Cargill, Incorporated
Solar Sea Salt System 10-year Maintenance & Operations Permit – Berm Integrity

Presentation to BCDC Engineering Criteria Review Board

August 30, 2023

© 2023 Cargill, Incorporated. All rights reserved.

Introductions

- Connie Lee, Senior Land Management Engineer, Cargill, Inc.
- Matt Pitcher, Solar Plant Manager, Cargill, Inc.
- Don Brown, Land Resources Manager, Cargill, Inc.
- Christine Boudreau, Boudreau & Associates
- Michael Whelan, Geotechnical Engineer, Anchor QEA
- Justin Vandever, Coastal Engineering Manager, AECOM

© 2023 Cargill, Incorporated. All rights reserved.

Agenda

- Recap of November 16, 2022 ECRB Meeting and requests in December 20, 2022 BCDC Letter
- Wave Run-up Memo and Sea Level Rise Risk Assessment Update - AECOM
- Static and Seismic Stability Analysis – Anchor QEA
- Conclusions
- Discussion

© 2023 Cargill, Incorporated. All rights reserved.

Recap of Requests from BCDC for ECRB

- Conduct site specific borings / cone penetration tests and associated analysis of the P2-12 / P2-13 berms
- Provide site-specific surveys and cross-sections of the berms
- History of P2-12 and P2-13 berm maintenance
- Static and seismic stability analysis
- Ecological and human development risk analysis based on expected performance of berms during various earthquake scenarios
- Updated sea level rise assessment

© 2023 Cargill, Incorporated. All rights reserved.

Cargill pond berms wave runup and overtopping analysis

Justin Vandever, PE, PMP

Coastal Engineering Manager

Justin.Vandever@aecom.com

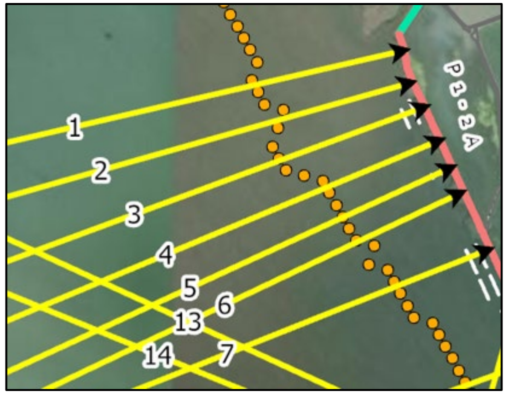
Background

- Cargill prepared a SLR Assessment in 2020/2021 to support its long-term operations and BCDC 10-year O&M permit renewal
- Assessment included:
  - Mapping of shoreline and inland berms and assets
  - Evaluation of SLR impacts through 2100
  - Identification of berm segments vulnerable to storm tide overtopping
  - Vulnerability and risk assessment for Cargill assets, operations, and environment
  - Conceptual phased SLR adaptation approach and adaptation considerations
- December 2022 – BCDC requested that Cargill evaluate impacts of wave runup and overtopping with SLR on bayfront berms based on request from ECRB

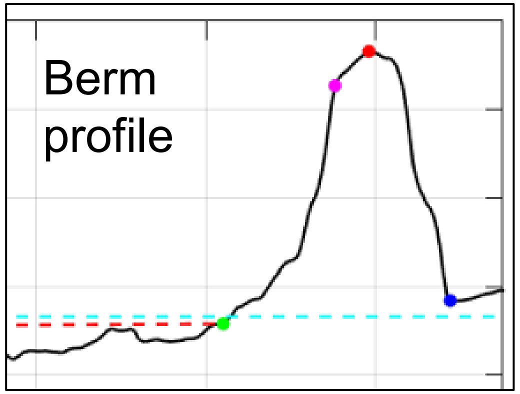
Purpose of Wave Runup and Overtopping Assessment

- Prior SLR assessment focused on impacts of high tide and “storm tide” overtopping of berms
- Evaluate effects of wave runup and overtopping on Cargill’s berms for existing and future conditions with SLR
- Wave runup and overtopping metrics evaluated and mapped spatially for each SLR scenario:
  - Duration of berm toe exceedance & wave height >1 ft (average hours per year)
  - Frequency of berm crest overtopping (return period storm event)
- Results will help Cargill identify berm segments that may experience increased exposure to wave impacts due to SLR

Approach Overview

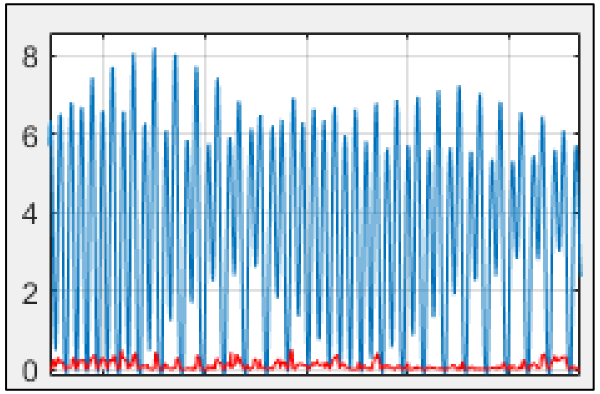


(1) Wave analysis transect layout

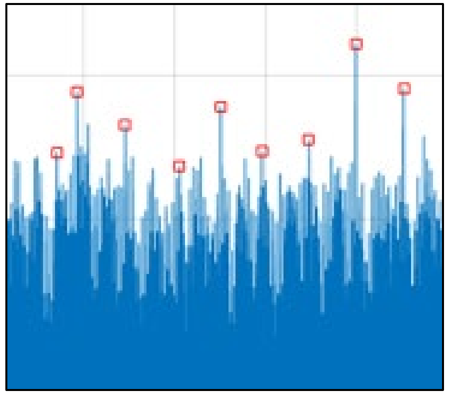


(2) Topo/bathy profile extraction & feature ID

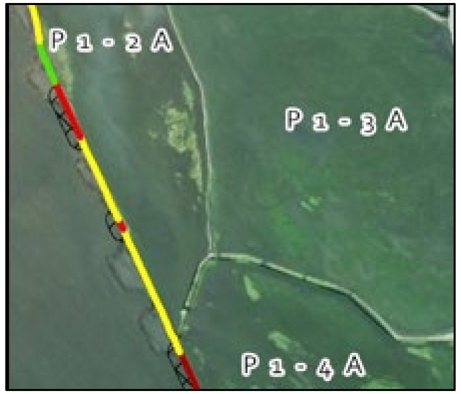
(3) Assign representative transect to each berm segment



(4) Compile water level & wave model output data



(5) Calculate TWL hindcast & perform statistical analysis



(6) Tabulate berm exposure metrics & map the results

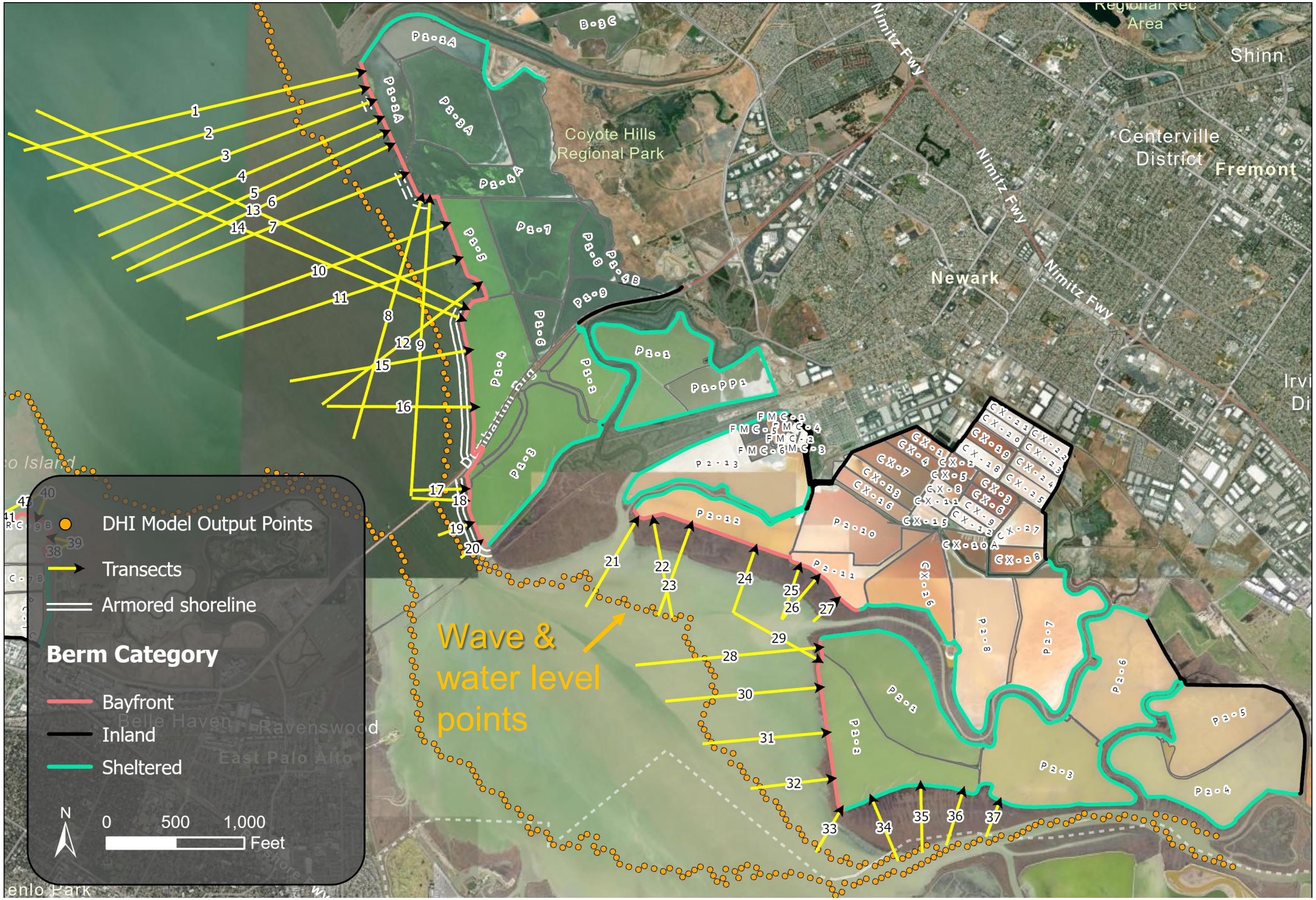
Transect Layout

Newark Ponds

Transect placement considers:

- Shoreline orientation
- Wave exposure
- Marsh width
- Armored vs. unarmored shoreline

Each transect paired with model output point.



aecom.com

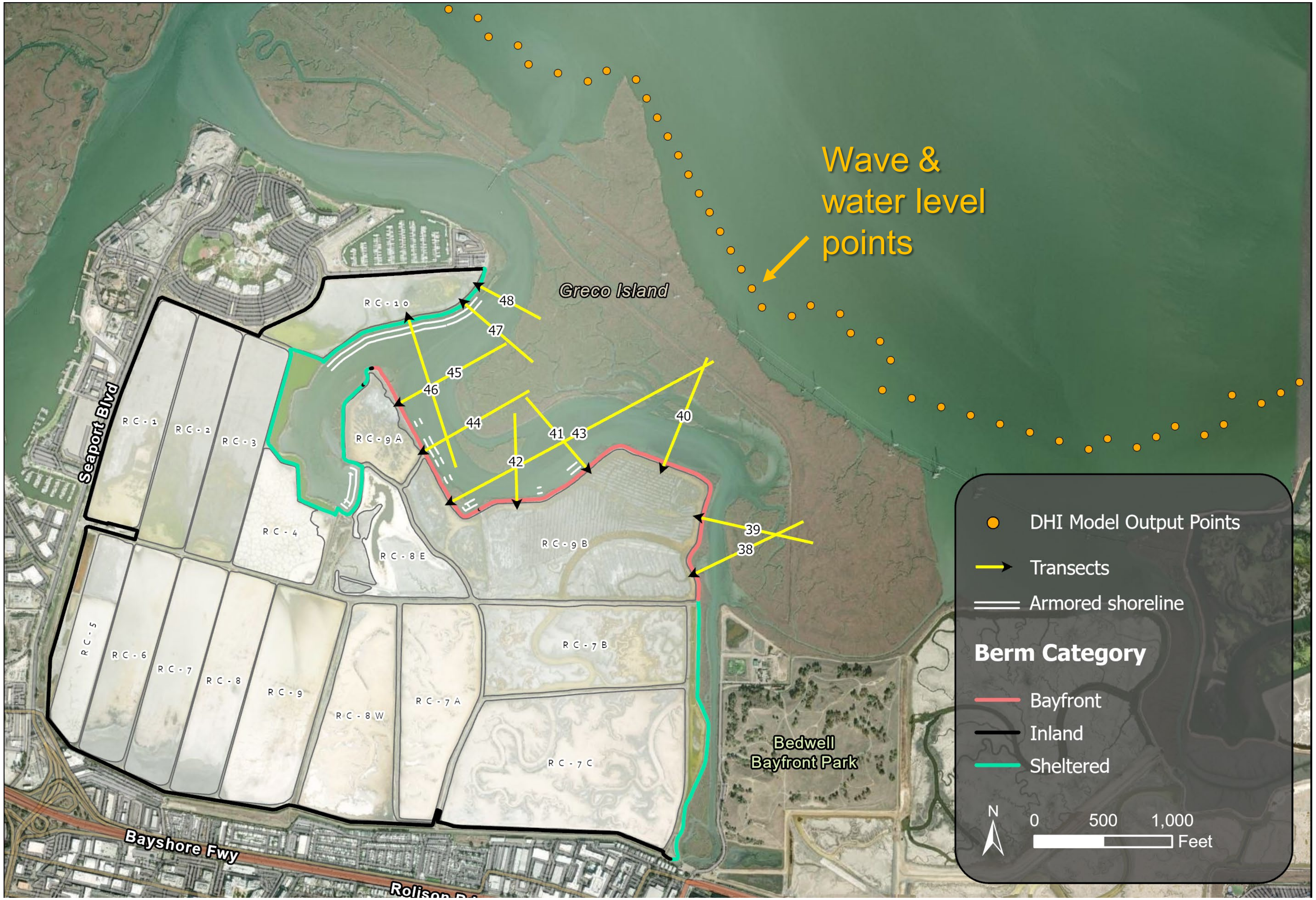
Transect Layout

Redwood City Ponds

Transect placement considers:

- Shoreline orientation
- Wave exposure
- Marsh width
- Armored vs. unarmored shoreline

Each transect paired with model output point.



Transect Assignment to Berm Segments

Shoreline subdivided into segments

Average crest elevation calculated for each transect

Each segment assigned a representative wave analysis transect

Transect Assignment to Berm Segments

Shoreline subdivided into segments

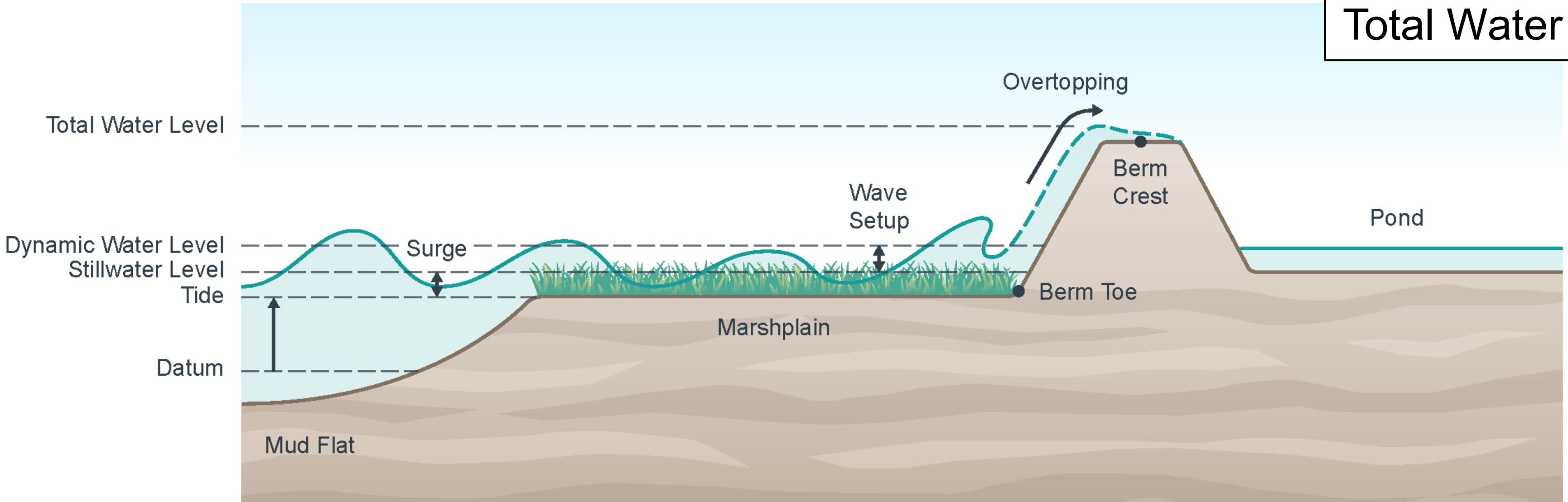
Average crest elevation calculated for each transect

