3.5

GEOLOGY

3.5.1 Introduction

This section presents the geologic conditions for the proposed project area and analyzes: (1) seismic hazards, including surface rupture, ground shaking, liquefaction, subsidence, tsunamis, and seiches; (2) other geologic issues, including potentially unstable soils and slopes; and (3) mineral resources. This analysis is based on published reports and the general geologic setting as indicators of potential geologic hazards. During both construction and operation, the proposed Project would be exposed to significant and unavoidable seismic-related impacts as a result of numerous active faults in southern California.

3.5.2 Environmental Setting

3.5.2.1 Regional Setting

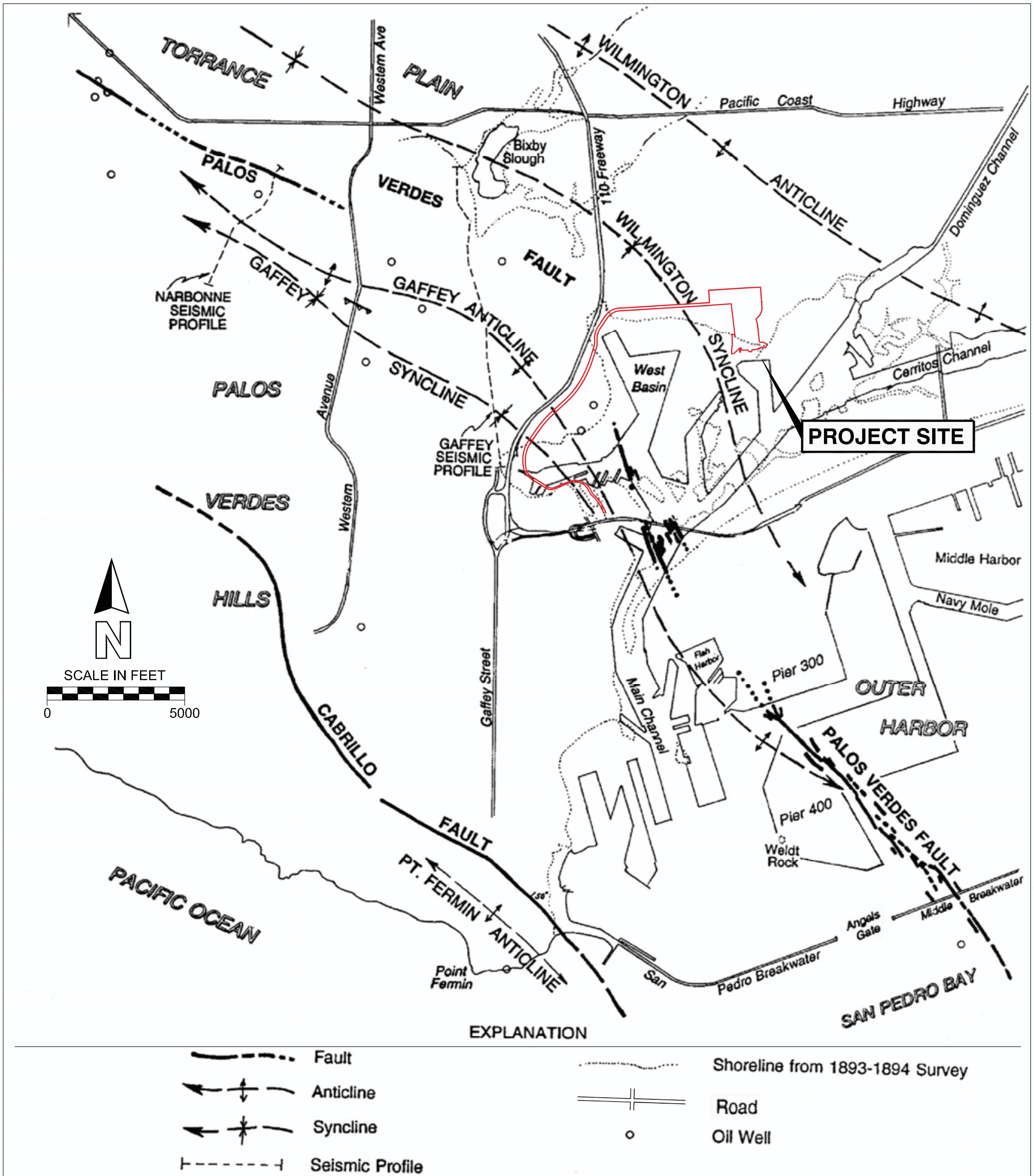
The proposed project site is located near sea level in the coastal area of the Los Angeles Basin, a low-lying plain that rises inland to the Santa Monica Mountains to the north, the Repetto and Puente Hills to the northeast, the Santa Ana Mountains to the east, and the San Joaquin Hills to the southeast. The basin is bordered on the west by the Pacific Ocean and the Palos Verdes Hills. The geologic structure of the West Los Angeles Basin is characterized by several northwest-trending folds and faults. The major folds in the area include the Gaffey and the Wilmington anticline-synclines. The Wilmington syncline crosses the proposed project site through the proposed Harry Bridges Boulevard Buffer, and the smaller Gaffey anticline-syncline crosses the proposed bike lane and California Coastal Trail expansion along John S. Gibson Boulevard in the westerly portion of the proposed project site. The Gaffey anticline-syncline folds are the result of deformation along the Palos Verdes fault zone. The major faults in the region that contribute to the seismic hazard at the proposed project site include the Palos Verdes fault zone, which crosses John S. Gibson Boulevard in the westerly portion of the proposed project site, and the more distant Newport-Inglewood fault zone, located approximately 5 miles northeast. The Cabrillo fault, located just south of the federal breakwater, may be a branch of the Palos Verdes fault zone, but not much is known about its seismic activity. Figure 3.5-1 presents the faults and geologic structure in the area.

Surficial geology of the Los Angeles Harbor is characterized by Holocene-age, near-shore, marine and non-marine deposits, including beach, estuary, tidal flat, lagoon, shallow-water bay sediments, and shoreline terrace deposits. The proposed project site is primarily underlain by Holocene-age beach sediments that may be overlain in some areas by artificial fill. Dredging and filling operations within the Los Angeles Harbor area have created extensive land masses to the south of the proposed project site, including Mormon Island. The Waterfront Red Car Line/California Coastal Trail expansion along John S. Gibson Boulevard in the westerly portion of the site is underlain primarily by older alluvial deposits and beach sediments (Dibblee 1999). Figure 3.5-2 presents a geologic map of the area surrounding the proposed project site.

3.5.2.1.1 Seismicity and Major Faults

An earthquake is classified by the magnitude of wave movement (related to the amount of energy released), which traditionally has been quantified using the Richter scale. This is a logarithmic scale, wherein each whole number increase in magnitude (M) represents a tenfold increase in the wave magnitude generated by an earthquake. A M8.0 earthquake is not twice as large as a M4.0 earthquake; it is 10,000 times larger (i.e., 10^4, or 10 x 10 x 10 x 10). Damage typically begins at M5.0. A limitation of the Richter magnitude scale is that at the upper limit large earthquakes have about the same magnitude. As a result, the Moment Magnitude Scale, which does not have an upper limit magnitude, was introduced in 1979 and is often used for earthquakes greater than M3.5. Earthquakes of M6.0 to 6.9 are typically classified as moderate; those between M7.0 and M7.9 are classified as major; and those of M8.0 or greater are classified as great.

