine grade stainless steel handrails.

6.7.3 Secondary Pedestrian Paths

- CAST-IN-PLACE CONCRETE on compacted aggregate base for pedestrian use. Standard grey concrete. Top-cast exposed sand/aggregate finish with tooled joints. Minimum width 12 feet.
- ASPHALT PAVING on compacted aggregate base for pedestrian use.
- STABILIZED CRUSHED STONE PAVING (SCSP) on aggregate base for pedestrian use: 3-inch SCSP over 4-inch aggregate base minimum. Basis of Design supplier: Granitecrete.

6.8 Irrigation

The landscape irrigation system will be a fully automated water efficient system and designed to comply with the San Mateo County Water Efficient Landscape Ordinance. The system will be installed to be compatible with the City of Menlo Park's recycled water supply should it come online.

6.8.1 Water Quality Standards

Recycled water should be tested for the following to determine if any on-site treatment is required based on plant palettes. There are two levels of water quality to consider.

6.8.1.1 High Quality (Level I)

- Acceptable pH – 6.5 to 8.4
- Total dissolved solids – less than 600 mg/L
- Electrical Conductivity – less than 0.8 millimho/cm
- Boron - less than 0.5 mg/L
- Chloride – less than 100 mg/L
- Sodium – less than 70 mg/L
- Adjusted SAR (sodium adsorption ratio) – less than 3.0
- Bicarbonate – less than 100 mg/L
- Redox – 300 millivolts or higher
- Dissolved oxygen – 2 mg/liter or higher
- BOD - less than 3 mg/liter

If Level I standards are too stringent to be economically complied with, users can be apprised of the best management practices and use relaxed standards.

6.8.1.2 Relaxed Standards (Level II)

- Acceptable pH – 6.5 to 8.4
- Total dissolved solids – less than 700 mg/L
- Electrical Conductivity – less than 1.1 millimho/cm
- Boron - less than 1 mg/L
- Chloride – less than 150 mg/L
- Sodium – less than 100 mg/L
- Adjusted SAR (sodium adsorption ratio) – less than 5.0
- Bicarbonate – less than 150 mg/L
- BOD - less than 10 mg/liter
- Total hydrocarbons – less than 20 parts per million
- BTEX – less than 0.5 parts per million

6.8.2 Irrigation System Design

The landscape irrigation system will be 2-wire. Basis of Design irrigation equipment: Rain Bird ESP-LXD on LX controller series on IQ4 central control with an Ethernet or GPS communication cartridge. Controllers require (2) CAT6A non-continuous foil cables back to the transmitter in 1-inch diameter conduit.

The irrigation system will include the following:

- a. All piping and components will be purple pipe and compliant for use of recycled water.
- b. Primary irrigation for all planting areas will be sub-surface drip or bubbler-based irrigation, with drip tubes at 18 inches on center, or pop-up sprinklers with low-volume rotary nozzle. No point-source irrigation will be used.
- c. Quick couplers will be provided and spaced every 100 feet of mainline.
- d. The system will be valved based on hydrozones and plant types to minimize irrigation use.
- e. Locations of valves and other components shall be consolidated to reduce visual impact.
- f. Subsurface irrigation drip lines are generally placed 1-inch to 3 inches below the soil surface to achieve the greatest saturation in soil
- g. Irrigation systems shall contribute to reducing the use of water for irrigation including rain sensors.

Points of connection, water meters, and backflow preventers will be located based on operation zones and existing water supply infrastructure in the vicinity.

6.9 Understory Planting and Trees

This part of the planting design focuses on resiliency, creating a robust landscape that is immersive, diverse, moderate in its maintenance requirements and sustainable from a water usage standpoint. Additionally, it will provide access to nature and help define outdoor spaces with mitigation of exposure to sun and wind. Most significantly, planting will contribute to the identity and unique regional character of the Menlo Park Shoreline.

6.9.1 General Landscape Criteria

All plants shall be primarily native species.

- Landscape areas include tree mulch rings.
- The project Landscape Architect will provide CAD files and plant quantity take-offs for plant quantity verification based on detailed planting plans and schedules.
- Contractor is required to verify plant quantities and areas provided by Landscape Architect and provide sufficient plant materials based on plans and schedules.
- Contract Documents will provide an allowance for additional plant material to address field adjustments during construction and replacement during the warranty period.
- Final plant selection and layout will be refined based on the following selection criteria:
 - Soils and horticultural suitability
 - Salt and wind tolerance
 - Water Efficient Landscape Ordinance (WELo) requirements
 - Aesthetic quality
 - Ecological value/habitat and environmental considerations
 - Sun + shade
 - Recycled water quality and availability

6.9.1.1 Inboard Levee Embankments

Levee embankments on the inboard (land) side of the protective elevation will be planted with a base of hydroseeded grasses, with additional groundcover, perennials, shrubs, and bunch grasses installed as container plants in sizes as indicated on Drawings.

6.9.1.2 Outboard Levee Embankments

Bayside levee embankments will be planted with bay edge species appropriate to the adjacent ecological conditions.

6.10 Bioretention Areas

Stormwater quality bioretention areas will be planted with a mix of perennials, grasses and perennials installed as containers and plugs as indicated on drawings.

6.11 Trees

Trees will be a mix of native species and sizes ranging from 24" box to 48" boxes as indicated on the Drawings. All trees will have sub-drainage per typical planting details unless otherwise noted.

6.12 USACE Levee Vegetation Criteria

The Corps publishes specific vegetation criteria for levee systems aimed at ensuring levee integrity and functionality, primarily through the establishment of a vegetation-free zone and proper vegetation management.⁶ Unfortunately, adherence to the Corps' guidelines often results in a stark levee experience that is not compatible with aesthetic goals for this type of public recreational space and may not be compatible with grant funding opportunities or be accepted by the public, including one of the major private project sponsors.

The JPA intends to obtain a variance from these criteria through the USACE during the regulatory authorization phase of the Program. This variance is crucial to the maintenance of Program impact mitigation goals. (Appendix A Section 2.8 provides a detailed discussion of SAFER Bay's views on the Corps vegetation criteria.)

For these reasons, the landscape design intent is to proceed without necessarily adhering to the VFZ while being cognizant of the types of landscapes that belong in a shoreline environment and the need to provide for effective levee inspection and maintenance. The VFZ is provided informationally as Figure 6-1.

The Corps wants a three-dimensional corridor surrounding levees, floodwalls, and appurtenant structures. The purpose of VFZ is primarily to provide access for inspection and maintenance, and to facilitate emergency flood-fighting activities. Figure 6-1 illustrates the VFZ. The only vegetation allowed within the VFZ are perennial grasses that are acceptable as ground cover, and their primary function must be erosion control.

Species selection within the VFZ would consider local climate, conditions, and surrounding land uses, with preference for native species. Vegetation in the VFZ would be maintained to ensure it can be mowed to a low height (e.g., 3 inches) for inspections and flood conditions. If designed features like planting berms or benches are used, species selection and management are crucial to prevent root penetration into the levee structure.

⁶ USACE, "Guidelines for Landscape Planting and Vegetation," (EP 1110-2-18), May 2019.

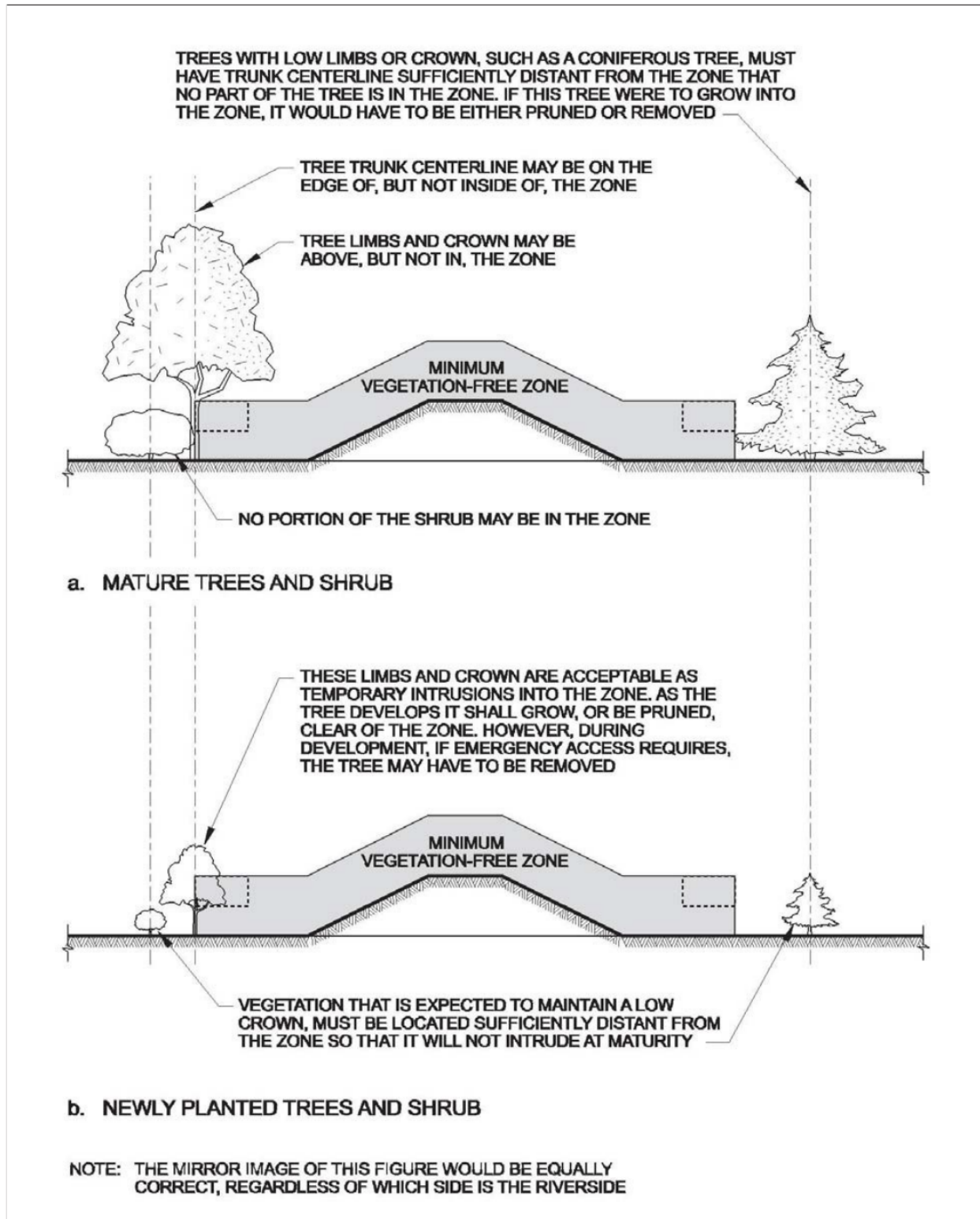


Figure 6-1: USACE Vegetation-Free Zone (EP 1110-2-18)

6.13 Site Elements and Furnishings

A consistent family of contemporary site furnishings will support the continuity of the project's pedestrian character. These elements include benches, signage, trash, recycling and compost receptacles, bicycle racks, and bollards. Integrated site walls and bleacher seating take advantage of topography to create social seating for small groups and individuals. Material selection takes into consideration long term ease of maintenance and durability of finishes, as well as reinforcing landscape identity. See also the 60% landscaping plans and Appendix C.

- CIP concrete seat walls
- CIP concrete seat walls with wood seating
- Optional bridge over Ravenswood Slough at Bay Trail: Hardwood decking, Galvanized or Corten railings.
- CIP bleacher seat, steps, and sloped path.
- Wayfinding signage
- Boulders of various sizes from 1-foot to 8 feet that are consistent with regional availability for rock slope protection.
- Bike racks, waste receptacles, manufactured benches (Landscape Forms or similar)

6.14 Site Signage

The landscape design will be coordinated with the following wayfinding and signage program (TBC) while providing budgetary allowances for:

- Monument Signage
- Pedestrian Wayfinding and Directional Signage

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7. Other Design Considerations

Other design considerations including constructability are described in this section, understanding that as detailed design and construction document preparation, these issues will be further resolved.

7.1 Earthen Levee Construction

Earthen levees may be raised using approved fill materials pending completed geotechnical investigation and analyses regarding the potential for seepage. The following design recommendations are preliminary and may be changed upon completion of additional detailed geotechnical engineering.

7.1.1 Equipment

Subsurface conditions consist of variable thicknesses of existing fill overlying young Bay Mud and earthwork activities are anticipated to be near or extend into young Bay Mud deposits. Earthwork activities will likely require methods and equipment suitable for soft soil conditions. Construction equipment should be limited to lightweight sizes that reduce the potential for subgrade disturbance, slope instability and damage to shallow utilities. The use of rubber-tired equipment should be minimized to prevent the creation of rutting and soil instability. Equipment fitted with mud tracks may be required.

Temporary haul routes for trucks and other equipment should be designed and regularly maintained for their intended use.

7.1.2 Wet Soil Conditions

The contractor will likely encounter excessively wet soil moisture conditions during winter or spring grading operations, during and following periods of rain, during periods of high tide and within young Bay Mud deposits. Year-round construction may be necessary to meet a proposed schedule for soil import, stockpile, placement. Construction will not take place, however, within any area exposed to streamflow or other sources of non-tidal floodwater.

Wet soil can make proper compaction more difficult or impossible. Potential mitigation measures that will be considered when preparing contract documents include:

- Frequent spreading and mixing during warm dry weather.
- Mixing with drier materials.
- Removal and replacement with drier materials.
- Mixing with a lime, lime-flyash or cementitious product.
- Stabilizing with aggregate, geotextile stabilization fabric, or both.

The use of cementitious products and chemical treatments to help dry and stabilize wet soil material are subject to approval by regulatory permit agencies given the proximity to San Francisco Bay.

7.1.3 Site Preparation

For those areas to receive additional earthen fill without prior installation of sheet pile walls, surface and subsurface deleterious materials must be cleared including abandoned buried structures, utilities, irrigation lines, pavements, debris, trees, shrubs and associated roots.

Tree root balls should be removed to a depth of at least three feet below finish grade. Buried utilities and foundations, which could act to trap water and deteriorate must also be demolished and removed. Vegetation, debris and other deleterious materials must be removed from grading areas.

Following site clearing, the subgrade should be stripped to remove surface organic materials to a depth of at least two to three inches below the surface, or as directed by the geotechnical engineer in the field. Stripped organic soil may be re-used in landscape areas or off-hauled.

7.1.4 Grading

Levee embankments should be constructed by benching and keying into existing levee embankments as described herein and generally shown in the typical sections. It is important to retain the existing top of levee elevation to maintain the current level of flood protection during construction. Where these grading activities extend into or close to young Bay Mud deposits, unstable subgrade conditions may be encountered. Consequently, a layer of geotextile stabilization fabric should be placed over the exposed subgrade prior to fill placement.

Benches should be cut into the original slope grade as filling proceeds every three feet vertically. Deeper bench depths may be required depending upon field conditions observed during construction.

Graded cut and fill slopes less than ten feet in vertical height should be constructed at gradients no steeper than 2:1 (horizontal to vertical) unless otherwise noted during design. If steeper bank slopes are required to avoid jurisdictional habitat, adjacent improvements or other encroachments, soil reinforcement techniques using a geogrid may be necessary. Exposed graded slopes will be landscaped as described in this Basis of Design or provided with appropriate slope protection to minimize erosion.

7.1.5 Fill Material

Import fill used as new levee fill, including lightweight fill, should meet the following criteria:

- Fill shall consist of lean clay, sandy clay, silty clay or clayey silt with a maximum total unit weight of 125 pounds per cubic foot when compacted and an organic content 3 percent or less.
- Vertical hydraulic conductivity shall be no greater than 10^{-4} cm/sec when compacted.
- The Plasticity Index shall be no less than 10 and no greater than 30, with a minimum liquid limit of 45.
- Fill gradation shall be such that at least 50 percent passes a No. 4 sieve and at least 30 percent passes a No. 200 sieve. The fill material shall not contain rock or aggregate larger than 3 inches in greatest dimension with no more than 15 percent larger than 1 inch.
- Fill material shall not be more corrosive than the native material or existing levee fill based on laboratory testing.

Select native soil may also be used as new levee fill provided it is stripped of vegetation and debris and meets the above-listed criteria.

7.1.6 Fill Placement and Compaction

Once a suitably firm sub-base is achieved, the exposed non-yielding surface is scarified to a depth of at least 10 inches; moisture conditioned and re-compacted to provide adequate bonding with the initial lift of fill. Fill shall be placed in thin lifts no more than 10 inches thick or the depth of penetration of the compaction equipment used, whichever is less. Vibratory compaction equipment should be avoided, and new fill should be benched into existing levee fill as previously described.

Fill should be compacted to not less than 90 percent relative compaction at no less than 2 percentage points above optimum moisture content.

Perimeter grades should be positively sloped to provide for the rapid removal of surface water runoff away from graded areas, thereby preventing ponding of water during or after construction. Ponded water may cause undesirable soil swell and loss of strength.

Furthermore, if large lifts of fill are placed over previously unconsolidated YBM foundation material, mud waves and a failed fill placement could result as exemplified by Figure 7-1, which is from an analysis of mass fill placement off Candlestick Point in San Francisco. While the typical sections shown on the 35% plans have generally stable embankment slopes, detailed slope stability analyses will be performed to confirm the capacity of the levee embankment and foundation soils.

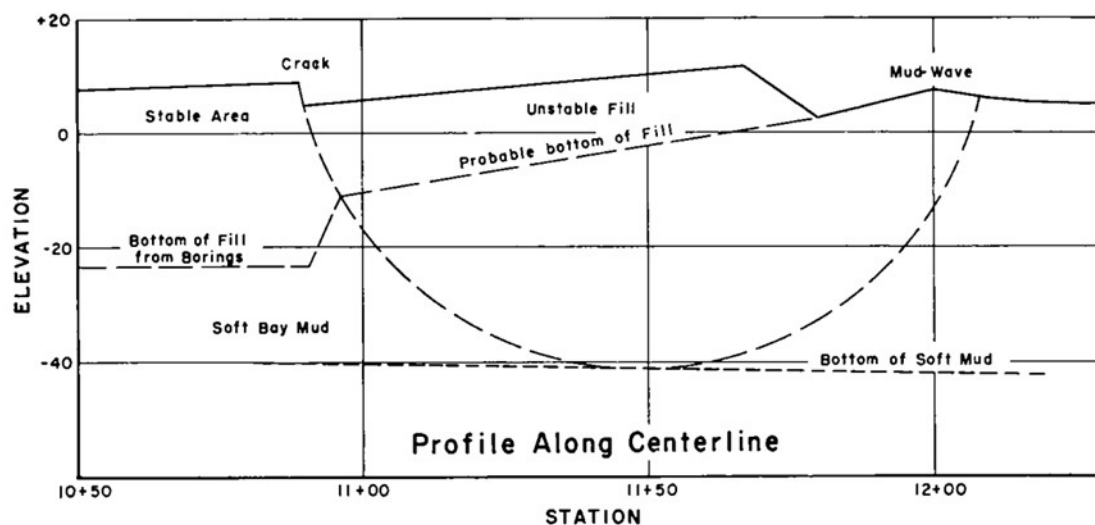


Figure 7-1: Example of Fill Failure due to Instability and Mud Wave Formation

7.2 Floodwall Construction

Floodwalls include driven pile and grade beam foundations as shown on the 60% plans and potentially conventional gravity concrete floodwalls should design circumstances call for that type of improvement. Gravity floodwalls and their foundations must be supported in conformance with applicable local, state and federal regulations including the California Department of Industrial Relations Construction Safety Orders and Occupational Safety and Health Administration (OSHA) Excavation and Trench Safety Standards. The Contractor will be solely responsible for excavation and trench safety during the prosecution of work related to levee and floodwall improvements.

7.3 Design Loading Conditions

After collaborating with the SFCJPA and East Palo Alto's design team, the overall flood protection system, of which Menlo Park is an integral reach, is designated as a critical infrastructure system. Accordingly, design will follow the risk-informed framework of ER 1110-2-1806 and applicable USACE guidance, including EM 1110-2-1913 (Levees), EM 1110-2-2502 (Floodwalls), EM 1110-2-6050 (Seepage), and the Coastal Engineering Manual (EM 1110-2-1100).

The system is intended to achieve FEMA accreditation (44 CFR 65.10) and must withstand the one percent annual chance coastal flood, including storm surge, wave effects, and associated erosion processes. Numerical analyses will be performed using FLAC-based modeling to capture coupled hydraulic, geotechnical, and structural response.

Design of the coastal flood protection system will follow a USACE risk-informed framework (ER 1110-2-1806), combining deterministic safety factors with deformation-based and probabilistic fragility analyses to demonstrate acceptable performance under storm surge, wave, and seismic loading conditions.

7.3.1 Hydraulic Loading Conditions

Hydraulic loading includes storm surge, tides, wave loading, and coastal erosion processes, which govern both levee and floodwall design.

7.3.1.1 Base Flood (1% Annual Chance Event)

- Storm surge elevation and wave setup from Section 3.4
- Hydrostatic and hydrodynamic forces on floodwalls
- Seepage gradients under surge conditions
- Wave impact pressures on vertical floodwalls
- Increased pore pressures due to cyclic loading

7.3.1.2 Long-Duration Storm / Steady-State Seepage

- Sustained surge condition producing fully developed seepage
- Underseepage beneath levees and floodwalls
- Evaluation of uplift, exit gradients, and piping

7.3.1.3 Rapid Drawdown (Post-Storm Recession)

- Rapid water level reduction following storm surge (tide cycle)
- Governs landside slope stability due to elevated pore pressures

7.3.1.4 Erosion and Scour

- Wave-induced erosion of levee slopes
- Toe scour from wave attack and surge currents
- Loss of section geometry as a governing failure mode

7.3.1.5 Sea Level Rise (SLR) Sensitivity Case

- Evaluated as a risk-informed future condition

7.3.2 Seismic Loading Conditions

- OBE and MDE Events
- Pseudo-static Stability Analysis
- Dynamic Deformation Analysis (FLAC)
- Liquefaction Potential
- Saturated sands and silty sands typical of levee and floodwall foundations along the Bayfront
- Post-liquefaction deformation affecting crest elevation and floodwall alignment
- Combined Seismic + Elevated Groundwater Condition
- Conservative assumption of high phreatic surface due to proximity to sea level

7.3.3 Structural and Earth Loads

- Wave impact pressures added to hydrostatic loads on floodwalls
- Cyclic loading effects influencing soil strength degradation
- Increased importance of uplift pressures under surge conditions

7.3.4 Other Loading Conditions (Coastal-Specific Additions)

- Long-term exposure to saltwater affecting:
 - Steel corrosion
 - Concrete durability (chloride intrusion)
- Floating storm debris loads
- Wind Loading
 - Acts concurrently with surge to generate wave conditions
 - Minor structural effect but include for completeness

7.3.5 Load Combinations and Performance Criteria

Load combinations will explicitly include coincident surge, wave, and tidal conditions, consistent with Section 3.4 and USACE guidance. Performance requirements include:

- No breaching under the 1% annual chance coastal storm (surge + wave)
- Crest elevation maintained considering wave runup and erosion
- Acceptable deformation limits under cyclic and dynamic loading
- Stability and seepage safety factors per USACE criteria

7.4 Structural Modeling Approach

Modeling will incorporate coastal-specific processes, including:

- Coupled seepage and stress analysis under fluctuating tidal/surge conditions
- FLAC dynamic modeling with cyclic loading
- Erosion and scour screening (empirical + analytical approaches)

7.5 Summary of Governing Load Cases

1. 1% annual chance storm surge + tide + wave setup
2. Storm surge + wave loading (primary governing case)
3. Wave runup and overtopping condition
4. Steady-state seepage under sustained surge
5. Rapid drawdown following storm recession
6. Erosion/scour-induced reduced section case
7. Extreme coastal storm (risk-informed)
8. OBE seismic loading
9. MDE seismic loading
10. Seismic + high groundwater/surge condition
11. Liquefaction-induced deformation case
12. Uplift and underseepage critical condition
13. Construction staging
14. Surcharge loading

7.6 Factors of Safety and Design Targets

Design will satisfy or exceed minimum USACE factors of safety (FoS) and deformation performance targets for a critical flood risk management system, recognizing that final acceptance will be governed by risk-informed evaluation per ER 1110-2-1806.

7.6.1 Levee Stability (per EM 1110-2-1913 / EM 1110-2-6051)

- End-of-construction stability: FoS ≥ 1.3
- Steady-state seepage (maximum water level): FoS ≥ 1.4 –1.5
- Rapid drawdown: FoS ≥ 1.2 –1.3
- Pseudostatic seismic (OBE/MDE as applicable): FoS ≥ 1.0 –1.1 (with deformation checks governing)

7.6.2 Seepage and Underseepage (EM 1110-2-6050)

- Exit gradient / heave: FoS ≥ 1.5 (typical USACE target)
- Piping/boiling: Factors consistent with critical gradient ratios (risk-informed where warranted)
- Uplift beneath structures: FoS ≥ 1.3 –1.5 against flotation/sliding

7.6.3 Floodwall Stability (EM 1110-2-2502)

- Sliding: FoS ≥ 1.5 (static), ≥ 1.1 (seismic)
- Overturning: Resultant within middle third; FoS ≥ 2.0 equivalent
- Bearing capacity: FoS ≥ 3.0 (static), reduced appropriately for seismic

7.6.4 Deformation-Based Criteria

- Maximum crest settlement and lateral displacement (levees and floodwalls) shall be limited such that:
 - Required freeboard + wave runup margin is maintained, or
 - Residual risk is demonstrated acceptable via fragility/risk analysis
- Permanent seismic and cyclic loading deformations will be explicitly evaluated using FLAC

7.7 Risk-Informed Framework and Fragility Assessment

Consistent with ER 1110-2-1806, the system will be evaluated using a risk-based framework supplementing deterministic design checks.

