

Geotechnical Desktop Study

MEMO

TITLE Geotechnical Desktop Study
Port of Redwood City - Ferry Terminal Project

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REVISION 3

1 Introduction

The proposed Port of Redwood City Ferry Terminal Project (Project) includes development of a ferry terminal, parking lot, hotel, restaurant, and office space at the Port of Redwood City.

COWI was tasked with performing a geotechnical desktop study to review the currently available geotechnical information and provide recommendations for additional geotechnical investigations for the Project.

1.1 Background

The Project Site is located in Redwood City, in the southwestern portion of San Francisco Bay. Figure 1-1 presents the Project Site Regional Map. As shown in Figure 1-2, the Project Site is bordered by Redwood Creek to the west, Westpoint Slough to the north, Frontage Road and Union Pacific Railroad tracks to the east, and an aggregate and cement marine terminal operated by Cemex Construction Materials (CEMEX) to the south.

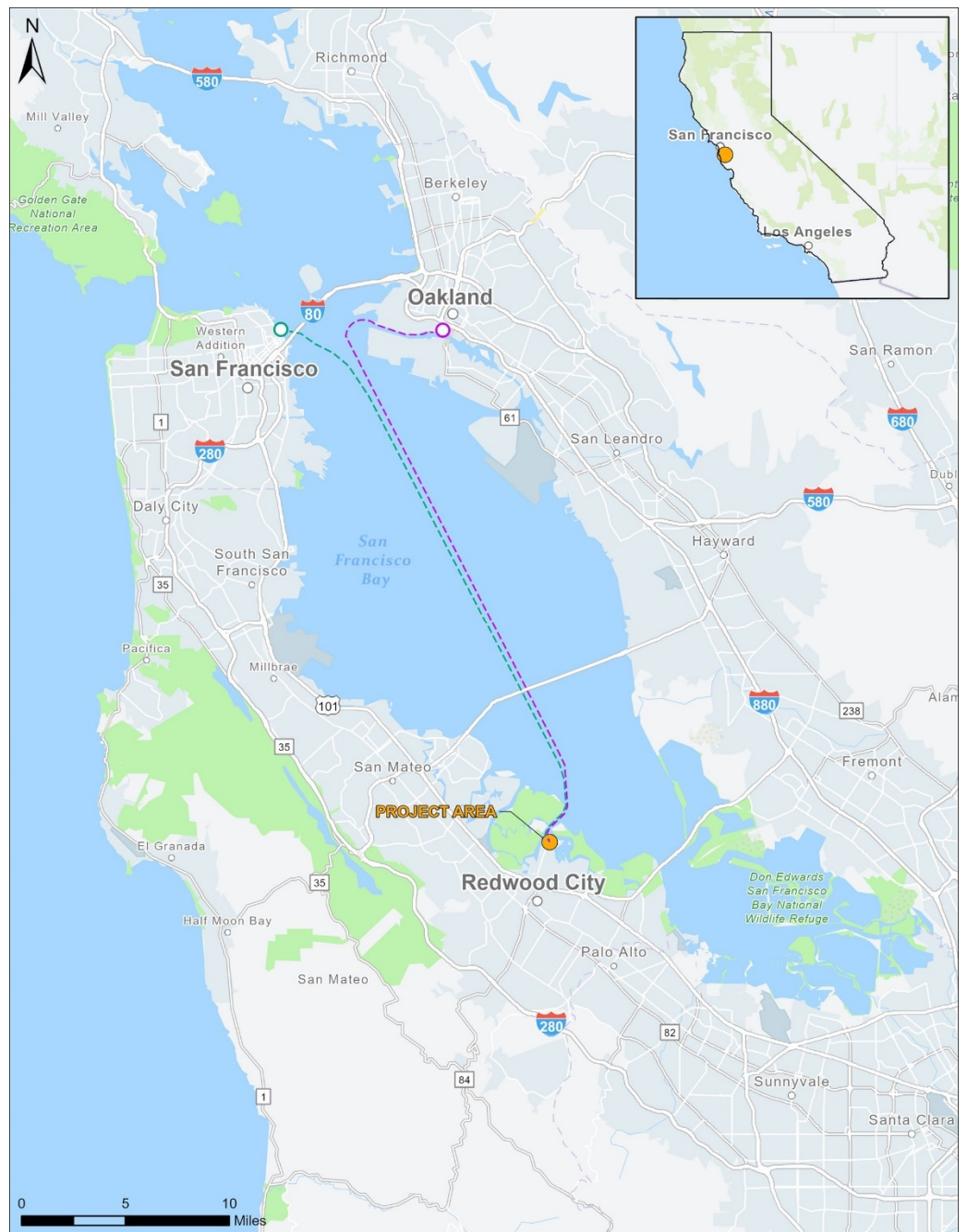
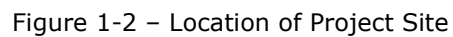


Figure 1-1 – Project Site Regional Map



VIEWPOINT

PROPOSED METAL OFFICE AND PARKING FOOTPRINT

SF BAY TRAIL

TERMINAL

ICYCLE PARKING LOCKERS (16 SPACES)

