4.7 Geological Resources/Soils

This section addresses Proposed Project impacts related to geologic hazards and resources. In addition to evaluating potential impacts at each of the Proposed Project sites, the assessment identifies the potential for impacts that might be in the Proposed Project vicinity or subregion, such as induced seismicity and subsidence (onshore or offshore) due to oil and gas extraction. The discussion below draws on several sources, including geotechnical studies prepared by the Applicant's consultants for this EIR, included in Appendix F (NMG Geotechnical 2012; Geosyntec 2012), as well as geologic reports and maps pertaining to the Proposed Project area.

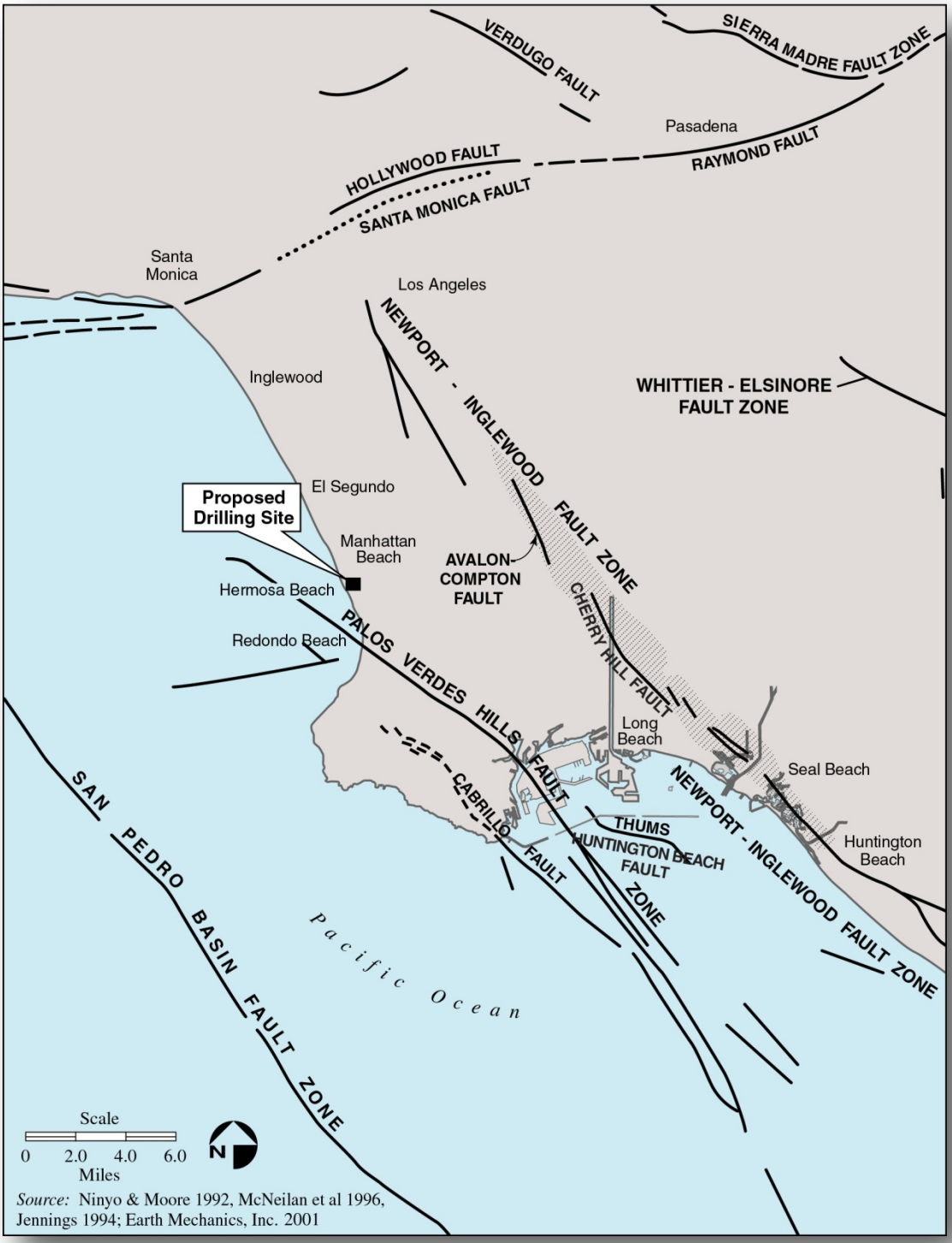
4.7.1 Environmental Setting

4.7.1.1 Regional Geology

The Proposed Project is located along the southwestern margin of the Los Angeles Basin and Coastal Plain, approximately 0.4 miles inland (east) of the coastline and the Pacific Ocean, at the southwest end of Santa Monica Bay. The Los Angeles Basin is an alluvial-filled basin that is bound to the north and east by the Santa Monica, San Gabriel, and Santa Ana mountains and to the west and south by the Pacific Ocean and the Palos Verdes Hills. The Los Angeles Basin is approximately 70 miles long and 10 miles wide, and is a structural basin formed in the mid-Miocene epoch as a result of tectonic processes. As the basin formed, it filled with a thick sequence of sedimentary deposits (up to 35,000 feet thick). The Los Angeles Basin is also referred to as a "depositional basin" in order to describe the simultaneous deepening of the basin by tectonic processes and infilling with sediment. Prior to approximately five million years ago, this basin was submerged under the ocean and much of the sediment was deposited in a marine environment.

This thick sequence of sedimentary materials provides the large reservoir for the Los Angeles area oil and gas fields. Of the 43 active oil fields in the Los Angeles Basin, approximately 35 produce from the Upper Miocene and Pliocene age reservoirs (Table 4.7-1), including the Proposed Oil Project's Hermosa Beach oil field that is located on what is called the Los Angeles Western Shelf, at the extreme northwest end of the Torrance-Wilmington Anticline. The anticline plunges down to the southeast, from Torrance towards Wilmington. The targeted oil-producing geologic units for the Proposed Oil Project include: the Upper Main, the Lower Main, and the Del Amo units of the Miocene age Puente Formation (Figure 2.8).

Figure 4.7-1 Regional Active Fault Map



Source: Ninyo & Moore 1992, McNeilan et al 1996, Jennings 1994; Earth Mechanics, Inc. 2001

Table 4.7-1 General Stratigraphic Section for Hermosa Beach Oil field Area

Age	Formation/Lithology	Approximate Thickness (feet)	Proposed Oil Project Target Oil Zones
Holcene and Upper Pleistocene	Undifferentiated sands and Lakewood Formation (?)	~0 – 100	--
Lower Pleistocene	San Pedro Formation	~200 – 400	--
Pliocene	Pico Formation	~800 – 1,500	--
	Repetto Formation	~100 – 1,200	--
Miocene	Puente Formation	~1,000 – 2,000	Upper Main Lower Main Del Amo
	Schist Conglomerate	~100 – 400	Schist Conglomerate
Cretaceous-Jurassic	Catalina Schist Basement Rock	--	--

Source: Geosyntec 2012. Subsidence and Induced Seismicity Technical Report for E&B Oil Development Project

4.7.1.2 Local Geology

The Proposed Project sites are underlain by Holocene-age dune sands located west of the adjacent older alluvial deposits of the Los Angeles Basin to the east. The on-site deposits, which were encountered in borings drilled at the Project Site to depths of 45 feet below ground surface, generally consist of dune and drift sands that were deposited as ancient eolian (wind-blown) deposits. The wind-blown dune sands are described as yellowish brown, slightly silty to clean, well-sorted sands that are medium dense to very dense (NMG Geotechnical 2012).

Artificial fill (inert landfill material) was encountered in the northeast area of the Project Site, where an onsite landfill had operated from the 1920s through the 1940s. Small amounts of undocumented artificial fill were also found scattered across the Project Site (NMG Geotechnical 2012).

Beneath the surficial dune sands is the Pleistocene age San Pedro Formation, consisting of unconsolidated and semi-consolidated stratified sands with some clays, silts, and gravels. Beneath the San Pedro Formation is the late Pliocene age Pico Formation, consisting of marine siltstones and sandstones (Figure 2-8, Applicant Proposed Project Lease Areas Cross Sections). Beneath the Pico Formation is the early Pliocene age Repetto Formation, consisting of siltstones with layers of sandstones and conglomerates. Beneath the Repetto Formation is the Miocene age Puente Formation, which is the primary oil reservoir in the Hermosa Beach area.

Within the Puente Formation, the Proposed Oil Project targets the Upper Main, Lower Main, and Del Amo reservoir units. The Upper Main is expected to be the shallowest oil productive section for the Proposed Oil Project and it is known to be the most prolific oil-producing zone for this area of the Los Angeles Basin. Beneath Hermosa Beach, the Upper Main is expected to be over 300 feet thick (Figure 2-8, Applicant Proposed Project Lease Areas Cross Sections) and

composed of interbedded thin sands and shales. The shales are already fractured and provide both fracture porosity and permeability, which is important to oil production in the area.

The Lower Main directly underlies the Upper Main, is similar in lithology to the Upper Main but with fewer interbedded fine-grained sands, and is also fractured. This geologic unit is expected to be over 500 feet thick.

The Del Amo Zone directly underlies the Lower Main and is considered to be the poorest producing oil zone from the Puente Formation, for the Proposed Oil Project. Similar to the overlying Upper and Lower Main zones, the Del Amo Zone is fractured and varies in thickness from 200 to 700 feet in the Proposed Oil Project area.

Underlying these three units targeted by the Proposed Oil Project is the Late Miocene age Schist Conglomerate. This geologic unit may have some oil potential north and northeast of Hermosa Beach, and possibly in Wilmington to the southeast, and may be a viable exploration target for the Proposed Oil Project.

4.7.1.3 Geologic Hazards

Faulting and Seismicity

Faulting

The seismicity of southern California is dominated by the intersection of the northwest-trending San Andreas Fault System and the east-west trending Transverse Ranges Fault System. The Los Angeles Basin is located at the intersection of these two systems. Both systems are responding to strain produced by the relative motions of the Pacific and North American tectonic plates. The strain is relieved by right lateral strike slip faulting on the San Andreas and related faults and by vertical, reverse slip, or left lateral, strike slip displacement on faults in the Transverse Ranges. The effects of this deformation include mountain building, basin development, deformation of Quaternary marine terraces, widespread regional uplift, and generation of earthquakes.

The Proposed Project sites are not located within a fault-rupture hazard zone, as defined by the Alquist-Priolo Special Studies Zones Act (California Division of Mines and Geology 1999; California Geological Survey 2010; Geosyntec 2012; and NMG Geotechnical 2012). Based on mapping by the State (California Geological Survey 2010), there are no known major active faults at the Proposed Project sites and no evidence of active faulting was observed during NMG's geologic/geotechnical Project Site investigation. The closest active faults are the Newport-Inglewood Fault, located 5.8 miles east of the Project Site, and the Palos Verdes Fault, located 1.9 miles west of the Project Site (California Geological Survey 2010; Geosyntec 2012; and NMG Geotechnical 2012) (Figure 4.7-1). These and other regional active faults are included in Table 4.7-2.

The closest potentially active fault is the Charnock Fault, located approximately 7 miles north of the Project Site (USGS 2014). An inactive offshore fault, named Offshore Fault 103, is located approximately 1.4 miles west of the Project Site (Geosyntec 2012).

Table 4.7-2 – Regional Active Faults		
Fault	**Maximum Moment Magnitude**	**Approximate Distance and Direction from the Site**
Palos Verdes	7.7	1.9 miles west
Newport Inglewood	7.0	5.8 miles east
Santa Monica	6.6	13.1 miles north
Malibu Coast	6.7	14.2 miles north
Puente Hills Blind Thrust	7.1	14.2 miles east-southeast
Hollywood	6.4	15.5 miles northeast
Upper Elysian Park Blind Thrust	6.4	17.1 miles north
Anacapa-Dume	7.5	19.3 miles northwest
Northridge	7.0	20.5 miles north
Raymond	6.5	20.6 miles east

Source: NMG Geotechnical 2012

Ground Shaking

The energy released during an earthquake propagates from its rupture surface as seismic waves. The resulting strong ground motion from the seismic wave propagation can cause significant damage to structures. At any location, the intensity of the ground motion is a function of the distance to the fault rupture, the local soil and bedrock conditions, and the earthquake magnitude. Intensity is usually greater in areas underlain by unconsolidated material, such as the Proposed Project area, than in areas underlain by more competent rock.