Each segment assigned a representative wave analysis transect

Calculating Wave Runup (Total Water Level) on Cargill Berms

- Astronomical tide (predicted tide): **+6 to 8 ft**
- Surge components: atmospheric pressure, wind setup, El Niño effects: **+1 to 3 ft**
- Wave components: wave setup + wave runup: **+2 to 5 ft**
- Extreme TWL events: **+10 to 15 ft NAVD88**

Terminology
Stillwater Level: SWL = Tide + surge
Dynamic Water Level: DWL = SWL + setup
Total Water Level: TWL = SWL + setup + runup

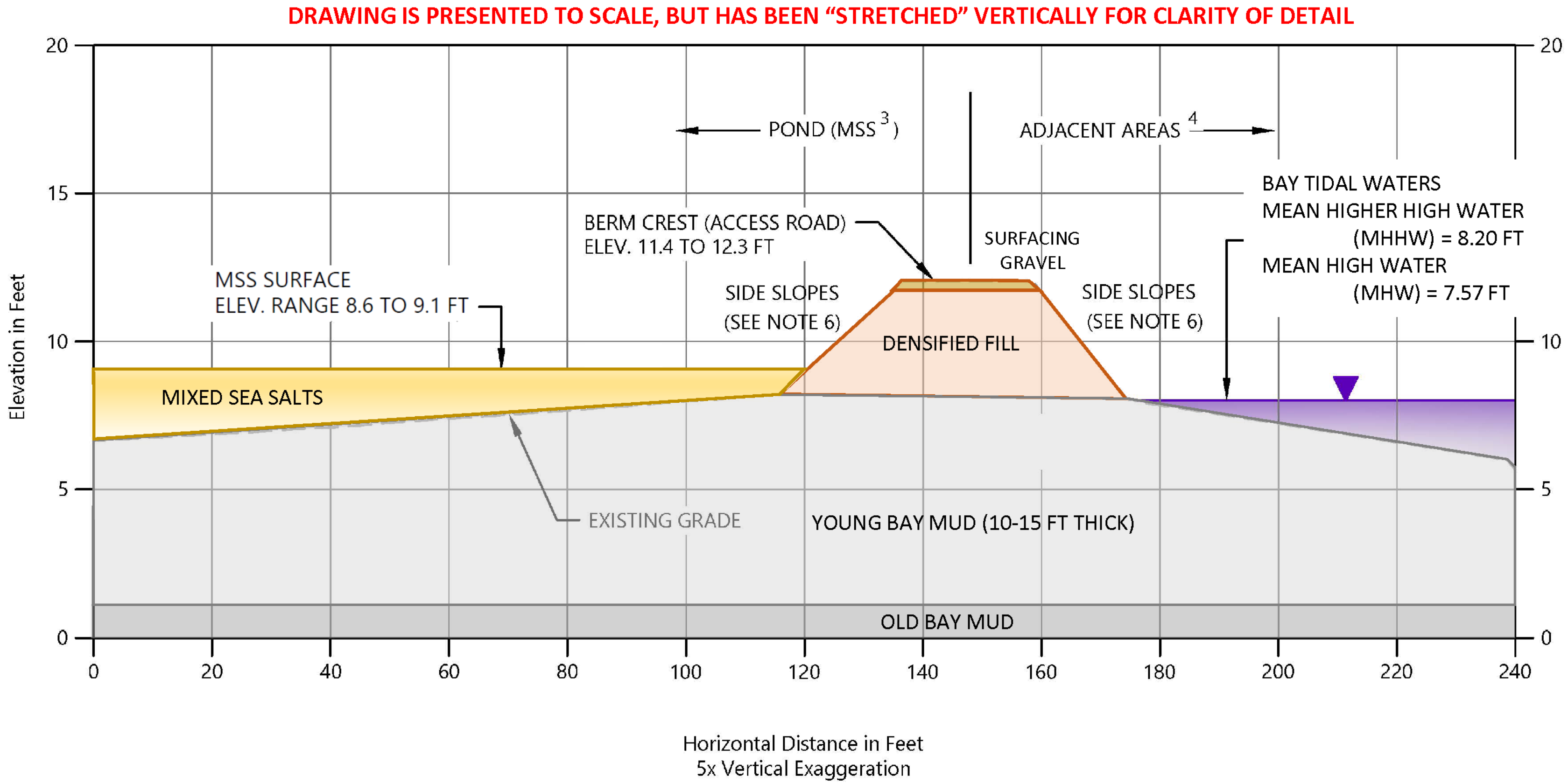


Note: Conceptual schematic. Berm and marsh not shown to scale.

Future Conditions:
$SWL_{SLR} = SWL + SLR$

aecom.com

Bayfront Berm
Typical Section



NOTES:

1. Horizontal datum: California state plane, Zone III, North American Datum of 1983 (NAD83), U.S. survey feet
2. Vertical datum: National Geodetic Vertical Datum of 1929 (NGVD29)
3. MSS = Mixed Sea Salts
4. Adjacent areas include San Francisco Bay waters, marshlands, Plummer Creek, and related tributary creeks
5. MHH = Mean Higher High Water
6. Berm side slopes range from 2H:1V to 2.5H:1V

Publish Date: 2023/06/23 9:32 AM | User: psciaba
Filepath: K:\Projects\2168-Cargill Salt\Brine Ditch Improvements\2168-RP-003 Conceptual Cross Section.dwg Figure 1

ANCHOR QEA

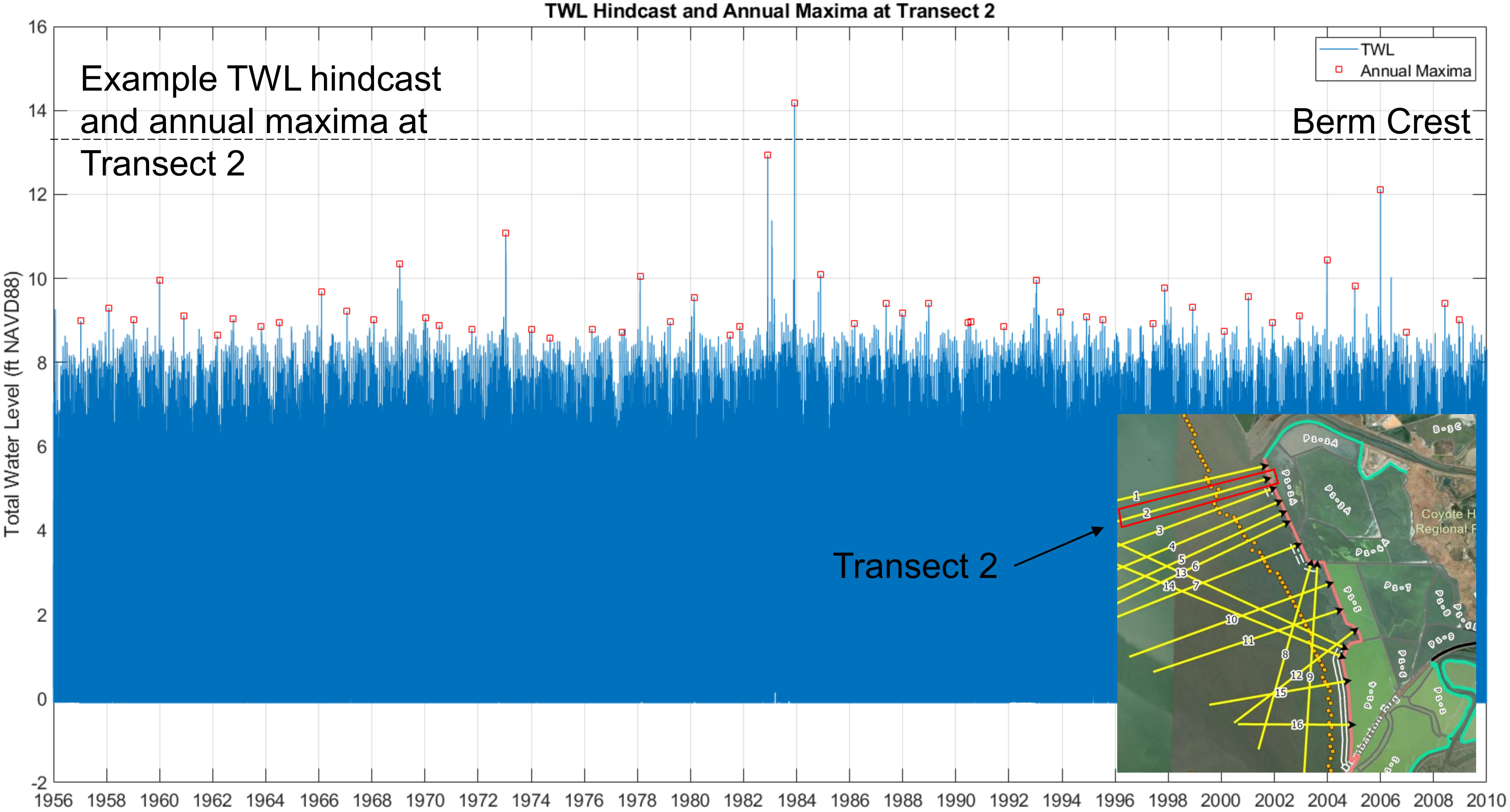
Figure 1
Representative Cross-Section of Typical Berm
Cargill Salt
Ponds P2-12 and P2-13, Newark Facility

Total Water Level Hindcast

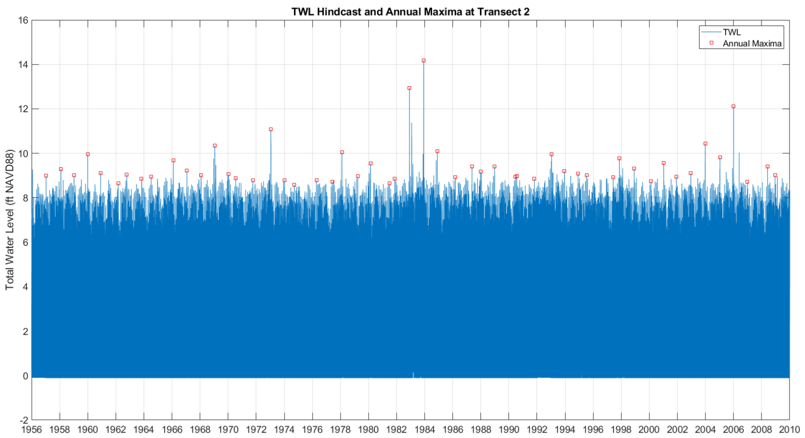
54-year SWL & wave hindcast from FEMA model

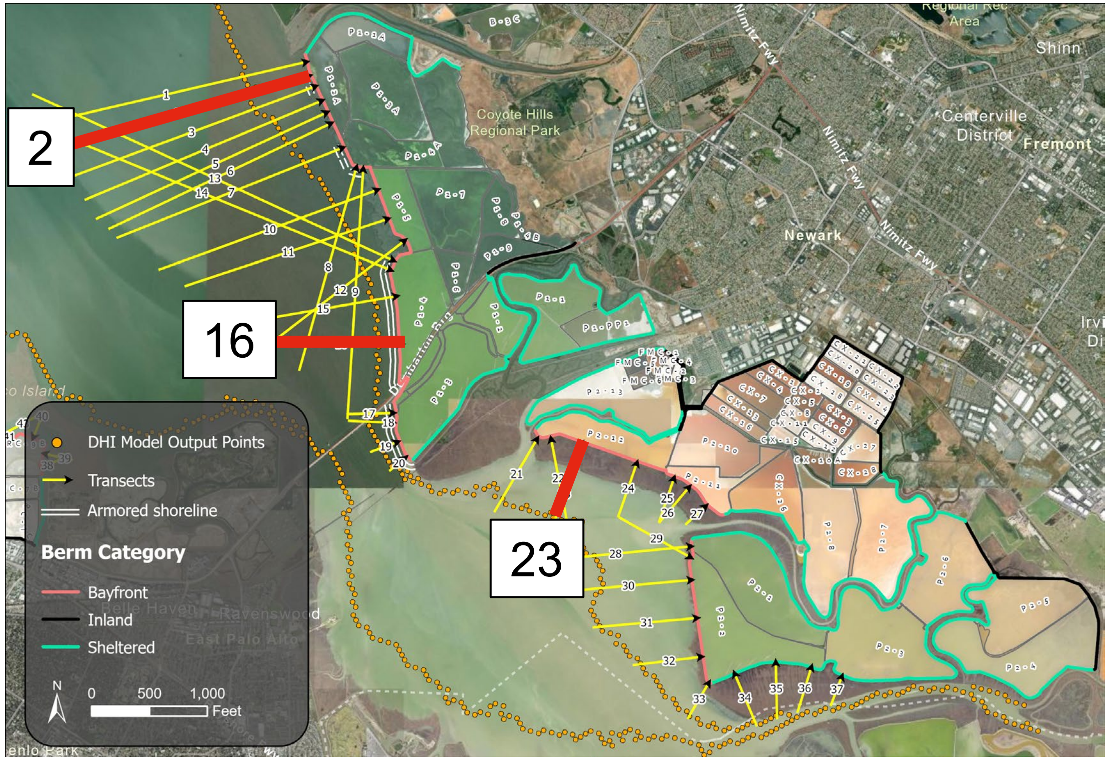
TWL = SWL + wave setup + runup

TWL analysis repeated for each SLR scenario: 0”, 6”, 12”, and 36” SLR



Total Water Level Hindcast





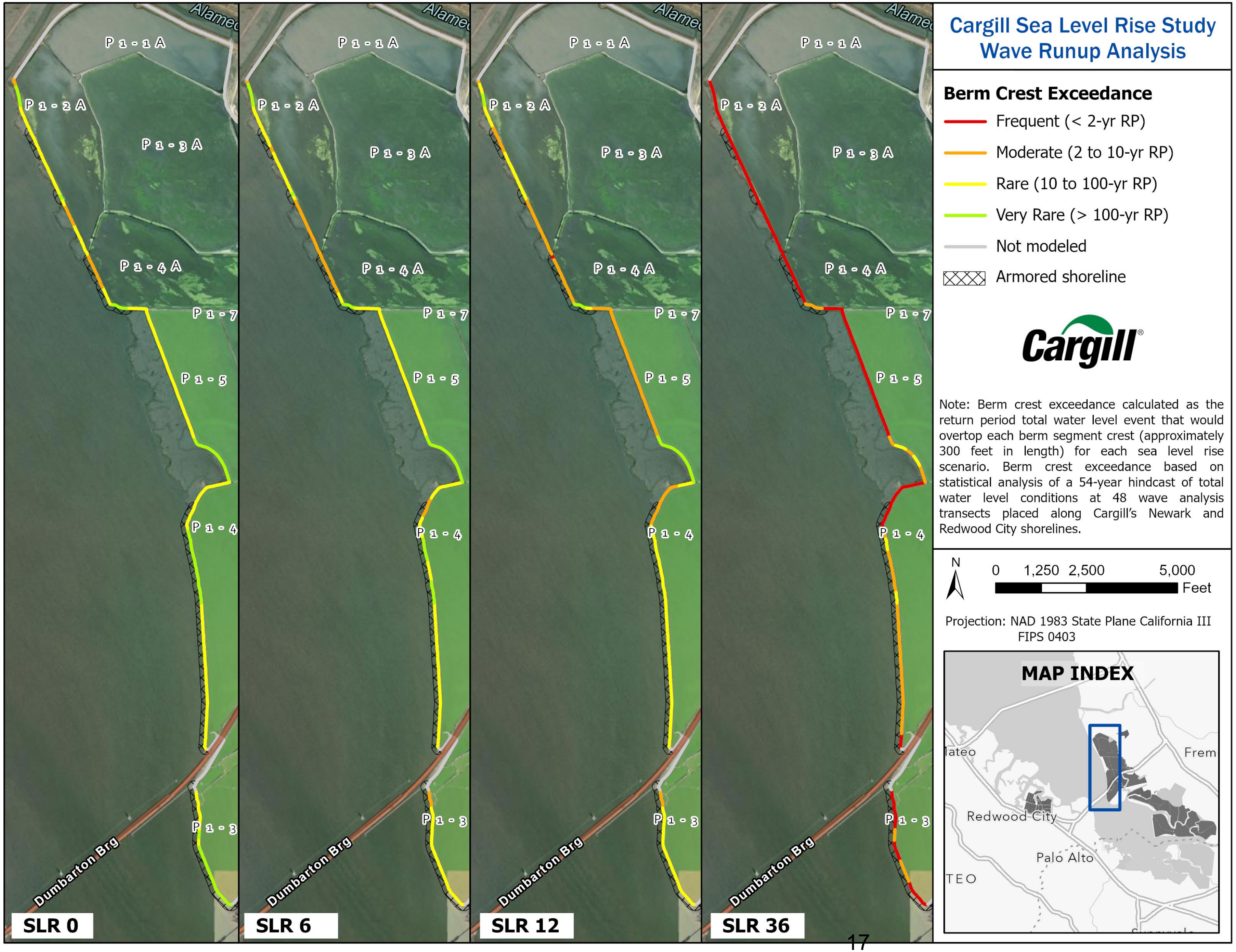
Perform statistical analysis of annual max events to estimate extreme TWLs (i.e., return period storm) at each transect.

- TWL return period storms estimated from 1-yr to 500-yr event.
- Estimate return period TWL that would result in berm crest overtopping for each segment.

Tabulate average annual hours of berm toe exceedance with wave height > 1ft for each transect.