BUS STOP AND TURNOUT

PULLOUT/LOADING AREA
APPROX 100' OFFSET FROM SHORE

20' GREEN BUFFER

200 PARKING SPACES

APPROX LOCATION OF PROPERTY LINE

REMOVE AND REPLACE RAIL TRACKS

RELOCATE MAINTENANCE SHED

5 PARKING SPACES REMOVED

EXISTING RAIL LINES

22' WIDENING

2 PARKING SPACES REMOVED

TWO-WAY CLASS 1 BIKEWAY

13' WIDENING

TYPICAL SECTION

20' GREEN BUFFER

200 PARKING SPACES

APPROX LOCATION OF PROPERTY LINE

REMOVE AND REPLACE RAIL TRACKS

RELOCATE MAINTENANCE SHED

5 PARKING SPACES REMOVED

EXISTING RAIL LINES

22' WIDENING

2 PARKING SPACES REMOVED

TWO-WAY CLASS 1 BIKEWAY

13' WIDENING

TYPICAL SECTION

Figure 1-3 - Project Site Plan

The Project Site, covering approximately 9 acres on Port property, was used by CEMEX for gravel stockpiling and distribution operations. CEMEX is currently in the process of vacating the site and, pursuant to lease terms, is removing landside improvements located on-site, including a storage building, equipment and machinery, and stockpiles. According to a Light Detection and Ranging (LiDAR) survey conducted by eTrac Inc. in 2023, the ground surface elevation varies significantly across the Project Site, depending on the locations of gravel stockpiling. At gravel stockpiling locations, ground surface elevation ranges from 30 feet to 40 feet MLLW¹, otherwise, ground surface elevation ranges from about 7 feet to 11 feet MLLW. The gravel stockpiling locations can be seen in the aerial background image of Figure 1-3.

1.2 Scope of Work

Spatially, this study covers the onshore portions of the Project Site (see Figure 1-4). The conclusions and recommendations of this memo apply to these extents only.

Note, this study does not cover the offshore portions of the Project, including the ferry terminal structures. Conclusions and recommendations from this memo should not be assumed to extend to offshore areas.

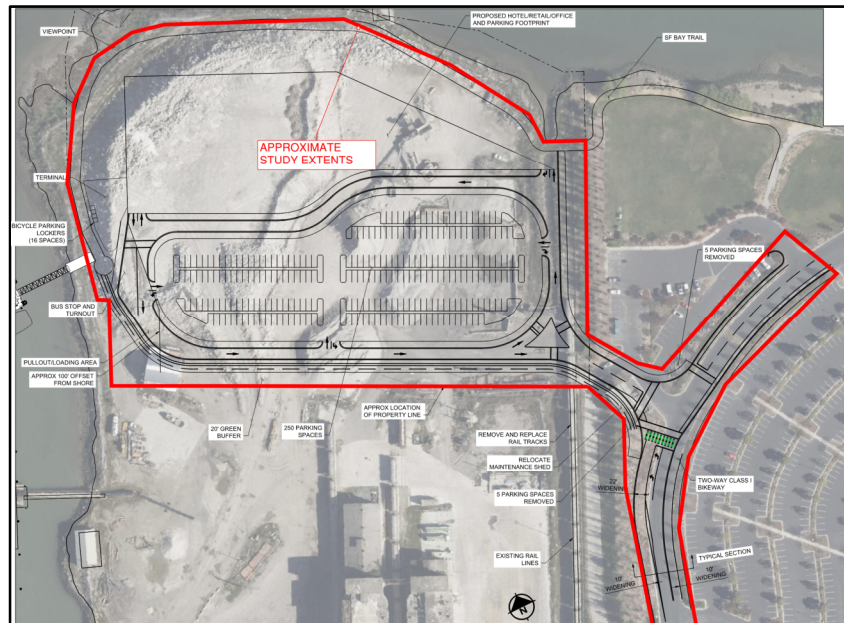


Figure 1-4 – Desktop Study Extents

This memo documents the following for the onshore portion of the Project Site:

¹ Elevations are based on Mean Lower Low Water (MLLW) datum.

- > Summary of available information (Section 2 and Section 4)
 - > Subsurface exploration, laboratory testing, and interpreted subsurface conditions (Section 2)
 - > Seismicity and seismic hazards (Section 4)
- > Applicability of available information to the Project (Section 3 and Section 4)
 - > Subsurface exploration, laboratory testing, and interpreted subsurface conditions (Section 3)
 - > Seismicity and seismic hazards (Section 4)
- > Considerations for other specific potential geotechnical hazards (Section 5)
- > Conclusions and recommendations for site-specific geotechnical investigations (Section 6)

2 Summary of Available Geotechnical Information

A summary of the currently available information is provided in this Section 2 and in Section 4.

- > "Preliminary Geotechnical Evaluation, CEMEX Port of Redwood City Ready-Mix Concrete Plant, Redwood City, California." Prepared by GEOCON Consultant Inc. Dated December 7, 2020.
- > "Geotechnical Investigation, Port of Redwood City - Wharves 1 & 2 Replacement Project, Redwood City, California." Prepared by Treadwell & Rollo (A Langan Company). Dated January 16, 2012.
- > "Mitigated Negative Declaration for the RMC Pacific Materials Construction Materials Park, Port of Redwood City, California." Prepared by Science Applications International Corporation. Dated November 2001.
- > "Final Environmental Impact Report for the Pacific Shores Center Project." Prepared by RECON Environmental Corp. Dated March 1995.

This section summarizes the scope of the 2012 Report and the available geotechnical exploration, testing, and interpreted subsurface conditions only. Applicability of this information to the Project Site is discussed in Section 3. The summary of seismicity and seismic hazards is provided in Section 4.

Note that the 2020 Report outlines the geotechnical/seismic conditions at the CEMEX Port of Redwood City Ready-Mix Concrete Plant, situated directly south of the Project Site. The geotechnical/seismic conditions discussed are primarily based on the information provided in the 2012 Report and include a summary similar to that presented in this memorandum. Nevertheless, the 2020 Report includes the results of soil corrosion and soil expansion index tests, which are not included in the 2012 Report and are therefore inferred in Sections 5.2 and 5.3, respectively.

The 2001 Report and the 1995 Report primarily present the environmental setting and impacts of their proposed developments. The 2001 Report is about the Construction Materials Park development (CEMEX) which is currently at the Project Site. The 1995 Report is about the Pacific Shores Center development located directly east of the Project Site.