Earthquakes are characterized by a moment magnitude, which is quantitative measure of the strength of the earthquake based on strain energy released during the event. The magnitude is independent of the site, but it is dependent on several factors including the type of fault, rock type, and stored energy. Moderate to severe ground shaking will be experienced in the Proposed Project area if a large magnitude earthquake occurs on one of the nearby active faults.

Historical records indicate that the Proposed Project area has experienced shaking from a number of seismic events over the last century and a half. The seismic events that likely caused varying degrees of ground motion at the Proposed Project sites include the earthquakes of 1812, 1827,

1852, 1855, 1857, 1893, 1936, 1952, 1956, 1965, 1971, 1974, 1977, 1987, 1991, and 1994. The 1812 and 1857 events are thought to have occurred along the Mojave Segment of the San Andreas Fault and caused significant damage to developed areas of southern and central California. Those earthquakes were estimated to have had moment magnitudes of approximately M7.1 and 7.8, respectively. The 1952 Tehachapi earthquake had an estimated moment magnitude of M7.7. The 1933 Long Beach earthquake, which occurred on the nearby Newport-Inglewood Fault, caused serious damage to weak masonry structures and killed 115 people. The earthquake had an estimated moment magnitude of M6.4 (USGS 2012; Southern California Earthquake Data Center 2014).

A Project Site-specific seismic analysis completed for the Proposed Oil Project indicated that the maximum moment magnitude would be a magnitude 7.7 earthquake, generated from the Palos Verdes Fault (NMG Geotechnical 2012).

Probabilistic Ground Acceleration Analysis

The California Geological Survey has prepared probabilistic seismic hazard maps, expressed in terms of the probability of exceeding a certain ground motion. For example, the 10 percent probability of exceedance in 50 years map depicts an annual probability of 1 in 475 of being exceeded each year. These maps have been prepared for use in designing buildings in high seismic areas. The maps for 10 percent probability of exceedance in 50 years show ground motions that the California Geological Survey do not believe will be exceeded in the next 50 years. In fact, there is a 90 percent chance that these ground motions would not be exceeded. This probability level allows engineers to design structures for larger ground motions than what is expected during a 50 year interval. In the Proposed Project area, there is a 10 percent probability of exceedance of ground acceleration of 0.4 to 0.5 g (percent of gravity) (California Geological Survey 2013).

In confirmation of the maps described above, Project Site-specific acceleration values were calculated (NMG Geotechnical 2012). A peak horizontal ground acceleration of 0.433g and peak vertical ground acceleration of 0.560g was calculated for the Project Site. Based on these predicted ground accelerations and underlying earth material conditions, moderate to severe ground shaking due to a seismic event can be expected in the Proposed Project area.

Secondary Seismic Hazards

Potential hazards resulting from the secondary effects of ground shaking include: liquefaction, lateral spreading, differential settlement, and landslide-induced earthquakes.

Liquefaction

Liquefaction is a type of ground failure that occurs as a result of loss of shear strength or shearing resistance in loose and sometimes medium dense, cohesionless soils, due to seismically induced ground shaking. Liquefaction typically occurs in sediments where static, relatively widespread groundwater is less than 50 feet (15 m) below ground surface.

Factors that affect the degree of liquefaction include:

- Magnitude and proximity of the earthquake;
- Duration of shaking;
- Soil types;
- Grain size distribution;
- Clay fraction content;
- Density;
- Angularity;
- Effective overburden;
- Cyclic loading; and
- Soil stress history.

Based on the dense native sand dune deposits and the depth to groundwater (48 to 49 feet below ground surface) at the Proposed Project sites, the liquefaction potential is considered to be low (Figure 4.7-2) (NMG Geotechnical 2012).

Lateral Spreading

Lateral spreading occurs as a result of liquefaction in which a subsurface layer becomes a liquefied mass, and gravitational and inertial forces cause the mass to move downslope. This type of failure is common in over-steepened slopes comprised of unconsolidated silts and sands. The magnitude of lateral spreading movements depends on earthquake magnitude, distance between the site and the seismic event, thickness of the liquefied layer, ground slope or ratio of free-face height to distance between the free face and structure, fines content, average particle size of the materials comprising the liquefied layer, and the standard penetration rates of the materials. Lateral spreading during a strong seismic event at the Proposed Project sites is not anticipated to occur due to the lack of liquefaction potential, as described above.

Differential Settlement

Differential settlement is a process whereby soils settle non-uniformly, potentially resulting in stress and damage to pipelines or other overlying structures. Such movement can occur in the absence of seismically induced ground failure, due to improper grading and soil compaction or discontinuity of naturally occurring soils; however, strong ground shaking often greatly exacerbates soil conditions already potentially prone to differential settlement, resulting in distress to overlying structures. Elongated structures, such as pipelines, are especially prone to damage as a result of differential settlement. Pipe connections at storage facilities are especially vulnerable to the differing earthquake response between buried pipe and rigid structures (California Division of Mines and Geology 1988).

Based on site-specific borings completed for the Project, native earth materials, aside from those that will be removed and recompacted, are relatively dense and therefore not prone to significant seismically induced settlement. It is anticipated that the native materials will settle less than 0.5 inch during seismic ground shaking. However, the existing inert landfill material may be prone to seismic settlement up to 8.5 inches at their current conditions/thickness (NMG Geotechnical 2012).

Figure 4.7-2 Liquefaction and Landslides Map

Source: NMG Geotechnical 2012

Oil Field Induced Seismicity

Based on studies by the National Academy of Sciences (2013), a very small fraction of oil field extraction and associated wastewater injection activities in the United States have induced seismicity at levels that are noticeable to the public. The United States currently has approximately 30,000 Class II wastewater disposal wells. The National Academy of Sciences investigation indicates that very few induced seismic events (felt by humans) have been reported as either caused by or likely related to these wells. In cases where wastewater injection has produced seismic events, such events are typically less than moment magnitude (M) 5.0.

However, there are oil producing areas that are exceptions to the conclusions of the National Academy of Sciences, including parts of Oklahoma, Arkansas, Ohio, and Colorado. From January 2009 to mid-2013, more than 200 M 3.0 or greater earthquakes have rattled Central Oklahoma, marking a significant rise in the frequency of these seismic events. The U.S. Geological Survey (USGS) and Oklahoma Geological Survey have been conducting collaborative research quantifying the changes in earthquake rate in the Oklahoma City region, assessing the implications of this earthquake swarm for large earthquake hazard, and evaluating possible links between these earthquakes and wastewater disposal related to oil and gas production activities in the region (USGS 2013).

One to three M 3.0 earthquakes or larger occurred yearly from 1975 to 2008 in Central Oklahoma, while the average grew to around 40 earthquakes per year from 2009 to mid-2013. These earthquakes do not seem to be due to typical, random fluctuations in natural seismicity rates. The analysis suggests that a contributing factor to the increase in earthquakes triggers may be from activities such as wastewater disposal. Similar scenarios have occurred in Arkansas, Ohio, and Colorado (USGS 2013). The Arkansas Oil and Gas Commission has established a permanent disposal well moratorium area where a swarm of earthquakes appear to have been triggered by wastewater disposal wells located along two faults (Arkansas Oil and Gas Commission 2011).

There are examples of past oil field operations in the Los Angeles Basin inducing seismic events. For example, very shallow earthquakes at the Wilmington Oil Field occurred between 1947 and 1961, as well as possible fault creep at the Inglewood Oil Field in the early 1960s. These events have been associated with extreme amounts of land subsidence that occurred in these fields that resulted from lack of proper water re-injection operations (Geosyntec Consultants 2012).

The calculated probabilities of shaking felt at the surface, of strong shaking, and of structures and people being affected in a given area can be generalized from former drilling projects. Information can then become the basis for decisions on whether and how to minimize the impacts of induced seismicity (National Academy of Sciences 2013). As indicated below in Section 4.7.3.2, Proposed Project Design Features, Geosyntec Consultants (2012) (Appendix F) conducted a seismic study for the Proposed Project area in order to identify past seismic activity that may have coincided with and been a result of past nearby oil field operations. An evaluation of historical seismicity was conducted for nearby oil fields, including the Wilmington and Torrance oil fields. These fields occur along a similar structural setting, which consists of a

northwest trending anticlinal structure. The Hermosa Beach Project area is located in the northwest portion of the Torrance Oil Field, which also includes the Redondo Beach oil field. Therefore, the structural geology in the Project area is similar to the area studied by Geosyntec (2012), in that the area proposed to be drilled is an extension of the same geologic structural regime. The results of their study concluded that past seismic activity did not coincide with past oil field operations (such as drilling, fracturing, oil extraction, or water injection) and there were no patterns of seismic activity relative to those past oil field operations.

Most of the recent seismicity (1981 to 2010) in the northwest portion of the Los Angeles Basin, which includes the Project Site, occurs at depths below 5 miles, as a result of normal tectonic stresses. Except for one shallow, low magnitude (M 2.2) earthquake located west of the Wilmington Oil Field, no shallow earthquakes (less than 4 kilometers below ground surface) were recorded in the active Wilmington or Torrance oil fields, including the Redondo Beach area located immediately adjacent to Hermosa Beach. Most of the shallow earthquakes occurred near oil fields located along the Newport-Inglewood Fault Zone, which is generally considered a different structural setting than that which exists beneath Hermosa Beach.

Geotechnical Hazards

Expansive Soils

Expansive soils swell or heave with increases in moisture content and shrink with decreases in moisture content. Montmorillonitic clays are most susceptible to expansion. Structure foundations constructed on expansive soils require special design considerations (2010 California Building Code, Title 24, Part 2). No clay soils that would be expansive clays or soils exhibiting shrink-swell characteristics were encountered during field investigations at the Project Site (NMG Geotechnical 2012).

Subsidence

One of the most serious environmental problems caused by oilfield operations within the Los Angeles Basin has been subsidence, which exists in virtually every oil field within the Los Angeles Basin. Oil production related subsidence is a function of rock type, reservoir pressure, thickness of the reservoir, width of the reservoir to depth ratio, the mechanical properties of the rock in and above the reservoir, and pre-consolidation effects including prior pressure drops activities. The resulting increase in the effective stress causes compaction, which is propagated to the surface, typically causing a bowl-shaped subsidence at the surface, centered over the oil field (Chilingar and Endres 2005; Coastal Environments 1998).

The most dramatic example of subsidence damage has taken place in the Wilmington Oil Field, near Long Beach. The area that subsided is intensively industrialized and initially was only 5 to 10 feet above sea level. In 1966, 29 feet of subsidence was measured in this area, placing much of the area well below sea level and requiring extensive construction of dikes and raising of dock facilities. Surface deformation within the subsidence bowl caused extensive damage to pipelines, railroad tracks, and buildings. In addition, an unusual set of earthquakes were triggered by subsidence-induced fault movement. Damaging shocks occurred in 1947, 1949,

1951, 1954, 1955, and 1961 (Kovach 1974). Although not complete, significant rebound has occurred in this area as a result of water injection, which occurs routinely at numerous oil fields to minimize subsidence, both onshore and offshore (City of Long Beach 2014; Poland and Davis 1969).

Subsidence bowls have been associated with the Inglewood, Long Beach, and Huntington Beach oil fields along the Newport-Inglewood Fault Zone. In addition, minor localized differential subsidence has been documented over the Dominguez oil field. Based on work completed by Hamilton and Meehan (1971) and Barrows (1974), the maximum cumulative subsidence of any of the areas along the Newport-Inglewood Fault Zone was centered over the Inglewood Oil Field, where 67,000 acre-feet of oil, water, and sand had been withdrawn from shallow production horizons by 1971. Since 1971, water injection into the shallow production horizons has limited the overall withdrawals from these horizons. Subsidence is often accompanied by large-scale earth-cracking, and in some cases the earth-cracking includes horizontal and/or vertical movement, creating incipient or actual faulting. Although the precise failure mechanism is unclear, subsidence may have contributed to failure of the former 20-acre Baldwin Hills Reservoir in 1963, killing five people and damaging or destroying 277 homes. The reservoir was built on a small splay of the Newport-Inglewood Fault, known as the Reservoir Fault.

