San Francisco International Airport
Shoreline Protection Program

BCDC ECRB Meeting

September 27, 2023

SFO

Agenda

1. Introduction & Project Purpose
2. Structural Analysis
3. Geotechnical Analysis
4. Adaptations for Sea-level Rise Flood Hazards
5. Questions

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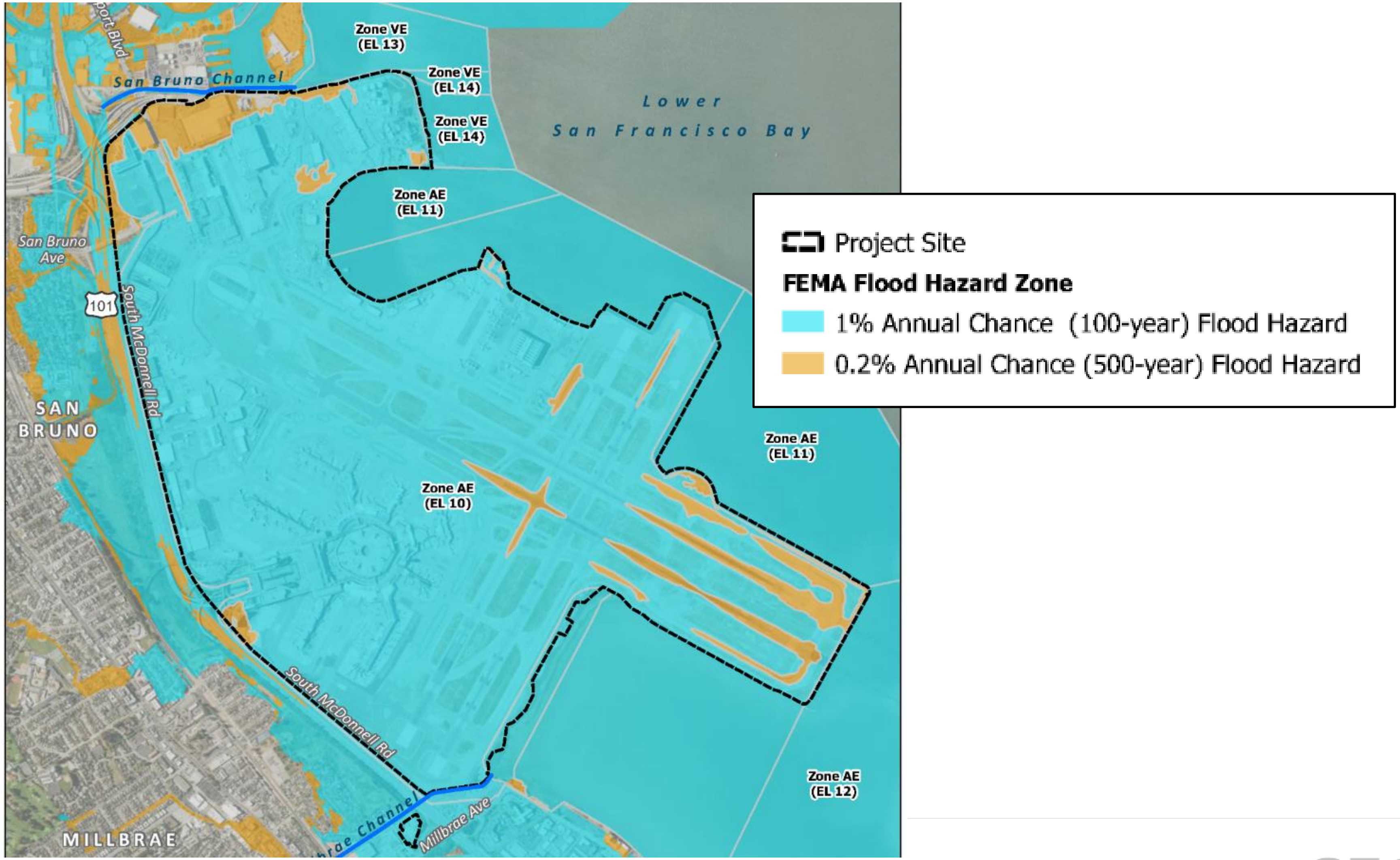
SPP Project Team

- SFO
  - Audrey Park
  - David Kim, PhD
- ESA
  - Bob Battalio, PE
  - Matt Brennan, PhD, PE
  - Melissa Denena
- COWI
  - James Connolly, PE, SE
  - Brian Lindawson, PE
  - Evan Vinyard
- TERRA engineers
  - Bob Kirby, PE, GE
  - John Lim, PE
- Geosyntec
  - Juan Pestana, ScD, PE

Existing Flood Hazard



Source: FEMA (2021)

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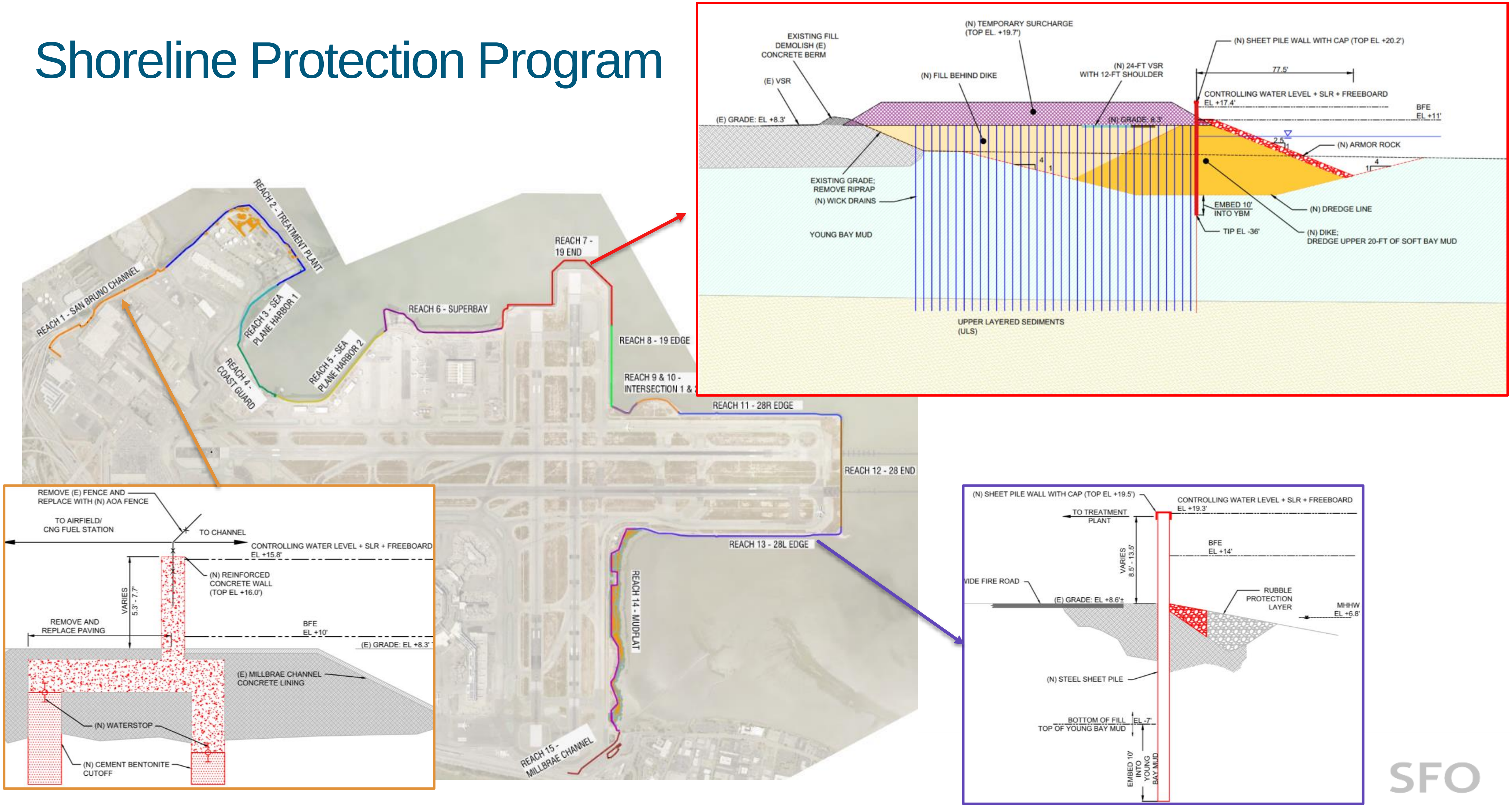
Shoreline Protection Program



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Project Objectives

1. Protect travelers and workers, Airport operations, and City assets
2. Remove Airport from 100-year FEMA floodplain via C/LOMR
3. Create protection system that is adaptable to future projections of sea-level rise
4. Create protection system that poses no safety hazards to Airport operations, maintains runway capacity, and satisfies FAA design standards
5. Enhance emergency vehicle access near fuel tank farm
6. Minimize hazardous wildlife attractants to prevent bird strikes
7. Create protection system as expeditiously as possible for safe and continuous Airport operations and minimizing disruption to aircraft operations during construction

The Airport acknowledges avoidance and minimization of impacts on the San Francisco Bay to the extent practicable.

Project Description

Remove:

- Existing shoreline protection: Concrete walls, sheet pile walls, concrete debris, armor rock, sandbags, K-rails, embankment walls/dikes, earthen and vegetated berms.
- Existing infrastructure in areas where it conflicts with the proposed shoreline protection system.

Construct New Shoreline Protection System:

- Reinforced concrete walls and steel sheet pile walls, some with armor rock revetments and/or open water fill. Approximately 40,335 feet (7.6 miles) long, 3.9 to 13.5 feet above existing or newly graded ground surfaces and driven to maximum depth of approximately 50 feet.
- New perimeter dike, for Reaches 7 and 8, extend shoreline protection system additional 100 to 215 feet beyond existing shoreline into Bay.
- Armor rock revetments used in tandem with walls to dissipate wave energy and prevent sediment scour.
- Open water fill intended to stabilize the shoreline and create a necessary slope for support of the shoreline protection system.
- Fill in wetlands in Sub-reach 2B and Reach 14 areas.

Project Description (continued)

Construct Associated Improvements:

- **Roads:** For Reaches 7–11, 13, and 14, vehicle service road relocated approximately 12 to 140 feet toward the Bay.
- **Storm Drain Pump Station Outfalls/Water Utility Lines:** Existing infrastructure retrofitted and rerouted.
- **Lighting Trestle:** To accommodate construction of perimeter dike and shoreline protection system for Reach 7 per FAA design standards, existing lighting trestle at end of Runway 19L to be demolished and new lighting trestle constructed.
- **Gates:** Floodgates and other access control gates would be installed in various areas associated with the shoreline protection system and/or roadways.

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    - COWI
        - James Connolly, PE, SE
        - Brian Lindawson, PE
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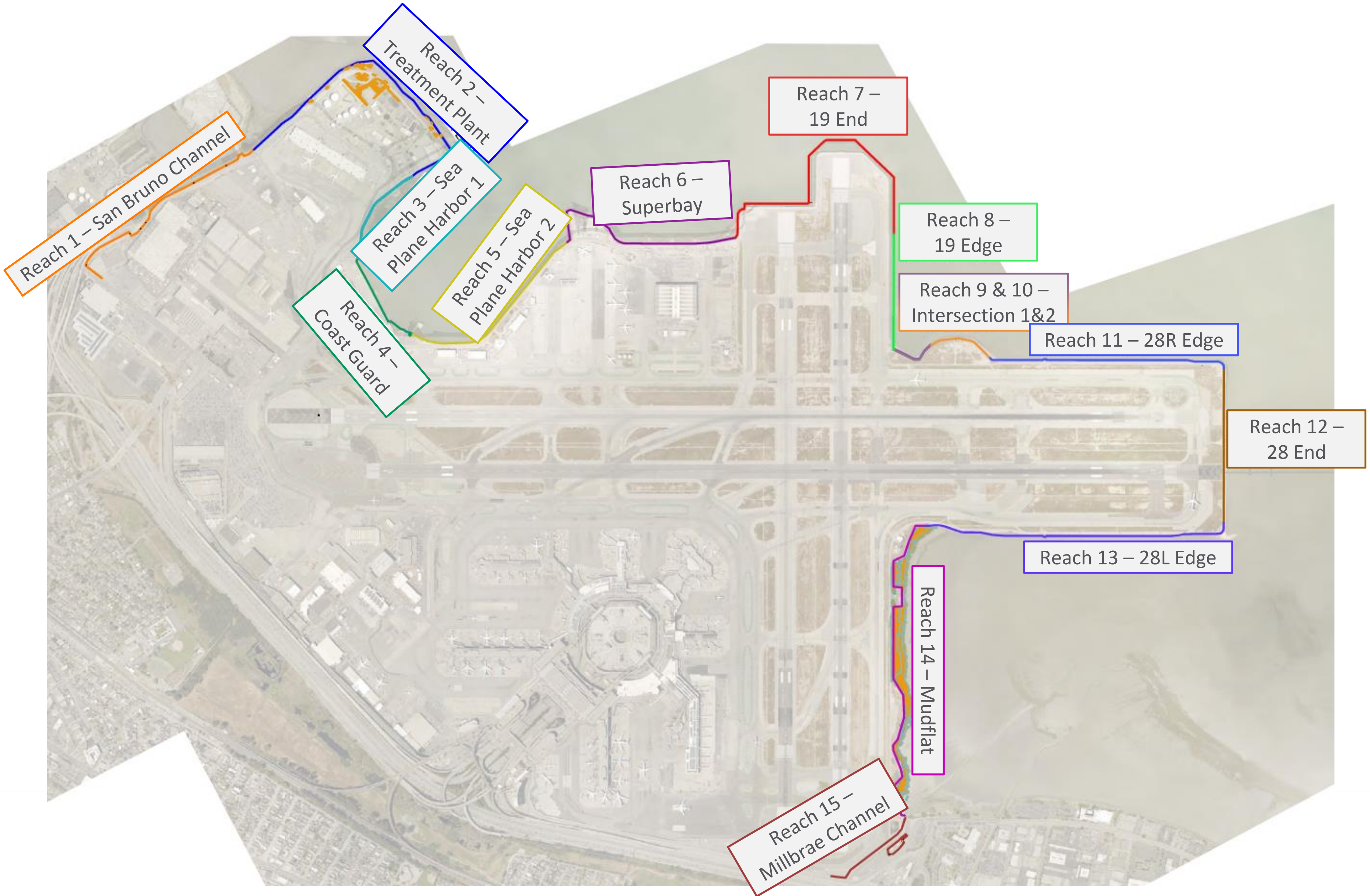
Sea-Level Rise Protection Program: Plan View



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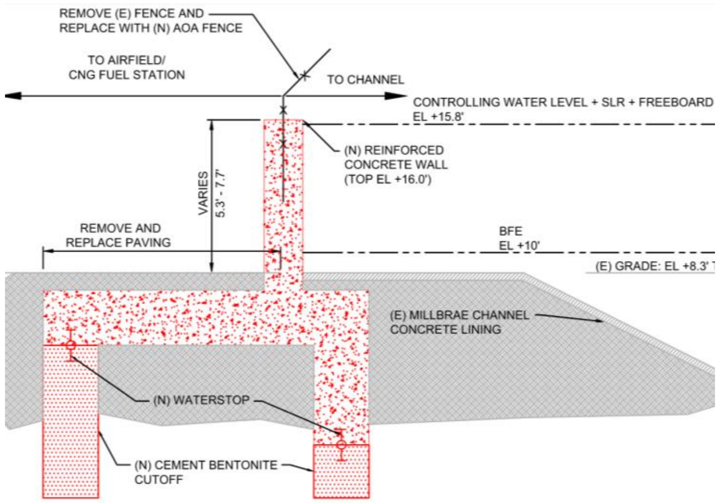
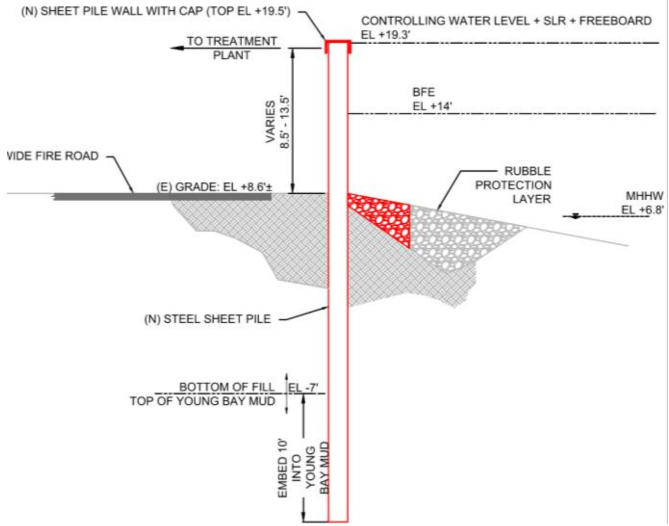
Typical Cross Sections



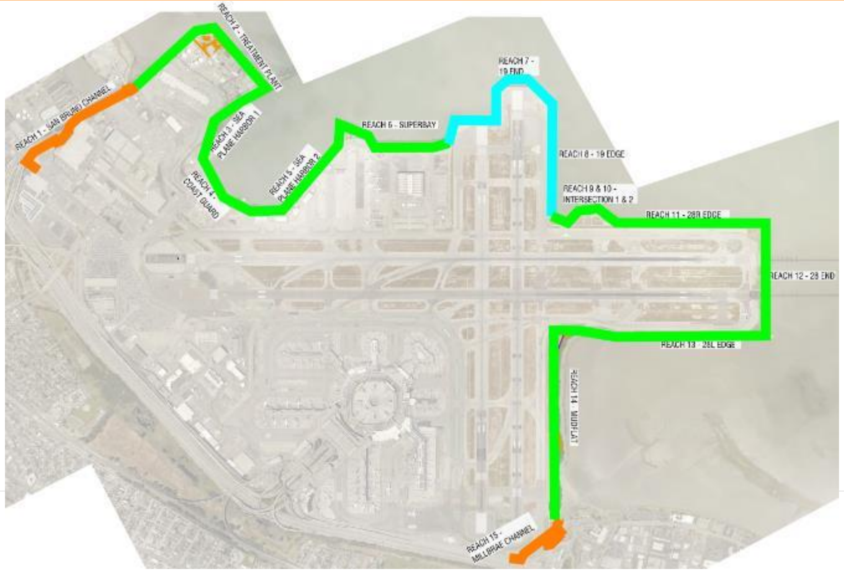
CIP T-WALLS ALONG CHANNELS

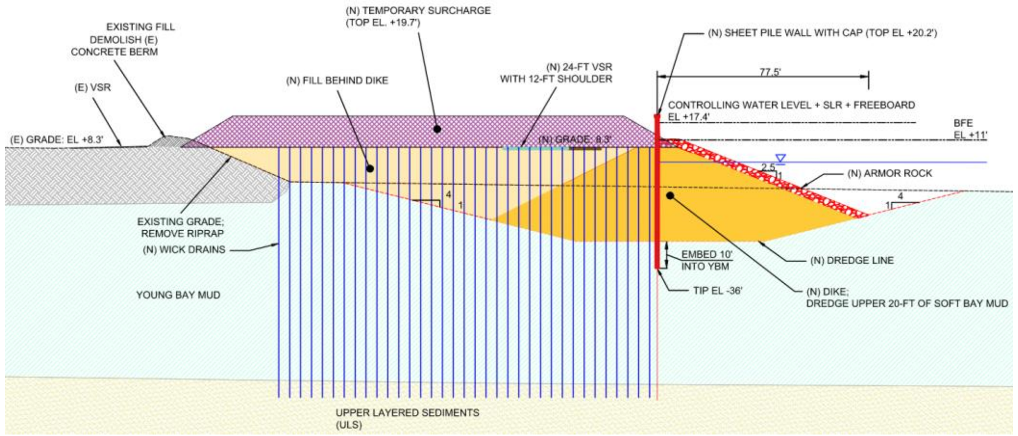
Reaches 1 and 15



SHEET PILE WALLS ALONG SHORELINE

Reaches 2 – 6, 9 - 14





SHEET PILE WALLS THRU NEW DIKE

Reaches 7 & 8

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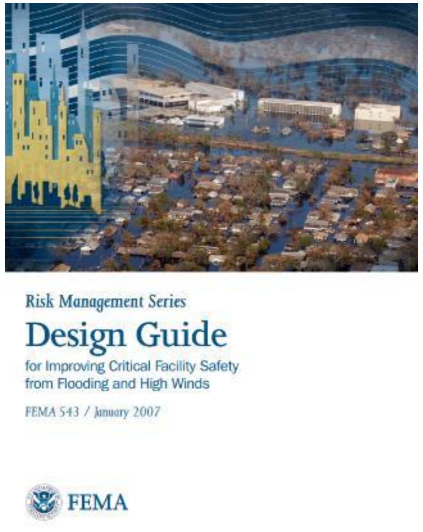
Design Basis