Example results for 10-yr TWL event (ft NAVD88):

Transect	Existing	6” SLR	12” SLR	36” SLR
2	10.4	11.8	13.1	16.7
16	12.7	13.2	13.7	15.7
23	11.1	11.9	12.5	13.7



Frequency of berm crest overtopping
Newark Ponds
Plant 1

Return period TWL event that would result in berm crest overtopping.

Characterized qualitatively as "very rare" (>100-yr) to "frequent" (<2-yr).

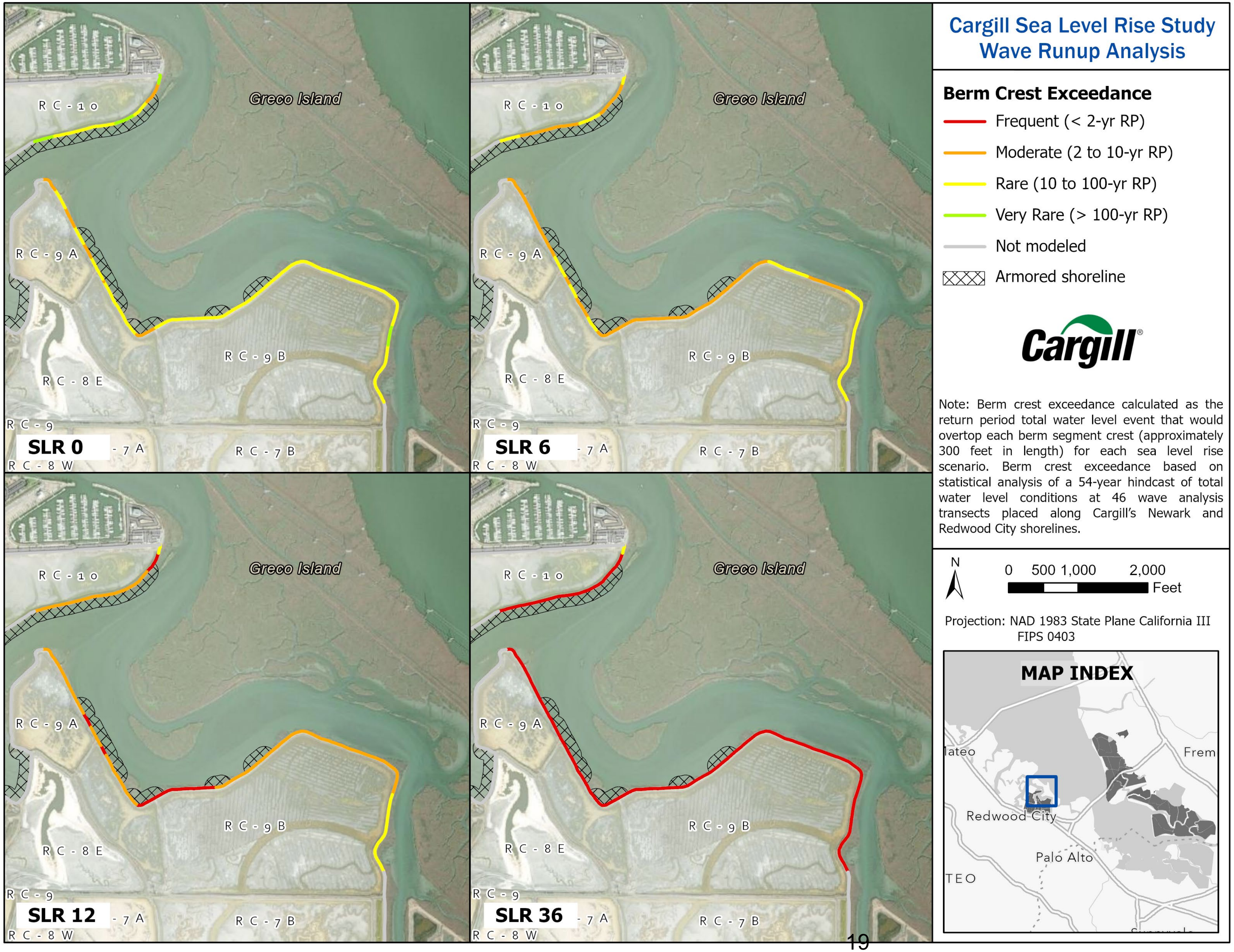
aecom.com

Frequency of berm crest overtopping
Newark Ponds Plant 2

Return period TWL event that would result in berm crest overtopping.

Characterized qualitatively as “very rare” (>100-yr) to “frequent” (<2-yr).

aecom.com

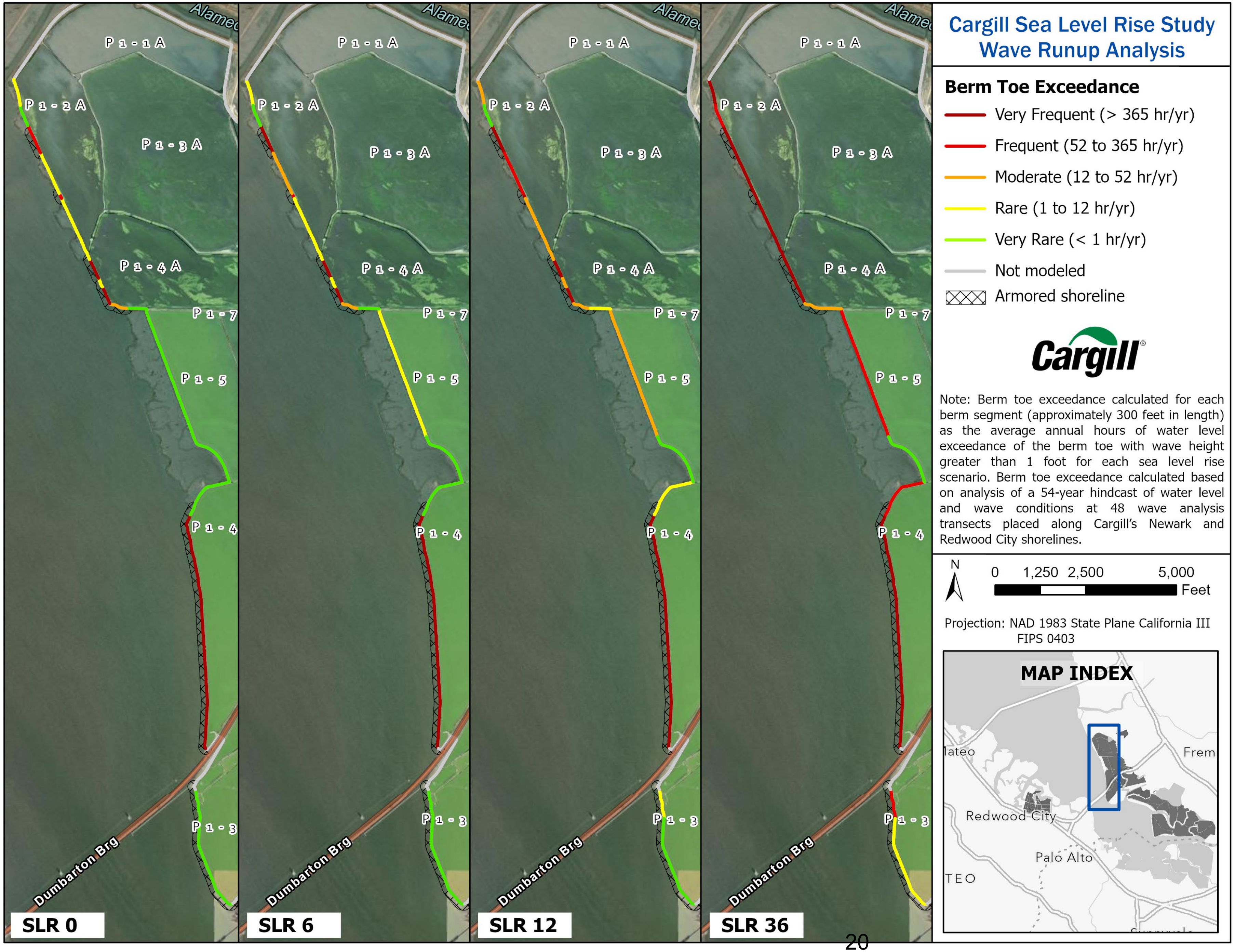


Frequency of berm crest overtopping Redwood City Ponds

Return period TWL event that would result in berm crest overtopping.

Characterized qualitatively as “very rare” (>100-yr) to “frequent” (<2-yr).

aecom.com



Frequency of berm toe exceedance

Newark Ponds Plant 1

Average annual number of hours where TWL exceeds berm toe and wave height >1 ft.

Characterized qualitatively as “very rare” (<1 hr/yr) to “very frequent” (>365 hr/yr).

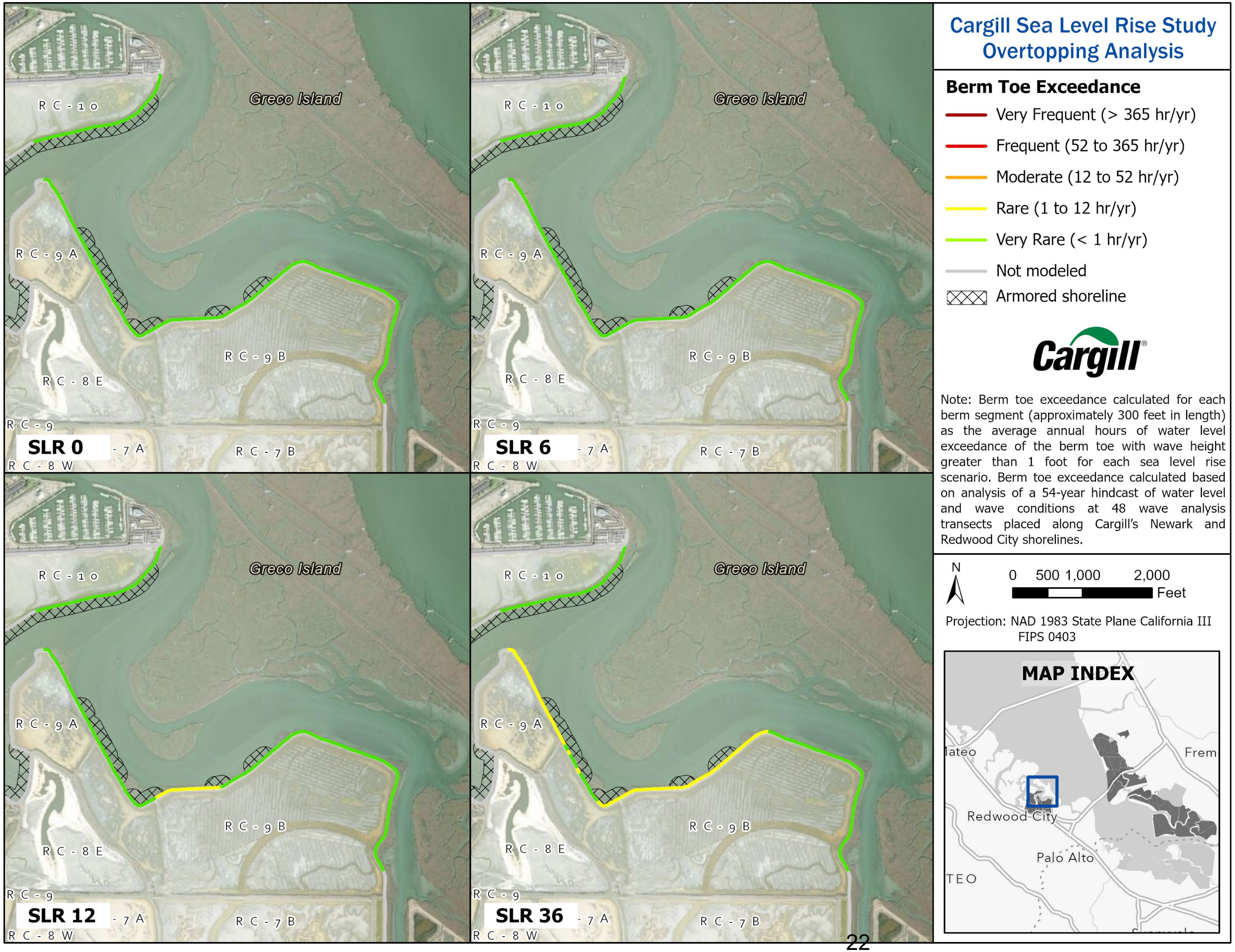
aecom.com

Frequency of berm toe exceedance
Newark Ponds
Plant 2

Average annual number of hours where TWL exceeds berm toe and wave height >1 ft.

Characterized qualitatively as “very rare” (<1 hr/yr) to “very frequent” (>365 hr/yr).

aecom.com



Frequency of berm toe exceedance Redwood City Ponds

Average annual number of hours where TWL exceeds berm toe and wave height >1 ft.

Characterized qualitatively as “very rare” (<1 hr/yr) to “very frequent” (>365 hr/yr).

aecom.com

AECOM Delivering a better world

Static and Seismic Stability Evaluation of Berms P2-12 and P2-13, Cargill Salt Ponds

