India Basin Shoreline Park

ENGINEERING CRITERIA REVIEW BOARD MEETING
Prepared for San Francisco Recreation and Parks and The Trust for Public Land
by GGN with Jensen Architects, Sherwood Design Engineers, Rana Creek, Moffatt & Nichol, Jon Brody Structural Engineers, Interface Engineering, Niteo Lighting, and Boudreau Associates

For Review on December 6th, 2023 by the San Francisco Bay Conservation and Development Commission's Engineering Criteria Review Board (ECRB)

THE TRUST FOR PUBLIC LAND
SF Parks Alliance
APRI San Francisco
SAN FRANCISCO RECREATION & PARKS

Team Overview

Client Team:

- The Trust for Public Land
- San Francisco Recreation and Parks Department
- SF Parks Alliance
- A. Philip Randolph Institute

Design Team:

- Katherine Liss, GGN Landscape Architects
- Sean Hart, Moffatt & Nichol Coastal Engineers
- Kamran Ghiassi, AGS Geotechnical Engineer

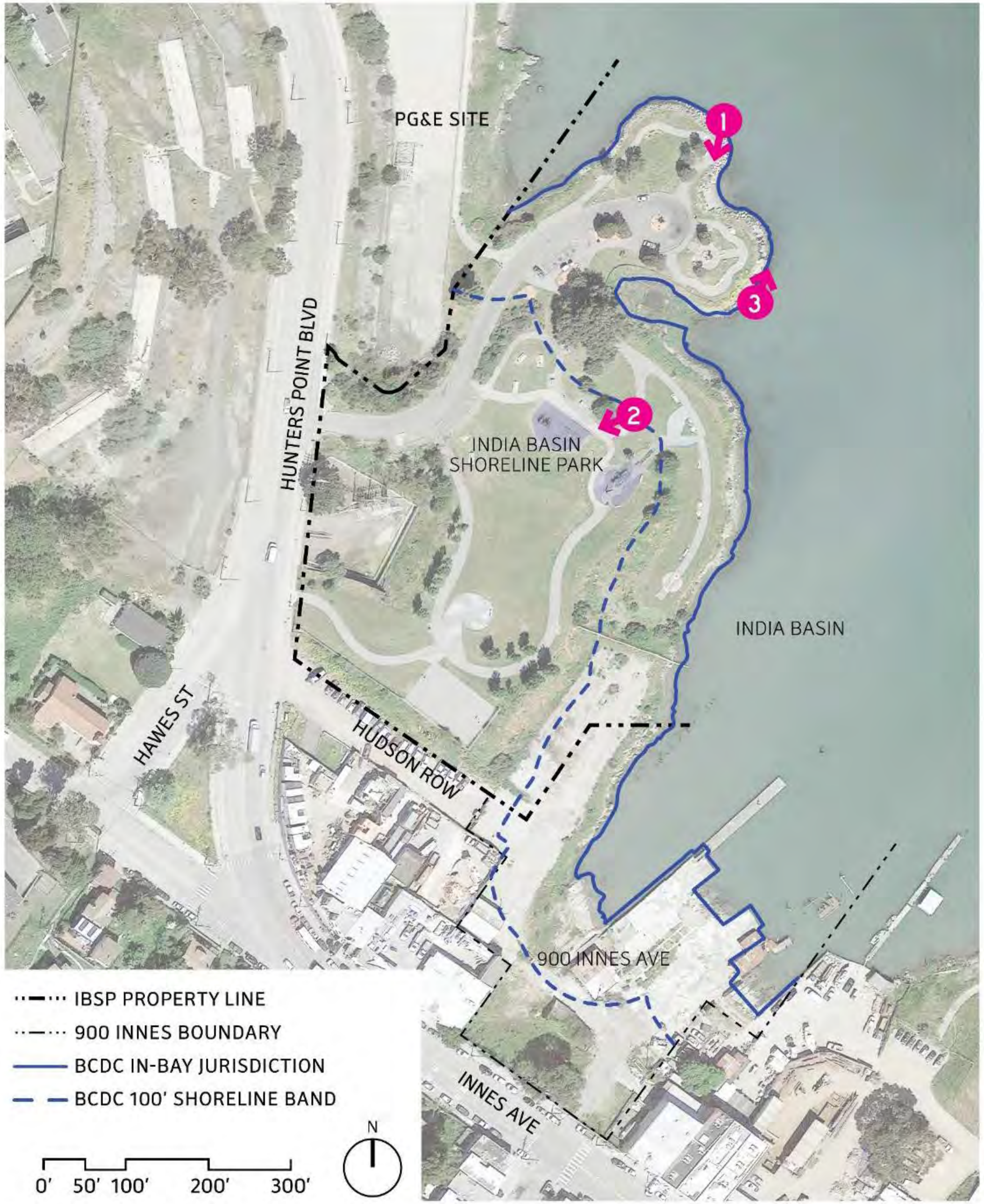
Presentation Overview

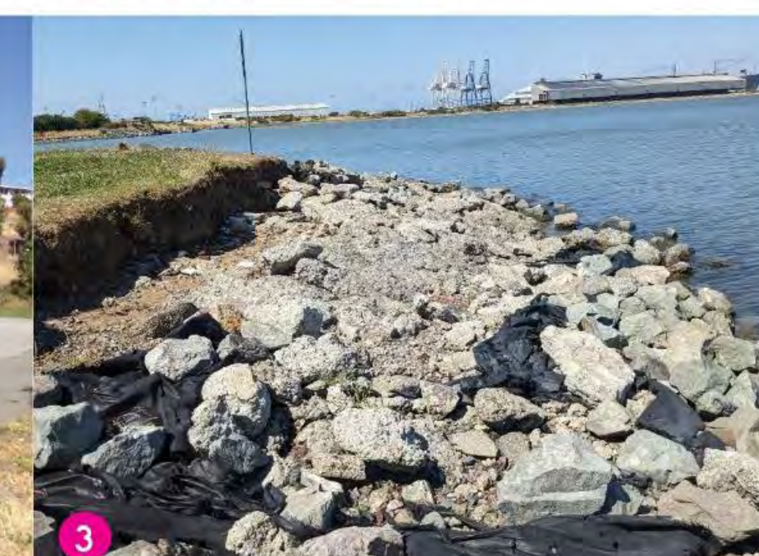
1. Project Context
2. Overview of Shoreline Features
3. Geotechnical Conditions and Recommendations
4. Shoreline Elements for Today's Discussion
    a. Deep Soil Mixing
    b. Mechanically Stabilized Earth Wall
    c. Pile supported Pier/Intermediate Landing
    d. Marine Way Wall
    e. Overall sea level rise adaptation plan

Project Location

900 Innes: Construction Completion Anticipated Summer 2024
IBSP: Construction Start Summer 2024

Existing Site





Shoreline Elements for Today's Discussion

INTERMEDIATE LANDING
Water access, habitat viewing, pile supported

PIER
Water access, pile supported

MARINEWAY WALL
Water access, shoreline protection
MSE, DSM

PARK BOUNDARY
BCDC IN-BAY JURISDICTION
BCDC 100' SHORELINE BAND

Existing Soil Types and Thickness Used In The Structural Analysis

Material	Thickness (ft)
Undocumented, Uncontrolled Fill	0-41
Young Bay Mud (YBM)	0-77
Interbedded Sands and Clays	0-30
Old Bay Clay (OBC)	0-20
Colluvium/Residual Soil	0-20
Bedrock	>0

Groundwater Depth ranging from 9 to 22 feet bgs (Elev. +5 to +13 feet NAVD88)

Soil Properties Used In The Structural Analysis

Soil	Effective Unit Weight	Undrained Cohesion	Strain Factor E50	Friction	K	Uniaxial Compressive Strength	Initial Modulus of Rock Mass	RQD	Strain Factor
	(pcf)	(psf)		(degrees)	(pci)	(psi)	(psi)	(%)	(k, rm)
Fill	58	-	-	30	225				
Liquefied Fill	58	250	0.024	-	-				
YBM	38	200	0.024	-	-				
ISC	63	-	-	35	63				
Liquefied ISC	63	400	0.019	-	-				
OBC	68	1000	0.009	-	-				
Weak Rock	83					250	25,000	50	0.0025

Source: Google Earth Pro Aerial Dated 4/2/2018

LEGEND

B-20	⊕	Approximate Location of AGS Borings
CP-14	⊕	Approximate Location of AGS CPTs
B-8	⊗	Langan and Associates, 2014
T27	⊗	Becker and Associates

A — A' Subsurface Profile Section

1 — section — 1' Slope Stability Section

Approximate Project Boundary

0 75 150 300 ft

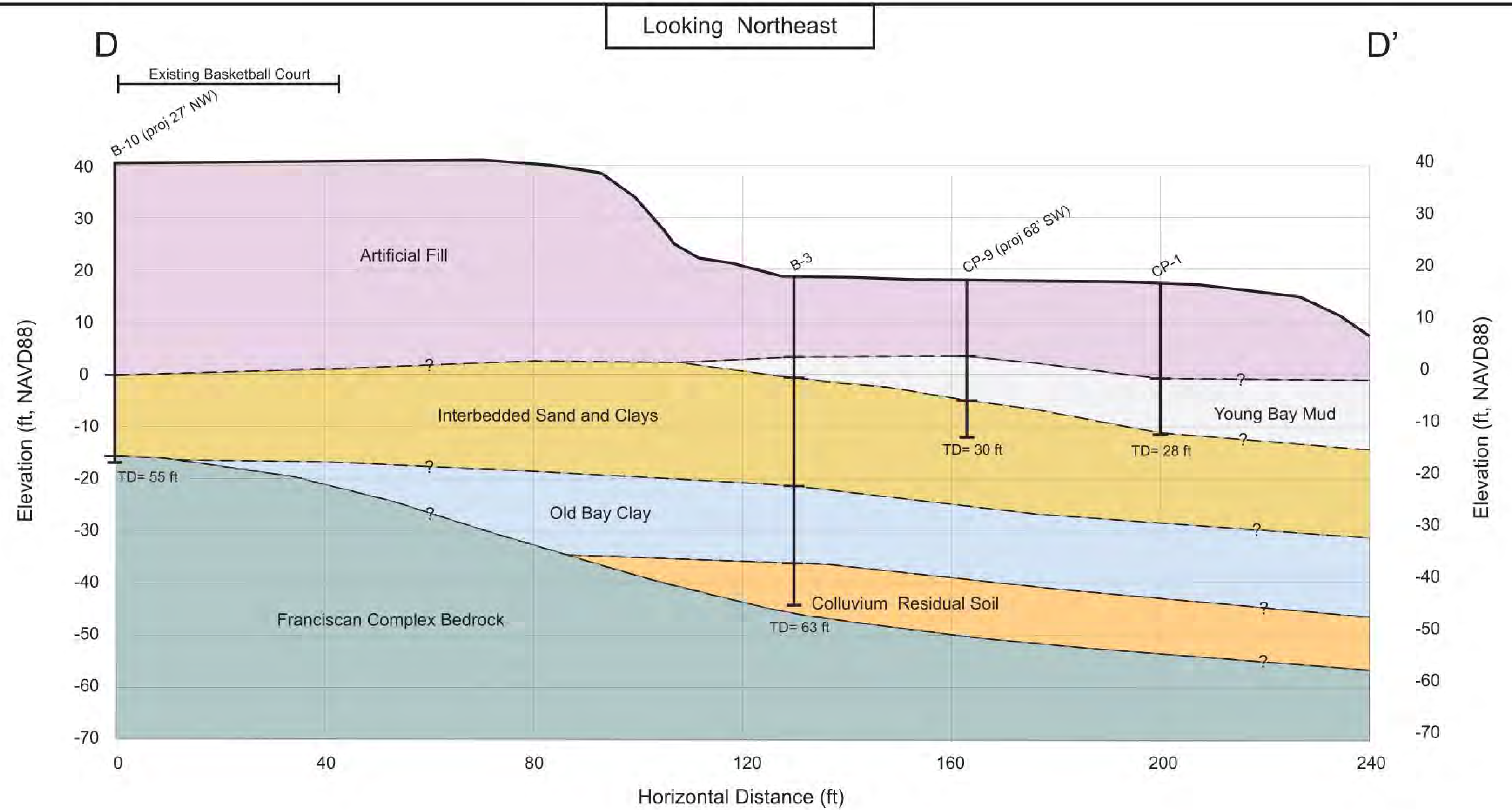
APPROXIMATE SCALE

SITE PLAN AND EXPLORATION PROGRAM MAP

INDIA BASIN SHORELINE PARKS PROJECT
HUNTER'S POINT BOULEVARD & HAWES STREET
SAN FRANCISCO, CALIFORNIA

AGS

JOB NO. AGS-18-057	DATE: FEB 2020	PLATE 2



Legend

Artificial Fill	Old Bay Clay	B-10 (proj 27' NW) — Boring Name and Projection Distance & Direction; TD= Total Depth (ft)
Young Bay Mud	Colluvium / Residual Soil	- - - -?- Approximate Stratigraphic Contact
Interbedded Sands and Clays	Franciscan Complex Bedrock	High High Sea Level