Scope	Design Standard	Details
Floodwall Design Standard	**USACE EM1110-2-2502** “Floodwalls and other Hydraulic Retaining Walls” DEPARTMENT OF THE ARMY *EM 1110-2-2502 U.S. Army Corps of Engineers 441 G Street, NW CECW-EC Washington, DC 20314-1000 Engineer Manual No. 1110-2-2502 1 August 2022 Engineering and Design FLOODWALLS AND OTHER HYDRAULIC RETAINING WALLS	Define • Non-seismic loads and combinations • Wall limit states • Non-seismic performance requirements
Seismic Performance Requirements	**FEMA 543** “Design Guide for Improving Critical Facility Safety from Flooding and High Winds”	(see performance tables below)



INCREASING LEVEL OF PERFORMANCE — Performance Groups

MAGNITUDE OF DESIGN EVENT (Increasing Magnitude of Event)	Performance Group I	Performance Group II	Performance Group III	Performance Group IV
Very Large (Very rare)	Severe	Severe	High	Moderate
Large (Rare)	Severe	High	Moderate	Mild
Medium (Less Frequent)	High	Moderate	Mild	Mild
Small (Frequent)	Moderate	Mild	Mild	Mild

DESIGN EVENT

MAGNITUDE OF DESIGN EVENT	Seismic	Flood	Wind
Very Large (Very rare)	2,475 Years	Determined on Site-Specific Basis	125 Years
Large (Rare)	475 Years (Not to Exceed Two-Thirds of the Intensity of Very Large	Determined on Site-Specific Basis	100 Years
Medium (Less Frequent)	72 Years	500 years	75 Years
Small (Frequent)	25 Years	100 Years	50 Years

Load Combinations

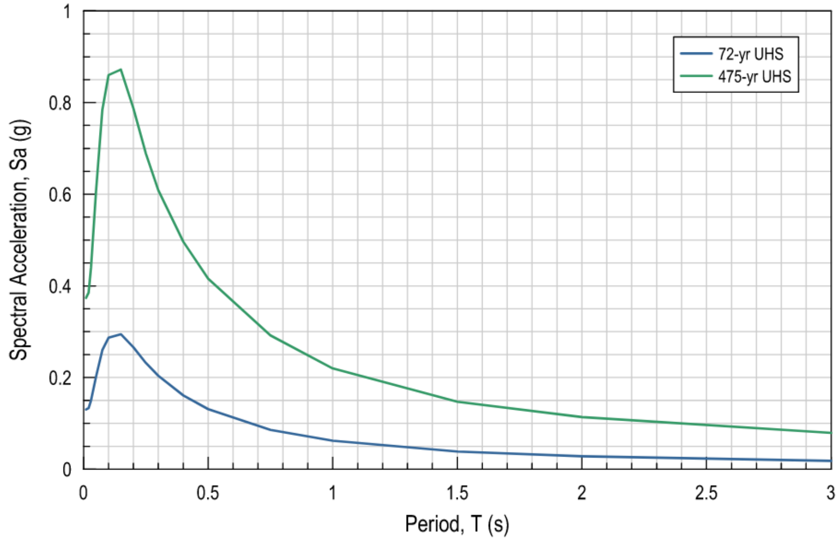
Load Combo & Category	Nominal Load Case Description	Unfactored Load Combination
1 Usual	10-year Flood Event *(including future SLR)*	D + EH + EV + $(Hs+Hw+Hd)_U$ + W
2 Unusual	FEMA 1% AEP Flood with SLR	D + EH + EV + $(Hs+Hw+Hd)_N$ + W
3 Extreme	FEMA 1% AEP Flood with SLR and Debris Impact	D + EH + EV + $(Hs+Hw+Hd)_N$ + IM + W
4 Extreme	750-year Flood Event	D + EH + EV + $(Hs+Hw+Hd)_X$ + W
5A Unusual	Seismic – 72-year Event	D + EH + EV + Hs_c + EQ_{N-72}
5B Unusual	Seismic – 475-year Event	D + EH + EV + Hs_c + EQ_{N-475}

Symbols

- D – Dead
- EV – Vertical Earth Pressure
- EH – Lateral Earth Pressure
- Hs – Hydrostatic
- ES – Soil Surcharge
- L – Live Load
- Hw – Wave Loading
- Hd – Hydrodynamic (not seismic) Load
- IM – Debris/Floating Ice Impact
- W – Wind
- EQ – Earthquake (Inertial + Kinematic)
- Subscripts $_U$, $_N$, and $_X$ for Usual, Unusual, and Extreme load categories, respectively.
- Subscripts $_{pr}$ and $_c$ designate principal and companion loads, respectively.

Seismic Loading

Seismic Hazard



- Peak Ground Acceleration
  - 72 years – 0.13 g
  - 475 years – 0.37 g

Performance Criteria

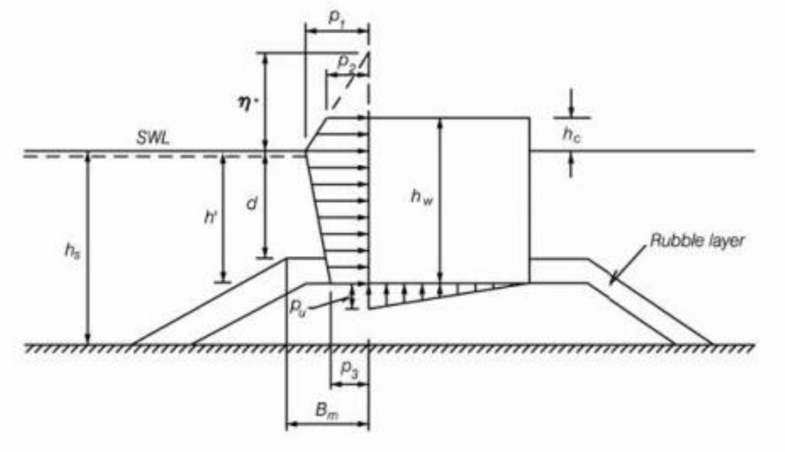
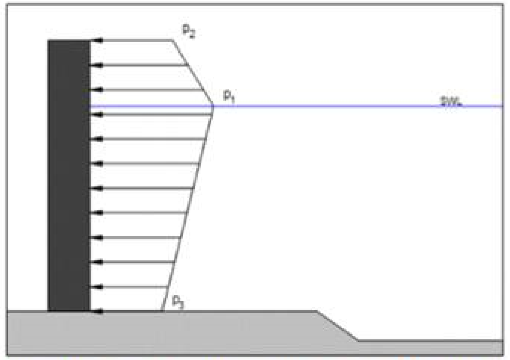
- FEMA 453 Guidelines

- 72 years – “Mild”
  - No structural damage
  - Overall extent of damage is minimal

- 475 years – “Moderate”
  - Damage is repairable and some delay in re-occupancy expected
  - Extent of damage can be locally significant, but moderate overall

Wave Loading

Basis	Technical Approach

<u>USACE EM 2502 General Loading Criteria</u>
• Usual – 10 years
• Unusual – 100 years
• Extreme – 750 years
 	
<u>SFO SPP Wave Loading Analysis</u>
• Condition Input Parameters
    • Surge
    • Wave
• Return Periods
    • 1, 2, 5, 10, 50, 100, 375, 750 years
• Envelope of Combined Surge and Wave Events to Determine Worst Case
    • 10-yr event
    • 100-yr event
    • 750-yr event
	<u>Goda (1974) - </u> Wave Distribution Diagrams
	
	
	

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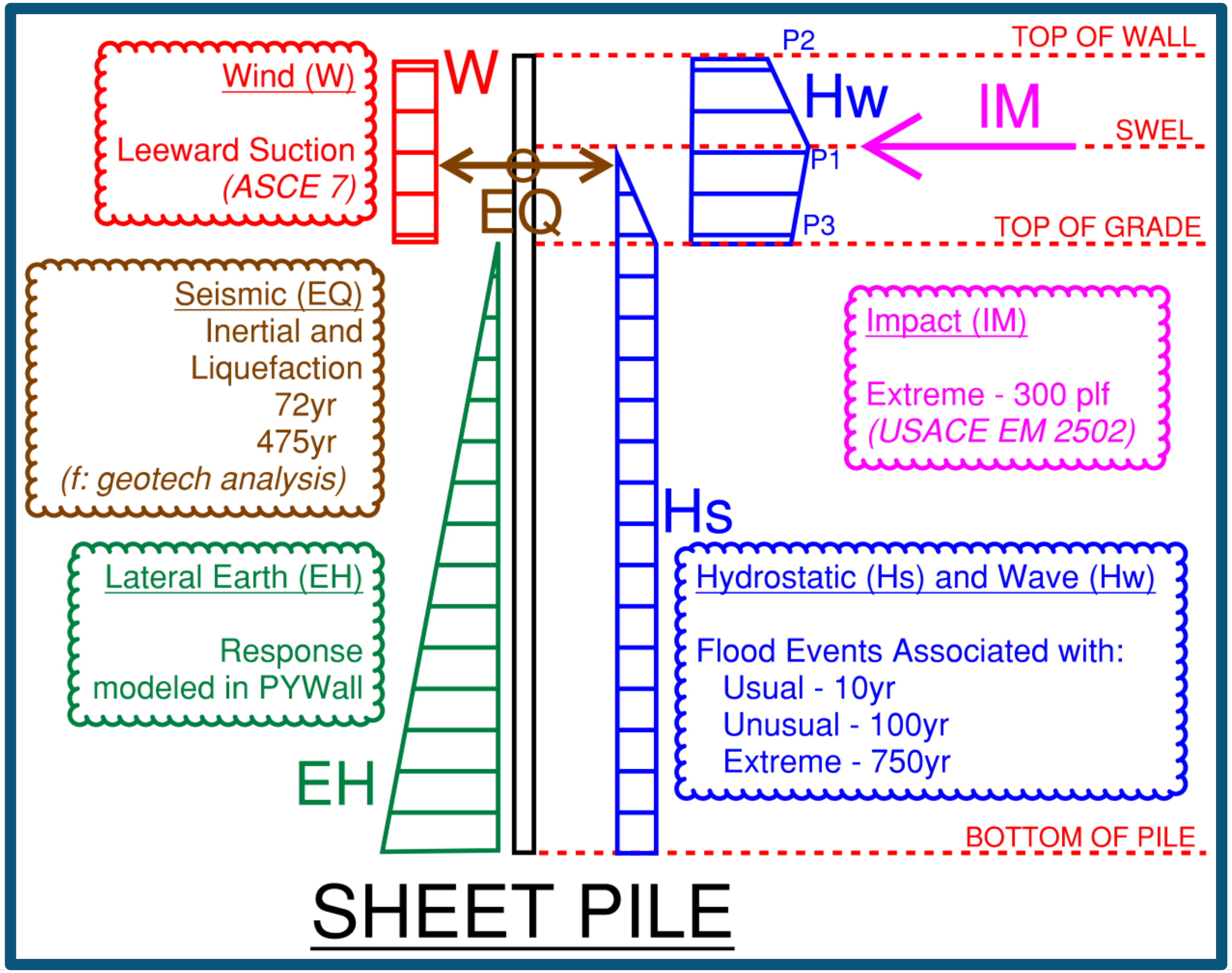
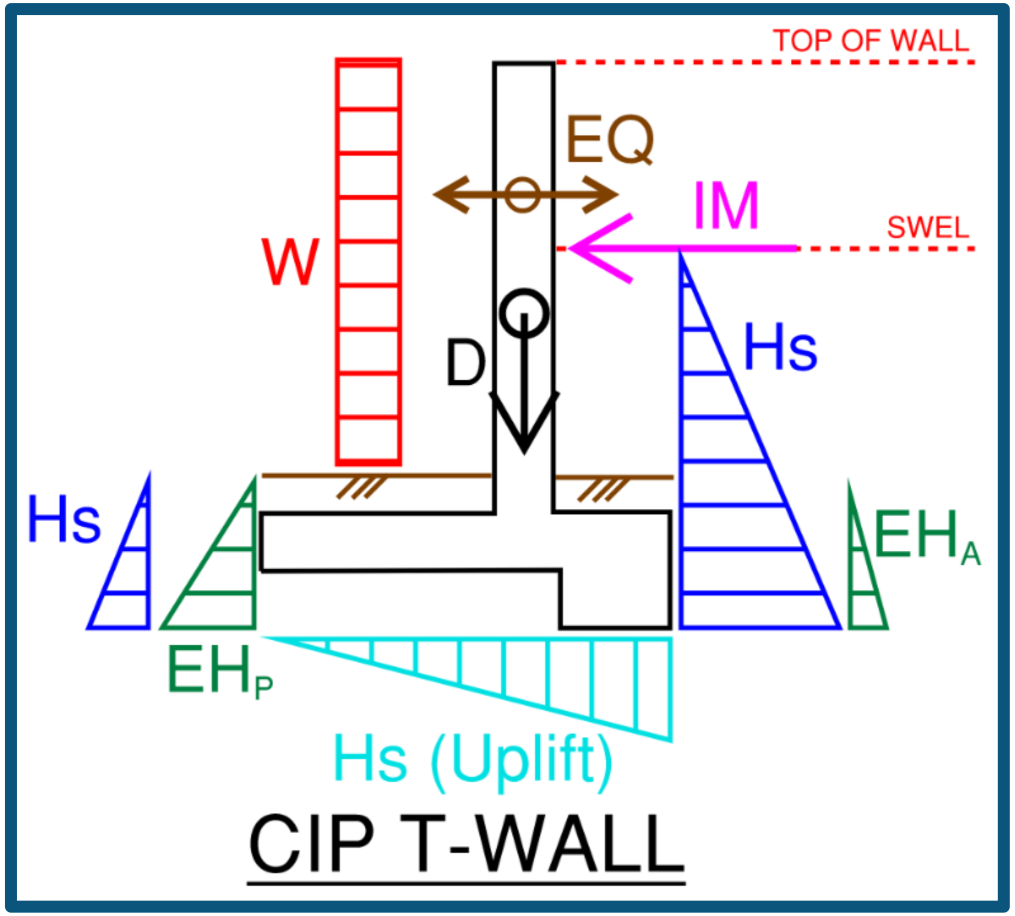
Load Diagrams





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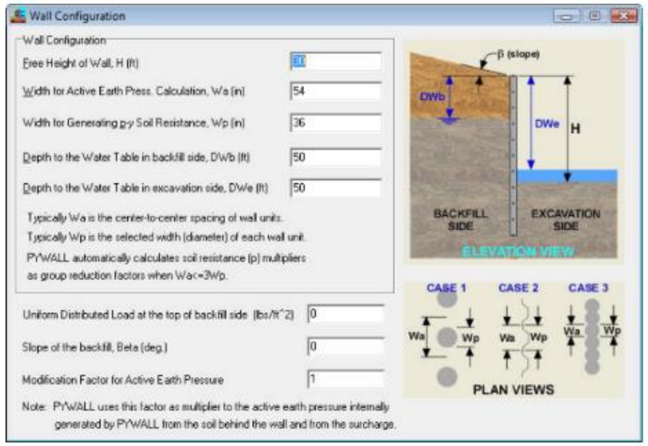
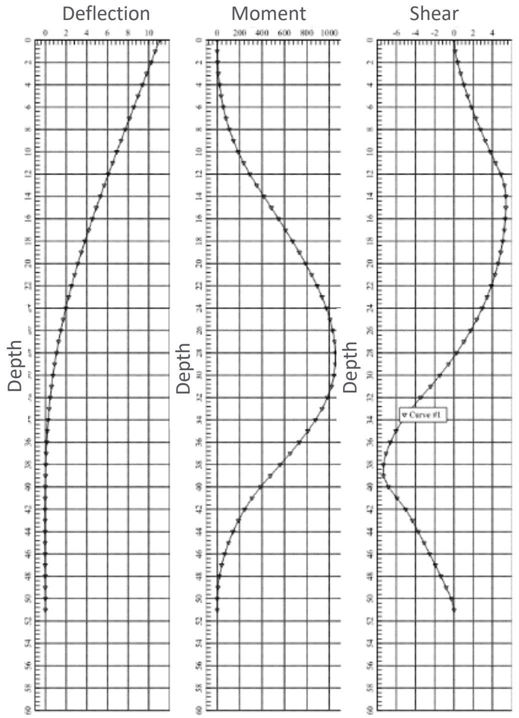
Analysis Approach





SHEET PILES

<u>Non-Seismic</u>

- PYWall Analysis
- Model Corroded Properties

<u>Seismic</u>

Demand From Geotechnical Analysis

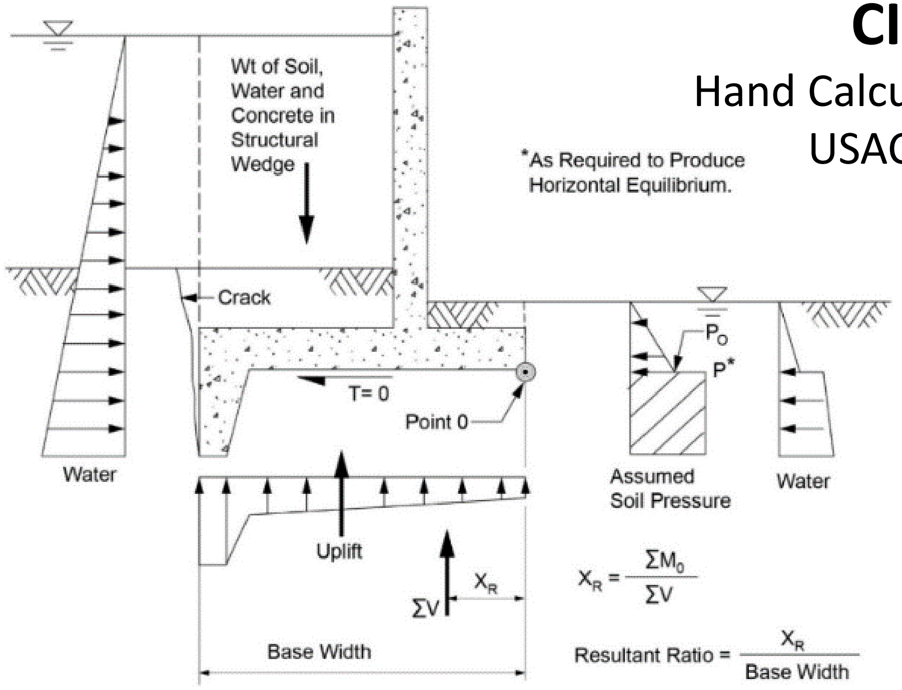
- Inertial - Plaxis2D
- Liquefaction - Zhang et al