Presented to BCDC ECRB, San Francisco

Presented by Michael Whelan, PE; Andrew Barrett; and Cole Bales

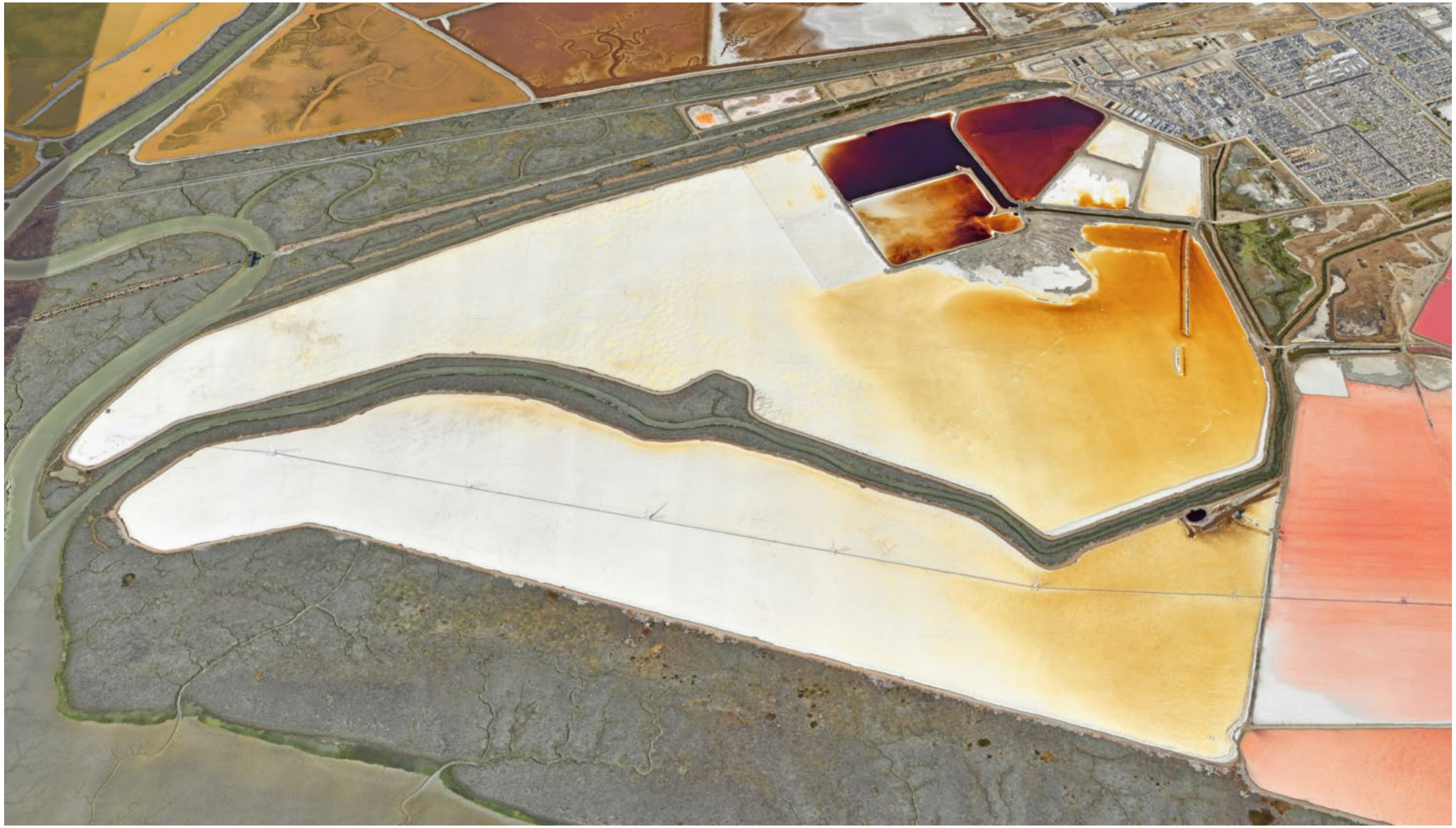
August 30, 2023

ANCHOR QEA

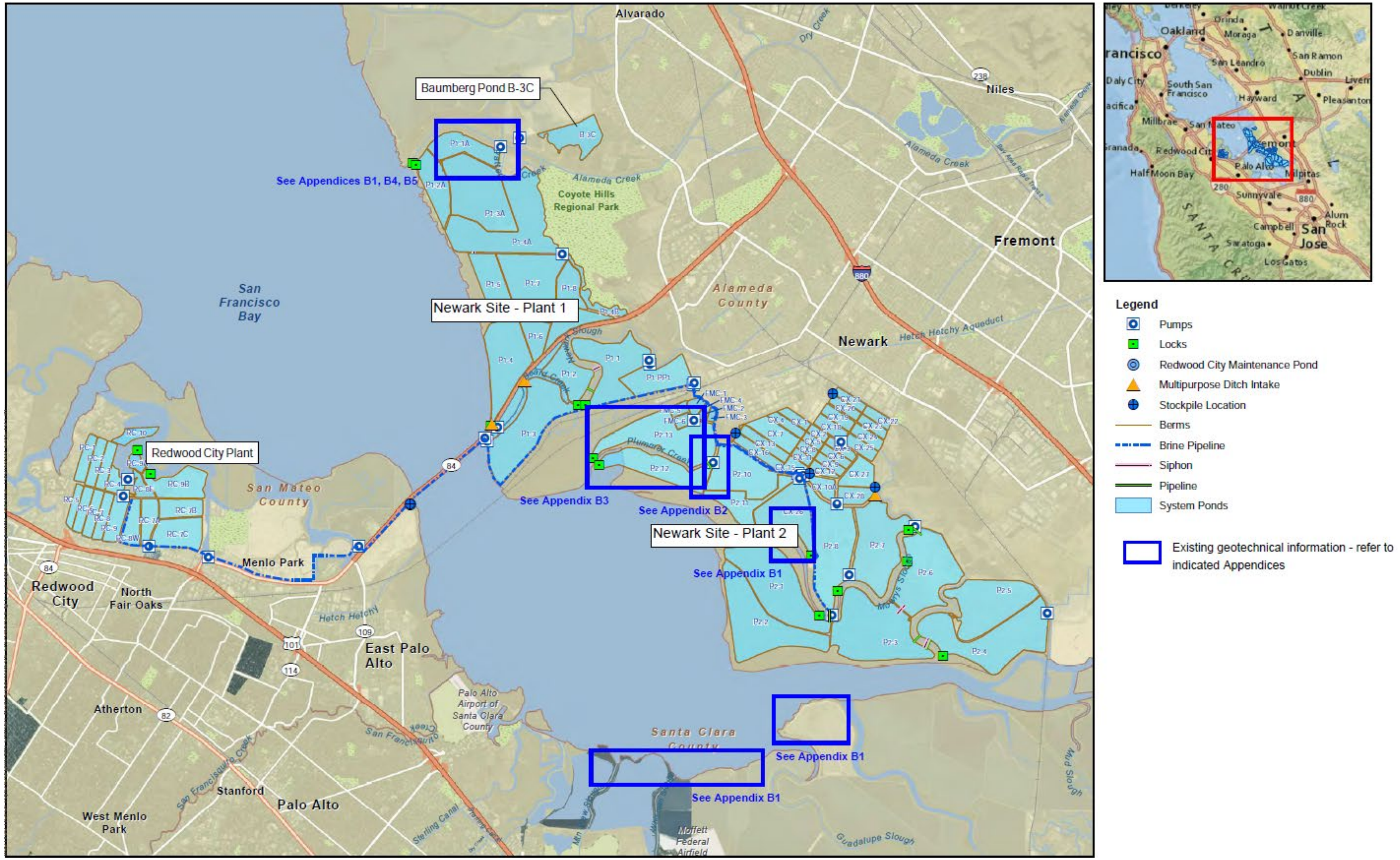
Overview of Berm Stability Analysis Presentation

- Site overview, Ponds P2-12 and P2-13
- Available site and subsurface information
- Berm cross-sectional geometry
- Subsurface conditions and water levels
- Static stability results
- Selection of "design-level" seismic event
- Seismic stability results
- Proposed additional explorations

P2-12 and P2-13 Area of Analysis



Overview of Existing Geotechnical Data in Region



Berm Characteristics

- Berms originally constructed using adjoining soils, compacted (densified berm fill)
- Wider than they are tall
- Flat upper surface
- Berms are graded for vehicle access
- Outboard side adjoined by marsh or tidal water areas

ANCHOR QEA

Key Geotechnical Conditions

- Berms at ponds P2-12 and P2-13 were analyzed per BCDC request
- December 20, 2022 letter from BCDC ECRB
  - *Item 4a: Conduct a static condition assessment of the berms to analyze the influence of daily operations, routine tides, and seepage on berm stability.*
  - *Item 5a: Conduct a seismic risk assessment to analyze and describe performance of the berms under a range of earthquake scenarios, including smaller earthquakes up to a maximum credible earthquake. Analyze any expected damage that may occur, and any expected associated release of MSS [Mixed Sea Salt] material into the environment. For each earthquake scenario, please also analyze that earthquake occurring simultaneously with a Base Flood Event (BFE). We understand this would be unlikely, but it is important to understand a full range of scenarios, including the worst-case scenarios, particularly given the potential ecological risks associated with a substantial breach and release of MSS material into the Bay.*

ANCHOR QEA

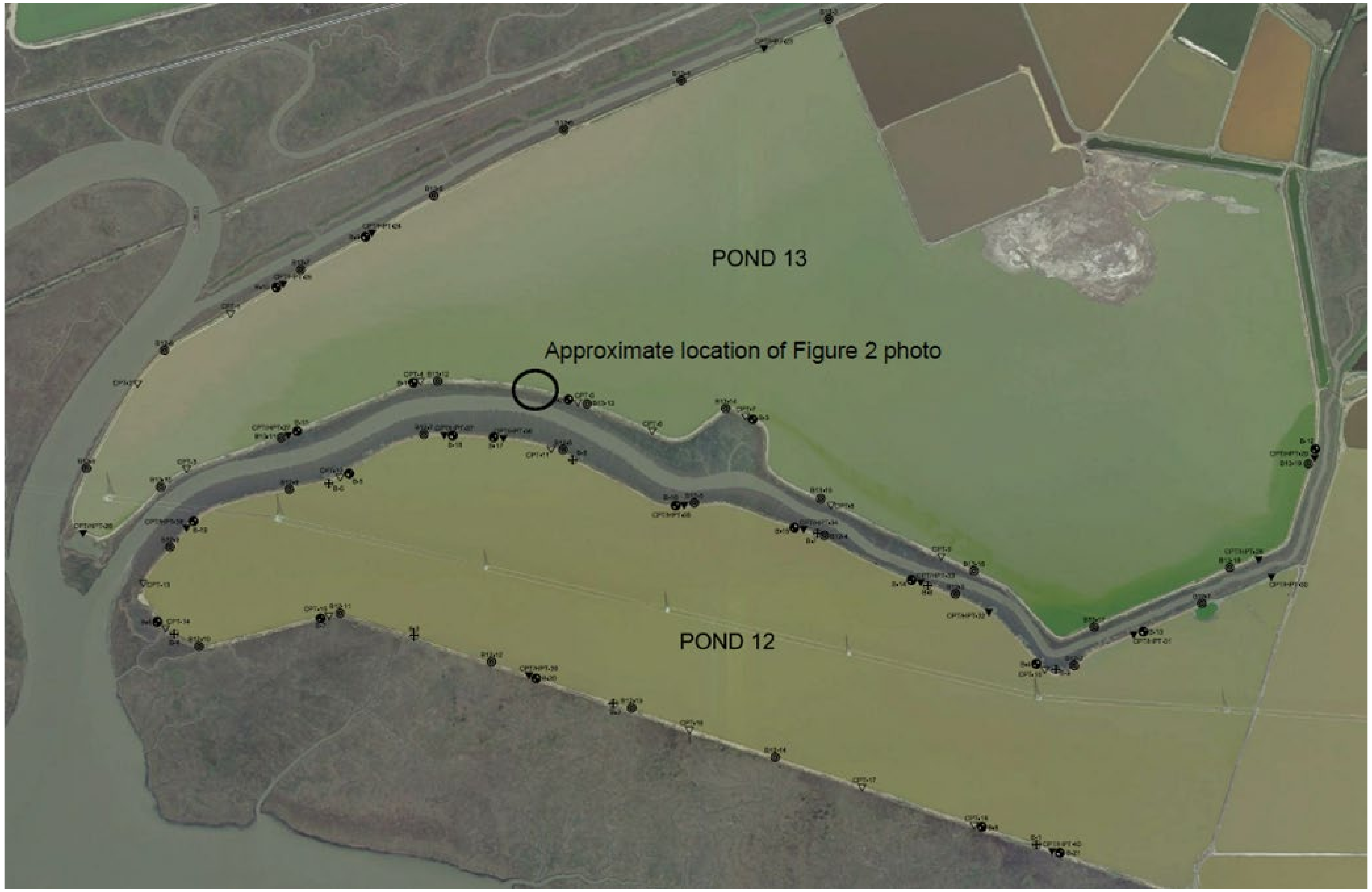
Key Geotechnical Conditions

- Numerous geotechnical investigations have been performed over the last 20 years around South San Francisco Bay area and Cargill facilities
  - Provide understanding of conditions and berm performance and stability implications
- Salt pond berms at Cargill have demonstrated long term integrity and stability for over a century
  - Berms at P2-12 and P2-13 have withstood over 50 years' worth of seismic events
- Cargill performs routine maintenance, which includes keying, rip rap, and grading
  - Minimum amount and extents needed to maintain berm protectiveness against natural erosion

ANCHOR QEA

Available Geotechnical Information at Ponds

- 24 borings to depths of 11 to 16 feet
- 2 borings at NE corner to depths of over 80 feet
- 43 cone penetration tests (CPTs), many with hydraulic profiling tool

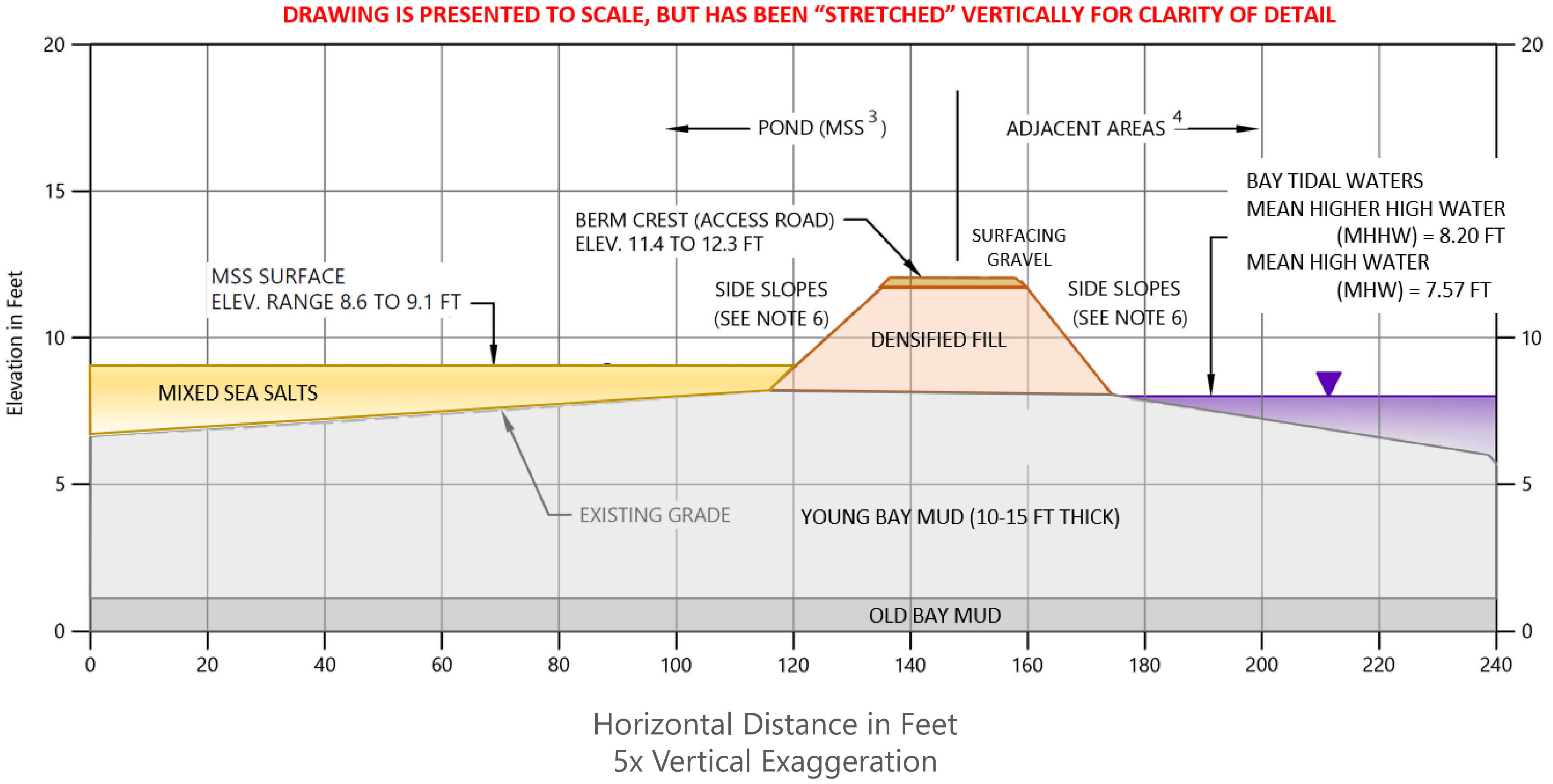


Subsurface Conditions

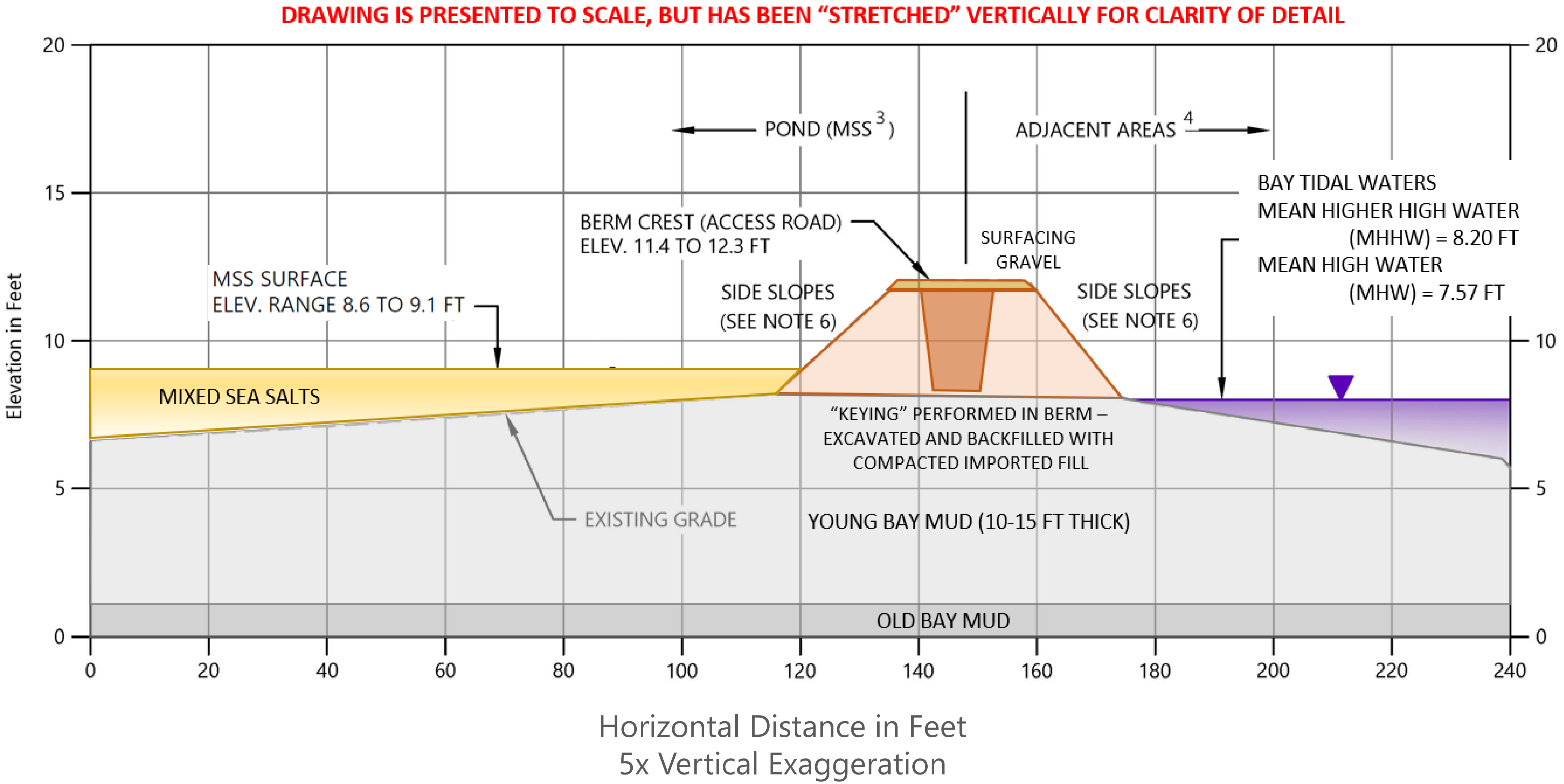
Three basic soil units underlie the ponds

- Densified Fill (composes the berms)
    - Represents original reuse of trenched bay muds to create berms
- Young Bay Mud overlying Old Bay Mud which are prevalent throughout the region

