

5.6 Geology and Soils



5.6 GEOLOGY AND SOILS

This section evaluates the geologic and seismic conditions within the City of El Segundo and evaluates the potential for geologic hazard impacts associated with implementation of the proposed project. Information in this section is based on the following documentation:

- *Geology, Soils, Seismicity Report in Support of Raytheon El Segundo South Campus Specific Plan (Geology and Soils Report)*, prepared by D. Scott Magorien, C.E.G., March 6, 2013; refer to Appendix 10.6, *Geology and Soils Report*);
- *City of El Segundo General Plan Public Safety Element (1992)*; and
- *City of El Segundo Municipal Code*.

5.6.1 EXISTING REGULATORY SETTING

FEDERAL AND STATE

Soil and Water Resources Conservation Act

The purpose of the Soil and Water Resources Conservation Act of 1977 (16 U.S.C. §§ 2001, *et seq.*) is to protect or restore the functions of the soil on a permanent sustainable basis. Protection and restoration activities include prevention of harmful soil changes, rehabilitation of the soil of contaminated sites and of water contaminated by such sites, and precautions against negative soil impacts. If impacts are made on the soil, disruptions of its natural functions and of its function as an archive of natural and cultural history should be avoided, as far as practicable. In addition, the requirements of the Federal Water Pollution Control Act (also referred to as the Clean Water Act [CWA]) through the National Pollution Discharge Elimination System (NPDES) permit) provide guidance for protection of geologic and soil resources. These regulations also include provisions to minimize soil erosion.

Alquist-Priolo Earthquake Fault Zoning Act

The Alquist-Priolo Earthquake Fault Zoning Act (Public Resources Code §§ 2621-2624) was adopted to mitigate the hazard of surface faulting to structures for human occupancy. The Act's main purpose is to prevent the construction of buildings used for human occupancy on the surface trace of active faults. The Act only addresses the hazard of surface fault rupture and is not directed toward other earthquake hazards. The Act requires the State Geologist to establish regulatory zones, known as "Earthquake Fault Zones," around the surface traces of active faults and to issue appropriate maps. Local agencies must regulate most development projects within these zones. Before a project can be permitted, cities and counties must require a geologic investigation to demonstrate that proposed buildings would not be constructed across active faults. An evaluation and written report of a specific site must be prepared by a licensed geologist. If an active fault is found, a structure for human occupancy cannot be placed over the trace of the fault and must be set back from the fault (typically 50 feet set backs are required). According to the Alquist-Priolo Earthquake Fault Zone Map - Venice Quadrangle, the Project site is not affected by a State-designated AP Earthquake Fault Zone.¹

¹ State of California Department of Conservation, California Geological Survey, Alquist-Priolo Earthquake Fault Zone Maps, <http://www.consrv.ca.gov/cgs/rghm/ap/Pages/index.aspx>, Accessed March 18, 2013.



Effective June 1, 1998, the Natural Hazards Disclosure Act requires that sellers of real property and their agents provide prospective buyers with a “Natural Hazard Disclosure Statement” when the property is being sold lies within one or more State-mapped hazard areas, including Earthquake Fault Zones. The closest Earthquake Fault Zone to the Project site is the Newport Inglewood Fault Zone (NIFZ) located approximately 4.0 miles to the east.

Seismic Hazards Mapping Act

The Seismic Hazards Mapping Act (SHMA) of 1990 (Public Resources Code §§ 2690, *et seq.*) directs the Department of Conservation, California Geological Survey to identify and map areas prone to liquefaction, earthquake-induced landslides, and amplified ground shaking. The purpose of the SHMA is to minimize loss of life and property through the identification, evaluation, and mitigation of seismic hazards.

Geologists in the Seismic Hazard Zonation Program gather existing geological, geophysical, and geotechnical data from numerous sources to produce the Seismic Hazard Zone Maps. They integrate and interpret these data regionally in order to evaluate the severity of the seismic hazards and designate as Zones of Required Investigation (ZORI) those areas prone to liquefaction and earthquake-induced landslides. Cities and counties are then required to use the Seismic Hazard Zone Maps in their land use planning and building permit processes.

The Seismic Hazards Mapping Act requires site-specific geotechnical investigations be conducted within the ZORI to identify and evaluate seismic hazards (i.e., liquefaction and earthquake induced landslides) and formulate mitigation measures prior to permitting most developments designed for human occupancy.

Liquefaction Hazard

Liquefaction occurs when loose, water-saturated sediments lose strength and fail during strong ground shaking. Liquefaction is defined as the transformation of granular material from a solid state into a liquefied state as a consequence of increased pore-water pressure. The process of zonation for liquefaction combines Quaternary geologic mapping, historical ground-water information and subsurface geotechnical data. The liquefaction hazard ZORI boundaries are based on the presence of shallow (< 40 feet depth) historic groundwater in uncompacted sands and silts deposited during the last 15,000 years and sufficiently strong levels of earthquake shaking expected during the next 50 years. According to the Seismic Hazards Zones Map, the Project Site is not located within a ZORI for liquefaction hazard.²

Earthquake-Induced Landslides

Landslides tend to occur in weak soil and rock on sloping terrain. The ZORI for earthquake-induced landslides generally indicate areas characterized by steep slopes composed of weak materials that may fail when shaken by an earthquake. The process for zonation of earthquake-induced landslides incorporates expected levels of future earthquake shaking, evidence of existing landslides, slope gradient, and strength of hillslope materials. According to the Seismic

² State of California Department of Conservation, California Geological Survey, Seismic Hazard Zonation Program, <http://www.consrv.ca.gov/cgs/shzp/Pages/Index.aspx>, Accessed March 18, 2013.



Hazard Zones Map, the Project site is not located within a ZORI for earthquake-induced landslide hazard.³

International Building Code

Development standards require projects to comply with appropriate seismic design criteria in the International Building Code (IBC) (with California Amendments), adequate drainage facility design, and preconstruction soils and grading studies. Seismic design standards have been established to reduce many of the structural problems occurring because of major earthquakes. In 1998, the IBC was revised, as follows:

- Upgrade the level of ground motion used in the seismic design of buildings;
- Add site amplification factors based on local soils conditions; and
- Improve the way ground motion is applied in detailed design.

California Building Code

California building standards are published in the California Code of Regulations, Title 24, also known as the California Building Standards Code (CBC). The recently published 2013 CBC took effect January 1, 2014. The CBC, which applies to all applications for building permits, consists of 12 parts, including among others Part 2 - California Building Code and Part 11 - California Green Building Standards Code (CALGreen Code). CBC Part 2 is based upon the 2009 International Building Code. Local agencies must ensure that all development complies with the CBC guidelines. Cities and counties have the ability to adopt additional building standards beyond the CBC.

CITY OF EL SEGUNDO

El Segundo General Plan Public Safety Element

The El Segundo General Plan Public Safety Element addresses hazards associated with geology and seismicity, flooding, fire, petroleum storage, and hazardous materials. The purpose of the Public Safety Element is to reduce death, injuries, property damage, and economic and social dislocation resulting from natural and man-made hazards such as urban fire, flooding, mudslides, earthquakes, and hazardous incidents.

It is the City's goal (Goal PS1) to "protect the public health and safety and minimize the social and economic impacts associated with geologic hazards." In furtherance of this goal, it is the City's objective (Objective PS1-1) to reduce exposure to potentially hazardous geological conditions through land use planning and project review. To this end, the City has established the following policies/programs:

Policy PS1-1.1: Continue to review proposals for new development and for the expansion of existing development in areas of potential geological hazards.

³ Ibid.



Policy PS1-1.2 Enforce, monitor, and improve development standards which place the responsibility on the developer, with advice from qualified engineers and geologists, to develop and implement adequate mitigation measures as conditions for project approval.

Program PS1-1.2A The City shall review projects to ensure that adequate geotechnical investigation has been completed in areas susceptible to landsliding and debris flows and in areas where collapsible or expansive soils occur, and to approve only those which mitigate these hazards to the satisfaction of the City Engineer.

Program PS1-1.2B The City shall review projects to ensure that adequate geotechnical investigation has been completed in areas underlain by the Oceano group of soils, and to approve only those which mitigate any hazards to the satisfaction of the City Engineer.

It is also the City's goal (Goal PS2) to "Minimize injury and loss of life, property damage, and social, cultural and economic impacts caused by earthquake hazards." In furtherance of this goal, the City has established the following policies/programs:

Program PS2-1.1A The City shall continue to enforce the Uniform Building Code.

Policy PS2-1.2 The City shall assist in the prevention of structural damage in areas with a high potential for liquefaction, landslides, and mudslides by requiring geotechnical studies for new development to mitigate potential impacts.

Program PS2-1.2A The City shall require geotechnical evaluation of the potential for seismically induced landslide, mudslide, and liquefaction in areas where such hazards have been identified.

Refer to Section 5.7, *Hazards and Hazardous Materials*, for policies pertaining to hazardous materials, and Section 5.8, *Hydrology and Water Quality* for policies pertaining to drainage and water quality.

El Segundo Municipal Code

ESMC CHAPTER 5-4, STORM WATER AND URBAN RUNOFF POLLUTION CONTROL

El Segundo Municipal Code (ESMC) § 5-4-9 specifies that each person applying to the City for a Grading or Building Permit for projects for which compliance with regulations governing state construction activity storm water permits (GCASPs) is required, must submit satisfactory proof to the City that:

1. A Notice of Intent (NOI) to comply with the GCASP was filed; and
2. A Storm Water Pollution Prevention Plan (SWPPP) has been prepared, before the City can issue any Grading or Building Permit on the construction project.

ESMC CHAPTER 13-1, BUILDING CODE

According to ESMC Title 13 Chapter 1, the California Building Code, 2013 Edition was adopted by the City, subject to the amendments, additions and deletions set forth in Title 13.



ESMC CHAPTER 14-1, GENERAL PROVISIONS

Upon approval of a Tentative Map or Parcel Map, the City will determine whether a Soils Report and/or grading and erosion control are required. Additionally, every map approved pursuant to ESMC Title 14 will be conditioned on compliance with the requirements for grading and erosion control, including the prevention of sedimentation or damage to off-site property set forth in the ESMC.

According to ESMC § 14-1-9, *Soils Report*, if the City has knowledge of, or the preliminary soils report indicates the presence of critically expansive soils or other soils problems which, if not corrected, would lead to structural defects, a soils investigation of each lot in the subdivision may be required by the Director of Planning and Building Safety before approval of the Final Map or Parcel Map. The Soils Report must be prepared in accordance with the latest edition of the California Building Code. Such soils investigation must be done by a Civil Engineer, who will recommend the appropriate corrective action, which is likely to prevent structural damage to each structure proposed to be constructed in the area where such soils problems exist.

5.6.2 EXISTING ENVIRONMENTAL SETTING

GEOLOGIC SETTING

Regionally, the site is located within the Peninsular Ranges geomorphic province. This province is characterized by elongated northwest-trending mountain ridges separated by straight sided sediment-filled valleys. The northwest trend is further displayed in the dominant, geological structural features of the province, which include northwest to west-northwest trending folds and faults, such as the nearby Newport-Inglewood fault zone, located approximately 5.0 miles east of the site. There are no documented active or potentially active faults within or projecting towards the site.

The Project site is situated within a coastal area referred to as the western Los Angeles basin characterized by an extensive coastal belt of late Pleistocene age, non-migrating dunes, and more recent eolian (wind-blown) sand, which is referred to as the El Segundo Sandhills. The sand hills located at the Project site are made up of stabilized dunes that, prior to development, had crests ranging from 85 to 185 feet above mean sea level (msl). The main part of this coastal belt is represented by stabilized dunes and parallel ridges and aligned hills that have formed by wind and stream action, since their deposition during late Pleistocene time.

This coastal belt includes middle Pleistocene age sediments that were deposited on an ancient ocean floor (i.e., marine deposits) and includes the San Pedro formation and the older, underlying Lakewood formation. The sandy sediments that make up these two geologic formations comprise the main groundwater-bearing strata in this portion of the Los Angeles basin.

There are no documented metallic or non-metallic mineral deposits or significant paleontological (i.e., fossil) sites within the site. However, the Project site does lie within the El Segundo oil and gas field; refer to Exhibit 5.6-1, *Geologic Map*.



SITE CONDITIONS

Based on 1923-50, U.S. Geological Survey topographic data for the Venice 7.5 minute Quadrangle, before any development activities, the western two-thirds of the Project site was represented by two aligned hills that attained elevations of approximately 135 feet msl. These two hills, and unremarkable saddle between them, were bounded on the east by a relatively flat topographic surface having an elevation of approximately 105 feet msl. Today, the elevation of the site varies from approximately 115 to 125 feet msl along the western margin, to approximately 102 feet msl along the eastern margin.

GEOLOGIC MATERIALS

The geologic materials that underlie the Project site include undocumented artificial fill soils and late Pleistocene age dune sand. The following descriptions of these soil-like materials are based in part from shallow exploratory boring data obtained by RGI, as part of its 2005 preliminary geotechnical engineering investigation for the proposed building sites on the property.

Undocumented Artificial Fill

Undocumented artificial fill soils were encountered within all of the 14 exploratory borings, and vary in thickness from less than 3.0 feet in the central portion of the site, approximately 7.0 feet thick in the northeastern corner, and more than 18 feet thick in the southeast corner. Although no exploratory borings were drilled in the western portions of the site, it is very likely that fill soils also blanket much of the remainder of the Project area. These soils are considered “undocumented” because there apparently was no observation or density testing by a qualified geotechnical engineering firm when they were placed, and are likely derived from the older dune deposits that underlie the fill.

Based on the exploratory boring data, the fill soils consist mainly of fine- to medium-grained sand and silty sand with subordinate amounts of gravel and clay, and what appears to be miscellaneous construction-related debris, in the form of concrete blocks, and asphalt and brick fragments. Aside from the construction-type debris, the non-engineered fill soils are reported to be orange-brown to dark gray in color, moist, and dense.

Older Stabilized Dune Sand

Late Pleistocene age coastal dune (eolian) sands associated with the El Segundo Sandhills directly underlie the undocumented fill soils across much, if not the entire Project site. These natural soils were likely deposited in a near-shore, non-marine environmental setting, and may include sediments deposited by intermittent stream flows and periods of severe flooding.

The overall lithologic character of the dune material is represented by fine-to medium-grained sand with lesser amounts of silty and clayey sand. These sandy soils are typically light orange to “golden orange” in color, moist and dense to very dense. Exposures of similar deposits along the Bellona Escarpment, located approximately 4.5 miles to the north of the Project site, display crude bedding that dips very gently to the southwest, and rests uncomfortably on the older Pleistocene age San Pedro formation.

MAP UNITS

Late Holocene (Surficial Deposits)

- af** **Artificial Fill** - deposits of fill resulting from human construction, mining, or quarrying activities; includes engineered fill for buildings, roads, dams, airport runways, harbor facilities, and waste landfills
- Qb** **Beach Deposits** - unconsolidated marine beach sediments consisting mostly of fine- and medium-grained, well-sorted sand
- Qe** **Eolian and Dune Deposits** - unconsolidated, generally well-sorted wind-blown sand; may occur as dune forms or sheet sand

Holocene to Late Pleistocene (Surficial Deposits)

- Qye** **Young Eolian and Dune Deposits** - unconsolidated to slightly consolidated, undissected to slightly dissected wind-blown sands

Late to Middle Pleistocene (Surficial Deposits)

- Qoa** **Old Alluvial Valley Deposits** - slightly to moderately consolidated, moderately dissected clay, silt, sand, and gravel along stream valleys and alluvial flats of larger rivers
- Qoe** **Old Eolian and Dune Deposits** - slightly to moderately consolidated, moderately dissected wind-blown sands

SYMBOL EXPLANATION

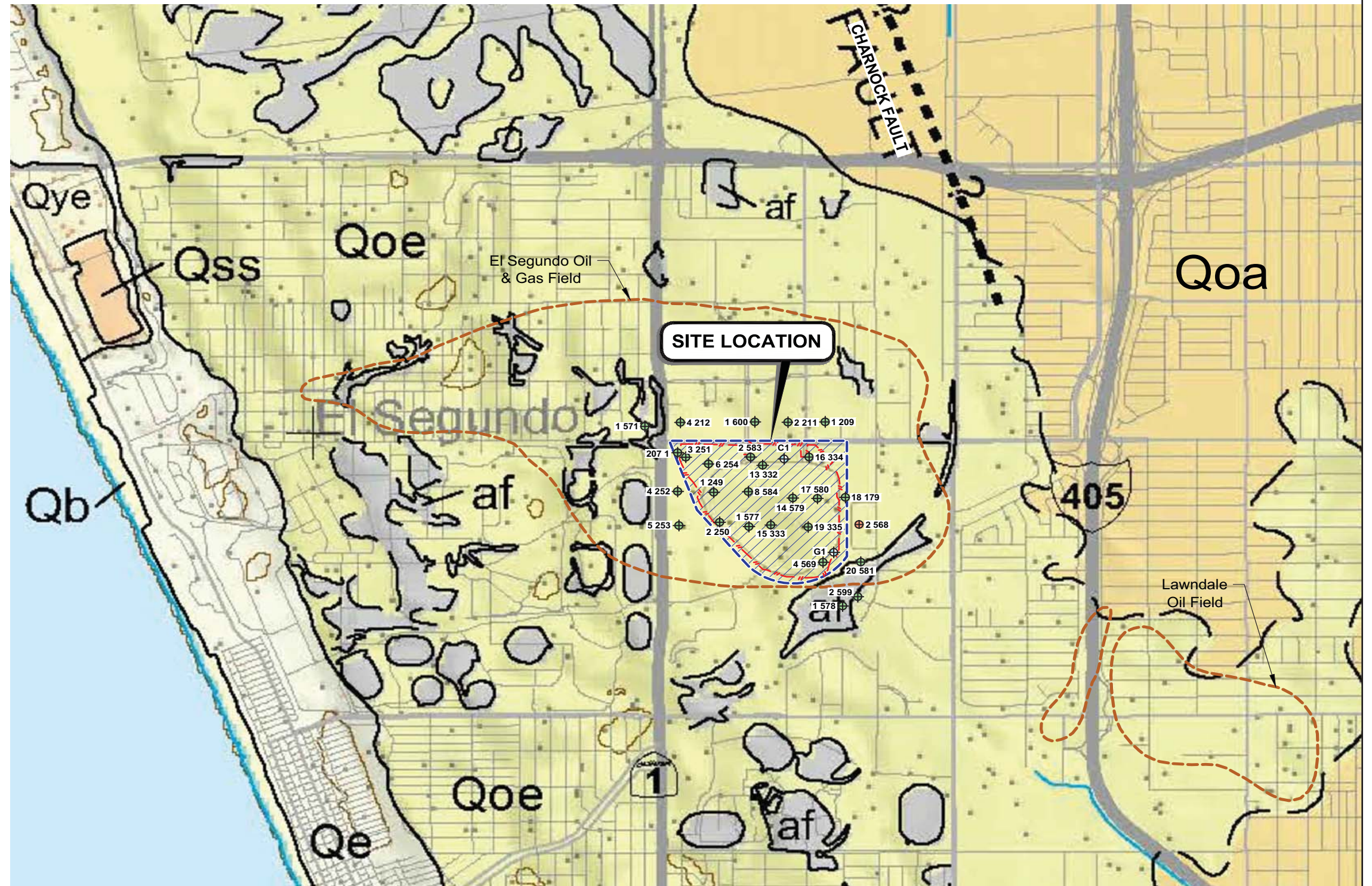
[For geologic line symbols: lines are solid where location is accurate, long-dashed where location is approximate, short-dashed where location is inferred, dotted where location is concealed. Queries added where identity or existence may be questionable.]

- Contacts**
- Contact
 - Reference contact -- Used to delineate geologic units that were mapped as separate units on the original source map, but are consolidated on this map.
 - Fault -- Includes strike-slip, normal, reverse, oblique, and unspecified slip
 - Folds -- Showing direction of plunge where appropriate
 - Stream
 - Wet area
 - Road

Explanation

- 2 568** ⊕ Oil well and state number
- 5 767** ⊕ Abandoned oil and gas well and state number located within approximately 500 ft of site
- C1** ⊕ Water well, status unknown
- Approximate boundary of oil & gas field
- Approximate limits of grading (Psomas, 2013)

Note: Basemap modified from California Geological Survey, July 2010, Geologic Compilation of Quaternary Surficial Deposits in Southern California Onshore Portion of the Long Beach 30'x60' Quadrangle.



Source: Scott Magorien, *Geology and Soils Report*, March 6, 2013.

NOT TO SCALE



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The dune sand deposits are generally non expansive; however, there are 6.0 to 7.0 foot-thick clay-rich layers that were encountered in the exploratory borings directly below the base of the undocumented fill soils in the southern portion of the Project site that are considered to be moderately to highly expansive. Expansive soils are types of soil that shrink or swell as the moisture content decreases or increases. Limited corrosion testing of finer grained soils indicates a mild degree of corrosion potential.

Given the relatively dense nature of these deposits, and the depth to groundwater, there are no significant constraints associated with seismically-induced landsliding, liquefaction, or lateral spread.

GROUNDWATER

The principal groundwater aquifer that lies beneath the Project site is referred to informally as the “Silverado water-bearing zone,” which is part of the Pliocene age San Pedro formation and is approximately 150-feet-thick. Depth to groundwater beneath the Project site within the Silverado is more than 100 feet below ground surface (bgs). Historic documents reference two water wells located in the southeast portion of the site (in close proximity to proposed Parcel No. 10), and the other at the northeast portion of the site (in close proximity to proposed Parcel No. 14).

No evidence of springs or seeps has been documented within or adjacent to the site.

MINERAL RESOURCES

There are no economic metallic or non-metallic ore deposits within or in the vicinity of the Project area. However, the Project site is basically surrounded by the relatively inactive El Segundo oil and gas field. Between 1935 and 1987, 76 oil and gas wells were drilled in this field, producing more than 13.6 million barrels of oil. According to a State of California Division of Oil, Gas, and Geothermal Resources District 1 (State) map, there are 15 plugged/abandoned oil and gas wells within the confines of the Project site (see [Exhibit 5.6-1](#)), and numerous others bordering all but the southern edge of the Project site. The closest active oil and gas well is located approximately 300 feet east of the eastern site boundary, adjacent to Douglas Street; refer to [Exhibit 5.6-1](#). This well (identified by the State as Brayton-Hodges Petro Inc., Operator Code B5835, API 03707568) has reportedly been in operation since approximately 1976.

GEOLOGIC HAZARDS AND GEOTECHNICAL CONSTRAINTS

Given the historic land use, current site soil conditions, physiographic setting, and the nature of the proposed site grading and structures, the following geologic hazards and geotechnical constraints are present on the site:

- Seismically-induced moderate to strong ground shaking;
- Seismically-induced settlement and/or collapse of artificial fill soils;
- Expansive and possibly corrosive soils; and
- Methane gas from old oil and gas wells, and soil contamination from past oil field drilling activities (i.e., former pits containing drilling mud).



Although the Project area is located within a highly seismically active portion of the state, there are no documented active or potentially active faults transecting or projecting towards the site. Moreover, there are no documented landslides within or adjacent to the Project area.

Given the dense nature of the older dune deposits, elevation and distance from the Pacific Ocean, and depth to groundwater, secondary seismic hazards due to moderate to strong earthquake ground motions from future earthquakes in the region (such as liquefaction, lateral spreading, seismically-induced landsliding, seiche, and tsunami run-up) do not present hazards at the site.

Non seismic-related geologic hazards at the site include the presence of soils that are expansive, corrosive, and subject to sloughing and caving during excavation. There is no current evidence that suggests the presence of soils containing collapsible and organic peat deposits on the site.

Land subsidence that has in the past been associated with withdrawals of oil from a number of oil and gas fields in southern California (i.e., Wilmington, Inglewood, Buena Vista Hills, Santa Fe Springs, and Huntington Beach) has not been identified within the El Segundo oil and gas field. Assuming the El Segundo oil field does experience a large resurgence in oil production, the likelihood of land subsidence in the future is not considered significant.

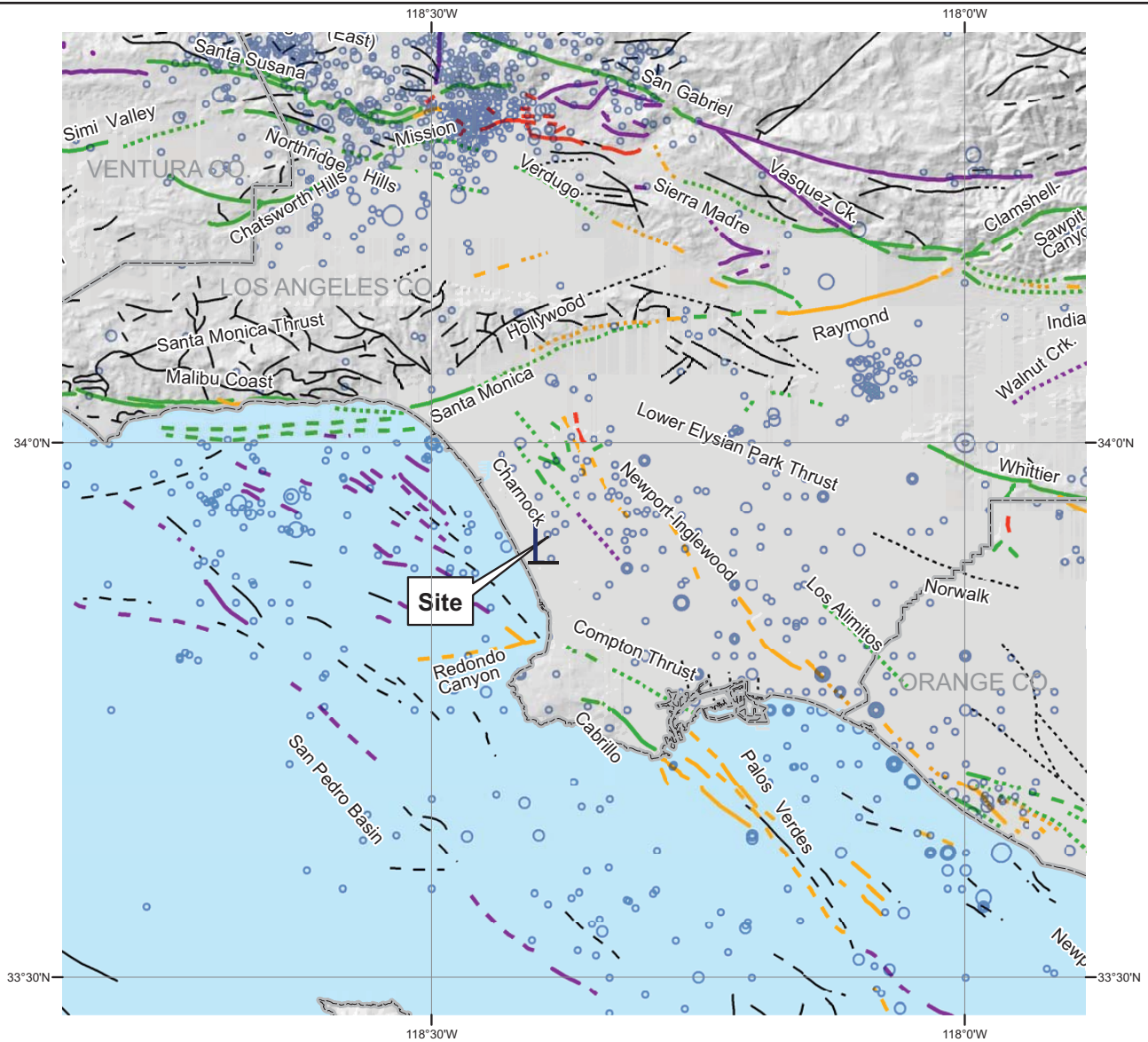
Faulting and Seismicity

The Project area is situated within a highly seismically active area of southern California referred to as the Los Angeles Basin; refer to Exhibit 5.6-2, *Fault Location and Seismicity Map*. Hazards associated with earthquakes include primary seismic hazards, such as ground shaking and surface rupture, and secondary seismic hazards, such as liquefaction, lateral spreading, seismically-induced settlement and landsliding, tsunamis, and seiche.

In accordance with the California Geological Survey (CGS), a fault is defined as a fracture in the crust of the earth along which rocks on one side have moved relative to those on the other side. Most faults are the result of repeated displacements over a long period of time. An inactive fault is a fault that has not experienced earthquake activity within the last three million years. In comparison, an active fault is one that has experienced earthquake activity in the past 11,000 years. A fault that has moved within the last two to three million years, but has not been proven by direct evidence to have moved within the last 11,000 years, is considered potentially active. No active or potentially active faults are located within or project towards the Project area.

As concluded above, the Project area is not currently known to be located within an Alquist-Priolo Earthquake Fault Zone, according to the CGS. The closest Earthquake Fault Zone to the Project site is the Newport Inglewood Fault Zone (NIFZ) located approximately 4.0 miles to the east.

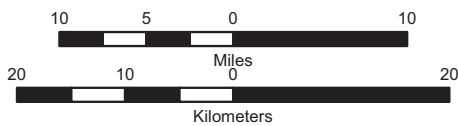
Ground shaking accompanying earthquakes on nearby faults can be expected to be felt within the Project site. However, the intensity of ground shaking would depend upon the magnitude of the earthquake, the distance to the epicenter, and the geology of the area between the epicenter and the property. The Modified Mercalli Intensity (MMI) scale was developed in 1931 and measures the intensity of an earthquake's effects in a given locality, and is perhaps much more meaningful to the layman because it is based on actual observations of earthquake effects at specific places. On the MMI scale, values range from I to XII. The most commonly used adaptation covers the range of intensity from the conditions of: "I" – not felt except by very few, favorably situated, to "XII" – damage total, lines of sight disturbed, and objects thrown into the



Explanation

- | | |
|---|---|
| <p>Fault Recency Classification (Jennings, 1994)</p> <ul style="list-style-type: none"> — Faults with historic surface rupture or creep — Faults that displace Holocene (~10 ka) deposits or geomorphic surfaces — Faults that displace late Quaternary (~700 ka) deposits or geomorphic surfaces — Quaternary faults; show evidence for displacement within past 1.6 Million years — Pre-Quaternary faults [Anza] Fault Segments | <p>Historic earthquakes, 1769-2003</p> <p>Magnitude</p> <ul style="list-style-type: none"> ○ 3.0 to < 4.0 ○ 4.0 to < 5.0 ○ 5.0 to < 6.0 ○ 6.0 to < 7.0 ○ 7.0 or greater |
|---|---|

Note: See text of report for description of seismicity catalog.



Source: Scott Magorien, *Geology and Soils Report*, March 6, 2013.

ENVIRONMENTAL IMPACT REPORT
EL SEGUNDO SOUTH CAMPUS SPECIFIC PLAN (EA 905)

Fault Location and Seismicity Map



air. While an earthquake has only one magnitude, it can have many intensities, which decrease with distance from the epicenter. Ground motions, on the other hand, are often measured in percentage of gravity (percent g), where $g = 32$ feet per second per second (980 cm/sec^2) on the earth.

STRONG SEISMICALLY-INDUCED GROUND MOTION

Based on the California Division of Mines and Geology Seismic Hazard Zone Report for the Venice 7.5-Minute Quadrangle that applies a PGA for 10 percent exceedance in 50 years for alluvial-type soils, the level of ground motion at the Project site is expected to be approximately 0.46 g.

A listing of active faults considered capable of producing strong ground motion at the site, their closest distances to the property, and the maximum expected earthquake along each fault is presented in Table 5.6-1, Summary of Active Faults and Generalized Earthquake Information. Also presented are generalized evaluations of maximum ground shaking at the Project site for the maximum earthquakes, and generalized predictions of the likelihood of such events occurring.

The greatest amount of ground shaking at the site would be expected to accompany large earthquakes on the Palos Verdes fault, the NIFZ, and the Puente Hills (Los Angeles section), and Upper Elysian Park Blind Thrust faults. Earthquake magnitudes (M) in the range of M6.5 to M7.3 could produce MMI in the range of VIII to XI within the property.

The potential for secondary earthquake hazards, including ground deformation associated with liquefaction, lurching, lateral spreading, seismically-induced settlement, earthquake-induced landsliding, tsunamis, and seiche, is considered nonexistent.

**Table 5.6-1
Summary of Active Faults and Generalized Earthquake Information**

Name	Miles from Project Site	Maximum Magnitude (M)	Expected Level of Ground Shaking	Likelihood
Newport-Inglewood (NIFZ)	4.0	7.5	High	High
Palos Verdes	4.4	7.3	High	High
Puente Hills (LA) Blind Thrust*	8.8	7.0	High	High
Santa Monica	9.3	7.4	High	Moderate
Malibu Coast	11.3	7.0	High	Moderate
Elsinore	11.6	7.8	High	High
Hollywood	11.9	6.7	High	Moderate
Anacapa-Dume	12.1	7.2	High	Moderate
Upper Elysian Blind Thrust*	14.1	6.7	High	High
Raymond	17.4	6.8	High	Moderate
Sierra Madre Cucamonga	23.8	6.7 to 7.2	Moderate	High
Santa Susana	28.4	6.9	Low	Moderate
San Joaquin Hills Blind Thrust*	30.4	7.1	Moderate	Moderate
San Andreas (Southern)	46.9	8.2	High	High
San Jacinto (Anza)	54.4	7.9	Moderate	High

* These faults are termed "blind thrust faults" because they have no surface exposure. The closest distance from the Project site is based on a projection of the rupture area along the subsurface trace of the fault.



LIQUEFACTION

Seismic ground shaking of relatively loose, granular soils that are saturated or submerged can cause the soils to liquefy and temporarily behave as a dense fluid. Liquefaction is caused by a sudden temporary increase in pore water pressure due to seismic densification or other displacement of submerged granular soils. Liquefaction more often occurs in earthquake-prone areas underlain by young (i.e., Holocene age) alluvium where the groundwater table is higher than 50 feet bgs.

As discussed above, the CGS has designated certain areas within California as potential liquefaction hazard zones. As shown on the State of California's Seismic Hazard Zone Map for the Venice 7.5' Quadrangle, the Project site does not lie within an area of high liquefaction potential. This assessment is further validated by the results of the subsurface geotechnical studies performed by RGI.

LATERAL SPREADING

Lateral spreading involves the dislocation of near surface soils generally along a near-surface liquefiable layer. In many cases, this phenomenon of shallow landsliding occurs on relatively flat or gently sloping ground adjacent to a "free face," such as a river embankment. Given the Project site conditions, the likelihood for lateral spread beneath the Project site during a major earthquake in the area is nonexistent.

SEISMICALLY-INDUCED LANDSLIDING

Based on the essentially flat nature of the Project site, and the absence of any adversely-oriented, weak clay beds, the potential for seismically-induced landsliding within the Project site is considered nonexistent.

SEISMICALLY-INDUCED SOIL SETTLEMENT

Strong ground shaking can cause settlement by allowing sediment particles to become more tightly packed, thereby reducing pore space. Unconsolidated, loosely packed sediments, such as young alluvial soils (of which there are none on the site) are especially susceptible to this phenomenon. Poorly compacted artificial fills may also experience seismically-induced settlement. Based on the subsurface data obtained from the exploratory borings drilled by RGI, portions of the site that are mantled with non-engineered (i.e., loose) fill soils may likely be subject to seismically-induced settlement and/ or development of ground cracking.

GROUND LURCHING

Lurching is a phenomenon in which loose to poorly consolidated deposits move laterally as a response to strong ground shaking during an earthquake. Lurching is typically associated with loose soil deposits on or adjacent to steep slopes. Lurching that occurred in the Santa Monica and Santa Susana mountains during the 1994 Northridge earthquake usually was attributable to the outer 2.0 to 8.0 feet of loose fill soils that spilled over the edges of graded pads cut into bedrock. Graded and compacted housing pads did not experience lurching during this very damaging earthquake.



Certain soils have been observed to move in a wave-like manner in response to intense seismic ground shaking, forming ridges or cracks on the ground surface. Areas underlain by thick accumulations of alluvium appear to be more susceptible to ground lurching than bedrock. Under strong seismic ground motion conditions, lurching can be expected within loose, cohesionless soils, or in clay-rich soils with high moisture content. Generally, only lightly-loaded structures such as pavement, fences, pipelines and walkways are damaged by ground lurching; more heavily loaded structures appear to resist such deformation. Ground lurching may occur on the Project site where deposits of loose dune sand and/or undocumented fill soils exist.

OTHER GEOLOGICAL HAZARDS

Methane

Probably the most common sources of human-related methane stems from production of natural gas and petroleum. Given that the site is located with a relatively inactive oil and gas field, the potential exists for methane to be found within the Project site. Exhibit 5.6-1 depicts the location of one active, and other abandoned oil/gas wells internal to, and within 500 feet, of the site. Issues associated with methane levels within and adjacent to the Project site may be a constraint. Potential impacts involving methane are addressed in Section 5.7, *Hazards and Hazardous Materials*.

Corrosive Soils

Corrosive soils contain chemical constituents that can react with construction materials, such as concrete and ferrous metals, that may cause damage to foundations and buried pipelines. One such constituent is water-soluble sulfate which, if in high enough concentration, can react with and damage concrete. Electrical resistivity and pH level are indicators of the soil's tendency to corrode ferrous metals. According to limited laboratory testing by RGI, near surface soils have a relatively mildly alkaline pH value (7.7 to 8.1), and relatively high to moderate resistivity (between 5900 and 15000 ohm-cm), indicating these soils are considered mildly corrosive to ferrous metals in contact with these soils. Laboratory tests by RGI also indicate water soluble sulfate contents of 7 to 36 parts per million, which is an indication of negligible sulfate exposure. As such, no particular recommendations for cement type or water ratio were deemed necessary by RGI to provide sulfate resistance. Overall, RGI indicates that onsite soils are mildly to moderately corrosive to ferrous metals.

Expansive Soils

Expansive soils are clay-rich soils that can undergo significant increase in volume with increased water content and significant decrease in volume with a decrease in water content. Significant changes in moisture content within moderately to highly expansive soil can produce cracking differential heave, and other adverse impacts to structures constructed on such soils. Based on the results of a single laboratory test performed by RGI, clayey soils encountered in exploratory borings exhibited "moderate to high" expansion potential. Therefore, the potential for expansive soils to be present on the site is considered high.



Subsidence

The extraction of groundwater or oil from sedimentary source rocks can cause the permanent collapse of pore space that was previously occupied by the removed fluid. The compaction of subsurface sediments resulting from fluid withdrawal can and has caused the ground surface overlying fluid reservoirs to subside. If sufficiently great, the subsidence can cause significant damage to nearby engineered structures. As stated earlier in this report, the Project site is situated within an active or historic oil or gas field.

According to the El Segundo General Plan, no subsidence associated with fluid withdrawal (groundwater or petroleum), peat oxidation, or hydrocompaction has occurred in the City of El Segundo. Therefore, there is no potential for subsidence to impact the Project site.

Soil Erosion

Soil erosion is most prevalent in more weakly consolidated (i.e., highly weathered) dune sand and surficial soils, which are prone to downcutting during and after heavy rainstorms. Strong wind forces can also produce varying amounts of soil erosion of the more weakly consolidated surficial soils.

Sloughing or Caving of Excavations

The poorly unconsolidated/noncohesive artificial fill that are present on the Project site are subject to sloughing and caving.

5.6.3 IMPACT THRESHOLDS AND SIGNIFICANCE CRITERIA

The environmental analysis in this section is patterned after the Initial Study Checklist recommended by Appendix G of the *CEQA Guidelines*, as amended, and used by the City of El Segundo in its environmental review process. The Initial Study Checklist includes questions relating to geology and soils. The issues presented in the Initial Study Checklist have been utilized as thresholds of significance in this section. Accordingly, a project may create a significant environmental impact if it would:

- Expose people or structures to potential substantial adverse effects, including the risk of loss, injury, or death involving:
 - Rupture of a known earthquake fault, as delineated on the most recent Alquist-Priolo Earthquake Fault Zoning Map issued by the State Geologist for the area or based on other substantial evidence of a known fault. Refer to Division of Mines and Geology Special Publication 42 (refer to Section 8.0, *Effects Found Not to be Significant*).
 - Strong seismic ground shaking.
 - Seismic-related ground failure, including liquefaction.
 - Landslides (refer to Section 8.0).



- Result in substantial soil erosion or the loss of topsoil.
- Be located on a geologic unit or soil that is unstable, or that would become unstable as a result of the project, and potentially result in on-or off-site landslide, lateral spreading, subsidence, liquefaction or collapse.
- Be located on expansive soil, as defined in Table 18-1-B of the California Building Code (2004), creating substantial risks to life or property.
- Have soils incapable of adequately supporting the use of septic tanks or alternative waste water disposal systems where sewers are not available for the disposal of waste water (refer to Section 8.0).

Earth resource and/or topographic impacts resulting from a project could be considered significant if any of the following occur:

- Exposure of people or property to substantial geological hazards, such as flooding due to dam or reservoir failure, landslides, mudslides, ground failure or similar hazards; or soil and/or seismic conditions so unfavorable that they could not be overcome by design using reasonable construction and/or maintenance practices;
- Location of a structure within a mapped hazard area or within a structural setback zone (refer to Section 8.0);
- Location of a structure within an Alquist-Priolo Fault-Rupture Hazard Zone, or within a known active fault zone, or an area characterized by surface rupture that might be related to a fault (refer to Section 8.0);
- Triggering or acceleration of geologic processes, such as landslides or erosion that could result in slope or embankment/levee failures;
- Substantial irreversible disturbance of the soil materials at the Project site or adjacent sites, such that their use is compromised;
- Modification of the surface soils such that abnormal amounts of windborne or waterborne soils are removed from the Project site;
- Earthquake-induced ground shaking capable of causing ground rupture, liquefaction, soil settlement, landsliding resulting in substantial damage to people and/or property;
- Deformation of foundations by expansive soils (those characterized by shrink/swell potential) or collapsible soils; and
- Modification of the on-site topography (i.e. grading) in a manner that results in decreased stability for adjacent residential, commercial or industrial enclaves.

Based on these standards, the Project's effects have been categorized as either a "less than significant impact" or a "potentially significant impact." Mitigation measures are recommended for potentially significant impacts. If a potentially significant impact cannot be reduced to a less than significant level through the application of mitigation, it is categorized as a significant unavoidable impact.



5.6.4 IMPACTS AND MITIGATION MEASURES

The level of geotechnical and landform information contained herein is adequate to analyze the potential project effects on earth resources and landforms, and to determine appropriate mitigation measures for the proposed development.

STRONG SEISMIC GROUND SHAKING

- **THE PROJECT COULD EXPOSE PEOPLE OR STRUCTURES TO POTENTIAL SUBSTANTIAL ADVERSE EFFECTS INVOLVING STRONG SEISMIC GROUND SHAKING.**

Impact Analysis: A moderate to large magnitude earthquake on a regional fault could cause moderate to severe seismic shaking in the City, thus exposing people or structures on the Project site to potential substantial adverse effects, including the risk of loss, injury, or death. The possibility of moderate to high ground acceleration or shaking in the City may be considered as approximately similar to the entire Southern California region, as a whole. The intensity of ground shaking on the Project site would depend upon the magnitude of the earthquake, distance to the epicenter, and the geology of the area between the epicenter and the Project site.

Numerous controls would be imposed on the Project through the permitting process. In general, the City regulates development (and reduces potential seismic and geologic impacts) under the requirements of the California Building Code, ESMC Chapter 13-1, and project specific mitigation measures. As previously noted, the level of ground motion at the Project site is expected to be approximately 0.46 g, based on a PGA for 10 percent exceedance in 50 years for alluvial-type soils. However, given the changes to the latest CBC, as well as the nature of the Project, the Geology and Soils Report recommends that more stringent earthquake ground motions (i.e., 2 percent chance of exceedance in 50 years) be utilized as part of the Project's future lot-specific geotechnical investigations. All structures associated with the proposed development must be designed to withstand this recommended "design-level" earthquake, as set forth in the latest edition of the CBC. The Report further recommends an in-depth seismic design analysis for structures over two stories. The potential adverse impacts to new structures due to strong, seismically-induced, vibratory ground motion would be sufficiently mitigated through proper seismic design. No significant geotechnical-related constraints that would preclude designing adequate foundations and structural elements for the taller structures are anticipated. Therefore, compliance with the CBC and ESMC, and the Geology and Soils Report's recommendations, which include the use of more stringent earthquake ground motions and in-depth seismic design analyses, would ensure that Project implementation would result in a less than significant impact regarding the exposure of people or structures to potential substantial adverse effects involving strong seismic ground shaking.

Mitigation Measures:

- GEO-1 Before the City issues a Grading Permit or Building Permit, a lot-specific Geotechnical/Soils Investigation must be conducted, to the satisfaction of the Director of Planning and Building Safety. The Geotechnical/Soils Investigation must:



- Be prepared in accordance with the latest edition of the California Building Code by a civil engineer registered in this State;
- Comply with the recommendations specified in the Geology, Soils, Seismicity Report in Support of Raytheon El Segundo South Campus Specific Plan (D. Scott Magorien, C.E.G., March 6, 2013); and
- Recommend the appropriate corrective action, which is likely to prevent structural damage to each structure proposed to be constructed in the area where geotechnical/soils problems exist.

Level of Significance: Less Than Significant With Mitigation Incorporated.

SEISMICALLY-INDUCED SOIL/ GROUND SETTLEMENT AND LURCHING

- **THE PROJECT COULD EXPOSE PEOPLE OR STRUCTURES TO POTENTIAL SUBSTANTIAL ADVERSE EFFECTS INVOLVING SEISMICALLY-INDUCED SOIL/GROUND SETTLEMENT AND LURCHING.**

Impact Analysis: The geologic materials that underlie the Project site include a late Pleistocene age dune sand and undocumented artificial fill soils. From a geotechnical perspective, the older dune sands have sufficient soil engineering strengths to provide foundation support for the proposed structures. However, the undocumented artificial fill soils that are present in the southeast corner of the site, and are very likely present throughout much of the remainder of the Project area, are considered compressible and subject to consolidation due to the lack of adequate documentation when they were placed. Additionally, ground lurching may occur on the Project site where deposits of loose dune sand and/or undocumented fill soils exist. The Geology and Soils Report recommends that the undocumented fill soils and loose soil deposits be removed and replaced as properly engineered fill, in order to mitigate seismically-induced soil/ground settlement and lurching.

As previously noted, the City regulates development (and reduces potential geologic and soils impacts) under the requirements of the CBC, ESMC, and Project specific mitigation measures. According to ESMC § 14-1-9, if the City has knowledge of soil problems which, if not corrected, would lead to structural defects, a Soils Investigation of each lot in the subdivision may be required. The susceptibility of the onsite loose and undocumented fill soils to seismically-induced settlement and lurching present potentially significant impacts to the Project. Therefore, in compliance with ESMC § 14-1-9, a soils investigation of each lot in the proposed subdivision would be conducted and the appropriate corrective action recommended. Therefore, compliance with the CBC and ESMC, and the Geology and Soils Report's recommendations, which include removal of the undocumented fill soils and replacement as properly engineered fill, would ensure that Project implementation would result in a less than significant impact regarding the exposure of people or structures to potential substantial adverse effects involving seismically-induced soil/ground settlement and lurching.

Mitigation Measures: Refer to Mitigation Measure GEO-1.

Level of Significance: Less Than Significant With Mitigation Incorporated.



SOIL EROSION

- **THE PROJECT COULD RESULT IN SUBSTANTIAL SOIL EROSION OR THE LOSS OF TOPSOIL.**

Impact Analysis: Project implementation would result in ground-disrupting activities such as excavation and trenching for foundations and utilities; soil compaction and site grading; and the erection of new structures, all of which would temporarily disturb soils. However, the short-term effects of soil erosion during rough grading for the proposed Tentative Tract Map are not considered significant, given that the Project site is essentially flat and does not possess site conditions necessarily conducive to soil erosion. Notwithstanding, as concluded in Section 5.8, Hydrology and Water Quality, the Project is subject to compliance with the National Pollutant Discharge Elimination System (NPDES) permitting process, since one or more acres of soil would be disturbed. Additionally, all construction activities would be subject to compliance with ESMC Chapter 5-4-9, which specifies that each person applying to the City for a Grading or Building Permit for projects for which compliance with regulations governing state construction activity storm water permits (GCASPs) is required, must submit satisfactory proof to the City of compliance. Following compliance with the established regulatory requirements (i.e., NPDES and ESMC Chapter 5-4-9), Project implementation would result in a less than significant impact involving soil erosion or the loss of topsoil.

Mitigation Measures: No mitigation is required.

Level of Significance: Less Than Significant Impact.

UNSTABLE GEOLOGIC UNIT OR SOILS

- **THE PROPOSED DEVELOPMENT COULD BE LOCATED ON A GEOLOGIC UNIT OR SOIL THAT IS UNSTABLE, OR THAT WOULD BECOME UNSTABLE AS A RESULT OF THE PROJECT, EXPOSING PEOPLE OR STRUCTURES TO POTENTIAL SUBSTANTIAL ADVERSE EFFECTS.**

Impact Analysis:

Sloughing or Caving of Excavations and Unstable Soils

During Project construction, excavations associated with remedial grading/ground stabilization and underground utilities would encounter the poorly unconsolidated/noncohesive artificial fill. If unsupported, these soils would be subject to sloughing and caving, hence creating a short-term hazard to construction workers and equipment. Additionally, if the undocumented artificial fill soils are not removed and/or replaced with properly engineered/compacted fill beneath proposed buildings, the foundations and/or structural elements could experience moderate to significant distress.

Slope Stability

The Phase I and Phase II Grading Plans (Psomas Engineering, Revised February 12, 2013) indicate several proposed 2:1 to approximately 3:1 (horizontal to vertical), 4.0- to 8.0-foot-high



fill and cut slopes in the southeastern portion of the Project site. These proposed fill and cut slopes may be prone to instability either statically (or during severe ground shaking from a future seismic event). The Geology and Soils Report recommends that the lot-specific Geotechnical/Soils Investigations address both the long-term surficial and gross stability of the slopes, together with grading recommendations to provide an adequate factor of safety against either form of instability. Pursuant to the CBC, all 2:1 slopes are required to have a minimum factor of safety of 1.5.

In compliance with ESMC § 14-1-9, a soils investigation of each lot in the proposed subdivision would be conducted and the appropriate corrective action recommended. Therefore, compliance with the CBC and ESMC, and the Geology and Soils Report's recommendations, which include removal of the undocumented fill soils and replacement as properly engineered fill, as well as a slope design with a minimum factor of safety of 1.5, would ensure that Project implementation would result in a less than significant impact regarding the exposure of people or structures to potential substantial adverse effects involving unstable geologic units or soils.

Mitigation Measures: Refer to Mitigation Measure GEO-1.

Level of Significance: Less Than Significant With Mitigation Incorporated.

EXPANSIVE SOILS

● THE PROPOSED DEVELOPMENT COULD BE LOCATED ON EXPANSIVE SOIL CREATING SUBSTANTIAL RISKS TO LIFE OR PROPERTY.

Impact Analysis: Based on the results of the laboratory test performed by RGI, both native and undocumented clay soils are anticipated to exhibit a high expansion potential. Therefore, the potential for expansive soils to impact new development is considered high. Significant changes in moisture content within moderately to highly expansive soil can produce cracking differential heave, shifting, tilting damage, and other adverse impacts to structures constructed on such soils without mitigation. The Geology and Soils Report recommends that all moderately to highly expansive clay soils that are encountered during rough/remedial grading not be reused as engineered fill, but rather be disposed of off-site. According to the Geology and Soils Report, the placement of any clayey soils as compacted fill should be avoided.

In compliance with ESMC § 14-1-9, because there is knowledge of the presence of critically expansive soils (and other potential soils problems), a soils investigation of each lot in the subdivision and recommendations for appropriate corrective action are required. Therefore, compliance with the CBC and ESMC, and the Geology and Soils Report's recommendations, which include removal of all moderately to highly expansive clay soils and avoidance of clayey soils in compacted fill, would ensure that Project implementation would result in a less than significant impact regarding the creation of substantial risks to life or property by locating development on expansive soil.

Mitigation Measures: Refer to Mitigation Measure GEO-1.

Level of Significance: Less Than Significant With Mitigation Incorporated.



CORROSIVE SOILS

- **THE PROPOSED DEVELOPMENT COULD BE LOCATED ON CORROSIVE SOIL CREATING DAMAGE TO PROPERTY.**

Impact Analysis: The near surface soils are mildly to moderately corrosive to ferrous metals in contact with these soils. The Geology and Soils Report recommends that the lot-specific Geotechnical/Soils Investigations address evaluate the nature and extent of these types of soils. The recommendations also involve requiring a corrosion specialist to develop a mitigation plan upon completion of rough grading. At a minimum, the Report recommends that buried metal piping be protected with suitable coatings, wrapping, or seals.

In compliance with ESMC § 14-1-9, a soils investigation of each lot in the proposed subdivision would be conducted and the appropriate corrective action recommended. Therefore, compliance with the CBC and ESMC, and the Geology and Soils Report's recommendations, which include conducting an evaluation of the nature and extent of corrosive soils, development of a corrosion mitigation plan, and protection of buried metal piping, would ensure that Project implementation would result in a less than significant impact regarding the creation of substantial risks to life or property by locating development on corrosive soil.

Mitigation Measures: Refer to Mitigation Measure GEO-1.

Level of Significance: Less Than Significant With Mitigation Incorporated.

5.6.5 CUMULATIVE IMPACTS

- **THE PROPOSED PROJECT, COMBINED WITH OTHER RELATED CUMULATIVE PROJECTS, COULD EXPOSE PEOPLE OR STRUCTURES TO POTENTIAL SUBSTANTIAL ADVERSE EFFECTS INVOLVING GEOLOGY AND SOILS.**

Impact Analysis: As concluded above, compliance with the CBC and ESMC, and the Geology and Soils Report's recommendations would ensure that Project implementation would result in less than significant impacts involving strong seismic ground shaking, seismically-induced soil/ground settlement and lurching, and corrosive soils. Therefore, the Project's incremental effects involving geology and soils are not cumulatively considerable. Moreover, the geotechnical and soil characteristics of each cumulative project site would be evaluated on a project-by-project basis, and appropriate mitigation measures would be required, as necessary to reduce potential impacts to a less than significant level. Further, all development would be required to comply with the CBC, the Municipal Code of each respective jurisdiction, and the recommendations of the site-specific geotechnical and soils investigations, if required.

As concluded above, Project implementation would result in a less than significant impact involving soil erosion or the loss of topsoil, following compliance with the established regulatory requirements (i.e., NPDES and ESMC Chapter 5-4-9). Therefore, the Project's incremental effects involving erosion and loss of topsoil are not cumulatively considerable. Although, cumulative development would result in ground-disrupting activities that would temporarily disturb soils, all construction activities would be subject to compliance with the established regulatory requirements (i.e., NPDES and ESMC), which would ensure a less than significant impact involving soil erosion or the loss of topsoil would occur.



Mitigation Measures: No mitigation is required.

Level of Significance: Less Than Significant Impact.

5.6.6 SIGNIFICANT UNAVOIDABLE IMPACTS

No significant impacts related to geology and soils have been identified following implementation of the recommended mitigation and compliance with the CBC and ESMC regulatory requirements.

5.6.7 SOURCES CITED

City of El Segundo, *City of El Segundo General Plan Public Safety Element*.

City of El Segundo, *City of El Segundo Municipal Code*.

D. Scott Magorien, C.E.G., *Geology, Soils, Seismicity Report in Support of Raytheon El Segundo South Campus Specific Plan*, March 6, 2013.

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