<u>Limit States</u>

- Rotational Stability *(embedment)*
- Strength of Elements
- Deflection

CIP T-Wall

Hand Calculations per USACE EM 2502



<u>Limit States</u>

- Flotation
- Sliding
- Bearing Capacity
- Strength of Elements
- Resultant Location (overturning)

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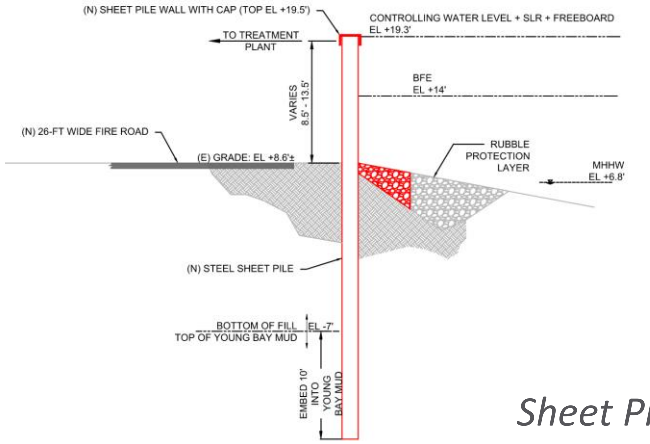
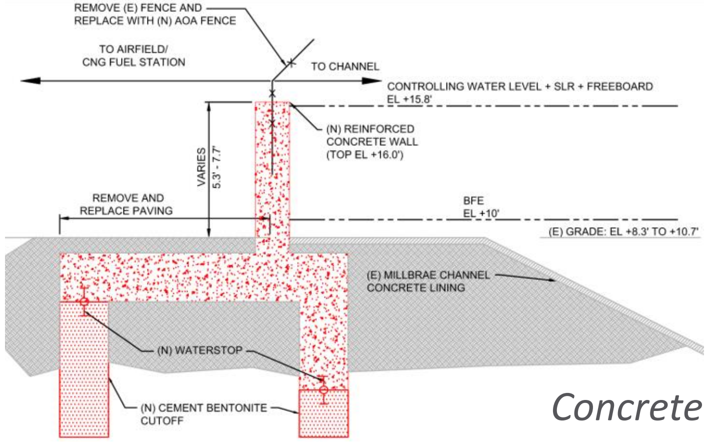
Design Results

Sheet Pile	CIP T-Wall
<u>Applicable Reaches</u> • 2 – 14, inclusive <u>Reference Section</u> • NZ19 or AZ19-700 • Grade 60 <u>Tip Elevation</u> • Min 10 ft Embedment Into Young Bay Mud • Min -35 ft NAVD88	<u>Applicable Reaches</u> • 1 and 15 <u>Design Details</u> • Conventionally Reinforced Concrete • Includes Shear Key • Includes Cement Bentonite Hydraulic Cutoffs
 *Sheet Pile Floodwall*	 *Concrete Floodwall*

Analytical Results

<table>
<tr><th>Sheet Pile</th><th colspan="2">CIP T-Wall</th></tr>
<tr><td><u>Strength of Structural Elements</u>
(checked with corroded section properties)
• Flexure Max Demand/Capacity (D/C) = 0.74
• Shear Max D/C = 0.08

<u>Rotational Stability</u>
(embedment)
• Max D/C = 0.90</td><td><u>Strength of Structural Elements</u>
Wall thicknesses provide ample section depth for reinforcing

<u>Flotation Check</u>
• D/C = 0.61</td><td><u>Sliding Stability</u>
• D/C = 0.15

<u>Resultant Location</u>
• Within allowable limits – all LC’s

<u>Bearing Capacity</u>
• FS = 3.5</td></tr>
<tr><td colspan="3"><u>Key Conclusions:</u>
• Flood Loading – No Damage
• Seismic Inertial – No Damage</td></tr>
</table>

Coastal Hydraulics – Technical Approach

Approach

- Based on Central San Francisco Bay Flood Hazard Study (BakerAECOM, 2012)
- Previous approach improved upon and applied to shoreline with SFO SPP structures, to support FEMA map revision via C/LOMR process

Primary Data Source

- San Francisco Bay Regional-Scale Wave and Hydrodynamic Modeling (DHI, 2011)
- 31-year hindcast model providing hourly wave and surge time series

Passpoints along SFO Shoreline where surge and wave time series data are available

Coastal Hydraulics – Methodology

Wave Transformation

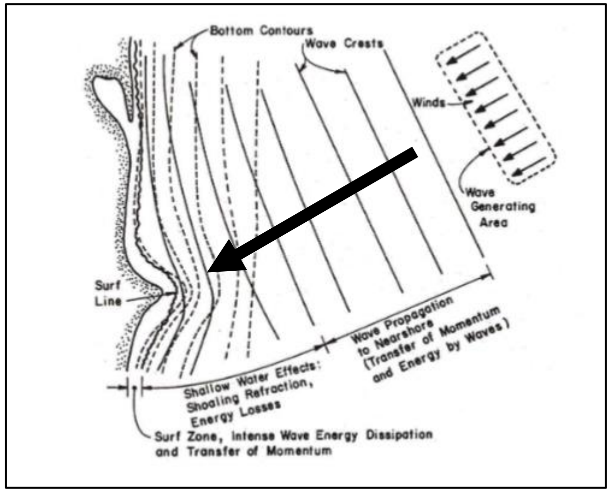
- Waves transformed from passpoint to shoreline
- Filtering, refraction, breaking, etc.

Wave Runup

- Height of runup on SPP structures

Extreme Statistics

- Process results from 31-year time series to generate 100-year surge and wave conditions



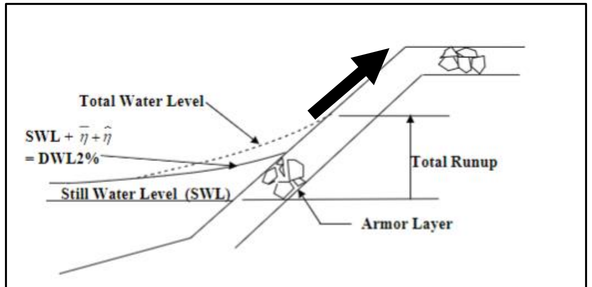
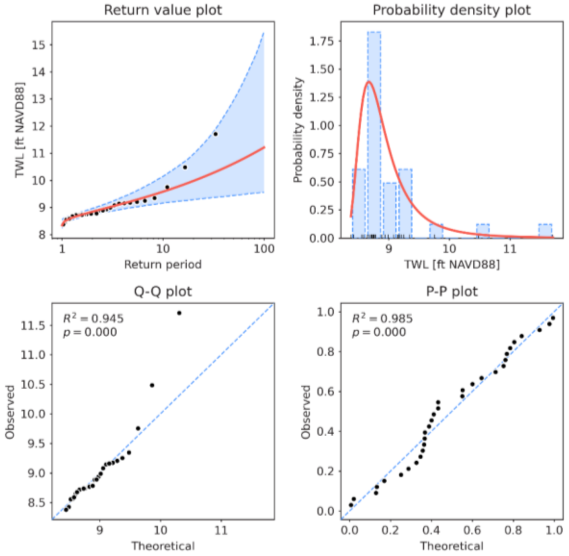


Figure D.4.5-6. Runup on Coastal Structures, Definition Sketch



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Coastal Hydraulics – Flood Water Levels & Top of Wall

Total Water Level (TWL)

- 1% Still Water Elevation (SWEL)
- Wave Runup (Rmax)
- Sea Level Rise (SLR) = 42” (3.5 ft)

Top of Wall (T/Wall)

- TWL or SWEL
- Additional Freeboard Allowance
- Confirm Against FEMA Base Flood Elevations (BFE)

SLR Adaptation

- Potential for Future T/Wall Raise

Reach ID	FEMA BFE	1% SWEL + 2ft Freeboard	1% TWL (Rmax) + 1ft Freeboard	COWI Design Elevation Indicator	COWI Proposed Design Elevation
1	10	15.8	NA	15.8	16
2a	13	15.8	15.3	15.8	16
2b	14	15.8	19.3	19.3	19.5
2c	11	15.8	15.9	15.9	16
3	11	15.8	15.6	15.8	16
4	11	15.8	15.6	15.8	16
5	10	15.8	17.0	17.0	17
6	10	15.8	15.4	15.8	17
7a	11	15.8	16.8	16.8	20.2
7b	11	15.8	17.4	17.4	20.2
7c	11	15.8	17.3	17.3	20.2
8	11	15.8	17.3	17.3	17.5
9	11	15.8	16.5	16.5	17
10	11	15.8	16.6	16.6	17
11	11	15.8	17.1	17.1	17
12	12	15.8	17.3	17.3	17
13	10	15.8	15.2	15.8	17
14	12	15.8	18.0	18.0	18
15	10	15.8	NA	15.8	16

all elevation values in ft NAVD88

Coastal Hydraulics – Riprap Design

Methodology

- Caltrans Highway Design Manual
- Caltrans Bank and Shore Rock Slope Protection Design Guide

Design Conditions

- 100-year wave
- Significant Wave Height: 3.0 ft
- Mean Wave Period: 3.5 s

Results

- Size: RSP Class IV
- Minimum Thickness: 2.5 ft
- Geotextile Layer: RSP-Fabric Class 8

Riprap Design Parameter	Value
Riprap Class	RSP Class IV
Median Stone Size	15 in
D_{100}	30 in
D_{50}	15 in
Median Stone Weight	300 lb
Minimum Riprap Layer Thickness	2.5 ft
Toe Thickness	5.0 ft
Backing Layer	None
Geotextile Layer	RSP-Fabric Class 8

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4. Adaptations for Sea-level Rise Flood Hazards
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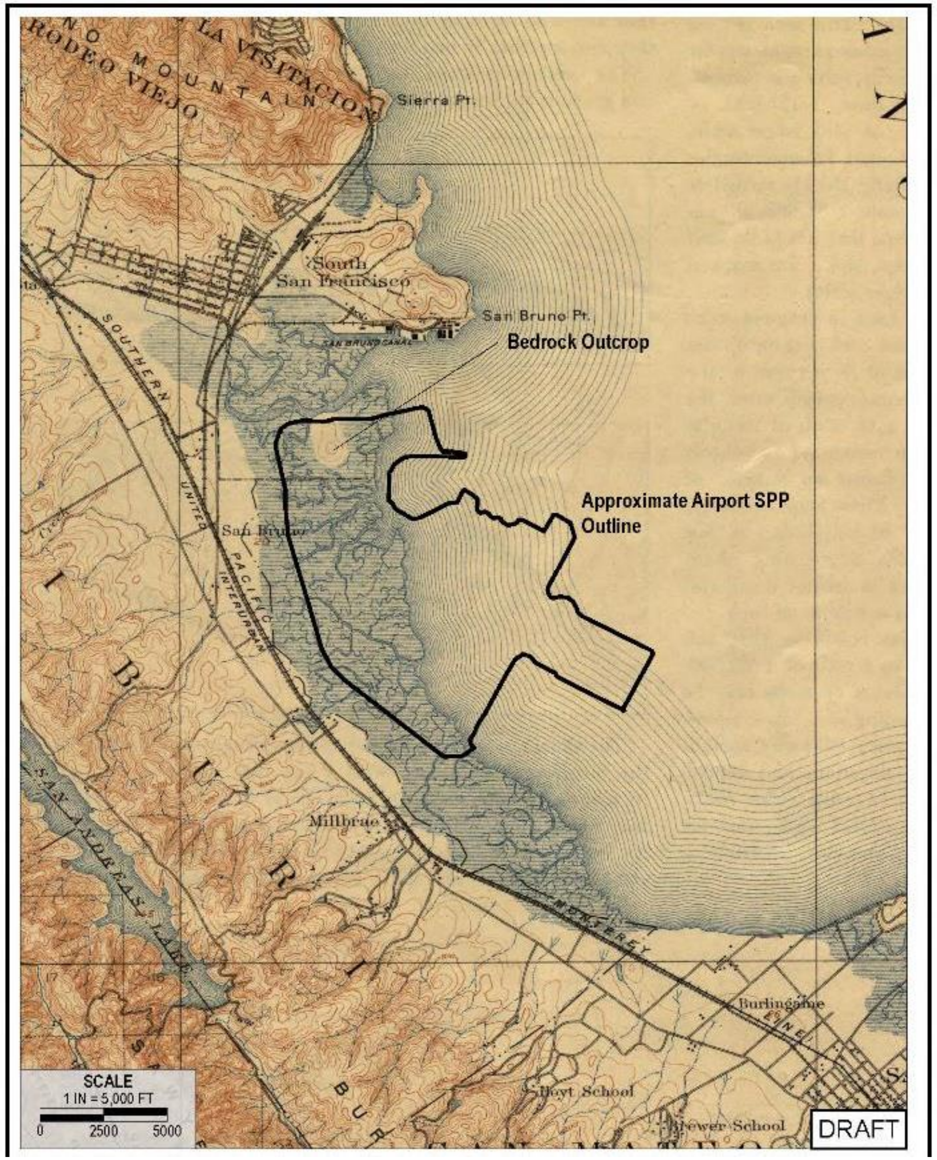
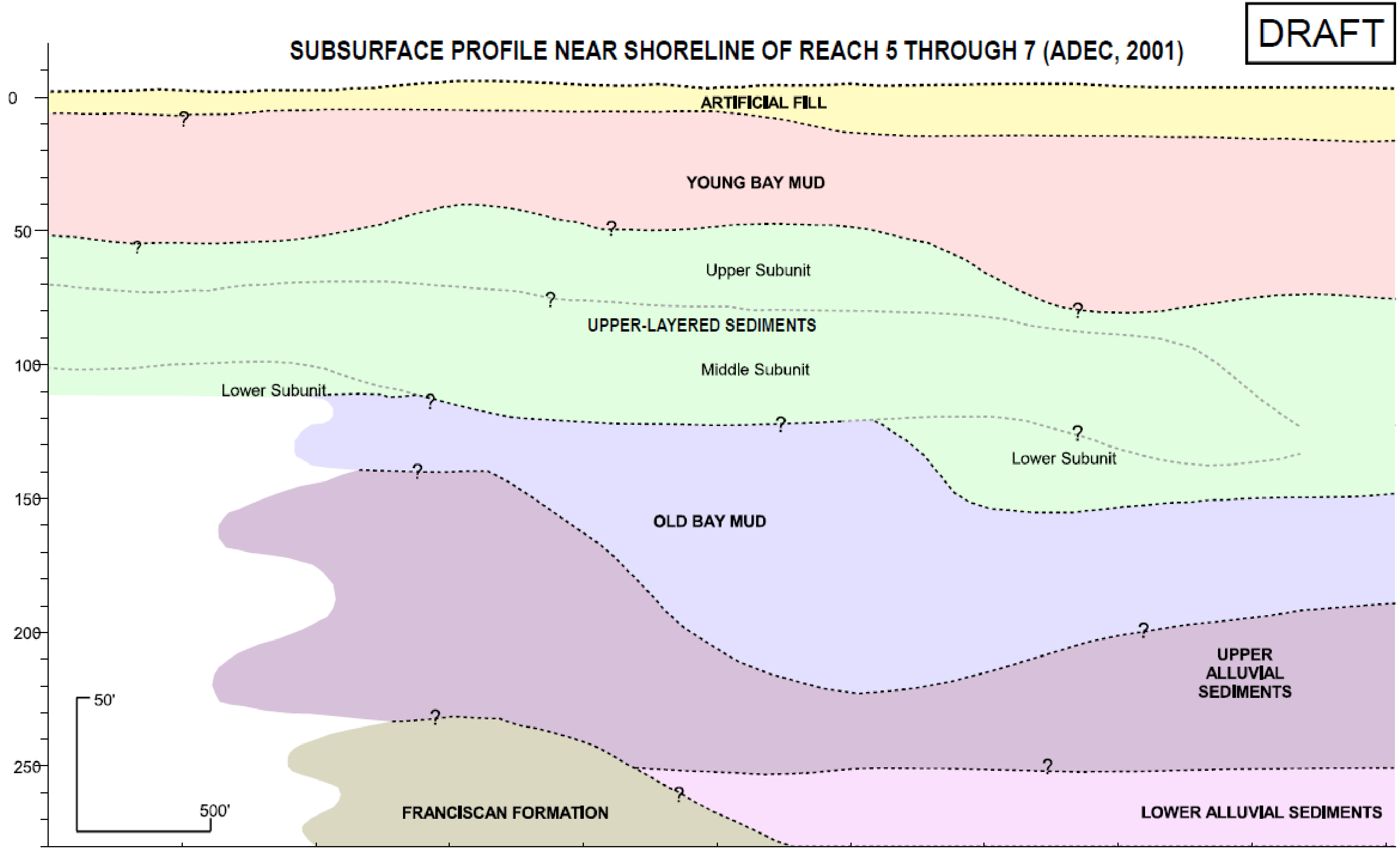
Geotechnical Analysis

- Subsurface Conditions
- Site Seismicity and Site Response Analyses
- Seismic Performance of SPP
- Geotechnical Design of SPP