Berm Cross Section

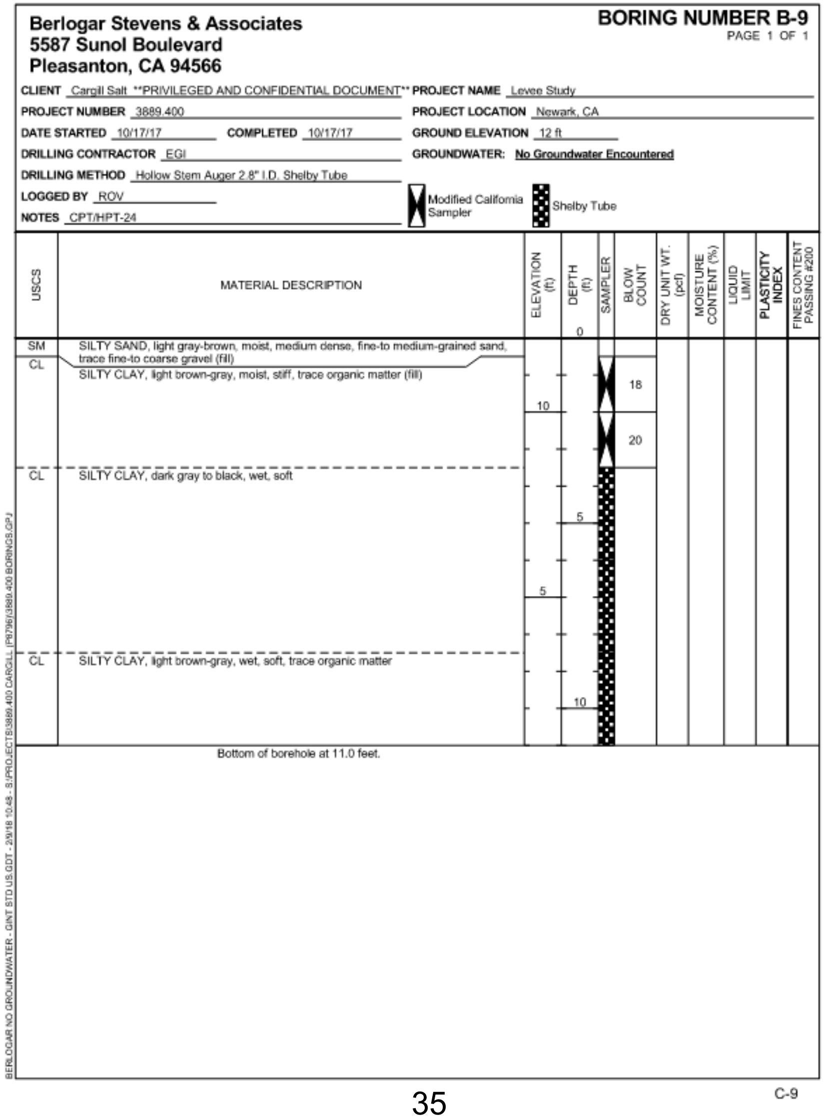


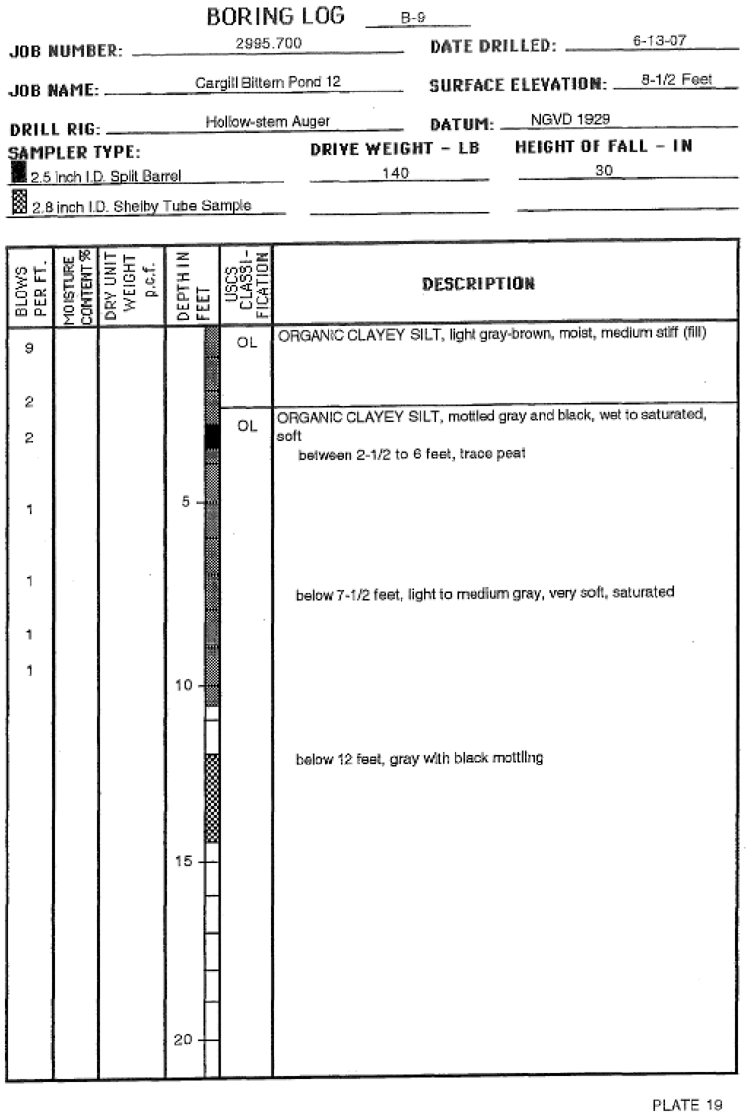
Berm Cross Section with “Keyed” Interior



Examples of Relevant Subsurface Logs

- Note the continuous presence of silt and clay materials in these example logs
- No distinct sand layers noted





Further Examples of Relevant Subsurface Logs

Berlogar Stevens & Associates
5587 Sunol Boulevard
Pleasanton, CA 94566

BORING NUMBER B-7
PAGE 1 OF 1

CLIENT Cargill Salt **PRIVILEGED AND CONFIDENTIAL DOCUMENT** PROJECT NAME Levee Study
PROJECT NUMBER 3889.400 PROJECT LOCATION Newark, CA
DATE STARTED 10/19/17 COMPLETED 10/19/17 GROUND ELEVATION 11 ft
DRILLING CONTRACTOR EGI GROUNDWATER: No Groundwater Encountered
DRILLING METHOD Hollow Stem Auger 2.8" I.D. Shelby Tube
LOGGED BY ROV
NOTES CPT-15

Modified California Sampler; Shelby Tube

USCS	MATERIAL DESCRIPTION	ELEVATION (ft)	DEPTH (ft)	SAMPLER	BLOW COUNT	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	LIQUID LIMIT	PLASTICITY INDEX	FINES CONTENT PASSING #200
CL	SANDY CLAY, light gray-brown, moist, stiff, fine-to coarse-grained sand, trace fine-to coarse gravel and silt (fill)	10	0							
CL	SILTY CLAY, light brown-gray, moist, medium stiff, limonite stains (fill)				14 11					
CL	SILTY CLAY, light gray, wet to saturated, soft below 6-1/2 feet, heavy black mottling, trace to some organic matter	5 0	5 10							

Bottom of borehole at 11.0 feet.

BERLOGAR NO GROUNDWATER - GINT STD US.GDT - 2/9/18 10:48 - S:\PROJECTS\3889.400 CARGILL (P8796)\3889.400 BORINGS.GPJ

C-7

BORING LOG B-2

JOB NUMBER: 2995.700 DATE DRILLED: 6-12-07
JOB NAME: Cargill Bittern Pond 12 SURFACE ELEVATION: 8 Feet
DRILL RIG: Hollow-stem Auger DATUM: NGVD 1929

SAMPLER TYPE:	DRIVE WEIGHT - LB	HEIGHT OF FALL - IN
2.5 inch I.D. Split Barrel	140	30
2.8 inch I.D. Shelby Tube Sample		

BLOWS PER FT.	MOISTURE CONTENT %	DRY UNIT WEIGHT p.c.f.	DEPTH IN FEET	USCS CLASSI-FICATION	DESCRIPTION
10				OL	ORGANIC CLAYEY SILT, light brown-gray, moist, soft to medium stiff, trace organic matter black mottling (fill)
2 1	70.6	52		OL/Pt	ORGANIC CLAYEY SILT with PEAT, mottled brown gray and black, saturated, soft
1			5	OL	ORGANIC CLAYEY SILT, light gray, saturated, soft, trace peat
1				Pt/OL	PEAT with ORGANIC CLAYEY SILT
				OL	ORGANIC CLAYEY SILT, light gray, saturated, soft to very soft
2				Pt/OL	PEAT with ORGANIC CLAYEY SILT
2			10	OL	ORGANIC CLAYEY SILT, light gray, saturated, soft to very soft, trace peat light gray, saturated, very soft, strong smell
	121.5 113.7	39 40			
			15		below 14-1/2 feet, less peat
			20		

PLATE 5

Development of Geotechnical Engineering Properties

Summary of Undrained[1] Soil Properties Used for Analyses

Soil Units	Unit Weight (lbs/ft^3)	Cohesion, top of unit (psf[2])	Cohesion increase with depth (psf per ft)	Cohesion, base of unit (psf)
Densified Berm Fill	115	700	12	1,250
Young Bay Mud (YBM)	105	300	8	1,000
Old Bay Mud (OBM)	115	1,500	12	4,000

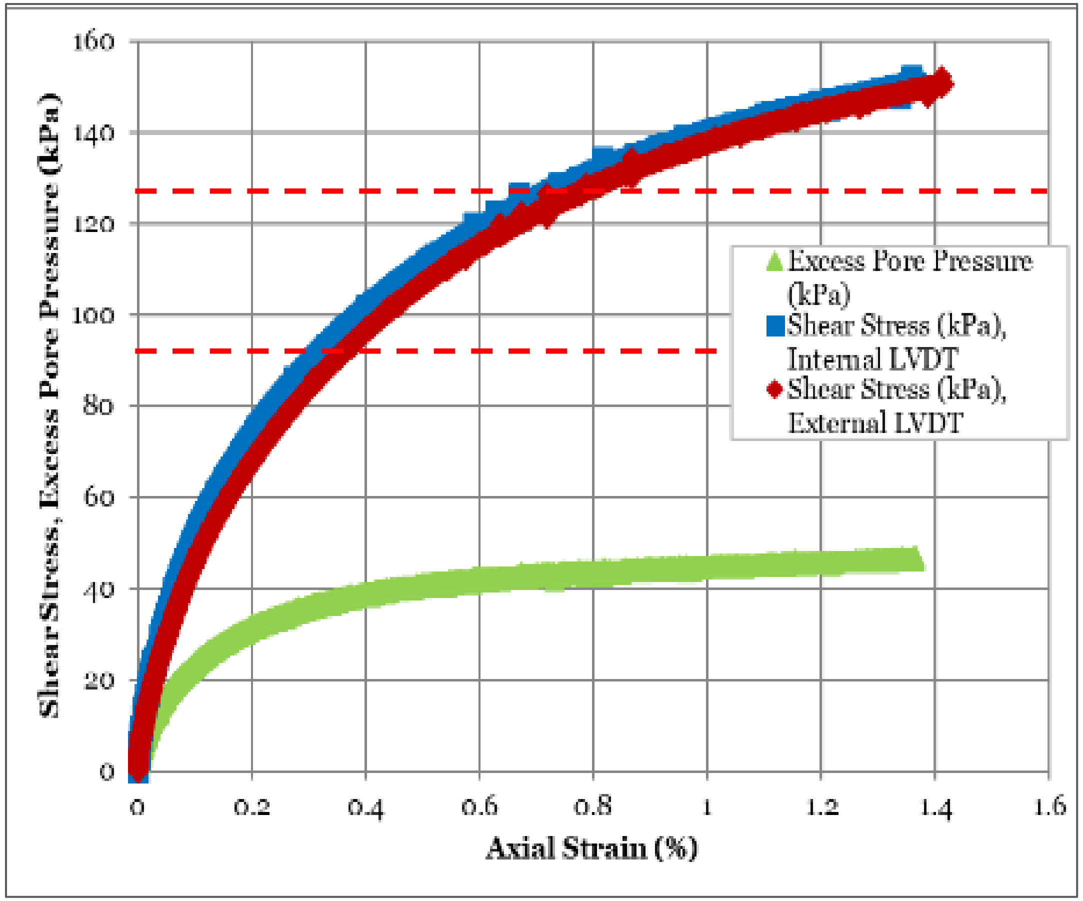
Notes:

1. Undrained properties are most appropriate for the soil types encountered at this Site, as discussed in text.
2. psf = Pounds of force per square foot

ANCHOR QEA

Selection of Geotechnical Parameters for Bay Muds

- Old Bay Mud shows shear strength values between 1,600 and 2,500 psf (80 to 120kPa) through material strength testing (undrained compression testing)
- Young Bay Mud composite data from available boring logs suggest compressive strengths between 300 and 700 psf



Integration of numerous strength tests for Old Bay Mud throughout surrounding area. Red lines indicate selected strength ranges

ANCHOR QEA

Development of Geotechnical Engineering Properties

Summary of Undrained[1] Soil Properties Used for Analyses

Soil Units	Unit Weight (lbs/ft^3)	Cohesion, top of unit (psf[2])	Cohesion increase with depth (psf per ft)	Cohesion, base of unit (psf)
Densified Berm Fill	115	700	12	1,250
Young Bay Mud (YBM)	105	300	8	1,000
Old Bay Mud (OBM)	115	1,500	12	4,000

Notes:

1. Undrained properties are most appropriate for the soil types encountered at this Site, as discussed in text.
2. psf = Pounds of force per square foot

ANCHOR QEA

Development of Geotechnical Engineering Properties

Summary of Undrained[1] Soil Properties Used for Analyses

Soil Units	Unit Weight (lbs/ft^3)	Cohesion, top of unit (psf[2])	Cohesion increase with depth (psf per ft)	Cohesion, base of unit (psf)
Densified Berm Fill	115	700	12	1,250
Young Bay Mud (YBM)	105	300	8	1,000
Old Bay Mud (OBM)	115	1,500	12	4,000

Notes:

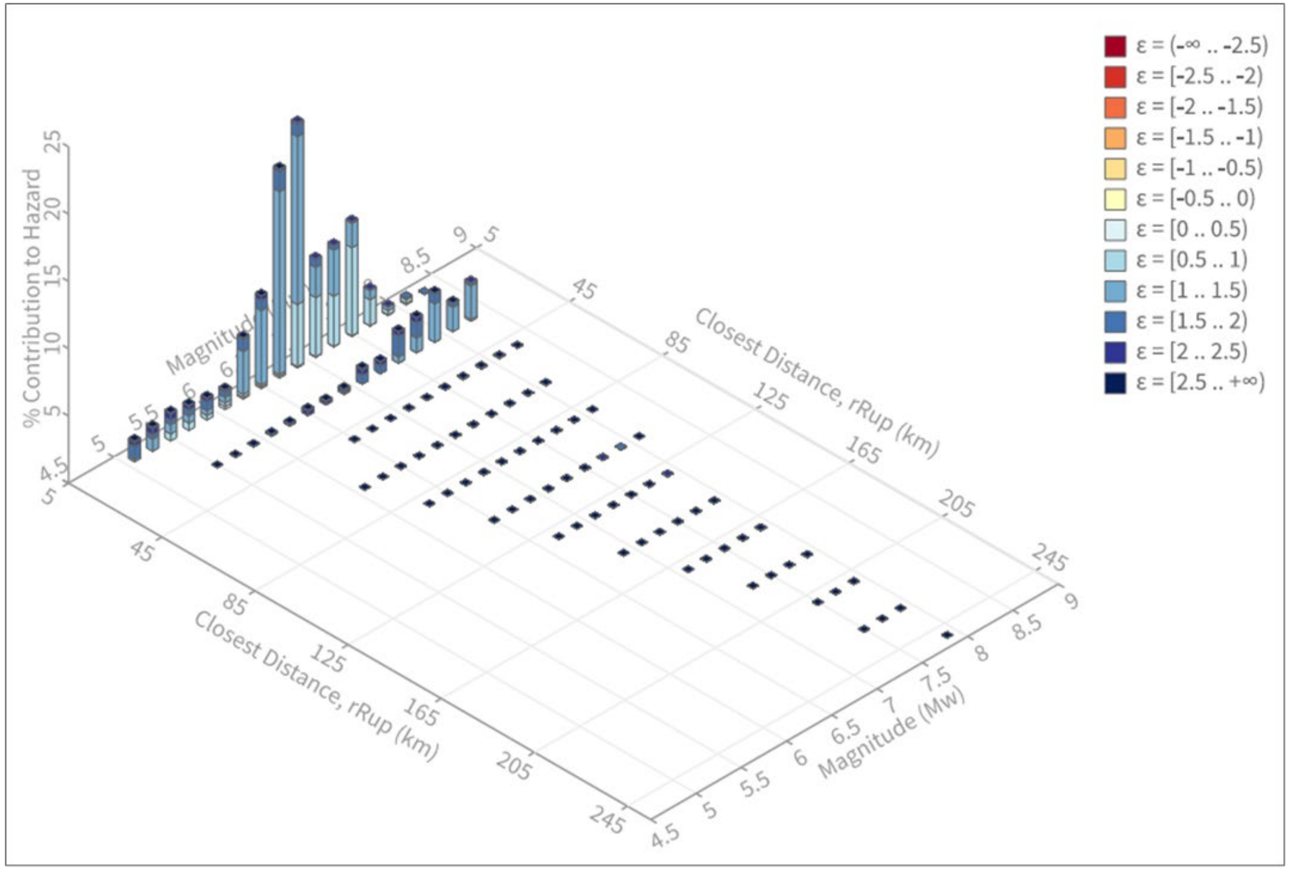
1. Undrained properties are most appropriate for the soil types encountered at this Site, as discussed in text.
2. psf = Pounds of force per square foot