1"=20' HORIZONTAL 1"=20' VERTICAL

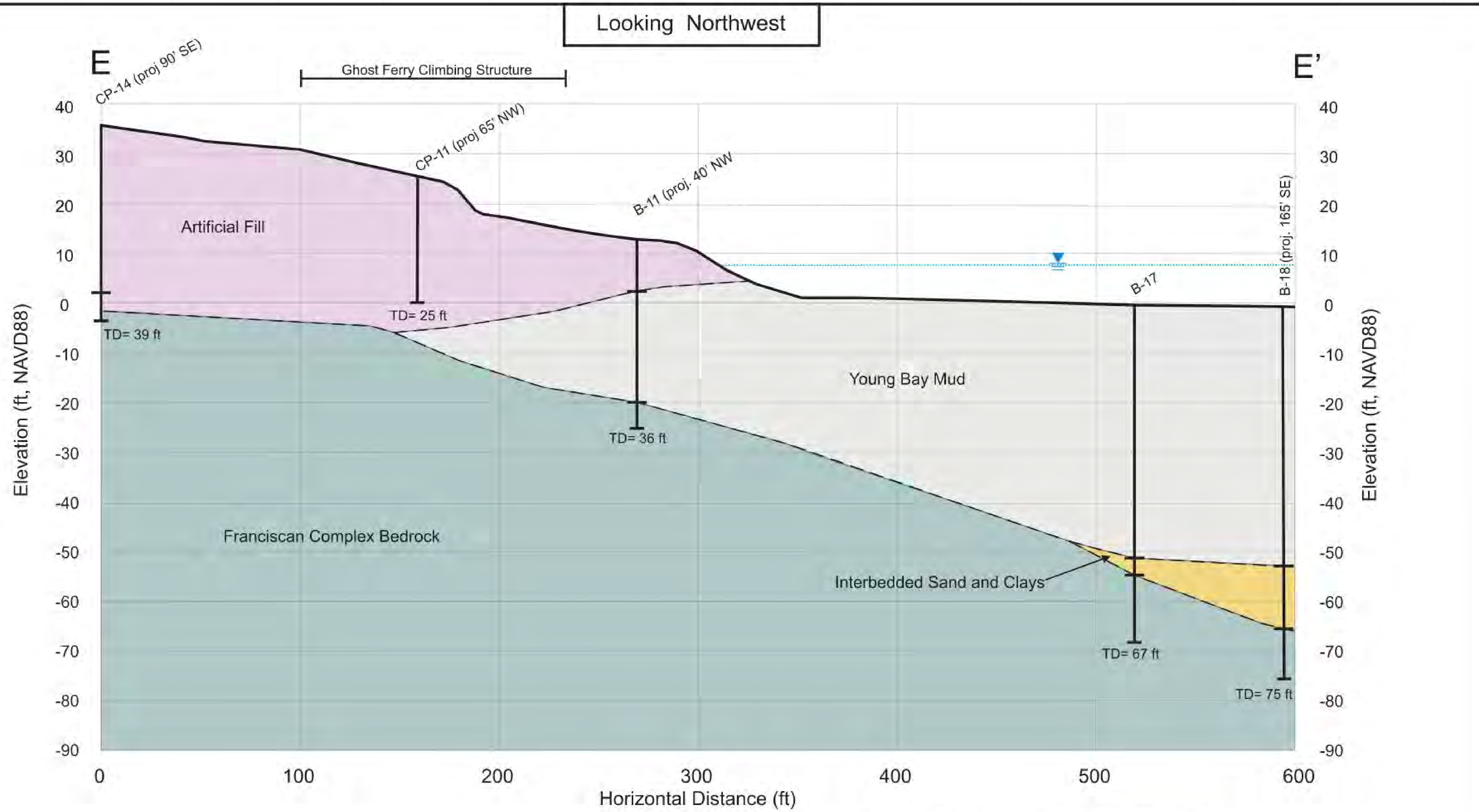
See Notes on Plate 5A.

GENERALIZED GEOLOGIC CROSS SECTION D-D'

INDIA BASIN SHORELINE PARKS PROJECT
HUNTER'S POINT BOULEVARD & HAWES STREET
SAN FRANCISCO, CALIFORNIA

AGS

JOB NO. AGS-18-057	DATE: JAN 2020	PLATE 5D



Legend

- Artificial Fill
- Young Bay Mud
- Interbedded Sands and Clays
- Franciscan Complex Bedrock

CP-14 (proj 90' SE) Boring Name and Projection Distance & Direction

TD= Total Depth (ft)

- - - -?- Approximate Stratigraphic Contact

High High Sea Level

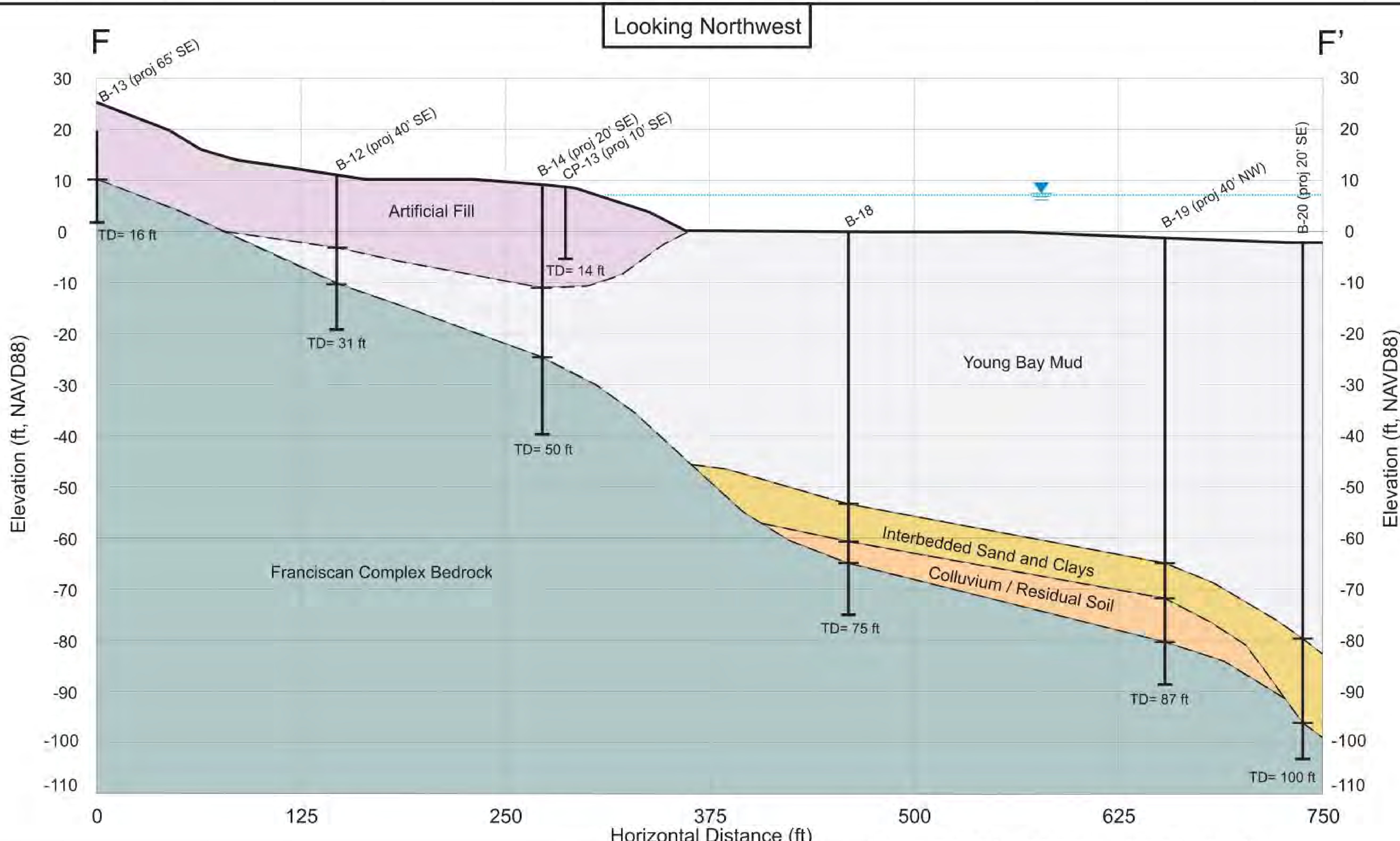
1"=50' HORIZONTAL 1"=20' VERTICAL

See Notes on Plate 5A.

GENERALIZED GEOLOGIC CROSS SECTION E-E'
INDIA BASIN SHORELINE PARKS PROJECT
HUNTER'S POINT BOULEVAR &D HAWES STREET
SAN FRANCISCO, CALIFORNIA

AGS

JOB NO. AGS-18-057 | DATE: JAN 2020 | PLATE 5E



Legend

- Artificial Fill
- Young Bay Mud
- Interbedded Sands and Clays
- Franciscan Complex Bedrock
- Colluvium / Residual Soil

B-13 (proj 65' SE) — Boring Name and Projection Distance & Direction

TD= Total Depth (ft)

- - - -?- Approximate Stratigraphic Contact

High High Sea Level

1"=62.5' HORIZONTAL 1"=20' VERTICAL

See Notes on Plate 5A.

GENERALIZED GEOLOGIC CROSS SECTION F-F' INDIA BASIN SHORELINE PARKS PROJECT HUNTER'S POINT BOULEVARD & HAWES STREET SAN FRANCISCO, CALIFORNIA		AGS
JOB NO. AGS-18-057	DATE: JAN 2020	PLATE 5F

Exploration Program / Findings

Major geotechnical considerations affecting the project includes:

- **Static settlement due to presence of undocumented fill and highly compressible clays below the fill,**
- **Seismically-induced deformation due to presence of potentially liquefiable soils and loose unsaturated soils**
- **Strong ground shaking**
- **Ground movement due to earthquake-induced slope failure.**

Seismic Criteria Based on ASCE 41-17 and ASCE 7-16

	Retrofit	New			
Location	Onshore Structures	Onshore Structures	Boat Launch Pier	Bay City Ferry Pavilion	Pier at 900 Innes
Site Class	Site Class D	Site Class D	Site Class F	Site Class F	Site Class F
S_S	1.5	1.5	1.5	1.5	1.5
S_1	0.6	0.6	0.6	0.6	0.6
S_{MS}	1.5	1.5	1.5	1.5	1.5
S_{M1}	1.5	1.5	2.4	2.4	2.4
S_{DS}	1	1	1	1	1
S_{D1}	1	1	1.6	1.6	1.6
$S_{XS_}$BSE-2N	-	1.5	1.95	1.95	1.95
$S_{X1_}$BSE-2N	-	1.02	2.52	2.52	2.52
$S_{XS_}$BSE-1N	-	1	1.3	1.3	1.3
$S_{X1_}$BSE-1N	-	0.68	1.68	1.68	1.68
$S_{XS_}$BSE-2E	1.414	-	-	-	-
$S_{X1_}$BSE-2E	0.961	-	-	-	-
$S_{XS_}$BSE-1E	0.899	-	-	-	-
$S_{X1_}$BSE-1E	0.556	-	-	-	-

PGA and Assumptions For Seismic Analysis

- Site Specific Acceleration (PGAm) **0.78g** for Onshore and **0.65** for Offshore;
- Return Period (2% in 50 years) **2,475** year;
- Maximum Moment Magnitude **8.05**;
- Site Classifications: **D and F**; and
- 2/3 of 2% in 50 year (2,475) was used in seismic design which is roughly **475 return period**

Assumptions For Liquefaction Analysis

- Magnitude 8.05 earthquake;
- PGA_M of 0.78g at the onshore location and 0.65g at the offshore location;
- No depth limit;
- Thin layer transition;
- Clay-like and sand-like method; and
- Groundwater at elevation +8 feet at the onshore location and 0 feet at the offshore location.

Assumptions For Liquefaction-Induced Lateral Deformations

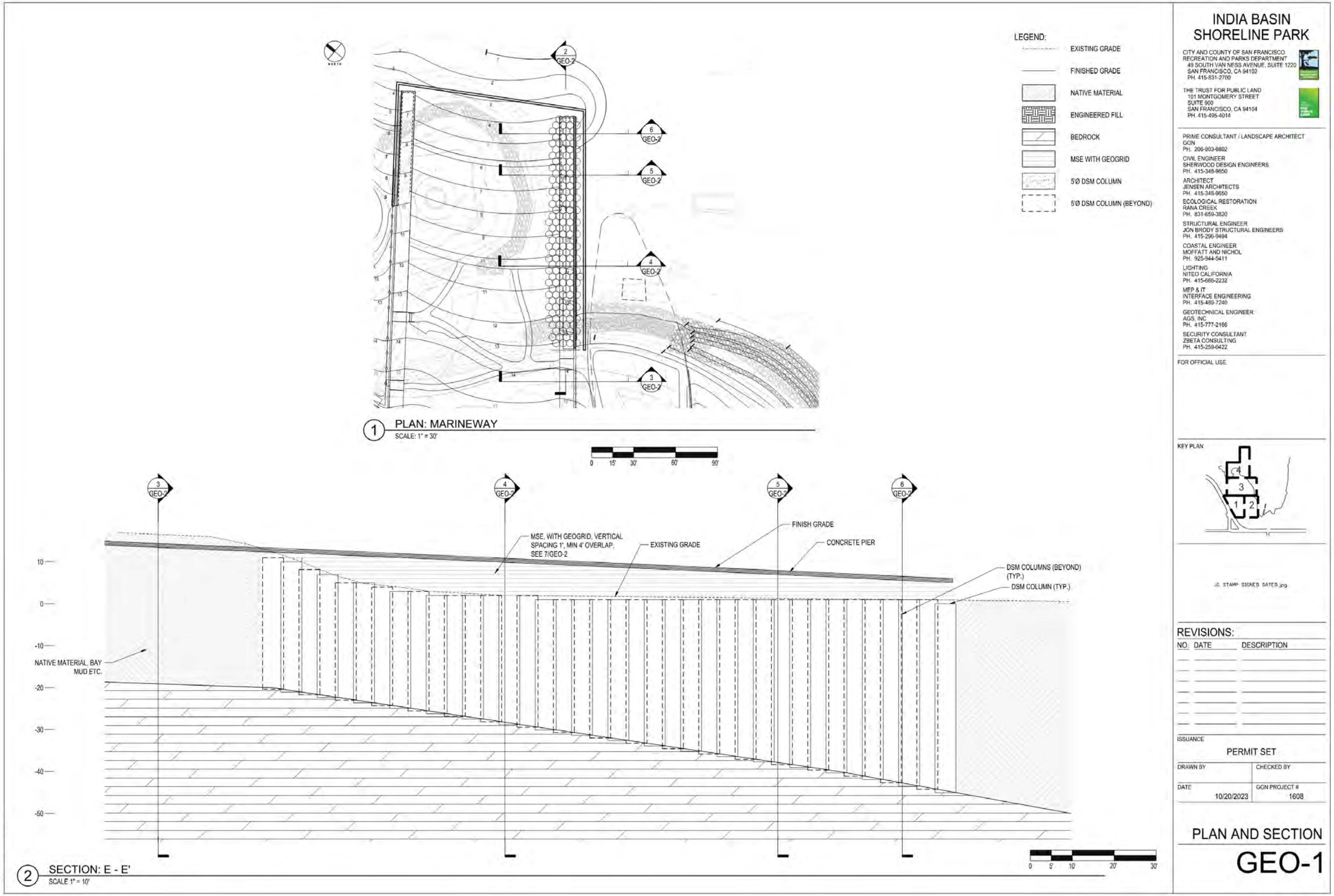
- Continuity of the liquefiable layers;
- Free face or sloping ground conditions; and
- Lateral Displacement Index (LDI) method (Zhange, 2014).

Deep Soil Mixing – Design/Analysis Approach

DSM was selected to increase allowable bearing pressure. Since the DSM will provide a bearing layer, tangential layout extending to bedrock was used.

Performance-based approach was selected by specifying the maximum design bearing capacity of the treated YBM of 20 psi for dead plus live load.