Fill of Historic Shoreline



Typical Subsurface Profile



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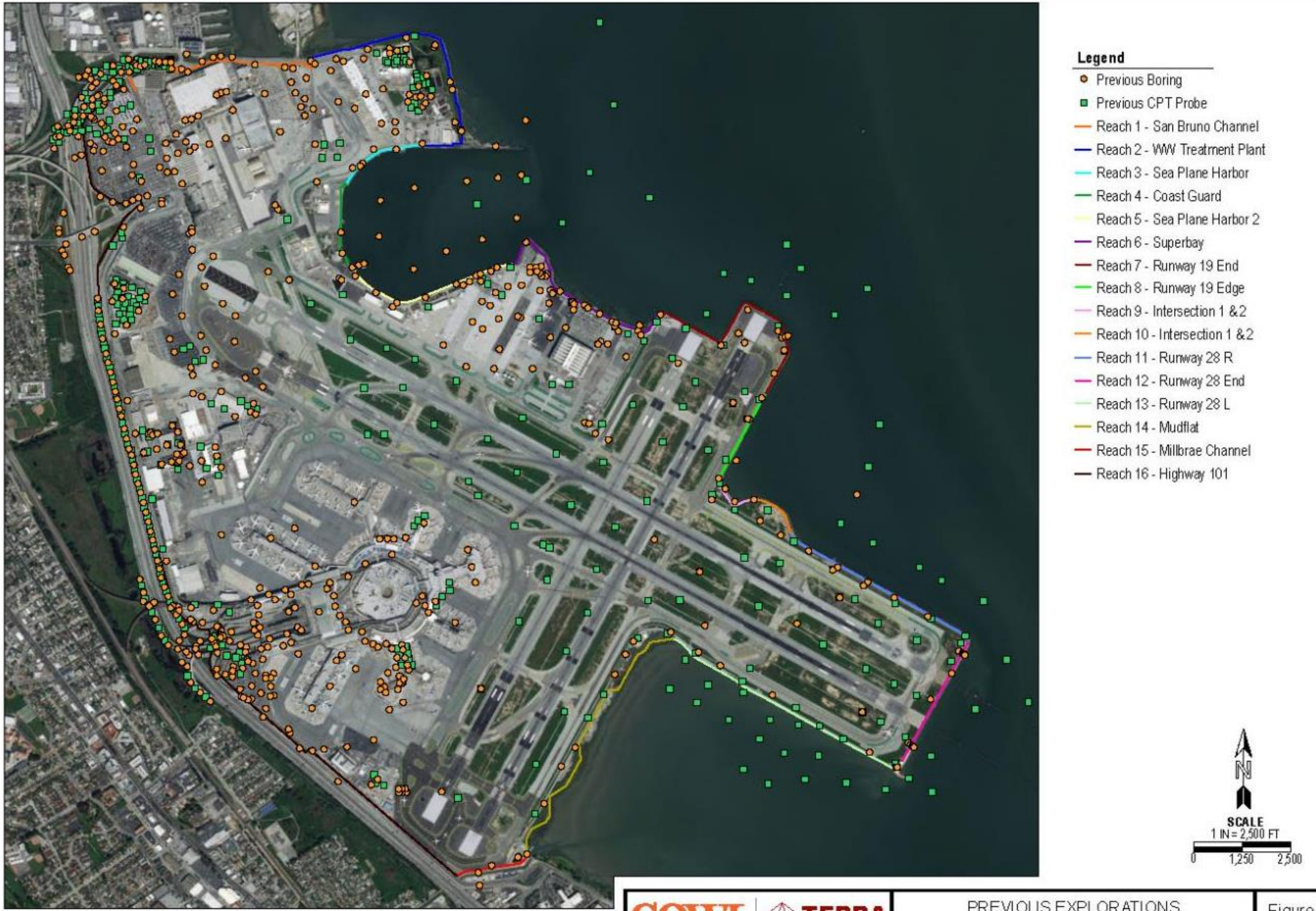

Basemap: ArcGIS World Imagery (2016)

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COWI TERRA engineers, inc. JOINT VENTURE

PREVIOUS EXPLORATIONS
BORINGS AND CPT PROBES
AIRPORT SHORELINE PROTECTION PROGRAM

Figure 3

Rev. 0 04/06/2020

SCALE
1 IN = 400 FT
0 200 400

N

Legend

-4 Previous Boring with Bottom of Fill / Top of YBM

-24 Previous CPT Probe with Bottom of Fill / Top of YBM

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JOINT VENTURE

PREVIOUS EXPLORATIONS - REACH 6
ELEVATION OF TOP OF YOUNG BAY MUD
AIRPORT SHORELINE PROTECTION PROGRAM

Figure
9B

Rev. 0 04/06/2020

SCALE
1 IN = 400 FT
0 200 400

Legend
-70 Previous Boring with Bottom of YBM
-53 Previous CPT Probe with Bottom of YBM

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PREVIOUS EXPLORATIONS - REACH 6
ELEVATION OF BOTTOM OF YOUNG BAY MUD
AIRPORT SHORELINE PROTECTION PROGRAM

Figure
9C

Rev. 0 04/06/2020

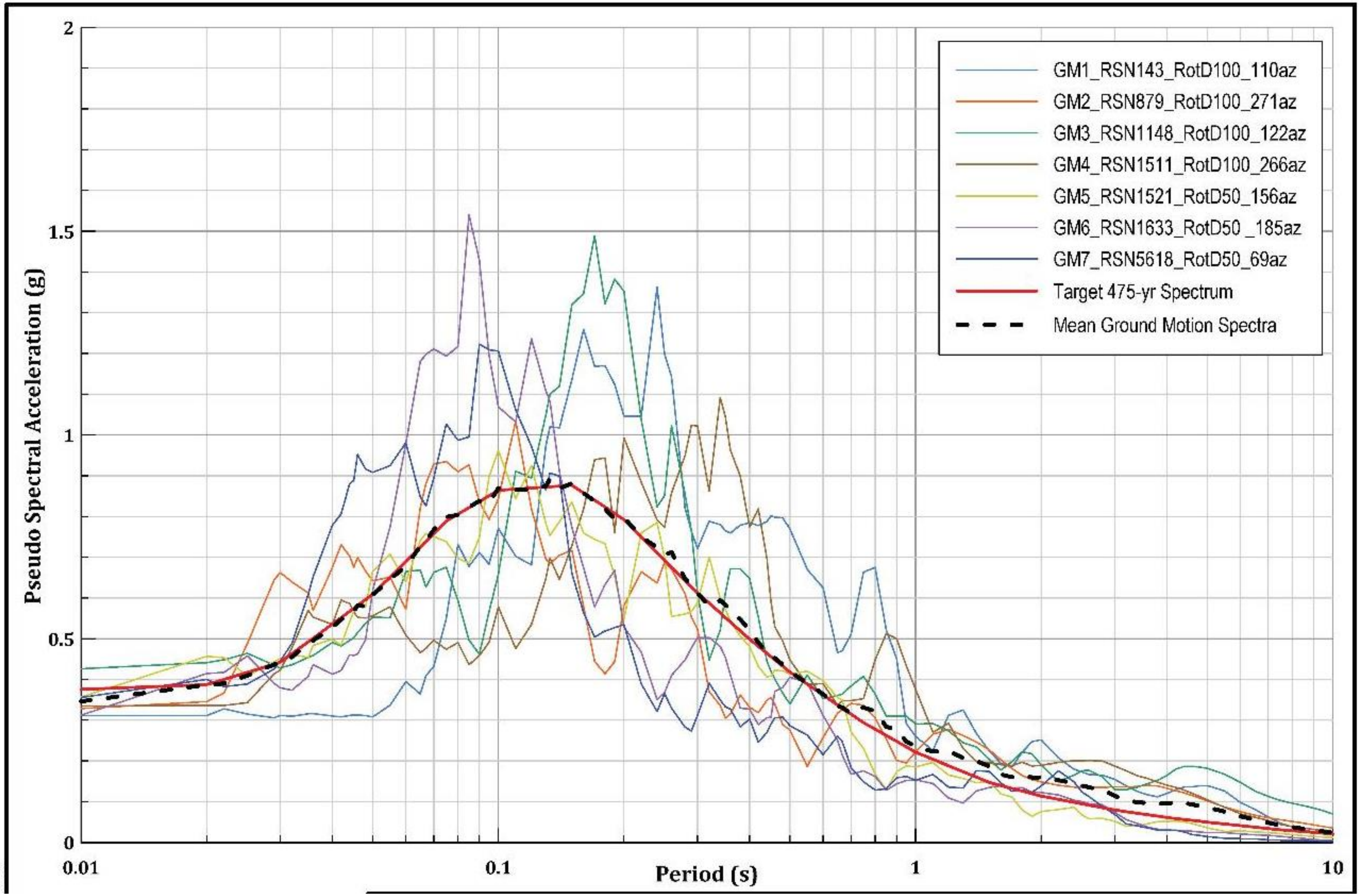
Site Seismicity and Site Response

- 475-year return period design earthquake
- Probabilistic Seismic Hazard Assessment (PSHA) used to develop hazard curve for design earthquake
- Controlling earthquake is San Andreas event with Mw 7.8 at 5.6 km
- PEER time history database screened to select seven time histories for dynamic analyses
- Four of seven time histories included pulse characteristics

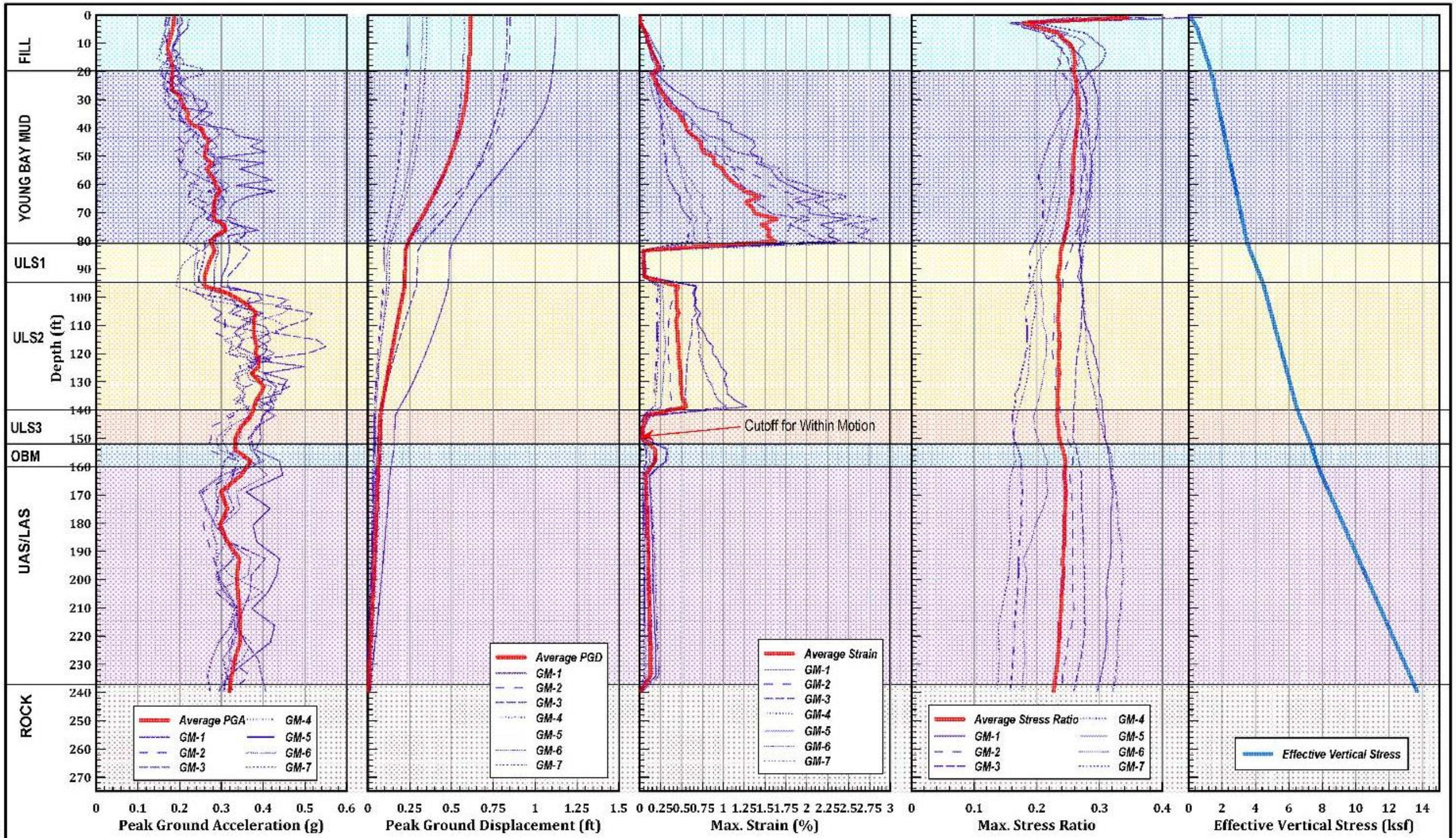
Summary of Selected Time Histories and Scaling Factor

RSN	Earthquake	Pulse Period (sec)	Magnitude. (M_W)	R_{RUP} (km)	Fault Type	V_{S30} (m/s)	D_{5-95} (sec)	Azimuth (◦)	Initial Scale Factor	Ia (m/s)	PGA (g)	PGV (cm)
143	Tabas, Iran	6.2	7.35	2.05	Reverse	767	16.6	110	0.38	2.1	0.31	48.6
879	Landers	5.1	7.28	2.19	Strike-Slip	1369	13.5	91	0.46	1.5	0.33	60.9
1148	Kocaeli, Turkey	7.8	7.51	13.5	Strike-Slip	523	9.8	122	2.31	1.4	0.43	75.3
1511	Chi-Chi, Taiwan	4.7	7.62	2.74	Reverse Oblique	615	29.1	86	0.93	3.1	0.33	51.3
1521	Chi-Chi, Taiwan	-	7.62	9	Reverse Oblique	672	27.7	156	1.22	2.7	0.36	18.3
1633	Manjil, Iran	-	7.37	12.6	Strike-Slip	724	31.3	185	0.57	2.9	0.32	16.4
5618	Iwate, Japan	-	6.9	16.3	Reverse	826	26.7	69	1.11	1.7	0.36	17.3
									Average	2.2	0.35	41.1

Response of Scaled Time Histories Compared to Target Spectrum



Site Response Analysis (Reach 6)



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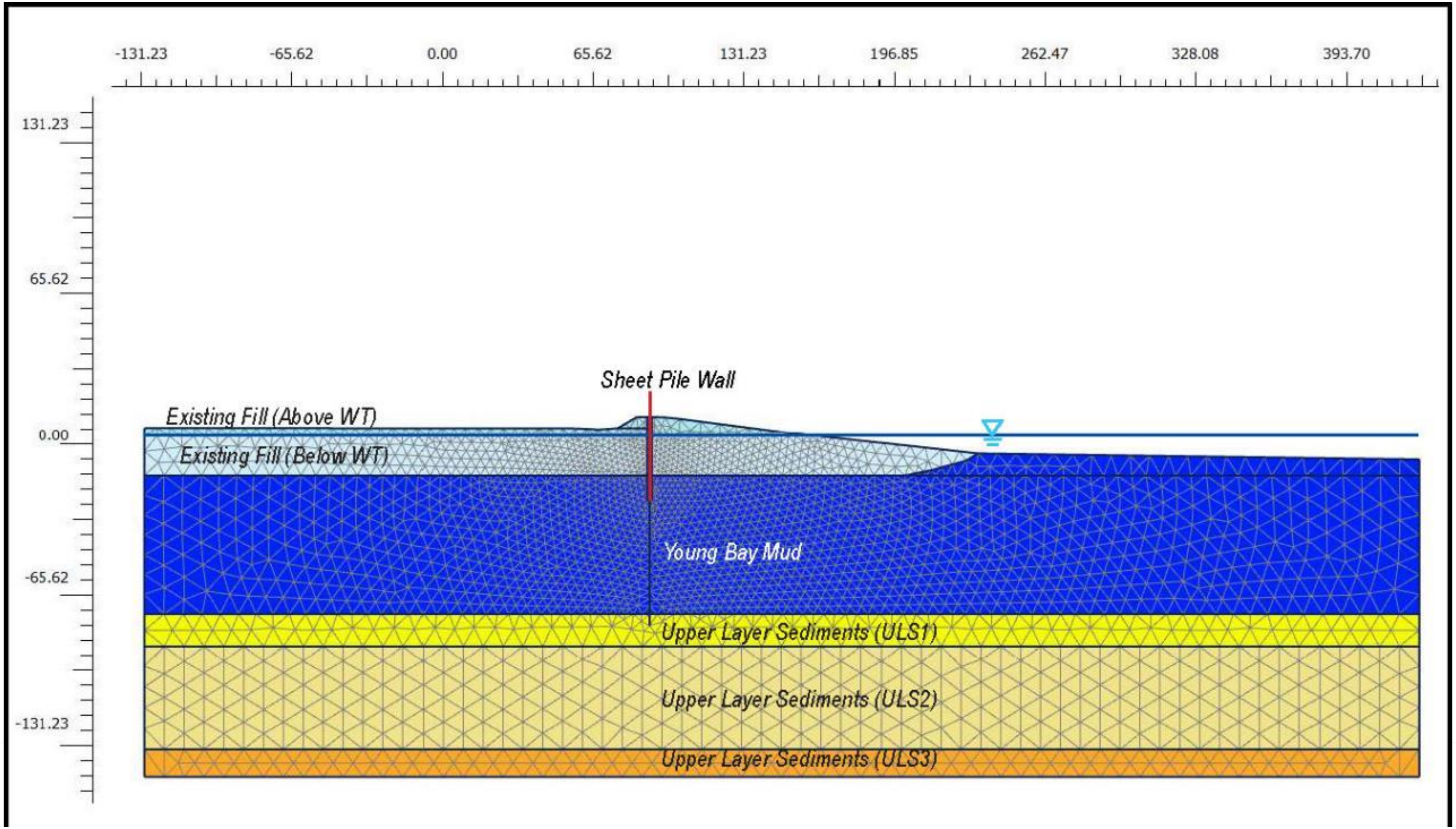
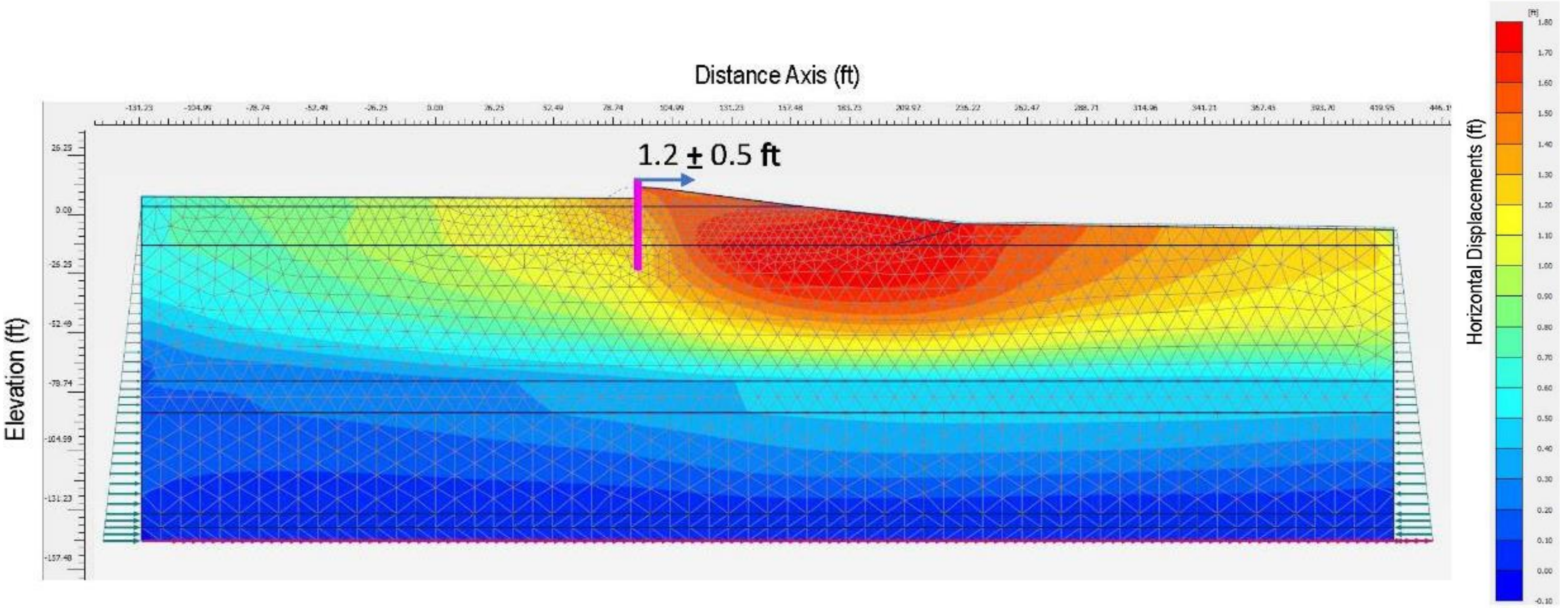
Seismic Performance of SPP