Southern California is recognized as one of the most seismically active areas in the United States. The region has been subjected to at least 50 earthquakes of M6 or greater since 1796. Ground motion in the region is generally the result of sudden movements of large blocks of the earth's crust along faults. Large earthquakes, like the 1857 San Andreas Fault earthquake, are quite rare in southern California. Earthquakes of M7.8 or greater occur at the rate of about two or three per 1,000 years, corresponding to a 6 to 9% probability in 30 years. However, the probability of a M7.0 or greater earthquake in southern California before 2024 is 85% (Working Group on California Earthquake Probabilities 1995). Table 3.5-1 lists selected earthquakes that have caused damage in the Los Angeles Basin.



REFERENCE: EARTH MECHANICS, INC., 2006, PORT-WIDE GROUND MOTION AND PALOS VERDES FAULT STUDY, PORT OF LOS ANGELES, CALIFORNIA, DECEMBER 22.

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Figure 3.5-1
Faults and Geologic Structures
Wilmington Waterfront Development Project

REFERENCE: 1999, THOMAS DIBBLEE, JR., GEOLOGIC MAP OF THE PALOS VERDES PENNINSULA AND VICINITY, MAP #DF–70.

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Figure 3.5-2
Geologic Map and Soils
Wilmington Waterfront Development Project

Table 3.5-1: Earthquakes in the Los Angeles Basin Area

Fault Name	*Place*	*Date*	*Moment Magnitude*
Palos Verdes	*	*	*
San Pedro Basin	*	*	*
Santa Monica-Raymond	*	1855	6.0
San Andreas	Fort Tejon Kern County	1857 1952	8.2† 7.7
Newport-Inglewood	Long Beach	1933	6.3
San Fernando/Sierra Madre-Cucamonga	San Fernando Sierra Madre	1971 1991	6.4 6.0
Whittier-Elsinore	Whittier Narrows	1987	5.9
Camp Rock/Emerson	Landers	1992	7.4
Blind thrust fault beneath Northridge	Northridge	1994	6.6

Notes:
*No known earthquakes within the last 200 years
†Approximate magnitude

Source: USGS 2007

Seismic analyses generally include discussions of maximum credible and maximum probable earthquakes. A maximum credible earthquake (MCE) is the largest event a fault is believed to be capable of generating. The probability of occurrence is not considered in this characterization. The maximum probable earthquake (MPE) is an earthquake having a 10% probability of being exceeded in 50 years, which corresponds to a return interval of approximately 475 years. In addition, the Port uses a combination of probabilistic and deterministic seismic hazard assessments for seismic design. Probabilistic hazard assessments are required to define two-level design events, including the Operational Level Earthquake (OLE), which is the peak horizontal firm ground acceleration with a 50% probability of exceedance in 50 years, and the Contingency Level Earthquake (CLE), which is the peak ground acceleration with a 10% probability of exceedance in 50 years.

3.5.2.1.2 Faults

Segments of the active Palos Verdes Fault zone cross the Los Angeles Harbor in the vicinity of the westerly portion of the proposed project site. Current data suggest that segments of the fault may cross beneath the proposed bike lane and CCT expansion along John S. Gibson Boulevard (Figure 3.5-1). Recent studies indicate that the Palos Verdes Fault zone is capable of producing an earthquake of moment M6.7 to

M7.2, and peak ground accelerations in the Port area of 0.23g[1] and 0.52g, for the OLE and CLE, respectively (Earth Mechanics, Inc. 2006).

Numerous other active faults and fault zones are located within the general region, such as the Newport-Inglewood, Whittier-Elsinore, Santa Monica, Hollywood, Malibu Coast, Raymond, San Fernando, Sierra Madre, Cucamonga, San Jacinto, and San Andreas Faults. Table 3.5-2 lists the potentially hazardous faults and the anticipated earthquake magnitudes in the Los Angeles Basin area. Active faults, such as those noted above, are typical of Southern California. Therefore, it is reasonable to expect a strong ground motion seismic event during the lifetime of any proposed project in the region.

Numerous active faults located off site are also capable of generating earthquakes in the proposed project area (Tables 3.5-1 and 3.5-2). The Newport-Inglewood Fault zone, which was the source of the 1933 Long Beach M6.4 earthquake, is noteworthy due to its proximity to the proposed project site. Large events could occur on more distant faults in the general area, but because of the greater distance from the site, earthquakes generated on these faults are less significant with respect to ground accelerations.

In 1974, the California Division of Mines and Geology (CDMG) was designated by the Alquist-Priolo Act to delineate those faults deemed active and likely to rupture the ground surface. No faults within the area of the Port are currently zoned under the Alquist-Priolo Act; however, there is evidence that the Palos Verdes Fault, which lies beneath John S. Gibson Boulevard, may be active and ground rupture cannot be ruled out (Fischer et al. 1987; McNeilan et al. 1996).

3.5.2.1.3 Liquefaction

Liquefaction is defined as the transformation of a granular material from a solid state into a liquefied state as a consequence of increased pore pressure, which results in the loss of grain-to-grain contact. Seismic ground shaking is capable of providing the mechanism for liquefaction, usually in fine-grained, loose to medium density, saturated sands and silts. The effects of liquefaction may be excessive if total and/or differential settlement of structures occurs on liquefiable soils.

Natural drainages at Port berths have been backfilled with undocumented fill materials. Dredged materials from the Los Angeles Harbor area were spread across lower Wilmington from 1905 until 1910 or 1911 (Ludwig 1927). In addition, the natural alluvial deposits and beach sediments below the site generally are unconsolidated, soft, and saturated. Groundwater is present at shallow depths beneath the site. These conditions are conducive to liquefaction.

[1] g = acceleration due to gravity

Table 3.5-2: Major Regional Faults

Fault		*Maximum Moment Magnitude*	*Fault Type*	*Slip Rate (mm/yr)*	*Approximate Distance from Site in Miles*
Palos Verdes		7.2*	SS	3	0
Newport-Inglewood		7.1	SS	1	5.2
Whittier-Elsinore		6.8	SS	2.5	20.5
Malibu-Santa Monica-Raymond Fault Zone	Santa Monica	6.6	DS	1	22.0
	Hollywood	6.4	DS	1	23.3
	Malibu Coast	6.7	DS	0.3	23.9
	Raymond	6.5	DS	1.5	24.5
Cucamonga		6.9	DS	5	39.2
San Andreas		7.4	SS	30	52.4
San Jacinto		6.7	SS	12	61.4

Notes:
DS = Dip Slip
SS = Strike Slip

Source: Blake 2001b; *Earth Mechanics, Inc. 2006

Some authors (Tinsley and Youd 1985) have indicated that the liquefaction potential in the harbor area during a major earthquake on either the San Andreas or Newport-Inglewood Fault is high. The Seismic Hazards Zone Maps published by the State of California (CDMG 1999a and 1999b) and the City of Los Angeles General Plan, Safety Element (City of Los Angeles 1996b) show the site to be in an area susceptible to liquefaction because of the nature of the soils (recent alluvial deposits and hydraulic fill) and the presence of groundwater approximately 10 feet or less below the ground surface. Extended ground shaking could result in liquefaction and settlement of saturated subsurface materials. Figure 3.5-3 presents a liquefaction map of the area of the proposed project site.