The Redondo Beach King Harbor Breakwater, located in the project area, settled approximately five feet from 1955 to 1985. The precise cause of the settlement is unclear; however, contributing factors appear to be offshore slumping of the adjacent Redondo Submarine Canyon; underlying unconsolidated, ancestral lagoonal sediments; a possible coastal landslide in the vicinity of the breakwater; combined with regional subsidence associated with oil and gas extraction from the Torrance Oil Field. Data collection and design of the breakwater and interior facilities did not consider evidence suggesting regional and local developmental constraints. Potential adverse effects of regional subsidence and local differential settlement on the long-term performance of the King Harbor breakwater and inner harbor structures were predictable, based on data existing at the time of their construction (Elwany et al. 2006). Five feet of settlement of the breakwater with no evidence of similar amounts of settlement and attendant structural damage throughout the adjoining coastal areas suggests localized settlement due to improper construction rather than regional subsidence associated with oil and gas extraction.

Offshore subsidence can result in a bowl like depression which can affect onshore structures, beaches, offshore structures (breakwaters, piers, outfall pipelines, etc.). Changes to bathymetry due to subsidence can alter the wave formation characteristics of the ocean floor, altering local surf breaks (an important recreational resource). Although it is not feasible to predict changes in wave formation characteristics, a change in sea floor elevation equivalent to 25% of local wave height is considered a good rule of thumb as the minimum bathymetric change before local surf breaks are affected (Surfrider Foundation, pers. comm. 2014). Offshore subsidence can induce sand migration to offshore canyons or depressions, affecting the balance of sediments in the sand wedge within the littoral zone, potentially impacting the width of local beaches (an impact that, in turn can exacerbate adverse effects of sea level rise and the intensified storms anticipated as a result of climate change).

Both onshore and offshore subsidence can be measured and monitored through various survey techniques, including Global Positioning System (GPS) and InSAR imagery technology.

Onshore subsidence monitoring is currently underway at the Inglewood Oil Field (Fugro 2013). Monitoring indicates that subsidence slowed substantially from 2011 to 2012, and locally rebounded, in comparison to monitoring from 2010 to 2011; however, vertical ground displacements are not necessarily consistent with oil activities. Elevation increases have been recorded for monuments within areas where oil production exceeded water injection; elevation losses were recorded for monuments within areas where injection exceeded production; and elevation gains and losses have been recorded in areas where no oilfield activities (production or injection) have occurred.

Changes in elevation of offshore bench mark elevations with accuracy of ~ 4 cm (~1.6 inch) are believed feasible using established methods (Coastal Environments 1998). Onshore measurements using GPS and/or InSAR imagery technology are capable of much higher vertical resolutions in the range of ~5mm (Brock 1994; Earth Consultants International 2012, Section 3, in Geosyntec 2012, Appendix B). These resolutions are within the range needed to detect the earliest stages of subsidence offshore or onshore well before subsidence impacts become significant.

Corrosion

Soils and bedrock throughout Southern California have varying degrees of sulfate and corrosion potential. Corrosion of oil and gas related pipelines and other infrastructure can result in weakening of the metal and resultant leaks to the environment. Onsite soils are corrosive to metals (NMG Geotechnical 2012).

4.7.2 Regulatory Setting

4.7.1.4 California Building Code (CBC)

The California Building Code contains requirements related to excavation, grading, and construction. According to the California Building Code, a grading permit is required if more than 50 cubic yards of soil is moved. The California Building Code specifies the acceptable design criteria for construction of facilities with respect to seismic design and load-bearing capacity.

Applicable codes and industry standards related to various geologic and soil features are identified in the ASCE Standard 7.05 Minimum Design Loads for Buildings and other Structures. The Proposed Project sites are not located within a State of California Seismic Hazard Zone for landslides.

4.7.1.5 Alquist-Priolo Earthquake Fault Zoning Act of 1972

In response to the 1971 San Fernando Earthquake, which damaged numerous homes, commercial buildings, and other structures, California passed the Alquist-Priolo Earthquake Fault Zoning Act. The goal of the act is to avoid or reduce damage to structures like that caused by the San Fernando Earthquake by preventing the construction of buildings on active faults.

In accordance with the law, the California Geological Survey maps active faults and the surrounding earthquake fault zones for all affected areas. Any project that involves the construction of buildings or structures for human occupancy, such as residential housing, is subject to review under this law. Structures for human occupancy must be constructed at least 50 feet from any active fault. Oil drilling facilities and associated pipelines would not be considered structures for human occupancy (i.e., expected to have a human occupancy rate of more than 2,000 person-hours per year) and would therefore not be subject to provisions of this zoning act.

4.7.1.6 Seismic Hazards Mapping Act of 1990

The California Seismic Hazards Mapping Act is designed to protect the public from the effects of strong ground shaking, liquefaction, landslides, other ground failures, or other hazards caused by earthquakes. The Act requires site-specific geotechnical investigations to identify the hazard and formulation of mitigation measures before the permitting of most developments designed for human occupancy.

Special Publication 117, Guidelines for Evaluating and Mitigating Seismic Hazards in California, (California Geological Survey 1997) constitutes the guidelines for evaluating seismic hazards other than surface fault rupture, and for recommending mitigation measures as required by Public Resources Code Section 2695(a). This document contains no special provisions related to oil and gas facilities.

4.7.1.7 California Coastal Act

The California Coastal Act of 1972 created the Coastal Commission to enact policies as standards in its coastal development permit decisions. Among many issues, the California Coastal Commission and the coastal development permit program protect against loss of life and property from coastal hazards, including geologic hazards (Section 30006.5, Public Resources Code, Division 20, California Coastal Act of 2013). Section 30262 [5] of the Act also provides that: “The development will not cause or contribute to subsidence hazards unless it is determined that adequate measures will be undertaken to prevent damage from such subsidence”.

4.7.1.8 California Division of Oil, Gas, and Geothermal Resources

The California Division of Oil, Gas, and Geothermal Resources (DOGGR) recognizes the California Department of Conservation Committee of California Oil Producers in recommending to DOGGR maximum efficient rates of oil and gas production, within the State of California. DOGGR regulations, defined in California Code of Regulations, Title 14, Chapter 4, include well design and construction standards, surface production equipment and pipeline requirements, and well abandonment procedures and guidelines, including the following:

- DOGGR oversees well abandonment procedures to ensure effectiveness in preventing migration of oil and gas from a producing zone to shallower zones, including potable groundwater zones.

- DOGGR oversees well operations. When an operator ceases well operation or production, state law requires the well is abandoned within a reasonable time period.

Regulations require well operators to maintain detailed records of abandonment operations and file copies with DOGGR. In addition, DOGGR regulates environmentally sensitive wells and pipelines within the administrative boundaries of the underlying oil field, as determined by the Supervisor of DOGGR. Environmentally sensitive pipelines are defined under California Code of Regulations Section 1760(e) as:

- A pipeline or well located within 300 feet of any public recreational area, or a building intended for human occupancy, that is not necessary to the operation of the production operation, such as residences, schools, hospitals, and businesses;
- A pipeline or well located within 200 feet of any officially recognized wildlife preserve or environmentally sensitive habitat that is designated on a United States Geological Survey topographic map, designated waterways, or other surface waters, such as lakes, reservoirs, rivers, canals, creeks, or other water bodies that contain water throughout the year;
- A pipeline or well located within the coastal zone, as defined in Section 30103(b) of the Public Resources Code;
- Any pipeline or well for which the Supervisor determines there may be a significant potential threat to life, health, property, or natural resources, in the event of a leak, or that has a history of chronic leaks; and
- California Code of Regulations, Title 14, Section 1774 requires a pipeline management plan for environmentally sensitive pipelines.

4.7.1.9 2012 Los Angeles County NPDES Permit

In November 2012, the Los Angeles Regional Water Quality Control Board adopted the NPDES Municipal Separate Storm Sewer System (MS4) Permit and waste discharge requirements for storm water and non-storm water discharges from the MS4, within the coastal watersheds of Los Angeles County. The City of Hermosa Beach, along with other cities in Los Angeles County, is transitioning to the new 2012 permit and is preparing a watershed management plan for compliance with the new permit, which will include even more stringent rules governing stormwater runoff for development projects. If the Proposed Project is approved by the voters of Hermosa Beach, it may be subject to SUSMP requirements or even more stringent requirements in the 2012 permit. Currently, the SUSMP is still required, but the rules may become more stringent in the near future.

4.7.1.10 City of Hermosa Beach General Plan, Seismic Safety Element

The Seismic Safety Element of the City of Hermosa Beach General Plan generally describes the seismic setting for the area, describes seismic related problems associated with existing older structures, and provides recommendations for new development. In addition, the plan provides recommendations for educating the public on geologic hazards and associated disaster preparedness.

4.7.2 Significance Criteria

In determining whether or not an impact is significant, this EIR draws on the criteria provided in Appendix G of the State CEQA Guidelines and the Los Angeles County CEQA Guidelines. In general, the guidelines indicate that a substantial adverse impact would occur if a project would expose people or structures to major geologic hazards. This recognizes any and all unstable geologic conditions as a result of construction, as well as hazards associated with earthquakes, ground shaking, ground movement, fault rupture, groundwater, and other geologic hazards, features, or events. In terms of construction, significant adverse impacts are determined based on whether construction of the project would generate unstable geologic conditions lasting beyond the short-term construction phase. The Proposed Project would be considered significant if it:

- Exposes people or structures to potentially substantial adverse effects, including the risk of loss, injury, or death involving rupture of a known earthquake fault, strong seismic ground shaking, and seismic-related ground failure, including liquefaction or landslides;
- Is located within any of the following areas: (1) a State of California designated Alquist-Priolo Special Fault Study Zone, (2) a designated Fault Hazard Area, (3) a mapped area of tsunami hazard;
- Is located in an area at risk of landslides/mudflows; defined as areas with slopes greater than 10 percent; Results in substantial soil erosion or the loss of topsoil;
- Is 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;
- Is located on expansive soil, as defined in the 2010 California Building Code, creating substantial risks to life or property; or
- Is underlain by soils incapable of adequately supporting the use of septic tanks or alternative wastewater disposal systems where sewers are not available for the disposal of water.

4.7.3 Project Impacts and Mitigation Measures

4.7.3.1 Introduction

The Proposed Project is located in a geologically complex and seismically active region that is subject to earthquakes and potentially strong ground shaking. Proposed Oil Project facilities and infrastructure during Phases 2 and 4, including proposed oil and gas pipelines, as well the Proposed City Maintenance Yard Project facilities, would be subject to such seismically induced ground motion. In addition, wastewater injection would potentially induce seismicity in the vicinity of the Proposed Project during Phases 2 and 4. Soils at the Project Site, along the pipeline route, and at the Proposed City Maintenance Yard Project Site, would be subject to sloughing and caving during temporary excavations during Phases 1 and 3. The Proposed Oil Project will remove an unknown volume of oil, gas, and associated water. In the absence of injection of wastewater back into the subsurface, the potential for settlement of overlying infrastructure increases during Phase 2 and 4 operations. Similarly, offshore subsidence could

occur, as oil would be extracted beneath offshore waters. During Phases 1 and 3, grading and construction activities would temporarily increase the amount of suspended solids in surface flows derived from the Proposed Project sites during storm events.