ANCHOR QEA

"Design-Level" Seismic Event

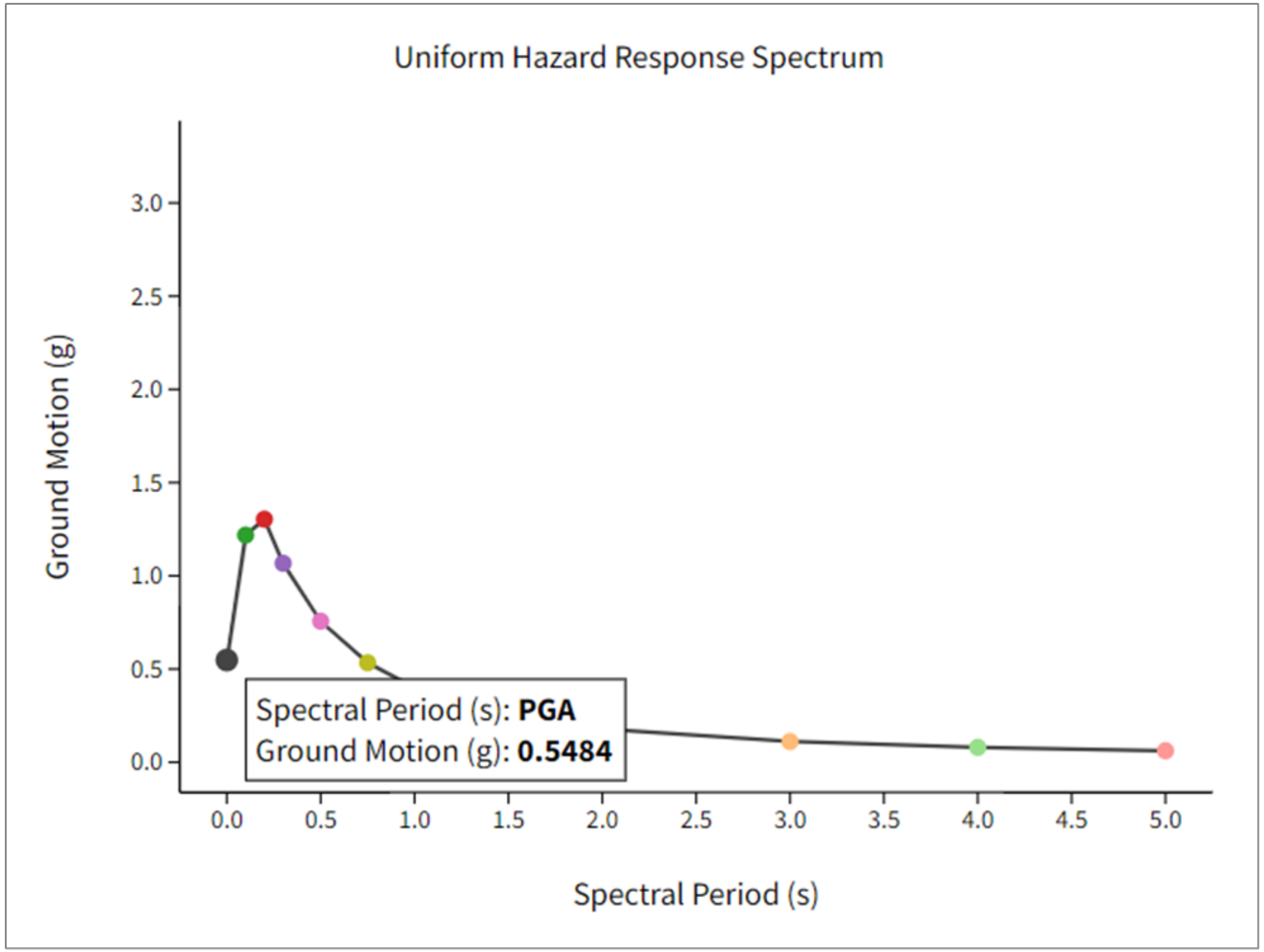
Probabilistic Earthquake Evaluation

- The goal was to determine peak ground accelerations (PGAs) corresponding to two return periods at the Site:
  - 50-year return period ("50-year event"; Operating-Level Earthquake [OLE])
  - 475-year return period ("475-year event"; Contingency-Level Earthquake [CLE])
- Site Class "E" (soft deposits)



Selection of Peak Ground Acceleration Values

- Base peak ground acceleration (PGA) obtainable for site using USGS Unified Hazard Tool
- Integrates information on overall risk from existing faults throughout the region
- The 475-year earthquake for Newark results in a PGA of 0.5484 g (0.55 g)



ANCHOR QEA

Site Amplification

- Consistent with AASTHO (2020) guidance
- Combining the base PGA from the probabilistic analysis yields PGA to be used in analysis
- A factor of 0.9 is appropriate for short period acceleration and Site Class E, resulting in a PGA of 0.9 x 0.55 g = 0.5 g
- For the smaller OLE event, the PGA is estimated as 1.6 x 0.21 g = 0.34 g

Table 3.10.3.2-1—Values of Site Factor, F_{pga}, at Zero-Period on Acceleration Spectrum

Site Class	Peak Ground Acceleration Coefficient (*PGA*)[1]				
	PGA < 0.10	*PGA* = 0.20	*PGA* = 0.30	*PGA* = 0.40	*PGA* > 0.50
A	0.8	0.8	0.8	0.8	0.8
B	1.0	1.0	1.0	1.0	1.0
C	1.2	1.2	1.1	1.0	1.0
D	1.6	1.4	1.2	1.1	1.0
E	2.5	1.7	1.2	0.9	0.9
F[2]	*	*	*	*	*

Notes:

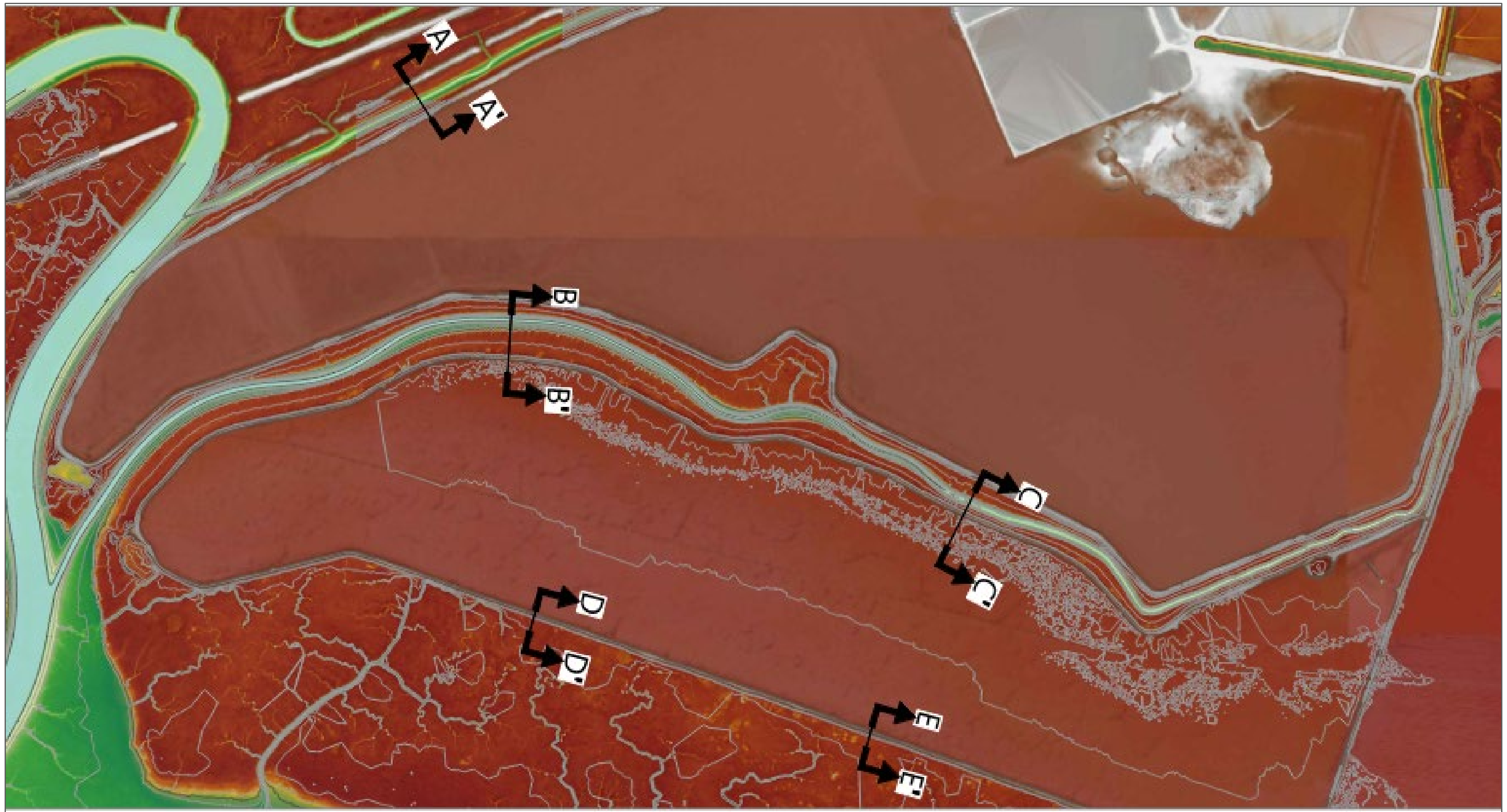
[1]Use straight-line interpolation for intermediate values of *PGA*.

[2]Site-specific geotechnical investigation and dynamic site response analysis should be performed for all sites in Site Class F.

ANCHOR QEA

Cross Sections and Stability Analysis

Representative Cross Sections



SOURCE: Survey, Aerial and/or CAD file provided by...
HORIZONTAL DATUM: California State Planes Zone III, US Foot NAD83
VERTICAL DATUM: NAVD88
NOTES:
1. Note.
2. Notes.

0 1000
Feet

ANCHOR QEA

Factor of Safety (FOS) Criteria

- AASHTO standards were used
- Resistance factor design
- For static conditions, AASHTO recommends resistance factors of 0.75 and 0.65 for long and short term durations, respectively
- This resistance factor is equivalent to FOS of 1.5 and 1.33, respectively
  - Analyses presented here used a FOS criteria of 1.5 (worse of the two cases)
- For seismic conditions AASHTO recommends a FOS of 1.1
  - Analyses presented here used a FOS criteria of 1.1

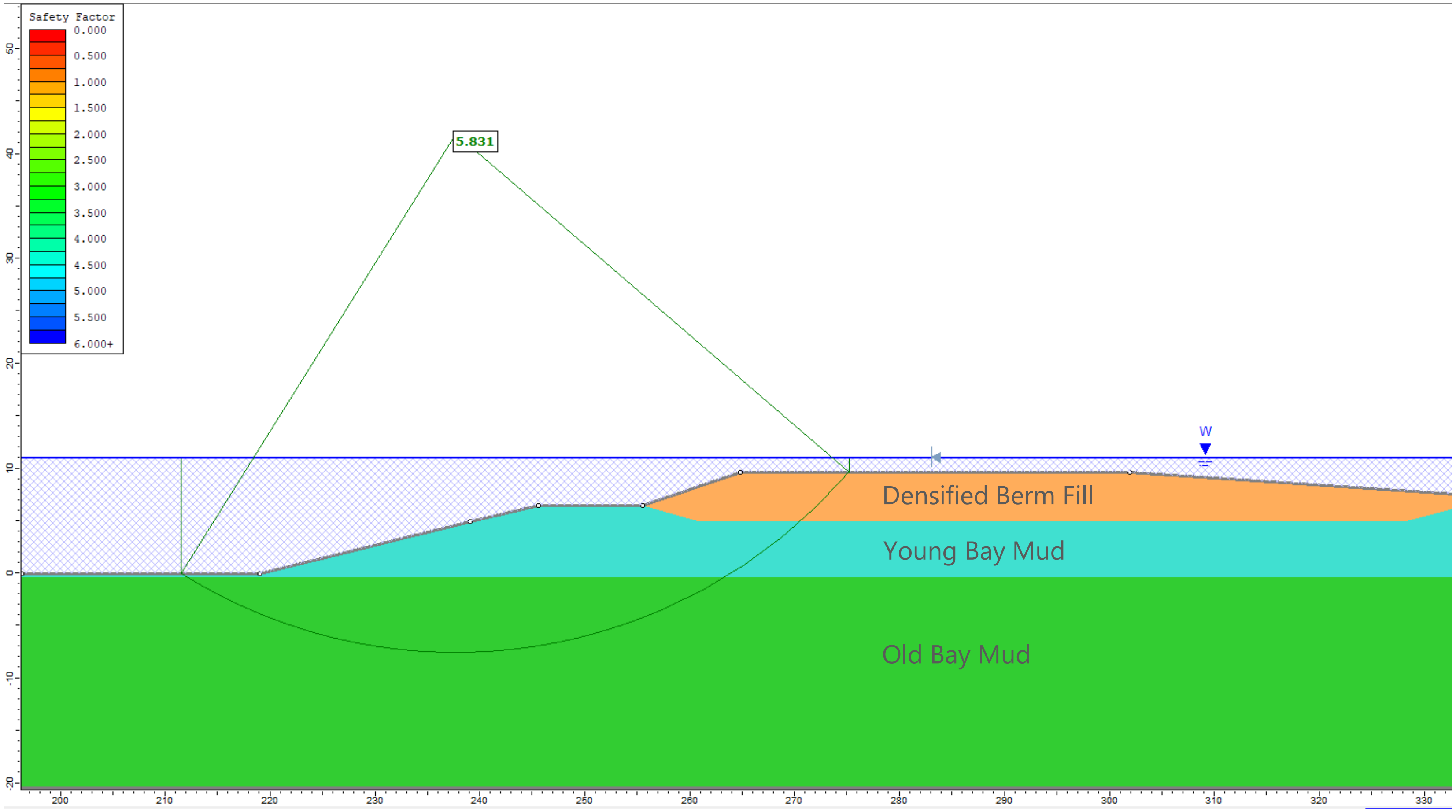
ANCHOR QEA

Summary of Analysis Results

Cross-Section	Pond water level	Bay/Slough water level	Static FOS[2]	Seismic FOS[2] – OLE (50-year event)	Seismic FOS[2] – CLE (475-year event)
A-A′	9 ft[1]	Flood (11 ft[1])	>2.5	1.9	1.3[3]
		High tide (7 ft[1])		1.9	1.3
		Low tide (2 ft[1])		1.8[3]	1.3[3]
B-B′	9 ft[1]	Flood (11 ft[1])	>2.5	> 1.9	1.6
		High tide (7 ft[1])		1.9	1.3
		Low tide (2 ft[1])		1.9[3]	1.3[3]
C-C′	9 ft[1]	Flood (11 ft[1])	>2.5	> 1.8	1.4
		High tide (7 ft[1])		1.8	1.2
		Low tide (2 ft[1])		1.7	1.2
D-D′	9 ft[1]	Flood (11 ft[1])	>2.5	>1.8	1.4
		High tide (7 ft[1])		1.8	1.3
		Low tide (2 ft[1])		1.8	1.2
E-E′	9 ft[1]	Flood (11 ft[1])	>2.5	> 1.7	1.6[3]
		High tide (7 ft[1])		> 1.7	1.5
		Low tide (2 ft[1])		>1.7	1.5[3]

ANCHOR QEA

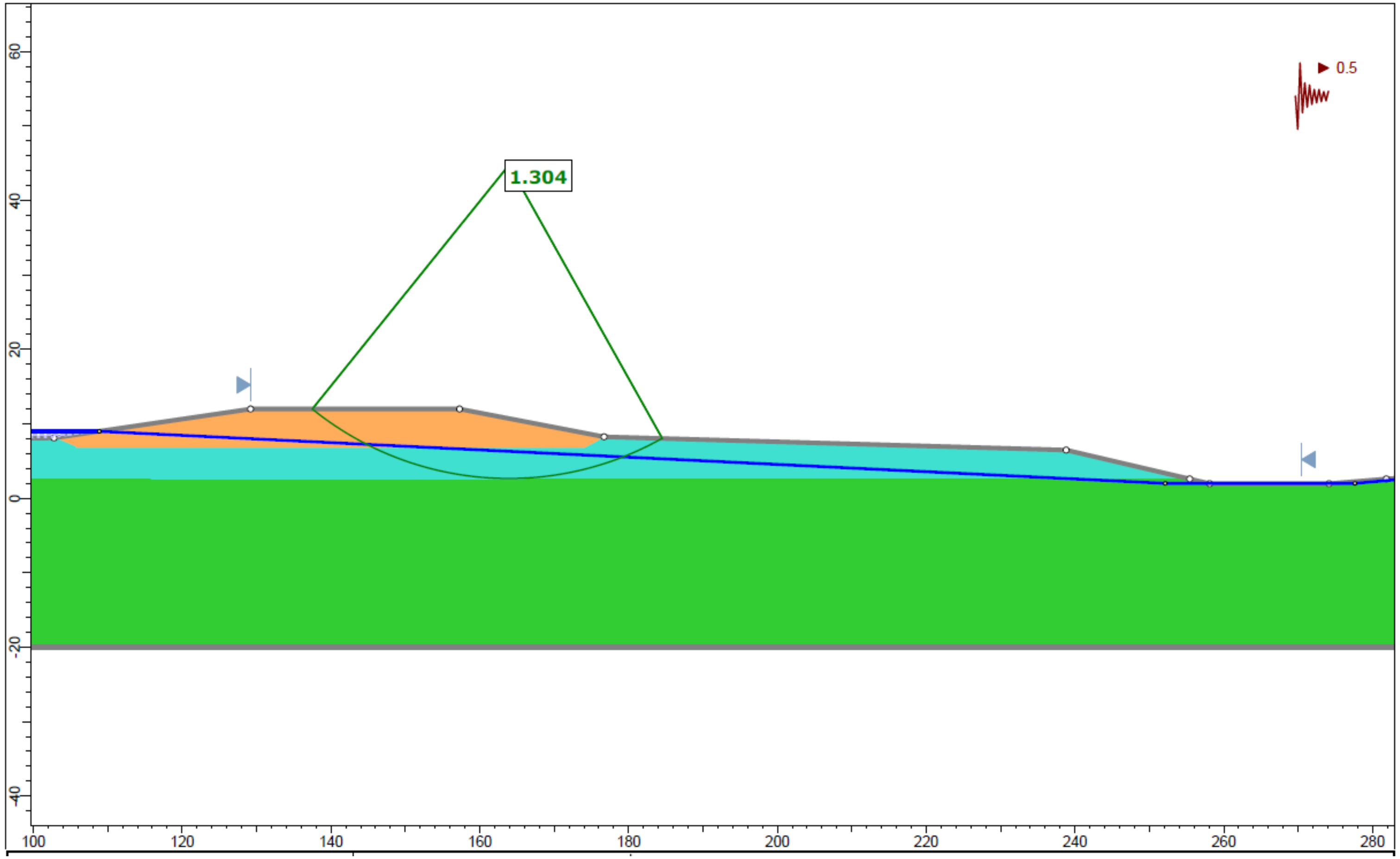
Stability under Static Conditions



No. 1 of 9. Section C-C' in static conditions

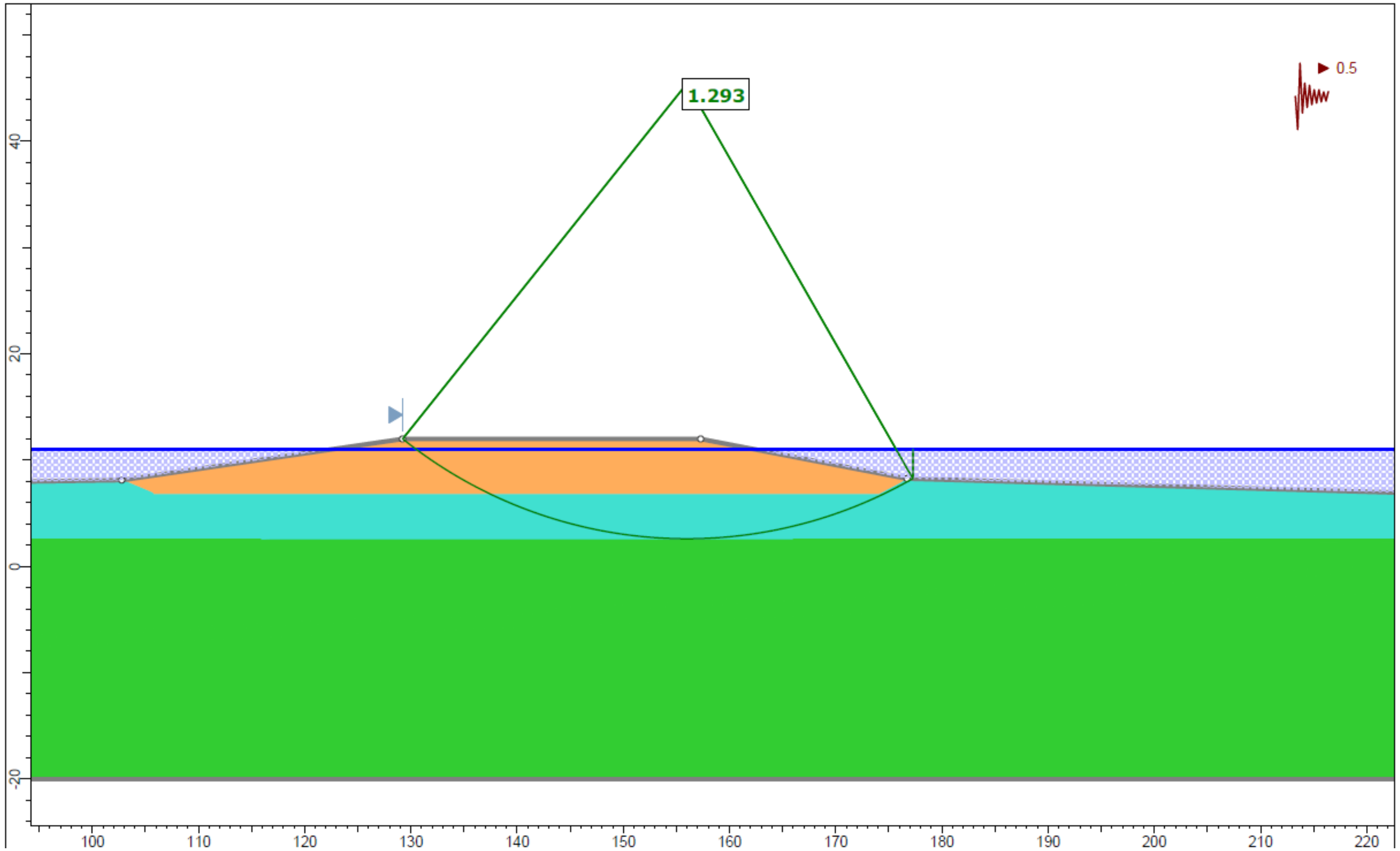
ANCHOR QEA

Seismic Stability: Effect of Water Level



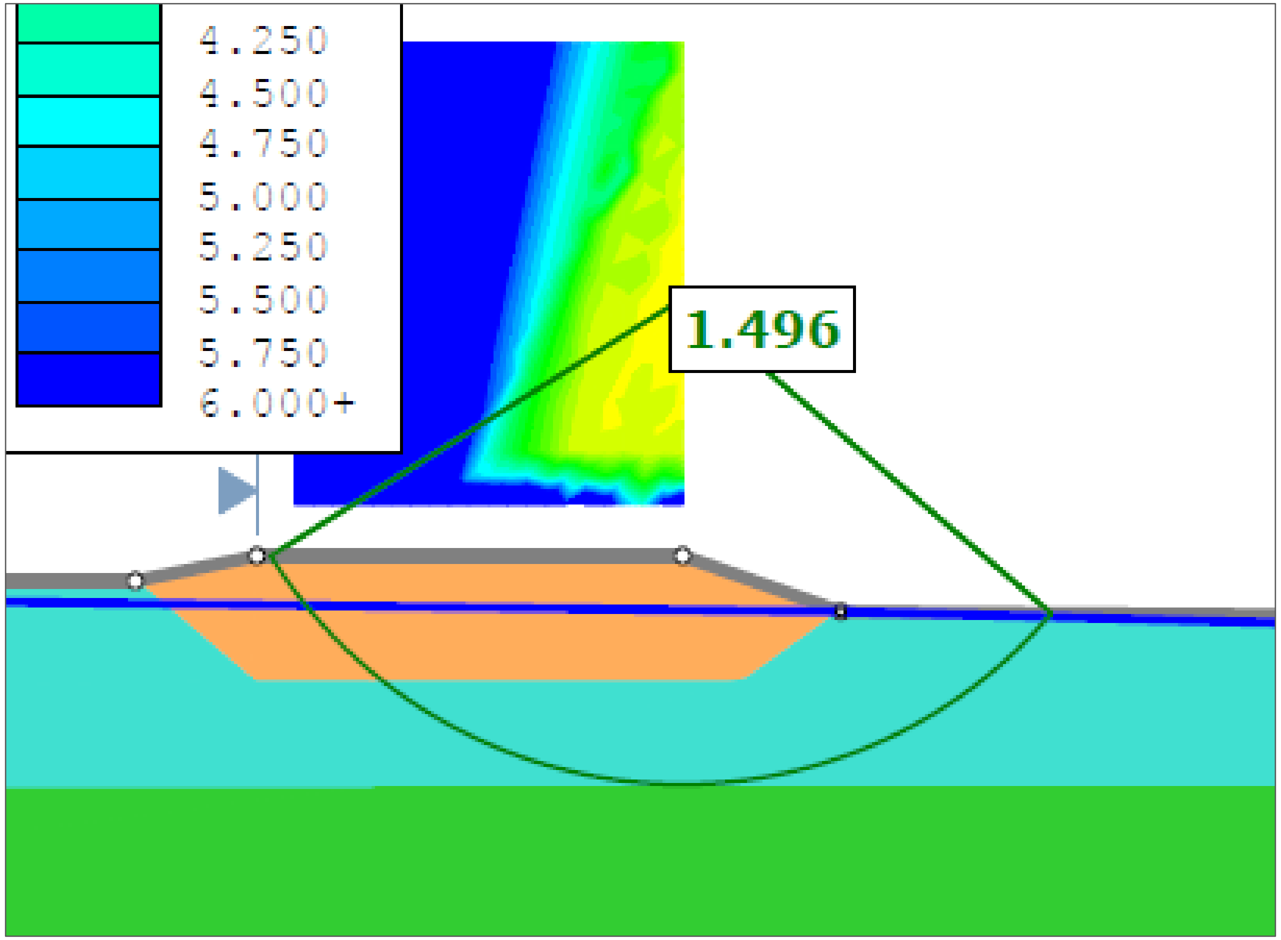
No. 2 of 9. Section A-A'; low tide

Seismic Stability: Effect of Water Level



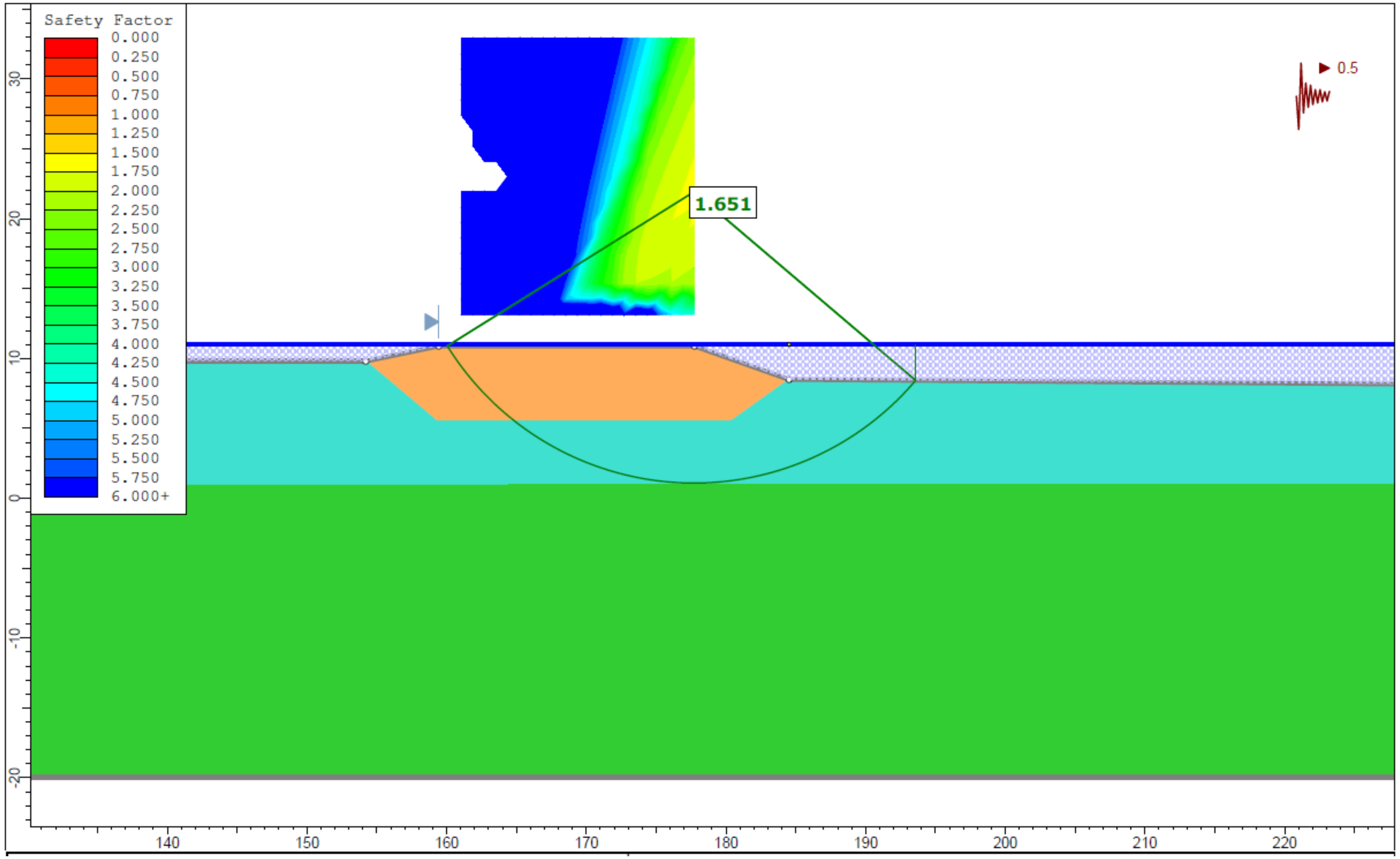
No. 3 of 9. Section A-A'; water at flood elevation