- 2D Plaxis analysis Reaches 6 and 7
- Liquefaction-induced lateral displacements
- Evaluation of combined performance of SPP

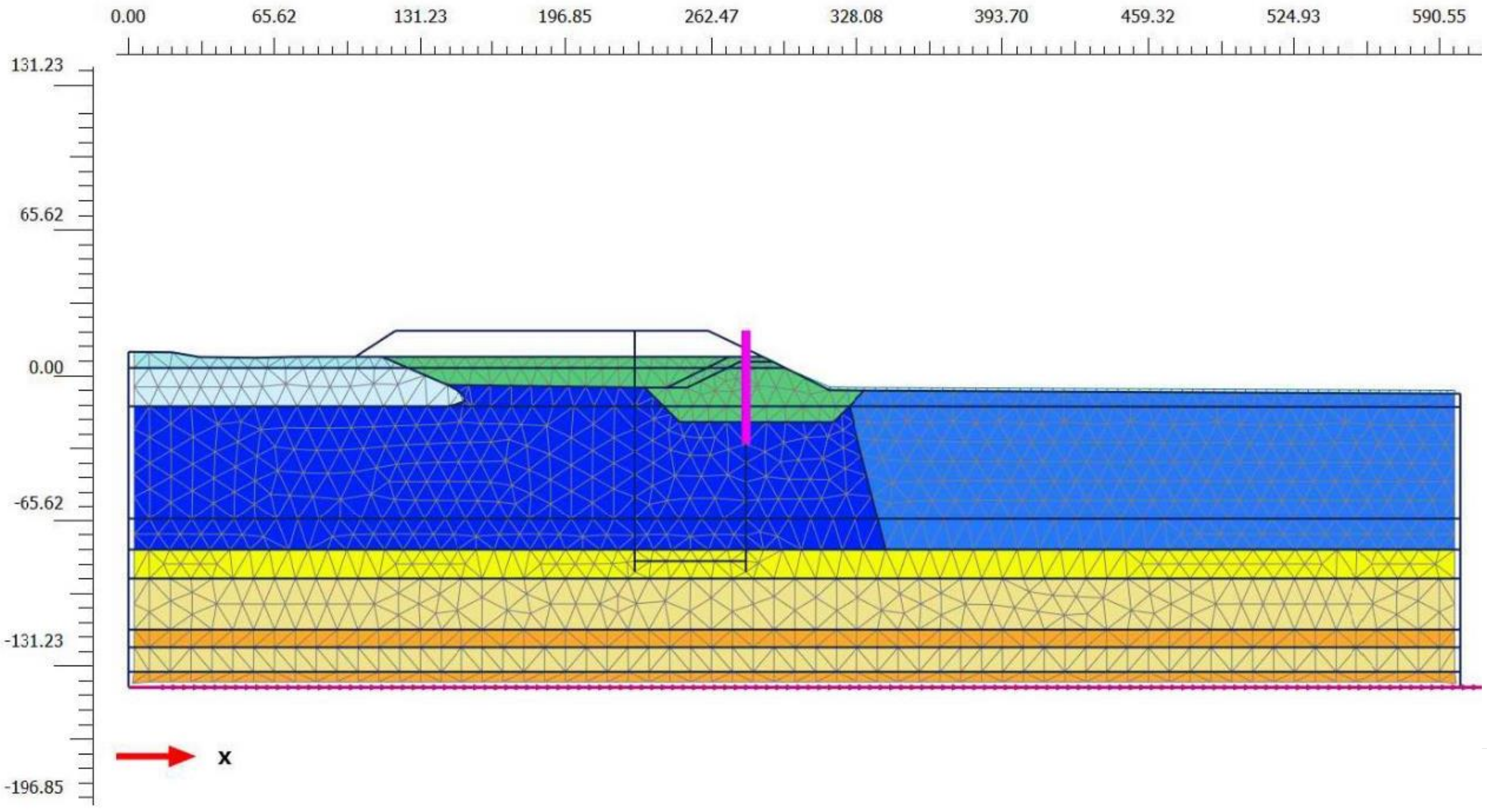
Plaxis 2D Finite Element Mesh (Reach 6)



Typical Lateral Displacements (Reach 6)



Plaxis 2D Finite Element Mesh (Reach 7)



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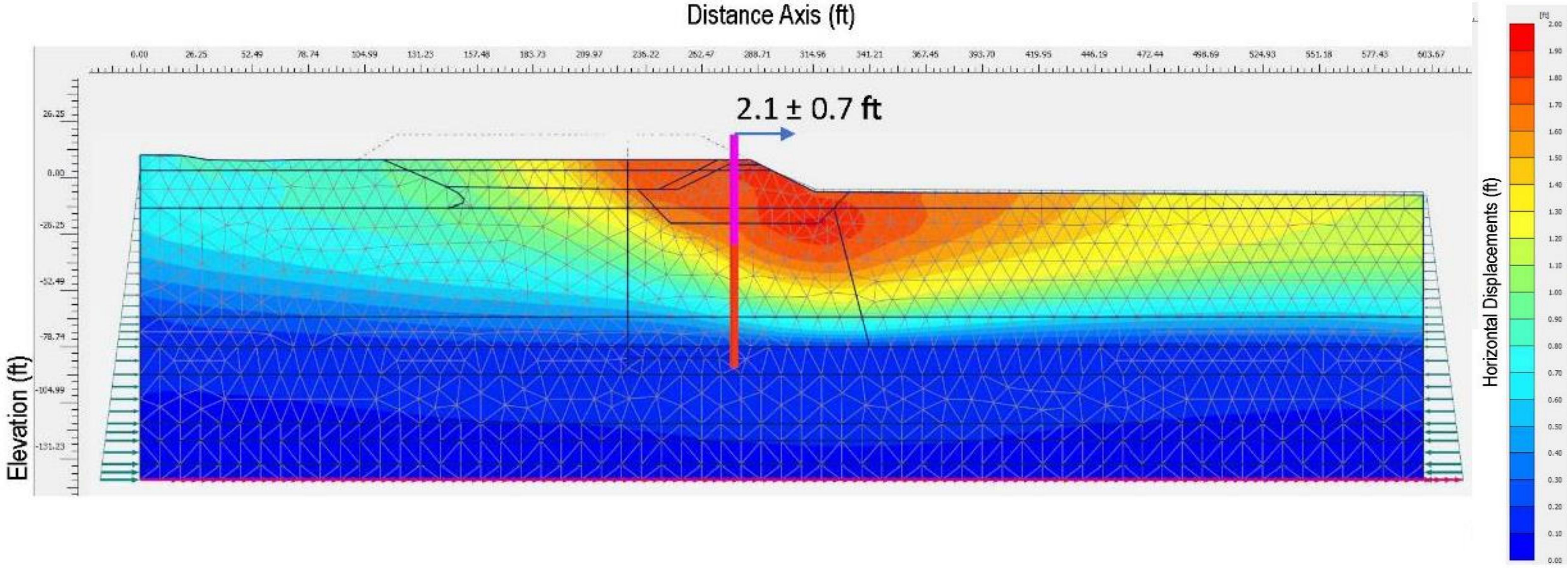
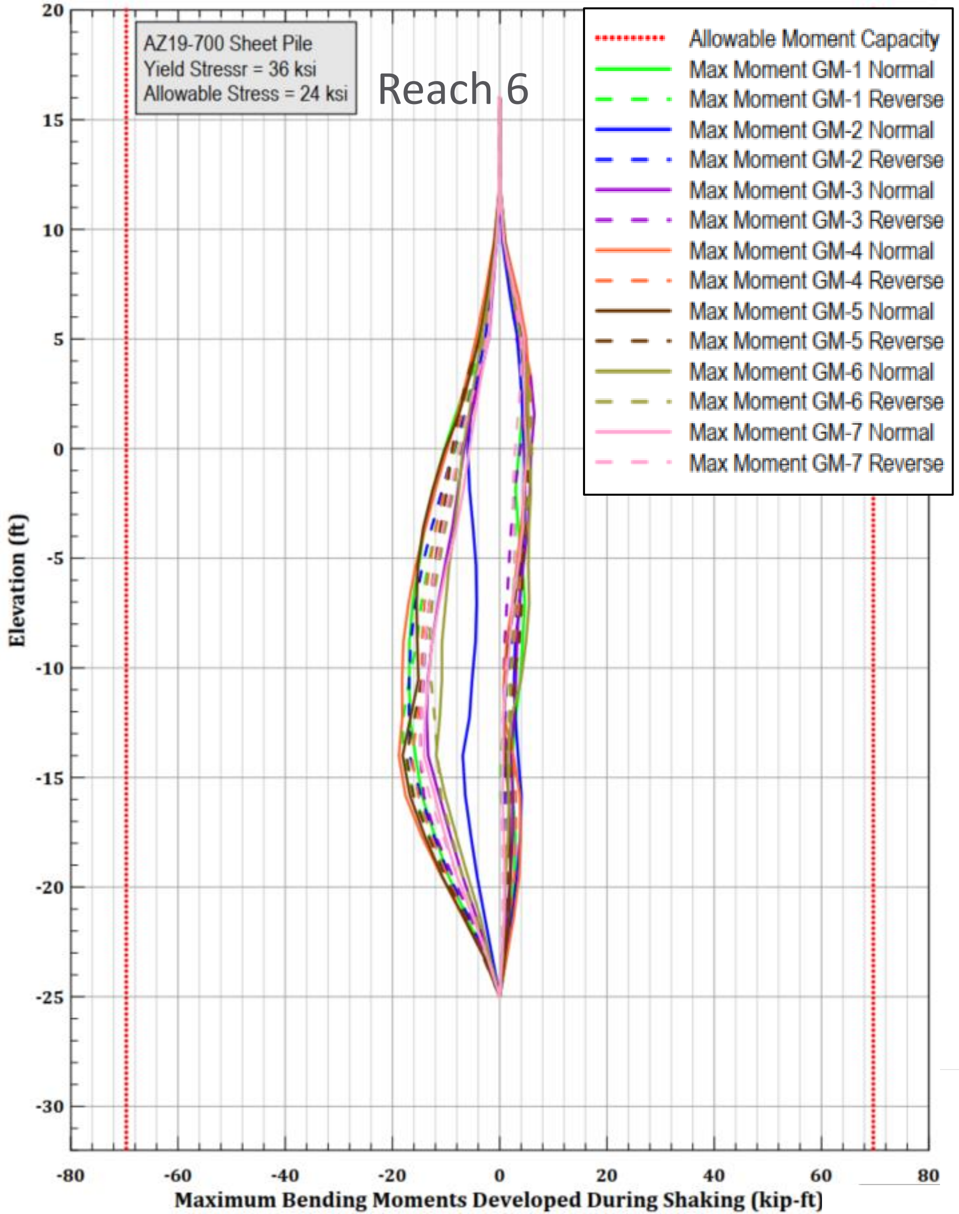
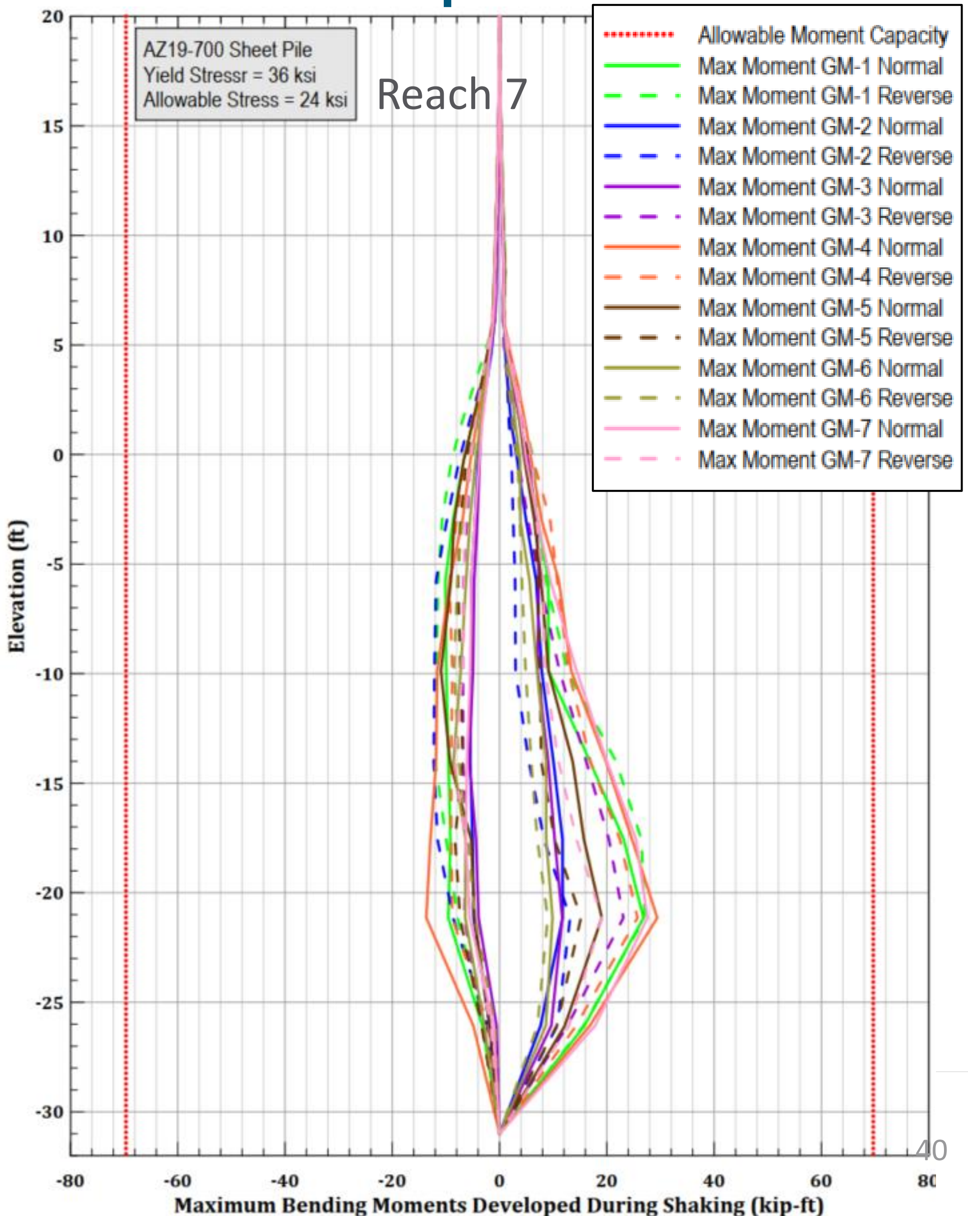
Typical Lateral Displacements (Reach 7)



Sheet Pile Wall Moment Demand Envelope





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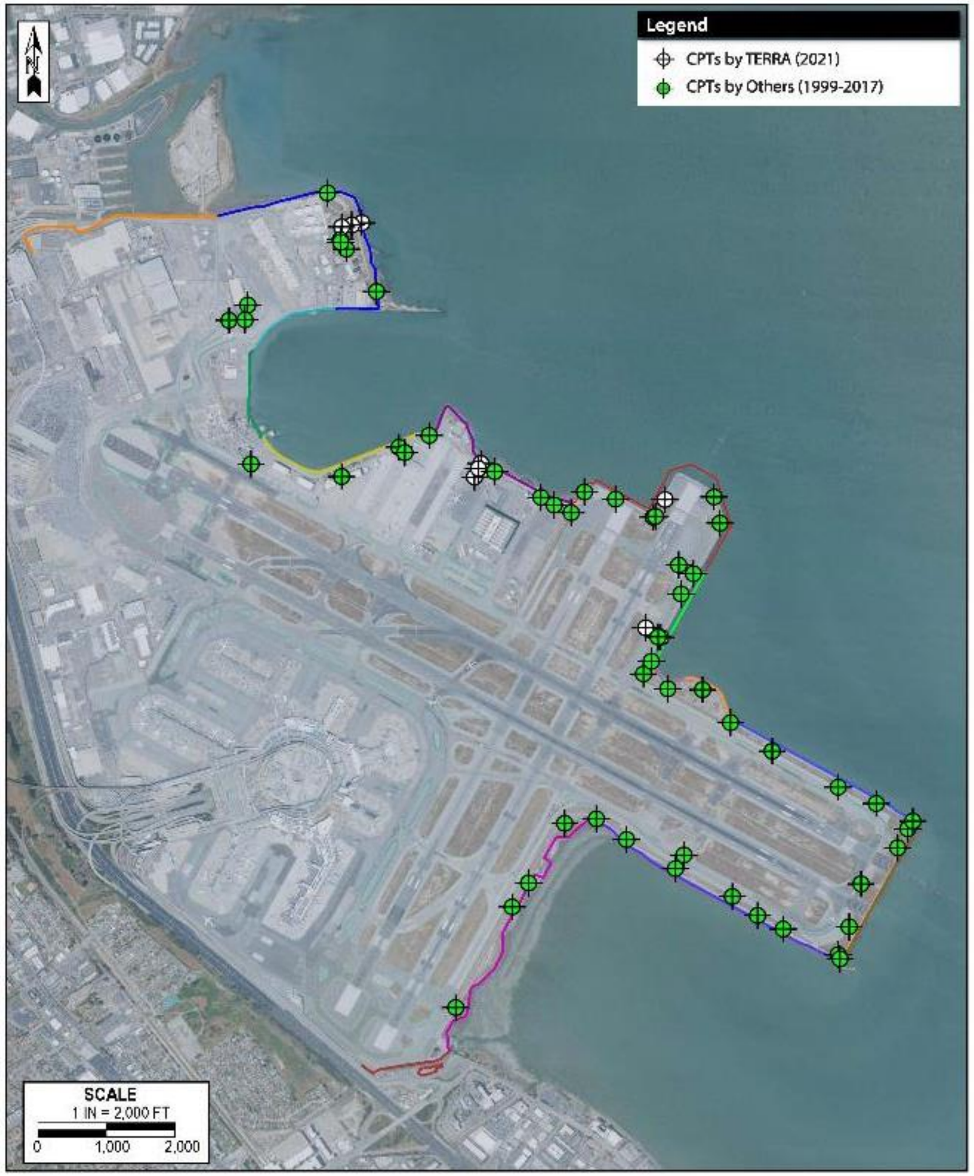
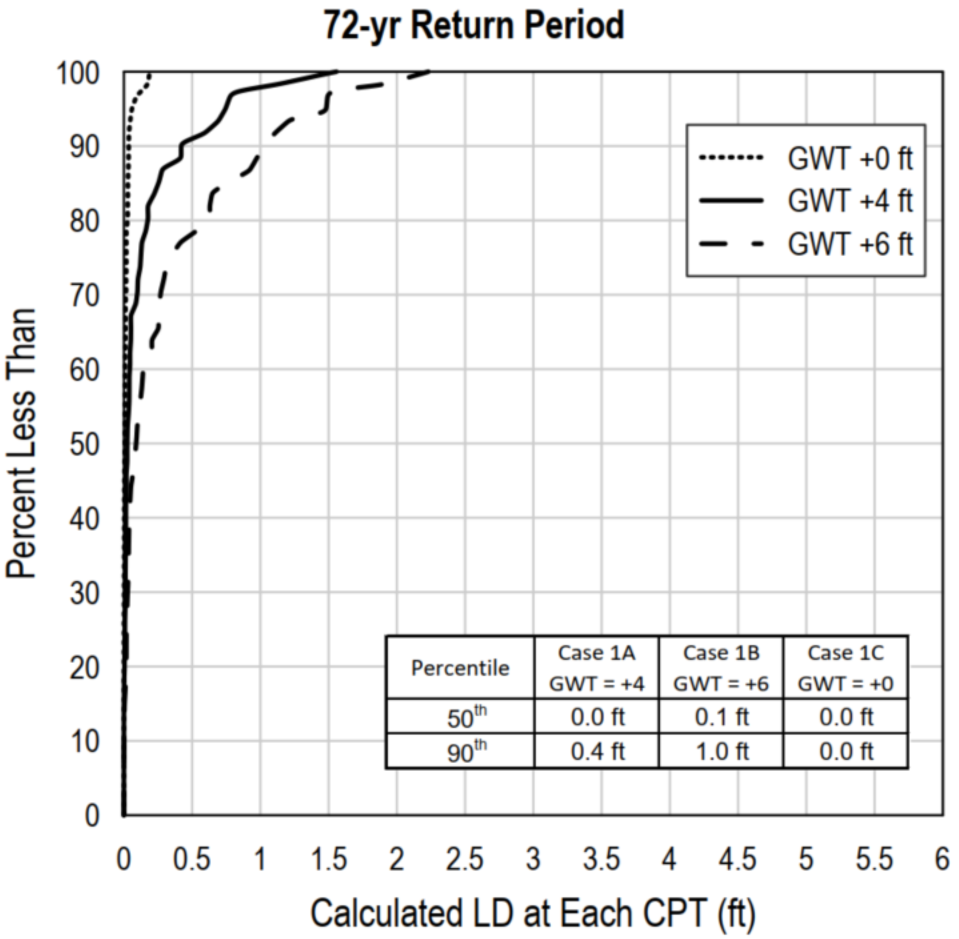
Liquefaction-Induced Lateral Displacements