4.7.3.2 Proposed Project Design Features

Phase 1

During Phase 1 of the Proposed Oil Project, there would be demolition and construction activities with various combinations of construction equipment working on the Project Site. Phase 1 demolition and construction activities would incorporate the following operational practices related to geology and soils:

- A Geotechnical Exploration and Design Report, prepared by NMG Geotechnical, Inc., dated October 19, 2012, has been completed for the Proposed Oil Project and submitted to the City for review. The Geotechnical Exploration and Design Report includes an assessment of the geologic setting, including faulting and seismicity, and a site specific seismic analysis, including liquefaction and settlement potential.
- Prior to grading, grading plans would be reviewed by the Geotechnical Consultant to determine if additional recommendations are needed. A detailed geotechnical report would be prepared by a registered Civil Engineer specializing in geotechnical engineering and submitted with engineered grading plans to provide a design and/or construction level recommendations for the Proposed Project. Geotechnical rough grading plan review reports would be prepared in accordance with the County of Los Angeles Department of Public Works, Geotechnical and Materials Engineering Division, Manual for Preparation of Geotechnical Reports.
- Grading and earthwork would be performed under the observation of a Registered Civil Engineer and Certified Engineering Geologist to ensure proper sub-grade preparation, selection of satisfactory fill materials, and placement and compaction of structural fill, as well as to provide professional review and written approval.
- Prior to the issuance of grading permits for the Project Site, grading level details of proposed temporary slopes would be evaluated for stability and necessary shoring to protect the adjacent property and improvements. The detailed geotechnical report would provide design parameters for shoring.
- Once the Project Site is cleared, retaining walls would be constructed along the western boundary of the Project Site and set back 10 feet along the western portion of the southern property boundary. A minimal amount of rough grading would occur in the western and southwestern portions of the Project Site to allow for: the construction of a well cellar for three exploratory oil wells and a water injection well; a change in grade to provide surface drainage towards the well cellar in the event of an oil spillage or rainfall; the set up and movement of the drill rig; and the installation of temporary production equipment. In addition, the trenches for the existing utilities and the basement under the existing maintenance building would need to be filled in. It is not anticipated that the rough grading would require the import or export of fill material.

- The surface of the Project Site would be covered with crushed aggregate base material to serve as a dust inhibitor and driving surface. The grading would ensure storm water from up to a 100-year event would not leave the Project Site and soil erosion would not occur.
- Excavation and grading would occur off-site to implement the following improvements which would be provided as a part of the Proposed Oil Project:
    - Undergrounding of the existing overhead power lines and communication lines on poles that run through the existing trees along Valley Drive to a location in the right-of-way adjacent to the Project Site;
    - To provide electrical service to the Project Site, installation of underground conduit in the right-of-way in Valley Drive from 8th Street to the northeast corner of the Project Site;
    - Installation of a six-inch lateral water line from an existing reclaimed waterline in the Veterans Parkway, across Valley Drive, to a location south of the Project Site entrance driveway, to provide reclaimed water for irrigation of the landscape areas and drilling in Phases 2 and 4; and
    - The construction of improvements at the southwestern corner of 6th Street and Valley Drive, including the undergrounding of power lines.
    - The specific locations of the improvements would be determined by the respective utilities and the City. As appropriate, the areas disturbed would be returned to their existing condition to the satisfaction of the City.

Phase 2

During Phase 2 of the Proposed Oil Project, four wells, <u>including three oil wells and one water injection well,</u> would be drilled utilizing an electric drill rig and temporary production equipment would be installed and used to process the extracted oil, gas, and water. The processed oil would be removed from the Project Site by truck and delivered to an off-site location for sale. No additional grading would occur in Phase 2. The construction trailer, temporary production equipment, and tanks would be trailer mounted and the temporary piping would be above ground.

Phase 3

During Phase 3 of the Proposed Oil Project, there would be construction activities resulting in various vehicles traveling to and from the Project Site, including trucks used in the export of soil during the implementation of the remedial action plan for the Proposed Oil Project. In addition, there would be construction activities associated with the installation of off-site pipelines resulting in short-term road closures in the Cities of Hermosa Beach, Redondo Beach, and Torrance. Phase 3 construction activities would incorporate the following design features and operational practices related to geology and soils.

Design Features and Operational Practices

The Remedial Action Plan (RAP) would be implemented to remove the lead contaminated soil within the former landfill area on the northeastern portion of the Project Site. The impacted soil would be removed to a depth of 15 feet below ground surface (bgs) within the former landfill area. Upon confirmation that the lead contaminated soil has been removed to the extent

identified in the RAP, the excavations would be backfilled with a minimum of 5 feet of clean soil. It is anticipated that approximately 9,000 cubic yards of contaminated soil would be removed from the Project Site and hauled to a Class 1 landfill. During the grading for the remediation activities, shoring may be required.

The RAP would be implemented to address the total petroleum hydrocarbon (TPH) contaminated soil in the northeastern portion of the Project Site. The TPH contaminated soil would be treated on-site via vapor extraction conducted by two to four extraction wells on the northern portion of the Project Site. The only visible indication that the wells are present would be a grade level metal cover on the ground.

Following completion of the RAP, construction of the remaining retaining walls and the final grading of the Project Site would occur. The Phase 3 grading plan requires the removal of 9,000 cubic yards of material from the Project Site, consistent with the RAP to obtain the grades needed, including the depressed containment area for the tanks. The soil balance was engineered to accommodate the need to remove the 9,000 cubic yards of lead contaminated soil without requiring any import of clean fill. Fill would be placed in accordance with the Geotechnical Exploration and Design Report (NMG Geotechnical 2012) as engineered fill.

Prior to grading, grading plans would be reviewed by the Geotechnical Consultant to determine if additional recommendations are needed. A detailed geotechnical report has been prepared by a registered Civil Engineer specializing in geotechnical engineering (NMG Geotechnical 2012), which would be submitted with engineered grading plans to provide a design and/or construction level recommendations for the Proposed Oil Project. Geotechnical rough grading plan review reports would be prepared in accordance with the County of Los Angeles Department of Public Works, Geotechnical and Materials Engineering Division, Manual for Preparation of Geotechnical Reports.

Grading and earthwork would be performed under the observation of a Registered Civil Engineer and Certified Engineering Geologist to ensure proper sub-grade preparation, selection of satisfactory fill materials, placement and compaction of structural fill, and to provide professional review and written approval.

Prior to the issuance of grading permits, grading level details of the proposed temporary removal excavation slopes would be evaluated for stability and necessary shoring to protect the adjacent property and improvements. The detailed geotechnical report would provide design parameters for shoring. Shoring would be designed by a shoring engineer and the reviewed by the geotechnical engineer and the City for approval prior to installation.

Structures would be designed to the findings stated in the Geotechnical Exploration and Design Report (NMG Geotechnical 2012). This report would be submitted to the City with engineered grading plans to provide a design and/or construction level recommendations for the Proposed Oil Project. The proposed oil drilling facility, spill containment vaults, Proposed Oil Project-related pipelines, and Proposed City Maintenance Yard Project structures would be designed and constructed to withstand anticipated horizontal and vertical ground acceleration in the Proposed Project area, based on the California Building Code. The calculated design base ground motion for Proposed Project components would consider the soil type and the most current and

applicable seismic attenuation methods that are available. All surface facilities and equipment would have suitable foundations and anchoring design, surface restraints, and moment-limiting supports to withstand seismically induced ground shaking.

Grading of the Project Site that would occur during Phase 3 would result in the construction of retaining walls along Valley Drive, the remainder of the retaining wall along 6th Street, and retaining walls within the Project Site for the containment area. After completion of the retaining walls, the final grading of the Project Site would occur to allow for: the completion of the well cellars; the completion of the final drainage facilities; the installation of the permanent production equipment, storage tanks, the small office building, and electrical equipment; and the construction of the perimeter block wall and other site improvements.

The grading would not be anticipated to come in contact with the existing oil well (Stinnett Oil Well #1) that was drilled in the western portion of the Project Site in 1931. The well was abandoned in 2005 to the current standards of the California Division of Oil, Gas, and Geothermal Resources (DOGGR). Grading and construction would be completed in conformance with the DOGGR Site Plan Review Program (Department of Conservation 2013a) and Well Review Program (Department of Conservation 2013b), which were designed to assist local permitting agencies in identifying and reviewing the status of oil or gas wells located near or beneath proposed structures, and upon proper well abandonment, to provide advice when development occurs near oil or gas wells. Before issuing building or grading permits, the City of Hermosa Beach would review and implement DOGGR's preconstruction well requirements, which include mandatory well abandonment to current DOGGR standards. Because the well was properly abandoned in 2005, additional abandonment activities may not be required; therefore, DOGGR would provide advice regarding development of the site. For example, the property owner would be responsible for providing future access to the abandoned well, in the event additional corrective actions were needed on the well. In addition, DOGGR recommends that during grading, any soil containing significant amounts of hydrocarbons be disposed in accordance with local, state, and federal laws and that the appropriate authorities be notified if such soil is discovered. Coordination with DOGGR would also ensure that the exact location of the abandoned well would be located prior to grading, such that the well would not be damaged.

There are two 550-gallon underground storage tanks that were abandoned in place by filling with concrete in the southerly portion of the Project Site. In April 1989, the County of Los Angeles issued a closure letter with no further action. The exact location of these tanks are not known and they may be encountered during grading at the Project Site and may require removal if they are in the way of grading or improvements.

The permanent oil, gas, and water production equipment would be installed on the eastern portion of the Project Site. This would include storage tanks with a maximum height of 16 feet. The tank area on the Project Site would have a finished grade of 6 to 7 feet below ground surface, be surrounded by a 6- to 7-foot retaining wall in the interior of the Project Site, and a 16-foot split-face block wall around the perimeter of the Project Site. The storage tanks and any piping for the vapor recovery system would be below the height of the 16-foot perimeter wall.

Some of the tanks, equipment, and walls in the northern and northeastern portions of the Project Site would be located in the vicinity of the former landfill and the contaminated soil would be

remediated with the implementation of the RAP. This area would be subject to potential seismic settlements of up to 3.5 inches as a result of the landfill material left in place. To address this issue, the Proposed Oil Project would implement one of the two following feasible options to address settlements for proposed structures that cannot tolerate settlements of 3.5 inches or significant differential settlement: ground improvements and/or deep foundations including drilled-in-place, grouted pipe piles; or cast-in-drilled hole piles. The final design and selection of the most appropriate option to address potential settlement would be required once site plans and structural plans are finalized.

The ground surface of the Project Site would be paved with concrete or asphaltic concrete. In addition, the construction of final street improvements along the frontage of the Project Site along 6th Street and Valley Drive would occur. This would include the installation of new curbs, gutters, and sidewalks.

Phase 4

During Phase 4 of the Proposed Oil Project, remaining wells would be drilled utilizing an electric drill rig and production equipment would be installed and used to process the extracted oil, gas, and water. Phase 4 of the Proposed Oil Project would incorporate the following design features and operational practices related to geology and soils.

Design Features and Operational Practices

No additional grading would occur in Phase 4 as all of the improvements on the Project Site needed for drilling and ongoing operations would be completed in Phase 3.

A comprehensive Subsidence Monitoring Program would be implemented as a part of the Proposed Oil Project in order to monitor subsidence in the area during oil extraction and water injection. The Program would include land surface monitoring using Global Positioning Survey (GPS) and InSAR technology. The purpose of the Program would be to facilitate the early identification of potential subsidence caused by oil extraction. The primary objective of the Program would be to measure whether subsidence occurs; measure potential vertical ground movement (either up or down); collect information that could definitively distinguish between measurable subsidence caused by oil extraction operations and subsidence attributable to other human activity or natural processes; and implement defined action level requirements, thus minimizing or eliminating the potential for damaging subsidence. The Program would ensure that subsidence would not occur to the degree that it could endanger the facility, surrounding properties/structures, shoreline areas, and offshore areas.

A comprehensive Induced Seismicity Monitoring Program would be implemented as a part of the Proposed Oil Project in order to monitor seismic activity in the area during oil extraction and water injection. The Program would monitor seismic activity using the Southern California Seismic Network (SCSN). The primary objective of the Program would be to measure, if it occurs, potentially induced seismicity that might result from drilling activities and water injection, collect information that would allow for a determination of the causes of any measurable seismicity, and implement defined action level requirements, thus minimizing the potential for continued induced seismicity. If activity is detected and the overseeing agencies consider it necessary, the Proposed Oil Project operations would be modified or ceased.

4.7.3.3 Applicant Prepared Studies

As discussed in Section 4.7.4.2, Proposed Project Design Features, a site-specific geotechnical investigation was completed in association with the Proposed Oil Project (NMG Geotechnical 2012). This report provides a summary of the geologic setting and includes an analysis of the potential for seismically induced ground movement and associated ground failure. The geotechnical report provides recommendations for grading, temporary excavations, and foundation construction.