7.7.1 Failure Modes and Mechanisms

Key potential failure modes to be evaluated include:

- Slope instability (waterside and landside)
- Underseepage, piping, and heave
- Floodwall sliding, overturning, or foundation failure
- Seismic deformation and liquefaction-induced loss of grade
- Wave-induced erosion and structural impact damage

7.7.2 Fragility Curves

- Develop fragility relationships expressing probability of failure vs. loading intensity (e.g., water level, wave height, seismic demand)
- Incorporate uncertainty in geotechnical parameters, hydraulic loading, and modeling assumptions
- Evaluate sensitivity to sea level rise and future conditions

7.7.3 System Reliability

- Consider system-wide performance, including reach transitions, penetrations, and closures
- Identify critical weak links governing overall system reliability

7.7.4 Uncertainty and Sensitivity Evaluation

The analysis will explicitly consider uncertainty in:

- Soil strength and stratigraphy
- Hydraulic boundary conditions (surge, waves, SLR)

- Construction variability
- Model selection (LEM vs FLAC vs empirical methods)

Sensitivity analyses will be performed to:

- Identify controlling parameters
- Support conservative but efficient design decisions
- Provide defensible justification during Engineering Criteria Review Board (ECRB) and permitting reviews

7.8 Documentation for Review and Accreditation

To support USACE, FEMA, and other agency reviews, the following will be documented:

- Clear definition of governing load cases and combinations
- Basis for selected factors of safety and deformation limits
- FLAC modeling approach, calibration, and validation
- Fragility methodology and assumptions
- Demonstration that the system:
 - Meets 44 CFR 65.10 accreditation requirements
 - Achieves acceptable performance under risk-informed criteria

7.9 Dewatering and Groundwater Management During Construction

Groundwater may be encountered in excavations extending into or within proximity to young Bay Mud deposits. Temporary dewatering during construction may be required. An assessment of subsurface water migration rates should be made during initial construction excavation procedures to determine the level of groundwater control and dewatering necessary.

Groundwater may be removed from excavations using sumps, pumps or other methods. The water level at excavation locations should be maintained below the bottom of the excavation. The selection of equipment and methods for dewatering are left to the Contractor. The dewatering system should be designed to prevent pumping soil fines with the discharge water, as uncontrolled dewatering could cause settlement and affect existing improvements near the excavation site.

Groundwater management including temporary storage in Baker tanks (or similar) and testing prior to disposal will likely be a requirement of the San Francisco Regional Water Quality Control Board. With proper treatment groundwater may be discharged directly into San Francisco Bay with appropriate erosion prevention measures.

7.10 Flood Protection during Construction

Temporary flood protection measures may be required during the excavation of existing levees for floodwall foundation construction if the top elevation of the existing levee is reduced to accommodate the new levee or floodwall foundation. A flood barrier at an elevation equivalent to the existing top of levee or shoreline must be installed prior to excavation. Sheet FPD of the 60% plan set shows a schematic flood protection plan during construction. Contractor means and methods would produce the actual plan subject to submittal review prior to implementation.

Temporary sheet pile walls would be one form of a flood barrier, which would also serve to keep tidal water out of the excavation. Other types of barriers are inflatable dams and temporary earthen cofferdams.

7.11 Interior Drainage

Stormwater runoff and drainage on the land side of the levee system must be considered in design, for FEMA accreditation, and to avoid project actions that induce flooding on the interior of the levee that would be considered inverse condemnation of property.

An interior drainage study for the Project has been completed and is included as Appendix E. This study uses the Menlo Park Storm Drain Master Plan hydraulic model focused on the Menlo Park reaches while compatible with similar work undertaken in East Palo Alto for consistency. The model is used to design the drainage handling facilities shown on the 60% plans and will form the basis for an eventual submittal to FEMA as part of the levee certification package.

It may be noted that interior drainage is not a driving factor in the design of this Project.

7.11.1 FEMA Accreditation Requirements

FEMA accreditation requirements for interior drainage are provided in 44 CFR 65.10(b)(6):

An analysis must be submitted that identifies the source(s) of such [interior] flooding, the extent of the flooded area, and, if the average depth is greater than one foot, the water-surface elevation(s) of the base flood. This analysis must be based on the joint probability of interior and exterior flooding and the capacity of facilities (such as drainage lines and pumps) for evacuating interior floodwaters.

Sources of flooding that could potentially contribute to residual interior inundation have been evaluated:

- Land-based runoff
- seepage inflow
- stream overflow
- coastal over-wash (not applicable with this levee system)
- pump stations
- storm drains
- detention or retention ponds and other stormwater management facilities

Interior drainage analyses have been completed using HEC-RAS and the Integrated Catchment Model (ICM) prepared by Wood Rodgers, Inc. for the City of Menlo Park Storm Drain Master Plan in 2023. Both models have been approved by FEMA for such a purpose. The modeled scenarios will be based on joint probability analysis of conditions on both sides of the levee and include, at a minimum, the 1% annual chance event (100-year flood).

The interior drainage study serves two purposes: 1) provides for flood hazard mapping of residual interior drainage per FEMA mapping standards; and 2) verifies that the project as proposed would not increase flood depth where flooding already occurs, or cause flooding where no flooding presently occurs.

7.11.2 Interior Drainage Study Synopsis

Menlo Park SAFER Bay could potentially intercept both local stormwater runoff from Highway 84, the City of Menlo Park's storm drainage system and overflows from San Francisquito Creek.⁷ Figure 7-3 shows the exposure of the Menlo Park SAFER Bay interior to flooding sources based on effective Flood Insurance Rate Maps.

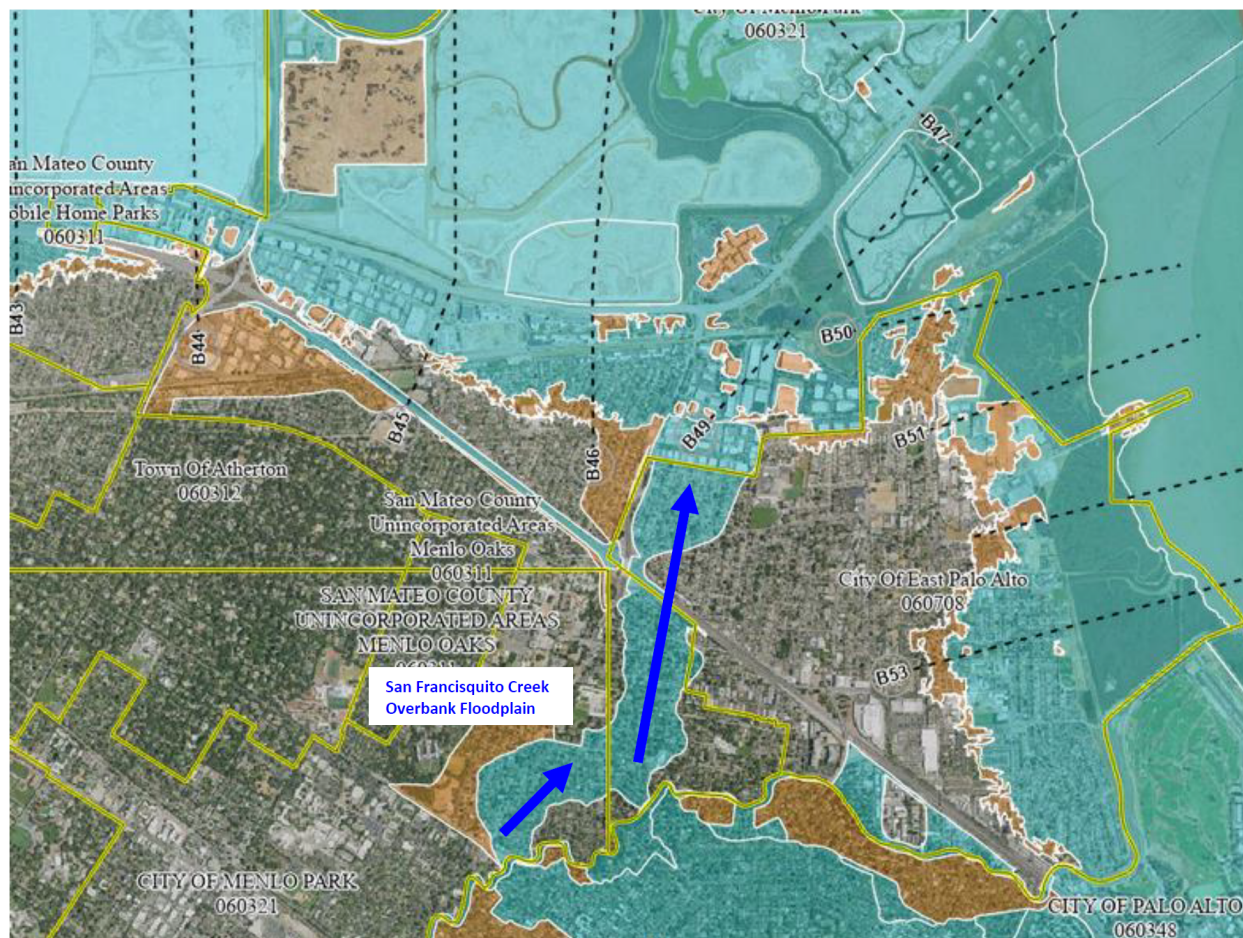


Figure 7-2: FEMA Flood Insurance Rate Map (annotated by ESA, 2025)

The portion of Menlo Park landward of the Substation and Marsh Reach (Figure 2-2) only includes a few landowners: USFWS, PG&E, and Caltrans. These entities manage stormwater on their parcels, and this management is not included in the Menlo Park Stormwater Master Plan. The USFWS owns and manages the former salt Pond R1 (closer to the bay) and Pond R2 (closer to the substation) as wetland habitat. These ponds are currently separated from the bay by a series of berms. Culverts and water control structures associated with these culverts are used to manage water levels in the ponds, which always have water in them. JPA's mitigation action will breach the levees around Pond R1 and R2 to reconnect all of Pond R1 and most of Pond R2 to full tidal exchange with the bay. (ESA, 2025) Stormwater that falls within Pond R1 and the tidal portion of Pond R2 will drain to the bay through these restoration breaches.

⁷ ESA, Draft Memorandum, "Strategy to Advance Flood Protection Ecosystems and Recreation along the Bay (SAFER Bay Project) – Interior Drainage Summary." June 13, 2025.

The SAFER Bay levee will be offset outboard of the substation fill by more than 100 feet. Stormwater currently drains from the PG&E substation fill directly to Pond R2, where it is stored across all of Pond R2's 143 acres for dispersal by evaporation and/or seepage. SAFER Bay levee construction will reduce the inboard storage area of Pond R2 to about 12 acres. Water budgets described in Appendix E suggest the inboard portion of Pond R2 has capacity to store the 30-day duration, one percent annual chance precipitation falling directly on the pond itself and the runoff from the substation parcel.

California Highway 84 and Meta drain to the south and under the Bayfront Expressway to the Ravenswood Pump Station, which is labeled on Figure 2-2. This drainage facility is owned and operated by Caltrans. The pump station drains runoff from a tributary area that includes Meta, Highway 84, a portion of northwest East Palo Alto, and the portion of Menlo Park north of Middlefield Road and east of Del Norte Avenue. (Wood Rodgers, 2023) The pump station has a design capacity of 560 cubic feet per second (cfs). Pump station discharge outfalls are located on the north side of Highway 84 at a headwall at the upper end of Ravenswood Slough, which flows directly to San Francisco Bay. A gravity outfall with a tide gate is in the same headwall, providing drainage for the open space south of the expressway between the pump station and University Avenue, colloquially known as "the triangle".

SAFER Bay's proposed levee alignment (Control Line 1 on the 35% plan set and Control Line 2 on the 60% plan set) crosses the tidal slough in line with the levee segment along the north side of the campus. This alignment creates a shorter levee segment compared to the longer alignment around the channel. However, this alignment also creates the need for either a tidal basin or pump station located within the slough remnant created by the proposed project. The feasibility and cost of additional drainage features have been evaluated against an optional alignment that leaves the tidal slough intact but may require modifications to the Ravenswood Pump Station as further discussed in Section 9.

Runoff from Highway 84 along the Bayshore Expressway Reach is also routed to the Ravenswood Pump Station. South of the expressway, interior drainage is tributary to the nearly rehabilitated Chrysler Pump Station and should not be of concern to Menlo Park SAFER Bay, but rather the Bedwell Bayfront Park Reach.

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8. Estimated Construction Value

Appendix F contains detailed quantity estimates and calculations for the estimated construction value of Menlo Park SAFER Bay. These are summarized at a high roll-up level in Table 8-1. Costs are in 2026 dollars, which could be escalated to future dates using an assumed annual discount rate and construction mid-point. The estimated construction subtotal is \$300 million including the optional interior wall across the front of the PG&E substation. A 30% design contingency is added to reflect plan development at the 60% submittal. An allowance of \$7 million is added for property acquisition that may include Meta and will include the State Lands Commission leases. The total estimated construction value is \$400 million.

Table 8-1: Menlo Park SAFER Bay 60% Cost Estimate

#	Item Description	Qty	Unit	Unit Cost (\$)	Total Cost (\$ M)
1	Mobilization (6%)	1	LS	12,600,000	12.6
2	Bonds and Insurance (2.5%)	1	LS	5,300,000	5.3
3	Pedestrian & Traffic Control (4%)	1	LS	8,400,000	8.4
4	Work Planning & Submittals (0.5%)	1	LS	1,100,000	1.1
5	Erosion Control & SWPPP Measures (4%)	1	LS	8,400,000	8.4
6	Temporary Shoring & Excavation Protection (4%)	1	LS	8,400,000	8.4
7	Cofferdams and Dewatering	1	LS	7,600,000	7.6
8	Site Preparation, Clearing, and Demolition	2,500,000	SF	2.5	6.3
9	Levee Degrade and Handling	63,000	CY	55	3.5
10	Concrete Floodwall (STA 259+25 to STA 263+30)	405	LF	23,000	9.3
11	Ravenswood Pump Station Outfall Modification	1	LS	4,000,000	4.0
12	Concrete Floodwall (STA 264+60 to STA 273+20)	860	LF	25,000	21.5
13	Ground Improvement	700,000	CY	140	98.0
14	Off Haul	150,000	CY	45	6.8
15	Imported Select Levee Fill	50,000	CY	60	3.0
16	Miscellaneous Concrete Walls and Structures	1	LS	500,000	0.5
17	Rock Slope Protection	7,500	SF	100	0.8
18	Lift PGE High Voltage Power Line	1	LS	1,000,000	1.0
19	Bay Trail Access Ramps, Overlooks, Paving, Furnishings	1	LS	2,500,000	2.5
20	Landscape Planting, Irrigation, and Topsoil	1	LS	22,000,000	22.0
21	Restoration Planting, Top Soil, & Environmental Fill	1	LS	5,000,000	5.0
22	Utility Relocation and Reconstruction	1	LS	7,000,000	7.0
23	Asphalt Concrete Trail Paving and Trail Markings	220,000	SF	15	3.3
24	Trail Shoulders & Curb	18,000	LF	300	5.4
25	Design-build Pedestrian Bridge	1	EA	2,000,000	2.0
26	Restoration of Damaged Improvements	1	LS	500,000	0.5
27	Plant Maintenance	1	YR	250,000	0.3
28	All Work of Contract Not Specified Elsewhere	1	LS	500,000	0.5
29	Daily Rate for Compensable Delay	60	DAY	1,000	0.1
30	Concrete Floodwall and Flood Gates at PG&E	1,640	LF	29,000	47.6
SUBTOTAL					\$ 302 M
30% DESIGN CONTINGENCY					\$ 91 M
META PROPERTY ACQUISITION AND SLC LEASE					\$ 7 M
TOTAL ESTIMATED CONSTRUCTION COST					\$ 400 M

This estimate of construction cost is a professional opinion, based upon the engineer's experience with the design and construction of similar projects. It is prepared only as a guide and is based upon incomplete information. The estimate is subject to change. Schaaf & Wheeler makes no warranty, whether expressed or implied, that the actual costs will not vary from these estimated costs and assumes no liability for such variances. This estimate specifically excludes any costs associated with designing for, handling and disposal of hazardous waste and contaminated materials. Permitting costs are excluded.

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9. Value Engineering

The larger SAFER Bay project has been conceived through a rigorous process over several years and Menlo Park SAFER Bay does not seek to dramatically change the program-level work or affect the environmental documentation in progress.

Nonetheless, more detailed design offers opportunities for value engineering concepts that have been evaluated to lower the \$450 million estimated project cost at the 35% completion level, or help offset some increases in project cost occasioned by more detailed design work. Seven value engineering concepts have been evaluated and six of these have been incorporated into the 60% design and cost estimate as highlighted in blue.

1. Levee fill materials
2. Settlement mitigation
3. Seepage control
4. Landscape program
5. Alignment at Ravenswood Slough
6. Alignment between Pond R4 and R5
7. Alignment at PG&E substation

9.1 Levee Fill Materials

Table 9-1 presents modeled earthwork quantities based on the grading plan provided with the 35% plan set and revisions made to the 60% plan set. At the 35% design level, most of the soil excavated as part of the levee degrade would be unsuitable for reuse within the project, so these quantities were mostly off haul and import.

Ground improvements described for settlement mitigation in Section 9.2 mitigate the need for levee degrades while producing treated spoils that can be used as levee fill material. This helps reduce both off haul and import with a better balance of on-site materials.

Table 9-1: Estimated Import and Off Haul Quantities Based on Design Progression

	35% Quantity	60% quantity
Levee Degrade (excavation – off haul)	289,000 cubic yards	150,000 cubic yards
Levee Fill Material (import)	826,000 cubic yards	150,000 cubic yards
Total Earthwork	1,115,000 cubic yards	300,000 cubic yards

The cost to off haul and dispose unsuitable material and likewise source, import, and stockpile suitable levee fill has been replaced with the cost to complete ground improvements through deep soil mixing. Horticultural, wetland suitability, and other requirements make some fill import inevitable.

Earthwork and ground improvement accounts for about 40 percent of the estimated Project cost, so value engineering will continue through to the bid documents to specify appropriate alternative fill materials in conjunction with seepage control methods described in Section 9.3.

9.2 Settlement Mitigation

Differential settlement transverse to the levee alignment needs to be managed since newly placed levee fill will cross previously consolidated YBM near the road and previously unconsolidated YBM further into the Baylands. Settlement mitigation represents performance-added value rather than necessarily cost savings.

The primary geotechnical concerns associated with the project improvements are non-uniform consolidation settlement of Young Bay Mud (YBM) and slope stability. Geotechnical measures considered feasible for the project to mitigate these concerns are discussed herein.

9.2.1 Cellular Concrete

Cellular concrete is a low-density material consisting of a cement and water mixture injected with stable foam. The material can cure in-place to a unit weight of approximately 30 pounds per cubic foot (pcf) (i.e., 90 pcf less than the typical unit weight of soil). To limit consolidation settlement, cellular concrete can be used as fill to raise site grades, in lieu of heavier soil fill.

Where settlement is detrimental to the existing or planned improvements, existing heavier onsite soil can be over-excavated and replaced with cellular concrete such that there is no increase in load, resulting in negligible future settlement. Cellular concrete also has a high shear strength compared to soil fill, and its use as fill in lieu of soil fill will improve potential slope stability concerns, which could potentially result in steeper bank slopes and substantial savings in fill quantities. It would also result in reduced or potentially negligible lateral earth pressures on structural floodwalls, sheet pile walls, or other retaining walls for public access trails, ramps, and overlooks.

Unfortunately, where settlement is excessive at the east end of the Project alignment, there is not sufficient existing fill to be degraded and replaced with lightweight material to create the load offset (i.e. a neutral or minimal increased load), while not becoming buoyant and unstable. The feasibility of this technique is likely limited to the western extents where preliminary estimates show that settlement is not especially problematic.

9.2.2 Surcharge Fill

A surcharge program can be used to pre-consolidate YBM deposits by placing extra fill over improvement areas to adequately drive consolidation of the YBM and preload the soil to loads higher than the weight of the planned fills. The surcharge fill areas, grades and extent would be determined during design depending on desired surcharge period, planned loads, and surcharge materials to allow the desired degree of consolidation to be achieved. Surcharge fill may be used in combination with wick drains (used to accelerate settlement rates).

Given the quantity of earthwork and need to store and stage fill, that staging and storage could potentially be along the levee alignment so that additional fill is not needed for the surcharge program. One downside is that the logistics of this may interfere with a contractor's means and methods of scheduling and come with some additional cost risk.

Surcharging that accelerates settlement could result in a better performing levee system, particularly when considering the paved Bay Trail. Furthermore, a surcharge program could also lower the required top of constructed levee elevation to meet flood protection requirements and save material and labor costs. That said, while the total amount of consolidation settlement can be predicted with some uncertainty, it is very difficult to predict the rate of settlement before the surcharge program is underway and carefully monitored. This uncertainty increases bid pricing.

9.2.3 Ground Improvement

Ground improvement is preferred over conventional surcharge/settlement programs for this Project due to schedule, performance reliability, and reduced risk of post-construction deformation in soft foundation soils. Surcharge methods rely on time-dependent consolidation and require extended durations, significant preload heights, and careful observational management, with residual settlement risk remaining particularly in thick deposits of soft cohesive soils.

Ground improvements like rigid inclusions and deep soil mixing (DSM), however, provide immediate enhancement of stiffness, strength, and deformation control, enabling earlier construction of levee loads and improved predictability consistent with USACE risk-informed design. For the site-specific condition of Young Bay Mud (YBM) ranging from approximately 5 feet to 35 feet below ground surface (bgs), DSM is expected to outperform rigid inclusion systems such as rammed aggregate columns.

The YBM is characterized by very low shear strength, high compressibility, and limited lateral confinement, which reduces the effectiveness of rigid inclusions that rely on mobilization of surrounding soil to provide confinement and load transfer. In contrast, DSM creates a continuous soil-cement matrix, significantly increasing undrained shear strength, reducing compressibility, and providing both bearing support and seepage reduction independent of native soil confinement. Additionally, DSM is less sensitive to variability in stratum thickness and can be designed to form cutoff or stiffness zones compatible with levee stability and seepage control requirements. As such, DSM provides a robust and reliable ground improvement solution for thick YBM deposits in a coastal levee system.

Deep soil mixing can also significantly reduce long-term subsidence locally, albeit without eliminating regional subsidence. The ground improvement technique fundamentally alters the soil behavior by reducing compressibility since the soft clay is converted into a soil-cement composite. This dramatically lowers both the compression index (C_c) and secondary compression index (C_α). Creep mechanisms are eliminated within the DSM treatment zone since the injection of cementitious material locks soil particles and prevents viscous rearrangement to effectively suppress the secondary compression. Loads are transferred deeper and the DSM columns act as stiff inclusions and load-sharing elements that reduce the effective stress carried by untreated YBM, thus minimizing consolidation settlement.

Cost estimates presented with this Basis of Design assume that the entire levee base footprint will be treated with DSM through the YBM to the stiffer material below, except for the structural floodwall along Highway 84 and the east side of Meta which will be founded on a grade beam and deep pile foundation. Should even more cost-effective settlement mitigation measures be employed toward the Bedwell Park end of the system, overall Project costs could be further reduced.

FLAC modeling for a DSM supported embankment focuses on simulating soil-cement columns and the surrounding soft foundation. This requires a coupled mechanical-fluid flow approach in either FLAC2D (plane-strain) or FLAC3D. The analysis determines settlement, overall stability, and load-transfer mechanisms between the embankment and the columns. However, based on the value engineering completed to date, DSM appears to be a viable and cost-effective settlement mitigation strategy in lieu of a lengthy surcharge program during and after construction.

Geogrid reinforcement can be placed in soil fills in conjunction with the ground improvement to create a composite soil material with increased strength and stiffness compared to general soil fill. Geogrid has limited use where underground utilities/trenching are present, although such locations will be limited. In addition, geogrid cannot be used in conjunction with cellular concrete as described above. Geogrid reinforcement should be considered in the following applications.

- Geogrid can be placed in general soil fill placed to raise grades within the levee improvement prism. The geogrid-reinforced fill will create a composite soil material that will settle more uniformly compared to soil fill and reduce potential for differential settlement and associated distress to surface improvements (such as asphalt paving) along the levee alignment. It will also result in reduced or potentially negligible lateral earth pressures on structural floodwalls, sheet pile walls, or other planned retaining walls. For planning purposes, geogrid should be assumed to be placed at a vertical spacing of 16 to 32 inches, with a minimum of 16 to 24 inches from the top layer of geogrid to planned finished grade.
- Geogrid reinforcement can be used in design and construction of mechanically stabilized earth (MSE) retaining walls. In general, MSE walls can typically tolerate larger vertical and lateral displacements, as compared to conventional structural walls leading to improved performance. The relative cost of building the more labor-intensive MSE walls compared to conventional cast-in-place concrete retaining walls needs to be weighed.
- Geogrid can also be used in design and construction of reinforced soil slopes (RSS). In general, design slope gradients are limited to 3:1 to 2:1 (horizontal:vertical) for general soil fill. The use of RSS will increase the stability of planned slopes, and potentially allow for steeper slope gradients than general soil slopes. In addition, RSS provide additional lateral confinement at the face of graded slopes, reducing erosion concerns and potentially allowing for heavier equipment during construction.