MSE Wall – Design

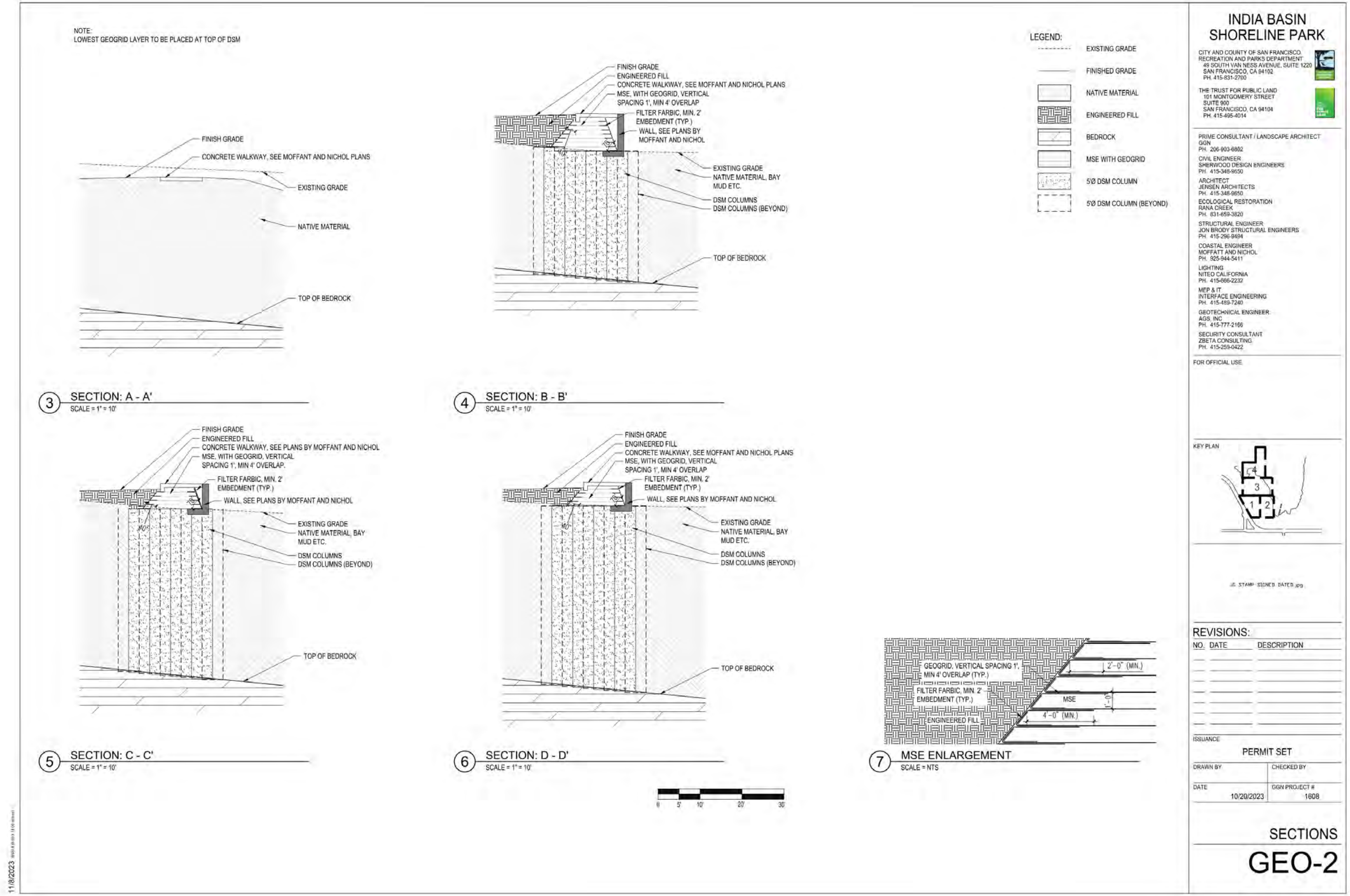


MSE Wall – Design/Analysis Approach

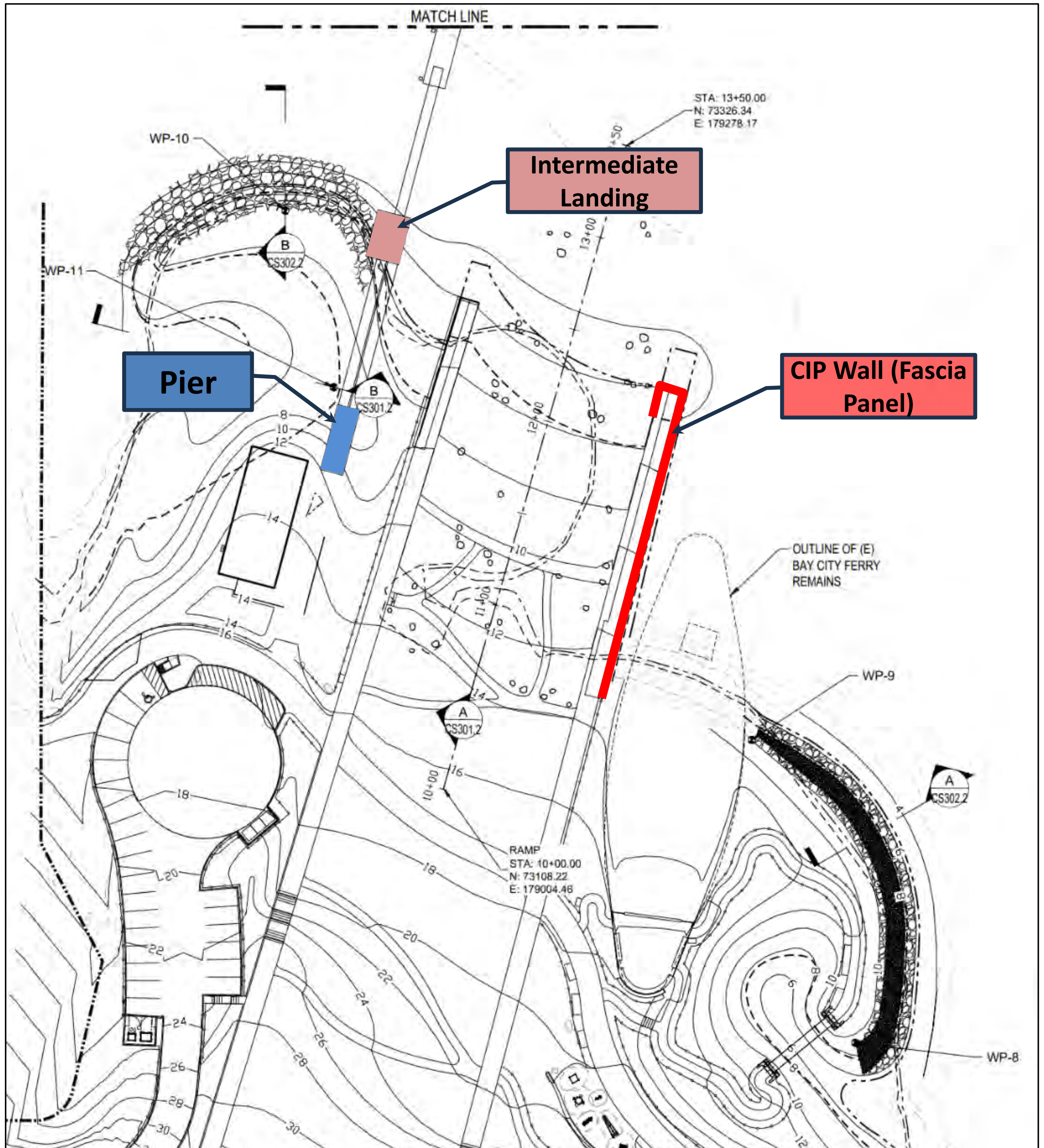
MSE wall was selected as the least expensive solution above existing grade
MSE will provide lateral support for the Marine Way fill and walkway slab.

Performance-based approach was selected by specifying minimum safety factor against sliding, creep, and construction.

MSE Wall – Sections



Pier and Intermediate Landing – Design Criteria



Design Criteria	
Dead Load	The weight of members and appurtenances permanently attached to the structure.
Live Load	Uniform: 100 psf (assembly areas per CBC Table 1607.1) Live loads tributary to Gangways supported by Pier and Intermediate Landing
Wave and Current Loads	Seismic loads govern the lateral design of these structures.
Berthing Loads	None (no mooring or berthing of vessels anticipated on Pier or Intermediate Landing)
Wind Loads	Seismic and Wave loads govern the lateral design of these structures.
Seismic Loads	Performance based design approach based on ASCE 61 Structure category is low based on low importance for regional economy and no function for post earthquake recovery. ASCE design earthquake (2/3 MCEr) and Life safety performance criteria. MCEr earthquake spectrum developed by AGS
Lateral Earth Pressure	None

Pier and Intermediate Landing – Design/Analysis Approach

1. Run pushover analyses for 16 load cases.
2. Calculate the displacement demand for the Design Earthquake (2/3 MCEr) using each pushover curve.
3. Verify that none of the plastic hinges deform beyond the LIFE Safety limit state (in other words, verify that displacement demand is less than the ultimate displacement where the ultimate displacement is controlled by first plastic hinge reaching the strain limits for Life Safety Limit as defined in ASCE 61-14 Table 3-2)
4. Evaluate the maximum demand in capacity protected elements (i.e., pile cap bending and shear, pile shear) at the step corresponding to the displacement demand for each pushover case; multiply these demands by an overstrength factor of 1.25 and perform design checks.
5. Develop actual deck displacements at the four corners of the deck at the step corresponding to the displacement demand for each pushover case to verify that the seismic gap is adequate.
6. Perform joint shear check for the worst case to verify the adequacy of the provided joint detail.

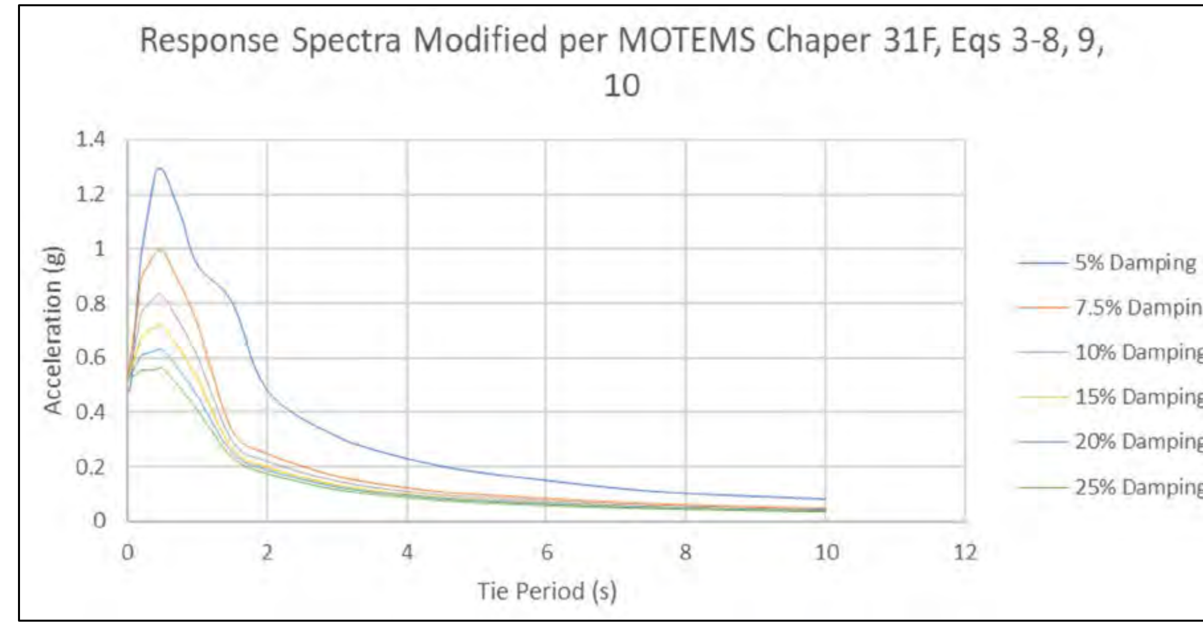


Table 3-3. Strain Limits for "Life Safety Protection" per Section 2.4.1

		Hinge location		
Pile type	Component	Top of pile	In ground	Deep in ground (>10D_p)
Solid concrete pile	Concrete	No limit	$\varepsilon_c \leq 0.005 + 1.1\rho_s \leq 0.012$	No limit
	Reinforcing steel	$\varepsilon_s \leq 0.8\varepsilon_{smd} \leq 0.08$		
	Prestressing steel		$\varepsilon_p \leq 0.035$	$\varepsilon_p \leq 0.050$

Pier and Intermediate Landing – Analysis Approach

The following components are explicitly represented in the models:

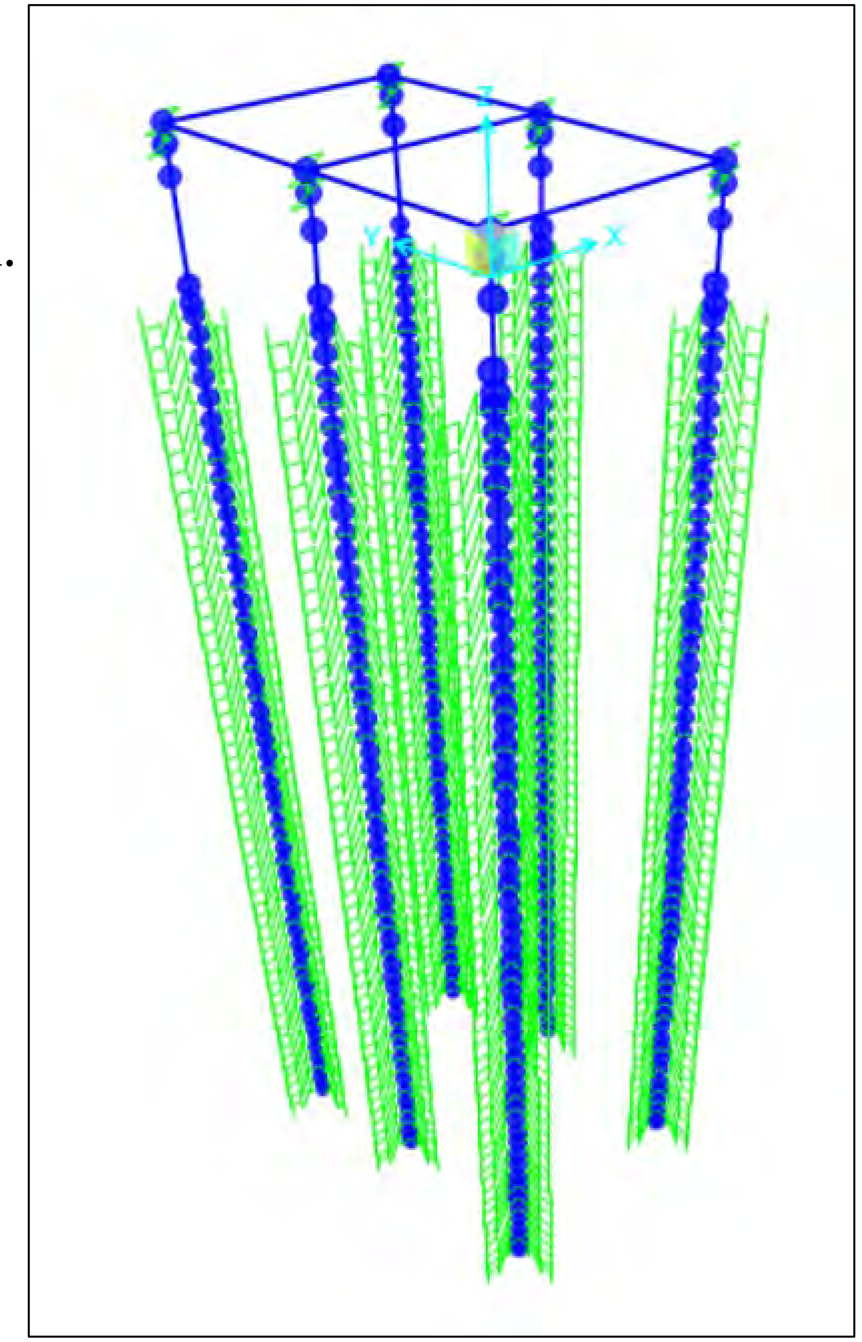
- Piles with nonlinear plastic hinges (PMM) at the top of the piles and in ground.
- Soil springs (with nonlinear force deformation characteristics)