In addition, Geosyntec Consultants (2012) conducted a seismic study for the Proposed Project area in order to identify past seismic activity that may have coincided with and been a result of past nearby oil field operations.

4.7.3.4 Impacts

The following environmental thresholds would result in no impacts, as discussed:

Septic Tanks

Geologic impacts would be significant if the Proposed Project:

Is underlain by soils incapable of adequately supporting the use of septic tanks or alternative wastewater disposal systems where sewers are not available for the disposal of water.

The Proposed Project would be served by existing sewer infrastructure. Water and sewer service would be provided by the California Water Service Company and the City/Los Angeles Sanitation District, respectively. Proposed Project development would not involve the use of septic tanks or alternative wastewater disposal systems for disposal of sanitary wastewater. Wastewater associated with oil and gas production would be disposed in deep injection wells at the Project Site. See Section 4.14, Water Resources, for additional information pertaining to disposal of sanitary waste and wastewater.

Impact GEO.1 pertains to the following significance criteria:

The Proposed Project would be considered significant if it:

- Exposes people or structures to potentially substantial adverse effects, including the risk of loss, injury, or death involving rupture of a known earthquake fault, strong seismic ground shaking, and seismic-related ground failure, including liquefaction or landslides; or
- Is located within any of the following areas: (1) a State of California designated Alquist-Priolo Special Fault Study Zone, (2) a designated Fault Hazard Area, (3) a mapped area of tsunami hazard.
- See Section 4.9, Hydrology and Water Quality, regarding potential tsunami impacts.

Impact #	Impact Description	Phase	Residual Impact
GEO.1	The Proposed Project would potentially expose people and structures to seismically induced ground shaking.	Phase 2 and 4	Class II Less Than Significant with Mitigation

The Project Site, proposed oil/gas pipelines, and Proposed City Maintenance Yard Project Site are not located within a fault-rupture hazard zone, as defined by the Alquist-Priolo Special Studies Zones Act, and no evidence of active faulting was observed during a site specific geotechnical investigation at the Project Site. Therefore, surface fault rupture is not anticipated to occur in the event of an earthquake.

As illustrated in Figures 2.8, the proposed oil wells would be drilled directionally from the Project site, both onshore and offshore. No active faults would be traversed by these wells. The closest active fault is the offshore Palos Verdes Fault, located approximately 0.5 mile southwest of the terminus of the proposed offshore wells, at the closest point (Figure 4.7-1). Similarly, the proposed wells would not traverse Off-shore Fault 103, which is not considered an active fault.

However, the City of Hermosa Beach is located in a geologically complex and seismically active region that is subject to earthquakes and potentially strong ground shaking. Major active or potentially active faults in the region include the Newport Inglewood and Palos Verdes faults. Available geologic data suggest that the highest peak ground accelerations at the Project Site, pipeline route, and Proposed City Maintenance Yard Project Site would occur as a result of an earthquake on the Palos Verdes and Newport-Inglewood faults, which have a maximum moment magnitude (M_W) of 7.7 and 7.0, respectively. The Proposed Oil Project facilities, associated oil/gas pipelines, and Proposed City Maintenance Yard Project facilities would be susceptible to damage as a result of an earthquake on these or other regional faults. Although the Proposed Project area is not susceptible to liquefaction hazards, the potential exists for seismically induced differential settlement and soil collapse.

As indicated in Section 4.8, Safety, Risk of Upset, and Hazards, atmospheric storage tanks could fail given a large magnitude earthquake producing ground acceleration values exceeding 0.5g. It is also assumed that an earthquake producing greater than 1.5 g would cause releases from the pipeline. See Section 4.8 for frequency of such ground motion events and failure rate uncertainties.

As indicated in Section 4.7.4.2, Proposed Project Design Features, a detailed geotechnical report has been prepared by a Registered Civil Engineer specializing in geotechnical engineering (NMG Geotechnical 2012). This report would be submitted to the City with engineered grading plans to provide a design and/or construction level recommendations for the Proposed Oil Project. The proposed oil drilling facility, spill containment vaults, oil and gas pipelines, and Proposed City Maintenance Yard Project structures would be designed and constructed to withstand anticipated horizontal and vertical ground acceleration in the Proposed Project area, based on the California Building Code. The calculated design base ground motion for Proposed Project components would consider the soil type and the most current and applicable seismic

attenuation methods that are available. All surface facilities and equipment would have suitable foundations and anchoring design, surface restraints, and moment-limiting supports to withstand seismically induced ground shaking.

However, as discovered during the 1971 San Fernando earthquake and the 1994 Northridge earthquake, existing building codes are often inadequate to completely protect engineered structures from hazards associated with large ground accelerations. Therefore, potential seismic impacts and associated damage to structures from a major earthquake on the nearby Newport Inglewood and Palos Verdes faults, or any other regional fault, would be considered *significant*.

Mitigation Measures

GEO-1a In coordination with the Caltech Seismological Laboratory, the Applicant shall install an accelerometer at the Project Site to determine site-specific ground accelerations as a result of any seismic event in the region (Los Angeles/Orange County and offshore waters of the Santa Monica Bay and San Pedro Channel). The drilling operator shall cease operations and inspect all onsite oil field-related pipelines, storage tanks, and other infrastructure following any seismic event that exceeds a ground acceleration at the Project Site of 13 percent of gravity (0.13 g). The drilling operator shall not reinstitute operations at the Project Site and associated pipelines until it can be determined that all oil field infrastructure is structurally sound.

GEO-1b All seismic related recommendations provided by NMG Geotechnical (2012) shall be incorporated into the Proposed Oil Project design. These measures shall include, but not be limited to the following:

- Drilled-in-place piles or cast-in-drilled-hole piles shall be constructed for foundations in the landfill area, i.e., northeast Project Site, to reduce seismically induced settlement.
- Ground improvement techniques, including high pressure grout injection, i.e., compaction grouting, shall be used in the landfill area to reduce seismically induced settlement and allow construction of conventional shallow foundations.
- Seismic design criteria for horizontal and vertical accelerations, identified in Tables 10 and 11 of the geotechnical report, shall be used during Proposed Project design (including incorporation of updated seismic design criteria from the 2013 California Building Code).
- During Phase 1, the upper 2 to 4 feet of soil in the vicinity of the proposed well cellars shall be excavated and replaced with compacted fill. In addition, the basement under the maintenance building shall be removed and filled in with compacted fill.
- During Phase 3, the eastern portion of the site shall be excavated approximately 7 feet deeper than the majority of the proposed building pad,

with a minimum of 3 feet of overexcavation below design grades, and recompacted to provide a uniform fill blanket below proposed tanks, compressors, and other equipment.

- Asphalt pavement and underlying subgrade soils shall be designed to accommodate the proposed drill rig.
- Positive surface drainage shall be provided to direct runoff away from slopes and structures and toward suitable drainage devices. Ponding of water on structural pads shall not be allowed.

GEO-1c A Registered Civil Engineer and Certified Engineering Geologist shall complete a geotechnical investigation specific to the Proposed City Maintenance Yard Project structures. All geotechnical recommendations provided in the report shall be followed during grading and construction at the site. The geotechnical evaluation shall include, but not be limited to, an estimation of both vertical and horizontal anticipated peak ground accelerations.

Residual Impacts

The mitigation measures presented above are standard mitigation requirements for most projects and are expected to result in standard requirements consistent with building codes and standard construction practices. Specifically, the geotechnical investigation for the relocated City Maintenance Yard is not expected to uncover any features that would result in significant and unavoidable geological impacts. With implementation of measures GEO-1a through GEO-1c, the residual impacts would be considered **less than significant with mitigation (Class II)**.

Impact GEO.2 pertains to the following significance criteria:

The Proposed Project would be considered significant if it:

Exposes people or structures to potentially substantial adverse effects, including the risk of loss, injury, or death involving rupture of a known earthquake fault, strong seismic ground shaking, and seismic-related ground failure, including liquefaction or landslides.

Impact #	Impact Description	Phase	Residual Impact
GEO.2	Wastewater injection would potentially induce seismicity in the vicinity of the Proposed Project.	Phase 2 and 4	Class II Less Than Significant with Mitigation

A very small fraction of oil field extraction and associated wastewater injection activities have induced seismicity at levels that are noticeable to the public. However, wastewater disposal related to oil and gas production activities has induced seismicity in parts of Oklahoma, Arkansas, Ohio, and Colorado. From January 2009 to mid-2013, more than 200 M 3.0 or greater earthquakes have rattled Central Oklahoma, marking a significant rise in the frequency of these seismic events. The USGS and Oklahoma Geological Survey have been conducting collaborative research quantifying the changes in earthquake rate in the Oklahoma City region, assessing the implications of this earthquake swarm for large earthquake hazard, and evaluating possible links between these earthquakes and wastewater disposal related to oil and gas production activities in the region. The Arkansas Oil and Gas Commission has established a permanent disposal well moratorium area where a swarm of earthquakes appear to have been triggered by wastewater disposal wells located along two faults (Arkansas Oil and Gas Commission 2011). There are examples of past oil field operations in the Los Angeles Basin inducing seismic events. For example, very shallow earthquakes at the Wilmington Oil Field occurred between 1947 and 1961, as well as possible fault creep at the Inglewood Oil Field in the early 1960s. These events have been associated with extreme amounts of land subsidence that occurred in these fields that resulted from lack of proper water re-injection operations (Geosyntec Consultants 2012, Appendix F). (See Impact GEO.4 related to subsidence.)

The risk of damage to overlying structures in the vicinity of oil field operations includes location of faults and net changes to subsurface pore pressure caused by fluid extraction or injection. These net changes involve the volume and pressure of fluids injected or extracted, the duration of injection and extraction, and the number of wells involved in the project. High injection volumes in the absence of corresponding extractions may increase pore pressure and in proximity to existing faults, could lead to an induced seismic event.

In general, the risk of damage to structures overlying oil fields is proportional to the amount of wells being drilled. Operation of only a few wells would not likely cause problems with induced seismicity. If 100 or more wells are drilled, there can be a significant likelihood that induced seismicity will cause damage to structures somewhere, as a result of the large number of earthquakes and ground motions that are induced, even though the probability of any one well producing such ground motions is small (National Academy of Sciences 2013). The Proposed Project would include up to 30 oil wells and 4 water injection wells. The calculated probabilities of shaking felt at the surface, of strong shaking, and of structures and people being affected in a given area can be generalized from former drilling projects. These probabilities can then become the basis for decisions on whether and how to minimize the impacts of induced seismicity (National Academy of Sciences 2013). As indicated in Section 4.7.4.2, Proposed Project Design Features, Geosyntec Consultants (2012) conducted a seismic study for the Proposed Project area in order to identify past seismic activity that may have coincided with and been a result of past

nearby oil field operations. The results of their study concluded that past seismic activity did not coincide with past oil field operations (such as drilling, fracturing, oil extraction, or water injection) and there were no patterns of seismic activity relative to those past oil field operations.

Most of the recent seismicity (1981 to 2010) in the northwest portion of the Los Angeles Basin, which includes the Project Site, occurs at depths below 5 miles, as a result of normal tectonic stresses. Except for one shallow, low magnitude (M 2.2) earthquake located west of the Wilmington Oil Field, no shallow earthquakes (less than 4 kilometers below ground surface) were recorded in the active Wilmington or Torrance oil fields, including the Redondo Beach area located immediately adjacent to Hermosa Beach. Therefore, the Hermosa Beach area should not experience an increase in seismicity as a result of oil production and wastewater injection during Proposed Oil Project operations (Geosyntec 2012). The time frame of the seismicity analysis by Geosyntec (2012), from 1981 to 2010, is representative of a time period in which the oil industry understood that oil, gas, and water extraction caused ground subsidence and water injection caused ground rebound. These phenomena were well understood following the substantial ground subsidence, and associated swarm of induced earthquakes, that occurred in the Wilmington Oil Field from 1947 to 1961. The swarm of subsidence induced earthquakes in the Wilmington Oil Field was highly unusual and occurred as a result of a lack of knowledge at that time.