Seismic Stability: Effect of Water Level



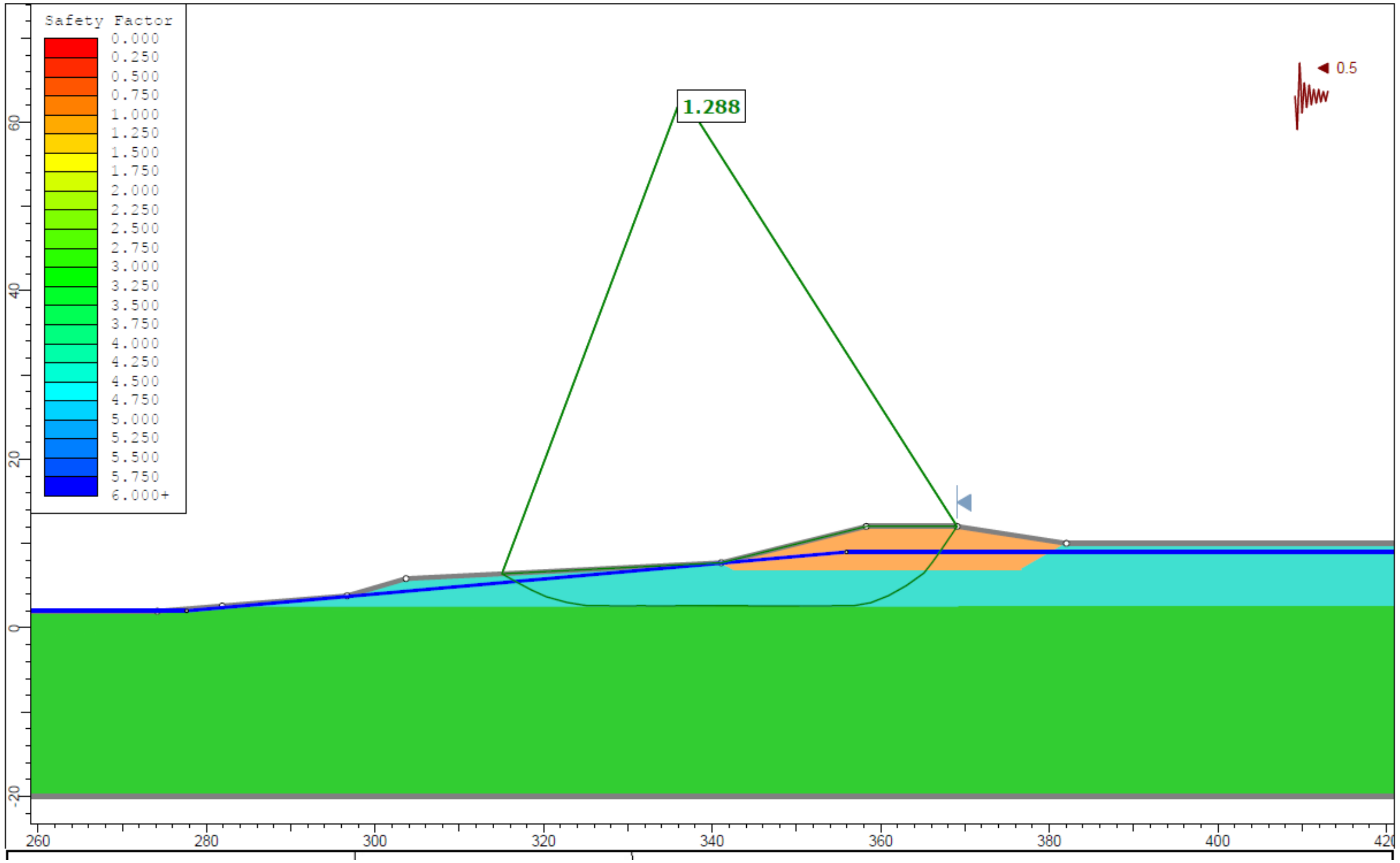
No. 4 of 9. Section E-E′; low tide

Seismic Stability: Effect of Water Level



No. 5 of 9. Section E-E'; water at flood elevation

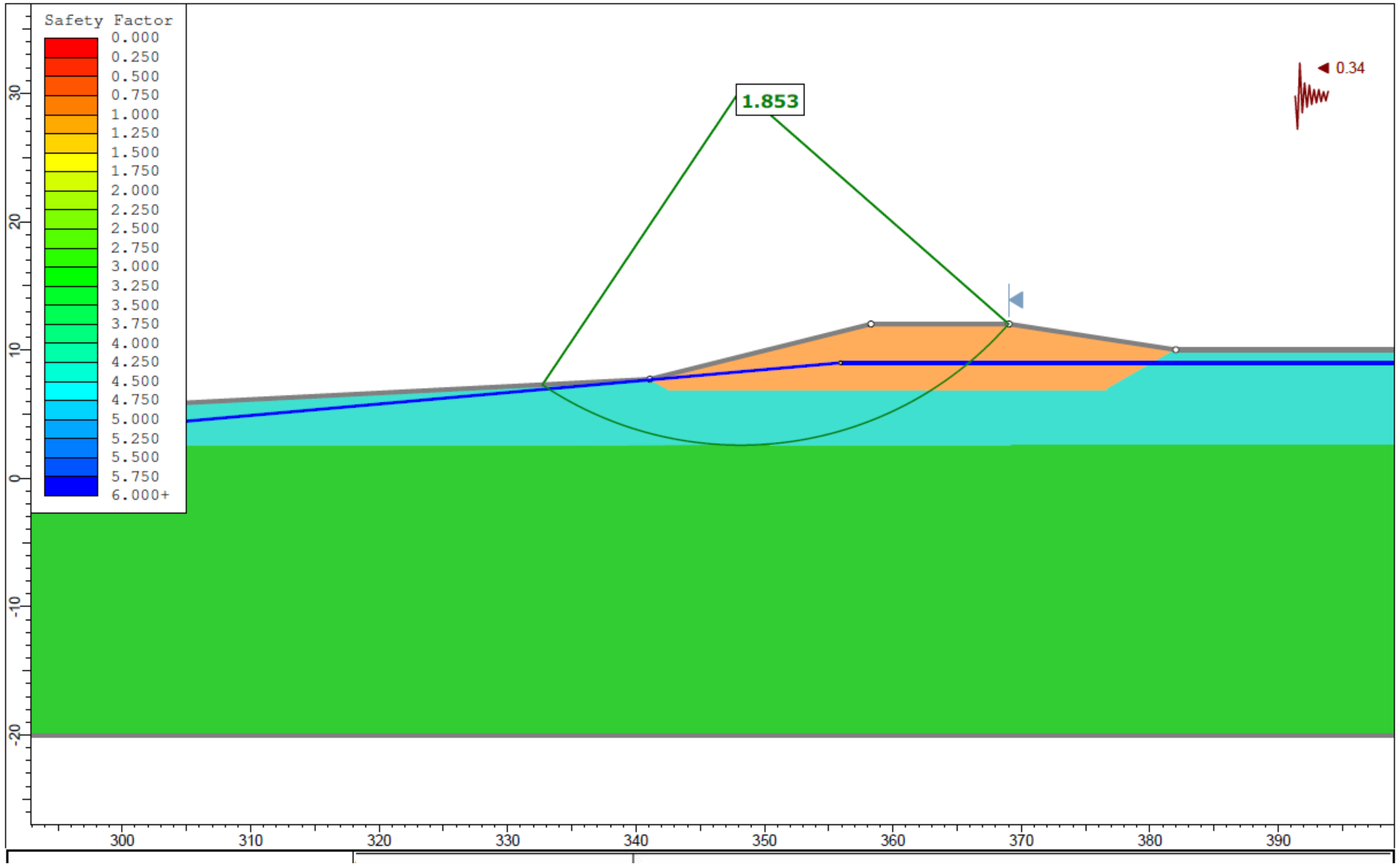
Seismic Stability: Effect of Earthquake Size



No. 6 of 9. Section A-A′ in CLE (475-year return interval)

ANCHOR QEA

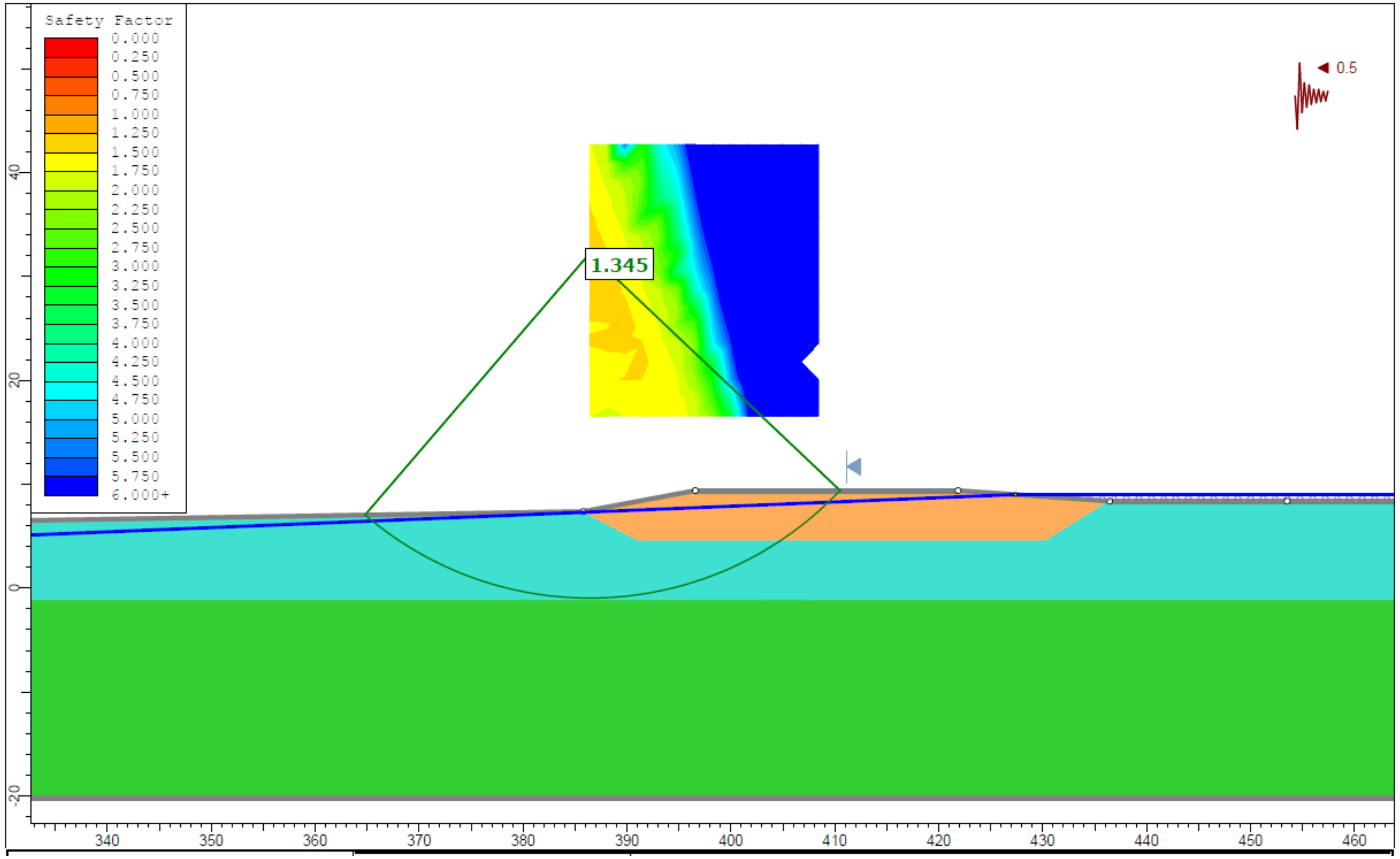
Seismic Stability: Effect of Earthquake Size



No. 7 of 9. Section A-A' in OLE (50-year return interval)

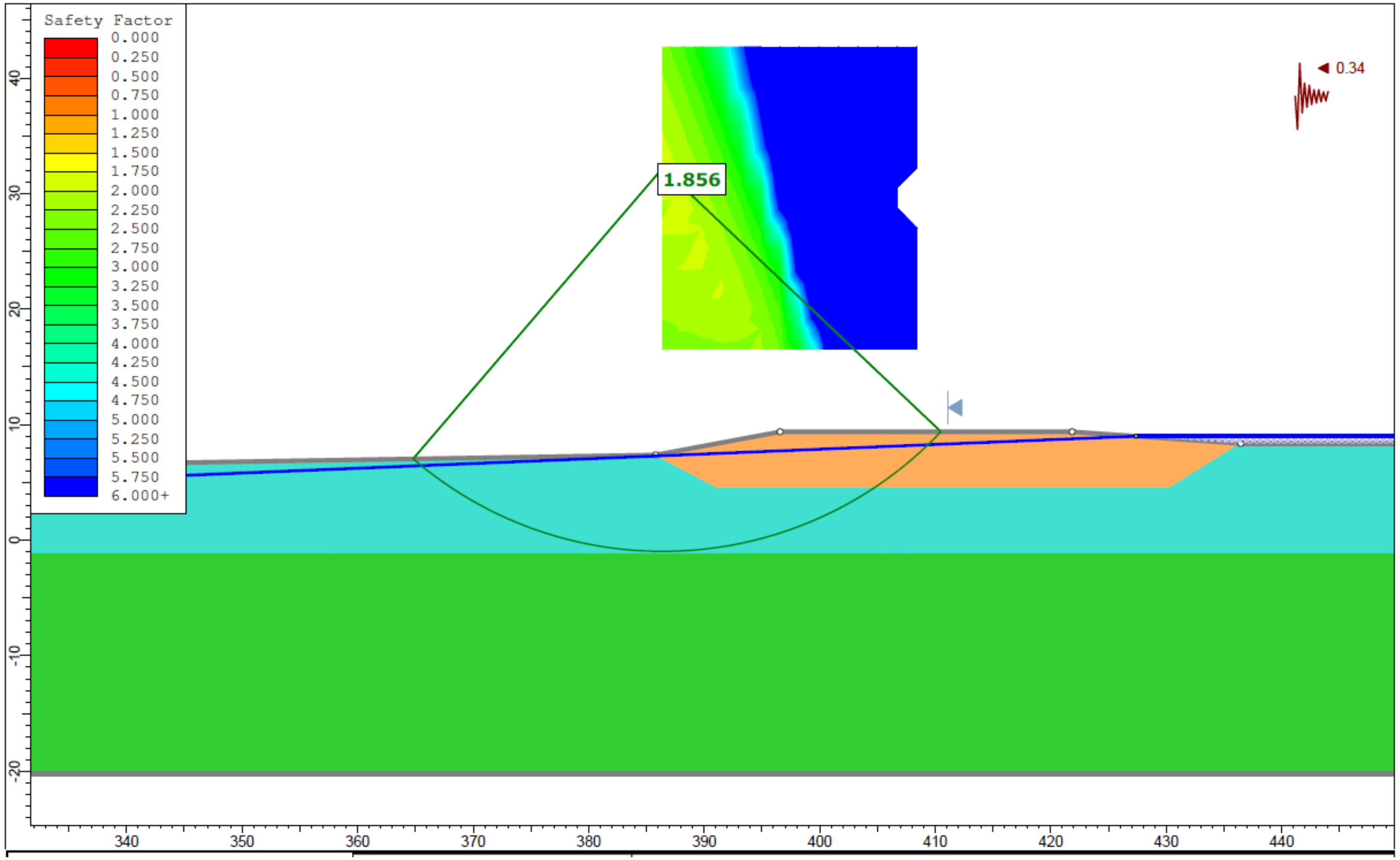
ANCHOR QEA

Seismic Stability: Effect of Earthquake Size



No. 8 of 9. Section B-B′ in CLE (475-year return interval)

Seismic Stability: Effect of Earthquake Size



No. 9 of 9. Section B-B′ in OLE (50-year return interval)

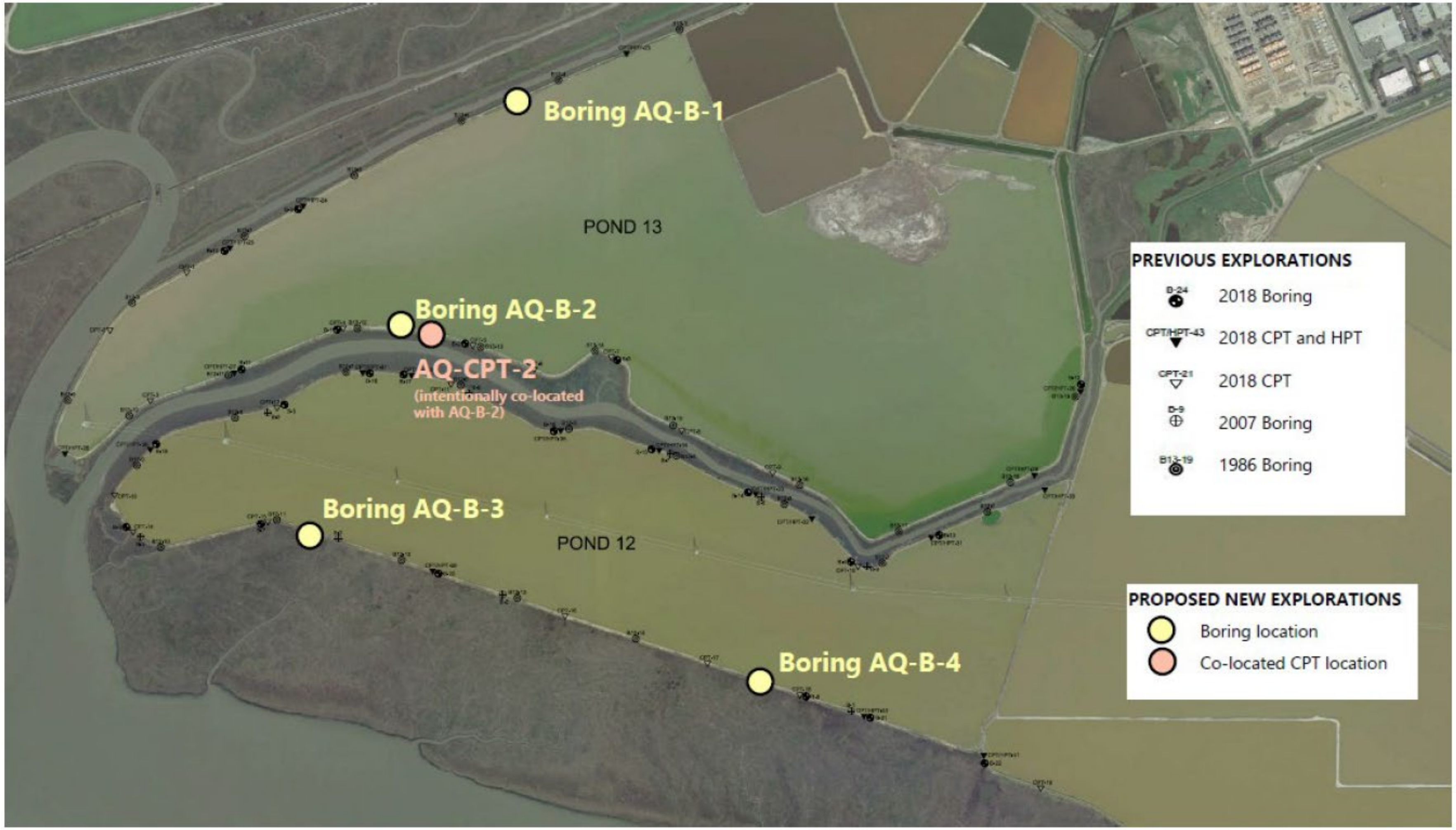
Conclusions

- There is a great deal of subsurface information available for the Pond P2-12 and P2-13 berms, allowing for a robust analysis of their stability.
- The berms appear sufficiently stable under static and conservatively selected seismic scenarios (475-year earthquake)
- Based on expected performance of berms during various conservative earthquake scenarios, the risk of a berm breach and MSS release is unlikely. Ecological or human development impacts are thus unlikely as well.

ANCHOR QEA

Proposed Additional Explorations

Proposed Additional Explorations



Additional Explorations

- Reaching deeper layers will improve estimation of seismic conditions, stability (including soil liquefaction potential), and other parameters
  - Propose: four 100-foot explorations, spread across ponds P2-12 and P2-13
  - Samples (with blow counts) every 5 feet from the surface to full depth
    - Shelby tubes at selected intervals, targeting expected clay layers
  - Laboratory tests: strength tests, plasticity (Atterberg limits), grain size, specific gravity, moisture content
  - One co-located CPT

ANCHOR QEA

Questions and Discussion

© 2023 Cargill, Incorporated. All rights reserved.