	Intermediate Landing	Pier
Fill Thickness (ft)	2	13
Liquefied Fill Thickness (ft)	8	7
YBM Thickness (ft)	30	10
Liquefied ISC Thickness (ft)		
ISC Thickness (ft)		
OBC Thickness (ft)		
Colluvium Thickness (ft)	2	3
Bedrock Depth (ft)	42	33

- Soil Properties used for L-Pile Spring generation

Formation	Fill	Liquefied Fill	YBM	ISC	Liquefied ISC	Colluvium & Greenstone/Serpentinite Bedrock
Type	Sand (Reese)	Soft Clay (Matlock)	Soft Clay (Matlock)	Sand (Reese)	Soft Clay (Matlock)	Weak Rock (Reese)
Effective Unit Weight (pcf)	120	57.6	37.6	62.6	62.6	82.6
Friction Angle (deg)	30			35		
k (pci)	225			63		
Undrained cohesion, c (psf)		250	200		300	
Strain Factor E50		0.024	0.024		0.019	
Strain factor , k rm						0.0025
Uniaxial Compressive Strength (psi)						250
Initial Modulus of Rock Mass (psi)						25000
RQD (%)						50

- Pile caps (capacity protected elements)



Typical 3D SAP Model (Intermediate Landing)

Pier and Intermediate Landing – PMM Hinge Definition

Plastic Hinges are developed using XTRACT and the expected material properties as defined by ASCE 61

$$f'_{ce} = 1.3 f'_c \quad (6\text{-}1)$$
$$f'_{ye} = 1.1 f_y \quad (6\text{-}2)$$
$$f_{yhe} = 1.0 f_{yh} \quad (6\text{-}3)$$
$$f_{pye} = 1.0 f_{py} \quad (6\text{-}4)$$
$$f_{pue} = 1.05 f_{pu} \quad (6\text{-}5)$$

XTRACT Analysis Report

Moffatt & Nichol
1/13/2023
900 Innes
20inSq
Page __ of __

Section Name: At Top
Loading Name: MC1
Analysis Type: Moment Curvature

Section Details:

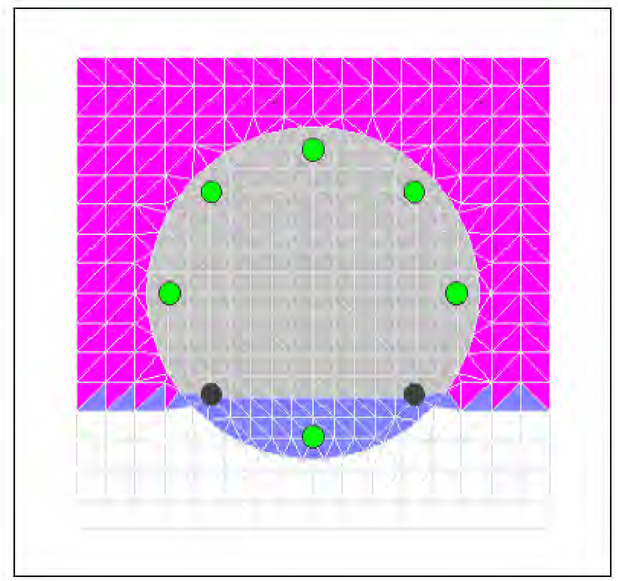
X Centroid:	-7.28E-17 in
Y Centroid:	-1.24E-16 in
Section Area:	400.0 in^2

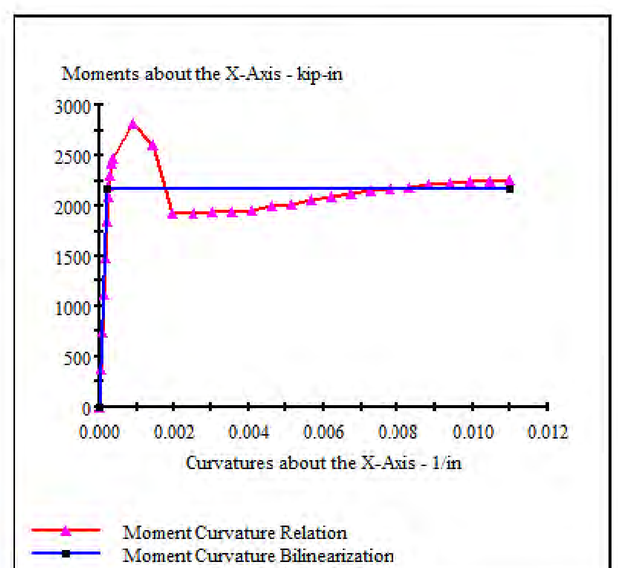
Loading Details:

Incrementing Loads:	Mxx Only
Number of Points:	30
Analysis Strategy:	Displacement Control

Analysis Results:

Failing Material:	Confined2
Failure Strain:	25.00E-3 Compression
Curvature at Initial Load:	0 1/in
Curvature at First Yield:	.1878E-3 1/in
Ultimate Curvature:	10.98E-3 1/in
Moment at First Yield:	1852 kip-in
Ultimate Moment:	2263 kip-in
Centroid Strain at Yield:	1.137E-3 Ten
Centroid Strain at Ultimate:	48.49E-3 Ten
N.A. at First Yield:	6.057 in
N.A. at Ultimate:	4.417 in
Energy per Length:	23.52 kips
Effective Yield Curvature:	.2195E-3 1/in
Effective Yield Moment:	2165 kip-in
Over Strength Factor:	1.0000
EI Effective:	9.861E+6 kip-in^2
Yield EI Effective:	0 kip-in^2
Bilinear Harding Slope:	0 %
Curvature Ductility:	50.01





Comments:

User Comments

XTRACT Analysis Report

Moffatt & Nichol
1/13/2023
900 Innes
20inSq
Page __ of __

Section Name: Bot
Loading Name: MC1
Analysis Type: Moment Curvature

Section Details:

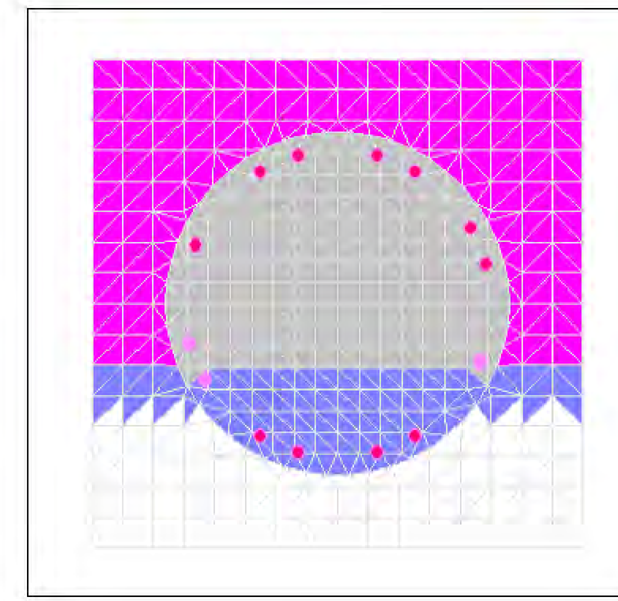
X Centroid:	3.49E-17 in
Y Centroid:	-2.62E-16 in
Section Area:	400.0 in^2

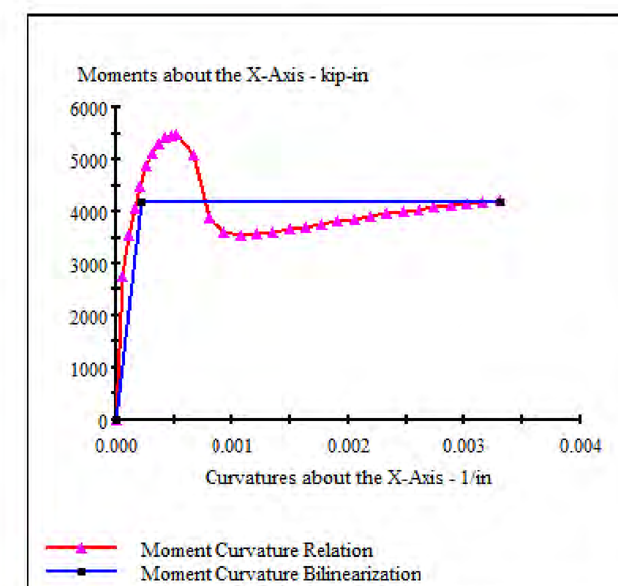
Loading Details:

Incrementing Loads:	Mxx Only
Number of Points:	30
Analysis Strategy:	Displacement Control

Analysis Results:

Failing Material:	PreStress1
Failure Strain:	35.00E-3 Tension
Curvature at Initial Load:	1.03E-21 1/in
Curvature at First Yield:	.2598E-3 1/in
Ultimate Curvature:	3.304E-3 1/in
Moment at First Yield:	4892 kip-in
Ultimate Moment:	4214 kip-in
Centroid Strain at Yield:	.9415E-3 Ten
Centroid Strain at Ultimate:	9.491E-3 Ten
N.A. at First Yield:	3.624 in
N.A. at Ultimate:	2.872 in
Energy per Length:	13.36 kips
Effective Yield Curvature:	.2222E-3 1/in
Effective Yield Moment:	4184 kip-in
Over Strength Factor:	1.0000
EI Effective:	18.83E+6 kip-in^2
Yield EI Effective:	0 kip-in^2
Bilinear Harding Slope:	0 %
Curvature Ductility:	14.87



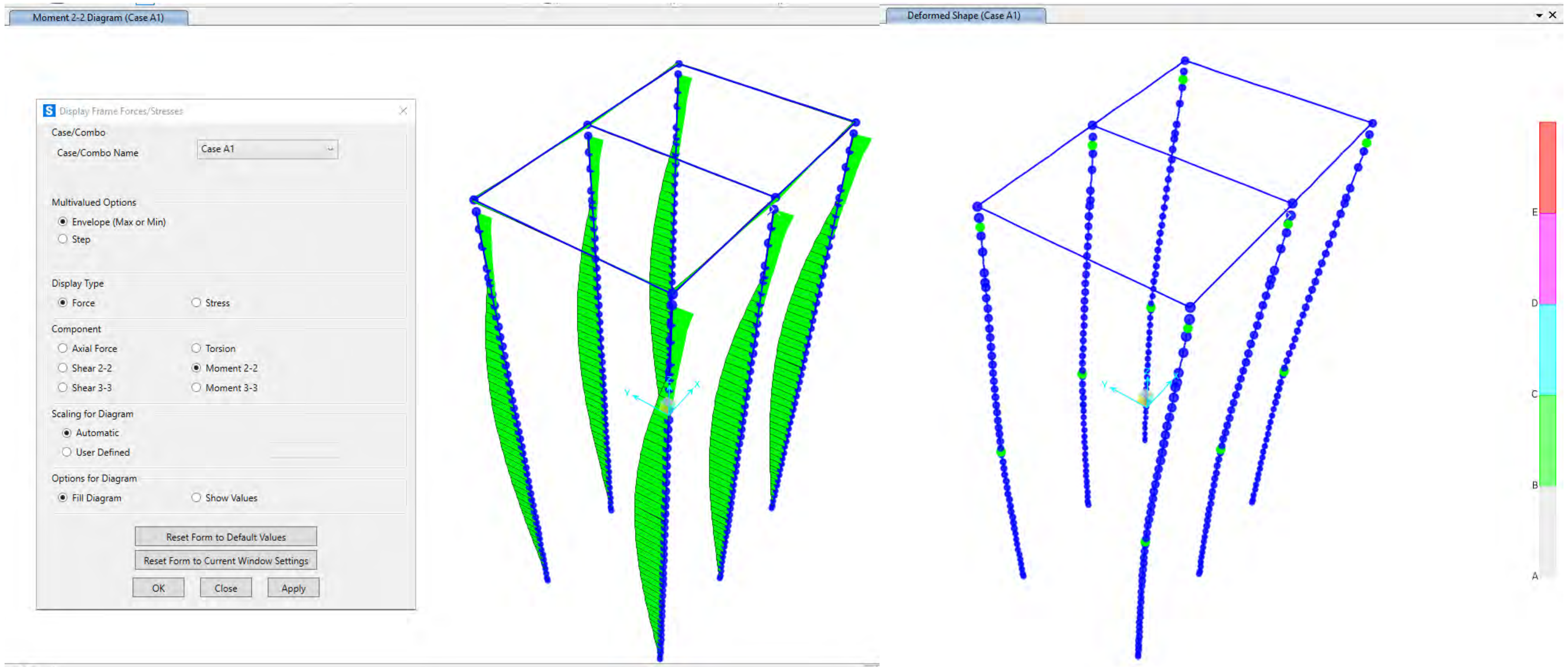


Comments:

User Comments

Pier and Intermediate Landing – Sample Case

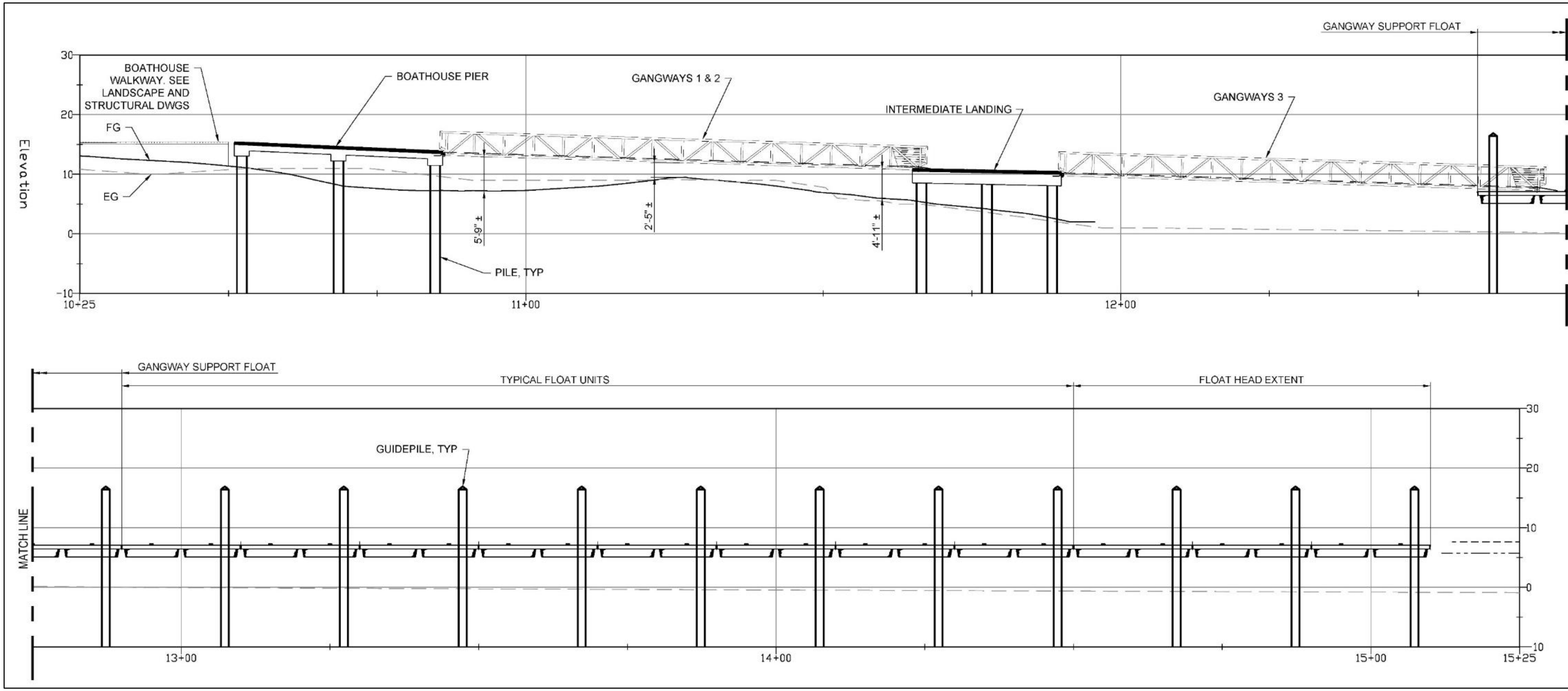
Case A1



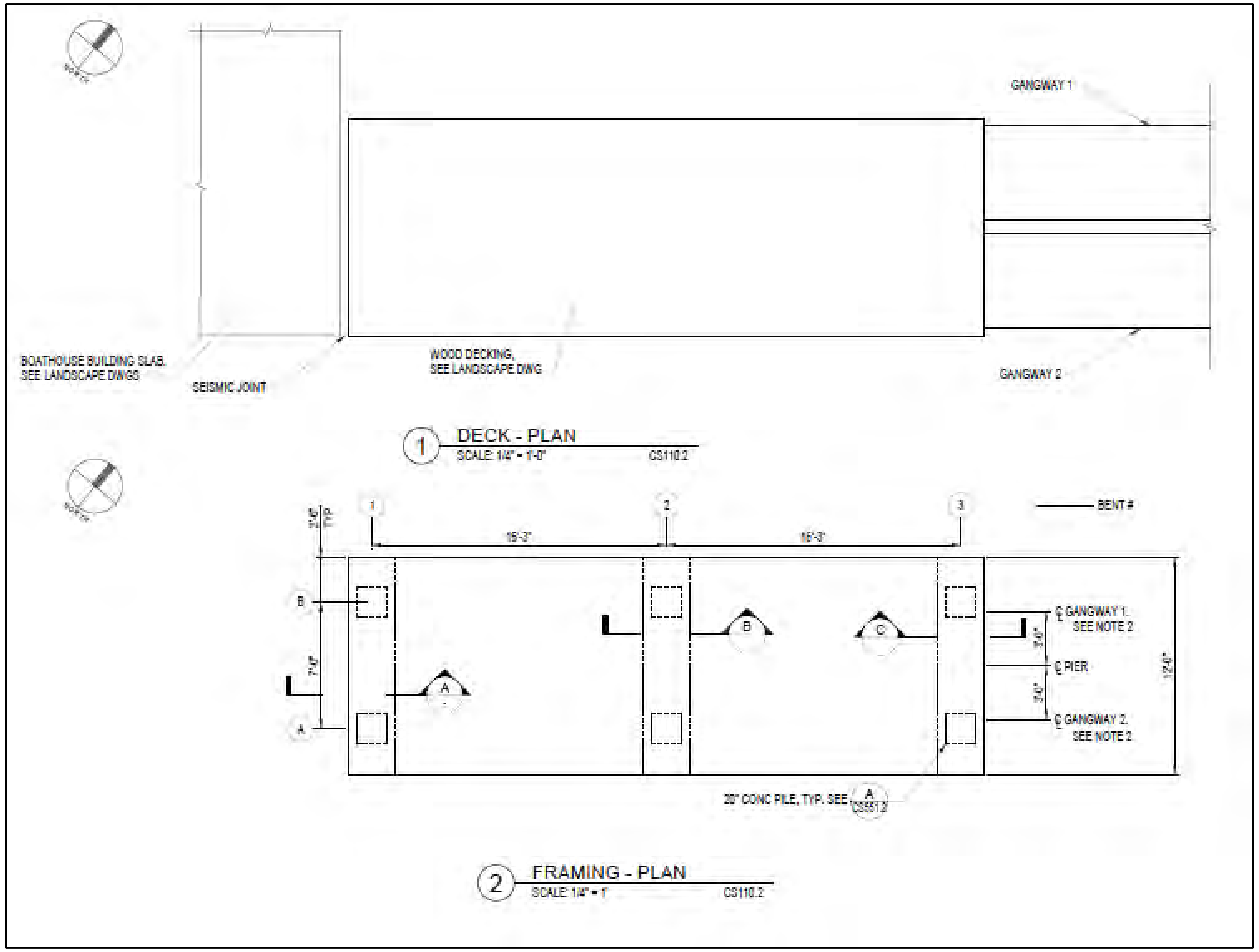
Pushover Load Cases Directions:

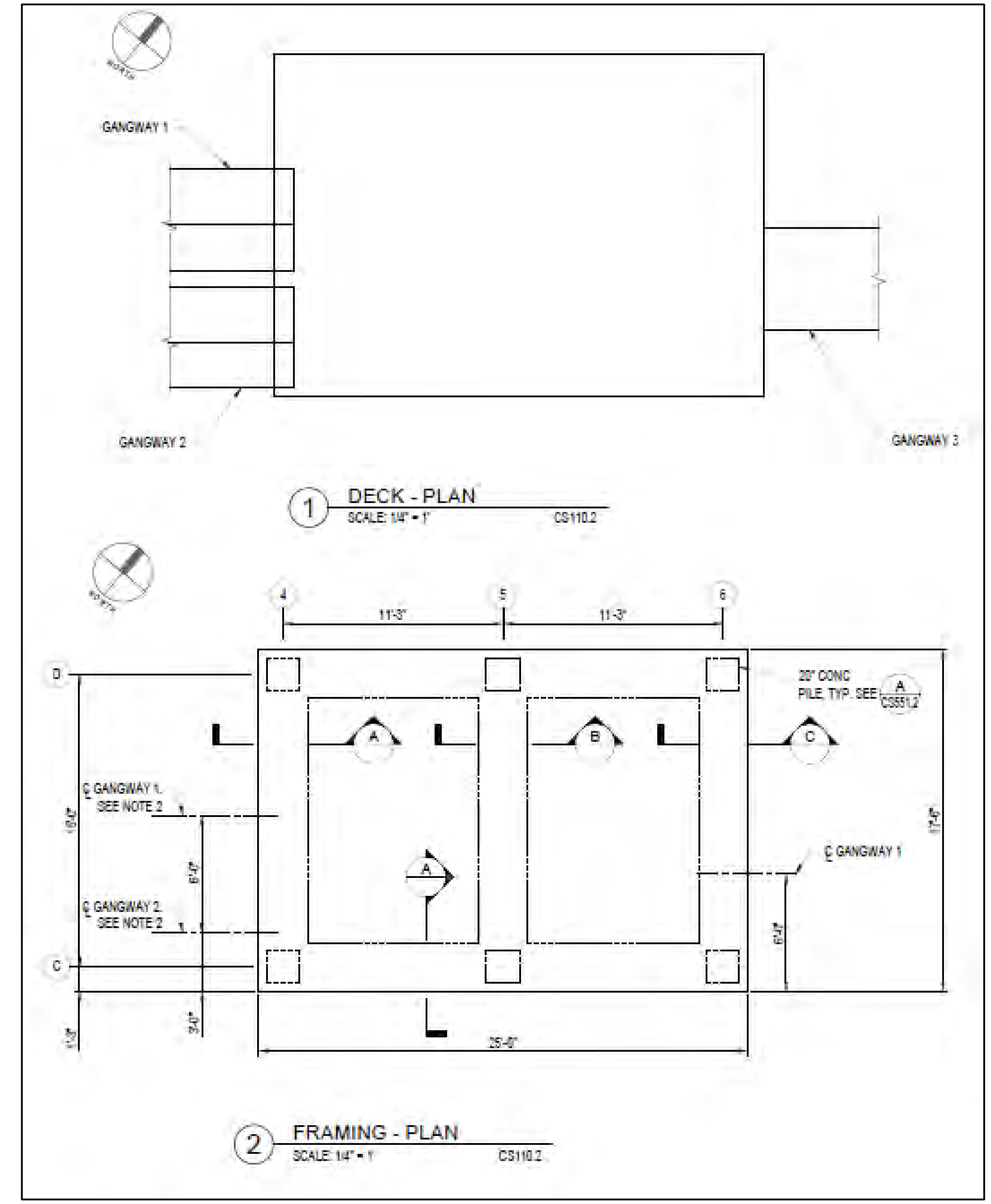
Load Case	Vertical	Horizontal
A1	1.24D + 0.1L	+Y +0.3X
A2	1.24D + 0.1L	+Y -0.3X
A3	1.24D + 0.1L	-Y -0.3X
A4	1.24D + 0.1L	-Y +0.3X
A5	1.24D + 0.1L	+X +0.3Y

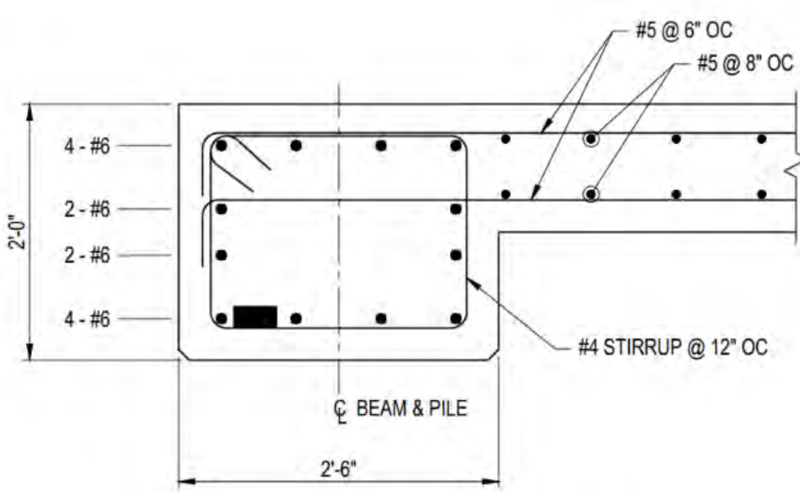
Pier and Intermediate Landing – Elevation



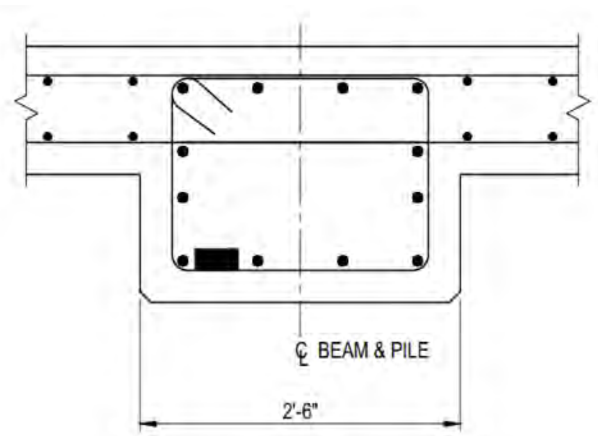
Pier and Intermediate Landing – Plan and Section



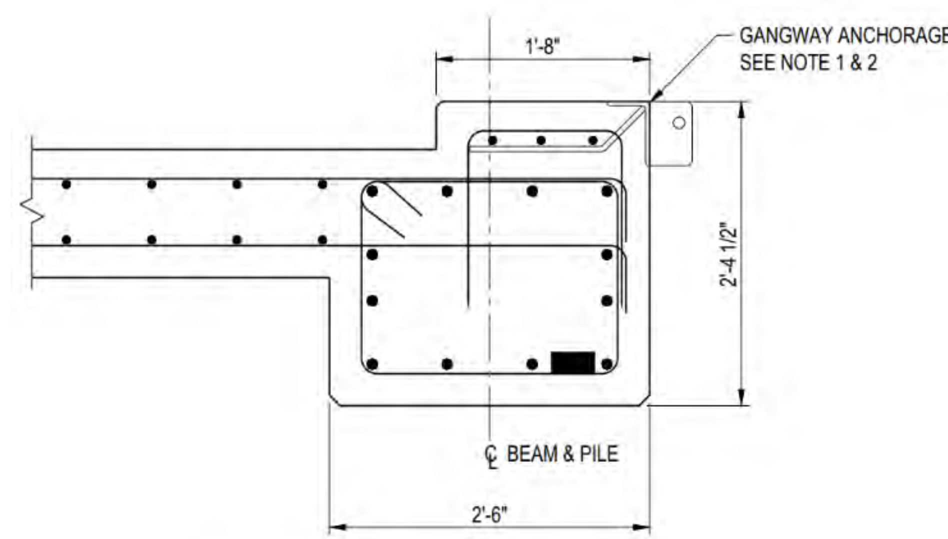




A SECTION
SCALE: 1" = 1'-0"