Reducing the injection volumes, rates, and pressures has been successful in decreasing rates of felt seismicity in cases where events have been induced (National Academy of Sciences 2013). Adherence to California regulations and oversight by DOGGR would minimize the potential for an earthquake induced by water injection. Based on California Code of Regulations Title 14, Division 2, Section 1724.10, an accurate, operating pressure gauge or pressure recording device would be available at all times, and all injection wells would be equipped for installation and operation of such a device. To determine the maximum allowable surface injection pressure, a step-rate test would be conducted prior to sustained liquid injection. A step-rate test involves incrementally increasing the injection pressure on a given well until fracture pressures are reached. Maximum allowable surface injection pressure would be less than the fracture pressure, thereby minimizing the potential for earthquakes and surface ground cracking. The appropriate DOGGR district office would be notified prior to conducting the test so that it may be witnessed by a Division inspector.

Conventional hydraulic fracturing operations (i.e., fracking), where high volumes of water are injected into large areas of the reservoir formation at relatively high rates, would not be utilized during Proposed Oil Project operations. Therefore, potential impacts related to fracking induced seismicity would not occur. Although Proposed Oil Project-induced seismicity is not anticipated to occur, impacts would be *potentially significant* in the absence of monitoring to verify that seismicity is not occurring. Therefore, the applicant proposes a Subsidence and Induced Seismicity Monitoring Program to detect seismicity as a result of wastewater injection activities to ensure that seismicity is not occurring. In addition, the following mitigation measures would further reduce potential impacts related to subsidence.

Mitigation Measures

GEO-2a Injection pressures associated with wastewater injection shall not exceed reservoir fracture pressures as specified in California Code of Regulations Title 14, Division 2,

Section 1724.10, and as approved by the California Division of Oil, Gas, and Geothermal Resources.

GEO-2b In coordination with the Caltech Seismological Laboratory, the Applicant shall install an accelerometer at the Project Site to determine site-specific ground accelerations as a result of any seismic event in the region (Los Angeles/Orange County and offshore waters of the Santa Monica Bay and San Pedro Channel). Readings from the accelerometer shall be recorded at the Oil Field and transmitted in real-time to the Caltech Seismological Laboratory. The drilling operator shall cease operations and inspect all onsite oil field-related pipelines, storage tanks, and other infrastructure following any seismic event that exceeds ground acceleration at the Project Site of 13 percent of gravity (0.13 g). The drilling operator shall not reinstitute operations at the Project Site and associated pipelines until it can be determined that all oil field infrastructure is structurally sound.

GEO-2c In the event that monitoring indicates that Proposed Oil Project-induced seismicity is occurring, wastewater injection operations shall be adjusted to alleviate such seismicity. The drilling operator shall first receive approval from the California Division of Oil, Gas, and Geothermal Resources prior to any change (increase) in the injection operations.

Residual Impacts

With implementation of measures GEO-2a, GEO-2b, and GEO-2c, residual impacts would be considered **less than significant with mitigation (Class II)**.

Impact GEO.3 pertains to the following significance criteria:

The Proposed Project would be considered significant if it:

Is located in an area at risk of landslides/mudflows; defined as areas with slopes greater than 10 percent.

Impact #	Impact Description	Phase	Residual Impact
GEO.3	The Proposed Project is not located in an area at risk of landslides/mudflows; defined as areas with slopes greater than 10 percent.	Phase 1, 2, 3, and 4	Class II Less Than Significant with Mitigation

The Project Site is generally flat to gently sloping. No steep hillsides potentially subject to failure are located adjacent to the site. Similarly, the Proposed City Maintenance Yard Project Site is gently to moderately sloped, with a 20 foot elevation difference across the site. There is very limited potential for landslides or mudflows on either site. However, these properties are underlain by loose dune sands and similarly loose fill material. These soils would be subject to sloughing and caving during temporary excavations related to removal of the former landfill in

the northeast portion of the Project Site, removal of 2 to 4 feet of material across the remainder of the Project Site, and grading for the Proposed City Maintenance Yard Project Site. Such sloughing and caving could result in adverse health and safety impacts to onsite grading and construction crews. In addition, temporary excavations along the northern Project Site boundary could potential destabilize offsite structures located immediately to the north. Impacts are considered *significant*.

Mitigation Measures

GEO-3 All slope stability related recommendations provided by NMG Geotechnical (2012) shall be incorporated into the Proposed Oil Project design. Temporary excavations shall be stabilized per the latest edition of Cal/OSHA requirements for loose sands, including shoring or laying back of trench walls. Shoring along the northern perimeter of the Project Site shall be designed by an experienced structural engineer due to the proximity to existing buildings that must be protected from potential settlement and lateral movements.

Residual Impacts

With implementation of measure GEO-3, residual impacts would be considered **less than significant with mitigation (Class II)**.

Impact GEO.4 pertains to the following significance criteria:

The Proposed Project would be considered significant if it:

Is 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.

See Impact GEO.1 with respect to the potential for seismically induced ground failure and Impact GEO.3 with respect to the potential for slope failure.

Impact #	Impact Description	Phase	Residual Impact
GEO.4	The Proposed Oil Project would potentially result in ground subsidence from oil and gas withdrawal.	Phase 2 and 4	Class II Less Than Significant with Mitigation

Subsidence due to oil, gas, and groundwater withdrawal generally occurs over a large area. As a result, differential settlement damage due to onshore subsidence is typically only evident in long linear features, such as pipelines, roadways, or aqueducts. Generally, damage to structures and underground utilities occurs only where a substantial amount of subsidence occurs. Similarly, offshore subsidence could damage offshore pipelines, outfalls, jetties, and piers, as well as change the dynamics of coastal depositional and erosional processes and/or near-shore

bathymetry – with the potential secondary effects discussed above in Section 4.7.1.3, Geologic Hazards.

As indicated in Section 4.7.4.2, Geosyntec (2012) conducted a subsidence study for the Proposed Oil Project that was peer reviewed by the EIR preparers. The report concluded that subsidence has not occurred to date in the Torrance Oil Field and subsidence is not expected to occur as a result of the Proposed Oil Project related oil extraction, for the following reasons:

- Sand-grain packing is mature in the Torrance Oil Field reservoir formations, unlike the adjacent Wilmington Oil Field reservoir formations, where historical subsidence has occurred.
- Lithology of the target reservoir formations includes lenses/layers of compacted and cemented shale units, which inhibits subsidence, unlike the greater unconsolidated thicknesses of sandstone of the adjacent Wilmington Oil Field.
- Water injection would be conducted to minimize subsidence as oil is extracted during the operational life of the Proposed Oil Project.

The Proposed Oil Project will remove an unknown volume of oil, gas, and associated water. In the absence of injection of wastewater back into the subsurface, the potential for settlement of overlying onshore and offshore infrastructure increases. Similarly, most of the subsidence could occur offshore, as oil would be extracted beneath offshore waters and most of the initial water reinjection is planned for portions of reservoir zones located beneath onshore areas. Waste water reinjection is a standard practice in the oil and gas industry, not only for the disposal of wastewater, but also to prevent ground subsidence. Although reinjection of wastewater in proposed injection wells would substantially reduce the potential for ground subsidence, such reinjection does not ensure avoidance of subsidence. Therefore, impacts would be *potentially significant* in the absence of onshore and offshore subsidence monitoring and corrective actions.

As indicated in Section 4.7.3.2, Proposed Project Design Features, the applicant proposes a Subsidence Monitoring Program to detect subsidence as a result of drilling activities to ensure that subsidence would not be allowed to the degree that it could endanger the facility, off-site structures, and the shoreline. In addition, DOGGR will review the Proposed Project operations including plans for fluid withdrawal, water re-injection and reservoir pressure maintenance. DOGGR maintains jurisdiction to arrest or ameliorate subsidence under Division 3, Chapter 1, Article 5.5 of the California Public Resources Code (beginning with Section 3315). Furthermore, section 3319 (c) requires that "field wide re-pressuring plans be based upon a competent engineering study that includes re-pressuring operations designed to most effectively arrest or ameliorate subsidence." Consequently, oil field operations will be conducted under the oversight of DOGGR and will be designed to reduce potential subsidence. In addition to the Applicant proposed Subsidence Monitoring Program, the following mitigation measures would further reduce potential impacts related to subsidence.

Mitigation Measures

GEO-4a Prior to approval of the first drilling permit, the Applicant shall have submitted and the City of Hermosa Beach and the California Coastal Commission shall have approved a Subsidence Monitoring and Avoidance Program, for both onshore and offshore areas.

The onshore monitoring plan shall be completed throughout the life of this Project, in accordance with Appendix A, Subsidence Monitoring Program, of the *Subsidence and Induced Seismicity Technical Report, E&B Oil Development Project* (Geosyntec Consultants 2012), included as Appendix F of this EIR. The offshore monitoring plan shall be completed throughout the life of this project in accordance with the *Offshore Subsidence Monitoring Program and Possible Mitigation Measures, Hermosa Beach, California* (Coastal Environments 1998), included as Appendix F of this EIR. The latter shall be updated, as applicable, to reflect advances in science since 1998. In addition, Section 7.6, Mitigation of Onshore Subsidence, of the latter report, shall not be applied to this mitigation measure, as the onshore monitoring program would be completed in accordance with the Geosyntec Consultants (2012) report.

GEO-4b The Subsidence Monitoring Program shall include:

- Ground elevation survey methodologies with high vertical resolution, including onshore surface elevations and offshore bathymetric elevations;
- Prior to Phase II drilling, establishment of a network of onshore and offshore survey or subsidence monitoring locations, including continuous GPS stations, GPS benchmarks, and tautly anchored offshore monitoring points, positioned within the City, outside the City, and in offshore areas, that are sufficiently spaced to draw conclusions about subsidence within the zone of influence of the Project;
- Because subsidence can occur for a variety of reasons, establishment of control points outside the zone of influence to allow differentiation of possible subsidence effects related to other activities;
- Use of InSAR imagery technology to evaluate regional subsidence patterns both within and beyond the proposed oil field;
- Sufficient monitoring frequency to establish trends in subsidence in order to distinguish background ground movement from any subsidence caused by proposed oil field operations;
- Reservoir monitoring, including documentation of produced fluid volume (oil, gas and water) and reservoir pressures at similar frequency to ground elevation measurements;
- Reporting requirements; and
- Action levels, as specified in the onshore and offshore subsidence monitoring reports.

Surveying for both vertical and horizontal ground movement shall be completed along the perimeter and throughout the interior of the oil field, including both onshore and offshore areas, utilizing Global Positioning System technology in combination with a network of ground stations. The onshore continuous monitoring GPS stations shall include:

- Hermosa Beach Pier. The pier will serve as the furthest offshore point in the onshore monitoring program.
- Longfellow Outfall. This Outfall is larger and more structurally stable than some of the other outfalls along the City's coast. (It is also in close proximity to a locally important surf break.)
- King Harbor Jetty. This location was selected to achieve a distribution of continuous monitoring points along the coast of Hermosa Beach. This will help provide a limited regional picture of the subsidence between survey events.

GEO-4c An onshore and offshore baseline subsidence report shall be completed and made available to the City of Hermosa Beach and the California Coastal Commission at least two months and no more than six months prior to planned commencement of Phase II drilling operations. Subsidence monitoring reports shall be completed annually and the results shall be forwarded to the California Coastal Commission and the City of Hermosa Beach for review, no more than one month following the end of each annual monitoring cycle. In addition, results shall be forwarded to the adjoining City of Redondo Beach and City of Manhattan Beach.

GEO-4d In the event that the Global Position System monitoring indicates that significant subsidence, as defined by the onshore and offshore subsidence monitoring reports described in GEO-4a, is occurring in and/or around the Proposed Project area, wastewater or water reinjection operations shall be increased to alleviate such subsidence. The Applicant shall coordinate with the California Division of Oil, Gas and Geothermal Resources, which will approve increased levels of wastewater or water reinjection operations in accordance with the approved Subsidence Monitoring Program. The Applicant will also coordinate with the City of Hermosa Beach, Public Works Department, to verify that subsidence has been mitigated sufficiently.

GEO-4e In the event that subsidence related mitigation induces seismicity, corrective actions related to subsidence shall proceed until baseline surface elevations have been achieved, as subsidence related damage would likely be more pronounced in comparison to damage associated with Project related micro-seismicity. Upon reestablishment of baseline elevations, drilling operations shall cease until a balance between subsidence avoidance and induced seismicity avoidance can be established, as agreed upon by the California Division of Oil, Gas and Geothermal Resources and the City of Hermosa Beach.