While the 2001 Report and 1995 Report have brief descriptions of the geotechnical/seismic conditions of their sites, the 2012 Report contains comparatively more detailed geotechnical and seismic descriptions with supporting field exploration records. Therefore, the information included in the 2012 Report

was utilized as the basis to summarize the geotechnical/seismic conditions of the Project Site and related content of the 2001 Report and 1995 Report are not inferred herein.

2.1 2012 Report Scope

Treadwell & Rollo conducted a geotechnical investigation for the Wharves 1 & 2 Replacement Project at the Port of Redwood City, California, including the demolition of existing structures and construction of a new wharf, parking lot, and Longshoreman's building. The Wharves 1 & 2 Replacement Project site is located approximate 1,000 feet southwest from the current (Ferry Terminal) Project Site, as shown in Figure 2-1.

The investigation aimed to develop conclusions and recommendations for the design and construction of the Wharves 1 & 2 Replacement Project improvements. Key seismic/geotechnical concerns, which are applicable to the Project Site, are identified in the 2012 Report. The 2012 Report concludes that the planned development in the Wharves 1 & 2 Replacement Project is feasible if the identified seismic/geotechnical concerns are addressed. The 2012 Report indicates that the conclusions made are based on limited subsurface exploration and laboratory testing. Variations in soil conditions may occur, which could necessitate adjustments to the conclusions if such variations are encountered at the Wharves 1 & 2 Replacement Project site. The 2012 Report indicated that additional subsurface exploration may be required for the final design of the Wharves 1 & 2 Replacement Project.

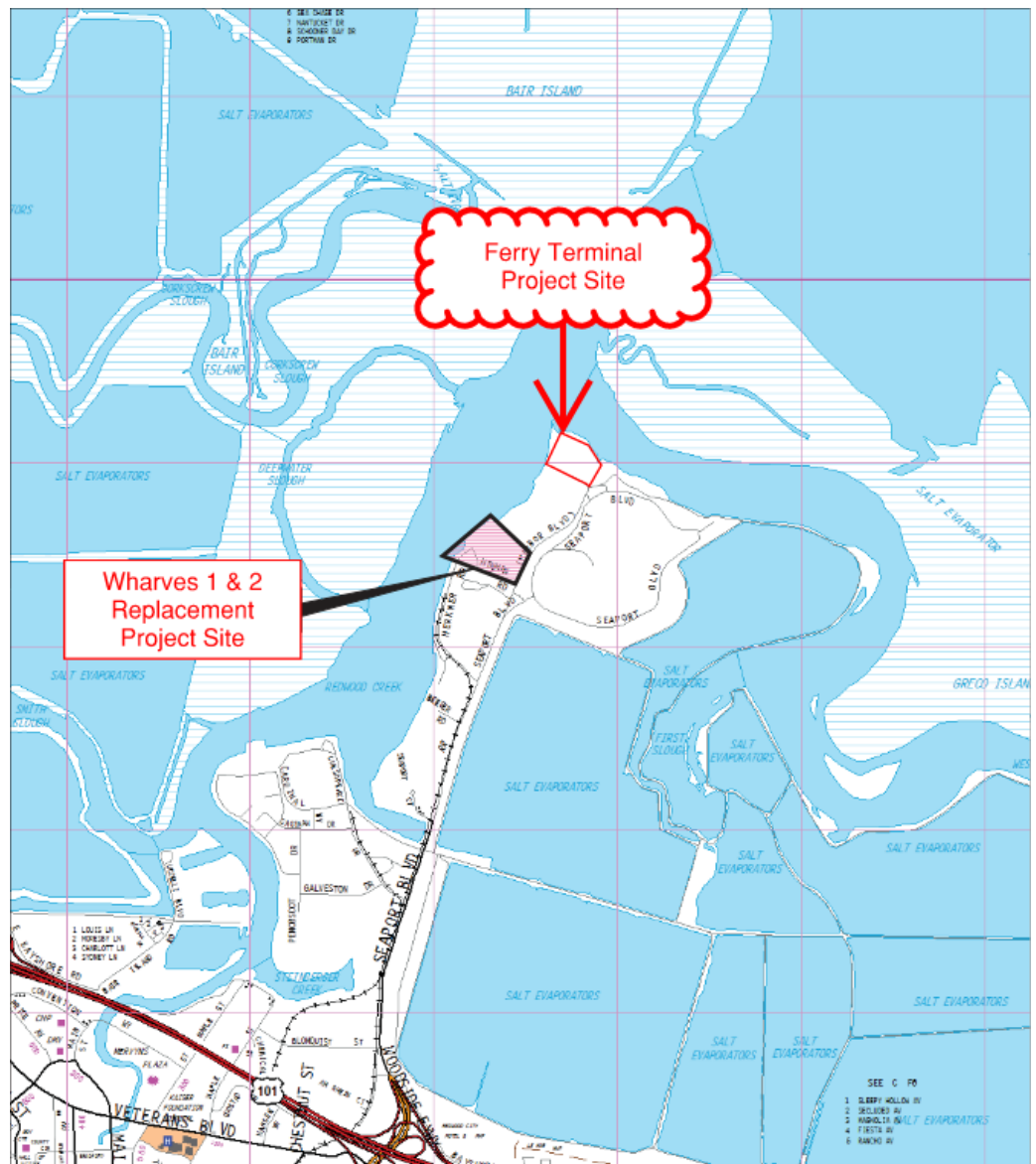


Figure 2-1 – Wharves 1 & 2 Replacement Project Site Vicinity Map (extracted from the Treadwell & Rollo 2012 geotechnical report)

2.2 Previous Geotechnical Explorations

The 2012 Report provides information from the following previously performed subsurface explorations:

- > Hultgren-Tillis Engineers (1999) exploration
- > Treadwell & Rollo (2011) exploration

2.2.1 Hultgren-Tillis Engineers (1999) Exploration

Four (4) rotary wash borings (offshore) and one (1) Cone Penetration Test (CPT) (onshore) were conducted during subsurface exploration at the RMC Lonestar Terminal, near the Project Site. The depth of this exploration ranges from 21 feet to 95 feet below mudline for borings and approximate 120 feet below ground surface for CPT. The Hultgren-Tillis Engineers 1999 exploration location is shown in Figure 2-2.

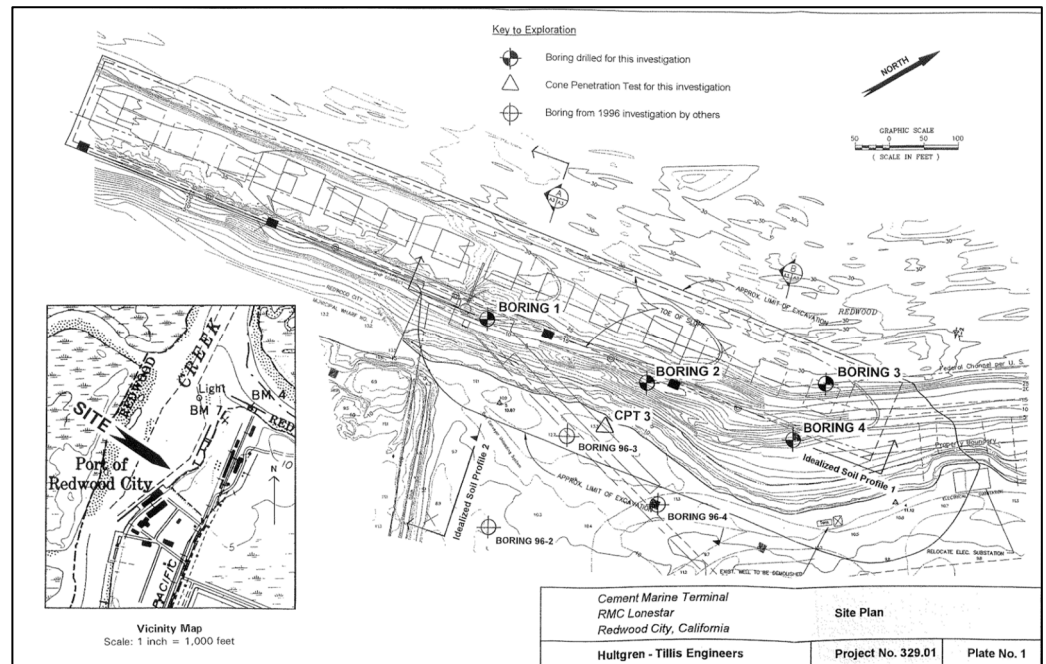


Figure 2-2 – Exploration Location Plan for Hultgren-Tillis Engineers (1999) exploration

2.2.2 Treadwell & Rollo (2011) Exploration

Additional investigations were conducted in the proximity of previous investigations. A total of four (4) test borings and six (6) CPTs of which two (2) borings (B-1 and B-2) and two (2) CPTs (CPT-1 and CPT-2) were offshore; two (2) borings (B-3 and B-4) and four (4) CPTs (CPT-3 through CPT-6) were onshore. The depths of the borings and CPT range from 56.5 feet to 146.5 feet below surface/mudline and 79.7 to 100 feet below surface/mudline, respectively. The Treadwell & Rollo 2011 exploration location is shown in Figure 2-3.