9.3 Seepage Control

Seepage control is typically achieved by using select levee material with low permeability and benching that material into the underlying impermeable YBM. Preliminary seepage evaluations suggest that because of the impermeable YBM, underseepage is not a design issue.

Deep soil mixing (DSM) provides effective through-seepage control when treated spoils are reused in the levee prism because the process fundamentally alters the hydraulic properties of both the foundation soils and the constructed embankment material. The in-situ mixing of cementitious binders with Young Bay Mud produces a low-permeability soil–cement matrix (typically several orders of magnitude lower hydraulic conductivity than untreated YBM), which interrupts seepage pathways and reduces pore pressure transmission beneath the levee. When DSM-treated spoils are excavated and placed within the levee prism, they retain this reduced permeability and improved gradation, thereby forming a levee section that is inherently less susceptible to internal seepage compared to conventional compacted fills. In combination, the continuous DSM columns or panels in the foundation act as a vertical seepage barrier (or cutoff), while the levee constructed with treated material reduces horizontal seepage gradients, resulting in an integrated system that limits through-seepage, mitigates uplift pressures, and improves overall seepage stability.

9.4 Landscape Program

The conceptual landscape program of planting and irrigation and the concomitant import of horticulturally suitable soil represents about 9 percent of the total project cost. This is not an exorbitant proportion for such a public-facing amenity. The recommendation at this stage is to publicly discuss what an appropriate budget for landscape is relative to available funds and continue to value engineer (architect) this part of the project.

9.5 Alignment at Ravenswood Slough

SAFER Bay's proposed levee alignment (Control Line 1 on the 35% plan set) crosses the tidal slough in line with the levee segment along the north side of the Meta campus. This alignment creates a shorter levee segment (about 600 feet) compared to the longer flood protection alignment shown on the 60% plans that is about 2,130 feet long.

The floodwall alignment is selected for final design because the JPA's levee alignment necessitates a large pumping facility to handle discharge through the Ravenswood Slough outfall, a second time in case of water from Caltrans' Ravenswood Pump Station. The estimated capital cost of such a facility, based on a capacity greater than 560 cfs (more likely on the order of 750 cfs), is \$50 million including contingencies. This completely ignores ongoing energy and maintenance costs to operate and maintain such a facility, let alone the increased liability to whomever operates this facility should it malfunction and flood Highway 84 or the Meta campus.

The control line alignment shown on the JPA plans is far better for the Bay Trail, so a pedestrian bridge spanning Ravenswood Slough is proposed along that alignment, with access to the Meta Campus and the crosswalk at University Avenue. This will be a design-build element.

9.6 Alignment Between Pond R4 and Pond R5

Rather than vary from the existing levee centerline alignment between Bayfront Expressway and the southern approach to Bedwell Bayfront Park as shown in the JPA plan set, the 60% plan set follows the existing levee alignment.

There are two major benefits to this alignment:

1. Without moving off the existing embankment, settlement is much reduced and degrading the existing levee degrade is unnecessary. Material off haul and material import are significantly less than originally planned.
2. The JPA-proposed alignment would require the demolition and rebuilding of pond interconnect structures, which can be avoided using structural wall systems at pond interconnect crossings to keep maintenance access and water control operation intact.

9.7 Alignment at PG&E Substation

Realigning the levee around the perimeter of the PG&E substation has been considered, to avoid the potential drainage issue (which does not seem like a significant issue) and keep the levee closer to previously consolidated YBM to reduce the predicted levee settlement. Discussion with the JPA and HDR, however, verified that the SAFER Bay alignment has been established after careful thought and would good reason, to avoid issues with transmission line and transmission tower clearances. Not relocating any transmission facilities is paramount. Furthermore, the distance between the levee and substation means PG&E is comfortable with pedestrian access to this reach of the Bay Trail.

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Appendix A SAFER Bay Design Criteria

As part of their 10% and 30% Designs for the JPA, HDR, Inc. established programmatic design criteria. Their September 6, 2024 “Design Criteria and Considerations Technical Memorandum” is appended in its entirety for reference.

Design Criteria and Considerations Technical Memorandum

Strategy to Advance Flood Protection Ecosystems, and Recreation along the Bay (SAFER Bay Project)

East Palo Alto and Menlo Park

San Francisquito Creek Joint Powers Authority

10% and 30% Designs

Cities of East Palo Alto, Palo Alto, and Menlo Park, San Mateo County, California

September 6, 2024

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Contents

1	Introduction	1
1.1	Purpose and Scope	1
1.2	Project Description	1
1.2.1	East Palo Alto and Menlo Park Project Area	1
1.2.2	Project Features	3
1.2.3	Project Area Descriptions	4
2	Levee Design Criteria	6
2.1	General Levee and Embankment Cross-Sectional Geometry	6
2.2	Levee and Embankment Fill Material	6
2.3	Underseepage and Through Seepage	7
2.4	Static Slope Stability	8
2.5	Seismic Stability Analysis	9
2.6	Levee Settlement	9
2.7	Embankment Protection	9
2.8	Levee Vegetation and Aquatic Life Contaminant Criteria	9
2.8.1	Levee Vegetation	9
2.8.2	Soil Contaminant Criteria for Protection of Aquatic Life in the Baylands	11
3	Civil Design Criteria	11
3.1	Penetrations and Encroachments	11
3.1.1	Levee Penetrations	11
3.1.2	Encroachments	12
3.2	Maintenance and Monitoring	14
3.3	Real Estate, Construction Access, and Staging	14
4	Structural Design Criteria	14
4.1	Floodwalls	14
4.1.1	Sheet Pile Floodwalls	15
4.1.2	Sheet Pile Material	15
4.1.3	Unit Weights	16
4.1.4	Design loads and loading Summary	16
4.1.5	Geotechnical Design Inputs and Foundation Properties	16
4.1.6	Strength Design for Floodwalls	17
4.1.7	Stability Evaluation Criteria	17
4.2	Appurtenant Structures	17
4.3	Structural Codes, Standards, and Regulations	17
5	Hydraulic Design Criteria	18
5.1	Hydraulic and Wave Modeling of Existing Hazards	19
5.2	Sea Level Rise	19
5.3	Design Water Surface Elevations with Sea Level Rise	20
5.4	Freeboard	20
5.5	Top of Levee and Floodwall Crown Elevation	21
6	References	21
6.1	Design Criteria Documents	21



6.1.1 US Army Corps of Engineers 21
 6.1.2 Other Federal Agencies 22
 6.1.3 State / County Agencies..... 22
 6.2 Design Reference Documents 23

Figures

Figure 1. 10% and 30% Project Locations 2
 Figure 2. Definition of Sheet Pile Wall Height 15

Tables

Table 1. Project Features 3
 Table 2. Sea Level Rise Projections for San Francisco, in Feet above 2000 Baseline..... 20

Appendices

Appendix A. *Hydraulic Review Technical Memorandum* (In Development)A-1

1 Introduction

1.1 Purpose and Scope

The San Francisquito Creek Joint Powers Authority (SFCJPA) is a regional government agency founded by the cities of East Palo Alto, Menlo Park, and Palo Alto, the San Mateo County Flood Control District and Santa Clara Valley Water District in 1999. SFCJPA is implementing the Strategy to Advance Flood protection, Ecosystems and Recreation along the San Francisco Bay (SAFER Bay) Project which addresses sea level rise and inundation, ecosystem restoration, and recreational improvements along the south San Francisco Bay shoreline.

The existing FEMA flood study mapping places East Palo Alto's and Menlo Park's entire Bay shoreline within the Special Flood Hazard Area for the 100-year coastal flood event (also referred to as the 1% annual chance of exceedance event or the base flood). This designation indicates that these communities are at risk of coastal flooding. Sea level rise will further exacerbate these coastal flood hazards.

To address these flood hazards, SAFER Bay comprises construction of new or improved flood risk reduction features along the Bay shoreline from the Menlo Park and Redwood City border south to San Francisquito Creek, where another SFCJPA flood protection ecosystem restoration project was recently completed along the East Palo Alto and Palo Alto border. Previous feasibility studies were completed in 2016 for reaches within East Palo Alto and Menlo Park, and in 2019 for Palo Alto. The current effort advances design for features within East Palo Alto and Menlo Park, referred to as Reaches 1 – 9 in previous studies.

The purpose of this document is to summarize the design criteria and considerations that have guided development of plans, specifications, and cost estimates (PS&E) for the SAFER Bay Project. Design criteria are defined for all major project components. These criteria also consider easements, stormwater collection and discharge, tidal effects, freeboard and uncertainty, Federal Emergency Management Agency (FEMA) Conditional Letter of Map Revision (CLOMR), efficiency, effectiveness, and acceptability of the overall project.

1.2 Project Description

1.2.1 East Palo Alto and Menlo Park Project Area

The SAFER Bay Project subject to this report extends from the Menlo Park and Redwood City border (including unincorporated areas) south to San Francisquito Creek along the East Palo Alto and Palo Alto border. In addition to protecting East Palo Alto and Menlo Park, this project will contribute to regional coastal flood protection for the neighboring City of Redwood City which could be inundated by coastal flooding via Menlo Park. The locations of the SAFER Bay Projects are shown on Figure 1.



Figure 1. 10% and 30% Project Locations

1.2.2 Project Features

Previous studies divided the Project into 9 reaches based on local geography and referred to them collectively as SAFER Bay East Palo Alto and Menlo Park. These reach limits have been modified since the feasibility study based on current design information and to package certain project areas and features together. There are currently three 30% design packages developed and the rest of SAFER Bay East Palo Alto and Menlo Park is considered a single 10% design package. A summary is provided in Table 1 which compares reach designations in the 2019 Feasibility Report to the current design effort. Note that these comparisons are approximate.

Table 1. Project Features

Level of Design (%)	Description	From STA	To STA	Current Description
30%	South of Bay Road Project	0+00	52+28	Floodwall with Embankment Embankment Crown Width: 20-feet Side Slopes: 3:1 Horizontal:Vertical (H:V) waterside, 2:1 with geogrid landside Top of Embankment Elevation: 14-feet NAVD 88 Sheet Pile Wall: Top Elevation: 16.5-feet NAVD 88 Tip Elevation: -25 to -40-feet NAVD 88
10%	North of Bay Road Project	52+00	119+50	Levee: Crown Width: 20-feet Side Slopes: 3H:1V Top of Levee Elevation: STA 52+00 to 98+25 17.5-feet NAVD 88 STA 98+25 to 119+00 18.5-feet NAVD 88 STA 119+00 to end 21.4-feet NAVD 88
30%	Pond SF2/Dumbarton Bridge Approach Project ¹	118+12	151+66	Levee: Crown Width: 20-feet Side Slopes: 3H:1V Top of Levee Elevation: 21.6-feet NAVD 88 Habitat Restoration: Modifications to Pond SF2 not included in Plans
10%	Dumbarton Approach Project	149+00	192+00	Sheet Pile Wall: Top Elevation: 18.4-feet NAVD 88
30%	Substation and Marsh Restoration Project ¹	190+00	243+00	Levee: Crown Width: 20-feet Side Slopes: 3H:1V Top of Levee Elevation: 21.0-feet NAVD 88 Bayside Habitat Berm: Side Slope: 10H:1V Habitat Restoration: Modifications to Ponds R1 and R2 not included in Plans

Level of Design (%)	Description	From STA	To STA	Current Description
10%	Tech Campus Project	242+00	293+00	Levee, STA 242+00 to 259+75: Crown Width: 20-foot Side Slopes: 3H:1V Top of Levee Elevation: 19.3-feet NAVD 88 22.3-feet NAVD 88 at new pump station Floodwall, STA 259+75 to 293+00 Top Elevation: 16.5-feet NAVD 88
10%	Bayfront Expressway Project	293+00	359+16	Levee: Crown Width: 20-foot Side Slopes: 3H:1V Top of Levee Elevation: STA 293+00 to 332+00 19.6-feet NAVD 88 STA 332+00 to 359+16 17.3-feet NAVD 88
10%	Bedwell Bayfront Park Project	333+00 500+07	359+16 507+50	Levee: Crown Width: 20-foot Side Slopes: 3H:1V Top of Levee Elevation: 18.7-feet NAVD 88
10%	Marsh Road Project	507+50	539+15	Levee: Crown Width: 20-foot Side Slopes: 3H:1V Top of Levee Elevation: 18.9-feet NAVD 88

¹See document ***SAFER Bay Preliminary Wetland Habitat and Western Snowy Plover Impacts and Restorations*** for habitat restoration design documentation.

1.2.3 Project Area Descriptions

The following describes and defines the limits of each 30% design package and the remaining portions of the Project at a 10% design level:

30% South of Bay Project Area Description

The South of Bay Road Project extends approximately 5,250-feet along an existing embankment south from Bay Road, across Runnymede Street, to the O'Connor Pump Station, which is the terminus of the SFCJPA's Bay to Highway 101 Creek Project for flood protection, ecosystem restoration, and recreation.

30% Pond SF2/Dumbarton Bridge Approach Project Area Description

South Bay Salt Ponds Restoration Project (SBSPRP) Pond SF2 is a non-tidal pond managed for shorebird habitat which abuts the southern Highway 84 frontage road. The Dumbarton Bridge Approach/Pond SF2 Project extends approximately 3,200-ft from the Highway 84 frontage road south across Pond SF2.

30% Substation and Marsh Restoration Project Area Description

The PG&E Ravenswood Electrical Substation is located north of Highway 84 near the Dumbarton Bridge between the highway and SBSPRP Pond R2. The 30% Project extends approximately 5,600-feet westerly around the waterside of the substation and connects to the berm parallel to the northside of Highway 84 north frontage road.

10% SAFER Bay East Palo Alto and Menlo Park Projects Area Descriptions

The remaining areas of the East Palo Alto and Menlo Park Project are described below:

North of Bay Road Area Description

This portion of the Project extends approximately 6,700-feet north from Bay Road, east of an area of existing high ground known as the “391 Demeter Street” parcel, across railroad right-of-way, to the existing berm on the south side of Pond SF2 and the 30% Pond SF2/Dumbarton Bridge Approach Project.

Dumbarton Approach Area Description

This portion of the Project extends from the north limit of the 30% Pond SF2/Dumbarton Bridge Approach Project, at the southern Highway 84 frontage road, along the frontage road, under the Dumbarton Bridge, and along the northern frontage road to the northeastern limit of the 30% Substation and Marsh Restoration project.

Tech Campus Area Description

This portion of the Project extends from the pedestrian and bicycle undercrossing of Highway 84 near the Meta campus, around the waterside of the campus, past the Ravenswood Pump Station Outfall, to the southwestern limit of the 30% Substation and Marsh Restoration project.

Bayfront Expressway Area Description

This portion of the Project extends approximately 6,600-feet from high ground within Bedwell Bayfront Park, south along SBSPRP Ponds R5, R4, and R3, then east along the southern limit of Pond R3 and the Bayfront Expressway to where the levee departs from the expressway west of the existing pedestrian and bicycle undercrossing near the Meta campus.

Bedwell Bayfront Park Area Description

This portion of the Project extends north-south between Flood Slough and Ponds R5 and S5 from high ground within Bedwell Bayfront Park.

Marsh Road Area Description

This portion of the Project extends west from Marsh Road, through the Silicon Valley Clean Water pump station yard, along the Bay Front Canal to the border of unincorporated San Mateo County, Menlo Park, and Redwood City.

2 Levee Design Criteria

SAFER Bay flood protection improvement design will follow Federal and State guidelines and design standards, included in the following regulations:

- Code of Federal Regulations (CFR), Title 44, Volume 1, Chapter I, Section 65.10 (44 CFR 65.10)
- California Code of Regulations (CCR) Title 23

While Title 23 is specific to California's Central Valley, applicable standards of practice are referenced from this document wherever practicable. In addition to these publications, HDR recommends following applicable USACE and DWR guidelines for the design of flood protection systems. While the CFR and CCR reference several USACE publications, there are several additional documents that provide standards and guidance for analyses and practices relevant to levee and floodwall construction and maintenance.

For levees and floodwalls to be accredited by FEMA, they must be certified by a licensed professional engineer or a Federal agency responsible for their design. Certification is a finding that, with reasonable assurance, sufficient data exists that the system in question provides protection from the 100-year flood event. These requirements are outlined in 44 CFR 65.10. The USACE and DWR criteria are followed for the design of levees and floodwalls based on the requirements of 44 CFR 65.10 as well as recent publications not cited in 44 CFR 65.10. This includes design criteria for levee and floodwall geometry, seepage, slope stability, and levee and floodwall settlement. Additionally, requirements for freeboard, closure structures, embankment erosion protection, interior drainage, and the requirements for an O&M plan are addressed in 44 CFR 65.10.

The most recent USACE published documents, including Engineer Manuals (EM), Engineer Regulations (ER), Engineer Circulars (EC) and Engineer Technical Letters (ETL) are the basis for the design criteria. These references can be found in Section 6.1.

2.1 General Levee and Embankment Cross-Sectional Geometry

USACE EM 1110-2-1913, Design and Construction of Levees (USACE 2000), was consulted for determining the minimum levee and embankment geometry. Based on this document, the following levee and embankment sections are used for levee design:

- Minimum levee/embankment crown width of 16 ft.
- Landside slope 3H:1V or flatter, or 2H:1V with geogrid.
- Levee waterside slope 3H:1V or flatter.

2.2 Levee and Embankment Fill Material

EM 1110-2-1913 does not provide specific requirements for levee fill material. Based on the available geotechnical data, previous experience and industry standard practice, the following material types are recommended:

- Levee Embankment Fill:
 - Liquid Limit (LL) less than or equal to 45.
 - Plasticity Index (PI) greater than or equal to 10 and less than or equal to 25.
 - Portion passing 2.5-inch sieve is 100%.
 - Portion passing No. 4 sieve is greater than or equal to 70%.
 - Fines content (Passing No. 200 sieve) is greater than or equal to 30%.
- Habitat Berm and General Purpose Fill:
 - All suitable borrow or existing embankment material.

See Section 2.8.2 below regarding soil contamination criteria.

2.3 Underseepage and Through Seepage

Levee, embankment, and floodwall stability can be compromised if hydraulic exit gradients caused by relatively high underseepage pressures exceed allowable values. Excessive hydraulic exit gradients can result in the formation of sand boils, piping, and levee failure if left unrepaired. Similarly, seepage through the levee or embankment can result in seepage breakouts on landslide levee/embankment slope and reduce levee, embankment, and floodwall stability.

The following USACE and DWR publications are used to evaluate underseepage and through seepage for the project levees, embankments, and floodwalls:

- EM 1110-2-1913, Design and Construction of Levees (USACE 2000).
- EM 1110-2-2502, Floodwalls and Other Hydraulic Retaining Walls (USACE 2022).
- California Department of Water Resources (DWR) Urban Levee Design Criteria (ULDC) (DWR 2012).
- DWR Guidance Document for Geotechnical Analyses, Urban Levee Evaluation (ULE) Project (DWR 2015) (hereafter “ULE Guidance Document”).

Geotechnical design criteria for the South of Bay Road segment are presented below. Design criteria for the project areas north of Bay Road will need to be established at a later time based on the design water surface elevations (DWSEs) in those areas and following the design guidance documents in effect at that time.

To comply with FEMA requirements, the proposed embankment/floodwall is intended to provide 100-year flood protection (Elevation 13.0 feet NAVD 88) plus 3.5 feet of Sea Level Rise (SLR) resulting in a final top of floodwall elevation of 16.5 feet. Elevation 13.0 feet is based on a 100-year flood elevation of 11.0 feet plus 2 feet of freeboard. Therefore, the design water surface elevation (DWSE) for analysis will be taken as 11.0 feet for the purpose of steady state seepage and stability analyses. To account for larger floods, as well as sea level rise, analyses were also performed with the flood level at the target top of embankment or floodwall elevation of 16.5 feet. This higher water level was designated as the Hydraulic Top of Levee (HTOL) herein.

For the purpose of selecting minimum Factor of Safety criteria (hereafter “FOS criteria”) for seepage and stability analyses, the DWSE of 11.0 feet will be taken as an “unusual”

load, and the HTOL of 16.5 feet was taken as an “extreme” load per USACE floodwall criteria in EM 1110-2-2502. Specific minimum FOS criteria selected for the project are discussed in subsequent sections. Further, a site classification of “ordinary” was assumed per EM 1110-2-2502. Note that the site does not currently meet the ordinary site classification definition which requires that subsurface investigations be spaced at a maximum of 500 feet and that sampling be performed within each geologic unit. Currently, there are several areas where spacing of investigation is greater than 500 feet, and quality sampling within the marsh soils (within which portions of the embankment/floodwall will be founded) is not currently available. Additional investigations would need to be performed in future design phases in order to fill these data gaps to meet the ordinary site classification requirements. HDR judges that designing the embankment/floodwall for the significantly higher minimum FOS criteria associated with a “limited” site classification per EM 1110-2-2502 would be unfeasible.

Allowable vertical exit gradients for each Water Surface Elevation (WSE) will be evaluated based on minimum vertical gradient FOS criteria using ordinary site classification in EM 1110-2-2502, as follows:

- Minimum vertical gradient FOS of 2.0 for the DWSE of 11.0 feet (unusual load category).
- Minimum vertical gradient FOS of 1.6 for the HTOL of 16.5 feet (extreme load category).

The vertical gradient Factor of Safety (FOS) will be evaluated as the ratio of the critical exit gradient (i_c) to the allowable exit gradient (i_e). The critical exit gradient (i_c) is calculated as the ratio of the buoyant unit weight (γ_b) of the blanket layer to the unit weight of water (γ_w). The maximum total unit weight (γ_t) used to evaluate the critical gradient is 112.5 pcf per the ULE Guidance Document.

FOS = minimum required factor of safety

$$\text{FOS} = \frac{i_c}{i_e}$$

Where:

$$i_c = \frac{\gamma_b}{\gamma_w} = \frac{(\gamma_t - \gamma_w)}{\gamma_w}$$

$$\gamma_t \leq 112.5 \text{ pcf}$$

2.4 Static Slope Stability

Static stability analyses will be performed to evaluate the proposed embankment/floodwall configurations for the conditions and minimum stability FOS criteria listed below:

- Long-term landside stability under steady state seepage conditions will be evaluated based on minimum stability FOS criteria for global stability of floodwalls in EM 1110-2-2502 with an ordinary site classification:
 - Minimum FOS of 1.5 for the DWSE of 11.0 feet (unusual load category).

- Minimum FOS of 1.4 for the HTOL of 16.5 feet (extreme load category).
- Waterside rapid drawdown conditions will be evaluated following guidance in EM 1110-2-1902 Slope Stability (USACE 2000):
 - Minimum FOS of 1.3 for the DWSE of 11.0 feet.
 - Minimum FOS of 1.1 for the HTOL of 16.5 feet; and
- End of construction (EOC) stability: minimum FOS of 1.3 per EM 1110-2-1902 Slope Stability (USACE 2000) and EM 1110-2-1913 Design and Construction of Levees (USACE 2000).

2.5 Seismic Stability Analysis

Following the guidelines presented in the ULDC, the seismic hazard level for seismic assessment of a levee or embankment is typically taken at the same return period as the design flood condition. Therefore, a 100-year return period Uniform Hazard Response Spectrum (UHS) will be developed to evaluate the seismic parameters for consistency with the 100-year flood level being evaluated.

Seismic slope stability will be evaluated using a pseudostatic analysis approach for the UHS. EM 1110-2-2502 suggests that typical minimum stability FOS for pseudostatic stability analyses range from 1.1 to 1.2. The following criteria will be adopted for this project:

- Minimum FOS of 1.2 for non-liquefied conditions.
- Minimum FOS of 1.1 for liquefied conditions.

2.6 Levee Settlement

Foundation settlement due to levee and embankment construction should be accounted for when establishing the top of levee (TOL) or top of embankment elevation. The recommended design TOL or top of embankment will be increased to account for the estimated post-consolidation settlement.

2.7 Embankment Protection

Embankment protection in front of the levees and floodwalls will be provided along all reaches with coastal erosion exposure, i.e. including consideration of waves. If indicated by erosion hazard that embankment protection is insufficient, then riprap or other erosion protection measures will be selected and designed appropriate to the level of erosion hazard.

2.8 Levee Vegetation and Aquatic Life Contaminant Criteria

2.8.1 Levee Vegetation

Design criteria for vegetation management in the project area shall be found in:

- EP 1110-2-18, Guidelines for Landscape Planting and Vegetation Management at Levee, Floodwalls, Embankment Dams, and Appurtenant Structures (USACE 2019).