Residual Impacts

With implementation of measures GEO-4a through GEO-4e, residual impacts would be considered **less than significant with mitigation (Class II)**.

Impact GEO.5 pertains to the following significance criteria:

The Proposed Project would be considered significant if it:

Results in substantial soil erosion or the loss of topsoil.

Impact #	Impact Description	Phase	Residual Impact
GEO.5	Site grading could increase erosion and impact water quality off-site.	Phase 1 and 3	Class III Less Than Significant

Phase 1 would include demolition of existing facilities, excavation of 2 to 4 feet of soil across the remainder of the site, and soil backfill and compaction. Subsequently, additional excavations would be completed for retaining walls, a well cellar, and a temporary retention basin. In addition, grading would occur for the Proposed City Maintenance Yard Project, to be located adjacent to City Hall.

Phase 3 would include additional grading and excavations for additional retaining walls, sound wall construction, excavation of office building footings, and installation of underground oil and gas pipelines. The 4-inch and 6-inch diameter gas pipelines would extend 0.43 mile and 1.4 miles, respectively, at a depth of 3.5 to 4 feet below ground. Similarly, the 8-inch diameter oil pipeline would extend for approximately 3.5 miles, at a depth of 3.5 to 4 feet below ground. The pipelines would be installed utilizing conventional trenching methods within roadway right-of-ways. Two 237-foot sections of pipeline would be constructed per day, including one new 237-foot section and one 237-foot segment being completed from the day before. Excavated soil associated with infrastructure and pipeline construction would be temporarily stockpiled pending backfill and compaction. In addition, during Phase 3, approximately 9,000 cubic yards of contaminated soil would be excavated from the Project Site and temporarily stockpiled prior to being exported off-site.

These grading and construction activities would temporarily increase the amount of suspended solids in surface flows derived from the Project Site during storm events, due to sheet erosion of exposed soil, thus potentially resulting in significant water quality impacts to the nearby Pacific Ocean, located approximately seven blocks to the west of the Project Site. The temporary retention basin would reduce offsite siltation of surface runoff by allowing sediment in the runoff to settle to the bottom of the basin prior to discharge. The Applicant submitted a Preliminary Standard Urban Stormwater Mitigation Plans (SUSMPs) prepared for Phases 2 and 4 of the Project that were provided as Attachment F of the Response to the Planning Application Completeness Review submitted to the City on 4/11/2013. As discussed, no surface runoff from within the perimeter fencing during Phase 2 and the perimeter wall in Phase 4 would be allowed to leave the Project Site. Therefore, no onsite or offsite erosion or siltation would occur as a result of the Proposed Project. In addition, water quality impacts would be mitigable with implementation of the following standard conditions of approval:

The Applicant would implement a Storm Water Pollution Prevention Plan (SWPPP) using Best Management Practices (BMPs) and would monitor and maintain stormwater pollution control facilities identified in the SWPPP, in a manner consistent with the provisions of the Federal

Water Pollution Control Act (National Pollutant Discharge Elimination System (NPDES) Program). Stormwater management protection measures and wet weather measures would be designed by a California registered, Qualified Storm Water Pollution Prevention Plan Developer. In addition, a California registered, Qualified Storm Water Pollution Prevention Plan Practitioner would oversee and monitor construction BMPs and stormwater management, in accordance with the State General Construction Permit and the MS4 Discharges within the Coastal Watersheds of Los Angeles County, Los Angeles Regional Water Quality Control Board Order No. R4-2012-0175.

Conventional measures typically recommended by the State Water Resource Board and the California Department of Transportation include the following:

- Implement permanent erosion and sediment control measures:
  - Minimize grading, clearing, and grubbing if possible;
  - Use mulches and hydroseed, free of invasive plants, to protect exposed soils;
  - Use geotextiles and mats to stabilize soils;
  - Use drainage swales and dissipation devices; and
  - Use erosion control measures outlined in the California Stormwater Quality Association Best Management Practice Handbook.
- Implement temporary Best Management Practice mitigation measures:
  - Use silt fences, sandbags, and straw wattles;
  - Use temporary sediment basins and check dams; and
  - Use temporary Best Management Practices outlined in the California Stormwater Quality Association Best Management Practice Handbook.
- Implement tracking control Best Management Practices to reduce tracking sediment offsite.
  - Use stabilized construction entrance and exit with steel shakers;
  - Use tire wash areas; and
  - Use tracking control Best Management Practices outlined in the California Stormwater Quality Association Best Management Practice Handbook.

Also, see Section 4.9, Hydrology and Water Quality with regard to other water quality impacts to be addressed by a standard SWPPP.

With implementation of these standard erosion control measures, impacts would be **less than significant (Class III)**.

Mitigation Measures

No mitigation measures would be required in the absence of significant impacts.

Impact GEO.6 pertains to the following significance criteria:

The Proposed Project would be considered significant if it:

Is located on expansive soil, as defined in the 2010 California Building Code, creating substantial risks to life or property.

Impact #	Impact Description	Phase	Residual Impact
GEO.6	Expansive soils could be present at Proposed Project sites.	Phase 1 and 3	Class II Less Than Significant With Mitigation

Expansive soils are typically associated with fine-grained clayey soils that have the potential to shrink and swell with repeated cycles of wetting and drying. As indicated in Section 4.7.4.2, Proposed Project Design Features, a geotechnical investigation was completed at the Project Site (NMG Geotechnical 2012). Based on this site investigation, the majority of native soils at the Project Site are sandy, including mixtures of sands, silty sands, and clayey sands, which are generally not prone to soil expansion (NMG Geotechnical 2012).

Preliminary geotechnical investigations have not been completed along the proposed pipeline route or for the Proposed City Maintenance Yard Project. In addition, although imported fill is not anticipated as part of the Proposed Oil Project, unforeseen import of soil could result in clay rich soils being laid at or near the surface, potentially resulting in cracks and failure of foundations and infrastructure. Impacts are considered *potentially significant*.

Mitigation Measures

GEO-6 A Registered Civil Engineer shall analyze surficial and near-surface soils at the Project Site subsequent to grading and prior to on-site construction, to determine whether expansive soils are present. Similarly, soils at the Proposed City Maintenance Yard Project Site and along the proposed pipeline route shall be analyzed for soil expansion potential. In the event that clay-rich, expansive soils are present, foundations shall be designed to accommodate expansive soils and pipelines shall be placed within a blanket of non-expansive soils to prevent structural damage and/or failure. Foundation and pipeline design shall be reviewed and approved by a Registered Civil Engineer.

Residual Impacts

With implementation of measure GEO-6, the residual impacts would be considered **less than significant with mitigation (Class II).**

Impact #	Impact Description	Phase	Residual Impact
GR.7	Corrosion could potentially damage the structural components and pipelines which would result in a pipe burst and subsequent oil spill.	Phase 4	Class II Less Than Significant With Mitigation

Soils and bedrock throughout Southern California have varying degrees of sulfate and corrosion potential. Long-term production could result in corrosion of pipelines and other components in contact with the soil and bedrock. Such corrosion could result in oil leaks. Onsite soils are corrosive to metals (NMG Geotechnical 2012) and therefore may pose a hazard to proposed concrete and metal components and improvements. If corrosion of pipelines were to occur, the pipelines would be weakened and increase the potential for an oil discharge. Degradation of concrete hold downs, slabs, and foundations could compromise the structural integrity of the elements. Therefore, the impacts due to corrosion would be significant.

Mitigation Measures

GEO-7a Proposed Oil Project design must conform to the recommendations of HDR Schiff (2012), included within Appendix C in NMG Geotechnical (2012), or as per the City Engineer, and should occur prior to completion of the final Project design.

GEO-7b All buried metal pipelines shall be coated and placed under impressed cathodic protection. To monitor for internal corrosion, corrosion coupons or equivalent measures can be utilized.

GEO-7c External pipe inspections shall be conducted for the exposed pipeline sections to ensure atmospheric coatings are in good conditions. All external inspections shall be documented and reviewed by the operations management and repairs documented, when necessary.

GEO-7d In accordance with California Division of Oil, Gas, and Geothermal Resources pipeline regulations (Public Resources Code Sections 3013 and 3782), a pipeline management plan shall be implemented for the Project Site. Similarly, in accordance with United States Department of Transportation, Pipeline and Hazardous Materials Safety Administration regulations, a pipeline management plan shall be implemented for proposed pipelines located beyond the perimeter of the Project Site. These plans shall include, but not be limited to mechanical testing, including ultrasonic and hydrostatic testing.

GEO-7e All concrete in contact with the high sulfate or corrosive soils shall be Type V concrete in accordance with the 2010 California Building Code.

Residual Impacts

Implementing mitigation measures GR-7a through GR-7e would reduce the severity of corrosion-related impacts to **less than significant with mitigation (Class II)**.

4.7.4 Other Issue Area Mitigation Measure Impacts

None of the mitigation measures identified in other sections of the EIR would increase the impacts to geological resources. Therefore, additional analysis or mitigation is not required.

4.7.5 Cumulative Impacts and Mitigation Measures

In general, the impacts due to the Proposed Project can be mitigated to less than significant levels. Cumulative impacts related to seismically-related ground shaking and associated ground failure, as well as landslides and other impacts, would be similar to what is described for Proposed Project-specific impacts. The impacts would be addressed on a project-by-project basis through compliance with existing building codes and any site-specific mitigation measures for individual projects. Remaining impacts associated with the cumulative projects in the vicinity of the Project Site will not have any impacts that result in cumulative impacts, since the impacts are site specific and not significant with mitigation

Compliance with applicable code requirements and the recommendations of site-specific geotechnical evaluations on a case-by-case basis would reduce cumulative impacts relating to geotechnical hazards to a less than significant level.

All mitigation measures are based on conventional techniques and standards within the industry. All geotechnical hazards can be mitigated to acceptable levels by licensed professionals who will provide guidelines and specifications to mitigate and remediate the specific hazard.

Therefore, cumulative impacts relating to geotechnical hazards would be less than significant.

4.7.6 Mitigation Monitoring Plan

Proposed Oil Project and Pipeline Mitigation Measures				
Mitigation Measure	Requirements	Compliance Verification		
		Method	Timing	Responsible Party
GEO-1a	In coordination with the Caltech Seismological Laboratory, the Applicant shall install an accelerometer at the Project Site to determine site-specific ground accelerations as a result of any seismic event in the region (Los Angeles/Orange County and offshore waters of the Santa Monica Bay and San Pedro Channel). The drilling operator shall cease operations and inspect all onsite oil field-related pipelines, storage tanks, and other infrastructure following any seismic event that exceeds a ground acceleration at the Project Site of 13 percent of gravity (0.13 g). The drilling operator shall not reinstitute operations at the Project Site and associated pipelines until it can be determined that all oil field infrastructure is structurally sound.	Inspection by a California Registered Civil Engineer	Following any seismic event that results in substantial ground accelerations at the Project Site, as pre-determined by a California-licensed geotechnical engineer.	City of Hermosa Beach
GEO-1b	All seismic related recommendations provided by NMG Geotechnical (2012) shall be incorporated into the Proposed Oil Project design. These measures shall include, but not be limited to the following: - Drilled-in-place piles or cast-in-drilled-hole piles shall be constructed for foundations in the landfill area, i.e., northeast Project Site, to reduce seismically induced settlement. - Ground improvement	Review and approval of geotechnical report.	Approve geotechnical report prior to issuance of grading permit.	City of Hermosa Beach

Proposed Oil Project and Pipeline Mitigation Measures				
Mitigation Measure	Requirements	Compliance Verification		
		Method	Timing	Responsible Party
	techniques, including high pressure grout injection, i.e., compaction grouting, shall be used in the landfill area to reduce seismically induced settlement and allow construction of conventional shallow foundations. - Seismic design criteria for horizontal and vertical accelerations, identified in Tables 10 and 11 of the geotechnical report, shall be used during Proposed Project design (including incorporation of updated seismic design criteria from the 2013 California Building Code). - During Phase 1, the upper 2 to 4 feet of soil in the vicinity of the proposed well cellars shall be excavated and replaced with compacted fill. In addition, the basement under the maintenance building shall be removed and filled in with compacted fill. - During Phase 3, the eastern portion of the site shall be excavated approximately 7 feet deeper than the majority of the proposed building pad, with a minimum of 3 feet of overexcavation below design grades, and recompacted to provide a uniform fill blanket below proposed tanks, compressors, and other equipment. - Asphalt pavement and underlying subgrade soils shall be designed to accommodate the proposed drill rig. Positive surface drainage shall be provided to direct			