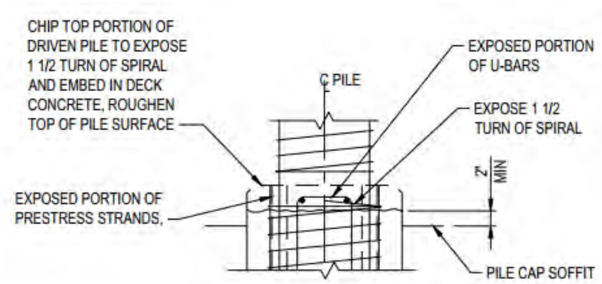


B SECTION
SCALE: 1" = 1'-0"

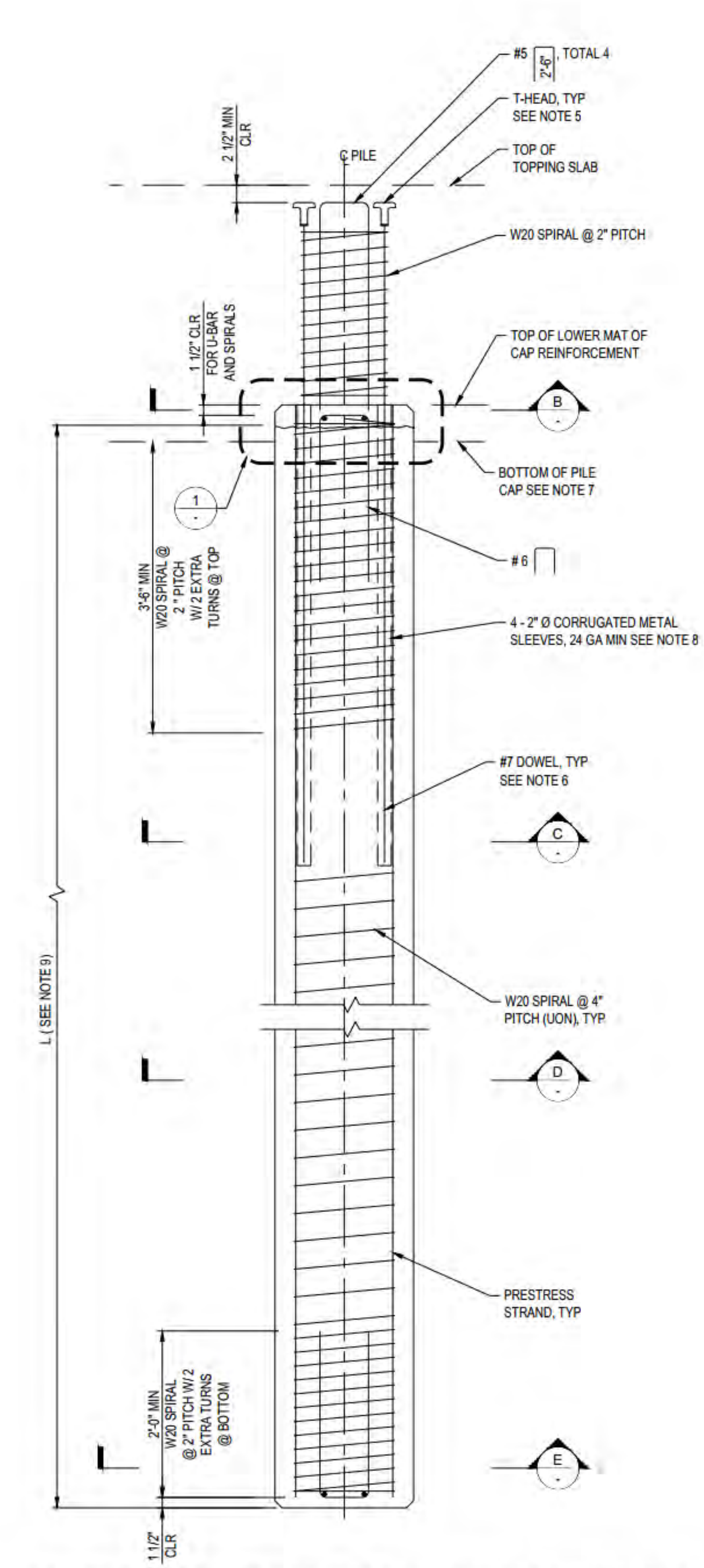


C SECTION
SCALE: 1" = 1'-0"

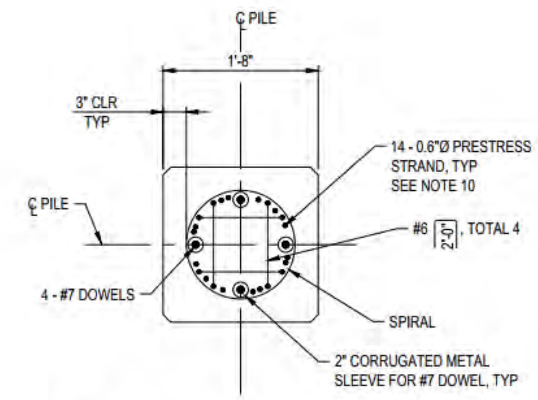
Pier and Intermediate Landing – Piles



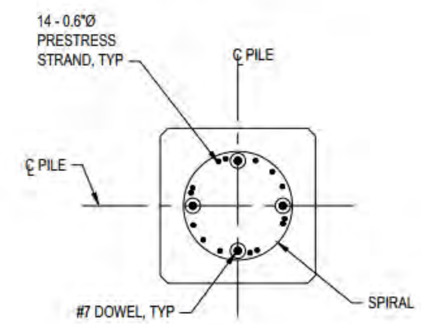
1 DETAIL
SCALE: 1" = 1'-0"



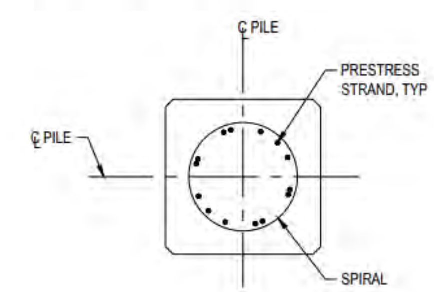
A 20 INCH SQUARE PRECAST PRESTRESSED CONCRETE PILE
SCALE: 1" = 1'-0" CS510.2, CS530.2, CS532.2



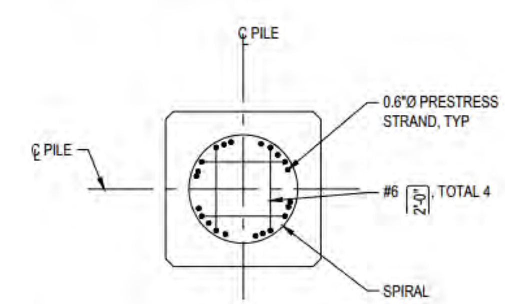
B SECTION
SCALE: 1" = 1'-0"



C SECTION
SCALE: 1" = 1'-0"

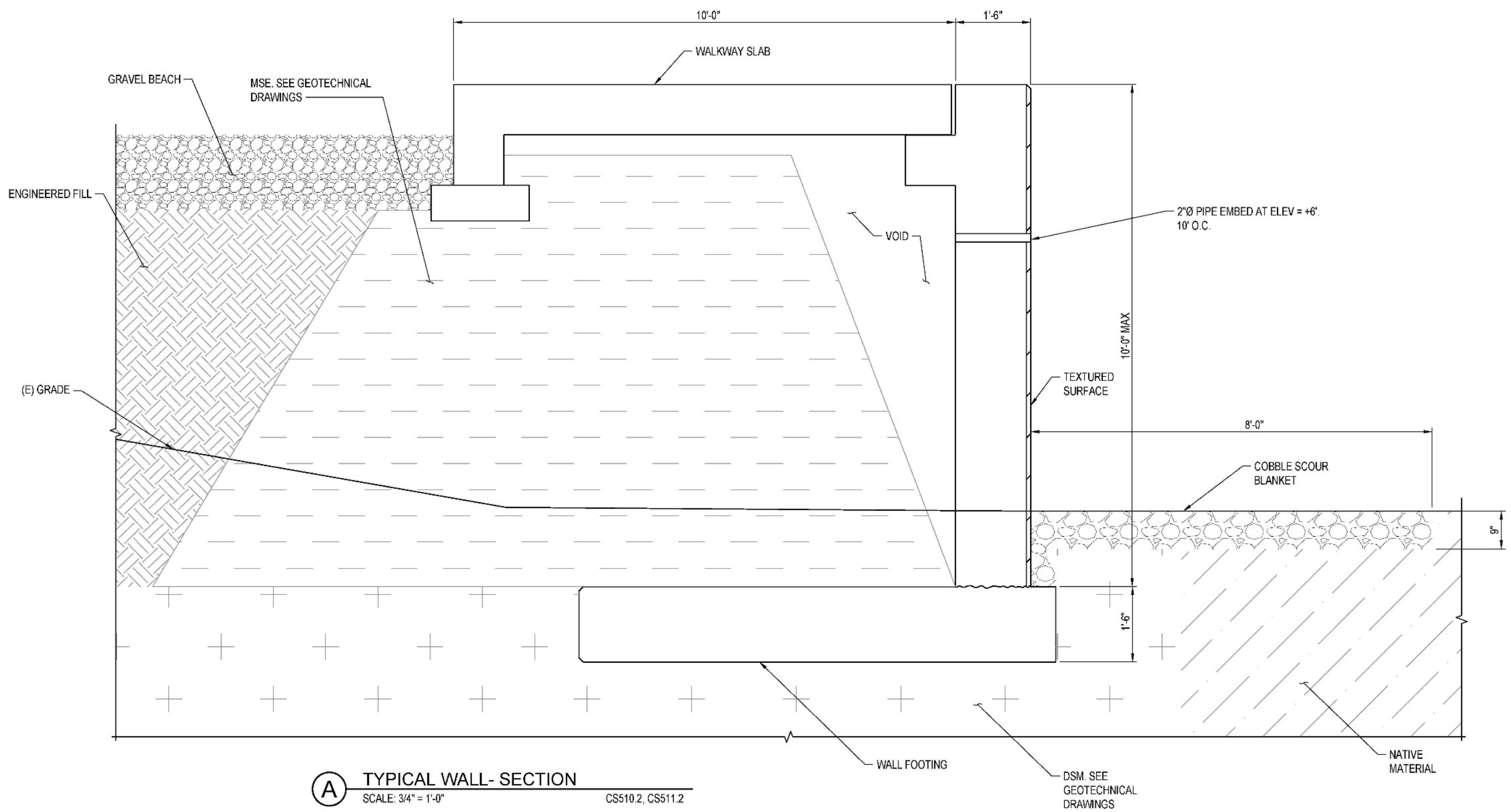


D SECTION
SCALE: 1" = 1'-0"

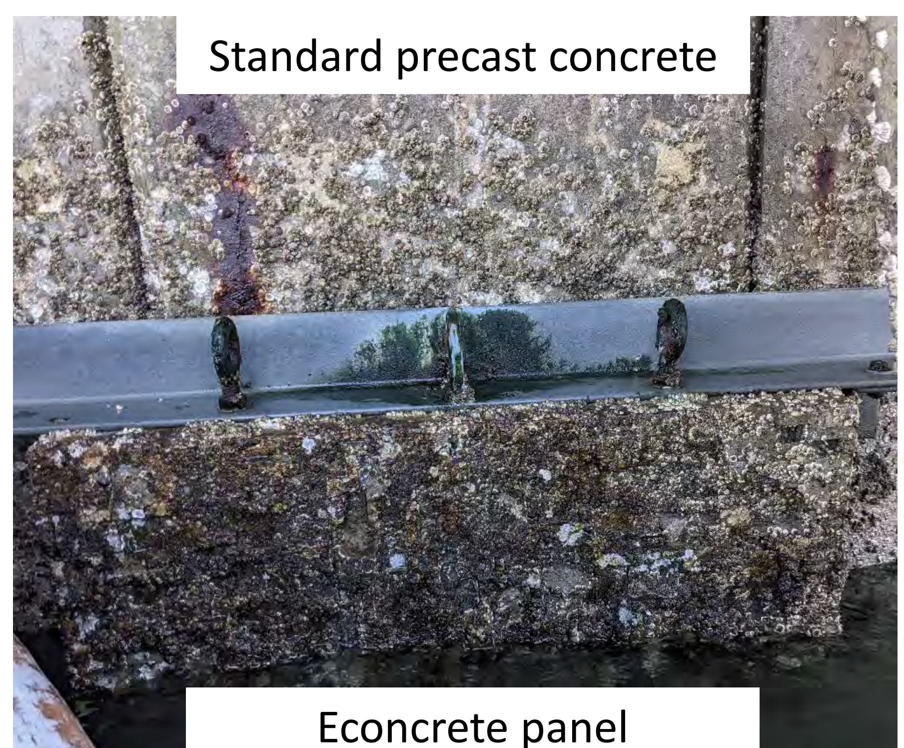


E SECTION
SCALE: 1" = 1'-0"

Marine Way Fascia Panel – Design

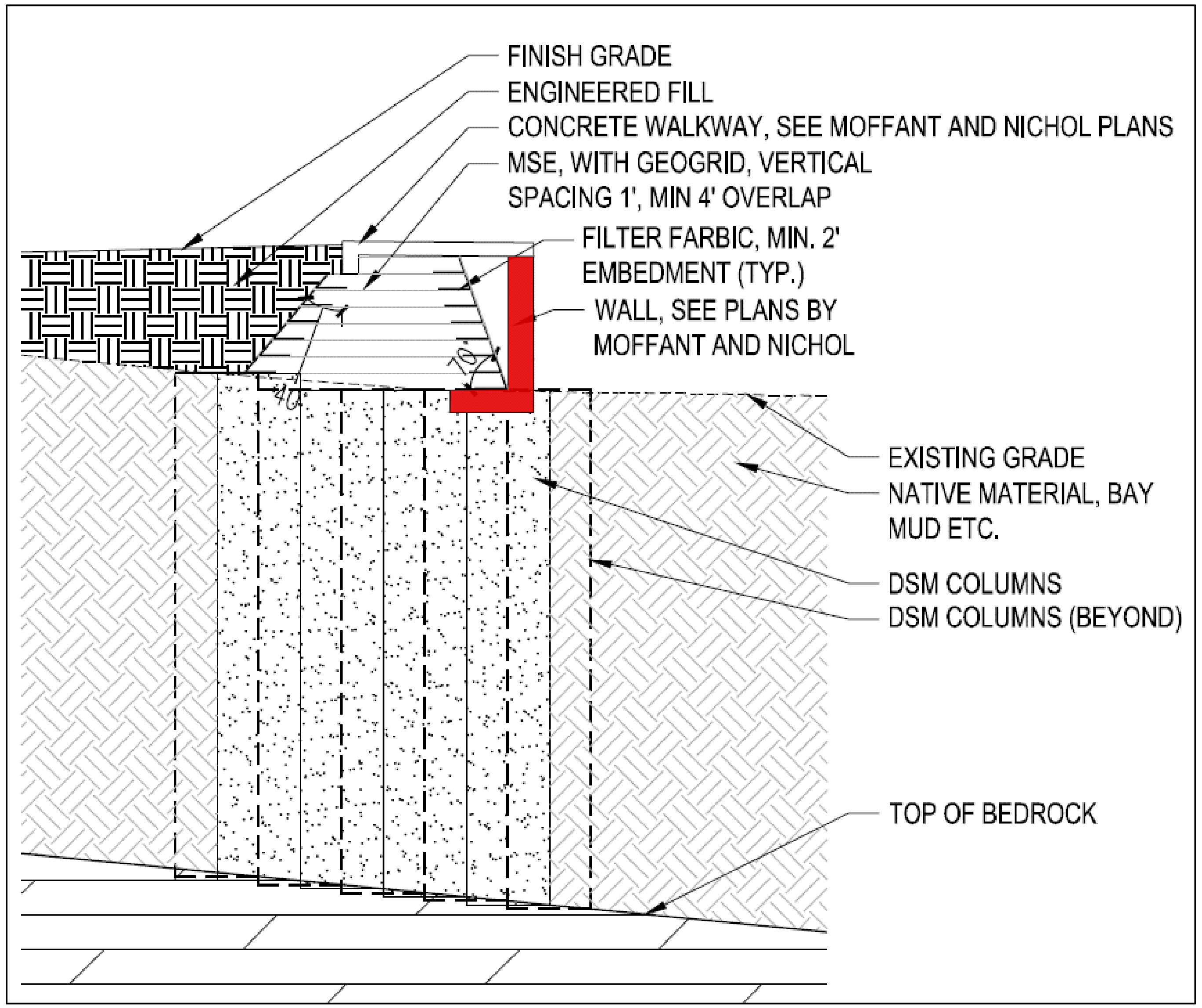


The textured surface (Econcrete) is meant to promote marine organisms



Design Criteria	
Dead Load	The weight of members and appurtenances permanently attached to the structure.
Live Load	Uniform: 100 psf (assembly areas per CBC Table 1607.1)
Wave and Current Loads	Wave Loads per ASCE 7-16 Section 5.4 Site Specific Coastal Analysis for 50 year return period Hs (2.9ft)
Berthing Loads	None (No mooring or berthing of vessels is anticipated onto wall)
Wind Loads	Seismic and Wave loads govern the lateral design of these structures.
Seismic Loads	ASCE 7 Seismic Load Criteria Site specific ground motions developed by AGS
Lateral Earth Pressure	None. Lateral earth pressure supported by MSE wall structure which is disconnected from concrete wall.

Marine Way Fascia Panel – Design Criteria



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Lateral Earth Pressure	None. Lateral earth pressure supported by MSE wall structure which is disconnected from concrete wall.

Marine Way Fascia Panel – Design/Analysis Approach

Overall Design Approach:

- MSE resists all lateral earth pressures
- Concrete wall acts as a "fascia panel" for the MSE
- Concrete wall resists wave loading and wall inertial loads

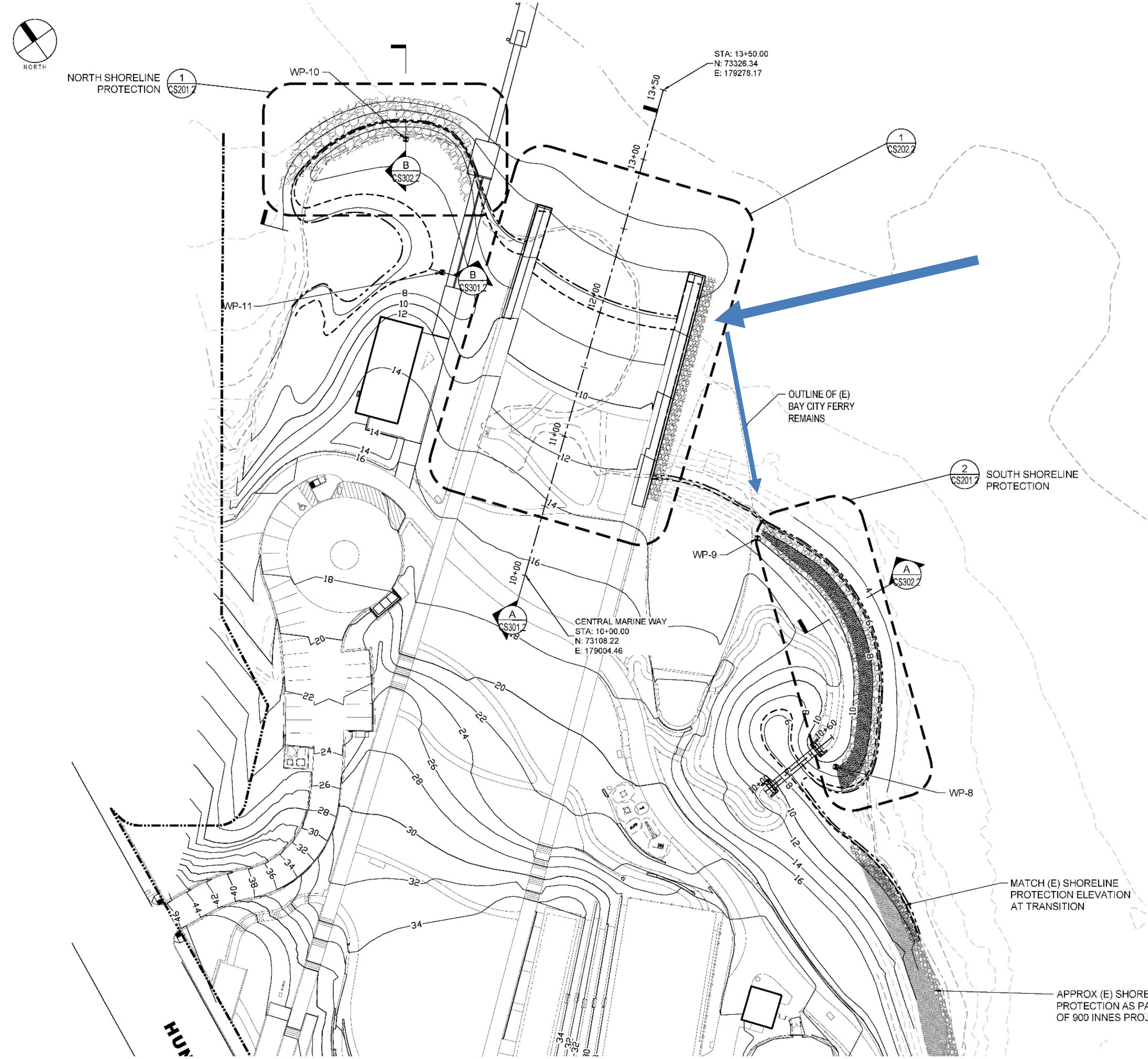
Design Approach for Concrete "Facial Panel" Wall:

- Wall design is based on a 2-D analysis of the wall section at the highest wall location.
- The MSE wall is not in contact with the CIP wall and therefore does not induce any active or passive pressures on the CIP wall.
- The concrete walkway slab will be integral with the wall. The gravity loads from the slab will be partially supported by the wall. The lateral loads on the slab will be resisted by completely by the CIP wall.

Marine Way Fascia Panel – Wave Reflection and Scour at Wall

<u>Addressed as follows:</u>

- Shoreline protection measures shall accommodate reflected waves.
- Scour at the bayside of the wall has been addressed with a scour apron.



SLR Analysis & Recommendations

Tidal Datums for Project Site

Tidal Plane	NAVD88 Datum (feet)	CCSF Datum (feet)
Annual Occurrence Water Levels		
King Tide (estimated)	+7.8	-3.5
Mean Higher High Water (MHHW)	+6.5	-4.8
Mean High Water (MHW)	+5.9	-5.4
Mean Tide Level (MTL)	+3.3	-8.0
Mean Low Water (MLW)	+0.7	-10.6
North American Vertical Datum, 1988 (NAVD)	0.0	-11.3
Mean Lower Low Water (MLLW)	-0.4	-11.7
Storm Water Levels		
10-yr Return Period Water Level	+8.8	-2.6
25-yr Return Period Water Level	+9.2	-2.1
50-yr Return Period Water Level	+9.5	-1.8
100-yr Return Period Water Level	+9.9	-1.4

Sea-Level Rise Projections for San Francisco, OPC (2018)

		Probabilistic Projections (in feet) (based on Kopp et al. 2014)					H++ scenario (Sweet et al. 2017) *Single scenario
		MEDIAN	LIKELY RANGE		1-IN-20 CHANCE	1-IN-200 CHANCE	
		50% probability sea-level rise meets or exceeds...	66% probability sea-level rise is between...		5% probability sea-level rise meets or exceeds...	0.5% probability sea-level rise meets or exceeds...	
				Low Risk Aversion		Medium - High Risk Aversion	Extreme Risk Aversion
High emissions	2030	0.4	0.3 -	0.5	0.6	0.8	1.0
	2040	0.6	0.5 -	0.8	1.0	1.3	1.8
	2050	0.9	0.6 -	1.1	1.4	1.9	2.7
Low emissions	2060	1.0	0.6 -	1.3	1.6	2.4	
High emissions	2060	1.1	0.8 -	1.5	1.8	2.6	3.9
Low emissions	2070	1.1	0.8 -	1.5	1.9	3.1	
High emissions	2070	1.4	1.0 -	1.9	2.4	3.5	5.2
Low emissions	2080	1.3	0.9 -	1.8	2.3	3.9	
High emissions	2080	1.7	1.2 -	2.4	3.0	4.5	6.6
Low emissions	2090	1.4	1.0 -	2.1	2.8	4.7	
High emissions	2090	2.1	1.4 -	2.9	3.6	5.6	8.3
Low emissions	2100	1.6	1.0 -	2.4	3.2	5.7	
High emissions	2100	2.5	1.6 -	3.4	4.4	6.9	10.2

Current and Future Tidal Planes

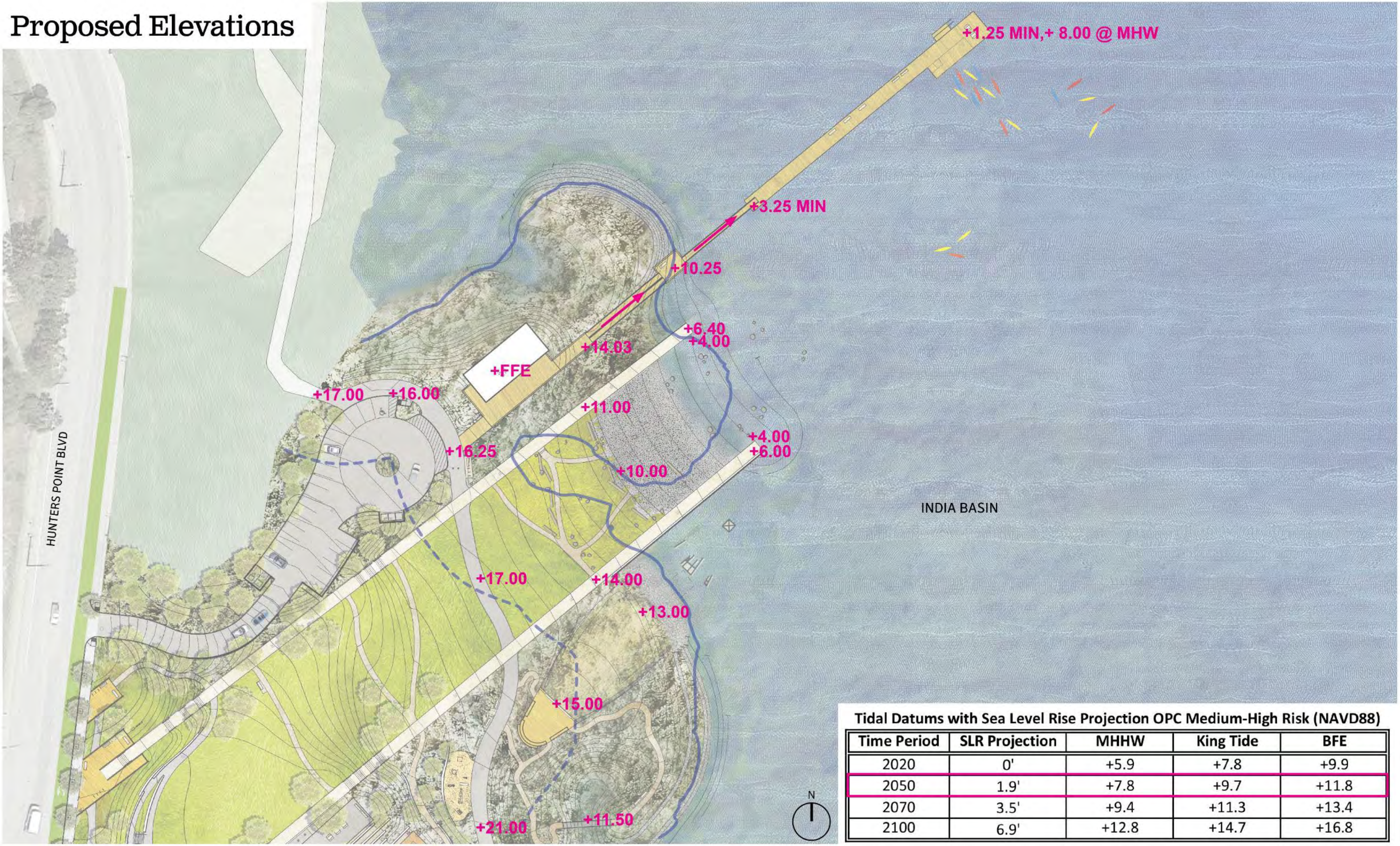
Year	SLR Projection	MHHW	King Tide[a]	BFE[b]
2020	0'	+5.9'	+7.8'	+9.9'
2050	1.9'	+7.8'	+9.7'	+11.8'
2070	3.5'	+9.4'	+11.3'	+13.4'
2100	6.9'	+12.8'	+14.7'	+16.8'

a. Occurs 4 to 6 times on average each year, with each event lasting approximately 3 hrs
b. 1% annual chance of flooding elevation as defined by FEMA