As required by the USACE, a “vegetation free zone” must be retained on and adjacent to levees and floodwalls, with the exception of perennial grass species. According to the USACE guidelines, the primary purpose of this zone is to provide access for inspection, maintenance, monitoring and flood-fighting. The secondary purpose is to control erosion and reduce the potential for tree and shrub root systems to provide pathways for lateral water movement/piping through the levee. The vegetation-free-zone contains the levee crown, the side slopes and a minimum 15-foot setback from the landside and waterside toes. For floodwalls, special consideration must also be given to the distance between large trees and the wall, and the potential for damage by root systems.

It is our understanding that the SFCJPA intends to pursue a variance from the aforementioned criteria through the USACE. Should a variance be granted, alterations to the design criteria will be made accordingly.

If a variance were not obtained, the SAFER Bay project would result in substantially greater impacts to existing tidal marshes because the existing USACE (2019) guidelines do not allow the establishment of the native shrubs and forbs that compose tidal marsh vegetation within the “vegetation-free zone”. This would extend the width of levee impacts 15 feet bayward of the toe of proposed 3H:1V levee slopes and would also preclude the re-establishment of tidal marsh and marsh-upland ecotone vegetation below the High Tide Line on the bayward slopes. Therefore, where bayward 3H:1V levee slopes abut existing tidal marshes, the HDR team recommends that the SFCJPA pursue a variance similar to the variance that the USACE approved internally for its South San Francisco Bay Shoreline Project (Shoreline Project). Bayward 3H:1V levee slopes adjacent to existing marshes, where broader Transition-zone (T-zone) habitat will not be constructed, should be designed to support establishment of native tidal marsh and ecotone vegetation to reduce the net loss of marsh habitat. As with the Shoreline Project, this would entail USACE approval of design criteria for vegetation that varies from the USACE guidelines, including:

- reduction in soil compaction requirements in the topsoil layer,
- incorporation of topsoil amendments, and
- establishment of native marsh/ecotone shrubs and forbs with shallow root systems.

The SAFER Bay project also includes the construction of wide, gently sloped (10H:1V in the Substation and Marsh Restoration Project design) T-zone habitats/horizontal levees adjacent to existing and restored tidal marshes. The proposed T-zones would consist of a thick layer of loosely placed horticultural soil over engineered 3H:1V levee slopes. The thickness of the horticultural soil layer will increase moving horizontally bayward from the levee crest, such that the horticultural soil layer will be amply thick for the majority of the T-zone to preclude substantial rooting of tidal marsh/ecotone vegetation into the levee soil. Therefore, similar to the Shoreline Project, we recommend that the SFCJPA request a USACE variance only for the upslope 15 horizontal feet of the proposed T-zones.

2.8.2 Soil Contaminant Criteria for Protection of Aquatic Life in the Baylands

The San Francisco Bay Regional Water Quality Control Board (RWQCB) typically requires that soil placed in the San Francisco baylands, upon which bayland habitats will establish, be screened and verified to meet RWQCB contaminant concentration criteria for the protection of aquatic life found in *Beneficial Reuse of Dredged Materials: Sediment Screening and Testing Guidelines Draft Staff Report* (RWQCB 2000). For example, the RWQCB Section 401 permits for both the Shoreline Project and the South Bay Salt Pond Restoration Project required the preparation and implementation of a RWQCB approved contaminant quality assurance project plan. The U. S. Fish and Wildlife Service (USFWS) Don Edwards National Wildlife Refuge prepared and is implementing the following RWQCB approved document for this purpose: *Master Quality Assurance Project Plan for Don Edwards San Francisco Bay National Wildlife Refuge* (USFWS and H. T. Harvey & Associates 2018). Therefore, the HDR team anticipates that the SAFER Bay project will also need to prepare and implement a similar quality assurance plan for import of soils to build both levees and T-zone habitats which also limits potential contaminants within the soils meeting various USACE criteria.

3 Civil Design Criteria

3.1 Penetrations and Encroachments

Design criteria for penetrations and encroachments considers the following:

- EM 1110-2-1913 Design and Construction of Levees.
- EM 1110-2-2502 Retaining Walls and Floodwalls.
- EM 1110-2-2902 Conduits, Culverts, and Pipes.
- ETL 1110-2-584 Design of Hydraulic Steel Structures.

Local utility owners and coordinating agencies will impose further design criteria on their facilities that will be considered in Project design. Ultimately, penetrations and encroachments are assessed on an individual basis and therefore as-built documents and record drawings review, site visits, coordination with local utility agencies, potholing, and direct ground surveys to identify vegetation, utilities, and encroachments impacted by the Project is recommended to inform design.

3.1.1 Levee Penetrations

Penetrations include all existing pipes, conduits, and water conveyance structures beneath or through the levee prism or within 10-feet of the landside and bayside of the projected levee toe. These facilities will be impacted by construction and the Project will consider replacement or modification as necessary to meet current USACE design requirements in EM 1110-2-2502 and EM 1110-2-2902.

Compliance with USACE standards would require pressure pipes and conduits crossing beneath or through the levee be redesigned to penetrate the levee above the DWSE and

be placed outside of the slope of the design levee prism, where feasible. Pressure pipes and conduits would be equipped with positive shutoff valves located at the waterside of the levee crown in a concrete vault.

Penetrations which cannot be modified to meet design criteria will require a variance and be assessed individually.

Water Control Structures

SAFER Bay will construct water control structures through new levees and protect several existing structures in place to accommodate drainage operations. Such structures will require sluice gates compliant with USACE standards, including ETL 1110-2-584 Design of Hydraulic Steel Structures (USACE 2014).

Gravity Pipes

Isolation gates will be provided on the landside of the levee for all gravity pipe crossings and a flap gate or duckbill will be provided on the waterside outfall. Isolation gates will be in either a manhole modified to accept a sluice gate, a new headwall, or concrete vault structure.

New pipes that pass through the levee will be CLSM-encased through the levee prism. Existing pipes that pass beneath the floodwall footing will be evaluated on a case-by-case basis to determine if modification to pipe type or CLSM encasement will be needed.

3.1.2 Encroachments

Encroachments are defined as existing or proposed features that may impact construction, compromise levee performance, or impede future flood fighting efforts. Encroachments may include adjacent ditches and canals, structures, utility poles, pumps, fences, gates, and ramps (EM 1110-2-1913).

Generally, the following encroachment actions would comply with levee design criteria:

- Encroachments within the levee footprint (from landside levee toe to waterside levee toe) relocated to outside of flood control Right of Way (ROW).
- Encroachments that interfere with levee construction relocated to outside of flood control ROW.
- Encroachments located within 20-feet of the landside levee toe and within-15 feet of the waterside levee toe (or projected levee toes) relocated.

However, it is not always practical or admissible to remove all encroachments from the flood control ROW as described and therefore encroachments must be considered on an individual basis. Discussion of specific types of encroachments is included below.

Bay Trail

The Bay Trail will be relocated extensively to accommodate the Project; in some areas, the relocated trail will be on the reconstructed levee crown. Trail design will balance public use and levee maintenance and performance. Criteria which would inform Bay Trail design:

- Vehicle access for maintenance and flood fighting efforts: trail surfacing, and widths will be required to accommodate all-weather vehicle access if the trail is located on the levee crown or other flood control access roads.
- ADA compliance: the Project may require Bay Trail ramps over the new Project levees or floodwalls. These ramps will require Americans with Disabilities Act (ADA) compliance.
- Habitat encroachment: proximity to habitat and potential impacts will be considered in Bay Trail relocation design.
- Metropolitan Transportation Commission (MTC) San Francisco Bay Trail Design Guideline and Toolkit (2016) and other local guidance.

Interior Drainage Channels

Several existing interior drainage channels are located along the proposed Project alignments. The interior drainage system in Menlo Park and East Palo Alto is initially collected by an underground stormdrain pipe network that discharge into these open channels which then eventually discharge into San Francisco Bay. These open ditches are managed by a series of gates and pump stations, which balance water surface elevations between the stormwater runoff and tidal cycle events.

These channels may also require relocation as appropriate to meet regulatory requirements because of the potential threat they pose to levee integrity and the potential obstruction of maintenance activities. Where such relocation is not feasible, measures should be taken to protect the flood control structures. Criteria which would inform drainage channel design:

- Drainage system functionality: Project design will ensure the interior drainage systems of East Palo Alto and Menlo Park function properly, without increasing stormwater flooding from the existing condition once SAFER Bay flood control levees and floodwalls are installed.
- Seepage: there are underseepage and through seepage criteria specific to ditches in proximity to levees, see Section 2.3.
- Habitat encroachment: proximity to habitat and potential impacts will be considered in interior drainage design.

Utility Poles and Transmission Towers

Several utility poles and transmission towers with concrete supports intersect the levee footprint or are located within 20-feet of the landside levee toe and within-15 feet of the waterside levee toe. In general, utility pole foundations are not allowed to penetrate the levee prism per USACE levee encroachment guidelines. These structures will be relocated outside of the levee prism unless approved by the SFCJPA and coordinated with the USACE San Francisco District and the utility in question for acceptability.

If tower foundations or other encroachments must remain in the levee prism, seepage must be reduced to acceptable levels, and their location must not interfere with normal or flood-fighting maintenance and operations. Coordination with the appropriate utility will

be required to ensure towers that are left within the levee prism are modified as required for the seepage requirements.

3.2 Maintenance and Monitoring

Maintenance and monitoring requirements will be considered during design as described in EM 1110-2-1913. This includes the following considerations:

- Access roads to levee: All-weather levee access roads should be provided to support maintenance and flood fighting efforts. Generally, there is suitable access to the Project alignment from existing public roads which should be maintained during design.
- Access road on levee: All-weather access roads, or patrol roads, should be located on the levee crown and at the levee toes wherever possible, with consideration of access to flood control appurtenances such as gates, closure structures, and pump stations. The Project will include such patrol roads where possible but, as discussed in Section 3.1.2, must also accommodate the public Bay Trail.
- Turnouts and turnarounds: The Project should consider where turnouts or turnarounds for two-way traffic or equipment maneuverability on the levee access roads may be necessary considering the eventual patrol road dimensions and levee access points.
- Ramps: Ramps providing access to the levee crown from the landside or waterside patrol roads, or access points will be included in Project design. However, similar to the patrol roads themselves, these ramps may also accommodate public Bay Trail access.

3.3 Real Estate, Construction Access, and Staging

The design process will include identifying right-of-way needs, including temporary construction easement and permanent flood protection easement, for the Project features, patrol roads, and construction access and staging. The permanent flood control easement is anticipated to accommodate the Project footprint as well as 15-foot-wide access corridors along both levee toes. Corridors less than 15-feet-wide may be incorporated into the Project in areas with space limitations after design and operation and maintenance are considered.

Maintenance of public access to the Bay Trail during construction will be considered in future phases of design and coordinated with SFCJPA and local agencies.

4 Structural Design Criteria

4.1 Floodwalls

The 30% South of Bay Road Project Area includes a sheet pile floodwall along the reconstructed embankment crown. The 10% Tech Campus Project Area also includes a sheet pile floodwall along the reconstructed embankment crown.

4.1.1 Sheet Pile Floodwalls

A cantilever sheet pile floodwall is included in the 30% South of Bay Road Project from STA 0+07.5 to 52+27.8. Sheet piles will have architectural facing utilizing precast concrete panels or form liners. The top of the sheet pile wall will have reinforced concrete pile caps in the exposed height and the base of the concrete pile cap will be 2 feet below the finish grade.

Sheet pile wall heights will be designed to meet EM 1110-2-2502, Section 2.4.3.4 Sheet Pile Wall Heights. The design height of the wall is defined as the height of exposed unsupported wall from the top of wall to the finished grade measured on the protected side of the wall, see Figure 2.

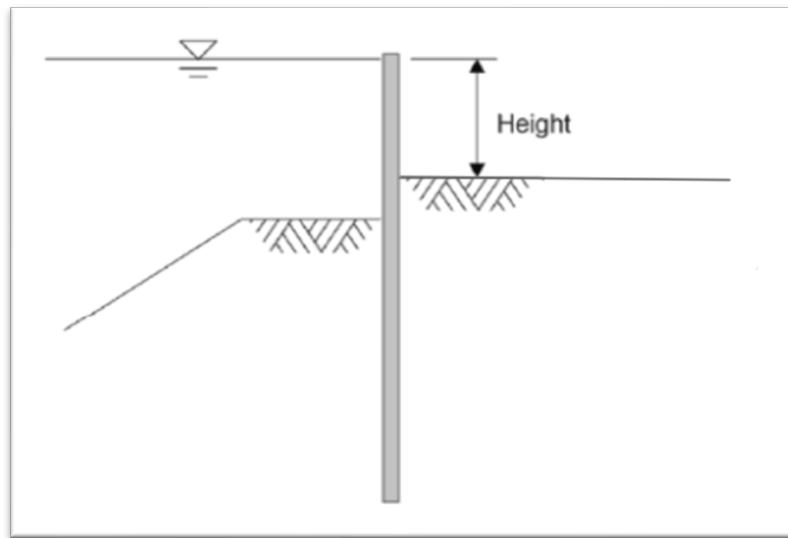


Figure 2. Definition of Sheet Pile Wall Height

The sheet pile wall is anticipated to be designed using the USACE sheet pile design software CWALSHT. CWALSHT uses classical soil mechanics procedures to determine the required depth of penetration of a new wall (or assess the factor of safety of an existing wall).

4.1.2 Sheet Pile Material

The following sheet pile materials will be considered for the flood protection project:

- ASTM A328
- ASTM A572 grades 50 or 60
- ASTM A690
- The corrosivity of the project site will be assessed using both field and laboratory testing. The electrical resistivity of the soil will be measured in place at regular intervals along the proposal retaining wall alignment using the Wenner four pin testing per ASTM G57. This procedure gives the average resistivity to a depth equal

to the spacing between the pins. Appropriate pin spacings will be predetermined, based on the preliminary sheet pile depth and geotechnical report data, so that variations with depth can be evaluated. Strata resistivities will be calculated from resistance data using the Barnes Procedure.

During the field testing, soil samples will be collected for laboratory testing. If soil samples from the geotechnical boring are available, provided samples will be included for laboratory testing. Testing of the soil samples will include as-received resistivity, saturated resistivity, pH, possibly sulfides and oxidation-reduction potential, and perform a chemical analysis for calcium, magnesium, sodium, potassium, ammonium, carbonate, bicarbonate, chloride, sulfate, and nitrate. Based on the results of this testing, 2-3 representative samples will be selected for Linear Polarization Resistance (LPR) testing, using a Cosasco 9030 Plus LPR instrument. This method uses electrochemical techniques derived from the Stern-Geary equation to measure corrosion rates.

The soil corrosivity and anticipated corrosion rates determined by field and laboratory testing data will be used to determine appropriate corrosion mitigation recommendations for the proposed construction materials.

4.1.3 Unit Weights

Below is a list of unit weights and material properties that will be used in the design:

- Water: 62.4 pcf for fresh water and 64 pcf for seawater.
- Concrete: 150 pcf.
- Structural Steel: 490 pcf.

4.1.4 Design loads and loading Summary

Design loads will be determined based on geographic settings and surroundings, material weight, code compliance, geotechnical data, and other operation/maintenance requirements of the floodwalls. After review of the classification of hydraulic structures defined in Appendix H of EM 1110-2-2100, the floodwalls would fall under coastal type floodwall. The floodwall is considered a critical structure since the wall could fail suddenly without warning during intermediate flood stage conditions. Therefore, the safety provisions applicable to critical structures must be used for flood loading conditions.

The design loads include the self-weight of the structure; weight of the water on top of it, which would correspond to the flood event WSE for the load case chosen, weight of the soils on top of it, hydrostatic forces, including uplift; and lateral earth pressures, construction surcharge loads, and seismic loading, including both inertial and hydrodynamic effects.

4.1.5 Geotechnical Design Inputs and Foundation Properties

Geotechnical design inputs, foundation properties, and lateral loads used in the structural design of the 30% South of Bay Road Area project will be based on two documents:

- Preliminary Geotechnical Report for South of Bay Road, SAFER Bay Project, June 2024.

- SAFER Bay Project Task Order No. 1 Geotechnical Report for the Feasibility Phase, May 2016.

Geotechnical information for Tech Campus Project Area will be obtained at a later date.

4.1.6 Strength Design for Floodwalls

The strength design for the sheet pile floodwall will be performed in accordance with EM 1110-2-2504 (USACE 1994) to determine the required sheet pile embedment, thickness, and section.

Strength design of the reinforced concrete elements will be performed in accordance with EM 1110-2-2104 (USACE 2016) to determine required reinforcement and thickness. The load factors used in design are applied accordingly for each load case.

4.1.7 Stability Evaluation Criteria

USACE EM 1110-2-2502 *Retaining Walls and Flood Walls* (2022) supplemented with USACE 1110-2-2100 will be used as the primary guiding documents for the stability analyses for the flood walls. For this analysis, the loading conditions include normal (usual) loading, seismic (extreme), and PMF (extreme) and other loading conditions will be considered as needed.

4.2 Appurtenant Structures

For any additional structural components, or when supplemental design criteria are appropriate, the following documents shall be referenced:

- ASCE/SEI 7-22, Minimum Design Loads for Buildings and Other Structures, (American Society of Civil Engineers 2022).
- ACI 318-19, Building Code Requirements for Structural concrete and Commentary, (American Concrete Institute, 2022).

4.3 Structural Codes, Standards, and Regulations

The various structural components of the SAFER Bay Project will be designed in accordance with current USACE and industry standards, including:

- American Concrete Institute (ACI) 318, Building Code Requirements for Structural Concrete
- American Society of Civil Engineers (ASCE) 7-22, Minimum Design Loads for Buildings and Other Structures
- ACI 350, Code for Environmental Engineering Concrete Structures and Commentary
- American Institute of Steel Construction (AISC) *Steel Construction Manual*
- USACE standards:
 - EM 1110-2-2100, Stability Analysis of Concrete Structures
 - EM 1110-2-2104, Strength Design for Reinforced Concrete Hydraulic Structures

- EM 1110-2-2502, Retaining and Flood Walls
- EM 1110-2-6050, Response Spectra and Seismic Analysis for Concrete Hydraulic Structures
- EM 1110-2-6053, Earthquake Design and Evaluation of Concrete Hydraulic Structures
- ETL 1110-2-584, Design of Hydraulic Steel Structures
- ER 1110-2-1806, Engineering and Design Earthquake Analysis, Evaluation, and Design for Civil Works Projects
- ER 1110-2-8157, Responsibility for Hydraulic Steel Structures

5 Hydraulic Design Criteria

The criteria that will be applied to the development of the hydraulic design for this project will be based on, but not limited to, the following guidelines set by federal regulations, FEMA, USACE, and the State of California:

- Code of Federal Regulations (CFR), Title 44, Volume 1, Chapter I, Section 65.10 (44 CFR 65.10)
- Guidance for Flood Risk Analysis and Mapping: Levees. (FEMA 2021)
- Guidance for Flood Risk Analysis and Mapping: Coastal Wave Runup and Overtopping. (FEMA 2021)
- ER 1110-2-1405, Hydraulic Design for Local Flood Protection Projects (USACE 1982)
- State of California Sea Level Rise Guidance, 2024 Science and Policy Update (California Ocean Protection Council 2024)

The Project will be designed to satisfy current FEMA coastal flood protection requirements (i.e., the existing 100-year event with required freeboard for FEMA accreditation) and an additional 3.5 feet to account for projected sea level rise.

The hydraulic and wave modeling conducted for FEMA's mapping existing flood hazards in the Bay will be used as the basis for characterizing current 100-year still water level (SWL) and wave runup (TWL) flood hazards. SAFER Bay's planning for sea level rise follows best-available projections for future conditions, as identified by California's Ocean Protection Council, by designing for 3.5 feet of sea level rise. This additional 3.5 feet will be added to current SWL to represent the sea level rise likely to occur by 2100. Wave conditions that occur with higher SWL will then be re-calculated for the nearshore to predict future TWL, providing design water surface elevations for future conditions. FEMA freeboard requirements for accreditation will be added to these future design water surface elevations to determine top of levee and floodwall crown elevations.

A summary of these components of the hydraulic design criteria as summarized in the sections below. A detailed description of the hydraulic modeling and analysis results for the project is included within ESA's *Hydraulic Review Technical Memorandum* (2024, In Development) which has been included in Appendix A

5.1 Hydraulic and Wave Modeling of Existing Hazards

To conduct an assessment of SWL and TWL for the SAFER Bay project, this study leverages Bay-wide analyses conducted on behalf of FEMA for the San Mateo County shoreline. DHI Water & Environment (DHI) performed hydraulic and wave modeling to hindcast 54 years of nearshore water level and wave conditions (DHI, 2013). These nearshore conditions were then used by Michael Baker, Jr. and AECOM to characterize shoreline flood hazard, including wave runup, overland propagation, and overtopping (BakerAECOM, 2014). This Bay-wide and nearshore analyses were used to update the FEMA Flood Insurance Study and Flood Insurance Rate Maps (FEMA, 2019) for the San Mateo County Bay shoreline, where the SAFER Bay project is located.

Water level and wave conditions (wave height, wave period, and wave direction) are provided outputs from the regional hydraulic and wave modeling results (DHI, 2013). Because wind-induced shear stress was applied to the hydraulic model, the SWL outputs from the hydraulic model account for wind setup. DHI's hydraulic and wave results are provided at nearshore locations at approximately 1,000 ft to 2,000 ft spacing along the SAFER Bay shoreline. The 54-year hindcast at these nearshore locations have been statistically analyzed to provide 100-year estimates of SWL and TWL.

FEMA does not currently consider sea level rise in its flood mapping, so SAFER Bay project design criteria for sea level rise are derived from California guidance, as described in the next section.

5.2 Sea Level Rise

The accumulation of human-produced greenhouse gases in the Earth's atmosphere is causing and will continue to cause the trapping of heat, thereby causing global warming and climate change. Along the Bay shoreline, climate change will cause sea-level rise due primarily to thermal expansion of the ocean's waters and melting of ice sheets. Over the last century, the tide gauge in San Francisco has recorded sea-level rise of eight inches. In addition to these observed sea-level rise trends, the best available science, as reviewed specifically for California (California OPC, 2024), predicts that sea level rise will continue and accelerate throughout this century and into the next century. Because specifics about future greenhouse gas emissions and climate response are not fully known, the exact sea level rise conditions that will occur is not precisely known at this time. Considering a range of scenarios, sea level rise by 2100 is projected to be between three and nearly seven feet in San Francisco Bay by 2100 (California OPC, 2024). Table 2 lists sea-level rise projections for San Francisco in 2050, 2080, and 2100 relative to sea level in 2000. San Francisco is the closest tide gauge location to SAFER Bay for which sea-level rise projections are provided.

California identified its strategy as ensuring resiliency to 3.5 feet of sea level rise (California OPC, 2020). SAFER Bay adopted this sea level rise target. Comparing this amount with Table 2, the latest science indicates that there is only small chance, on the order of about 1%, that this amount of sea level rise exceeded before 2100. Even if the highest projected sea level rise scenario occurs, 3.5 feet of sea level rise is not anticipated before about 2075.

Table 2. Sea Level Rise Projections for San Francisco, in Feet above 2000 Baseline

Sea Level Rise Scenario	Exceedance Probability ¹	2050	2080	2100
Intermediate	5%	0.8	1.8	3.1
Intermediate-High	0.1%	1.0	3.0	4.8
High	<0.1%	1.3	4.1	6.5

Source: OPC (2024)

NOTES:

¹ Exceedance probabilities for 3.0°C increase in global mean surface air temperatures, the current projection assuming current rates of emissions-driven warming.

5.3 Design Water Surface Elevations with Sea Level Rise

To determine the design water surface elevations with sea level rise, the hydraulic analysis for SAFER Bay will combine flood hazard conditions from the prior two sections.

Future SWL will be calculated by adding 3.5 ft of sea level rise to the current SWL determined by DHI's hydraulic modeling. These higher water levels will then be used as the conditions upon which waves are assumed to propagate from the nearshore to the SAFER Bay levee and floodwall improvements. In this way, the effects of deeper water and future ground surface elevations on wave conditions will be considered.

The nearshore to shoreline wave analysis will be conducted along shore-normal transects. Ten transects were already selected for FEMA mapping. In addition to performing design water surface elevation analysis along all these ten transects, additional transects will be added as needed to resolve differences between adjoining FEMA transects that could affect SAFER Bay hydraulics criteria.

Because of the shallow inundation anticipated to occur in the former salt ponds, managed wetlands, and salt marshes along the SAFER Bay shoreline, transect wave analysis was conducted with the WHAFIS wave modeling software (BakerAECOM, 2014). WHAFIS modeling will be repeated for the SAFER Bay analysis, with the higher SWL and wave conditions representing the addition of 3.5 feet of sea level rise. Waves from this modeling will then serve as input to Technical Advisory Committee for Water Retaining Structures (TAW) method for calculating wave runup on the proposed SAFER Bay levee and floodwalls. The resulting SWL and TWL from these analyses will serve as the design water surface elevations for SAFER Bay's levees and floodwalls.

5.4 Freeboard

To provide a margin of safety above the design water surface elevation, federal regulations (44 CFR 65.10) require that the crown elevation of certified levees be built above the design water surface elevation by an additional amount called 'freeboard' to provide a factor of safety.

The federal freeboard requirement for coastal levees is a minimum of:

- Two feet above the 100-year still water level.

and higher if this minimum is exceeded by either of these two wave-influenced freeboard elevations:

- One foot above the 100-year wave crest elevation.