3.5.2.1.4 Tsunamis

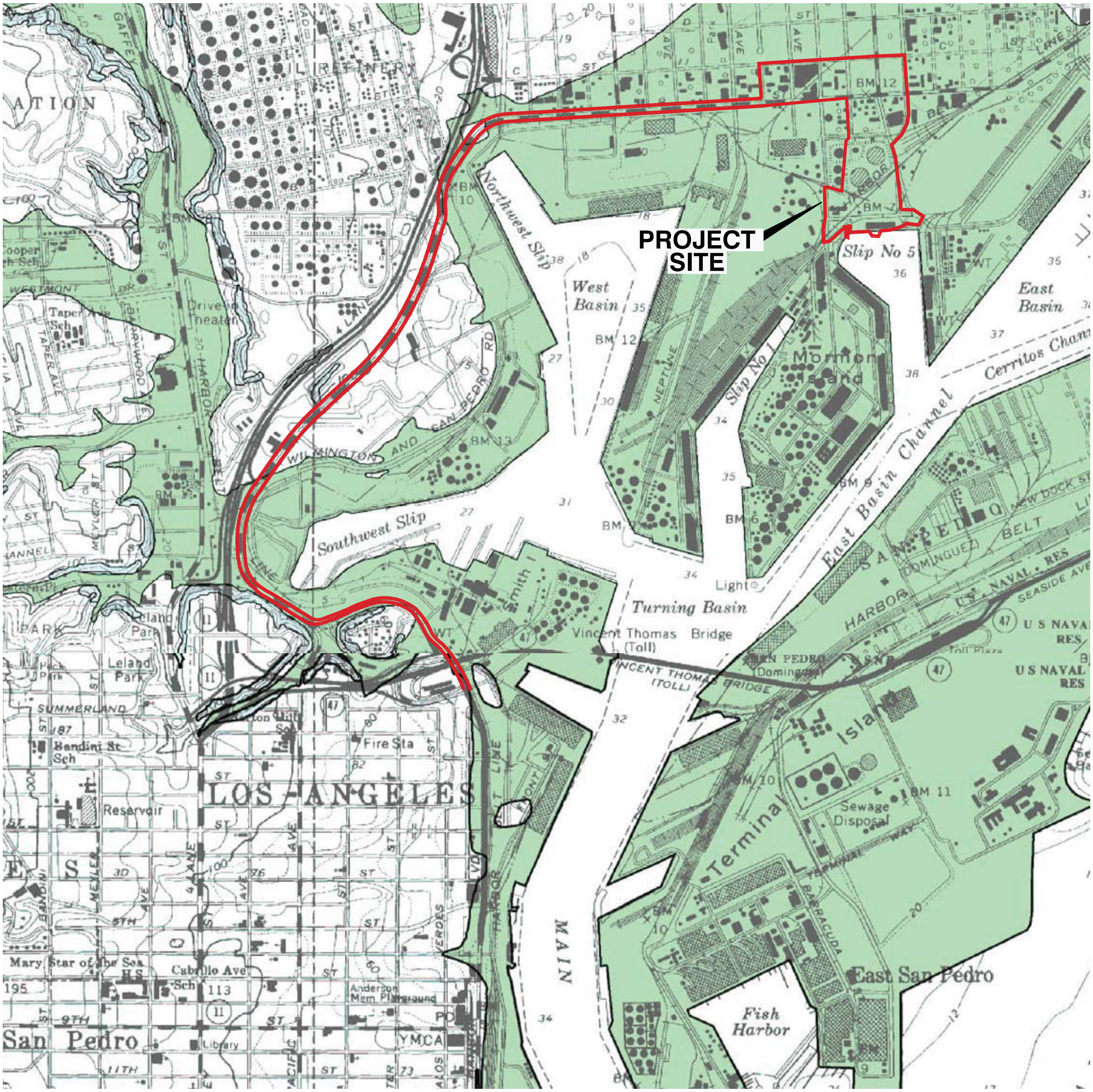
Tsunamis are gravity waves of long wavelength generated by a sudden disturbance in a body of water. Typically, oceanic tsunamis are the result of sudden vertical movement along a fault rupture in the ocean floor, submarine landslides or subsidence, or volcanic eruption, where the sudden displacement of water may set off transoceanic waves with wavelengths of up to 125 miles and with periods generally from 5 to 60 minutes. The trough of the tsunami wave arrives first, leading to the classic retreat of water from the shore as the ocean level drops. This is followed by the arrival of the crest of the wave, which can run up on the shore in the form of bores or surges in shallow water or simple rising and lowering of the water level in relatively deeper water, such as in harbor areas.

Tsunamis are a relatively common natural hazard, although most of the events are small in amplitude and not particularly damaging. However, in the event of a large submarine earthquake or landslide, coastal flooding may be caused by either run-up of broken tsunamis in the form of bores and surges or by relatively dynamic flood waves. In the process of bore/surge–type run-up, the onshore flow (up to tens of feet per second) can cause tremendous dynamic loads on the structures onshore in the form of impact forces and drag forces, in addition to hydrostatic loading. The subsequent drawdown of the water after run-up exerts the often crippling opposite drag on the structures and washes loose/broken properties and debris to sea; the floating debris brought back on the next onshore flow has been found to be a significant cause of extensive damage after successive run-up and drawdown. As has been shown historically, the potential loss of human life in the process can be great if such events occur in populated areas.

Recent studies (e.g., Synolakis et al. 1997; Borrero et al. 2001; Borrero et al. 2005) have projected larger tsunami run-ups based on near-field events, such as earthquakes or submarine landslides occurring in proximity to the California coastline. Offshore faults present a larger local tsunami hazard than previously thought, posing a direct threat to near-shore facilities. For example, one of the largest such features, the Catalina Fault, lies directly underneath Catalina Island, located only 22 miles from the Port. Simulations of tsunamis generated by uplift on this fault suggest waves in the Port in excess of 12 feet, with an arrival time within 20 minutes (Legg et al. 2004; Borrero et al. 2005). These simulations were based on rare events, representing worst-case scenarios.

In addition, landslide-derived tsunamis are now perceived as a viable local tsunami hazard. Such tsunamis can potentially be more dangerous due to the lack of warning for such an event. This mechanism is illustrated by an earthquake in 1998, centered onshore in Papua-New Guinea, which appears to have created an offshore landslide that caused tsunami inundation heights in excess of 33 feet, claiming more than 2,500 lives.

In a study modeling potential tsunami generation by local offshore earthquakes, Legg et al. (2004) considered the relative risk of tsunamis from a large catastrophic submarine landslide (likely generated by a seismic event) in offshore southern California versus fault-generated tsunamis. The occurrence of a large submarine landslide appears quite rare by comparison with the tectonic faulting events. Although many submarine landslides have been mapped off the southern California shore, few appear to be of the scale necessary to generate a catastrophic tsunami. Of two large landslides that appear to be of this magnitude, Legg et al. (2004) indicated that one is over 100,000 years old and the other is approximately 7,500 years old. In contrast, the recurrence of 3 to 20 feet of fault movement on offshore faults would be several hundred to several thousand years. Consequently, the study concluded that the likely direct cause of the majority of the local tsunamis in southern California was tectonic movement during large offshore earthquakes.



REFERENCE: STATE OF CALIFORNIA, 1999, SEISMIC HAZARD ZONES, SAN PEDRO QUADRANGLE; STATE OF CALIFORNIA, 1998, SEISMIC HAZARD ZONES, TORRANCE QUADRANGLE

N

0 2000 4000

APPROXIMATE SCALE IN FEET

LIQUEFACTION:
Areas where historic occurrence of liquefaction, or local geological, geotechnical and groundwater conditions indicate a potential for permanent ground displacements such that mitigation as defined in Public Resources Code Section 2693(c) would be required.

NOTE: ALL DIMENSIONS, DIRECTIONS AND LOCATIONS ARE APPROXIMATE

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Figure 3.5-3
Liquefaction Map
Wilmington Waterfront Development Project

Based on these studies (Synolakis et al. 1997; Borrero et al. 2001), the CSLC has developed tsunami run-up projections for the Ports of Los Angeles and Long Beach of 8.0 feet and 15.0 feet above MSL, at 100- and 500-year intervals, respectively, as a part of their Marine Oil Terminal Engineering and Maintenance Standards (MOTEMS) (CSLC 2005). However, these projections, which assume a 15-foot height, do not incorporate consideration of the localized landfill configurations, bathymetric features, and the interaction of the diffraction, reflection, and refraction of the tsunami wave propagation within the Los Angeles/Long Beach Port Complex in their predictions of tsunami wave heights.

3.5.2.1.5 Seiches

Seiches are seismically induced water waves that surge back and forth in an enclosed basin and may be expected in the harbor as a result of earthquakes. Any significant wave front could cause damage to seawalls and docks, and could breach sea walls at the proposed project site. Modern shoreline protection techniques are designed to resist seiche damage. The Los Angeles/Long Beach Port Complex model considered impacts from both tsunamis and seiches. In each case, impacts from a tsunami were equal to or more severe than those from a seiche.

3.5.2.1.6 Subsidence

Subsidence is the phenomenon where the soils and other earth materials underlying the site settle or compress, resulting in a lower ground surface elevation. Fill and native materials on site can be water saturated, and a net decrease in the pore pressure and contained water will allow the soil grains to pack closer together. This closer grain packing results in less volume and the lowering of the ground surface.

Subsidence in the Los Angeles-Long Beach Harbor area was first observed in 1928 and has affected the majority of the harbor area. Based on extensive studies by the City of Long Beach and the California Division of Oil and Gas and Geothermal Resources, it has been determined that most of the subsidence was the result of oil and gas production from the Wilmington Oil Field following its discovery in 1936, and the extraction of large volumes of groundwater for dry dock construction in the early 1940s. By 1945 subsidence of more than 4 feet was noted in the area of Long Beach Harbor (City of Long Beach 2006). By 1962 subsidence had spread over a wide area and reached approximately 26 feet in the area of Terminal Island (Parks 1999). Today, water injection continues to be maintained at rates greater than the total volume of produced substances, including oil, gas, and water, to prevent further reservoir compaction and subsidence (City of Long Beach, 2006). Subsidence in the vicinity of the proposed Project, due to previous oil extraction in the Port area, has been mitigated and no longer poses a risk at the proposed project site.

3.5.2.1.7 Landslides

Generally, a landslide is defined as the downward and outward movement of loosened rock or earth down a hillside or slope. Landslides can occur either very suddenly or slowly, and frequently accompany other natural hazards such as earthquakes, floods, or wildfires. Most landslides are single events, but more than a third are associated with heavy rains or the melting of winter snows. Landslides can also be triggered by ocean wave action or induced by the undercutting of slopes during construction, improper artificial compaction, or saturation from sprinkler systems or broken water pipes. In areas on hillsides where the ground cover has been destroyed, landslides are probable because there is nothing to hold the soil. Immediate dangers from landslides include destruction of property and possible fatalities from rocks, mud, and water sliding downhill or downstream. Other dangers include broken electrical, water, gas, and sewage lines. The proposed project site is relatively flat and paved, and no known or probable bedrock landslide areas have been identified (City of Los Angeles 1996b).

3.5.2.1.8 Expansive Soils

Expansive soils generally result from specific clay minerals that expand when saturated and shrink in volume when dry. These expansive clay minerals are common in the geologic units in the adjacent Palos Verdes Peninsula. Clay minerals in geologic units and previously imported fill soils at the proposed project area could have expansive characteristics.

3.5.2.1.9 Mineral Resources

The proposed project site is located within the Wilmington Oil Field, which is approximately 11 miles long and 3 miles wide, covering approximately 13,500 acres. From January 1998 through October 2002, the field as a whole produced 84.4 million barrels (bbl) of oil, making it the 6^{th} largest producing oil field in the state (California Department of Conservation 2002). However, the proposed project site is located primarily on Holocene-age beach sediments. According to the California Geological Survey (CGS), the proposed project site is located in a Mineral Resource Zone (MRZ) area classified as "MRZ-1," which is defined as an area where adequate information indicates that no significant mineral deposits (i.e., aggregate deposits) are present or where it is judged that little likelihood exists for their presence (CGS 2008).

3.5.3 Applicable Regulations

3.5.3.1 Geologic Hazards

Geologic resources and hazards in the proposed project vicinity are governed primarily by the City of Los Angeles. The Conservation and Safety Elements of the City of Los Angeles General Plan contain policies for the protection of geologic features and avoidance of geologic hazards (City of Los Angeles 1996b, 2001a). Local grading ordinances establish detailed procedures for excavation and earthwork required during construction in upland areas. In addition, City of Los Angeles building codes and building design standards for the Port establish requirements for construction of aboveground structures (City of Los Angeles 2002e). Local jurisdictions, including LAHD, rely upon the 1997 California Uniform Building Code (UBC) as a basis for seismic design for land-based structures. However, with respect to wharf construction, LAHD standards and specifications would be applied to the design of the proposed Project. The LAHD must comply with regulations of the Alquist-Priolo Act, which regulates development near active faults to mitigate the hazard of a surface fault rupture.

The Marine Oil Terminal Engineering and Maintenance Standards (MOTEMS) were approved by the California Building Standards Commission on January 19, 2005, and are codified as part of 24 Cal. Code Reg., Part 2, Marine Oil Terminals, Chapter 31F. These standards apply to all existing marine oil terminals in California and include criterion for inspection, structural analysis and design, mooring and berthing, geotechnical considerations, fire, piping, and mechanical and electrical systems. The MOTEMS became effective on January 6, 2006 (CSLC 2005). The process of developing the MOTEMS has produced parallel guidelines and recommended provisions. The Seismic Design Guidelines for Port Structures, published in 2001 by the Port International Navigation Association (PIANC) uses text virtually identical to that found in the MOTEMS. The language for the PIANC and the MOTEMS is derived from the Naval Facilities Engineering Service Center Technical Report (TR-2103-SHR), Seismic Criteria for California Marine Oil Terminals.

3.5.3.2 Mineral Resources

Excavations and construction in the immediate vicinity of abandoned oil wells is regulated in accordance with standards and procedures as set forth by the California Department of Conservation Division of Oil, Gas, and Geothermal Resources (DOGGR). Pub. Res. Code §3208.1 authorizes the State Oil and Gas Supervisor to order re-abandonment of any previously abandoned well when construction of any structure over or in proximity to the well could result in a hazard.

The Surface Mining and Reclamation Act of 1975 (SMARA, Pub. Res. Code §2710 et seq.) was enacted to promote conservation of the state's mineral resources and to ensure adequate reclamation of lands once they have been mined. Among other provisions, SMARA requires the State Geologist to classify land in California for mineral resource potential. To be considered significant for the purpose of mineral land classification, a mineral deposit, or a group of mineral deposits that can be mined as a unit, must meet marketability and threshold value criteria adopted by the California State Mining and Geology Board. The State Geologist submits the mineral land classification report to the State Mining and Geology Board, which transmits the information to appropriate local governments that maintain jurisdictional authority in mining, reclamation, and related land use activities. Local governments are required to incorporate the report and maps into their general plans and consider the information when making land use decisions.

3.5.4 Impact Analysis

3.5.4.1 Methodology

Geological impacts have been evaluated in two ways: (1) impacts of the proposed Project on the local geologic environment, and (2) impacts of geohazards on components of the proposed Project that may result in substantial damage to structures or infrastructure or expose people to substantial risk of injury. Impacts would be considered significant if the proposed Project meets any of the significance criteria listed in Section 3.5.4.2 below.

The description of the environmental setting in Section 3.5.2 was used as the baseline physical conditions by which significant potential impacts were evaluated. Some of the geologic maps and literature used to prepare the environmental setting are 10 to 20 years old. However, the geologic conditions do not change significantly over 10 to 20 years, and therefore the use of these materials is considered appropriate for this study.

The IS/NOP determined that the proposed Project would have less-than-significant impacts on the following geology issues; therefore, these will not be discussed in the geology impact analysis below:

- Result in substantial soil erosion or the loss of topsoil

The IS/NOP determined that the proposed Project would have a less-than-significant impact on soil erosion and/or the loss of top soil. Although the majority of the proposed project site is currently paved or developed, some soil erosion may occur during construction activities. Adherence to the requirements of the General Storm Water Permit for Construction Activities and to SCAQMD rules and regulations (such as Rule 403 for fugitive dust) will help to ensure that wind or water erosion impacts are reduced to less than significant. Additionally, during construction, the site will be managed in accordance with a Stormwater Pollution Prevention Plan (SWPPP) prepared in accordance with the General Construction Activity Storm Water Permit (GCASP) adopted by the State Water Resources Control Board (SWRCB). The proposed Project would result in the placement of some new impermeable surfaces as well as softscape and landscape materials. After construction activities and during operation, the proposed Project would not result in any further wind or water erosion of soils. Therefore, this criterion will not be discussed in the geology impact analysis below.

- Have soils incapable of adequately supporting the use of septic tanks or alternative wastewater disposal systems in areas where sewers are not available for the disposal of wastewater

The IS/NOP determined that the Los Angeles Department of Public Works Bureau of Sanitation provides sewer service to all areas within its jurisdiction, including the proposed Project site. The proposed Project would be connected to this system, and sewage would be sent to the Terminal Island Treatment Facility. There would be no use of septic tanks or alternative wastewater disposal systems and hence no impact from the proposed Project. Therefore, this criterion will not be discussed in the geology impact analysis below.

- Contribute to inundation by seiche, tsunami, or mudflow

Additionally, the IS/NOP determined that the proposed Project would have a less-than-significant impact on the following hydrology and water quality issue that is relevant to geology. As discussed on page 42 of the IS/NOP, [w]hile the proposed Project site is identified to be within an area "potentially impacted by a tsunami" (City of Los Angeles 1994c), detailed studies of tsunami risk within the Ports of Los Angeles and Long Beach indicate that the Wilmington Waterfront Project area is sufficiently interior and distant from open ocean such that waves under various scenarios would not reach above 0.6 meters and would not exceed deck elevations (Moffatt & Nichol 2007). Furthermore, the City of Los Angeles Tsunami Response Plan does not identify the Wilmington Waterfront Project area as part of the Tsunami Inundation Zone for San Pedro and the Harbor Area (City of Los Angeles 2007). Impacts [would be] considered less than significant. Therefore, this criterion will not be discussed in the geology impact analysis below.

Furthermore, the IS/NOP determined that the proposed Project would have a less-than-significant impact on the following mineral issue that is relevant to geology; therefore, it will not be discussed in the geology impact analysis below:

- Result in the permanent loss of availability of a known mineral resource of regional, state, or local significance that would be of future value to the region and the residents of the state

The proposed project area is not within a significant aggregate resource zone; the proposed project site is in a mineral resource zone area classified as MRZ-1, which is defined as an area where adequate information indicates that no significant mineral deposits are present, or where it is judged that little likelihood exists for their presence (California Department of Conservation, Division of Mines and Geology 1994). The proposed project site is within the identified boundaries of the Wilmington Oil Field, one of the major oil drilling areas of the Los Angeles basin

(City of Los Angeles 1994d). However, there are no oil drilling rigs or current oil exploration investigations within the proposed project area, and the proposed Project would not preclude the exploration or access to subsurface mineral resources.

The assessment of impacts is based on regulatory controls and on the assumptions that the proposed Project would include the following standards and engineering requirements:

- LAHD or authorized developers within the proposed project area will design and construct upland improvements in accordance with Los Angeles Building Code, Sections 91.000 through 91.7016 of the Los Angeles Municipal Code, to minimize impacts associated with seismically induced geohazards. These sections regulate construction in upland areas of the Port. These building codes and criteria provide requirements for construction, grading, excavations, use of fill, and foundation work, including type of materials, design, procedures, etc. These codes are intended to limit the probability of occurrence and the severity of consequences from geological hazards. Necessary permits, plan checks, and inspections are also specified. The Los Angeles Municipal Code also incorporates structural seismic requirements of the California Building Code, which classifies almost all of coastal California (including the proposed project site) within Seismic Zone 4, on a scale of 1 to 4, with 4 being most severe. The project engineers will review the proposed project plans for compliance with the appropriate standards in the building codes.
- LAHD will design and construct new wharf improvements in accordance with MOTEMS and LAHD standards, to minimize impacts associated with seismically induced geohazards. Such construction will include, but not be limited to, completion of site-specific geotechnical investigations regarding construction and foundation engineering. Measures pertaining to temporary construction conditions, such as protecting adjacent structures, will be incorporated into the design. A licensed geologist or engineer will monitor construction to check that construction occurs in concurrence with the proposed project design.

3.5.4.2 Thresholds of Significance

The following significance criteria are based on the *L.A. CEQA Thresholds Guide* (City of Los Angeles 2006) and are the basis for determining the significance of impacts associated with geology resulting from development of the proposed Project.

Geologic hazard impacts are considered significant if the proposed Project causes or accelerates hazards that would result in substantial damage to structures or infrastructure, or exposes people to substantial risk of injury. Because the region is considered to be geologically active, most projects are exposed to some risk from geologic hazards, such as earthquakes. Geologic impacts are, therefore, considered significant only if the proposed Project would result in substantial damage to structures or infrastructure, or expose people to substantial risk of injury from the following:

GEO-1: Fault rupture, seismic ground shaking, liquefaction, or other seismically induced ground failure

GEO-2: Land subsidence/settlement

GEO-3: Expansive soils

GEO-4: Landslides or mudflows

GEO-5: Unstable soil conditions from excavation, grading, or fill

In addition, a project would normally have a significant impact on landform alteration or mineral resources if:

GEO-6: One or more distinct and prominent geologic or topographic features would be destroyed, permanently covered, or materially and adversely modified. Such features may include, but not be limited to, hilltops, ridges, hillslopes, canyons, ravines, rock outcrops, water bodies, streambeds, and wetlands.

3.5.4.3 Impacts and Mitigation

The geology impact analysis presented below is based on the determinations made in the IS/NOP for issues that were determined to be potentially significant, or for issues identified by reviewing agencies, organizations, or individuals commenting on the IS/NOP that made a reasonable argument that the issue was potentially significant (Appendix A).

3.5.4.3.1 Construction Impacts

Impact GEO-1a: Construction of the proposed Project would result in substantial damage to structures or infrastructure, or expose people to substantial risk of injury from fault rupture, seismic ground shaking, liquefaction, or other seismically induced ground failure.

There would be a minor increase in the exposure of people and property to seismic hazards relating to the baseline condition. The proposed project area lies in the vicinity of the Palos Verdes Fault zone. Strands of the fault may pass beneath the westerly portion of the proposed project area, in the vicinity of John S Gibson Boulevard (Figure 3.5.1). Strong-to-intense ground shaking, surface rupture, and liquefaction could occur in these areas due to the location of the fault beneath the proposed project area and the presence of water-saturated soil. Projects in construction phases are especially susceptible to earthquake damage due to temporary conditions, such as temporary slopes and unfinished structures, which are typically not in a condition to withstand intense ground shaking. Strong ground shaking would potentially cause damage to unfinished structures resulting in injury or fatality to construction workers. With the exception of ground rupture, similar seismic impacts would occur due to earthquakes on other regional faults. Earthquake-related hazards, such as fault rupture, liquefaction, and seismic ground shaking cannot be avoided in the Los Angeles region and in particular in the harbor area where the Palos Verdes Fault is present and liquefaction-prone soils underlie the site.

Impact Determination

As discussed above, seismic activity along the Palos Verdes Fault zone, or other regional faults, would potentially produce fault rupture, seismic ground shaking, liquefaction, or other seismically induced ground failure. Seismic hazards are common to the Los Angeles region and are not increased by the proposed Project. However, because the proposed project area is potentially underlain by strands of the active Palos Verdes Fault and liquefaction-prone soil, there is a substantial risk of seismic impacts such as fault rupture, seismic ground shaking, liquefaction, or other seismically induced ground failure. Because construction would occur over an extended period, increased exposure of people and property during construction to seismic hazards from a major or great earthquake cannot be precluded, even with incorporation of modern construction engineering and safety standards. Therefore, impacts due to seismically induced ground failure would be significant and unavoidable.

Mitigation Measures

MM GEO-1: Seismic Design. A site-specific geotechnical investigation will be completed by a California-licensed geotechnical engineer and/or engineering geologist. The design and construction recommendations will be incorporated into the structural design of proposed project components.

Residual Impacts

Design and construction in accordance with recommendations of a site-specific geotechnical investigation, as well as applicable laws and regulations pertaining to seismically induced ground movement, would minimize structural damage in the event of an earthquake. However, increased exposure of people and property during operations to seismic hazards from a major or great earthquake cannot be precluded even with the incorporation of modern construction engineering and safety standards. Therefore, potential impacts due to seismically induced ground failure would remain significant and unavoidable.

Impact GEO-2a: Construction of the proposed Project would not result in substantial damage to structures or infrastructure, or expose people to substantial risk of injury from land subsidence/settlement.

Subsidence in the vicinity of the proposed Project, due to previous oil extraction in the Port area, has been mitigated through water injection and is not anticipated to adversely impact the proposed Project (City of Long Beach 2006). However, in the absence of proper engineering, proposed structures would potentially be cracked and warped as a result of saturated, unconsolidated/compressible sediments. During project design, the geotechnical engineer would evaluate the settlement potential in areas where structures are proposed.

The settlement potential of existing onshore soils would be evaluated through a site-specific geotechnical investigation, which includes subsurface soil sampling, laboratory analysis of samples collected to determine soil compressibility, and an evaluation of the laboratory testing results by a geotechnical engineer. Recommendations of the engineer would be incorporated into the design specifications for the proposed Project, consistent with City design guidelines, including Sections 91.000 through 91.7016 of the Los Angeles Municipal Code, in conjunction with criteria established by LAHD. Sections 91.000 through 91.7016 regulate construction in upland areas of the Port. These building codes and criteria provide requirements for construction, grading, excavations, use of fill, and foundation work, including type of materials, design, procedures, etc. These codes are intended to limit the probability of occurrence and the severity of consequences from geological hazards. Such geotechnical engineering would substantially reduce the potential for soil settlement and would allow for construction of the proposed Project that would not result in substantial damage to structures or infrastructure, or expose people to substantial risk of injury.

Impact Determination

Settlement impacts in upland areas would be less than significant, as the proposed Project would be designed and constructed in compliance with the recommendations of the geotechnical engineer, consistent with Sections 91.000 through 91.7016 of the Los Angeles Municipal Code and in conjunction with criteria established by LAHD, and would not result in substantial damage to structures or infrastructure, or expose people to substantial risk of injury.

Mitigation Measures

No mitigation is required.

Residual Impacts

Impacts would be less than significant.

Impact GEO-3a: Construction of the proposed Project would not result in substantial damage to structures or infrastructure, or expose people to substantial risk of injury from expansive soils.

Expansive soil may be present in the proposed project area and may be present in excavated or imported soils used for proposed project grading. Expansive soils beneath the proposed Project's foundations, pavement, or behind retaining structures would potentially result in cracking and distress of these structures. However, during the proposed project design phase, the geotechnical engineer would evaluate the expansion potential associated with onsite soils. The soil expansion potential would be evaluated through a site-specific geotechnical investigation, which includes subsurface soil sampling, laboratory analysis of samples collected to determine soil expansion potential, and an evaluation of the laboratory testing results by a geotechnical engineer. Recommendations of the engineer would be incorporated into the design specifications for the proposed Project, consistent with City design guidelines, including Sections 91.000 through 91.7016 of the Los Angeles Municipal Code, in conjunction with criteria established by LAHD. Recommendations for soils subject to expansion typically include over-excavation and replacement of expansive soils with sandy, non-expansive soils, which would allow for construction of a conventional slab-on-grade; construction of post-tensioned concrete slabs, which can accommodate movement of underlying expansive soils; or, alternatively, installation of concrete or steel foundation piles through the expansion-prone soils, to a depth of non-expansive soils. Therefore, required geotechnical site engineering would substantially reduce the potential for soil expansion and damage to overlying structures.

Impact Determination

Expansive soil impacts in upland areas would be less than significant as the proposed Project would be designed and constructed in compliance with the recommendations of the geotechnical engineer, consistent with implementation of Sections 91.000 through 91.7016 of the Los Angeles Municipal Code, and in conjunction with criteria established by LAHD. Therefore, the proposed Project would not result in substantial damage to structures or infrastructure, or expose people to substantial risk of injury, and the impact would be less than significant.

Mitigation Measures

No mitigation is required.

Residual Impacts

Impacts would be less than significant.

Impact GEO-4a: Construction of the proposed Project would not result in substantial damage to structures or infrastructure, or expose people to substantial risk of injury from landslides or mudslides.

Numerous ancient and recent landslides have occurred within the southerly portion of the Palos Verdes Hills, including the large Portuguese Bend landslide complex. This area is approximately 6½ miles to the southwest of the proposed project site. The topography of the proposed project site is flat with no significant slopes nearby; therefore, the risk associated with landslides or mudflows is considered low. In addition, the proposed project site and vicinity are not located in an area susceptible to earthquake-induced landslides (CDMG 1999a, 1999b).

Impact Determination

As the topography in the vicinity of the proposed project site is flat and not subject to landslides or mudflows, no impacts would occur.

Mitigation Measures

No mitigation is required.

Residual Impacts

No impacts would occur.

Impact GEO-5a: Construction of the proposed Project would not result in substantial damage to structures or infrastructure, or expose people to substantial risk of injury from unstable soil conditions from excavation, grading, or fill.

Natural alluvial deposits and beach sediments, as well as fill consisting of dredged deposits or imported soils, may be encountered during excavations for utility pipeline relocation or for construction of foundations, retaining walls, manholes, and other structures. Groundwater is present at depths of approximately 10 feet or shallower. Materials near and below the groundwater table would be relatively fluid and unstable, requiring implementation of geotechnical engineering standards, such as dewatering wells, installation of sheet piling, and other special handling procedures to facilitate excavation. For example, dewatering wells would lower the groundwater level, thus reducing the potential for unstable soils. Various types of temporary shoring would also be used to stabilize excavations.

The proposed waterfront park of the proposed project site will involve construction of engineered fill slopes and hills. A site-specific geotechnical evaluation would be performed during the design phase to provide recommendations for stability of the fill slopes. Such recommendations would include specification of the material type to be used for fill, compaction specifications, slope inclination, removal of unsuitable material prior to placing fill, and slope planting to enhance surficial stability.

Granular material, if encountered during excavation, may be suitable for reuse as fill during construction. Excess excavation material could be used at other nearby construction sites, if suitable, or transported to an appropriate disposal facility. Contaminated material, if encountered, would be evaluated by an environmental professional. Handling of contaminated soil, including disposal at an appropriate facility, would be performed under the direction of the environmental professional. Further information regarding the handling and disposal of contaminated materials is further discussed in Section 3.6 "Groundwater and Soils."

Impact Determination

Due to implementation of standard engineering practices regarding unstable soils, people and structures would not be exposed to substantial adverse effects from the proposed Project, and impacts associated with unstable soil would be less than significant.

Mitigation Measures

No mitigation is required.

Residual Impacts

Impacts would be less than significant.

Impact GEO-6a: Construction of the proposed Project would not result in one or more distinct and prominent geologic or topographic features being destroyed, permanently covered, or materially and adversely modified.

Since the proposed project area is relatively flat and paved, with no prominent geologic or topographic features, proposed project construction would not result in any distinct and prominent geologic or topographic features being destroyed, or permanently covered. The proposed Project includes the waterfront promenade floating docks at Slip #5. Currently, Slip #5 is a working slip used to support Port operations. Construction of the proposed Project would not materially or adversely modify the existing operation of Slip #5; rather the proposed Project would enhance and improve operations within Slip #5.

Impact Determination

Because the topography in the vicinity of the proposed project site is flat and does not contain prominent geologic or topographic features and the proposed Project would not materially or adversely modify Slip 5, no impacts would occur.

Mitigation Measures

No mitigation is required.

Residual Impacts

No impacts would occur.

3.5.4.3.2 Operations Impacts

Impact GEO-1b: Operation of the proposed Project would result in substantial damage to structures or infrastructure, or expose people to substantial risk of injury from fault rupture, seismic ground shaking, liquefaction, or other seismically induced ground failure.

As discussed above for Impact GEO 1a, the proposed project area lies in the vicinity of the Palos Verdes Fault zone. Strands of the fault may pass beneath the westerly portion of the proposed project area, in the vicinity of John S. Gibson Boulevard (Figure 3.5-1). Strong-to-intense ground shaking, surface rupture, and liquefaction would potentially occur in these areas due to the location of the fault beneath the proposed project area and the presence of water-saturated alluvial deposits and hydraulic fill. With the exception of ground rupture, similar seismic impacts could occur due to earthquakes on other regional faults. As previously stated, seismic hazards are common in the Los Angeles region. As discovered during previous earthquake events in the region, building codes are often inadequate to completely protect engineered structures from hazard associated with liquefaction, ground rupture, and large ground accelerations. Consequently, proposed project facilities, including new buildings, the Waterfront Red Car Line and other structures, may be subject to significant damage from a major or great earthquake on the Palos Verdes Fault or any other regional fault. Earthquake-related hazards, such as liquefaction, ground rupture, and seismic ground shaking cannot be avoided in the Los Angeles region and in particular in the harbor area where the Palos Verdes Fault is present and liquefaction-prone soils underlie the site. Because the proposed project area is potentially underlain by strands of the active Palos Verdes Fault and liquefaction-prone soils, there is a substantial risk of seismic impacts. For example, part of the proposed Project includes the adaptive reuse of the Bekins Storage Property for a Waterfront Red Car Museum. Even though the Bekins Building's structure would be reinforced to modern standards, structural upgrades would not preclude the possibility of serious damage and possible harm to occupants during a major earthquake event.

Increased exposure of people and property during operations to seismic hazards from a major or great earthquake cannot be precluded even with the incorporation of modern construction engineering and safety standards. Therefore, potential impacts due to seismically induced ground failure would remain. The proposed Project would not increase the risk of seismic ground shaking, but it would contribute to the potential for ground shaking to result in ground failure (e.g., liquefaction, differential settlement). It would also contribute to the potential for seismically induced ground shaking to result in damage to people and structures because it would increase the amount of structures and people working in the area.

Impact Determination

As discussed above, seismic activity along the Palos Verdes fault zone, or other regional faults, could produce fault rupture, seismic ground shaking, liquefaction, or other seismically induced ground failure. Seismic hazards are common to the Los Angeles region and are not increased by the proposed Project. However, because the proposed project area is potentially underlain by strands of the active Palos Verdes Fault and liquefaction-prone soil, there is a substantial risk of seismic impacts. Increased exposure of people and property during operations to seismic hazards from a major or great earthquake cannot be precluded, even with incorporation of modern construction engineering and safety standards. Therefore, impacts due to seismically induced ground failure would be significant and unavoidable.

Mitigation Measures

There are no mitigation measures available that would reduce impacts below significance.

Residual Impacts

Impacts would be significant and unavoidable.

Impact GEO-2b: Operation of the proposed Project would not result in substantial damage to structures or infrastructure, or expose people to substantial risk of injury from land subsidence/settlement.

As discussed for Impact GEO-2a, subsidence in the proposed project vicinity due to previous oil extraction in the Port area has been mitigated and would not adversely impact the proposed Project. However, in the absence of proper engineering, proposed structures would potentially be cracked and warped during proposed project operations as a result of saturated, unconsolidated/compressible sediments. Recommendations for soils subject to settlement typically include over-excavation and recompaction of compressible soils, which would allow for construction of a conventional slab-on-grade; or, alternatively, installation of concrete or steel foundation piles through the settlement-prone soils to a depth of competent soils. During the proposed project design phases, a geotechnical engineer would evaluate the settlement potential in areas where structures are proposed, as discussed for Impact GEO-2a, to reduce the potential for soil settlement.

Impact Determination

Settlement impacts in upland areas would be less than significant, as the proposed Project would be designed and constructed in compliance with the recommendations of the geotechnical engineer, consistent with implementation of Sections 91.000 through 91.7016 of the Los Angeles Municipal Code, and in conjunction with criteria established by LAHD, and would not result in substantial damage to structures or infrastructure, or expose people to substantial risk of injury. Therefore, impacts would be less than significant.

Mitigation Measures

No mitigation is necessary.

Residual Impacts

Impacts would be less than significant.

Impact GEO-3b: Operation of the proposed Project would not result in substantial damage to structures or infrastructure, or expose people to substantial risk of injury from expansive soils.

As discussed for Impact GEO-3a, subsidence in the proposed project vicinity, due to previous oil extraction in the Port area, has been mitigated and is not anticipated to adversely impact the proposed Project. However, in the absence of proper engineering, proposed structures could be cracked and warped during proposed project operations as a result of saturated, unconsolidated/compressible sediments. However, during the proposed Project's design phase, the engineer would evaluate the settlement potential in all areas where structures are proposed. The settlement potential would be evaluated during the construction phase, as discussed for Impact GEO-3a**,** to reduce the potential for soil settlement. As described in Impact GEO-3a, expansive soil may be present in the proposed project area and may be present in excavated or imported soils used for proposed project grading. In the absence of proper engineering the existence of expansive soils beneath proposed project foundations, pavement, or behind retaining structures would potentially result in cracking and distress of these structures during the proposed project operations. Part of the proposed Project includes the adaptive reuse of the Bekins Storage Property for a Waterfront Red Car Museum. Even though the Bekins Building's structure would be reinforced to modern standards, structural upgrades would not preclude the possibility of serious damage and possible harm to occupants during a major earthquake event.

Increased exposure of people and property to seismic hazards during operations from a major or great earthquake cannot be precluded even with the incorporation of modern construction engineering and safety standards. Therefore, potential impacts due to seismically induced ground failure would remain. The proposed Project would not increase the risk of seismic ground shaking, but it would contribute to the potential for ground shaking to result in ground failure (e.g., liquefaction, differential settlement). It would also contribute to the potential for seismically induced ground shaking to result in damage to people and structures because it would increase the amount of structures and people working in the area. However, during the design phase, the proposed Project's geotechnical engineer would evaluate the expansion potential associated with onsite soils and provide geotechnical design and construction recommendations for soil compaction, foundation specifications, and retaining structures, as described in Impact GEO-3a, to reduce the potential for soil expansion and damage to overlying structures.

Impact Determination

Expansive soil impacts in upland areas would be less than significant as the proposed Project would be designed and constructed in compliance with the recommendations of the geotechnical engineer and contained within the geotechnical report, consistent with Sections 91.000 through 91.7016 of the Los Angeles Municipal Code, and in conjunction with criteria established by LAHD, and would not result in substantial damage to structures or infrastructure, or expose people to substantial risk of injury. Therefore, impacts would be less than significant.

Mitigation Measures

No mitigation is required.

Residual Impacts

Impacts would be less than significant.

Impact GEO-4b: Operation of the proposed Project would not result in substantial damage to structures or infrastructure, or expose people to substantial risk of injury from landslides or mudslides.

As discussed above in Impact GEO-4a, numerous ancient and recent landslides have occurred within the southerly portion of the Palos Verdes Hills, including the large Portuguese Bend landslide complex. This area is approximately 6½ miles to the southwest of the proposed project site. The topography of the proposed project site is flat with no significant slopes nearby; therefore, the risk associated with landslides or mudflows is considered low. In addition, the proposed project site and vicinity are not located in an area susceptible to earthquake-induced landslides (CDMG 1999a, 1999b).

Impact Determination

As the topography in the vicinity of the proposed project site is flat and not subject to landslides or mudflows, no impacts would occur.

Mitigation Measures

No mitigation is required.

Residual Impacts

No impacts would occur.

Impact GEO-5b: Operation of the proposed Project would not result in substantial damage to structures or infrastructure, or expose people to substantial risk of injury from unstable soil conditions from excavation, grading, or fill.

Excavations, grading, or fill placement would not be performed as a part of proposed project operations; therefore, onsite soils would not be subject to unstable conditions.

Impact Determination

Excavations, grading or fill placement would not be performed as a part of proposed project operations; therefore, impacts associated with unstable soils would not occur.

Mitigation Measures

No mitigation is required.

Residual Impacts

No impacts would occur.

Impact GEO-6b: Operation of the proposed Project would not result in one or more distinct and prominent geologic or topographic features being destroyed, permanently covered, or materially and adversely modified.

Since the proposed project area is relatively flat and paved, with no prominent geologic or topographic features, proposed project operations would not result in any distinct and prominent geologic or topographic features being destroyed, permanently covered, or materially and adversely modified. The operation of the proposed Project includes the waterfront promenade floating docks at Slip #5. Currently, Slip #5 is a working slip used to support Port operations. Therefore, operations of the proposed Project would not materially or adversely modify the existing operation of Slip #5; rather, the proposed Project would enhance and improve operations within Slip #5.

Impact Determination

Because the topography in the vicinity of the proposed project site is flat and does not contain prominent geologic or topographic features and the proposed Project would not materially or adversely modify Slip 5, no impacts would occur.

Mitigation Measures

No mitigation is required.

Residual Impacts

No impacts would occur.

3.5.4.3.3 Summary of Impact Determinations

The following Table 3.5-3 summarizes the impact determinations of the proposed Project related to Geology, as described in the detailed discussion in Sections 3.5.4.3.1 and 3.5.4.3.2. Identified potential impacts may be based on Federal, State, or City of Los Angeles significance criteria, Port criteria, and the scientific judgment of the geotechnical engineers responsible for the preparation of the majority of this section.

For each type of potential impact, the table describes the impact and impact determinations, describes any applicable mitigation measures, and notes the residual impacts (i.e., the impact remaining after mitigation). Impacts, whether significant or not, are included in this table.

Table 3.5-3: Summary Matrix of Potential Impacts and Mitigation Measures for Geology Associated with the Proposed Project

Environmental Impacts	*Impact Determination*	*Mitigation Measures*	*Impacts after Mitigation*
3.5 Geology			
Construction			
GEO-1a: Construction of the proposed Project would result in substantial damage to structures or infrastructure, or expose people to substantial risk of injury from fault rupture, seismic ground shaking, liquefaction, or other seismically induced ground failure.	Significant and unavoidable	No mitigation measures are available to reduce below significance **MM GEO-1: Seismic Design.** A site-specific geotechnical investigation will be completed by a California-licensed geotechnical engineer and/or engineering geologist. The design and construction recommendations will be incorporated into the structural	Significant and unavoidable

Environmental Impacts	*Impact Determination*	*Mitigation Measures*	*Impacts after Mitigation*
		design of proposed project components.	
GEO-2a: Construction of the proposed Project would not result in substantial damage to structures or infrastructure, or expose people to substantial risk of injury from land subsidence/settlement.	Less than significant	No mitigation is required	Less than significant
GEO-3a: Construction of the proposed Project would not result in substantial damage to structures or infrastructure, or expose people to substantial risk of injury from expansive soils.	Less than significant	No mitigation is required	Less than significant
GEO-4a: Construction of the proposed Project would not result in substantial damage to structures or infrastructure, or expose people to substantial risk of injury from landslides or mudslides.	No impact would occur	No mitigation is required	No impact would occur
GEO-5a: Construction of the proposed Project would not result in substantial damage to structures or infrastructure, or expose people to substantial risk of injury from unstable soil conditions from excavation, grading, or fill.	Less than significant	No mitigation is required	Less than significant
GEO-6a: Construction of the proposed Project would not result in one or more distinct and prominent geologic or topographic features being destroyed, permanently covered, or materially and adversely modified.	No impact would occur	No mitigation is required	No impact would occur

Environmental Impacts	*Impact Determination*	*Mitigation Measures*	*Impacts after Mitigation*
Operations			
GEO-1b: Operation of the proposed Project would result in substantial damage to structures or infrastructure, or expose people to substantial risk of injury from fault rupture, seismic ground shaking, liquefaction, or other seismically induced ground failure.	Significant and unavoidable	No mitigation measures are available to reduce below significance	Significant and unavoidable
GEO-2b: Operation of the proposed Project would not result in substantial damage to structures or infrastructure, or expose people to substantial risk of injury from land subsidence/settlement.	Less than significant	No mitigation is required	Less than significant
GEO-3b: Operation of the proposed Project would not result in substantial damage to structures or infrastructure, or expose people to substantial risk of injury from expansive soils.	Less than significant	No mitigation is required	Less than significant
GEO-4b: Operation of the proposed Project would not result in substantial damage to structures or infrastructure, or expose people to substantial risk of injury from landslides or mudslides.	No impact would occur	No mitigation is required	No impact would occur
GEO-5b: Operation of the proposed Project would not result in substantial damage to structures or infrastructure, or expose people to substantial risk of injury from unstable soil conditions from excavation, grading, or fill.	No impact would occur	No mitigation is required	No impact would occur

Environmental Impacts	*Impact Determination*	*Mitigation Measures*	*Impacts after Mitigation*
GEO-6b: Operation of the proposed Project would not result in one or more distinct and prominent geologic or topographic features being destroyed, permanently covered, or materially and adversely modified.	No impact would occur	No mitigation is required	No impact would occur

3.5.4.4 Mitigation Monitoring

Table 3.5-4. Mitigation Monitoring for Geology

GEO-1a: Construction of the proposed Project would result in substantial damage to structures or infrastructure, or expose people to substantial risk of injury from fault rupture, seismic ground shaking, liquefaction, or other seismically induced ground failure.	
Mitigation Measure	**GEO-1: Seismic Design.**
Timing	Prior to the approval of the building plans and issuance of the building permit
Methodology	Implement design recommendations from the geotechnical investigation into new construction and site preparation
Responsible Parties	LAHD and Contractor
Residual Impacts	Significant

3.5.5 Significant Unavoidable Impacts

Design and construction in accordance with applicable laws and regulations pertaining to seismically induced ground movement would minimize structural damage in the event of an earthquake. However, increased exposure of people and property during construction and operation to seismic hazards from a major or great earthquake cannot be avoided, even with incorporation of modern construction engineering and safety standards. Therefore, impacts due to seismically induced ground failure would remain significant for the proposed Project.