- Based on semi-empirical procedure developed by Zhang et al. (2004)
- Factor of Safety (FS) against liquefaction and relative density from CPT data using methodology by Boulanger and Idriss (2015) used to estimate maximum cyclic shear strains
- Peak ground acceleration (PGA) based on Site Response Analysis for Reach 6
- Evaluation of performance based on a conservative assumption regarding side-slope of shoreline fill

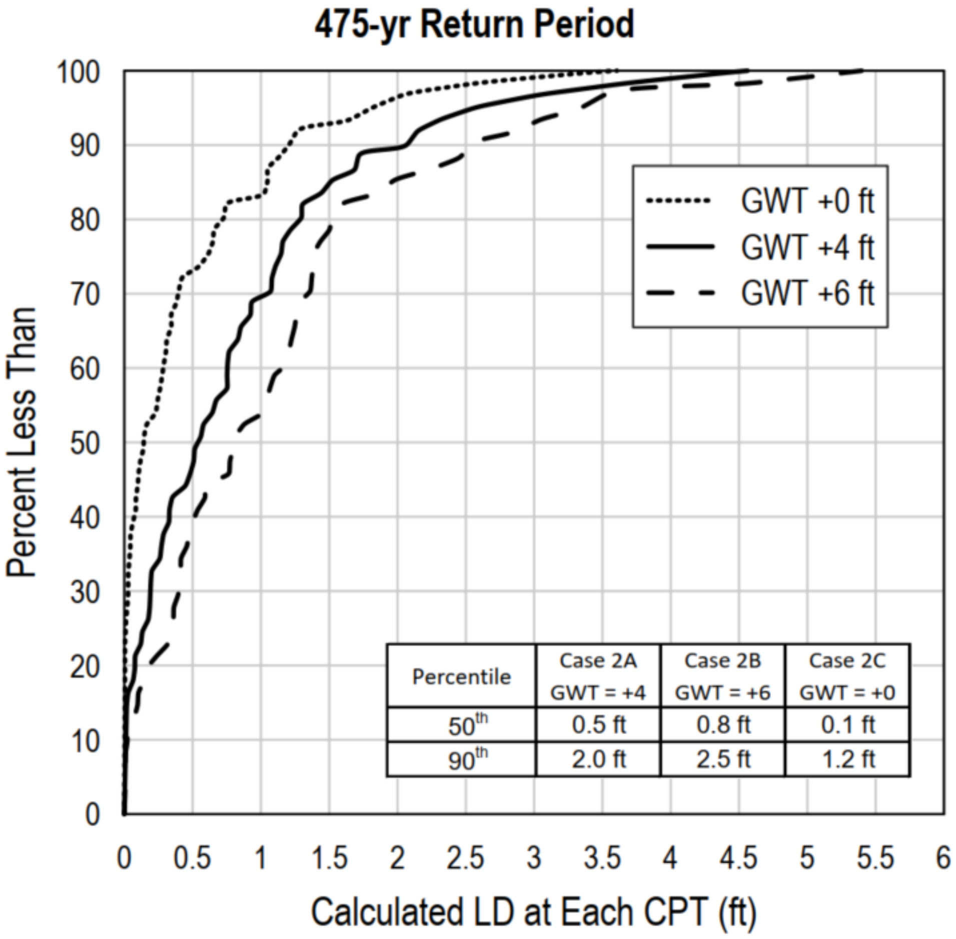
CPT Locations for Liquefaction Study



Lateral Displacement Distribution



Percentile	Case 1A GWT = +4	Case 1B GWT = +6	Case 1C GWT = +0
50th	0.0 ft	0.1 ft	0.0 ft
90th	0.4 ft	1.0 ft	0.0 ft



Percentile	Case 2A GWT = +4	Case 2B GWT = +6	Case 2C GWT = +0
50th	0.5 ft	0.8 ft	0.1 ft
90th	2.0 ft	2.5 ft	1.2 ft

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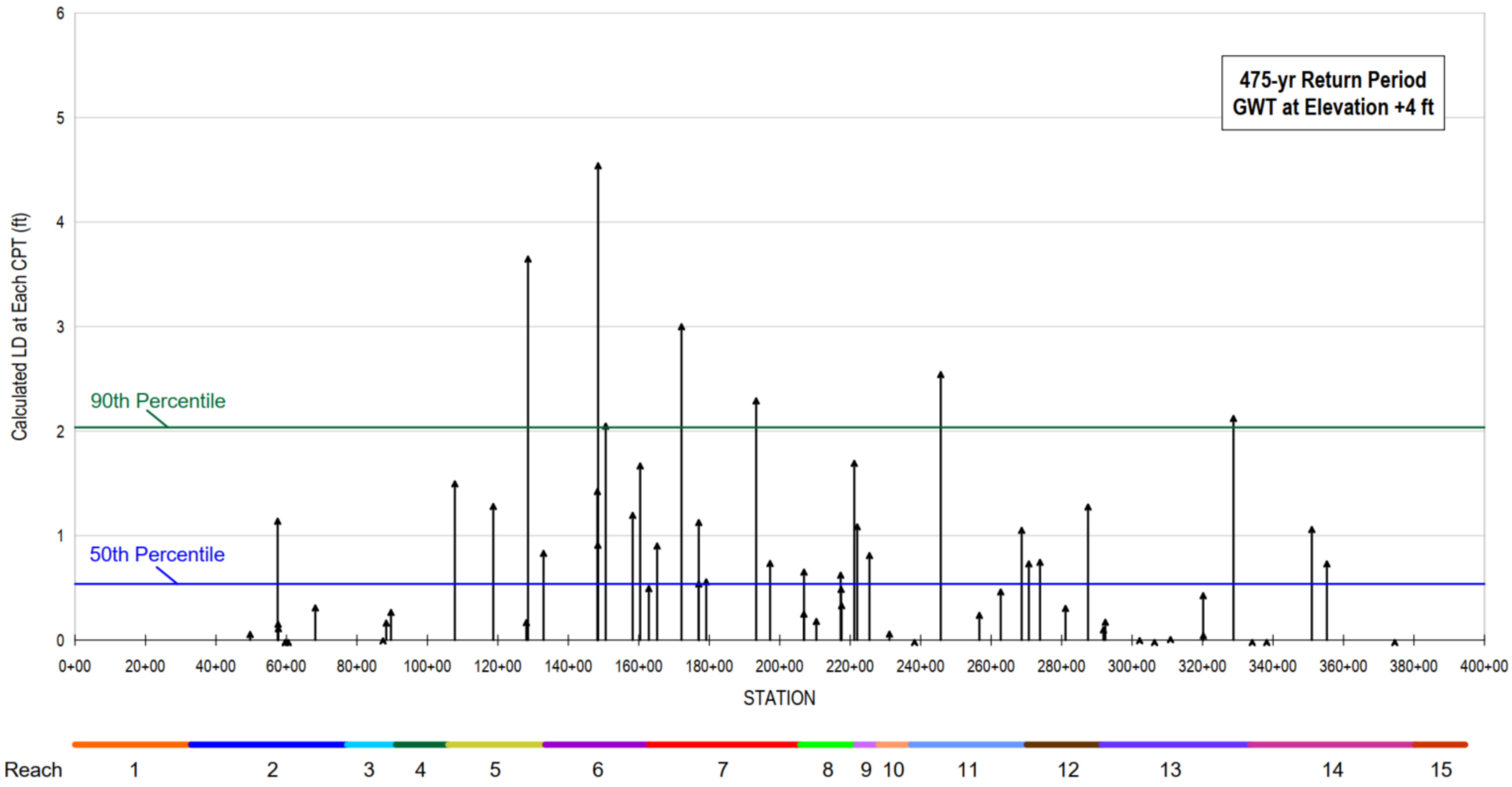
Lateral Displacements Along Shoreline



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Combined Performance of Sheet Piles Floodwalls

- Plaxis analysis – Max sheet pile Stress 27% of Allowable Stress
- Rotation at top of YBM proportional to displacement within fill of 0.4 feet
- Median value of liquefaction-induced displacement (LD) is 0.5 feet
- For 0.9 feet of combined displacement sheet pile stress increases to 60% of allowable stress
- For LD of 1 foot, max sheet pile stress increases to 95% of allowable stress

-continued-

Combined Performance of Sheet Piles Floodwalls

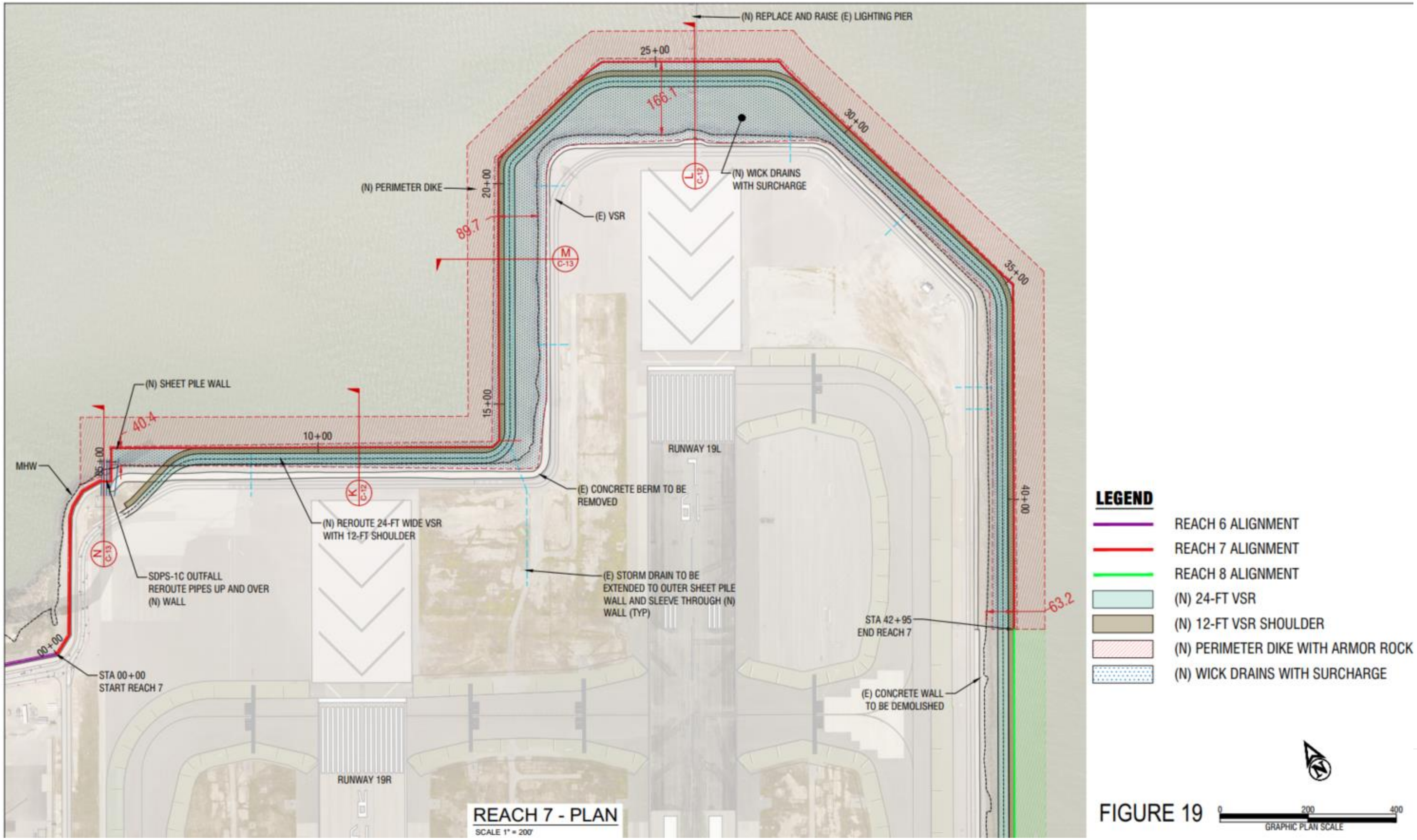
- LD controlled by local ***average*** value of LD from local CPT data
- Need to complete closely spaced CPTs to delineate areas with LD > 1 foot
- LD > 1 foot may require ground improvement within fill to meet moderate damage performance criteria
- Z-type sheet piles can accommodate elongation strains due to differential lateral movement along wall alignment by joint rotation at interlocks

Fill Placement and Ground Stabilization at Reach 7

Lateral expansion of Airport at Reach 7 via in-Bay fill will require ...

- Dredging and construction of perimeter dike
- Filling of area behind the perimeter dike
- Installation of wick drains to reduce time required for settlement of YBM below the fill
- Placement and removal of a temporary preload fill to reduce future settlement
- Deep compaction of fill and perimeter dike to mitigate liquefaction potential
- Installation of sheet pile floodwall

Conceptual Design (Reach 7)



Conceptual Cross Sections (Reach 7)

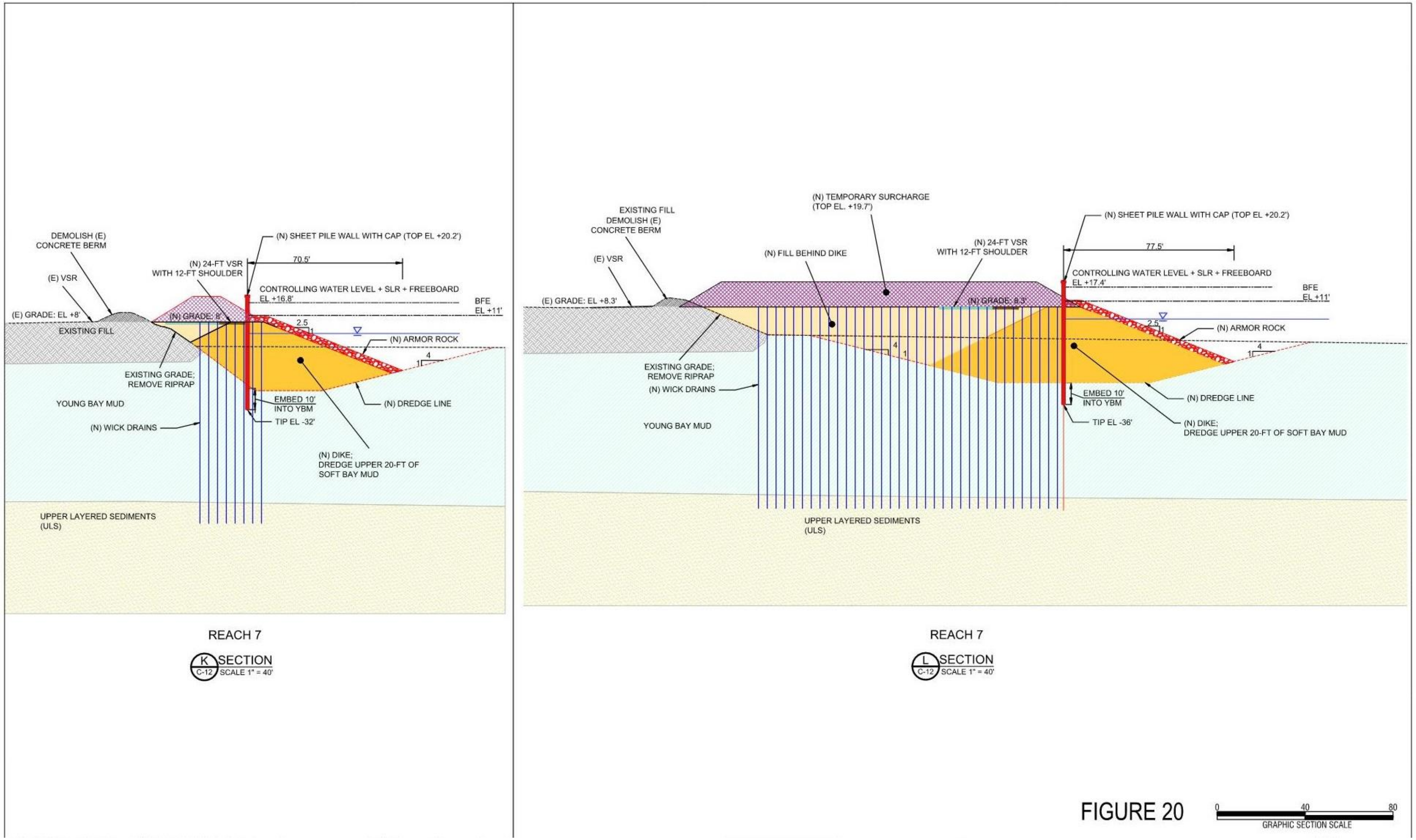
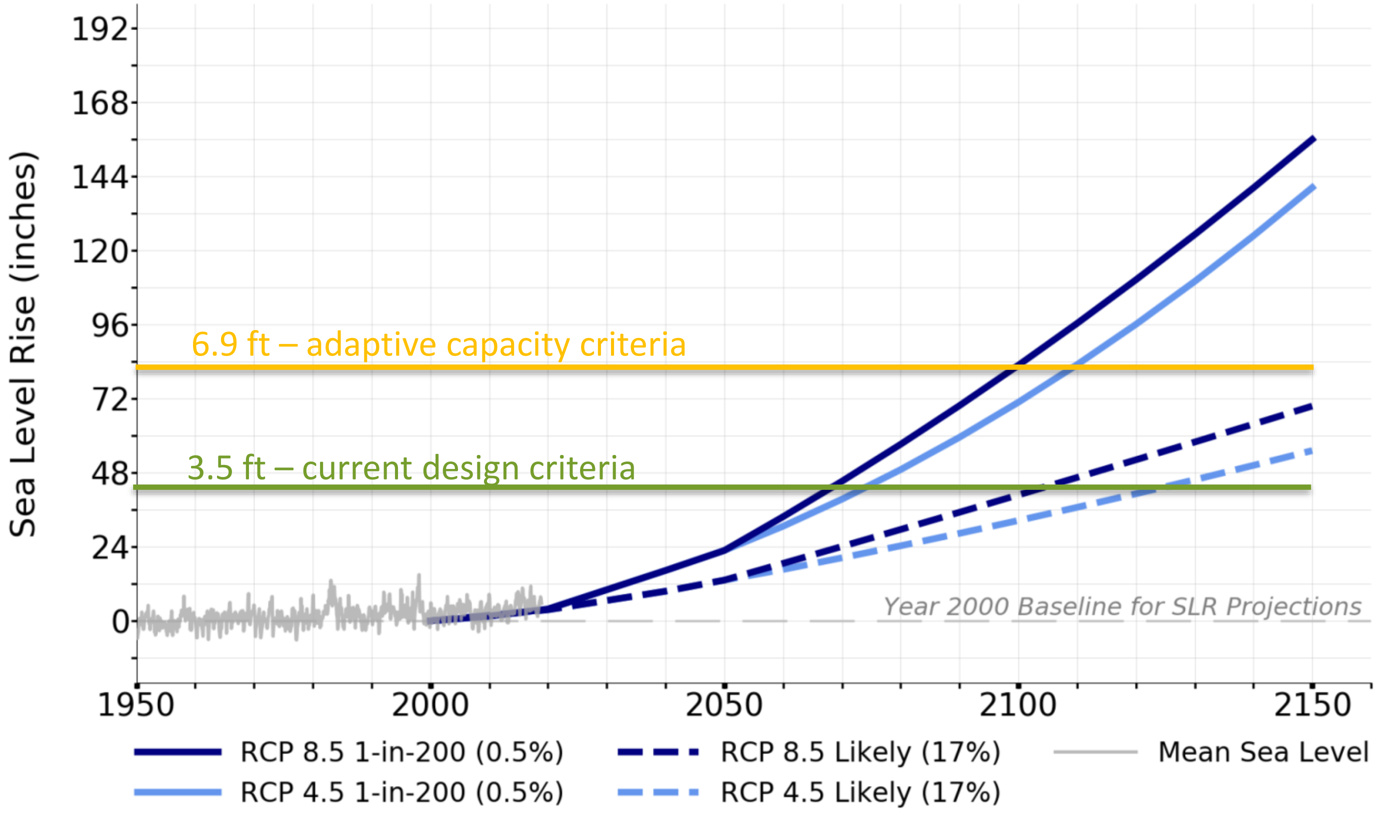


FIGURE 20

Agenda

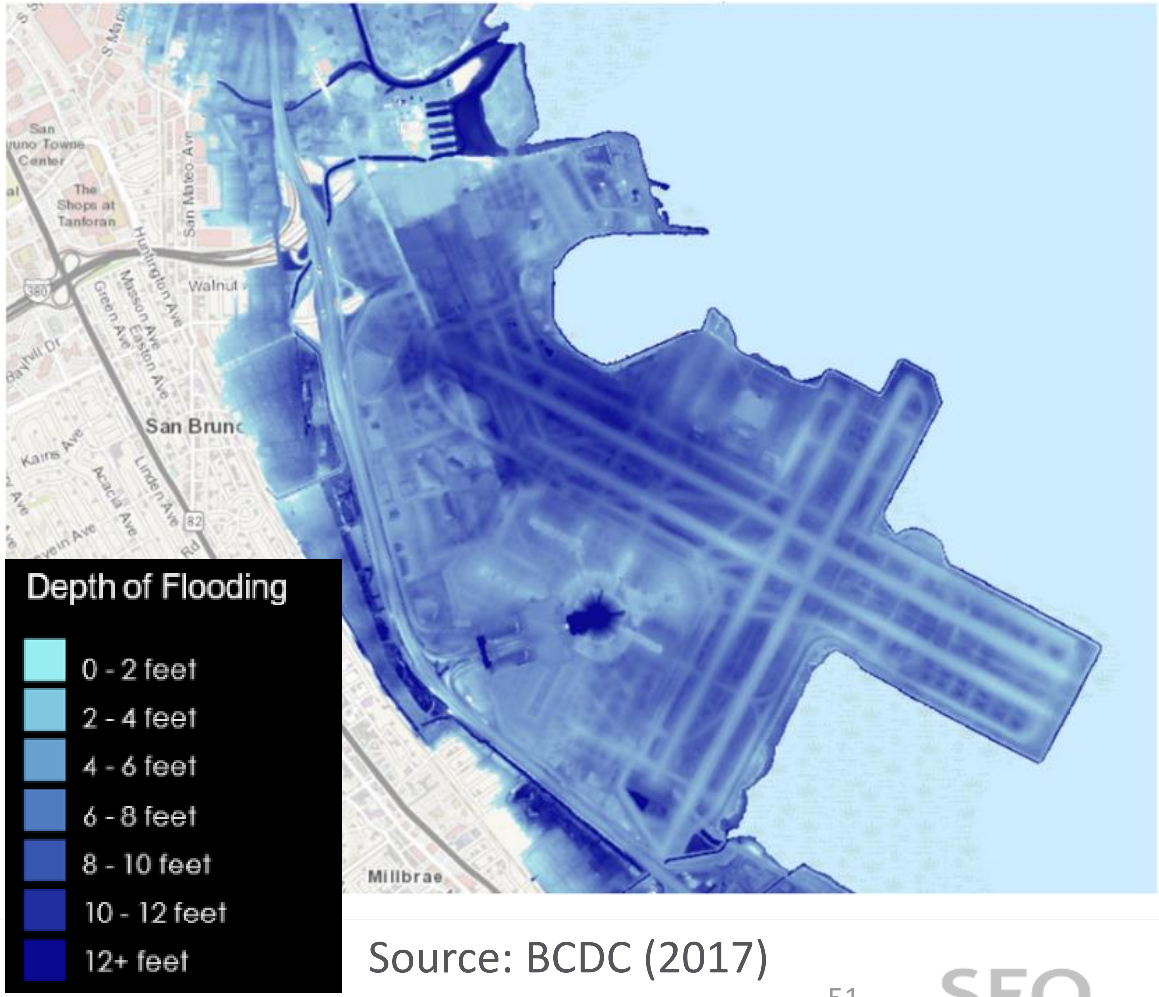
1. Introduction & Project Purpose
2. Structural Analysis
3. Geotechnical Analysis
4. <u>Adaptations for Sea-level Rise Flood Hazards</u>
   - ESA
     - Bob Battalio, PE
     - Matt Brennan, PhD, PE
5. Questions

Sea-Level Rise Projections and Flood Hazard



Source: OPC (2018)

100-Year Flood Inundation with 3.5-Foot SLR



Source: BCDC (2017)

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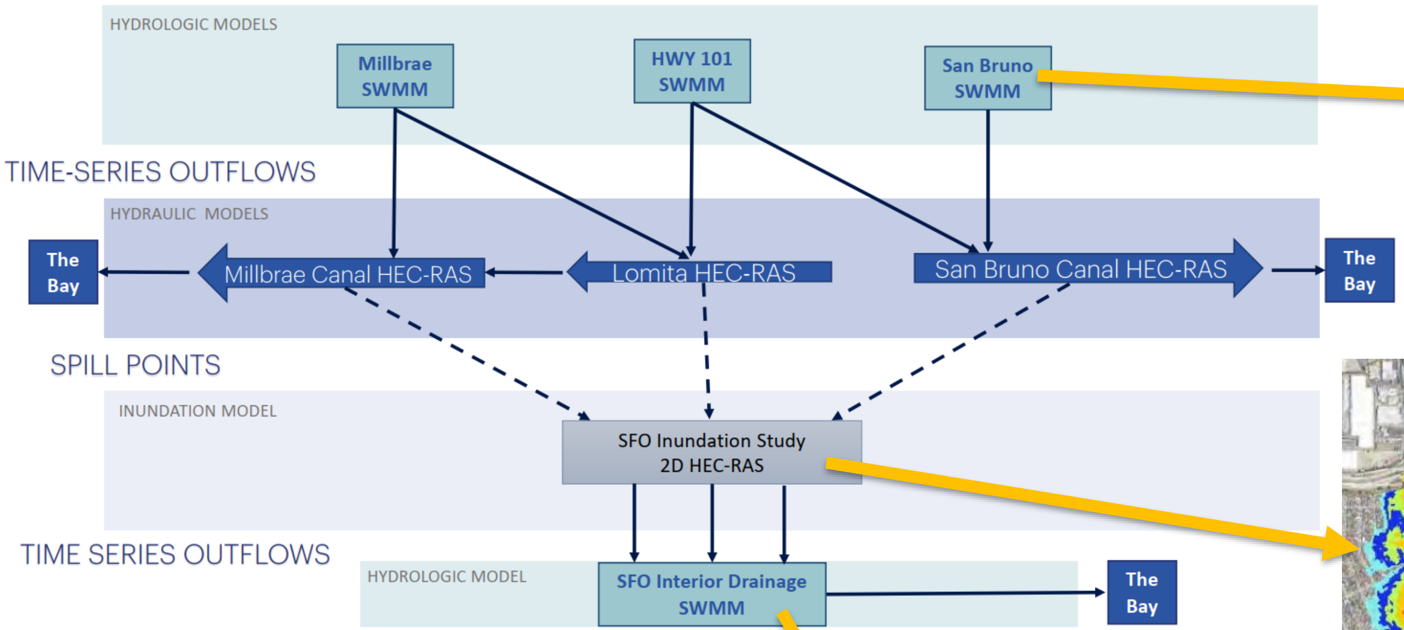
Crest Elevations and Total Water Levels with +3.5-Foot SLR

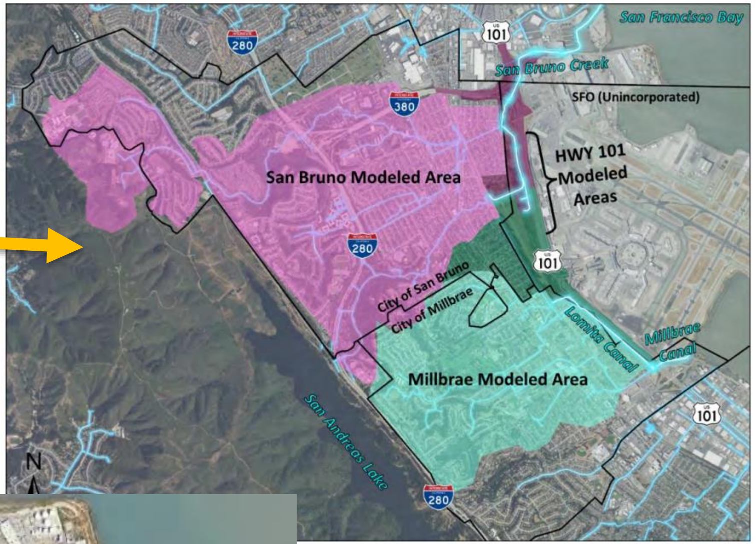
Reach ID	Reach Name	Proposed Design Elevation (ft NAVD88)	SWL (ft NAVD88)	SWL Freeboard (ft)	TWL (ft NAVD88)	TWL Freeboard (ft)
1	San Bruno Channel	16	13.8	2.2	13.8	2.2
2a	Treatment Plant	16	13.8	2.2	14.3	1.8
2b	Treatment Plant	19.5	13.8	5.7	18.3	2.5
2c	Treatment Plant	16	13.8	2.2	14.9	1.4
3	Sea Plane Harbor 1	16	13.8	2.2	14.6	1.6
4	Coast Guard	16	13.8	2.2	14.6	1.6
5	Sea Plane Harbor 2	17	13.8	3.2	16.0	1.5
6	Superbay	17	13.8	3.2	14.4	2.7
7a	19 End	20.2	13.8	6.4	15.8	4.9
7b	19 End	20.2	13.8	6.4	16.4	4.4
7c	19 End	20.2	13.8	6.4	16.3	4.5
8	19 Edge	17.5	13.8	3.7	16.3	1.8
9	Intersection 1	17	13.8	3.2	15.5	1.9
10	Intersection 2	17	13.8	3.2	15.6	1.8
11	28R	17	13.8	3.2	16.1	1.4
12	28 End	17	13.8	3.2	16.3	1.3
13	28L	17	13.8	3.2	14.2	2.9
14	Mudflat	18	13.8	4.2	17.0	3.0
15	Millbrae Channel	16	13.8	2.2	13.8	2.2

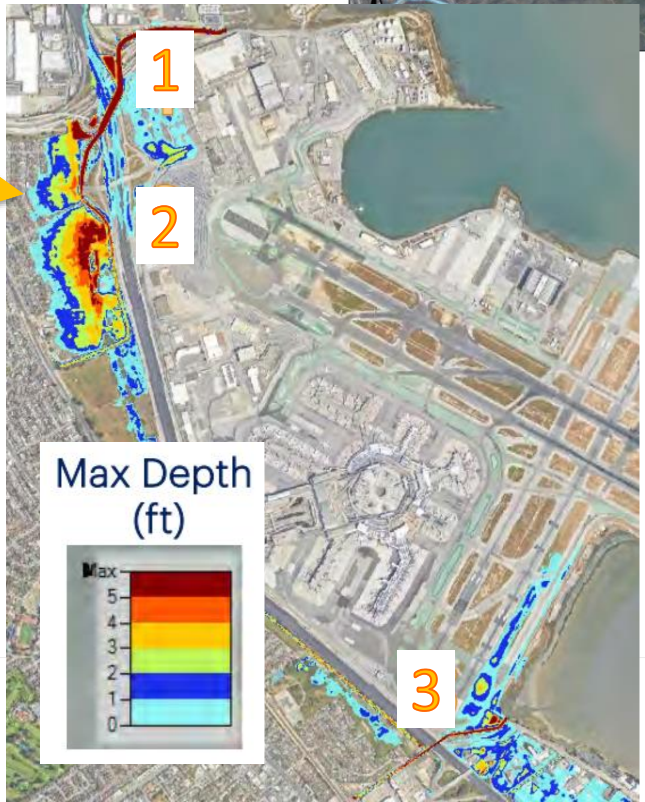
Adaptation to Future Sea-Level Rise

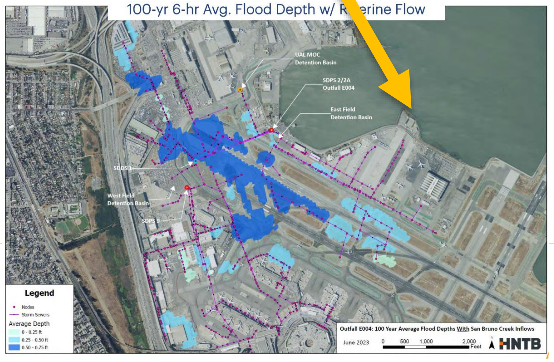
Sea-Level Rise (ft)	Projected Decade to Occur		Proposed 2030 Design Elevations versus:		Implications
	Low-Risk-Aversion Scenario	Medium-High-Risk-Aversion Scenario	Future 1% SWL	Future 1% TWL	
3.5	2100	2070	At least 2 feet freeboard for all reaches	At least 1 foot freeboard for all reaches	Meets FEMA accreditation, as per design criteria
4.5	2130	2080	At least 1 foot freeboard for all reaches	Within few tenths of a foot of design elevation along multiple reaches	Does not meet freeboard requirements for FEMA accreditation Potential for minimal wave overtopping
5.5	2140	2090	Freeboard about zero for most reaches	Negative freeboard of about 1 foot for most reaches	Potential wave overtopping, which could be managed by the interior drainage system
6.9	After 2150	2100	Negative freeboard of about 1 foot for most reaches	Negative freeboard of about 2 feet for most reaches	Structural modifications needed before this amount of sea-level rise

CLOMR Hydrologic & Hydraulic Modeling









Lotus Water

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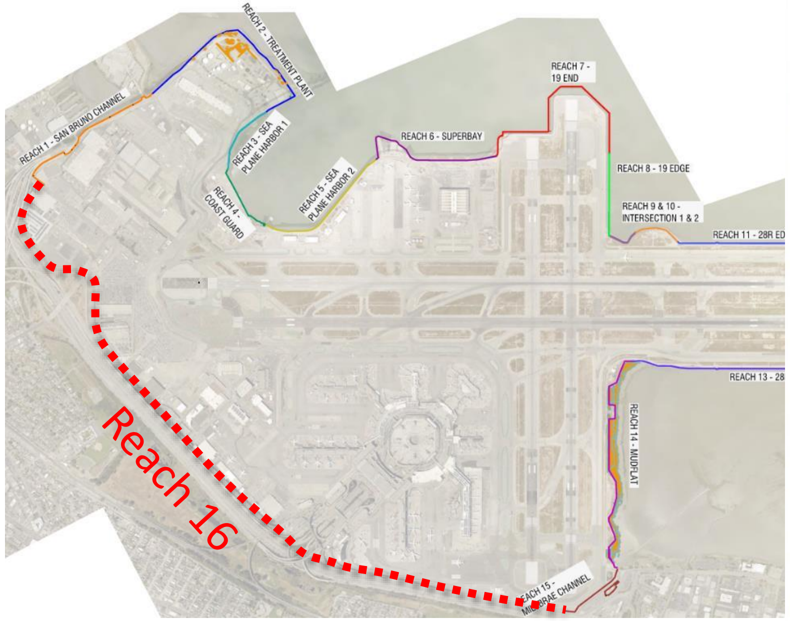
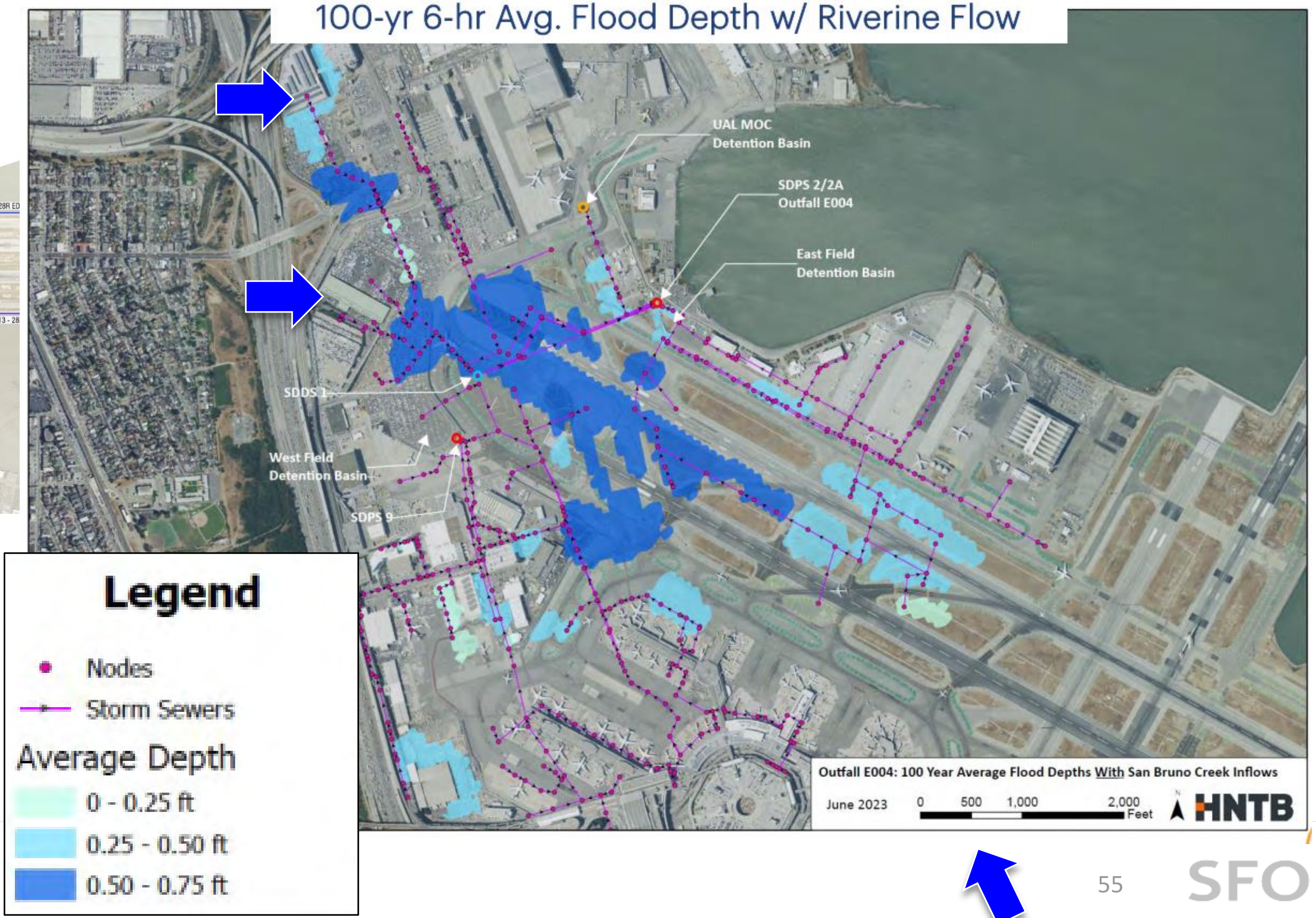
Reach 16: Airport Landside Protection (if needed)





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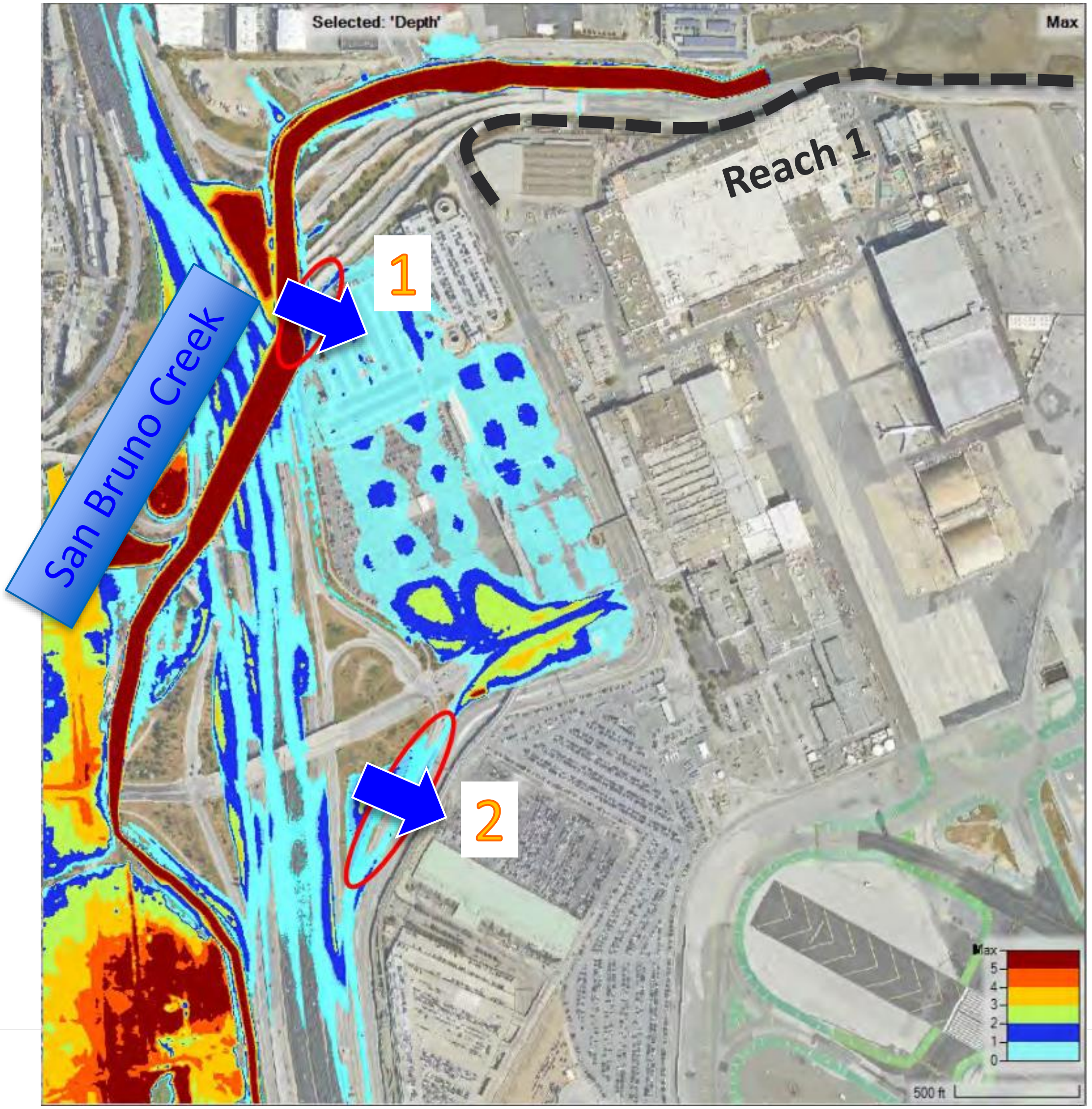
Reach 1 – Riverine Flood Hazard



Critical Area 1:

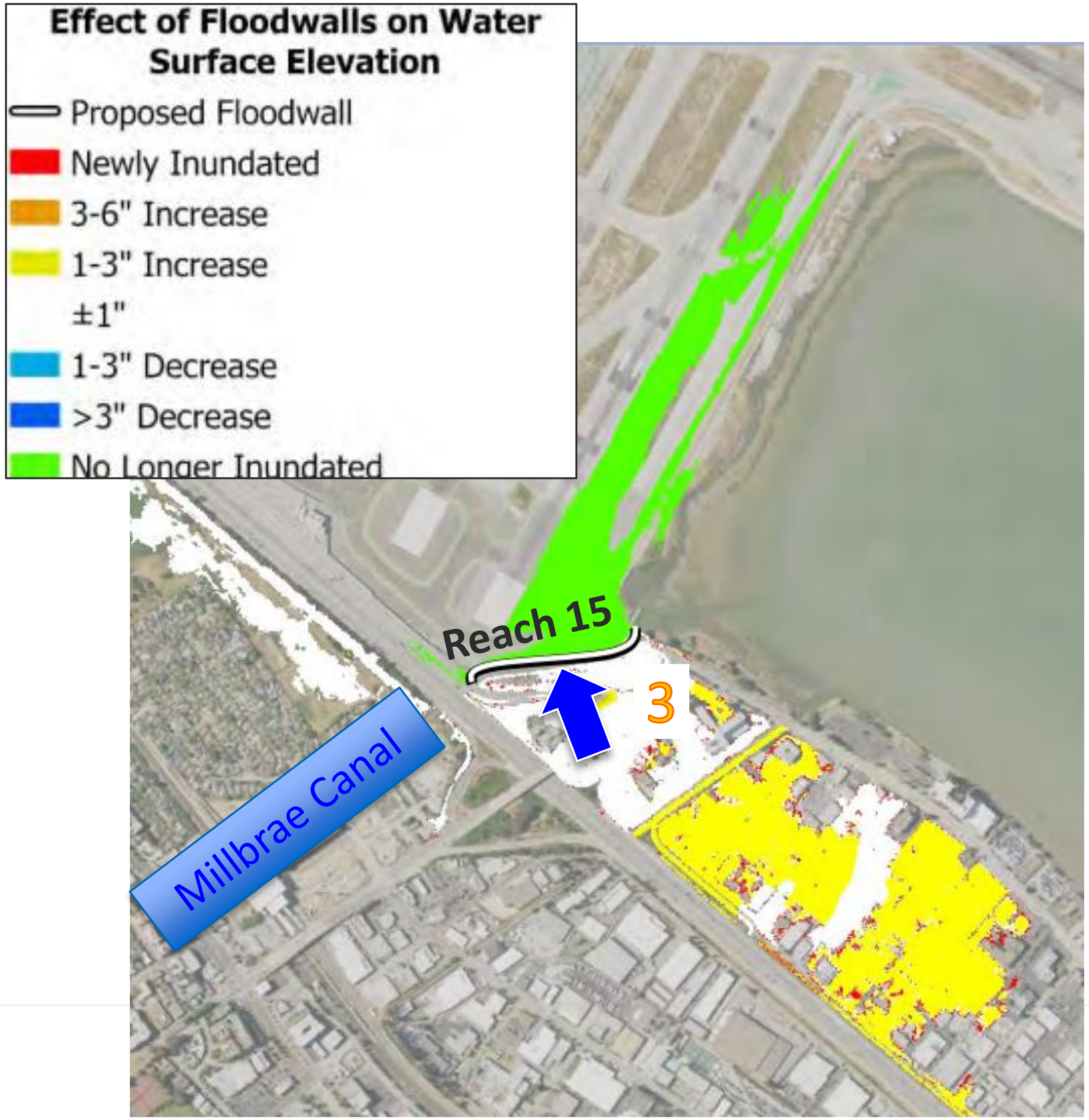
- Spill east of US101 driven by riverine flooding and coastal surge
- Water enters north of the long-term parking deck

Critical Area 2:

- Spill west of US101 driven mainly by riverine flooding
- Waters cross US101 and link with flood from SFO Long-Term Parking

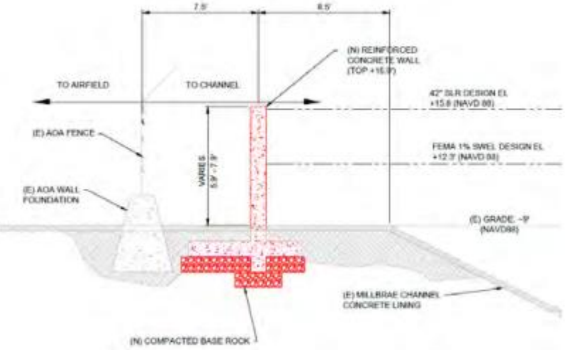
Source: Lotus Water

Reach 15 – Riverine Flood Hazard



CRITICAL AREA 3

- Millbrae Canal North Floodwall – Reach 15



- Floodwall prevents flooding on SFO property
- Floodwall has no Impact to Neighbors
  - 1-3" increase in BFE between Old Bayshore Hwy and US101 is due to separate riverine modeling
- Tides control BFE and **riverine spill has no impact on BFE**

Source: Lotus Water

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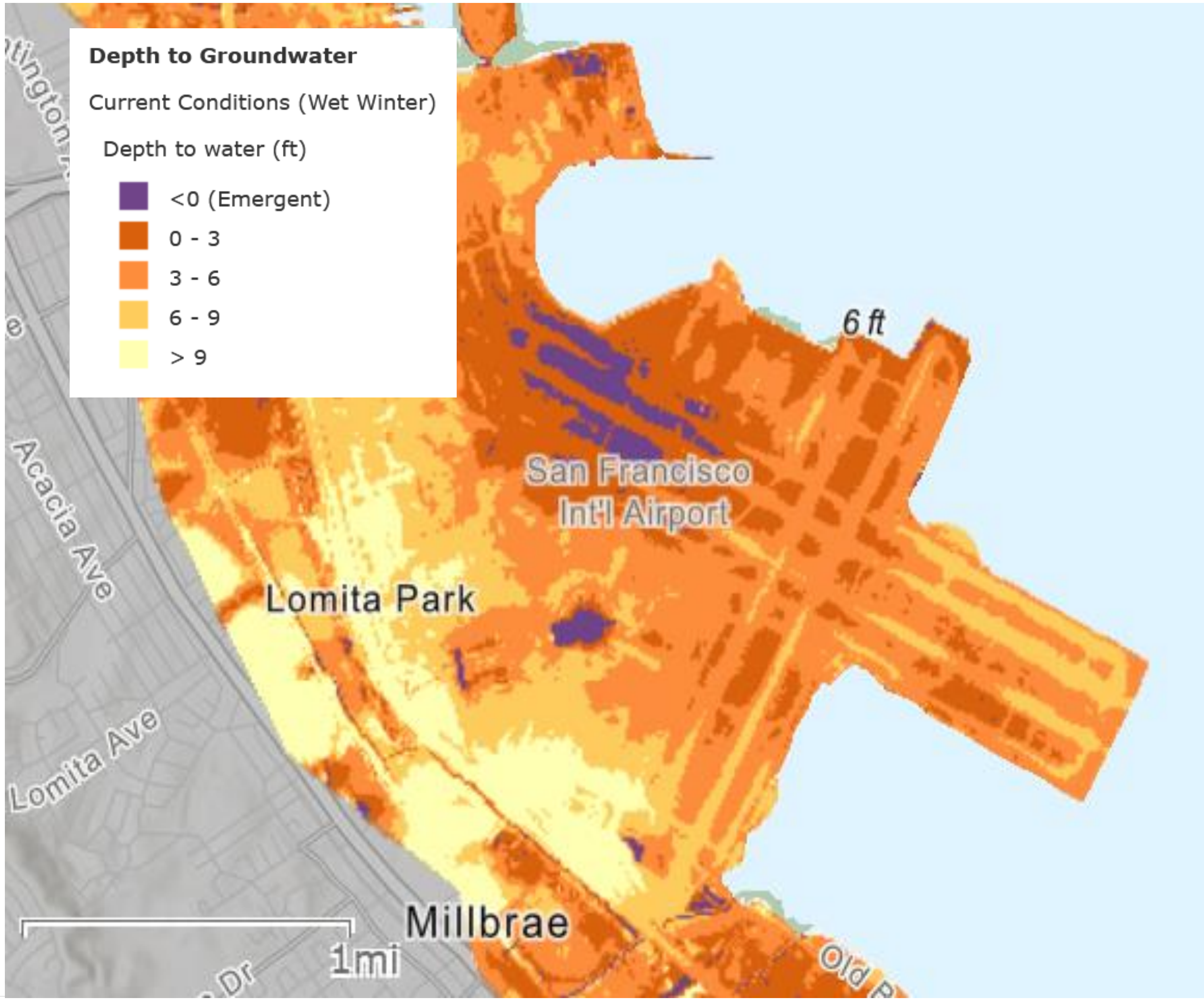
Groundwater Depths



Source: May et al. (2022)

Source: Point Blue and USGS (2023)

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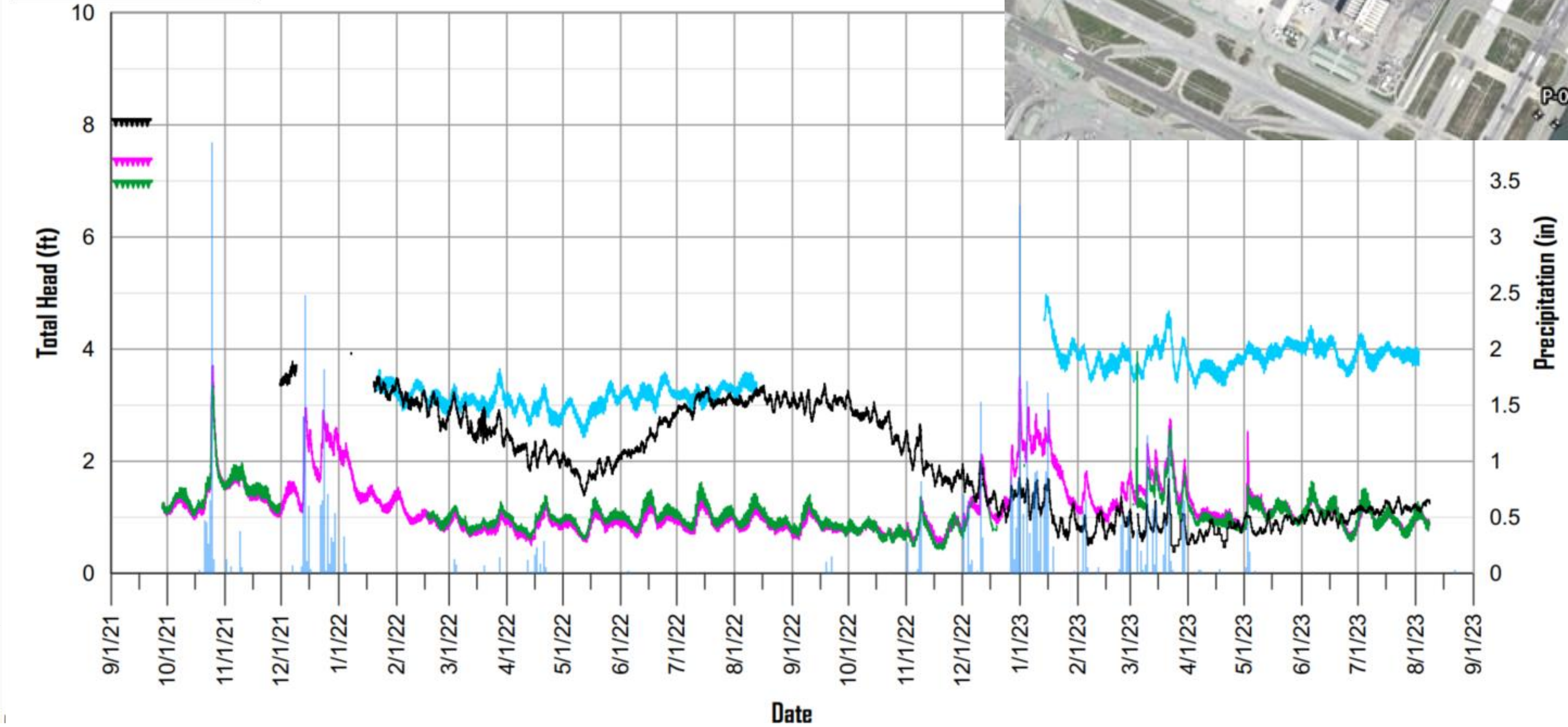
Groundwater Level Monitoring

Piezometer	Approximate Distance from Shore	Approximate Ground Surface Elevation (NAVD88)
P-04	65 feet	8.1 feet
P-05	145 feet	7.0 feet
P-06	285 feet	7.4 feet



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Control of Seepage and Groundwater Levels

- Piezometer data indicate current groundwater levels are generally at Mean Sea Level
- Groundwater levels can be higher or lower locally in ponded areas or areas where buried storm sewers may be leaking
- Sheet piles extend 10 feet into YBM and reduce seepage through the fill to or from the Bay
- Groundwater levels will rise as sea level rises unless engineering controls such as French drains are installed inboard of the sheet pile floodwall
- The sheet piles will substantially reduce the volume of water that the French drains would collect
- Groundwater collected by the French drains will be piped to buried sumps and pumped to the Bay
- Design and timing of the groundwater control system is under study

Questions?

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