OR

- One foot above the maximum wave runup elevation.

These freeboard requirements will be added to the design water surface elevation for the 100-year event and 3.5 feet of sea level rise.

5.5 Top of Levee and Floodwall Crown Elevation

The TOL is established to reduce the risk of overtopping by first determining the design WSE with the addition of 3.5 ft of sea level rise (Section 5.3) and then adding the required additional levee freeboard height (Section 5.4) in accordance with Federal and State design practice. The TOL elevation should also include an allowance for future levee and foundation settlement, as defined in the following publication:

- EM 1110-1-1904, Settlement Analysis (USACE 1990)

Preliminary settlement values were selected for planning purposes as defined in Section 2.6. These values will be updated once additional analyses are completed and incorporated into the TOL.

6 References

There are two types of references for this project: design criteria documents and basis of design reference documents. The design criteria documents are guidelines developed by regulatory agencies, and basis of design reference documents are other agency or consultant reports that contain information utilized in the Project.

6.1 Design Criteria Documents

6.1.1 US Army Corps of Engineers

USACE, Procedures for Drilling in Earth Embankments, EM 1110-1-1807, March 1, 2006.

USACE, Slope Stability, EM 1110-2-1902, October 31, 2003.

USACE, Geotechnical Investigations, EM 1110-1-1804, January 1, 2001.

USACE, Settlement Analyses, EM 1110-1-1904, September 30, 1990.

USACE, Design & Construction of Levees, EM 1110-2-1913, April 30, 2000.

USACE, Stability Analysis of Concrete Structures, EM 1110-2-2100, December 1, 2005

USACE, Strength Design for Reinforced Concrete Hydraulic Structures, EM 1110-2-2104, November 30, 2016

USACE, Response Spectra and Seismic Analysis for Concrete Hydraulic Structures, EM 1110-2-6050, June 30, 1999

USACE, Earthquake Design and Evaluation of Concrete Hydraulic Structures, EM 1110-2-6053, May 1, 2007

USACE, Retaining Walls and Floodwalls, EM 1110-2-2502, August 1, 2022.

USACE, Conduits, Culverts, and Pipes, EM 1110-2-2902, March 31, 1998.

USACE, Guidelines for Landscape Planting and Vegetation Management at Levee, Floodwalls, Embankment Dams, and Appurtenant Structures, EP 1110-2-18, May 1, 2019

USACE, Quality Management, ER 1110-1-12, September 30, 2006.

USACE, Laboratory Investigations and Testing, ER 1110-1-8100, December 31, 1997.

USACE, Engineering and Design for Civil Works Projects, ER 1110-2-1150, August 31, 1999.

USACE, Engineering and Design Earthquake Analysis, Evaluation, and Design for Civil Works Projects, ER 1110-2-1806, May 29, 2024

USACE, Responsibility for Hydraulic Steel Structures, ER 1110-2-8157, June 15, 2009

USACE, Flood Control Operations & Maintenance Policies, ER 1130-2-530, October 30, 1996.

USACE, Earthquake Design and Evaluation for Civil Works Projects, ER 1110-2-1806, July 31, 1995.

USACE, Design of Hydraulic Steel Structures, ETL 1110-2-584, June 30, 2014.

6.1.2 Other Federal Agencies

Federal Emergency Management Agency, Guidance on Levee Certification for the National Flood Insurance Program, March 25, 1997.

Federal Emergency Management Agency, Requirements of 44 CFR Section 65.10: Mapping of Areas Protected by Levee Systems, March 2007.

Federal Emergency Management Agency, Title 44 Emergency Management and Assistance. Chapter 1, Federal Emergency Management Agency Part 65 – Identification and Mapping of Special Hazard Areas, October 1, 2002.

Federal Emergency Management Agency, Guidelines and Specifications for Flood Hazard Mapping Partners, Appendix C: Guidance for Riverine Flooding Analyses and Mapping, November 2009.

6.1.3 State / County Agencies

California Department of Water Resources, California Code of Regulations, Title 23, Volume 32, October 4, 1996.

California Department of Water Resources, Urban Levee Design Criteria, May 2012.

California Department of Water Resources /URS, Guidance Document for Geotechnical Analyses, Urban Levee Evaluation, 2015.

California Department of Water Resources, Urban Level of Flood Protection Criteria, November 2013.

California Ocean Protection Council, Strategic Plan to Protect California's Coast and Ocean 2020-2025. 2020.

California Ocean Protection Council, State of California Sea Level Rise Guidance, 2024 Science and Policy Update. 2024.

6.2 Design Reference Documents

BakerAECOM. 2014. South San Francisco Bay Coastal Flood Hazard Study San Mateo County, California Study Report. Prepared for FEMA Region IX.

DHI. 2013. Regional Coastal Hazard Modeling Study for South San Francisco Bay. Prepared for Alameda County Flood Control District and FEMA Region IX.

Federal Emergency Management Agency, Flood Insurance Study, San Mateo County California and Incorporated Areas, and Flood Insurance Rate Maps 06081C302F, 06081C306F, 06081C307F, and 06081C309F April 5, 2019.

Noble Consultants, Inc. (2009), Final Report, San Francisquito Creek, Development and Calibration/Verification of Hydraulic Model. May 26.

USACE San Francisco District (2005), San Francisquito Creek Flood Damage Reduction & Ecosystem Restoration General Investigations Program, 905(b) Analysis Reconnaissance Study. March 14.

USACE San Francisco District (2005), San Francisquito Creek Flood Damage Reduction & Ecosystem Restoration General Investigations Program, San Mateo & Santa Clara Counties, CA, Proposed Feasibility Phase Project Management Plan. September 27.

USACE San Francisco District (2009), Appendix C, DRAFT Geotechnical Appendix and Reliability Analysis of Downstream Floodwalls and Levees, San Francisquito Creek, F3 Milestone Without Project. December.

Towill, Inc. (2010, 2019 and 2023), DTM & Orthophotos, San Francisquito Creek from Highway 101 to SF Bay. March.

Appendix A. (In Development)

Appendix B Landscape Basis of Design

CMG has prepared a graphic landscape basis of design in 11" x 17" format that is suitable as a starting point for public presentation material. This document may be downloaded using this [link](#).

Appendix C Design Review Board Material

CMG has prepared material for the BCDC Design Review Board presentation. This material may be downloaded using this [link](#).

Appendix D Coastal Flood Hazard Analysis

FlowWest's Coastal Flood Hazard Analysis is appended entirety for reference.

COASTAL HYDRAULICS STUDY

PREPARED FOR: Schaaf & Wheeler
PREPARED BY: Michael MacWilliams, PhD, PE and Aaron Bever, PhD
DATE: April 24, 2026

OVERVIEW

This Coastal Hydraulics Study (Study) was conducted for the Strategy to Advance Flood protection, Ecosystems and Recreation (SAFER) along San Francisco Bay project (Project) for the earthen levee from the westbound Menlo Park approach of Dumbarton Bridge to Bedwell Bayfront Park. The Study was designed to provide design recommendations to ensure the Project design can withstand 100-year flood events and accommodate an assumed 3.5 feet of sea level rise (SLR) (HDR 2024). This Study used the results from existing published studies to determine the maximum water surface elevation under the assumed SLR during 100-year events, including 100-year wind waves. The design elevation for the levee crest was developed by adding the 100-year stillwater surface elevation (e.g., tides, storm surge), 100-year wind-wave height, and the assumed 3.5 ft of SLR. The 100-year stillwater elevation and wave height were taken from previously published studies of San Francisco Bay. The resulting levee crest elevation was then compared to FEMA requirements for the crest elevation of levees.

FEMA provides guidance on minimum levee crest elevation for coastal levees but does not include future SLR in the guidance (FEMA 2023). As shown below, given the currently available information, the FEMA controlling condition for the levee crest elevation is 1 ft above the base flood wave crest elevation. The design elevation is above the current FEMA requirements for the levee crest.

SUMMARY OF COASTAL FLOODING

The Federal Emergency Management Agency (FEMA) describes coastal flooding as when water from an ocean, bay, or large lake inundates the normally dry land (FEMA 2021). Coastal flooding is generally a result of elevated stillwater elevation and waves. Stillwater elevation can increase from a range of factors, including storm surge, tides, and wave setup. Storm surge is the increase in WSE as a result of storm winds forcing water towards the coastline and creating WSE “setup” at the coastline and into embayments. High tides also lead to an increase in stillwater level relative to low tides, especially during periods of king tides. A storm tide is when storm surge and high tide occur at the same time. Wave setup is the process of breaking waves leading to an increase in WSE at the shoreline. Waves also result in a flood risk because when the waves break along the shoreline they “runup” the face of the shoreline, thus possibly reaching a higher elevation than expected simply based on the wave height.

FEMA (2023) provides guidance on levee heights to provide base flood hazard reduction in coastal areas. Following this guidance, the top of the levee must be equal to or greater than the higher of:

1. Two feet above the base stillwater storm surge elevation, including wave setup
2. One foot above the base flood wave crest elevation
3. One foot above the maximum base flood wave runup elevation

The base flood elevations are based on the 100-year recurrence interval event, equal to a 1% chance of occurrence or 1% annual exceedance probability (AEP). Wave setup was not included in this Study because waves in San Francisco Bay are relatively small and will propagate across a shallow marsh area where waves will attenuate instead of undergo breaking. Thus, wave breaking before the levee is not expected to cause setup, as determined in BakerAECOM (2014a, 2014b). The wave crest elevation is the stillwater elevation plus 70% of the controlling wave height (NAS 1977), where the controlling wave height is 1.6 times the significant wave height (FEMA 1988). Wave runup is the height that breaking waves travel up the levee face.

Based on FEMA’s National Flood Hazard Layer viewer, the flood hazard zone of the Project is AE. Flood hazard zone AE corresponds to a high-risk special hazard area with wave heights less than 3 ft. The FEMA expected base flood elevation of the Project area ranges from 11 ft to 12 ft NAVD88 (Figure 1). FEMA guidance does not address sea level rise. As such, the below comparison of the levee crest elevation to the FEMA requirements for coastal levees uses current conditions (no SLR) and then a range of SLR projections to understand when flood risk may increase in the future.

National Flood Hazard Layer FIRMette

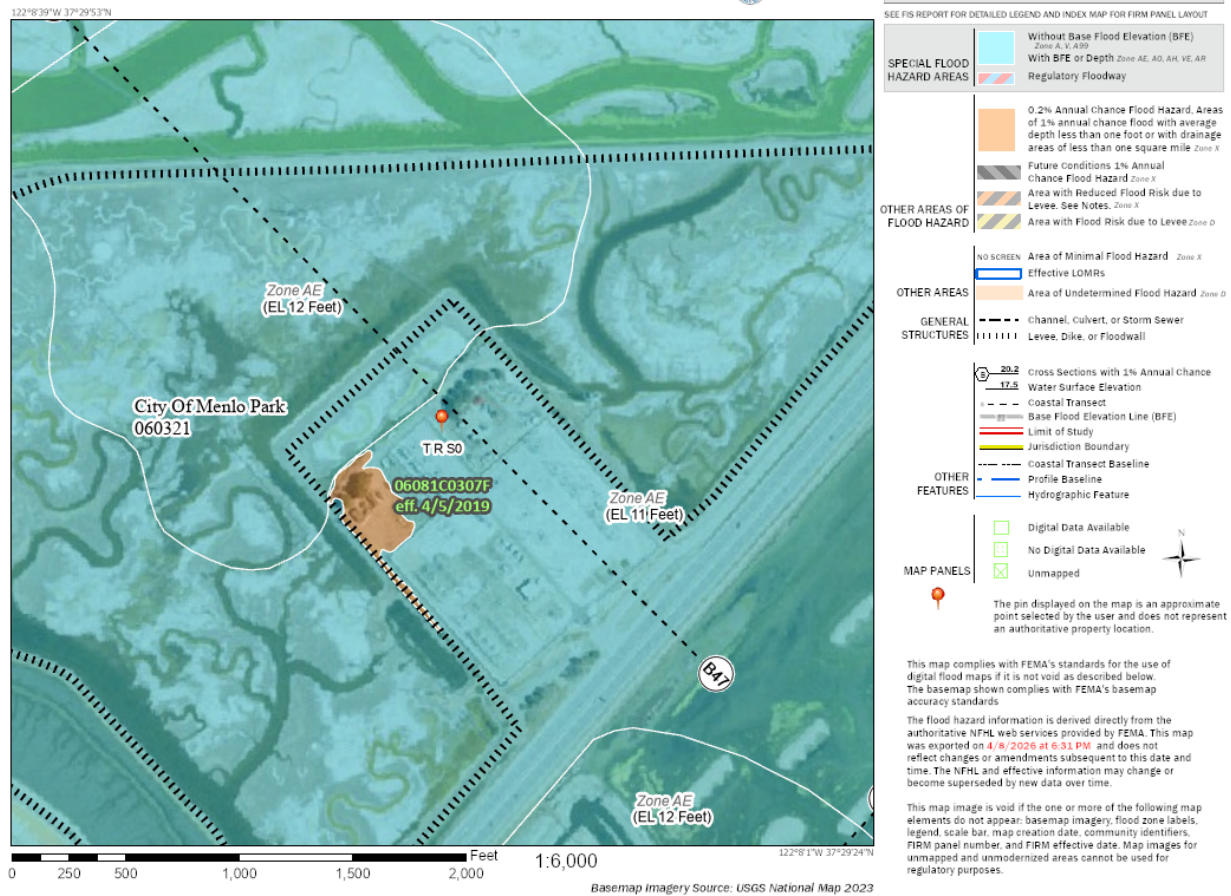


FIGURE 1: FEMA FIRMETTE OF THE PROJECT AREA

Source: <https://www.arcgis.com/apps/webappviewer/index.html?id=8b0adb51996444d4879338b5529aa9cd>

100-YEAR STILLWATER SURFACE ELEVATION

The 100-year WSE under existing conditions, without SLR, was determined based on information from a study conducted by AECOM (2016). The AECOM report provides tidal datums and/or extreme WSEs for more than 900 locations around the margin of San Francisco Bay. The 100-year stillwater surface elevation is included in these extreme WSEs. The extreme WSEs were calculated such that they represent approximately 2011 conditions. For this Project, the relevant locations from the AECOM report are stations 740 to 755. The 100-year extreme WSEs for these points ranged from 10.68 ft NAVD88 to 10.90 ft NAVD88 (see Appendix B in AECOM (2016)). For the purposes of this Coastal Hydraulics Study, a 100-year extreme stillwater elevation of 10.90 ft NAVD88 was used. This is slightly lower than the 11 to 12 ft base flood elevation shown on the FEMA National Flood Hazard Layer viewer (Figure 1).

100-YEAR WIND-WAVE EVENT

Wave heights for a 100-year event were based on a wave study of South San Francisco Bay conducted by DHI (2011, 2013) and retrieved through the San Francisco Estuary Institute and San Francisco Bay Area Planning and Urban Research Association Adaptation Atlas (Beagle et al. 2019). From the Adaptation Atlas, 100-year significant wave heights of 2.3 ft to 2.6 ft (0.7 m to 0.8 m) in the vicinity of the Project were obtained (Figure 2). For the purposes of this Study, a 100-year wave height of 2.6 ft was used for the 100-year wave height. This is likely a conservative estimate of the 100-year wave height at the toe of the levee because it is taken at the bayward margin of the project area and wave heights may be lower on the landward side of any shallow-water areas along the outside of the levee and after the waves have propagated across any shallow-water or vegetated areas between the open Bay and the Project levee.

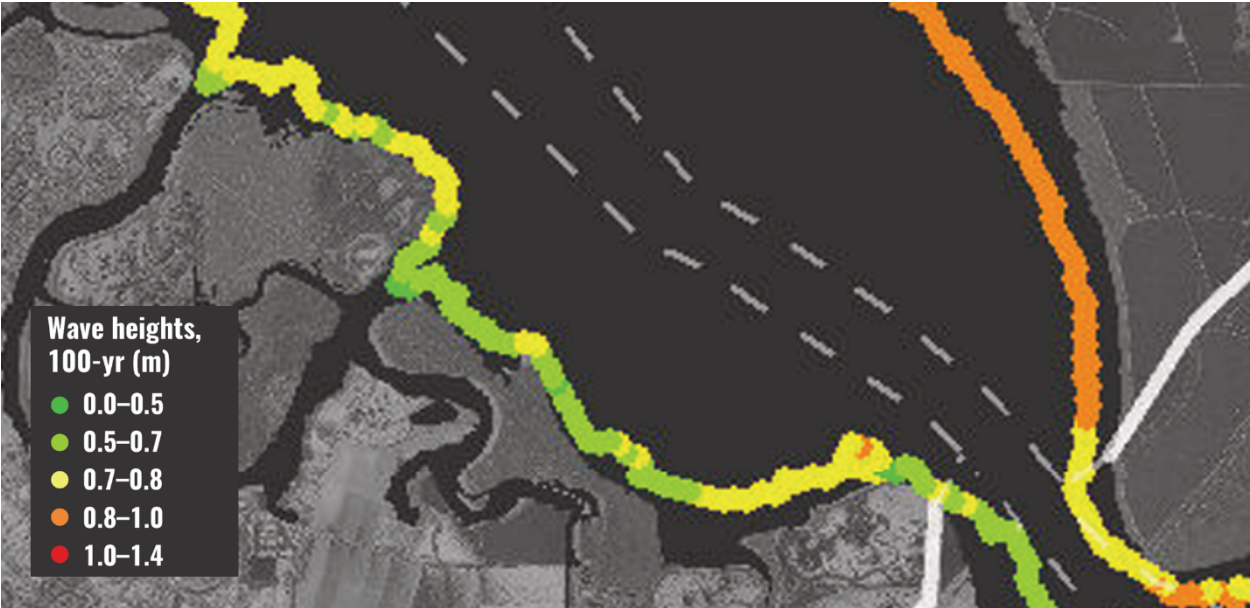


FIGURE 2: 100-YEAR WIND WAVES
Source: Beagle et al. (2019)

SEA LEVEL RISE

Two sources of projected SLR in San Francisco Bay are the California Ocean Protection Council (OPC, 2024) guidance report and the USACE-based SLR projections in the South San Francisco Bay Shoreline Study. In the OPC guidance, the “intermediate-low” to “intermediate” SLR scenarios are considered the most likely scenarios, whereas the “intermediate-high” SLR scenario represents a plausible high-end SLR projection (Table 1). The intermediate scenario represents a “reasonable upper bound of the most likely range of sea level rise by 2100. (OPC 2024)” Based on the OPC SLR scenarios, the assumed 3.5 ft of SLR would be surpassed:

- After 2150 under the low and intermediate-low scenarios
- Between 2100 and 2110 under the Intermediate scenario
- Around 2090 under the intermediate-high scenario
- Between 2070 and 2080 under the high scenario

Additional SLR projections were inferred from the OPC intermediate-high SLR scenario for comparison to other SLR estimates. The OPC intermediate SLR scenario projects SLR of 1.1 ft between 2020 and 2067 and 2.9 ft between 2020 and 2100. The OPC intermediate-high SLR scenario projects SLR of 1.7 ft between 2020 and 2067 and 4.5 ft between 2020 and 2100.

For comparison, the South San Francisco Bay Shoreline Study used USACE SLR curves (Anchor QEA 2017; USACE 2015a). From 2017 to 2067, after adjusting for SLR between the midpoint of the NOAA National Tidal Datum Epoch and 2017, the USACE SLR curves projected 0.33 ft for the “low” curve, 0.84 ft for the “intermediate” Curve, and 2.42 ft for the “high” curve. Further, the USACE high SLR scenario projected 4.88 ft of SLR between 2017 and 2100. The USACE high SLR scenario projected greater rates of SLR than the OPC intermediate scenario and similar but somewhat greater rates of SLR than the OPC intermediate-high scenario.

No SLR was assumed for the Project construction year (Year 0, 2031) WSE. No SLR was assumed because the extreme WSEs in the AECOM (2016) study were based on approximately 2011 conditions, with only a few tenths of a foot of SLR projected to the Year 0 of 2031, using the OPC guidance. Assuming no SLR in Year 0 is also acceptable in this case because the analysis combined the extreme 100-year stillwater level with the extreme 100-year wind-wave event, even though these extreme events do not necessarily occur at the same time in San Francisco Bay (BakerAECOM 2014a, 2014b).

TABLE 1: SEA LEVEL RISE BY DECADE FOR THE OPC (2024) GUIDANCE REPORT

TABLE 6. *Sea Level Scenarios for San Francisco.*

Median values of Sea Level Scenarios, in feet, for each decade from 2020 to 2150, with a baseline of 2000. All median scenario values incorporate the local estimate of vertical land motion.

YEAR	LOW	INT-LOW	INTERMEDIATE	INT-HIGH	HIGH
2020	0.2	0.2	0.2	0.3	0.3
2030	0.3	0.4	0.4	0.4	0.4
2040	0.4	0.5	0.6	0.7	0.8
2050	0.5	0.6	0.8	1.0	1.3
2060	0.6	0.8	1.1	1.5	2.0
2070	0.7	1.0	1.4	2.2	2.9
2080	0.8	1.2	1.8	3.0	4.1
2090	0.9	1.4	2.4	3.8	5.3
2100	1.0	1.6	3.1	4.8	6.5
2110	1.0	1.8	3.8	5.6	7.8
2120	1.1	2.0	4.4	6.4	9.0
2130	1.2	2.2	4.9	7.0	9.9
2140	1.3	2.4	5.4	7.6	10.8
2150	1.3	2.6	6.0	8.1	11.7

Source: OPC (2024)

TOTAL WATER SURFACE ELEVATIONS

Total WSEs for guiding the design levee crest elevation were assumed to be the summation of the 100-year stillwater surface elevation, 100-year wind-wave heights at the bayward margin of the project area, the assumed 3.5 ft of SLR, and 2 ft of freeboard. This summation of the 100-year stillwater surface elevation and 100-year wind waves is likely a conservative estimate of the 100-year total water level conditions. A prior report by BakerAECOM (2014a) notes that *“Investigations of the coincidence of water level and wave events for San Francisco Bay within the regional hydrodynamic and wave study data confirmed that elevated water levels are often decoupled from the local wave and wind events. Therefore, pairing the 1-percent water level with the 1-percent wave height is not appropriate and may result in the overestimation of the 1-percent flood hazard from overland wave propagation.”*

The resulting WSEs guiding development of the levee crest elevation are summarized below.

- 100-year stillwater surface elevation: 10.9 ft NAVD88
- 100-year wave height: 2.6 ft
- Assumed SLR: 3.5 ft
- Total 100-year future WSE: 17.0 ft NAVD88.
- Total levee crest elevation with 1 ft of freeboard and 1 ft of long-term subsidence/construction tolerance: 19.0 ft NAVD88

Allowing for 1 foot of long-term subsidence and construction tolerance will result in a long-term minimum levee crest elevation of 18.0 ft for this Project. This result is consistent with the assumptions in the Draft EIR for the SAFER Bay Project (ESA 2025) which assumes a solid barrier with elevations between 16.5 and 17.9 feet NAVD88. However, the design elevations documented in the DRAFT EIR (ESA 2025) are higher than 19 ft NAVD88 in some reaches because the assumed amount of long-term settling in the larger SAFER Bay project (up to 2.5 ft or more) is greater than the maximum amount of settling assumed in the levee design for this Project.

Based on the FEMA (2023) requirements for levees, the minimum crest elevation for the levee would be the higher of:

1. 12.9 ft NAVD88: Two feet above the base flood total stillwater storm surge elevation including wave setup
 - a. 10.9 ft stillwater elevation + 2 ft freeboard
2. 14.8 ft NAVD88: One foot above the base flood wave crest elevation
 - a. 10.9 ft stillwater elevation + 2.9 ft wave height¹ + 1 ft freeboard
3. The elevation corresponding to one foot above the maximum base flood wave runup elevation could not be determined without additional site-specific wave runup modeling which is outside the scope of this Study.

The second criteria elevation of 14.8 ft NAVD88 is likely a conservative estimate because it pairs the 1% stillwater level with the 1% wave heights, even though these may not occur at the same time (BakerAECOM 2014a, 2014b) and used wave heights at the bayward margin of the project area and not wave heights attenuated across any shallow areas or marshes. The 18.0 ft NAVD88 design elevation for the levee crest for this Project is above the current first and second FEMA requirements for levees.

The third FEMA requirement, based on wave runup, could not be determined because it would require additional site-specific modeling of wave transformation from the open Bay to the toe of the levee and then calculations of wave runup, which is outside the scope of this Study. These calculations for the SAFER Bay Project were noted in HDR (2024) as to be conducted. However, as a result of a berm surrounding the project area, projected future infilling of the surrounding pond to saltwater marsh elevations, and then a future low-gradient vegetated ecotone to the highest astronomical tide elevation, the project levee will be relatively sheltered from wind waves. As such, any wave runup on the levee face is expected to be relatively small. This is a similar expectation to that made in the South San Francisco Bay Shoreline Study (USACE 2015), which notes *“the occurrence of large waves is associated with a very low probability (as can be inferred from Table 11 (Comparison of 1% ACE Water Level with Prior Studies)) and did not affect the design crest elevation of the with-project levee.”*

Levee overtopping risk will increase in the future as a result of SLR. To understand when overtopping risk may increase, SLR projections were added to the 14.8 ft controlling case for the levee crest elevation. The resulting controlling case plus SLR was then used to estimate the time horizons during which the 18 ft NAVD88 design elevation will provide FEMA-level protection. That is, based on currently available information, to estimate when the current 14.8 ft NAVD88 minimum crest elevation plus SLR could result in loss of FEMA accreditation or begin to overtop the 18 ft NAVD88 design elevation. These estimates are provided in Table 2. Using the OPC low and intermediate-low SLR scenarios, the design elevation provides FEMA-level protection to at least 2150. Assuming the intermediate SLR scenario results in FEMA-level protection until 2101. This intermediate SLR scenario is considered the “reasonable upper bound of the most likely range of sea level rise by 2100” by the OPC (2024). Using the intermediate-high and high SLR scenarios reduces the FEMA-level protection to 2083 and 2073, respectively. This analysis suggests FEMA-level protection through at least 2101 using the reasonable upper bound SLR projection.