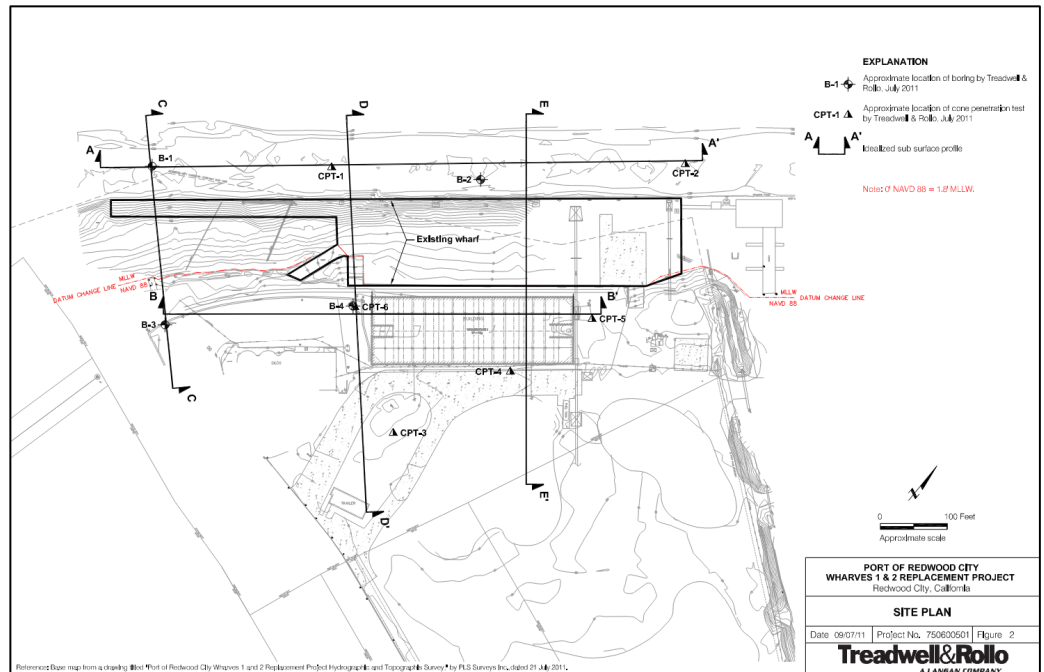


Figure 2-3 – Exploration Location Plan for Treadwell & Rollo (2011) exploration

2.2.3 Summary

Table 2-1 - Summary of Previous Geotechnical Investigation

Date	Boring/CPT No.	Offshore/ Onshore	Termination Depth (feet)	Performed by
12/10/98	Boring 1	Offshore	70	Hultgren-Tillis Engineers
12/05/98	Boring 2	Offshore	21	Hultgren-Tillis Engineers
12/03/98	Boring 3	Offshore	94.75	Hultgren-Tillis Engineers
12/04/98	Boring 4	Offshore	31.2	Hultgren-Tillis Engineers
Not known	CPT 3	Onshore	120	Hultgren-Tillis Engineers
07/05/11	B-1	Offshore	141.5	Treadwell & Rollo
07/08/11	B-2	Offshore	146.5	Treadwell & Rollo
07/12/11	B-3	Onshore	56.5	Treadwell & Rollo
07/13/11	B-4	Onshore	84.5	Treadwell & Rollo
07/06/11	CPT-1	Offshore	100	Treadwell & Rollo
07/07/11	CPT-2	Offshore	92.5	Treadwell & Rollo
07/11/11	CPT-3	Onshore	79.7	Treadwell & Rollo
07/11/11	CPT-4	Onshore	80	Treadwell & Rollo
07/11/11	CPT-5	Onshore	79.7	Treadwell & Rollo
07/11/11	CPT-6	Onshore	79.7	Treadwell & Rollo

2.3 2012 Laboratory Testing

Laboratory tests were performed on selected samples to measure soil fines content (percentage passing the No. 200 sieve), Atterberg limits, moisture content, dry density, and shear strength. The results of the laboratory testing are presented in Appendix C of the 2012 Report.

2.4 Interpreted Onshore Subsurface Conditions

The 2012 Report indicated diverse subsurface conditions across the Wharves 1 & 2 Replacement Project site at the Port of Redwood City. Onshore, the 2012 Report indicated that the Wharves 1 & 2 Replacement Project site consisted of the following:

- > Undocumented fill consisting of soft to stiff clay and silt with intermittent layers of sand and gravel, typically ranging from 8 to 12 feet thick.
- > Beneath this fill is a soft to medium stiff marine clay layer known as Bay Mud, which varies in thickness from approximately 24 to 40 feet and is highly compressible under new loads.
- > Below the Bay Mud, a layer of medium dense to very dense granular material composed of silty/clayey sand and gravel was found, extending up to 7 feet thick.
- > At greater depths, stiff to hard silt and clay with occasional sand lenses extend to the maximum explored depth.

2.5 Groundwater (Inferred from 2020 Report)

The 2020 Report reviewed the groundwater elevation information for ten (10) monitoring wells (MW-1 and MW-2 and MW-19 through MW-26) wells. Depth to groundwater at time of measurement (January 4, 2018) was reported at approximate depths ranging from just below the ground surface to 8.5 feet. The 2020 Report anticipate that the elevation of groundwater at the site will coincide with the water level in the shipping channel and Bay, and will likely fluctuate due to tidal variation, precipitation, and other factors.

3 Applicability of Available Subsurface Information to the Project Site

This section discusses the applicability of the available information summarized in Section 2 to the onshore portion of the Project Site.

3.1 Soil Stratification

Soil stratification interpreted in the 2012 Report can be considered reliable due to the following considerations:

- > A total of eight (8) drilled borings and seven (7) CPTs were previously conducted. The findings from the borings and CPTs are generally consistent.
- > The Project Site is approximately 1,000 feet northeast of the Wharves 1 & 2 Replacement Project site. Based on proximity, it is reasonable to expect similar soil strata at the Project Site.

3.2 Soil Engineering Properties

Engineering properties of each soil strata from the 2012 Report should be utilized for preliminary design only for the onshore portion of the Project Site due to the following considerations:

- > The engineering properties of fill can vary significantly due to differences in the fill source, placement method, as well as compaction effort.
- > Limited number of tests were performed for undocumented fill with only one standard penetration test and one undrained shear strength test conducted.
- > Detailed seismic hazard reviews with adequate site-specific data is needed. Given the Project Site's high seismicity (see Section 4 below), a thorough seismic hazard review with adequate site-specific data is essential. Anticipated strong ground shaking from nearby faults and associated seismic hazards, such as liquefaction-induced settlement, cyclic densification, lateral spreading, and seismic movement of shoreline slope, necessitate careful consideration and review.
- > The long-term consolidation behavior of the compressible Bay Mud is critical for the proposed development's performance. Excessive consolidation could adversely impact the pavement, grading, drainage and foundation system. Therefore, site-specific soil sampling and testing for Bay Mud are recommended to ensure the long-term functionality of the onshore portion of the Project Site.

4 Seismicity and Seismic Hazards

This section provides a summary on seismicity and seismic hazards and considers the applicability of this information for the onshore portion of the Project Site.

See Section 2 for further detail about the 2012 Report, which is the basis of the available information summarized here.

4.1 Seismicity

Based on the 2012 Report, the San Andreas and Hayward faults have the highest slip rates and are the most seismically active faults in proximity of the Project Site. Other important sources that are capable of producing large-magnitude earthquakes are the San Gregorio, Calaveras, Rodgers Creek, and Greenville fault zones. The location of the Wharves 1 & 2 Replacement Project site to these major faults in the San Francisco Bay Area is shown in Figure 4-1.

For each major active fault, the distance from the Wharves 1 & 2 Replacement Project site and estimated mean characteristic moment magnitude were extracted from the 2012 Report and are presented in Table 4-1 below.

A site-specific acceleration response spectrum for the Wharves 1 & 2 Replacement Project site was developed and presented in Appendix D of the 2012 Report. In summary, the peak ground accelerations of the Wharves 1 & 2 Replacement Project “onshore” site (relevant to the onshore portion of the Project Site) are 0.252g² for OLE³, 0.397g for CLE⁴, and 0.415g for DE⁵.

Note that the above peak ground acceleration values presented in the 2012 Report applied to the Wharves 1 & 2 Replacement Project and are provided here for reference only. The peak ground acceleration of the onshore portion of the Project Site may be different.

² Gravity (g) is equal to the acceleration of objects under its influence, which at the earth’s surface is approximately 32.2 feet per second squared (feet/sec²)

³ Operating Level Earthquake (OLE), which is defined as having a 50 percent probability of being exceeded in 50 years (72-year return period)

⁴ Contingency Level Earthquake (CLE), which is defined as have a 10 percent probability of being exceeded in 50 years (475-year return period)

⁵ Code-Level Design Earthquake (DE), which shall comply with the Design Earthquake requirements by the 2007 California Building Code (CBCD) and ASCE 7-05

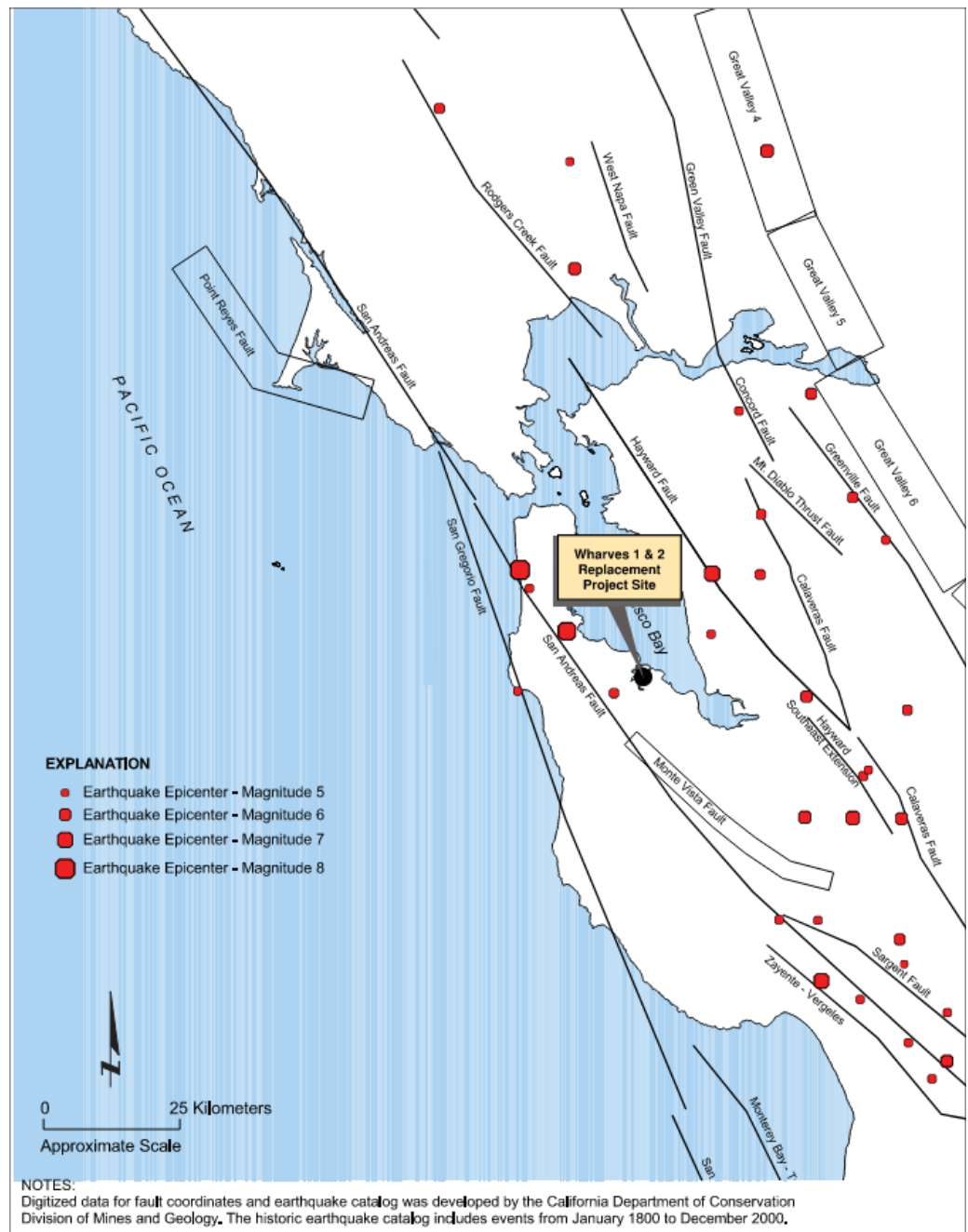


Figure 4-1 – Map of Major Faults and Earthquake Epicenters in the San Francisco Bay Area

Table 4-1 - Regional Faults and Seismicity (extracted from the Treadwell & Rollo 2012 geotechnical report for the Wharves 1 & 2 Replacement Project)

Fault Segment	Approx. Distance of the Wharves 1 & 2 Replacement Project site from fault (km)	Direction from the Wharves 1 & 2 Replacement Project site	Mean Characteristic Moment Magnitude
Monte Vista-Shannon	9.1	Southwest	6.5
N. San Andreas; SAO+SAN+SAP+SAS	10.1	West	8.1
N. San Andreas; SAP	10.1	West	7.2
Hayward-Rodgers Creek; RC+HN+HS	20	Northeast	7.3
San Gregorio Connected	24	West	7.5
Calaveras; CN+CC+CS	31	East	7.0
Hayward-Rodgers Creek; RC+HN	35	North	7.2
Calaveras; CC+CS	36	East	6.5
Mount Diablo Thrust	41	Northeast	6.7
N. San Andreas; SAS	42	Southeast	7.1
N. San Andreas; SAN	44	Northwest	7.5
N. San Andreas; SAO+SAN	44	Northwest	8.0
Green Valley Connected	47	Northeast	6.8
Greenville Connected	50	Northeast	7.0
Zayante-Vergeles	52	Southeast	7.0
Great Valley 5, Pittsburg Kirby Hills	65	Northeast	6.7
Great Valley 7	65	East	6.9
Monterey Bay-Tularcitos	66	South	7.3
Hayward-Rodgers Creek; RC	67	North	7.1
West Napa	73	North	6.7
Point Reyes	73	Northwest	6.9
Ortogonalita	86	East	7.1
Great Valley 4b, Gordon Valley	89	Northeast	6.8
Great Valley 8	93	East	6.8
Quien Sabe	99	Southeast	6.6

4.2 Seismic Hazards

The 2012 Report discussed potential seismic hazards from six primary sources:

- > surface fault rupture
- > ground shaking
- > liquefaction along with associated settlement
- > liquefaction-induced lateral spreading
- > cyclic densification
- > seismic movement of shoreline slope

4.2.1 Fault Rupture

Fault rupture occurs when movement on a fault breaks through to the earth's surface. The Alquist-Priolo Act requires the State Geologist (CGS) to map earthquake fault zones around the surface traces of active faults.

Based on the CGS Alquist-Priolo Earthquake Fault Zones map, the Project Site is not situated within an active fault zone. The potential for fault rupture at the Project Site is relatively low.

4.2.2 Ground Shaking

Based on the 2012 Report, strong to very strong ground shaking is expected to occur at the Wharves 1 & 2 Replacement Project site.

Similar magnitude of strong to very strong ground shaking is also expected at the Project Site. Strong ground shaking during an earthquake can result in ground failures such as soil liquefaction and associated settlement, lateral spreading, cyclic densification, and movement of shoreline slope.

4.2.3 Liquefaction and associated Settlement

Liquefaction is a transformation of soil from a solid to a liquefied state during which saturated soil temporarily loses strength resulting from the buildup of excess pore water pressure, especially during earthquake-induced cyclic loading. Soil susceptible to liquefaction includes loose to medium dense sand and gravel, low-plasticity silt, and some low-plasticity clay deposits.

The 2012 Report identified layers of loose to medium dense sand with varying amounts of silt that may be susceptible to liquefaction during a strong seismic event at the Wharves 1 & 2 Replacement Project site. The estimated liquefaction-induced settlement ranging from approximately 1 to 2.6 inches and 1 to 2 inches for the CLE/DE and OLE levels of ground shaking, respectively. The majority of the potentially liquefiable layers are relatively thin and appear to be discontinuous. An exception was encountered in onshore CPT-5 where a five-foot thick potentially liquefiable layer within five feet of the existing ground surface was encountered. In

addition, the 2012 Report concluded that liquefaction-induced ground surface damage could occur when the peak ground surface acceleration during an earthquake exceeds 0.3g.

Note that the above liquefaction assessments are from the 2012 Report and apply to the Wharves 1 & 2 Replacement Project site and are presented here for reference only. No site-specific soil sample and field testing is available at the Project Site. The actual liquefaction potential and associated settlement of the Project Site may be different and should be re-assessed once the site-specific geotechnical investigation is available.

4.2.4 Lateral Spreading

Lateral spreading is a phenomenon in which surficial soil displaces along a shear zone that has formed within an underlying liquefied layer. Upon reaching mobilization, the surficial blocks are transported downslope or in the direction of a free face by earthquake and gravitational forces.

The Project Site is anticipated to be formed as a flat-lying area which minimizes the formation of pre-existing shear zone. In addition, based on the 2012 Report, the liquefiable layer, if it exists at the Project Site, is not anticipated to be continuous. Therefore, it is unlikely that lateral spreading would occur at the Project Site.

Note that the above lateral spreading assessment is based on the assumption that the Project Site will be formed as a flat-lying area and the seismic-induced movement of the adjacent shoreline slope is minimal. The actual lateral spreading potential at the Project Site should be re-assessed once the site-specific geotechnical investigation is available.

4.2.5 Cyclic Densification

Seismically-induced compaction or cyclic densification of non-saturated sand (i.e., sand above the groundwater table) resulting from earthquake vibrations may cause differential settlement.

The 2012 Report calculated less than 2/3-inch of cyclic densification of the loose to medium dense sand encountered above Elevation 0 feet.

No site-specific soil sample and field testing is available at the Project Site. The cyclic densification calculated in the 2012 Report is provided for reference only. Due to variability in the composition of the existing fill, the amount of cyclic densification at the Project Site will likely vary significantly. The cyclic densification potential of the Project Site should be re-assessed once the site-specific geotechnical investigation is available.

4.2.6 Seismic Movement of Shoreline Slope

The 2012 Report evaluated the stability of the shoreline slope for the Wharves 1 & 2 Replacement Project and a minimum factor of safety (FOS) of 1.7 was calculated in static condition. This FOS is considered adequate. In addition, the estimated permanent lateral displacement of the shoreline slope due to CLE/DE and OLE seismic events is less than 4 inches but can be significantly increased to 17 inches, if 4 feet of fill is placed at the top of the slope.

The slope movement at the Project Site may differ significantly from movements discussed above, depending on the slope geometry, future site elevation, and service load, etc. In addition, no site-specific soil sample and field testing is available at the Project Site. The results of slope movement of shoreline slope calculated in the 2012 Report should be considered for reference only. The seismic movement of the shoreline slope at the Project Site should be re-assessed once the site-specific geotechnical investigation is available.

5 Other Geotechnical Hazards

5.1 Compressible Bay Mud

Based on Section 2.4, the Project Site is expected to consist of Bay Mud, typically characterized as normally consolidated and lightly consolidated, highly plastic clays. The Bay Mud thickness ranges from 24 to 35 feet, as noted in the 2012 Report. Although no consolidation tests were conducted, it is anticipated that the Project Site will experience consolidation settlement if additional fill is placed.

5.2 Soil Corrosion

The corrosivity of the onshore near-surface soil was evaluated by JDH Corrosion Consultants (JDH) of Concord, California as well as GEOCON of Sacramento, California as presented in the 2012 Report and 2020 Report, respectively. JDH and GEOCON conducted tests on a soil sample from Boring B-3 and CPT1/CPT2 to assess their corrosion potential for buried metals and concrete. The test results are summarized in Table 5-1, and JDH's detailed report can be found in Appendix C of the 2012 Report.

Table 5-1 - Summary of Corrosivity Test Results

Test Boring	Sample Depth (feet)	pH	Sulfate (ppm)	Resistivity (ohms-cm)	Redox (mV)	Chloride (ppm)
B-3	Near Surface	8.4	230	220	450	1,200
CPT1/CPT2-Bulk	0-5	6.5	42.4	250	N.A.	170.2

The soil sample tested (from B-3) by JDH is classified as "severely corrosive" to various materials, including iron, steel, and concrete. JDH recommended that all below-grade improvements incorporate corrosion control measures such as using Type II modified cement, special coatings, and cathodic protection systems. Detailed recommendations are provided in JDH's report in Appendix C of the 2012 Report.

GEOCON classified the soil as "very corrosive" (Ellis 1978) with respect to corrosion of buried steel improvements based on the measured minimum resistivity of tested sample (CPT1/CPT2-Bulk). Mitigation provided by GEOCON consists of cathodic protection or corrosion resistant coatings. It is also suggested other corrosion parameters do not indicate a significant corrosive environment to concrete and other materials.

5.3 Soil Expansiveness

Expansive surface soil above the groundwater level is subject to high volume changes during seasonal fluctuations in moisture content. These volume changes can cause cracking of foundations and floor slabs.

Based on Section 1803.5.3 of the 2022 California Building Code, soils meeting all four of the following provisions shall be considered to be expansive, except that tests to show compliance with Items 1, 2, and 3 shall not be required if the test prescribed in Item 4 is conducted:

- 1) Plasticity index (PI) of 15 or greater, determined in accordance with ASTM D4318.
- 2) More than 10 percent of the soil particles pass a No.200 sieve (75 μ m), determined in accordance with ASTM D422.
- 3) More than 10 percent of the soil particles are less than 5 micrometers in size, determined in accordance with ASTM D422.
- 4) Expansion index greater than 20, determined in accordance with ASTM D4829.

The above tests (for soil above groundwater level) are not discussed in the 2012 Report. The 2020 Report present the results of soil expansion potential test for a near-surface soil. The test result is summarized in Table 5-2.

Table 5-2 – Expansion Index and Atterberg Limits Test Summary

Test Boring	Sample Depth (feet)	Liquid Limit (%)	Plasticity Index (%)	USCS Classification	Expansion Index	Expansion Potential Classification*
CPT1/ CPT2-Bulk	0-5	35	11	ML	64	Medium

*Expansion Potential Classification per ASTM D4829.

Based on the test results and the predominant near-surface soil type at the site, the 2020 Report anticipate the overall expansion potential is low to medium. The 2020 Report provides typical mitigation measures for soils with low to medium expansion potential include placing a layer of low-expansive material beneath buildings and concrete flatwork, as well as utilizing deepened footings.

5.4 Soil Erosion

Soil erosion is the process by which the top layer of soil is removed and transported by natural forces such as water.

While the shoreline slope at the Project Site is susceptible to erosion from wave action, the developments on the onshore portion of the Project Site are expected to prevent soil exposure to wind or water. Therefore, the risk of soil erosion at the onshore portion of the Project Site is anticipated to be low.

6 Conclusions and Recommendations

The 2012 Report for the Wharves 1 & 2 Replacement Project provides information on the subsurface conditions that are likely relevant to the Project Site.

Conclusions regarding seismic hazards and other geotechnical hazards are summarized in Sections 6.1 and 6.2, respectively. Note that the conclusions are based on the 2012 Report and are provided for reference only. The actual seismic/geotechnical hazards or other unknown hazards at the onshore portion of the Project Site may differ and should be re-assessed with a site-specific geotechnical investigation.

The site-specific geotechnical investigations in Section 6.3 are recommended to evaluate/confirm the potential seismic/geotechnical hazards and ensure the successful development of the onshore portion of the Project Site.

6.1 Seismic Hazards

Based on the 2012 Report, the following potential seismic hazards should be considered at the onshore portion of the Project Site:

- > strong ground shaking,
- > liquefaction and associated settlement,
- > cyclic densification,
- > lateral spreading, and
- > seismic movement of shoreline slope

The risk of surface fault rupture at the Project Site appears to be relatively low.

6.2 Other Geotechnical Hazards

Based on the 2012 Report, the Project Site may have highly plastic Bay Mud 24 to 35 feet thick. Consolidation settlement may occur if additional fill is placed.

Soil tests presented in the 2020 Report and 2012 Report indicate a "very corrosive" and "severely corrosive" environments for buried metals and concrete, necessitating robust corrosion control measures.

While soil expansiveness could pose a risk to foundations and slabs, specific tests to determine the soil expansiveness were not available in the 2012 Report.

The anticipated developments on the onshore portion of the Project Site (parking lot and hotel/restaurant/office space) are expected to minimize soil exposure to wind and water actions, thereby minimizing the risk of soil erosion.

6.3 Recommendations for Site-Specific Geotechnical Investigations

For the Project Site, the following site-specific geotechnical investigations are recommended:

- > Additional Boreholes: additional borehole(s) to be drilled and terminated at minimum 100 feet with soil sampling across the Project Site to confirm subsurface conditions.
- > In-Situ Testing: Conducting Standard Penetration Tests (SPT) and/or Cone Penetration Tests (CPT) in the new boreholes.
- > Groundwater Monitoring: Installing piezometers to monitor groundwater levels at the Project Site.
- > Laboratory Testing: Performing laboratory tests on soil samples from the new boreholes, including grain size distribution, Atterberg limits, moisture content, compaction test, expansion index, shear strength, and consolidation tests, etc. When applicable, perform necessary tests on new fills, such as a compaction test, etc. for roadway design.