Minimum Recommended Site Grades

Open Space Feature (see Figure 3 for location of features)	Minimum Elevation	Basis for Minimum Elevation
Baytrail	+15	Higher of: • BFE by 2050 (+11.8) or • King Tide by 2100 (+14.7)
Shop Building Finish Floor	+15	
Bay City Ferry Platform	+15	
Boathouse Building	+15	
Parking Lot	+15	
Landward Ends of Pier 1 and 2	+15	
Landward Ends of Marine Rail 1 and 2	+15	
Overlook Terrace	+15	
Bayward Ends of Pier 1 and 2	+13	Add 1' of wave runup to Higher of: • BFE by 2050 (11.8) or • King Tide by 2070 (11.3)
Bayward Ends of Marine Rail 1 and 2	+7	Replace in-kind at their existing location and elevation for historic preservation

Proposed Elevations



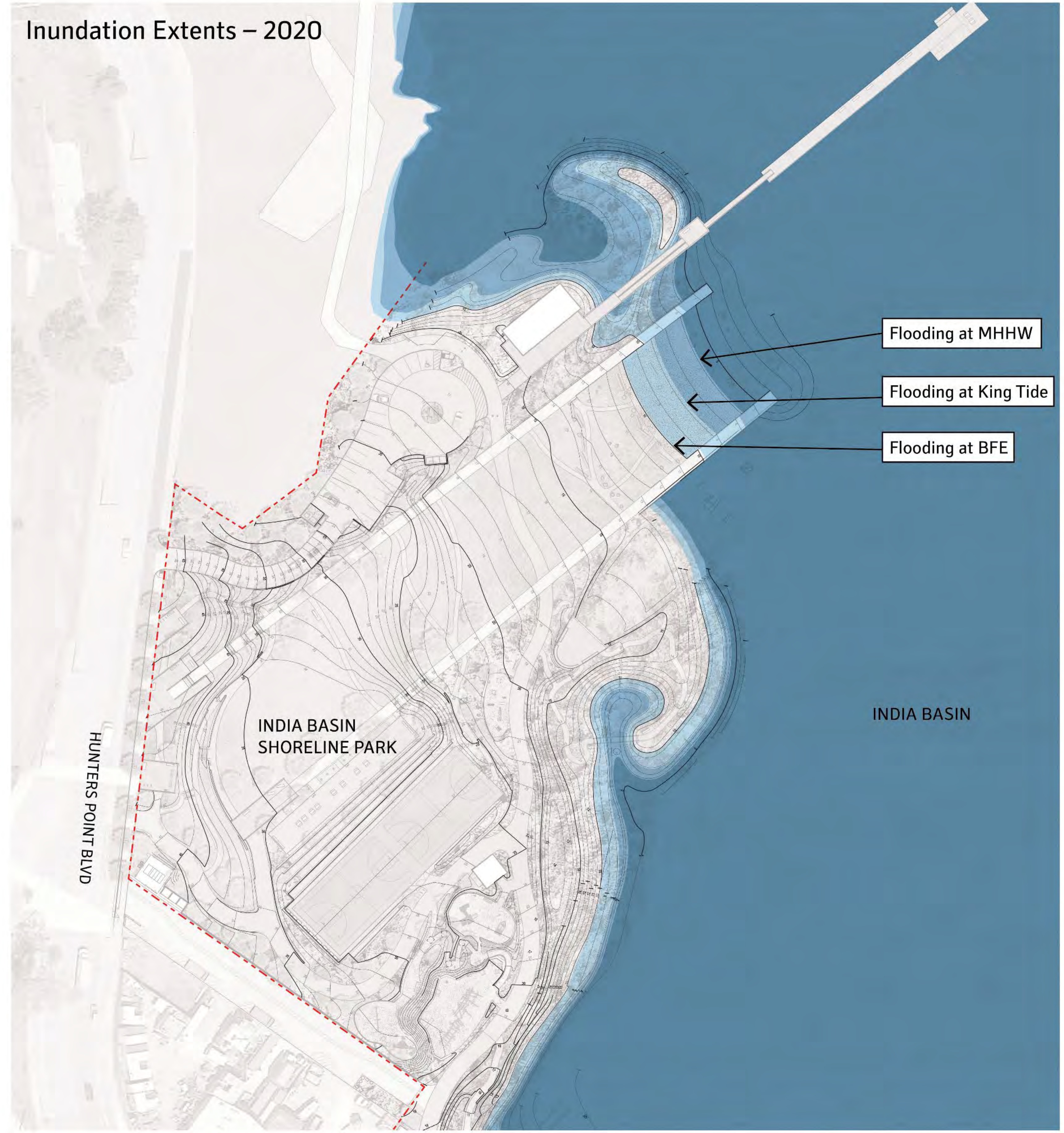
Tidal Datums with Sea Level Rise Projection OPC Medium-High Risk (NAVD88)

Time Period	SLR Projection	MHHW	King Tide	BFE
2020	0'	+5.9	+7.8	+9.9
2050	1.9'	+7.8	+9.7	+11.8
2070	3.5'	+9.4	+11.3	+13.4
2100	6.9'	+12.8	+14.7	+16.8

Inundation Extents - 2020

Tidal Datums with Sea Level Rise Projection OPC Medium-High Risk (NAVD88)

Time Period	SLR Projection	MHHW	King Tide	BFE
2020	0'	+5.9	+7.8	+9.9
2050	1.9'	+7.8	+9.7	+11.8
2070	3.5'	+9.4	+11.3	+13.4
2100	6.9'	+12.8	+14.7	+16.8



Inundation Extents - 2050

Tidal Datums with Sea Level Rise Projection OPC Medium-High Risk (NAVD88)

Time Period	SLR Projection	MHHW	King Tide	BFE
2020	0'	+5.9	+7.8	+9.9
2050	1.9'	+7.8	+9.7	+11.8
2070	3.5'	+9.4	+11.3	+13.4
2100	6.9'	+12.8	+14.7	+16.8

Inundation Extents - 2070

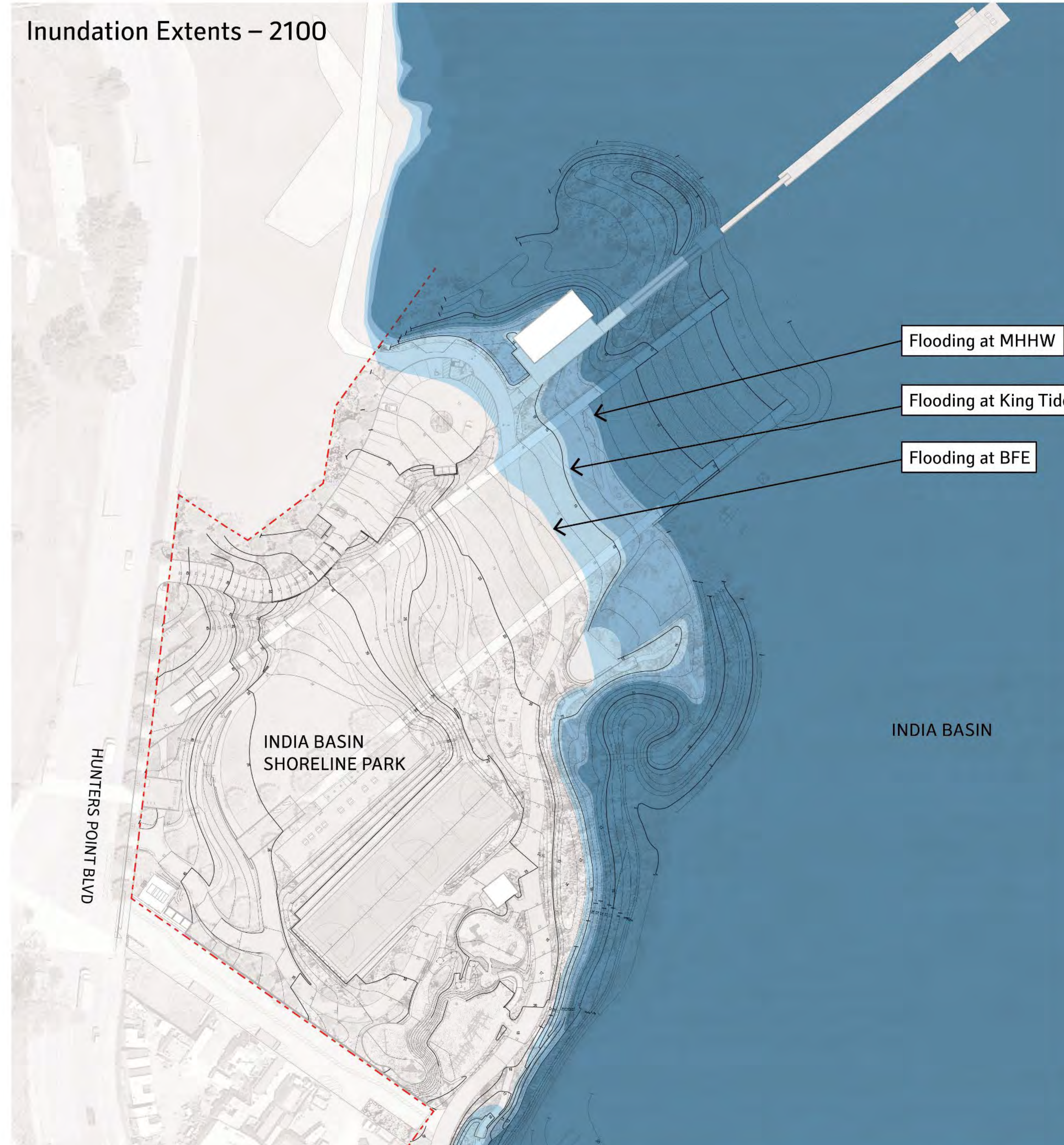
Tidal Datums with Sea Level Rise Projection OPC Medium-High Risk (NAVD88)

Time Period	SLR Projection	MHHW	King Tide	BFE
2020	0'	+5.9	+7.8	+9.9
2050	1.9'	+7.8	+9.7	+11.8
2070	3.5'	+9.4	+11.3	+13.4
2100	6.9'	+12.8	+14.7	+16.8

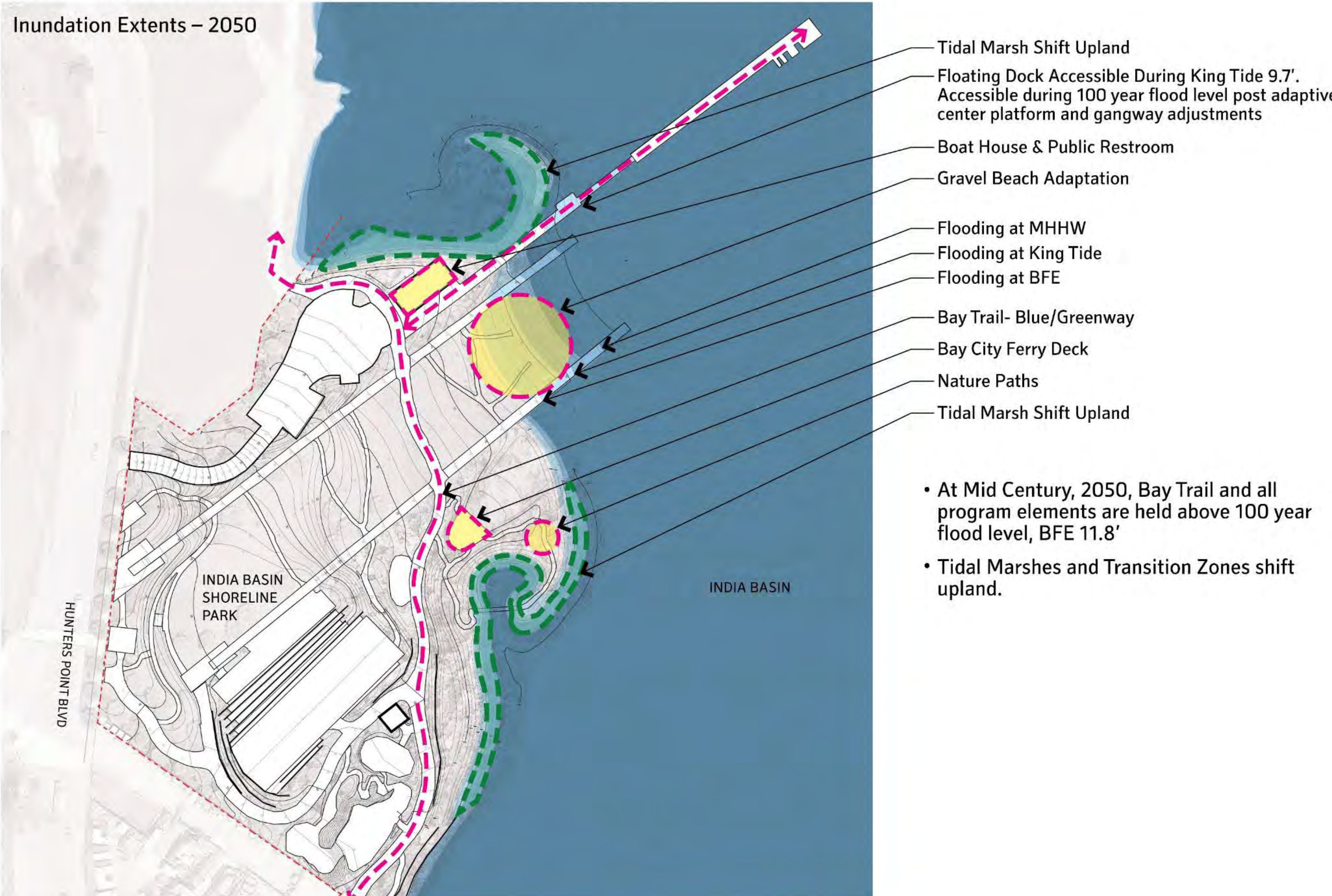
Inundation Extents - 2100

Tidal Datums with Sea Level Rise Projection OPC Medium-High Risk (NAVD88)

Time Period	SLR Projection	MHHW	King Tide	BFE
2020	0'	+5.9	+7.8	+9.9
2050	1.9'	+7.8	+9.7	+11.8
2070	3.5'	+9.4	+11.3	+13.4
2100	6.9'	+12.8	+14.7	+16.8



Inundation Extents - Current Plan 2050



- At Mid Century, 2050, Bay Trail and all program elements are held above 100 year flood level, BFE 11.8'
- Tidal Marshes and Transition Zones shift upland.