¹ Wave height for crest elevation was calculated as 70% of the controlling wave height ($0.7 \times 1.6 \times H_{sig}$ (significant wave height), with H_{sig} equaling 2.6 ft)

TABLE 2: YEAR WHEN FEMA-LEVEL PROTECTION COULD BE LOST AND WHEN LEVEE COULD BEGIN TO OVERTOP

OPC SLR Scenario	Lose FEMA-Level Protection	Levee Overtopping
Low	>2150	>2150
Intermediate-Low	>2150	>2150
Intermediate	2101	2117
Intermediate-High	2083	2094
High	2073	2081

Note: FEMA-level protection assumes 1 ft of freeboard while levee overtopping does not assume any freeboard. Table is based on current conditions 14.8 ft NAVD88 base flood wave crest elevation plus projected SLR.

REFERENCES

- AECOM, 2016. San Francisco Bay Tidal Datums and Extreme Tides Study. February 2016. Available at: https://www.adaptingtorisingtides.org/wp-content/uploads/2016/05/20160429.SFBay_Tidal-Datums_and_Extreme_Tides_Study.FINAL_.pdf
- Anchor QEA, 2017. Preliminary Feasibility Study for South San Francisco Bay Shoreline Economic Impact Areas 1–10 Appendix I: Long Wave Modeling Report. Prepared for Santa Clara Valley Water District. February 2017
- BakerAECOM, 2014a. A Central San Francisco Bay Coastal Flood Hazard Study San Mateo County, California Coastal Analysis Report. July 2014. Available at: https://fostercitylevee.org/wp-content/uploads/2021/01/coastal_flood_hazard_study.pdf
- BakerAECOM, 2014b. A South San Francisco Bay Coastal Flood Hazard Study Santa Clara County, California Study Report. March 2014
- Beagle, J, J. Lowe, K. McKnight, S.M. Safran, L. Tam, and S.J. Szambelan, 2019. San Francisco Bay Shoreline Adaptation Atlas: Working with Nature to Plan for Sea Level Rise Using Operational Landscape Units. SFEI Contribution No. 915. p. 255. Available at: <https://www.sfei.org/documents/san-francisco-bay-shoreline-adaptation-atlas-working-nature-plan-sea-level-rise-using>
- DHI (DHI Water and Environment, Inc.), 2011. Regional Coastal Hazard Modeling Study for North and Central San Francisco Bay. October 2011
- DHI, 2013. Regional Coastal Hazard Modeling Study for South San Francisco Bay. January 2013
- ESA, 2025. STRATEGY TO ADVANCE FLOOD PROTECTION, ECOSYSTEMS, AND RECREATION ALONG SAN FRANCISCO BAY (SAFER BAY) PROJECT, Environmental Impact Report State Clearinghouse No. 2022040504, Prepared by ESA, December 2025.
- FEMA (Federal Emergency Management Agency), 1988. Wave height Analysis for Flood Insurance Studies (Technical Documentation for WHAFIS Program Version 3.0). September 1988. Available at: https://hazards.fema.gov/femaportal/docs/WHAFIS/WHAFIS3.0_Manual_1988.pdf

- FEMA, 2021. Coastal Hazards & Flood Mapping A Visual Guide. January 2021. Available at: https://www.fema.gov/sites/default/files/documents/fema_coastal-glossary.pdf
- FEMA, 2023. Guidance for Flood Risk Analysis and Mapping Levees. November 2023. Available at: https://www.fema.gov/sites/default/files/documents/fema_rm-levee_guidance_nov_2023.pdf
- HDR, 2024. Design Criteria and Considerations Technical Memorandum Strategy to Advance Flood Protection Ecosystems, and Recreation along the Bay (SAFER Bay project). September 2024
- NAS (National Academy of Sciences), 1977. Methodology for Calculating Wave Action Effects Associated with Storm Surges. Washington D.C.
- OPC (California Ocean Protection Council), 2024. State of California Sea Level Rise Guidance 2024 Science and Policy Update. Available at: <https://opc.ca.gov/wp-content/uploads/2024/05/California-Sea-Level-Rise-Guidance-2024-508.pdf>
- USACE, 2015a. Tidal Flood Risk Analysis Summary Report South San Francisco Bay Shoreline (SSFBS) Study. Appendix D2. September 2015
- USACE, 2015b, Appendix D1 (to the Final South San Francisco Bay Shoreline Study Feasibility Study and Environmental Impact Statement): Coastal Engineering and Riverine Hydraulics Summary. December 2015

Appendix E Coastal Flood Hazard Analysis

The Interior Drainage Report may be accessed using this [link](#).

Appendix F Estimate of Construction Value

The native Excel worksheet used to generate the preliminary estimate of construction value summarized in Section 8 may be accessed using this [link](#).

Appendix G Geotechnical Data

Subsurface borings and consolidation curves provided by HDR and used in this Basis of Design are appended.

Due to the nature of this file, the content is not accessible to screen reader technology. If you require equivalent facilitation, please contact BCDC's staff engineer, Makena Wong, at Makena.Wong@bcdc.ca.gov.



Project: SAFER BAY PROJECT
 Project Location: SAN MATEO COUNTY, CA
 Project Number: 10363858

Boring ID: B24-05

Sheet 1 of 4 Sheets

Start Date: 10/17/2024	End Date: 10/17/2024	Logged By: Olen Gover	Checked By: Ed Woo	Date Checked: 2/28/2025
Drilling Company (Rig Type): Pitcher Services, LLC (Truck)		Inspector: Kian Atkinson	Weather Conditions: Overcast/Sunny	
Drill Method: Mud Rotary		Drilled By: Marcos Orazco	Elevation Top of Boring: 8.9 ft. Vertical Datum: NAVD88	
Drill Bit (Type/Size): Tricone / 5" (O.D)		Total Depth Drilled: 81.5 ft.	Latitude: 37.495796° Longitude: -122.133000° Horizontal Datum: NAD83	
Hammer Type: Automatic		Hole Backfill: Cement grout	Northing: 2,007,128 ft. Easting: 6,087,945 ft. Coordinate System: State Plane CA Zone 3	
Hammer Efficiency:	Rod Type:	Total Number of Samples: 18 Disturbed: 14 Undisturbed: 4	Initial Groundwater Depth: Not established Static Groundwater Depth: Not established	

ELEV	DEPTH	SAMPLE	Blows/6" or Press.	N _r	LEGEND	DESCRIPTION OF MATERIALS	% REC	Samp No	Laboratory					Su (ksf)	REMARKS
									Fines	LL	PL	DD	MC		
						FILL GRAVELLY LEAN CLAY (CL): brown, dry, low plasticity, low toughness.									Begin with 6" core barrel.
						FILL LEAN CLAY (CL): stiff, brown to reddish brown, moist, low plasticity, low toughness.									
	5					Soft to medium stiff, medium plasticity.		G1		38	20				Switch to 3" solid stem flight auger.
	5					FAT CLAY (CH): very soft, gray mottled reddish brown, moist, high plasticity, medium toughness.		G2							Rootlets throughout grab sample.
			0	0		Color change to gray mottled black.	89	L1					0.25 P		Install casing to 4' and began mud rotary with 5" tri-cone bit.
			0	0				L2				0.25 T			
	10					With organics.	100	T1	183	123	32 33	153 142	0.61 U		0 - 0.5': WOR 0.5' - 1.0': 30 psi 1.0' - 1.5': 60 psi 1.5' - 2.0': 80 psi 2.0' - 2.5': 100 psi
	15		0	0		Strong H2S odor.	100	L3					0.25 P 0.10 T		
	-10														

HDR SOIL BORING LOG 2017_MARCH_R1: 10363858 - SFCJPA TO4 SAFER BAY PROJECT - POST LAB.GPJ; HDR_FOLSOM_OAKLAND_SEP_2021_WIP.GLB; 3/6/25



Project: SAFER BAY PROJECT
 Project Location: SAN MATEO COUNTY, CA
 Project Number: 10363858

Boring ID: B24-05

Sheet 2 of 4
 Sheets

ELEV	DEPTH	SAMPLE	Blows/6" or Press.	N _r	LEGEND	DESCRIPTION OF MATERIALS	R% REC	Samp No.	Laboratory					Su (ksf)	REMARKS
									Fines	LL	PI	DD	MC		
						Strong H2S odor.	100	T2		100	60	48 49	95 90	0.39 U 0.25 P 0.12 T	0 - 1.5': WOR 1.5' - 2.0': 40 psi 2.0' - 2.5': 60 psi
	-25		0 0 0	0		Strong H2S odor.	100	L4							
	-30					Strong H2S odor, some crushed shell fragments at bottom of Shelby sampler.	100	T3							0 - 1.5': WOR 1.5' - 2.0': 60 psi 2.0' - 2.5': 100 psi
	-35		0 1 6	7		LEAN CLAY (CL): medium stiff, gray, moist, medium plasticity, medium toughness, noticeably stiffer at bottom of sample.	67	L5					0.68 P 0.70 T		
	-40					Very stiff to hard, color change to olive gray, low plasticity, medium toughness, trace fine sand.	60	T4							0 - 0.5': 320 psi 0.5' - 1.0': 460 psi 1.0' - 1.5': 500 psi Refusal at 1.5'.

HDR SOIL BORING LOG 2017_MARCH_R1: 10363858 - SFCJPA TO4 SAFER BAY PROJECT - POST LAB.GPJ; HDR_FOLSOM_OAKLAND_SEP 2021_WIP.GLB; 3/6/25



Project: SAFER BAY PROJECT
 Project Location: SAN MATEO COUNTY, CA
 Project Number: 10363858

Boring ID: B24-05

Sheet 3 of 4
 Sheets

HDR SOIL BORING LOG_2017_MARCH_R1: 10363858 - SFCJPA TO4 SAFER BAY PROJECT - POST LAB.GPJ; HDR_FOLSOM_OAKLAND_SEP_2021_WIP.GLB; 3/6/25

ELEV	DEPTH	SAMPLE	Blows/6" or Press	N _r	LEGEND	DESCRIPTION OF MATERIALS	% REC	Samp No.	Laboratory					Su (ksf)	REMARKS
									Fines	LL	PI	DD	MC		
-45	8			35		Very stiff, color change to yellowish brown, medium plasticity, medium toughness.	83	L6		49	27	101	25	2.48 U	> 2.0 KSF TV
-50	4			14		Stiff, yellowish brown mottled black.	55	S1							
-55						SILT (ML): stiff, yellowish brown, low plasticity, low toughness, trace medium grained sand, slow dilatancy.	100	T5	49	21	90	31	32	2.08 U	0 - 1.0': 180 psi 1.0' - 1.5': 250 psi 1.5' - 2.0': 300 psi 2.0' - 2.5': 320 psi
-60	2			13			78	L7						1.50 P 0.70 T	
-65	11			31		SILTY SAND (SM): dense, few 1/2" subrounded gravels, rounded to subrounded coarse sands, little low plasticity fines.	61	S2	14						Sand and gravel in drill fluid.
-60						Poorly Graded SAND with Silt and Gravel (SP-SM): very dense, brown, lightly cemented, few to little									



Project: SAFER BAY PROJECT
 Project Location: SAN MATEO COUNTY, CA
 Project Number: 10363858

Boring ID: B24-05

Sheet 4 of 4
 Sheets

ELEV	DEPTH	SAMPLE	Blows/6" or Press.	N _r	LEGEND	DESCRIPTION OF MATERIALS	R% REC	Samp No.	Laboratory					Su (ksf)	REMARKS	
									Fines	LL	PI	DD	MC			
-70			18		[Yellow dotted pattern]	pockets of low plasticity fines, gravels up to 3/4", medium to coarse grained sand.	72	S3								
			34	66												
			32													
-65					[Blue hatched pattern]	LEAN CLAY (CL): hard, moist, yellowish brown to gray brown mottled reddish brown, low plasticity, medium toughness.	45	L8						Driller notes transition to clayey material.		
-75			12													
			24	56												
			32													
-70					[Blue hatched pattern]		89	L9								
-80			13													
			24	56												
			32													

Boring terminated at 81.5'.

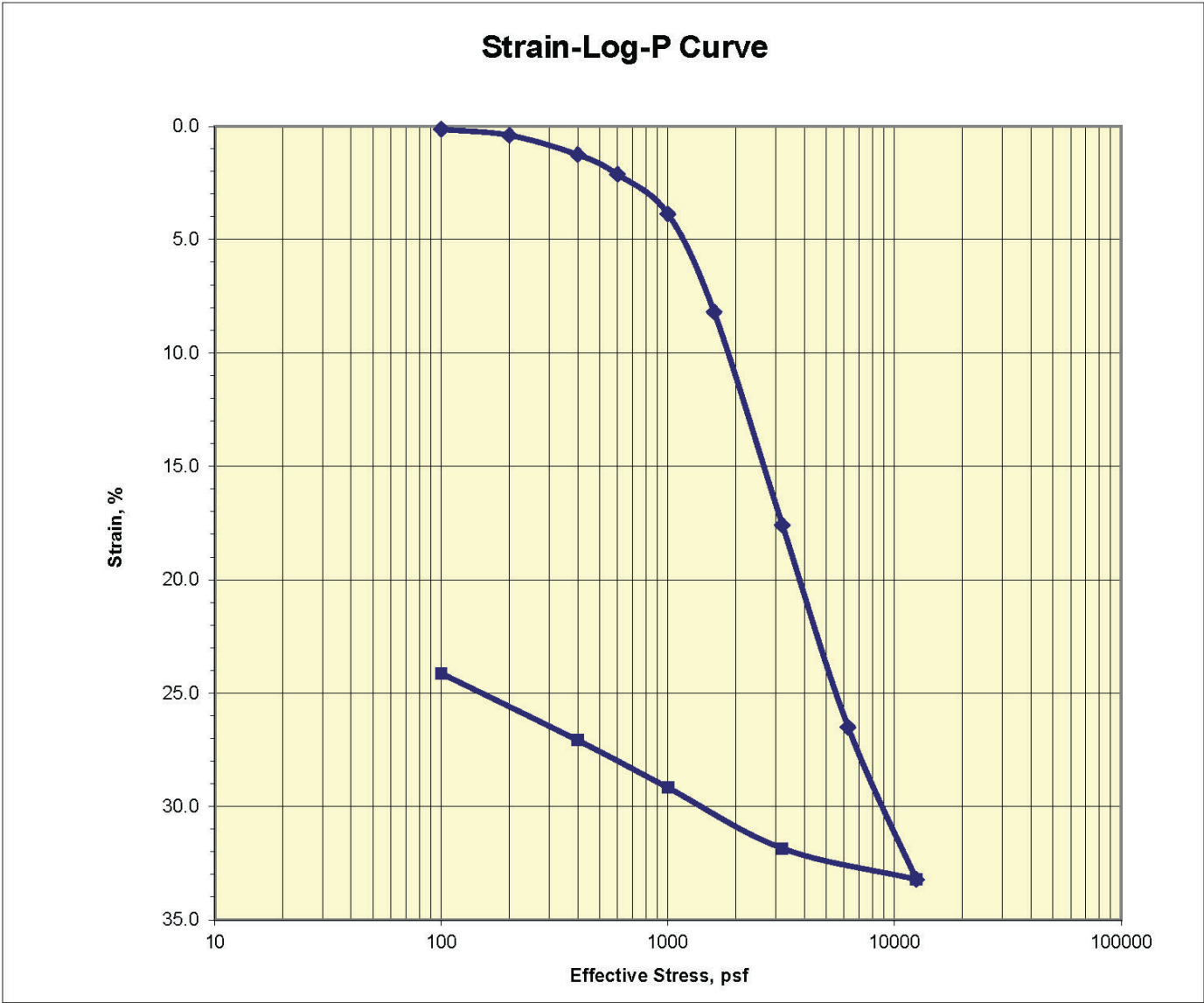
HDR SOIL BORING LOG_2017_MARCH_R1: 10363858 - SFCJPA TO4 SAFER BAY PROJECT - POST LAB.GPJ; HDR_FOLSOM_OAKLAND_SEP_2021_WIP.GLB; 3/6/25



Consolidation Test

ASTM D2435

Job No.: 855-055	Boring: B24-05	Run By: HM
Client: HDR Engineering	Sample: T2	Reduced: RU
Project: 10363858	Depth, ft.: 20-22.5	Checked: PJ
Soil Type: Dark Gray Fat CLAY (Bay Mud)		Date: 1/3/2025



Assumed Gs	2.8	Initial	Final
Moisture %:		95.4	63.5
Dry Density, pcf:		47.5	62.9
Void Ratio:		2.683	1.778
% Saturation:		99.5	100.0

Remarks:



Project: SAFER BAY PROJECT
 Project Location: SAN MATEO COUNTY, CA
 Project Number: 10363858

Boring ID: B24-06

Sheet 3 of 4
 Sheets

ELEV	DEPTH	SAMPLE	Blows/6" or Press.	N _r	LEGEND	DESCRIPTION OF MATERIALS	% REC	Samp No.	Laboratory					Su (ksf)	REMARKS
									Fines	LL	PI	DD	MC		
-45			7	26		toughness.	50	L5						3.75 P	> 2.0 KSF TV
-40			0	15		SILT (ML): stiff, yellowish brown mottled reddish brown, moist, low plasticity, low toughness, lenses of fine grained sand <1/2" thick throughout sample.	100	L6 L7							
-45			6	15		SANDY LEAN CLAY (CL): very stiff, olive brown, moist, medium plasticity, medium toughness, with fine to medium grained sand, trace gravels.	100	T5	48	24	95	29	2.08 U	0 - 0.5': 75 psi 0.5' - 1.0': 120 psi 1.0' - 1.5': 220 psi 1.5' - 2.0': 290 psi 2.0' - 2.5': 340 psi Driller notes gravels in drill fluid. Clay cuttings in drill fluid.	
-50			8	28		Poorly Graded SAND with Silt and Gravel (SP-SM): medium dense, rounded medium to coarse grained sands, subrounded to subangular gravels up to 1.5", few low plasticity fines.	67	L8						Transition is halfway through middle liner.	
-55			9	26		Same as above, gravels up to 1", trace clumps of plastic fines.	72	S1						Gravels in drill fluid.	

HDR SOIL BORING LOG 2017_MARCH_R1: 10363858 - SFCJPA T04 SAFER BAY PROJECT - POST LAB.GPJ; HDR_FOLSOM_OAKLAND_SEP_2021_WIP.GLB: 3/6/25



Project: SAFER BAY PROJECT
 Project Location: SAN MATEO COUNTY, CA
 Project Number: 10363858

Boring ID: B24-06

Sheet 4 of 4
 Sheets

ELEV	DEPTH	SAMPLE	Blows/6" or Press.	N _r	LEGEND	DESCRIPTION OF MATERIALS	R% REC	Samp No.	Laboratory					Su (ksf)	REMARKS
									Fines	LL	PI	DD	MC		
-70															
			3												
			3	9		SILTY SAND (SM): loose, olive, wet, fine-grained sand, brown, little low plasticity fines.	95	S2	37						Driller notes silt/clay cuttings in drill fluid at 69.5'.
			6			SILT with Sand (ML): stiff, gray, moist, very fine-grained sand, low plasticity, slow dilatancy.									
-65						LEAN CLAY (CL): very stiff, olive gray to gray brown, moist, medium toughness, low plasticity, few subrounded gravels up to 1", decreasing gravel content with depth.									Clay cuttings in drill fluid.
-75			7	40			95	L9				2.75 P 1.60 T			
			16												
			24												
-70															
-80			6	27		Same as above, no gravels present.	83	L10				2.00 P 1.90 T			
			11												
			16												

Boring terminated at 81.5'.

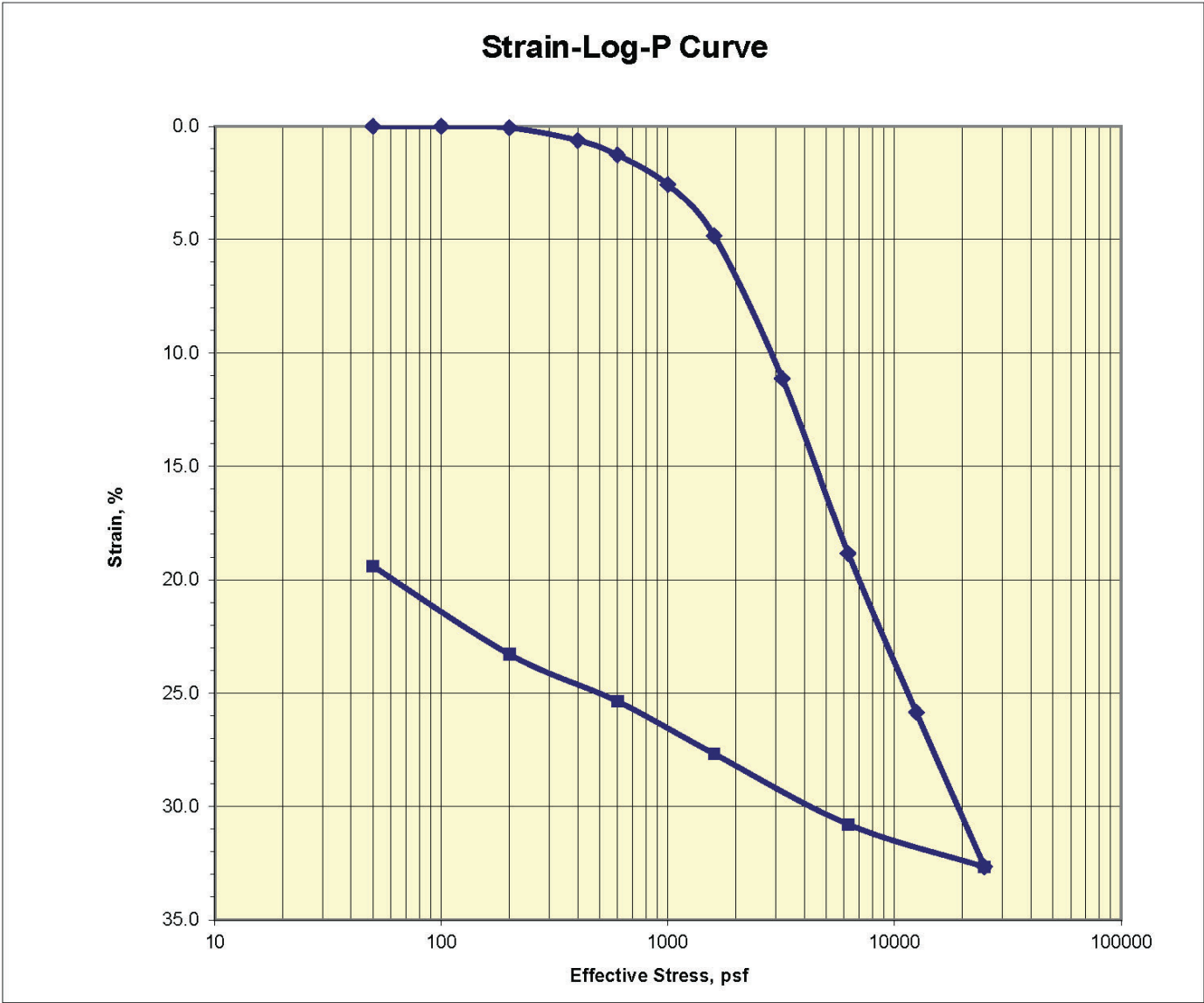
HDR SOIL BORING LOG_2017_MARCH_R1: 10363858 - SFCJPA TO4 SAFER BAY PROJECT - POST LAB.GPJ; HDR_FOLSOM_OAKLAND_SEP_2021_WIP.GLB; 3/6/25



Consolidation Test

ASTM D2435

Job No.: 855-055	Boring: B24-06	Run By: HM
Client: HDR Engineering	Sample: T2	Reduced: RU
Project: 10363858	Depth, ft.: 20-22.5	Checked: PJ
Soil Type: Dark Greenish Gray Fat CLAY (Bay Mud)		Date: 1/3/2025



Assumed Gs	2.75	Initial	Final
Moisture %:		75.6	53.7
Dry Density, pcf:		55.6	69.3
Void Ratio:		2.088	1.478
% Saturation:		99.6	100.0

Remarks:



Project: SAFER BAY PROJECT
 Project Location: SAN MATEO COUNTY, CA
 Project Number: 10363858

Boring ID: B24-07

Sheet 1 of 4 Sheets

Start Date: 10/21/2024 End Date: 10/21/2024 Logged By: Olen Gover Checked By: Ed Woo Date Checked: 2/28/2025