Proposed Oil Project and Pipeline Mitigation Measures				
Mitigation Measure	Requirements	Compliance Verification		
		Method	Timing	Responsible Party
	runoff away from slopes and structures and toward suitable drainage devices. Ponding of water on structural pads shall not be allowed.			
GEO-1c	A Registered Civil Engineer and Certified Engineering Geologist shall complete a geotechnical investigation specific to the Proposed City Maintenance Yard Project structures. All geotechnical recommendations provided in the report shall be followed during grading and construction at the site. The geotechnical evaluation shall include, but not be limited to, an estimation of both vertical and horizontal anticipated peak ground accelerations.	Review and approval of geotechnical report.	Approve geotechnical report prior to issuance of grading permit for Phase 3 City Maintenance Yard.	City of Hermosa Beach
GEO-2a	Injection pressures associated wastewater injection shall not exceed reservoir fracture pressures as specified in California Code of Regulations Title 14, Division 2, Section 1724.10, and as approved by the California Division of Oil, Gas, and Geothermal Resources.	Comparing pressure measurements on each injection well to formation fracture pressure	During wastewater injection operations	California Division of Oil and Gas and Geothermal Resources (DOGGR) and Hermosa Beach Public Works Department
GEO-2b	In coordination with the Caltech Seismological Laboratory, the Applicant shall install an accelerometer at the Project Site to determine site-specific ground accelerations as a result of any seismic event in the region (Los Angeles/Orange County and offshore waters of the Santa Monica Bay and San Pedro Channel). Readings from the accelerometer shall be recorded at the Oil	Coordinate with Cal Tech	Monthly	City of Hermosa Beach

Proposed Oil Project and Pipeline Mitigation Measures				
Mitigation Measure	Requirements	Compliance Verification		
		Method	Timing	Responsible Party
	Field and transmitted in real-time to the Caltech Seismological Laboratory. The drilling operator shall cease operations and inspect all onsite oil field-related pipelines, storage tanks, and other infrastructure following any seismic event that exceeds ground acceleration at the Project Site of 13 percent of gravity (0.13 g). The drilling operator shall not reinstitute operations at the Project Site and associated pipelines until it can be determined that all oil field infrastructure is structurally sound.			
GEO-2c	In the event that monitoring indicates that Proposed Oil Project-induced seismicity is occurring, wastewater injection operations shall be adjusted to alleviate such seismicity. The drilling operator shall first receive approval from the California Division of Oil, Gas, and Geothermal Resources prior to any change (increase) in the injection operations.	Seismicity monitoring	Following monthly monitoring, as necessary	City of Hermosa Beach
GEO-3	All slope stability related recommendations provided by NMG Geotechnical (2012) shall be incorporated into the Proposed Oil Project design. Temporary excavations shall be stabilized per the latest edition of Cal/OSHA requirements for loose sands, including shoring or laying back of trench walls. Shoring along the northern perimeter of the Project Site shall be designed by an	Submit temporary shoring plans and calculations.	Prior to permit issuance	City of Hermosa Beach

Proposed Oil Project and Pipeline Mitigation Measures				
Mitigation Measure	Requirements	Compliance Verification		
		Method	Timing	Responsible Party
	experienced structural engineer due to the proximity to existing buildings that must be protected from potential settlement and lateral movements.			
GEO-4a	Prior to approval of the first drilling permit, the Applicant shall have submitted and the City of Hermosa Beach and the California Coastal Commission shall have approved a Subsidence Monitoring and Avoidance Program, for both onshore and offshore areas. The onshore monitoring plan shall be completed throughout the life of this Project, in accordance with Appendix A, Subsidence Monitoring Program, of the *Subsidence and Induced Seismicity Technical Report, E&B Oil Development Project* (Geosyntec Consultants 2012), included as Appendix F of this EIR. The offshore monitoring plan shall be completed throughout the life of this project in accordance with the *Offshore Subsidence Monitoring Program and Possible Mitigation Measures, Hermosa Beach, California* (Coastal Environments 1998), included as Appendix F of this EIR. The latter shall be updated, as applicable, to reflect advances in science since 1998. In addition, Section 7.6, Mitigation of Onshore Subsidence, of the latter report, shall not be applied to this mitigation measure, as the onshore monitoring program would	Monitor subsidence with GPS technology.	Annually	Hermosa Beach Public Works Department

Proposed Oil Project and Pipeline Mitigation Measures				
Mitigation Measure	Requirements	Compliance Verification		
		Method	Timing	Responsible Party
	be completed in accordance with the Geosyntec Consultants (2012) report.			
GEO-4b	The Subsidence Monitoring Program shall include: Ground elevation survey methodologies with high vertical resolution, including onshore surface elevations and offshore bathymetric elevations; Prior to Phase II drilling, establishment of a network of onshore and offshore survey or subsidence monitoring locations, including continuous GPS stations, GPS benchmarks, and tautly anchored offshore monitoring points, positioned within the City, outside the City, and in offshore areas, that are sufficiently spaced to draw conclusions about subsidence within the zone of influence of the Project; Because subsidence can occur for a variety of reasons, establishment of control points outside the zone of influence to allow differentiation of possible subsidence effects related to other activities; Use of InSAR imagery technology to evaluate regional subsidence patterns both within and beyond the proposed oil field; Sufficient monitoring frequency to establish trends in subsidence in order to distinguish background ground movement from any subsidence caused by proposed oil field operations;	Monitor subsidence with GPS technology.	Annually	Hermosa Beach Public Works Department

Proposed Oil Project and Pipeline Mitigation Measures				
Mitigation Measure	Requirements	Compliance Verification		
		Method	Timing	Responsible Party
	Reservoir monitoring, including documentation of produced fluid volume (oil, gas and water) and reservoir pressures at similar frequency to ground elevation measurements; Reporting requirements; and Action levels, as specified in the onshore and offshore subsidence monitoring reports. Surveying for both vertical and horizontal ground movement shall be completed along the perimeter and throughout the interior of the oil field, including both onshore and offshore areas, utilizing Global Positioning System technology in combination with a network of ground stations. The onshore continuous monitoring GPS stations shall include: Hermosa Beach Pier. The pier will serve as the furthest offshore point in the onshore monitoring program. Longfellow Outfall. This Outfall is larger and more structurally stable than some of the other outfalls along the City's coast. King Harbor Jetty. This location was selected to achieve a distribution of continuous monitoring points along the coast of Hermosa Beach. This will help provide a limited regional picture of the subsidence between survey events.			
GEO-4c	An onshore and offshore baseline subsidence report shall be completed and made available to the City	Coordinate with Hermosa Beach	At least two months prior to Phase 2	Hermosa Beach Public Works Department

Proposed Oil Project and Pipeline Mitigation Measures				
Mitigation Measure	Requirements	Compliance Verification		
		Method	Timing	Responsible Party
	of Hermosa Beach and the California Coastal Commission at least two months and no more than six months prior to planned commencement of Phase II drilling operations. Subsidence monitoring reports shall be completed annually and the results shall be forwarded to the California Coastal Commission and the City of Hermosa Beach for review, no more than one month following the end of each annual monitoring cycle. In addition, results shall be forwarded to the adjoining City of Redondo Beach and City of Manhattan Beach.	Public Works Department	drilling operations	
GEO-4d	In the event that the Global Position System monitoring indicates that significant subsidence, as defined by the onshore and offshore subsidence monitoring reports described in GEO-4a, is occurring in and/or around the Proposed Project area, wastewater or water reinjection operations shall be increased to alleviate such subsidence. The Applicant shall coordinate with the California Division of Oil, Gas and Geothermal Resources, which will approve increased levels of wastewater or water reinjection operations in accordance with the approved Subsidence Monitoring Program. The Applicant will also coordinate with the City of Hermosa Beach, Public Works Department, to verify that subsidence has been mitigated sufficiently.	Coordinate with California Division of Oil and Gas and Geothermal Resources (DOGGR)	Following monitoring results indicating subsidence	California Division of Oil and Gas and Geothermal Resources (DOGGR) and Hermosa Beach Public Works Department

Proposed Oil Project and Pipeline Mitigation Measures				
Mitigation Measure	Requirements	Compliance Verification		
		Method	Timing	Responsible Party
GEO-4e	In the unlikely event that subsidence related mitigation induces seismicity, corrective actions related to subsidence shall proceed until baseline surface elevations have been achieved, as subsidence related damage would likely be more pronounced in comparison to damage associated with Project related micro-seismicity. Upon reestablishment of baseline elevations, drilling operations shall cease until a balance between subsidence avoidance and induced seismicity avoidance can be established, as agreed upon by the California Division of Oil, Gas and Geothermal Resources, the California Coastal Commission, and the City of Hermosa Beach.	Coordinate with California Division of Oil and Gas and Geotherma l Resources (DOGGR)	Following monitoring results indicating subsidence	California Division of Oil and Gas and Geothermal Resources (DOGGR) and Hermosa Beach Public Works Department
GEO-6	A Registered Civil Engineer shall analyze surficial and near-surface soils at the Project Site subsequent to grading and prior to on-site construction, to determine whether expansive soils are present. Similarly, soils at the Proposed City Maintenance Yard Project Site and along the proposed pipeline route shall be analyzed for soil expansion potential. In the event that clay-rich, expansive soils are present, foundations shall be designed to accommodate expansive soils and pipelines shall be placed within a blanket of non-expansive soils to prevent	Soil auger and analytical laboratory	Prior to final design	City of Hermosa Beach

Proposed Oil Project and Pipeline Mitigation Measures				
Mitigation Measure	Requirements	Compliance Verification		
		Method	Timing	Responsible Party
	structural damage and/or failure. Foundation and pipeline design shall be reviewed and approved by a Registered Civil Engineer.			
GEO-7a	Proposed Oil Project design must conform to the recommendations of HDR Schiff (2012), included within Appendix C in NMG Geotechnical (2012), or as per the City Engineer, and should occur prior to completion of the final Project design.	Design for protection against corrosion	Prior to final design	City of Hermosa Beach
GEO-7b	All buried metal pipelines shall be coated and placed under impressed cathodic protection. To monitor for internal corrosion, corrosion coupons or equivalent measures can be utilized.	Under impressed cathodic protection	Prior to final design	City of Hermosa Beach
GEO-7c	External pipe inspections shall be conducted for the exposed pipeline sections to ensure atmospheric coatings are in good conditions. All external inspections shall be documented and reviewed by the operations management and repairs documented, when necessary.	Visual inspections	Monthly	City of Hermosa Beach
GEO-7d	In accordance with California Division of Oil, Gas, and Geothermal Resources pipeline regulations (Public Resources Code Sections 3013 and 3782), a pipeline management plan shall be implemented for the Project Site. Similarly, in accordance with United States Department of Transportation, Pipeline and Hazardous Materials Safety Administration regulations, a pipeline management plan shall be	Prepare under guidance of California Department of Conservation Division of Oil, Gas, and Geothermal Resources and United States Department of	Prior to final design	California Division of Oil and Gas and Geothermal Resources (DOGGR), United States Department of Transporta-tion, Pipeline and Hazardous Materials Safety Administra-

Proposed Oil Project and Pipeline Mitigation Measures				
Mitigation Measure	Requirements	Compliance Verification		
		Method	Timing	Responsible Party
	implemented for proposed pipelines located beyond the perimeter of the Project Site. These plans shall include, but not be limited to mechanical testing, including ultrasonic and hydrostatic testing.	Transportation, Pipeline and Hazardous Materials Safety Administration		tion, City of Hermosa Beach and City of Redondo Beach
GEO-7e	All concrete in contact with the high sulfate or corrosive soils shall be Type V concrete in accordance with the 2010 California Building Code.	Pour proper concrete adjacent to corrosive soils	During construction	City of Hermosa Beach