Drilling Company (Rig Type): Pitcher Services, LLC (Truck) Inspector: Kian Atkinson Weather Conditions: Sunny

Drill Method: Mud Rotary Drilled By: Michael Sevilla Elevation Top of Boring: 10.8 ft. Vertical Datum: NAVD88

Drill Bit (Type/Size): Tricone / 5" (O.D) Total Depth Drilled: 81.5 ft. Latitude: 37.493465° Longitude: -122.140043° Horizontal Datum: NAD83

Hammer Type: Automatic Hole Backfill: Cement grout Northing: 2,006,315 ft. Easting: 6,085,887 ft. Coordinate System: State Plane CA Zone 3

Hammer Efficiency: Rod Type: Total Number of Samples: 20 Initial Groundwater Depth: 7 ft. Disturbed: 16 Undisturbed: 4 Static Groundwater Depth: Not established

ELEV	DEPTH	SAMPLE	Blows/6" or Press.	N _r	LEGEND	DESCRIPTION OF MATERIALS	% REC	Samp No	Laboratory					Su (ksf)	REMARKS
									Fines	LL	PL	DD	MC		
10						2" gravel base material..									Start with 6" core barrel.
						FILL SANDY LEAN CLAY with Gravel (CL): very stiff, dark brown, moist, low plasticity fines, angular gravels up to 1.5", fine to coarse grained sand.		G1							
5			9	26		FILL GRAVELLY LEAN CLAY with Sand (CL): medium stiff, olive brown to red, moist, angular/subangular gravels up to 1.5", coarse sand, medium plasticity, low toughness.	100	L1							Groundwater encountered at 7'.
5			12			LEAN CLAY with Sand (CL): medium stiff, brown to red, wet, medium plasticity, medium toughness, with coarse sand.		L2							
0			1	12			67	L3	39	20	122	14			Install casing to 9' and switch to mud rotary with 5" tri-cone bit.
0			6												
-5			6			FAT CLAY (CH): very soft, gray, moist, high plasticity, medium toughness, strong organic odor.	100	T1	125	83	46	99	0.25 P 0.05 T 0.52 U		Gravel slough at top of Shelby sampler. 0 - 0.5': 80 psi 0.5' - 1.0': 50 psi 1.0' - 2.5': 75 psi Advanced casing to 16.5'.
-5															

HDR SOIL BORING LOG 2017_MARCH_R1: 10363858 - SFCJPA TO4 SAFER BAY PROJECT - POST LAB.GPJ; HDR_FOLSOM_OAKLAND_SEP_2021_WIP.GLB; 3/6/25



Project: SAFER BAY PROJECT
 Project Location: SAN MATEO COUNTY, CA
 Project Number: 10363858

Boring ID: B24-07

Sheet 2 of 4
 Sheets

HDR SOIL BORING LOG 2017_MARCH_R1: 10363858 - SFCJPA TO4 SAFER BAY PROJECT - POST LAB.GPJ; HDR_FOLSOM_OAKLAND_SEP_2021_WIP.GLB; 3/6/25

ELEV	DEPTH	SAMPLE	Blows/6" or Press.	N _r	LEGEND	DESCRIPTION OF MATERIALS	R% REC	Samp No.	Laboratory					Su (ksf)	REMARKS
									Fines	LL	PI	DD	MC		
-10		X	0	0	[Diagonal Hatching]	Strong H2S odor.	83	L4						0.40 P 0.25 T	
-15			0					30	T2						0 - 1.0': WOR 1.0' - 2.5': 80 psi Poor recovery. Saved sample in bag. 2.0" angular gravel piece caught in sampler.
-20			0				Few fine angular gravels present at bottom of sample.	83	T3						0 - 0.5': 50 psi 0.5' - 1.0': 170 psi 1.0' - 1.5': 210 psi 1.5' - 2.0': 280 psi 2.0' - 2.5': 300 psi
-25		X	7	30	[Diagonal Hatching]	SANDY LEAN CLAY (CL): very stiff, greenish gray, moist, medium plasticity, medium toughness, pockets of greenish gray low plasticity fines, some sand.	83	L5	49	29	105	23	2.84 U 3.75 P	> 2.0 KSF TV	
-30		X	13				LEAN CLAY with Sand (CL): stiff, grayish brown and yellow, medium plasticity, low toughness.	78	L6					2.25 P	> 1.0 KSF TV
-35		X	17												
-40		X	4	15											
-45		X	7												
-50		X	8												



Project: SAFER BAY PROJECT
 Project Location: SAN MATEO COUNTY, CA
 Project Number: 10363858

Boring ID: B24-07

Sheet 3 of 4
 Sheets

HDR SOIL BORING LOG 2017 MARCH R1: 10363858 - SFCJPA TO4 SAFER BAY PROJECT - POST LAB GPJ; HDR_FOLSOM_OAKLAND_SEP 2021_WIP.GLB; 3/6/25

ELEV	DEPTH	SAMPLE	Blows/6" or Press	N _r	LEGEND	DESCRIPTION OF MATERIALS	% REC	Samp No.	Laboratory					Su (ksf)	REMARKS
									Fines	LL	PI	DD	MC		
-45			3			Poorly Graded SAND with Silt (SP-SM): medium dense, yellowish brown, fine grained sand, few low plasticity fines.	100	S1							Sand in drill fluid at 44.5'.
-35			10	23											
			13			SANDY LEAN CLAY with Gravel (CL): stiff to very stiff, yellowish brown, medium plasticity, low toughness, with medium sand and fine gravel.									Clay cuttings in drill fluid at 47.5'.
-50			4												
-40			9	22			61	L7	42	22	102	24	1.74 U 2.50 P 1.90 T		
			13			LEAN CLAY (CL): very stiff, yellowish brown, moist, low plasticity, low toughness.									
-55			5												
-45			12	26			95	L8					2.00 P 1.80 T		
			14			SILT (ML): medium stiff, olive brown, low plasticity, low toughness, slow dilatancy.									
-60			3												
-50			4	8			100	L9					0.50 P 0.30 T		
			4												
-65															
-55							87	T4							0 - 0.5': WOR 0.5' - 1.0': 120 psi 1.0' - 1.5': 220 psi 1.5' - 2.0': 300 psi 2.0' - 2.5': 450 psi Assumed contact based on Shelby sampler push pressure.
			0			Poorly Graded SAND with Clay (SP-SC): medium dense, brown, moist, fine-grained sand, few plastic fines. 3" - 4" lense of sandy lean clay.	100	S2							
			1	8											
			7												



Project: SAFER BAY PROJECT
 Project Location: SAN MATEO COUNTY, CA
 Project Number: 10363858

Boring ID: B24-07

Sheet 4 of 4
 Sheets

ELEV	DEPTH	SAMPLE	Blows/6" or Press.	N _r	LEGEND	DESCRIPTION OF MATERIALS	R% REC	Samp No.	Laboratory					Su (ksf)	REMARKS
									Fines	LL	PI	DD	MC		
-70			2	19		2" lense of CL/ML.	100	S3							
-60			7												
			12												
-75			11	20		Yellowish brown.	100	S4							
-65			9												
			11												
-80			6	21		Yellowish brown, fine to medium grained sand.	100	S6							
-70			9												
			12												

Boring terminated at 81.5'.

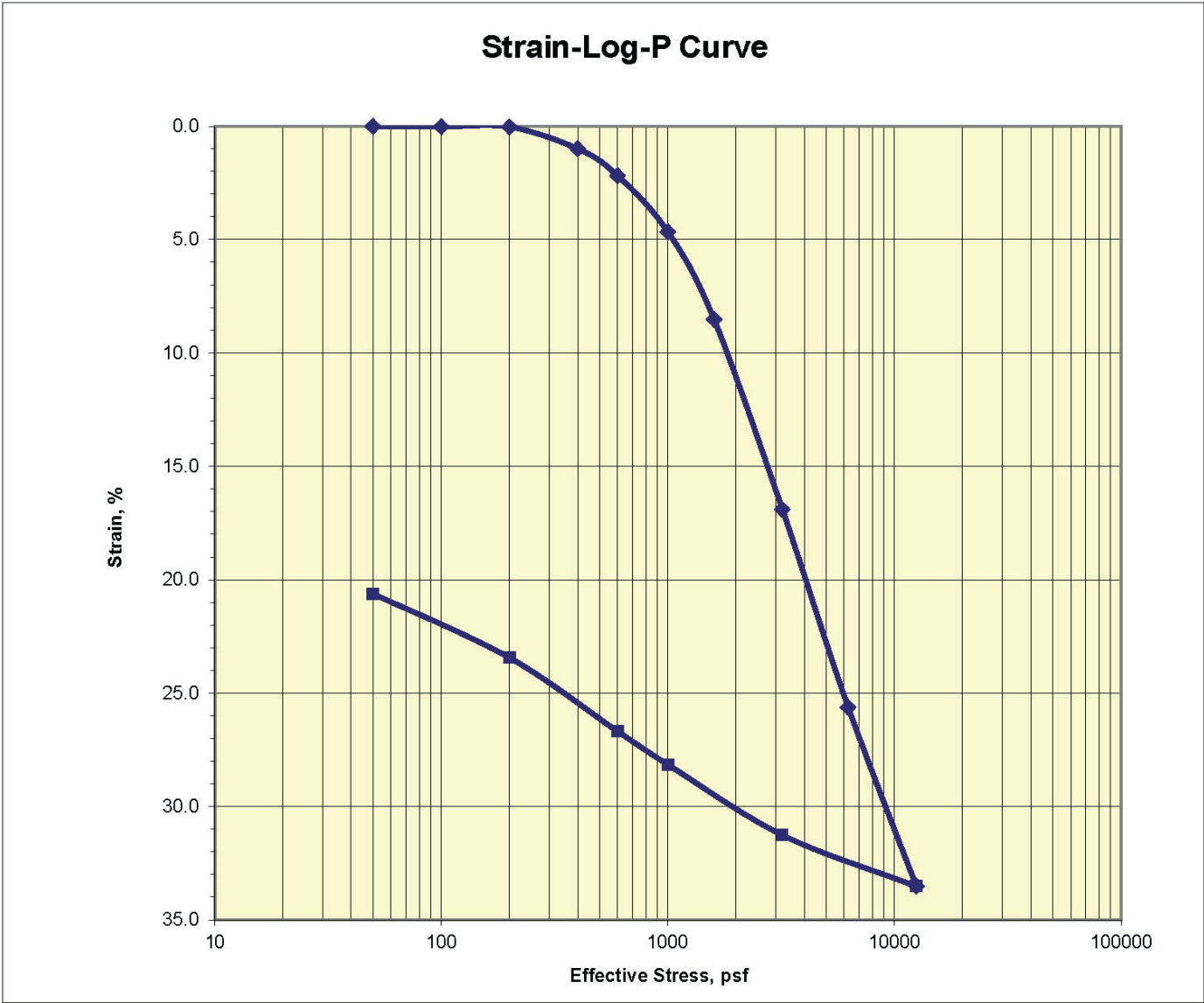
HDR SOIL BORING LOG_2017_MARCH_R1: 10363858 - SFCJPA TO4 SAFER BAY PROJECT - POST LAB.GPJ; HDR_FOLSOM_OAKLAND_SEP_2021_WIP.GLB; 3/6/25



Consolidation Test

ASTM D2435

Job No.: 855-055	Boring: B24-07	Run By: HM
Client: HDR Engineering	Sample: T1	Reduced: RU
Project: 10363858	Depth, ft.: 15-17.5	Checked: PJ
Soil Type: Dark Gray Fat CLAY (Bay Mud)		Date: 1/22/2025



Assumed Gs	2.65	Initial	Final
Moisture %:		98.8	70.5
Dry Density, pcf:		45.5	57.7
Void Ratio:		2.640	1.868
% Saturation:		99.2	100.0

Remarks:



Project: SAFER BAY PROJECT
 Project Location: SAN MATEO COUNTY, CA
 Project Number: 10363858

Boring ID: B24-08

Sheet of 1 4 Sheets

Start Date: 10/22/2024	End Date: 10/22/2024	Logged By: Olen Gover	Checked By: Ed Woo	Date Checked: 2/28/2025
Drilling Company (Rig Type): Pitcher Services, LLC (Truck)		Inspector: Kian Atkinson	Weather Conditions: Overcast/Sunny	
Drill Method: Mud Rotary		Drilled By: Eden Espinoza	Elevation Top of Boring: 9.0 ft. Vertical Datum: NAVD88	
Drill Bit (Type/Size): Tricone / 5" (O.D)		Total Depth Drilled: 71.5 ft.	Latitude: 37.488782° Longitude: -122.140602° Horizontal Datum: NAD83	
Hammer Type: Automatic		Hole Backfill: Cement grout	Northing: 2,004,613 ft. Easting: 6,085,695 ft. Coordinate System: State Plane CA Zone 3	
Hammer Efficiency:	Rod Type:	Total Number of Samples: 16 Disturbed: 12 Undisturbed: 4	Initial Groundwater Depth: Not established Static Groundwater Depth: Not established	

ELEV	DEPTH	SAMPLE	Blows/6" or Press.	N _r	LEGEND	DESCRIPTION OF MATERIALS	% REC	Samp No	Laboratory					Su (ksf)	REMARKS
									Fines	LL	PL	DD	MC		
						9" asphalt.								Begin with 6" core barrel.	
						5" aggregate base.									
						FILL LEAN CLAY with Sand (CL): medium stiff, olive gray to gray, moist, low plasticity, low toughness, trace gravels, little coarse sand.		G1							
						Soft.		G2							
						FAT CLAY (CH): soft, black, moist, with fibrous organics, organic odor, medium to high plasticity, medium toughness.		G3						0 - 2.0': 75 psi 2.0' - 2.5': 100 psi	
						Gray, H2S odor, high plasticity, medium toughness.	100	T1				81		Install casing to 5' and begin mud rotary with 5" tri-cone bit.	
						Organics in drill fluid, strong organic odor.			113	70	52	82	0.46 U		
			0	0	0	Yellow decomposed straw and trace shell fragments throughout sample.	67	L1					0.50 P 0.30 T		
						Few shell fragments.	100	T2		106	65	53 53	81 83 81	0.37 U	0 - 1.5': 75 psi 1.5' - 2.5': 100 psi No recovery on initial drive. Driller repushed sampler and recovered sample.

HDR SOIL BORING LOG 2017_MARCH_R1: 10363858 - SFCJPA TO4 SAFER BAY PROJECT - POST LAB.GPJ; HDR_FOLSOM_OAKLAND_SEP_2021_WIP.GLB; 3/6/25



Project: SAFER BAY PROJECT
 Project Location: SAN MATEO COUNTY, CA
 Project Number: 10363858

Boring ID: B24-08

Sheet 2 of 4
 Sheets

ELEV	DEPTH	SAMPLE	Blows/6" or Press.	N _r	LEGEND	DESCRIPTION OF MATERIALS	R% REC	Samp No.	Laboratory					Su (ksf)	REMARKS				
									Fines	LL	PI	DD	MC						
			0 0 0	0		Color change to dark gray.	100	L2											
						SANDY LEAN CLAY (CL): very stiff, yellowish brown, moist, low plasticity, low toughness, some sand.	0												
			11 16 21	37			89	L3					3.25 P						
			4 7 7	14		SILTY SAND (SM): medium dense, brown, fine to medium grained sand, little low plasticity fines.	67	S1	13										
			3 5 9	14		SANDY LEAN CLAY (CL): stiff, yellowish brown, moist, low plasticity, low toughness, some coarse sand.	89	L4					1.25 P 0.50 T						

HDR SOIL BORING LOG 2017_MARCH_R1: 10363858 - SFCJPA T04 SAFER BAY PROJECT - POST LAB.GPJ; HDR_FOLSOM_OAKLAND_SEP_2021_WIP.GLB; 3/6/25



Project: SAFER BAY PROJECT
 Project Location: SAN MATEO COUNTY, CA
 Project Number: 10363858

Boring ID: B24-08

Sheet 3 of 4
 Sheets

ELEV	DEPTH	SAMPLE	Blows/6" or Press.	N _r	LEGEND	DESCRIPTION OF MATERIALS	R% REC	Samp No.	Laboratory					Su (ksf)	REMARKS
									Fines	LL	PI	DD	MC		
-45						Olive brown.	100	T3		43	20	96 92	28 30	1.46 U	0 - 0.5': 100 psi 0.5' - 1.5': 150 psi 1.5' - 2.0': 300 psi 2.0' - 2.5': 400 psi
-50			4 6 10	16			83	L5							
-55			4 9 12	21		Yellow and grayish brown.	83	L6					2.25 P 1.30 T		
-60						Poorly Graded SAND with Silt (SP-SM): very dense, fine to medium grained sand, few fine gravel, little low plasticity fines.	67	T4						0 - 0.5': 80 psi 0.5' - 1.0': 200 psi 1.0' - 1.5': 300 psi 1.5' - 2.0': 700 psi (refusal) Contact assumed based on Shelby sampler push pressure. Fine-grained sand at bottom of Shelby sampler.	
-65			11 21 30	51		Poorly Graded GRAVEL (GP): rounded to subrounded fine gravels.	100	S2						Gravel zone assumed based on gravels in drill fluid.	

HDR SOIL BORING LOG 2017_MARCH_R1: 10363858 - SFCJPA T04 SAFER BAY PROJECT - POST LAB.GPJ; HDR_FOLSOM_OAKLAND_SEP 2021_WIP.GLB; 3/6/25



Project: SAFER BAY PROJECT
 Project Location: SAN MATEO COUNTY, CA
 Project Number: 10363858

Boring ID: B24-08

Sheet 4 of 4
 Sheets

ELEV	DEPTH	SAMPLE	Blows/6" or Press	N _r	LEGEND	DESCRIPTION OF MATERIALS	R% REC	Samp No.	Laboratory					Su (ksf)	REMARKS
									Fines	LL	PI	DD	MC		
	-70			10 16 26	42	LEAN CLAY (CL): hard, gray to olive gray, low plasticity, low to medium toughness.	83	L7						2.75 P	Clay cuttings in drill fluid.

Boring terminated at 71.5'.

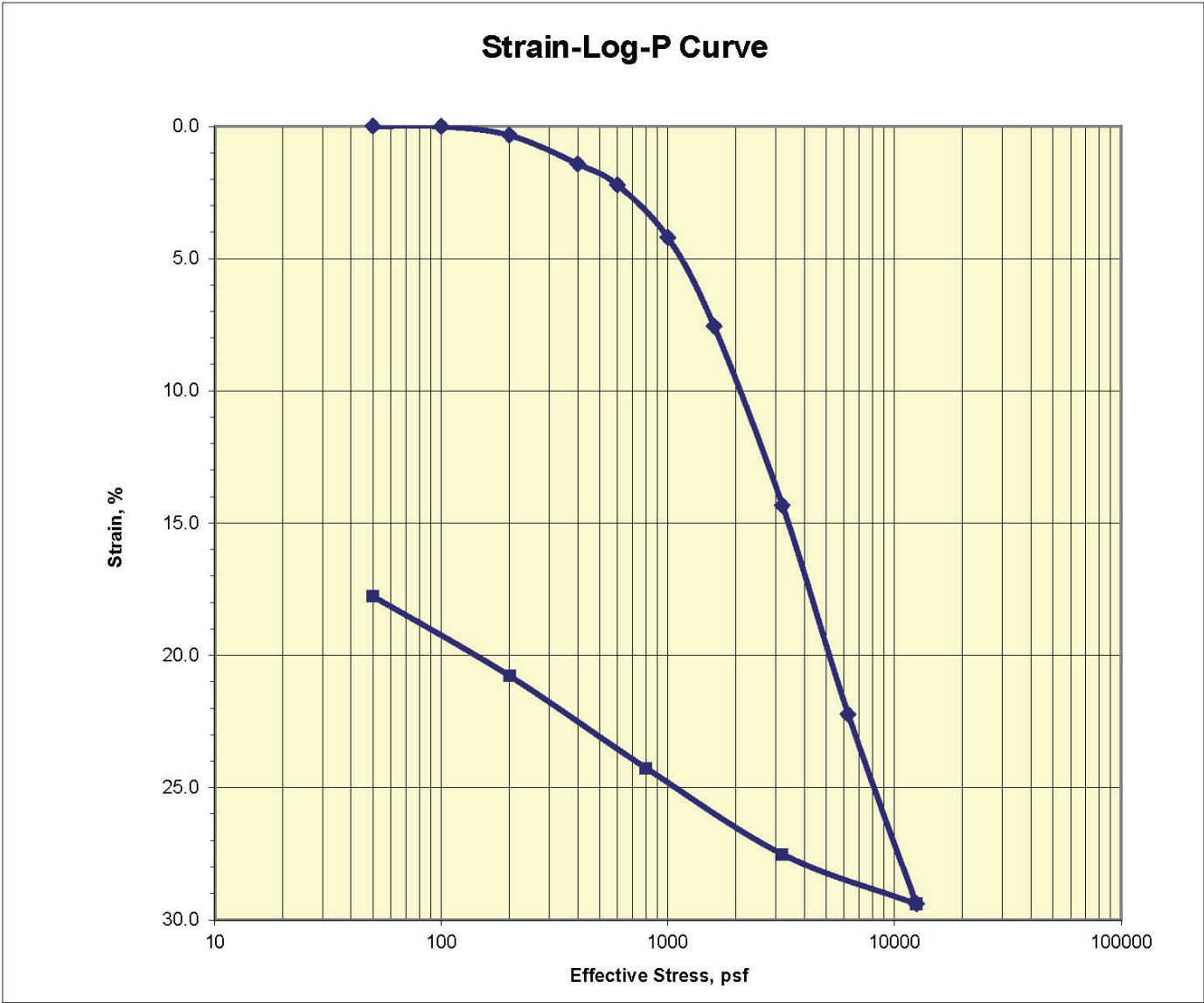
HDR SOIL BORING LOG_2017_MARCH_R1: 10363858 - SFCJPA TO4 SAFER BAY PROJECT - POST LAB.GPJ; HDR_FOLSOM_OAKLAND_SEP_2021_WIP.GLB; 3/6/25



Consolidation Test

ASTM D2435

Job No.: 855-055	Boring: B24-08	Run By: HM
Client: HDR Engineering	Sample: T2	Reduced: RU
Project: 10363858	Depth, ft.: 15-17.5(Tip-1")	Checked: PJ
Soil Type: Bluish Gray Fat CLAY (Bay Mud)		Date: 1/22/2025



Assumed Gs	2.7	Initial	Final
Moisture %:	81.2	60.8	
Dry Density, pcf:	52.6	63.8	
Void Ratio:	2.205	1.642	
% Saturation:	99.4	100.0	

Remarks:



Project: SAFER BAY PROJECT
 Project Location: SAN MATEO COUNTY, CA
 Project Number: 10363858

Boring ID: B24-09

Sheet 2 of 4
 Sheets

HDR SOIL BORING LOG_2017_MARCH_R1: 10363858 - SFCJPA T04 SAFER BAY PROJECT - POST LAB.GPJ; HDR_FOLSOM_OAKLAND_SEP_2021_WIP.GLB; 3/6/25

ELEV	DEPTH	SAMPLE	Blows/6" or Press.	N _r	LEGEND	DESCRIPTION OF MATERIALS	% REC	Samp No.	Laboratory					Su (ksf)	REMARKS
									Fines	LL	PI	DD	MC		
	0			4			72	L5							3" chunk of conglomerate in top liner.
	2							L6					0.25 P 0.20 T		
	10					CLAYEY SAND with Gravel (SC): loose, dark brown to gray, fine grained sand, subrounded gravels up to 1/2", few to little gray plastic fines.									Sand and rounded gravels up to 1/2" in drill fluid.
	25			13			67	L7	21	25	8	117	17		3" chunk of conglomerate in middle liner.
	15							L8							Well graded sand and fine gravels in drill fluid.
	30			19		LEAN CLAY with Gravel (CL): very stiff, yellowish brown, moist, medium plasticity, medium toughness, angular to subangular gravels up to 1/2", little coarse sand.	22	S2							No recovery on initial drive. Driller redrove SPT sampler. Blow counts of 1, 2, 6 on redrive.
	20			7		SANDY LEAN CLAY (CL): medium stiff, yellowish brown, moist, medium plasticity, medium toughness, some fine-grained sand.	67	L9							Driller flushed hole out after SPT sampler and drove Modcal at 32'.
	35							L10							
	25					CLAYEY SAND with Gravel (SC): very stiff, olive brown, moist, low plasticity, low toughness.	100	T2				109	19		0 - 1.0': WOR 1.0' - 2.5': 100 psi
	40			16		SANDY LEAN CLAY with Gravel (CL): stiff to very stiff, yellowish brown mottled black and red, low to medium plasticity, low toughness.									
	30					Poorly Graded SAND with Clay (SP-SC): medium dense, fine-grained sand, few plastic fines.	100	S3							Transition is in bottom 4" of SPT sample.
								S4							
						LEAN CLAY with Sand (CL): very stiff, olive brown,									Poorly-graded sand in drill fluid at 44' transitions to



Project: SAFER BAY PROJECT
 Project Location: SAN MATEO COUNTY, CA
 Project Number: 10363858

Boring ID: B24-09

Sheet 4 of 4
 Sheets

ELEV	DEPTH	SAMPLE	Blows/6" or Press.	N _r	LEGEND	DESCRIPTION OF MATERIALS	R% REC	Samp No.	Laboratory					Su (ksf)	REMARKS
									Fines	LL	PI	DD	MC		
	70					Dense.	67	L15							

Boring terminated at 71.5'.

HDR SOIL BORING LOG_2017_MARCH_R1: 10363858 - SFCJPA TO4 SAFER BAY PROJECT - POST LAB.GPJ; HDR_FOLSOM_OAKLAND_SEP_2021_WIP.GLB; 3/6/25



Project: SAFER BAY PROJECT
 Project Location: SAN MATEO COUNTY, CA
 Project Number: 10363858

Boring ID:
B24-10

Sheet
 of **1**
4 Sheets

Start Date: 10/11/2024	End Date: 10/11/2024	Logged By: Olen Gover	Checked By: Ed Woo	Date Checked: 2/28/2025
Drilling Company (Rig Type): Pitcher Services, LLC (Track)		Inspector: Kian Atkinson	Weather Conditions: Sunny	
Drill Method: Mud Rotary		Drilled By: Will Halai	Elevation Top of Boring: 9.7 ft. Vertical Datum: NAVD88	
Drill Bit (Type/Size): Tricone / 5" (O.D)		Total Depth Drilled: 71.5 ft.	Latitude: 37.482583° Longitude: -122.161269° Horizontal Datum: NAD83	
Hammer Type: Automatic		Hole Backfill: Cement grout	Northing: 2,002,462 ft. Easting: 6,079,660 ft. Coordinate System: State Plane CA Zone 3	
Hammer Efficiency:	Rod Type:	Total Number of Samples: 24 Disturbed: 22 Undisturbed: 2	Initial Groundwater Depth: Not established Static Groundwater Depth: Not established	

ELEV	DEPTH	SAMPLE	Blows/6" or Press.	N _r	LEGEND	DESCRIPTION OF MATERIALS	% REC	Samp No	Laboratory					Su (ksf)	REMARKS
									Fines	LL	PL	DD	MC		
						FILL CLAYEY GRAVEL with Sand (GC): stiff, grayish brown, moist, subangular to angular gravels up to 3/4".		G1						Begin with 6" core barrel. Geotextile at 3".	
						FILL LEAN CLAY with Sand (CL): stiff, dark grayish brown to black, moist, medium plasticity, medium toughness, with sand and gravel.		G2							
						FILL SILTY SAND with Gravel (SM): medium dense to dense, yellow, moist, fine grained sand, fine grained gravel up to 3/4", low plasticity fines.		G3							
						FILL LEAN CLAY with Sand (CL): stiff, dark grayish brown to black, moist, medium plasticity, medium toughness, with coarse sand and gravels up to 3/4". Stiff, moist, with fine to coarse grained sand, pockets of very light yellow to white low plasticity silt.		G4							
						FILL LEAN CLAY with Sand (CL): stiff, dark grayish brown to black, moist, medium plasticity, medium toughness, with coarse sand and gravels up to 3/4". Stiff, moist, with fine to coarse grained sand, pockets of very light yellow to white low plasticity silt.	72	L1	39	21	112	19			Install casing to 4' and begin mud rotary at 6.5' with 5" tri-cone bit.
						FAT CLAY with Sand (CH): very soft, gray, moist, high plasticity, high toughness, little fine sand.								Gray clay cuttings in drill fluid at 8.5'. 0 - 2.5': WOR	
						Increasing fine sand and gravel content.									
						SANDY LEAN CLAY (CL): stiff, light yellowish brown, moist, low plasticity, low dry strength, some fine grained sand.	100	T1	59	38	94 91	30 32	1.38 U 1.50 P 0.55 T		
							72	L2							
								L3	53		100	25	4.00 P	2-3" gravel piece in top of liner L3. Transition is in liner L3.	
						CLAYEY SAND with Gravel (SC): medium dense, brown, moist, well graded sand, fine rounded to subrounded gravel.								Fine rounded gravel and sand in drill fluid at 18.5'.	

HDR SOIL BORING LOG 2017_MARCH_R1: 10363858 - SFCJPA TO4 SAFER BAY PROJECT - POST LAB GP.; HDR_FOLSOM_OAKLAND_SEP_2021_WIP_GLB: 3/6/25



Project: SAFER BAY PROJECT
 Project Location: SAN MATEO COUNTY, CA
 Project Number: 10363858

Boring ID: B24-10

Sheet 2 of 4
 Sheets

HDR SOIL BORING LOG 2017_MARCH_R1: 10363858 - SFCJPA TO4 SAFER BAY PROJECT - POST LAB.GPJ; HDR_FOLSOM_OAKLAND_SEP 2021_WIP.GLB; 3/6/25

ELEV	DEPTH	SAMPLE	Blows/6" or Press.	N _r	LEGEND	DESCRIPTION OF MATERIALS	R% REC	Samp No.	Laboratory					Su (ksf)	REMARKS
									Fines	LL	PI	DD	MC		
	6														
	10			25				S1	19	28	12				
	15														
-15	25														
	24			49		SANDY LEAN CLAY (CL): very stiff, light yellowish brown, moist, low toughness, slow dilatancy, little rounded coarse sand to fine gravel.	100	S2							
	25					Poorly Graded SAND with Silt and Gravel (SP-SM): dense, reddish brown, red oxidation staining, fine rounded to subrounded gravel up to 1/2", medium to coarse sand, few fines.		S3							
						Poorly Graded GRAVEL (GP): medium dense, orange, black, red, and gray gravels, subrounded and subangular, fine gravels up to 1/2".									
-20	30			9				S4							
				13		Poorly Graded SAND with Silt and Gravel (SP-SM): medium dense, dark olive brown, medium to coarse sand, fine subrounded gravel up to 1/2", few fines.	72								
				15				S5	12						
						Poorly Graded SAND (SP): medium dense, coarse subrounded pea-sized sand, few fine subangular gravels.									
-25	35			7				S6							
				8		SANDY LEAN CLAY (CL): very stiff, grayish brown mottled red, moist, low to medium plasticity, medium toughness, low dry strength, some sand.	72	S7		35	16				
				9											
						Poorly Graded SAND with Gravel (SP): medium dense, rounded to subrounded pea-sized coarse sand to fine gravel.									
-30	40			0											
				8											
				12											
						SILTY SAND with Gravel (SM): dense, olive brown to reddish brown, few to little low plasticity fines, medium to coarse sand, subangular gravels up to 1/2".									
							0								

Fine rounded gravel and coarse sand in drill fluid at 29'.

Clay cuttings and gravels in drill fluid.

No recovery. Put catcher on sample and redrove.

Water spraying from drill rods.

Driller says hole caved.

Only recovered small amount of material in drive shoe.

Rounded/subrounded coarse pea-sized sand to fine gravel in drill fluid.

Rig chatter.



Project: SAFER BAY PROJECT
 Project Location: SAN MATEO COUNTY, CA
 Project Number: 10363858

Boring ID: B24-10

Sheet 3 of 4
 Sheets

HDR SOIL BORING LOG 2017_MARCH_R1: 10363858 - SFCJPA TO4 SAFER BAY PROJECT - POST LAB.GPJ; HDR_FOLSOM_OAKLAND_SEP_2021_WIP.GLB; 3/6/25

ELEV	DEPTH	SAMPLE	Blows/6" or Press	N _r	LEGEND	DESCRIPTION OF MATERIALS	R% REC	Samp No.	Laboratory					Su (ksf)	REMARKS
									Fines	LL	PI	DD	MC		
-35	45		15	37			67	S8	12						Water spraying from drill rods when pulling sample up. Top 3" of sample was majority gravel, likely slough.
	16														
	21														
						Poorly Graded GRAVEL with Sand (GP): medium dense, fine subrounded to subangular gravels up to 3/4", fine to medium grained sand, trace fines.									
-40	50		6	26			61	S9							
	16														
	10														
						LEAN CLAY with Sand (CL): stiff, dark greenish gray, moist, low to medium plasticity, medium toughness, with fine to medium sand.									Clay cuttings and gravels in drill fluid.
-45	55		6	20			83	L4							Clay cuttings in drill bit.
	9							L5				1.25 P 1.10 T			Driller put a sand catcher on the sampler. Gravel slough in top liner.
	11														
-50	60					Very stiff.	83	T2	39	19	98	25	3.25 P		Gravel slough observed in top of Shelby sampler 0 - 0.5': 0 psi 0.5' - 1.0': 200 psi 1.0' - 1.5': 300 psi 1.5' - 2.5': 400 psi
-55	65		9	27			83	L6							Gravel slough in top liner.
	12							L7				1.75 P 1.20 T			
	15					SANDY LEAN CLAY (CL): very stiff, yellow, moist, low plasticity, low toughness, some fine grained									



Project: SAFER BAY PROJECT
 Project Location: SAN MATEO COUNTY, CA
 Project Number: 10363858

Boring ID: B24-10

Sheet 4 of 4
 Sheets

ELEV	DEPTH	SAMPLE	Blows/6" or Press	N _r	LEGEND	DESCRIPTION OF MATERIALS	R% REC	Samp No.	Laboratory					Su (ksf)	REMARKS
									Fines	LL	PI	DD	MC		
-60	70		7	18	[Hatched Pattern]	sand.	61	S10							

Boring terminated at 71.5'.

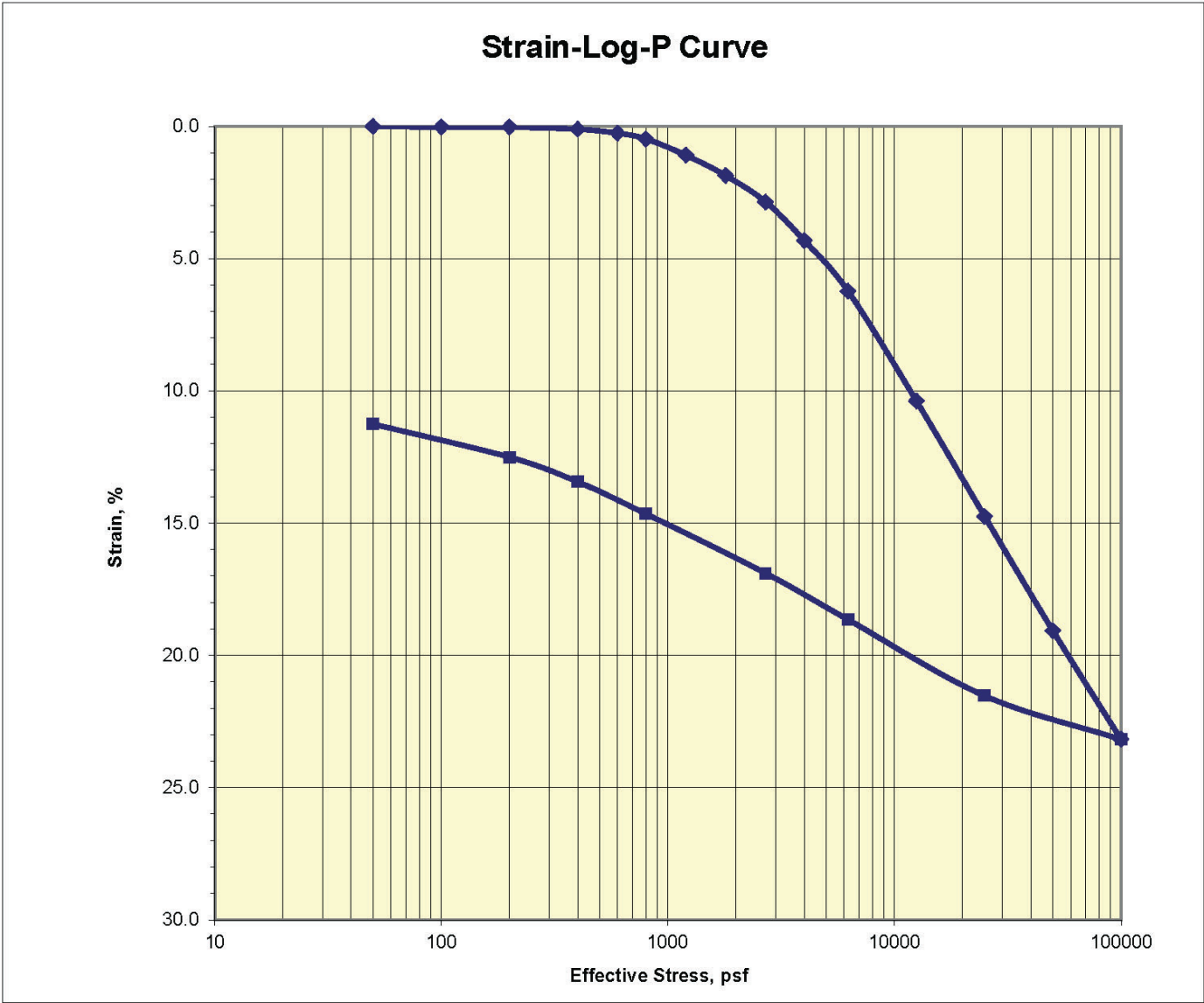
HDR SOIL BORING LOG_2017_MARCH_R1: 10363858 - SFCJPA TO4 SAFER BAY PROJECT - POST LAB.GPJ; HDR_FOLSOM_OAKLAND_SEP_2021_WIP.GLB; 3/6/25



Consolidation Test

ASTM D2435

Job No.: 855-055	Boring: B24-10	Run By: HM
Client: HDR Engineering	Sample: T1	Reduced: RU
Project: 10363858	Depth, ft.: 10-12.5	Checked: PJ
Soil Type: Very Dark Gray Fat CLAY w/ Sand		Date: 1/28/2025



Assumed Gs	2.8	Initial	Final
Moisture %:		30.4	25.0
Dry Density, pcf:		93.5	102.8
Void Ratio:		0.869	0.700
% Saturation:		97.8	100.0

Remarks:



Project: SAFER BAY PROJECT
 Project Location: SAN MATEO COUNTY, CA
 Project Number: 10363858

Boring ID:
B24-11

Sheet
 of **1**
4 Sheets

Start Date: 10/24/2024	End Date: 10/24/2024	Logged By: Olen Gover	Checked By: Ed Woo	Date Checked: 2/28/2025
Drilling Company (Rig Type): Pitcher Services, LLC (Truck)		Inspector: Kian Atkinson	Weather Conditions: Sunny	
Drill Method: Mud Rotary		Drilled By: Fine Taufatofua	Elevation Top of Boring: 12.8 ft. Vertical Datum: NAVD88	
Drill Bit (Type/Size): Tricone / 5" (O.D)		Total Depth Drilled: 71.5 ft.	Latitude: 37.487305° Longitude: -122.168116° Horizontal Datum: NAD83	
Hammer Type: Automatic		Hole Backfill: Cement grout	Northing: 2,004,217 ft. Easting: 6,077,704 ft. Coordinate System: State Plane CA Zone 3	
Hammer Efficiency:	Rod Type:	Total Number of Samples: 16 Disturbed: 13 Undisturbed: 3	Initial Groundwater Depth: Not established Static Groundwater Depth: Not established	

HDR SOIL BORING LOG_2017_MARCH_R1: 10363858 - SFCJPA T04 SAFER BAY PROJECT - POST LAB.GPJ; HDR_FOLSOM_OAKLAND_SEP_2021_WIP.GLB; 3/6/25

ELEV	DEPTH	SAMPLE	Blows/6" or Press.	N _r	LEGEND	DESCRIPTION OF MATERIALS	% REC	Samp No	Laboratory					Su (ksf)	REMARKS
									Fines	LL	PL	DD	MC		
						FILL SANDY LEAN CLAY (CL): stiff, yellowish brown, moist, low plasticity, low toughness, low dry strength, few gravels up to 1/2", some sand.									Begin with 6" core barrel.
	10					Color change to yellowish brown and gray brown, few gravels up to 1", trace sand.		G1		32	16				
	5					SANDY LEAN CLAY with Gravel (CL): very stiff, grayish brown, moist, low plasticity, low toughness, subrounded gravels 1/4" to 1/2", some sand.	100	L1							Install casing to 3' and begin mud rotary at 6.5' with 5" tri-cone bit.
	5		9	28		FAT CLAY (CH): very soft, very dark gray, moist, high plasticity, medium toughness, with yellow and brown decomposing organics.									Gray clay cuttings in drill fluid.
	10		14			FAT CLAY with Gravel (CH): stiff, dark gray, moist, strong organic odor, medium to high plasticity, medium toughness, little gravel.	60	T1				92			0 - 0.5': 0 psi 0.5' - 2.5': 50 psi
	0					LEAN CLAY with Sand (CL): very stiff, greenish gray to gray, moist, low plasticity, medium toughness, little sand, trace gravels up to 3/4".				123	81	53	80	0.44 U	
	15		2	15			67	L2		52	31	90	32	1.14 U 1.30 T	Strong organic odor from cuttings at 13.5'.
	-5		6												Cuttings feel noticeably stiffer at 19'.
			9												



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Boring ID: B24-11

Sheet 2 of 4
 Sheets

HDR SOIL BORING LOG_2017_MARCH_R1: 10363858 - SFCJPA TO4 SAFER BAY PROJECT - POST LAB.GPJ; HDR_FOLSOM_OAKLAND_SEP_2021_WIP.GLB: 3/6/25

ELEV	DEPTH	SAMPLE	Blows/6" or Press.	N _r	LEGEND	DESCRIPTION OF MATERIALS	R% REC	Samp No.	Laboratory					Su (ksf)	REMARKS
									Fines	LL	PI	DD	MC		
	7			31	[Hatched Pattern]		83	L3					4.5+ P		
	13														
	18														
-10															
	25			19	[Hatched Pattern]	Stiff, grayish brown.	67	L4					2.00 P 1.20 T		
-15															
	30				[Hatched Pattern]	Greenish gray.	87	T2		39	17	92 98	31 26	1.10 T 1.18 U	0 - 0.5': 70 psi 0.5' - 1.5': 300 psi 1.5' - 2.0': 400 psi 2.0' - 2.5': 700 psi
-20															
	35			7	[Hatched Pattern]	SANDY FAT CLAY with Gravel (CH): medium stiff, gray, moist, medium to high plasticity, medium toughness, little fine gravel, some fine sand.	100	L5					0.75 P 0.20 T	Sand and clay cuttings in drill fluid.	
-25															
	40				[Hatched Pattern]		73	T3					0.75 P 0.20 T	0 - 0.5': 75 psi 0.5' - 1.0': 200 psi 1.0' - 1.5': 300 psi 1.5' - 2.0': 400 psi 2.0' - 2.5': 600 psi	
-30															
					[Hatched Pattern]	SILT (ML): very stiff, yellowish brown, moist, low plasticity, rapid dilatancy, trace fine sand.									
					[Hatched Pattern]	LEAN CLAY (CL): stiff, yellowish brown to brown,									Clay cuttings in drill fluid.



Project: SAFER BAY PROJECT
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 Project Number: 10363858

Boring ID: B24-11

Sheet 3 of 4
 Sheets

HDR SOIL BORING LOG 2017_MARCH_R1: 10363858 - SFCJPA TO4 SAFER BAY PROJECT - POST LAB.GPJ; HDR_FOLSOM_OAKLAND_SEP 2021_WIP.GLB; 3/6/25

ELEV	DEPTH	SAMPLE	Blows/6" or Press	N _r	LEGEND	DESCRIPTION OF MATERIALS	% REC	Samp No.	Laboratory					Su (ksf)	REMARKS
									Fines	LL	PI	DD	MC		
-45			0			moist, with some pockets of gray, low plasticity, low toughness.	67	L6					1.25 P 0.65 T	Some sand in drill fluid.	
			5	13											
			8												
-35						LEAN CLAY with Sand (CL): stiff, grayish brown, low to medium plasticity, low toughness, little sand.									
-50			2												
			4	10				S1							
			6												
-40						SANDY LEAN CLAY (CL): medium stiff, greenish gray, medium plasticity, medium toughness, some sand.									
-55			0												
			5	10				L7	32	13	99	26	0.73 U 1.25 P 0.35 T		
			5												
-45						LEAN CLAY (CL): very stiff, grayish brown, low plasticity, medium toughness, trace sand.								Drilling slowed, stiffer clay at 58.5'.	
-60			9												
			15	34				L8					3.25 P 0.00 T		
			19												
-50						LEAN CLAY with Sand (CL): very stiff, grayish brown, medium plasticity, low toughness, little fine sand.								4" layer of poorly graded sand in sample.	
-65			9												
			7	16				S2							
			9												
-55															



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Sheet 4 of 4
 Sheets

ELEV	DEPTH	SAMPLE	Blows/6" or Press	N _r	LEGEND	DESCRIPTION OF MATERIALS	R% REC	Samp No.	Laboratory					Su (ksf)	REMARKS
									Fines	LL	PI	DD	MC		
	70		2	21			83	S3							
			10												
			11												

Boring terminated at 71.5'.

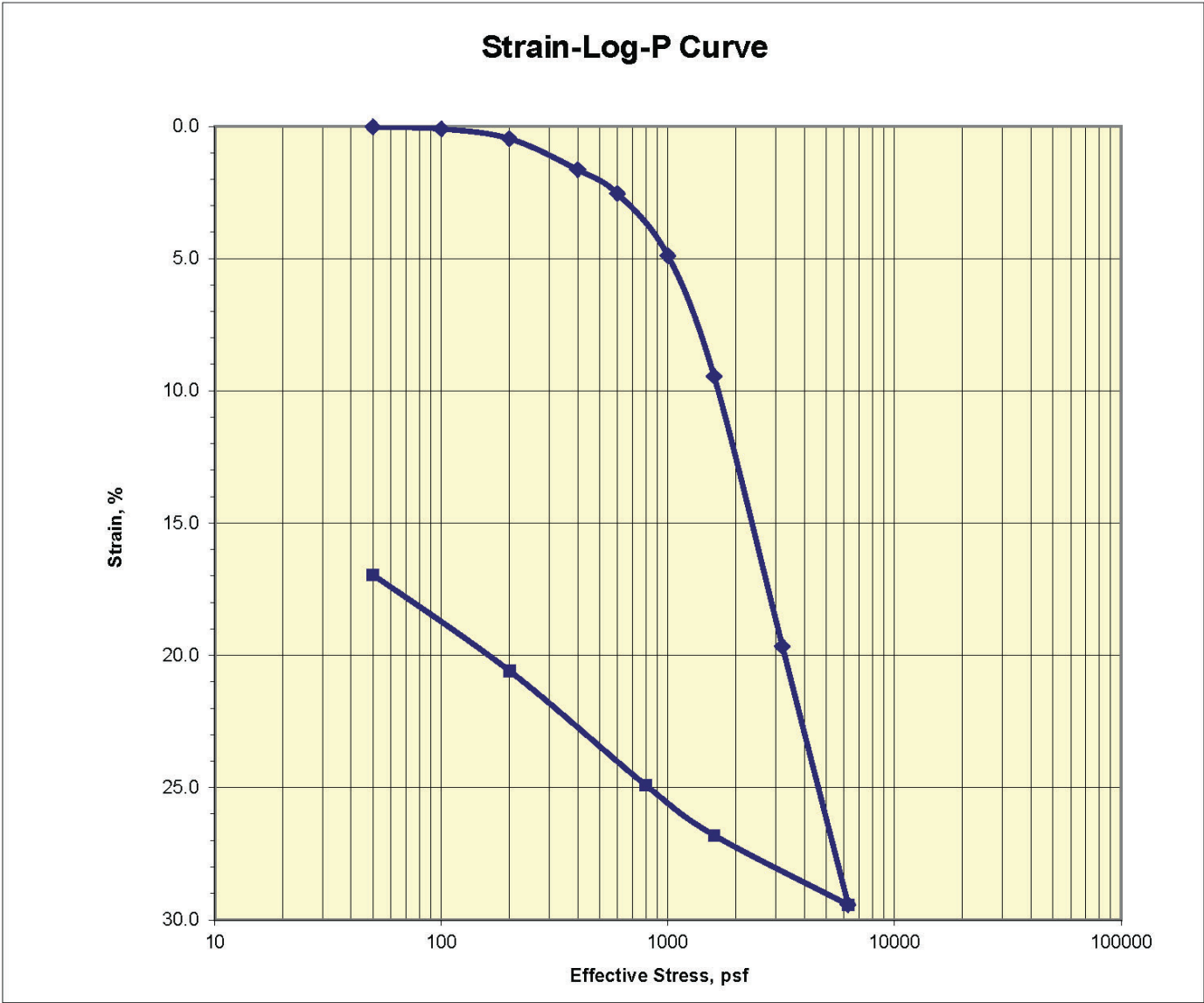
HDR SOIL BORING LOG_2017_MARCH_R1: 10363858 - SFCJPA TO4 SAFER BAY PROJECT - POST LAB.GPJ; HDR_FOLSOM_OAKLAND_SEP_2021_WIP.GLB; 3/6/25



Consolidation Test

ASTM D2435

Job No.: 855-055	Boring: B24-11	Run By: HM
Client: HDR Engineering	Sample: T1	Reduced: RU
Project: 10363858	Depth, ft.: 10-12.5	Checked: PJ
Soil Type: Very Dark Gray Fat CLAY (Bay Mud)		Date: 1/22/2025



Assumed Gs	2.6	Initial	Final
Moisture %:		112.0	86.3
Dry Density, pcf:		41.3	50.1
Void Ratio:		2.927	2.243
% Saturation:		99.5	100.0

Remarks: