4.7 Geological and Soil Resources

This section addresses all geologic and soil resources impacts that may be associated with the Project Site, including geologic structure, geomorphology, tectonic setting, existing mineral and ore deposits, and physical geologic properties.

Under the proposed Project, the Applicant would develop a portion of the Project Site for commercial and industrial land use and would dedicate the remainder as open space. The Project would be divided into phases. The initial phase would remediate and rehabilitate the Project Site through demolition, soil re-grading, and mitigation of existing petroleum-related soil and groundwater contamination. The next phase would develop the Project Site for commercial use with a business park, and for industrial use with services and manufacturing. The development would be completed either as part of an annexation to the City of San Luis Obispo (City) or as part of the County of San Luis Obispo (County). Major development would be concentrated in the northeastern portion of the site, near Reservoir 4 (refer to Section 2, Project Description, Figure 2-17), and the northwestern portion of the site near existing buildings from the previous tank farm facility (known as the Northwest Operations Area).

This section addresses and outlines the geologic setting and geologic impacts relating to the Project Site and the associated remediation and development. Utilizing thresholds of significance, this section assesses the major hazards associated with the existing geological resources for the Project Site and provides mitigation measures to avoid or lessen any significant geological hazards to the Project Site and proposed development.

4.7.1 Environmental Setting

4.7.1.1 Site Description

The Project Site is a large, relatively flat 332-acre property that was previously developed for petroleum storage. While the Project Site is generally flat, the northeast portion has some moderately descending slopes. The majority of the Project Site is currently undeveloped and contains native grasslands and both natural wetlands and wetlands from water accumulation in the former oil storage depressions.

4.7.1.2 Regional Geologic Setting

The Project Site is within the San Luis Obispo Valley, which lies on the westerly side of the San Lucia Mountains. The San Lucia Mountains are part of the Coast Range physiographic province of California. The Coast Range, extending parallel to the California and Oregon coastlines, is a series of northwest-southeast trending mountain ranges separated by valleys and basins as a result of regional faulting.

The Project Site is in the southern portion of the Coast Range Province, appropriately named the South Coast Range. The Coast Range Province is north of the Transverse Range Province, west of the Great Valley Province, and south of the Klamath Mountains Province. The South Coast Range includes a subduction zone complex (Franciscan Assemblage), forearc basin sediments (the Great Valley Sequence), and a magmatic arc (plutonic and metamorphic rocks of the Salinian Block) (See Figure 4.7-1). The age of the rocks varies from Mid to Late Mesozoic (160 million years old) to Holocene alluvium (11,000 years old to present day), with a very complex geologic structure due to the abundant faulting and folding from the San Andreas Fault system.

4.7.1.3 Local Geologic Setting

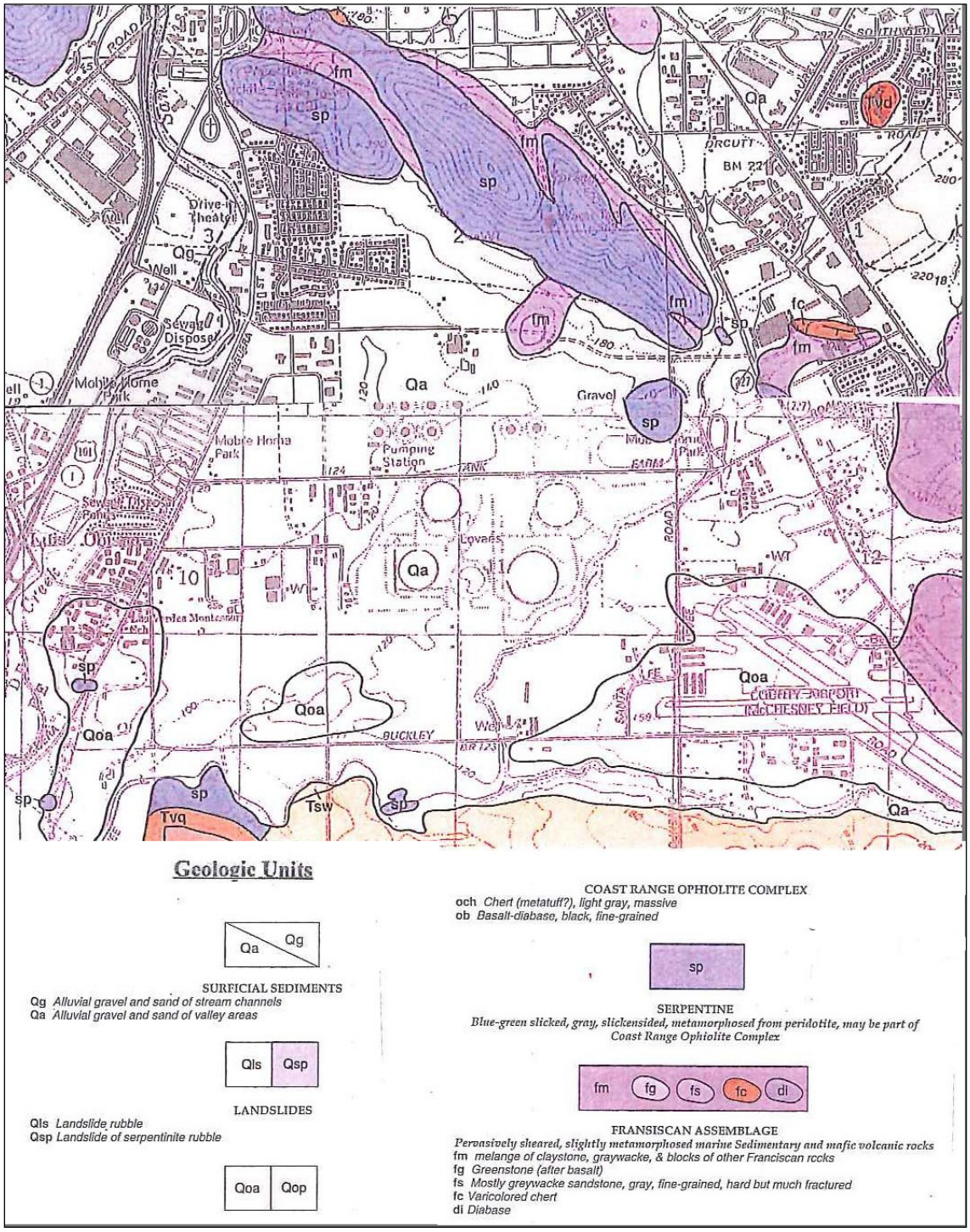
The Project Site consists of alluvial deposits of varying thickness overlying a mixture of sedimentary and meta-volcanic deposits from the Franciscan Formation. Serpentinite is a common metamorphic rock in the Franciscan Formation. The alluvium unit ranges in thickness from zero feet in the northwest corner of the property to 180 feet thick in the southwest corner of the property. The alluvial deposits consist of unconsolidated to consolidated conglomerate, gravel, sand, silt, and clay. Locally the Serpentine bedrock is highly fractured and weathered.

During the subsurface exploration program, bedrock was only encountered in the northeastern portion of the site, proximal to Reservoir Number 4 (refer to Figure 4.7-2) (Padre 2007). In this area fill depths are on the order of 6 feet. Underlying alluvium depths are on the order of 11 to 29 feet deep. Weathered greywacke sandstone of the Franciscan Assemblage overlies the alluvium in the northeastern portion of the Project Site. In the northeastern corner of the Project Site, where fill and alluvium are absent, there are moderately steep descending slopes of Franciscan Assemblage outcrops. No bedrock was encountered in any other portion of the site as the drill holes and test pits for the northwestern and southern portions of the site only found fill and alluvium. Alluvium depths were observed to be greater than 10 feet in the southern portion of the site within the Reservoir Number 3 (refer to Figure 4.7-2) area and greater than 36 feet in the northwestern portion where existing buildings and structures from the original tank farm are located.

As part of the Geotechnical Feasibility study, exploratory borings and excavated test pits were drilled (Padre 2007). A total of nine hollow stem borings were drilled, and ten test pits were excavated as part of the consultant geotechnical study. The subsurface investigation was focused within the northeastern, northwestern, and southern portion of the Project Site. Subsurface data was limited for the open space along the central northern portion of the site. The site investigations indicated that the subject site is underlain by artificial fill, alluvium, and Franciscan bedrock. During the investigation, petroleum hydrocarbons were observed on the surface and within subsurface earth materials at the Project Site.

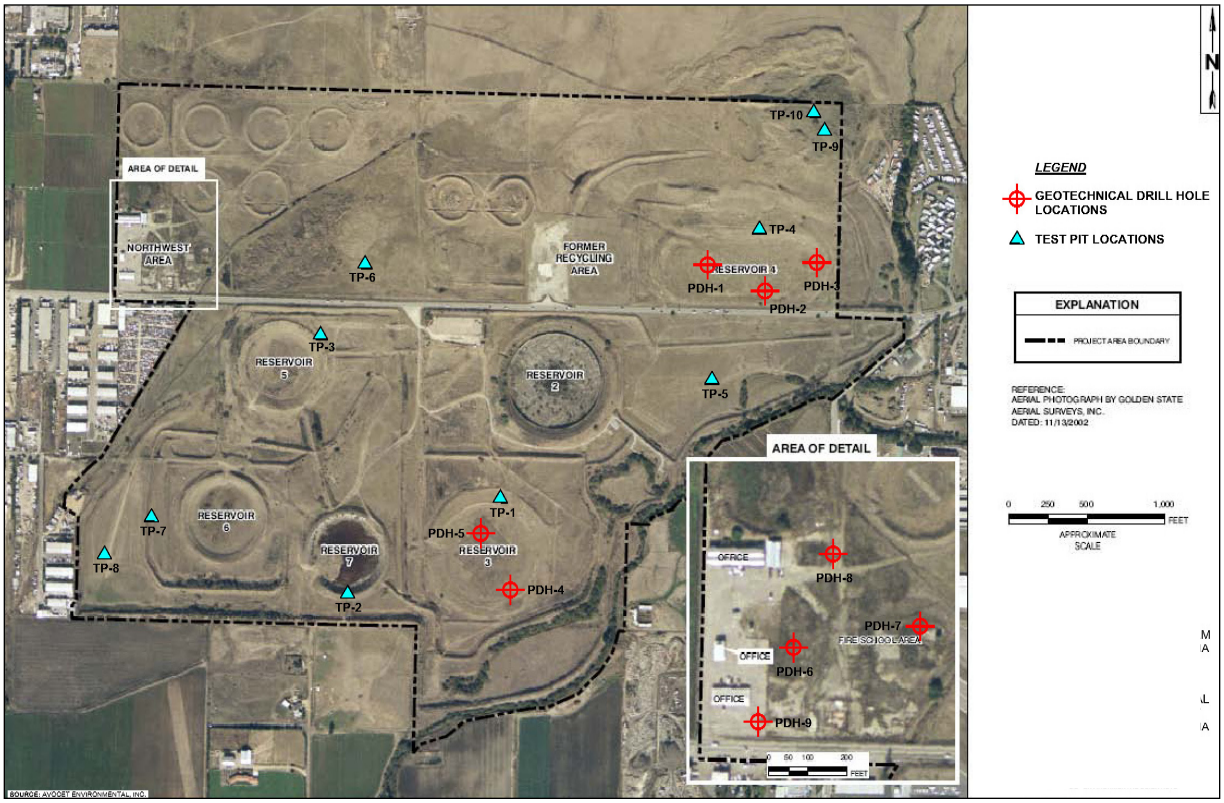
According to the Geotechnical Feasibility study, free phase heavy petroleum hydrocarbons were observed in all of the following areas (see Figure 4.7-2): Reservoir Number 3 on the ground surface and subsurface to a depth approximately 10 feet; Reservoir Number 4 at the base of the artificial fill as well as within the underlying alluvium and fractured Franciscan Assemblage rock to total depths of approximately 30 feet.

Figure 4.7-1 Regional Geologic Map



Source: Dibblee 2004

Figure 4.7-2 Boring Location Map



Source: Padre Associates, Inc. 2007

Free phase light end hydrocarbons were observed at the Northwest Operations Area in drill holes PDH-7, PDH-8, and PDH-9 to total depths of 6 to 20 feet.

Artificial Fill: The artificial fill consists of dark grey brown to dark brown to black sandy to silty clay. The fill material is stiff to very stiff, damp, and contains some iron oxide staining and mottling. Based on the subsurface investigation, fill accumulations are concentrated in the areas of the remnant man-made petroleum storage facilities. In these reservoirs, fill depths are on the order of 5 to 7 feet deep (Padre 2007).

Alluvium: The alluvium consists of medium dense to dense, interlayered, clay, silt, sand and gravel of varying thicknesses. The alluvium deposits vary in thickness from zero feet in the northeast corner of the Project Site to 180 feet in the southwest corner (Avocet 2007). Bedrock was only encountered in the northeastern portion of the site, where alluvium thicknesses were on the order of 15 to 25 feet (Padre 2007). The very northeast corner of the site consists of slopes with outcropping Franciscan Formation. The alluvium overlies a mélange of sedimentary and meta-volcanic rock derived from the Fransican Formation.

Bedrock: The bedrock across the site consists of Jurassic/Cretaceous aged deposits of the Franciscan Formation. The Franciscan Assemblage consists of metamorphosed marine sedimentary and mafic volcanic rock. The subsurface site investigation observed greenish grey to olive brown weathered mélange and greywacke. Secondary mineralization of serpentenite was

also observed. Fractured and weathered serpentinite is common locally to the Franciscan Formation. Based on the field observations identified in the Geotechnical Feasibility Study, the exposed Franciscan Assemblage in the northeast corner consisted of greenish gray to olive brown, hard, vitreous to greasy, shear and fractured, serpentenized mélange with secondary mineralization of quartz and gypsum (Padre 2007).

4.7.1.4 Geologic Hazards

Seismic Hazards

The Project Site is located within the seismically active area of Southern California, but outside an Earthquake Study Zone defined by the Alquist-Priolo Earthquake Hazards Act of 1972. In addition, the site is located outside the active portion of the Los Osos fault delineated as an AP Special Studies Zone by CDMG. The type and magnitude of the seismic hazard affecting the site are dependent on the distance and causative faults and the intensity and magnitude of the seismic event.

Seismic hazards can be divided into two general categories: hazards due to ground rupture and hazards associated with ground shaking

Potential for Ground Rupture

In general terms, an earthquake is caused when strain energy in rocks is suddenly released by movement along a plane of weakness. In some cases, fault movement propagates upward through the subsurface materials and causes displacement at the ground surface as a result of differential movement. Surface rupture usually occurs along traces of known or potentially active faults, although many historic events have occurred on faults not previously known to be active. Seismicity within this region is a result of the dominantly reverse-slip regime of the region.

The California Geologic Survey (CGS) establishes criteria for faults as active, potentially active or inactive. Active faults are those that show evidence of surface displacement within the last 11,000 years (Holocene age). Potentially active faults are those that demonstrate displacement within the past 1.6 million years (Quaternary age). Faults showing no evidence of displacement within the last 1.6 million years may be considered inactive for most structures, except for critical or certain life structures. In 1972 the Alquist-Priolo Special Studies Zone Act (now known as the Alquist-Priolo Earthquake Fault Zone Act, 1994, or APEHA) was passed into law which requires studies within 500 feet of active or potentially active faults. The APEHA designs “active” and “potentially active” faults utilizing the same age criteria as that used by the CGS. However, the established policy is to zone active faults and only those potentially active faults that have a relatively high potential for ground rupture.

Ground rupture caused by movement along a fault could likely result in catastrophic structural damage to buildings constructed along the fault trace. Consequently, the State of California via the APEHA prohibits the construction of occupied “habitable” structures within the designated fault zone and must demonstrate that the structure does not encroach on a 50-foot setback from the fault trace. Per the Alquist-Priolo (AP) legislation, no structure for human occupancy is permitted on the trace of an active fault. The term “structure for human occupancy” is defined as any structure used or intended for supporting or sheltering any use or occupancy, which is expected to have a human occupancy rate of more than 2,000 person-hours per year. Unless

proven otherwise, an area within 50 feet of an active fault is presumed to be underlain by active branches of the fault. Local government agencies may identify additional faults, in addition to those faults mandated by the state, for which minimum construction setback requirements must be maintained.

Several active and potentially active faults are located in the region. Table 4.7-1 illustrates the 10 nearest faults with distance in miles between the nearest point on the fault and the Project Site, the maximum magnitude, estimated peak ground accelerations and the slip rate.

Table 4.7-1 Partial List of Nearby Regional Faults

Fault Name	Source Type	Distance Between Site and Surface Projection of Earthquake Rupture (Miles)	Estimated Maximum Peak Ground Acceleration (g)	Estimated Maximum Earthquake (M_W)	Slip Rate (mm/yr)	Fault Type
Los Osos	B	1.3	0.983	6.8	0.50±0.40	DS
San Luis Range (S. Margin)	B	4.4	0.715	7.0	0.20±0.10	DS
Rinconada	B	9.3	0.421	7.3	1.00±1	SS
Hosgri	B	14.0	0.320	7.3	2.50±1	SS
Casmalia	B	21.7	0.188	6.5	0.25±0.20	DS
Lions Head	B	25.7	0.163	6.6	0.02±0.02	DS
San Juan	B	29.2	0.135	7.0	1.00±1	SS
San Andreas - Cholame	A	37.8	0.094	6.9	34±0.30	SS
San Andreas – 1857 Rupture	A	38.7	0.170	7.8	34±5	SS
Los Alamos – W. Baseline	B	40.3	0.110	6.8	0.70±0.70	SS

Source: EQFAULT, Ver. 3.0

In addition to the faults listed in Table 4.7-1, other large faults in the Southern California area have the potential to impact the Project Site. It should be understood that the exact prediction of future fault rupture is impossible and the lists are based on previously encountered faults or ground rupture. For instance, the 1994 Northridge Earthquake did not cause fault ground rupture but was a significant regional event. The Project Site is not located within an AP Earthquake Fault Zone.

Potential for Ground Shaking

The energy released during an earthquake propagates from its rupture surface in the form of 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/bedrock conditions, and the earthquake magnitude. Intensity is usually greater in areas underlain by unconsolidated material 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 is dependent on several factors including the type of fault, rock-, and stored energy. Moderate to severe ground shaking would be experienced in the area of the Project Site if a large magnitude earthquake occurs on one of the nearby principal late Quaternary faults and may cause structural damage to the on-site improvements.

Table 4.7-1 also presents peak ground accelerations anticipated for the ten nearest faults. Ground shaking is primarily a function of the distance between a particular area and the seismic source, the type of materials underlying the site and the motion of fault displacement. In addition, the Northridge (1994) earthquake showed how peculiarities in basin effects could play a significant role in ground accelerations at particular areas. For instance, ground accelerations exceeding 1.0 g were recorded at areas far from the epicenter of the Northridge earthquake.

Seismic analysis for the purposes of this study is based on a "Design Basis Earthquake Ground Motion" which would have a 10 percent probability of exceedance in a particular 50-year period, corresponding to a return interval of 475 years (CDMG 1996).

Detailed discussions of Probabilistic Seismic Hazard Analysis (PSHA) and Deterministic Seismic Hazard Analysis (DSHA) are presented in CDMG Reports (CDMG 1996). Extensive references of the available literature are presented in these references. The Southern California Earthquake Center indicates that local, possibly unknown or unrecognized surface faults present higher earthquake risks than known, large regional faults for most areas of Southern California that may generate ground accelerations in excess of 1.0 g

The number or frequency of large magnitude earthquakes that may occur during the life of the Project cannot be predicted reliably. However, it is probable that the study area would experience at least one major earthquake during the next 50 years.

The potential hazards or adverse effects of ground shaking would depend on several factors that include the severity of ground shaking; the nature, depth, and extent of the seismic event; the type of structures involved; and the local topography. Based on the observable effects from several events, including the Northridge Earthquake (1994), San Fernando Earthquake (1971), Loma Prieta Earthquake (1989) and the Alaska Earthquake (1964), building foundations may fail resulting in excessive building settlement or collapse; underground tanks or buried utilities may be prone to uplift or failure; and access roadways may become blocked or impassable, preventing emergency vehicles from accessing the sites. In addition, broken utility lines could result in fires, inhibit or contaminate water supplies, and cut off services to the residences and structures.

<u>Vertical Ground Motions:</u> No suitable empirical method has been developed to analyze vertical ground accelerations. Borzorgnia et al. determined that near-field seismic events, ratios could exceed the horizontal motions (1995). Subsequent recent studies determined that at close distances and for large earthquakes, the peak vertical accelerations can be about 1.6 times the peak horizontal acceleration (Borzorgnia et al. 1999).

Secondary Seismic Hazards from Groundshaking. Potential hazards resulting from the secondary effects of groundshaking include: liquefaction, lateral spreading, seismic settlement, and landslide-induced earthquakes.

Liquefaction. Seed (1979) defined liquefaction as a condition where a soil would undergo continued deformation at constant low residual stress or with low residual resistance, due to the buildup and maintenance of high pore water pressures, which reduce the effective confining pressure to a very low value. Pore pressure buildup leading to liquefaction may be due either to static or cyclic stress applications and the possibility of its occurrence would depend on the void ratio or relative density of sand and the confining pressure. It may also be caused by a critical hydraulic gradient during an upward flow of water in a sand deposit. Other factors include but are not limited to:

- 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.

Liquefaction is more likely in poorly-graded, saturated, low-density sands. With increasing overburden, density and increasing clay-content, the likelihood of liquefaction decreases. In regards to clay content, recent studies over the past ten years have demonstrated that clays with certain properties can be prone to liquefaction and thus the "Chinese Method" is not reliable, and therefore, both sand and clay deposits are herein evaluated and screened.

The semi-empirical field-based methods (Idriss & Boulanger 2006), which evolved from the simplified procedure by Seed and Idriss (1983) are by far the most widely used methods in assessing the cyclic liquefaction potential of sand. The simplified procedure has two essential components:

- An analytical framework to organize past case history experiences; and
- A suitable in situ index to represent soil liquefaction characteristics (Idriss & Boulanger 2006). In situ penetration tests have proved to be useful for representing soil liquefaction characteristics because they not only provide an indication of denseness, but also reflect other important characteristics such as fabric, gradation, cementation, age, and stress history (Seed 1983).

The simplified procedure provides a boundary curve that separates cases of observed liquefaction and those with no notable liquefaction in a two-dimensional plot of seismic loading, in terms of Cyclic Stress Ratio (CSR) versus a normalized in situ index test value. The boundary curve also serves as a correlation between the in situ index test value and the Cyclic Resistance Ratio (CRR). The term CRR may be considered as the maximum CSR that a soil can resist before liquefying. Traditionally, the result of the liquefaction potential analysis using the simplified procedure is presented in terms of a factor of safety (F_s) defined as the ratio of CRR over CSR.

No soil liquefaction is predicted if $F_s > 1$. The assessment of liquefaction potential in terms of factor of safety is generally known as the deterministic approach.

Based on the County of San Luis Obispo Safety Element Liquefaction Hazard map, the Project Site lies within an area considered to have high liquefaction hazard potential (SLO 1999). Additionally, field exploration indicated the presence of shallow groundwater and the presence of granular soils, which suggests an increased potential for liquefaction. However, on-site investigation and soil testing did not perform a liquefaction analysis to assess liquefaction.

Lateral Spreading. Lateral spread is the finite, lateral displacement of sloping ground (0.1 to < 6 percent) as a result of pore pressure buildup or liquefaction in a shallow, underlying soil deposit during an earthquake. Lateral spreading, as a result of liquefaction, occurs when a soil mass slides laterally on a liquefied layer, and gravitational and inertial forces cause the layer, and the overlying non-liquefied material, to move in a downslope direction. 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.

Widespread lateral spreading is generally not applicable to fine-grained soils, nor to sandy soils where:

- Standard penetration values [$(N_1)_{60}$] are greater than 15; and
- Where the standard penetration rates are less than 15 and the potentially vulnerable layer is less than 1 meter thick.

Further, the magnitude of ground displacement in a liquefaction failure is influenced by the volumetric response of these sandy soils during liquefaction. A contractive soils response can lead to very dramatic failures while a dilative response tends to limit the magnitude of displacements. Therefore, a low confining pressure can result in a dilative behavior, even for a somewhat loose packing of soil grains.

A potentially significant phenomenon in a lateral spread is the upward flow of pore water within the liquefied soils deposits without a change in the overall volume. In a liquefied state, individual grains tend to sink under the influence of gravity. The net result is for the liquefied soil in a layer to progressively densify near the bottom and loosen/soften near the top. Therefore, there is a tendency for an upward migration of pore water and void space.

Lateral spread may occur over looser, weaker soil near the top of the liquefied deposit. If the liquefied soils is overlain with a relatively impervious layer, upward slowing pore water would be trapped and contribute to the formation of a weaker soil zone in the top portion of the liquefied deposit. Since the movement of water and soil grains takes time, this phenomenon might develop in relatively thin layers, but not throughout the depth of thick liquefied deposits. However, even in thick, uniform soil deposits, the tendency for soil grains to settle would result in formation of a progressively, slightly weaker soil toward the top of the liquefied deposit. However, it is important to note that the general analysis assumes conservatively, undrained conditions (Seed 1983). However, the migrations of pore water in a partially drained condition

have a significant impact on the magnitude of displacements in the lateral spread. Stark (1994) found that partial drainage of excess pore pressures can produce an increase in shear resistance as sliding progresses. Rapid drainage of excess pore pressures from the liquefied soil zone may be sufficient to stabilize the slide before large deformations occur.

Numerous researchers have consistently observed a correlation between horizontal surface displacements in a lateral spread and the thickness of the underlying liquefied soil deposit (Yasuda et al. 1992a; Tokida et al. 1993; Hamada et al. 1986; Bartlett and Youd 1992a, 1992b, 1995; O'Rourke and Pease 1997). The influences of the liquefied thickness are as follows:

- Since shear deformations occur across the full depth of the liquefied deposits, the net surface displacement would increase the greater liquefied thickness. If the shear strain was constant with depth, the lateral displacement profile would be linear and, for a given shear strain, the net surface displacement would increase with liquefied thickness.
- As the thickness of the liquefied soil deposit increases, a greater upward migration of pore water might occur. Then, the significance of the resulting soft zone near the top of the deposits would increase with increasing liquefied thickness.
- The drainage path for excess pore pressures increases with the thickness of the liquefied soil. As a result, portions of a thicker liquefied deposit would remain liquefied for a longer period of time and cause greater surface displacements.

Horizontal displacements in a lateral spread can range up to several meters with smaller associated settlements. Characteristic patterns or ground deformation include ground fissures or tension cracks at the head of the slide. Subsidence typically occurs at the head of a lateral spread with heaving at the toe. Sand boils, a common indication of soil liquefaction, are frequently observed in the lower portions of a lateral spread. Lateral spread is defined here to include only lateral sliding of gently sloping ground due to soil liquefaction at relatively shallow depths and does not refer to the large horizontal slows associated with deep-seated liquefaction failures. This definition of lateral spread also specifically excludes two types of liquefaction-induced ground failure that can produce similar patterns of surface movements. These types of slumping or embankments and tilting of retaining walls have a genetic failure mechanism involving rotational slide or slumping (Varnes 1978).

Seismic Settlement. Seismic settlement occurs when cohesionless materials (sands) densify as a result of ground shaking. Settlement of medium-dense sands could result from a strong earthquake even if groundwater did not rise and groundshaking did not induce liquefaction.

The analysis divides the soil deposit into very thin layers and calculates the settlement for each layer. The calculations are divided into two parts, dry soil settlement and saturated soil settlement. The soil above the groundwater table is dry soil and soil below the groundwater table is saturated soil. The total settlement at a certain depth is the sum of the settlements of the saturated and dry soil. The low to moderate in-situ densities in the sandy soils would provide an initial indication that the portion of the site underlain by alluvium may be prone to seismic settlement.

Ground Lurching. Ground lurching occurs as a result of earthquake wave front striking stream banks, artificial embankments, bluffs and other geomorphic features at right angles resulting in

yielding of the materials in the unsupported direction. The initial affect is to produce a series of more or less parallel cracks separating the ground into blocks. With increasing intensity, lurch cracking develops ground fractures, cracks, and fissures, as well as, settlement, compaction, and sliding.

Earthquake-Induced Landslides. Hazards to the improvements of the Project Site include earthquake-induced landsliding, and rock topple. In general, the state of California has been identified to be in an area prone to seismic hazard in mountain areas.

Rock topple can occur when loose blocks of exposed bedrock are induced to move and travel downslope when set free by earthquake forces, undermining of supporting earth from erosion or animal disturbance. Generally, slopes with a gradient of greater than 3:1 (horizontal to vertical) are more susceptible to rock topple and rolling. Wilson and Keefer (1985) have reported that a ground acceleration of at least 0.10 g in steep terrain is necessary to induce earthquake-related rock falls, although exceeding this value does not guarantee that rock falls would occur. Only the northeastern corner of the site maintains any major descending slopes.

4.7.1.5 Geotechnical Hazards

Expansive Soils

Expansive soils swell or heave with increases in moisture content and shrink with decreases in moisture content. Montmorillontic clays are most susceptible to expansion. Foundations for structures constructed on expansive soils require special design considerations (CBC 2010). In general on-site soil deposits consist of silty and sandy clay.

Hydroconsolidation

Hydroconsolidation occurs when soil layers collapse (settle) when water is added under loads. Natural deposits susceptible to hydroconsolidation are typically aeolian, alluvial, or colluvial materials, with high apparent strength when dry. The dry strength of the materials may be attributed to the clay and silt constituents in the soil and the presence of cementing agents (i.e., salts). Capillary tension may tend to act to bond soil grains. Once these soils are subjected to excessive moisture and foundation loads, the constituency, including soluble salts or bonding agents, is weakened or dissolved, capillary tensions are reduced and collapse occurs, resulting in settlement.

Subsidence

Subsidence is the sinking of the ground surface caused by the compression of soil layers. The causes range from groundwater, oil and gas withdrawal, oxidation of organics, or the placement of additional fill over compressible layers.

Subsidence involves deep seated settlement caused by the compression of soil layers due to the withdrawal of fluid (e.g., oil, natural gas, and water.). The settlement can be exacerbated by increased loading, such as from the construction of on-site buildings or the placement of additional fill over compressible layers. Settlement can also result solely from human activities including improperly placed artificial fill, and structures built on soils or bedrock materials with differential settlement rates. This settlement can be mitigated prior to development through the removal and recompaction of loose soils

Existing Fill

Uncontrolled artificial fills are considered to be unsuitable for support of structures and other improvements. This is typically due to any number of reasons, which include but are not limited to: high voids which may collapse or consolidate upon loading; high organics which decay leaving additional voids or high moisture soils which compress; inconsistent mixtures of fills which may perform differently, changes in consistency over short spans which leads to differential settlement; uneven expansion potential which may result in differential movement of foundation elements; lack of proper benching which may lead to fill creep; and numerous other conditions. Older controlled fills tend to be prone to hydroconsolidation, excessive settlements or creep. This is a result in the change of compaction methods and efforts (i.e., three layer method versus five layer method for maximum density determinations), experience in keyways, subdrains, benching and many other factors. In addition, older fills may tend to lose integrity due to several factors including bioturbation, organic material decay, shrink swell cycles, and other mechanisms that adversely affect the fills. Therefore, the custom and practice in the industry typically dictates that these types of fills not be relied on for structural support of foundations or slabs. Typical mitigations range from total removal to specially designed structural elements or in-situ treatments.

Dam Inundation

The Project Site is located in the vicinity of several major reservoirs including Lake Santa Margarita (Salinas Dam) and Lopez Lake (Lopez Canyon and Lopez Terminal Dams). Though, based on the County of San Luis Obispo Dam Inundation Map (SLO 1999), the projected extents of flood inundation limits are outside the Project Site location.

Naturally Occurring Asbestos

Asbestos is a term used for several types of naturally occurring silicate minerals that occur as asbestiform fibers that are a human health hazard when airborne. Asbestos is a known carcinogen and inhalation may result in the development of lung cancer or mesothelioma. Chrysotile and amphibole asbestos are common to geologic settings in California. Serpentinite may contain chrysotile asbestos, especially near fault zones. Ultramafic rock, a rock closely related to serpentinite, may also contain asbestos minerals. Asbestos was identified as a toxic air contaminant by the California Air Resources Board (CARB) in 1986 (see Section 4.1, Air Quality).

Serpentinite and ultramafic rocks release asbestos when crushed or broken. Asbestos can be released to the atmosphere due to construction and grading projects, quarry activity, traffic on unpaved roads, etc. Natural weathering and erosion processes can also act on asbestos-bearing rock and make it easier for asbestos fibers to become airborne if such rock is disturbed.

Compressible Soils

Compressible soils consist of low density clays and silts that are prone to high strain rates resulting in consolidation of the layers with reduced groundwater levels or increased fill or foundation loading. Consolidation is a process by which soils decrease in volume. It occurs when stress is applied to a soil that causes the soil particles to pack together more tightly, therefore reducing its bulk volume. When this occurs in a soil that is saturated with water, water (and air) would be squeezed out of the soil. The magnitude of consolidation can be predicted by many different methods. In the Classical Method, developed by Karl von Terzaghi, soils are tested with

an oedometer test to determine their compression index. This can be used to predict the amount of consolidation. When stress is removed from a consolidated soil, the soil would rebound, regaining some of the volume it had lost in the consolidation process. If the stress is reapplied, the soil would consolidate again along a recompression curve, defined by the recompression index. The soil which had its load removed is considered to be *overconsolidated*. This is the case for soils which have previously had thicker sediment overburdern or more commonly been subjected to expansion pressures. The highest stress that it has been subjected to is termed the *preconsolidation stress*. The *over consolidation ratio* (OCR) is defined as the highest stress experienced divided by the current stress. A soil which is currently experiencing its highest stress is said to be *normally consolidated* and to have an OCR of one. A soil could be considered *underconsolidated* immediately after a new load is applied, but before the excess pore water pressure has had time to dissipate.

In addition to estimating the magnitude or primary and secondary consolidation is the time rate for consolidation to occur. Time rates can range from short temporal periods (almost instantaneous) to years. This is especially true in saturated clays because their hydraulic conductivity is extremely low, and this causes the water to take an exceptionally long time to drain out of the soil. While drainage is occurring, the pore water pressure is greater than normal because it is carrying part of the applied stress (as opposed to the soil particles).

Slope Stability and Landslides

Landslides are downslope motions of conglomerations of earth materials, bedrock, or combinations of both. Landslides are a more defined unit and are similar to slumps, but are on a larger scale. They can move in a translational movement or rotational settlement or motion. It occurs because of the loss of ability of earth materials to maintain their integrity at a specific gradient and settle or into lesser gradient or position of greater equilibrium. The internal strength of the material is lost and the material settles into a form where the mass is centralized on the downhill side of motion. The material is a cohesively connected unit that settles or moves as a unit. Landslides are usually associated with water increasing the unit weight and decreasing the internal strength of the materials. The chance of a landslide occurring are increased by increases in slope gradient, looseness of materials, unfavorable bedding (out of slope), clay content of the bedrock, underground springs, unfavorable slope orientation with existing fault boundaries, human disturbance of the landslide area or its boundaries, increases in groundwater, earthquake forces helping to mobilize the mass, looseness of materials insitu, increases in water content and disturbance of the lateral confining forces and/ or the toe of a slope.

Slope Deformation

A cursory evaluation of seismic displacement has been provided to give an order of magnitude estimate to the amount of displacement that could be expected in response to a range of median peak horizontal ground accelerations. Newmark's method treats a landslide or sliding block as a rigid-plastic body (i.e., the mass does not deform internally), experiences no permanent displacement at accelerations below the critical or yield level, and deforms plastically along a discrete basal shear surface when the critical acceleration is exceeded. Other assumptions in the analysis include:

- The static and dynamic shearing resistance of the soil is taken to be the same;
- The effects of dynamic pore pressure are neglected;

- The critical acceleration is not strain dependent and thus remains constant throughout the analysis;
- The upslope resistance to sliding is taken to be infinitely large such that displacement is prohibited.

The Newmark's sliding block analysis for estimating seismic displacements requires an initial estimate of the yield acceleration for a selected cross section. The yield acceleration is the horizontal seismic force required to produce a safety factor of 1.0.

4.7.2 Regulatory Setting

4.7.2.1 Federal Regulations

Federal Soil Conservation Law (Soil Conservation and Domestic Allotment Act of 1936) [16 UCS 590a]

This policy of Congress is to provide permanently for the control and prevention of soil erosion and in turn preserving natural resources, control floods, prevent impairment of reservoirs, maintain navigability of rivers and harbors, protect public health and public lands, and relieve unemployment. The purpose of this law is to preserve and improve soil fertility, promote the economic use and conservation of land, diminish the exploitation, and wasteful and unscientific use of national soil resources, protect rivers and harbors against soil erosion, and prevent and abate agricultural related pollution.

Clean Water Act Section 402 (National Pollutant Discharge Elimination System Program)

This act requires that construction activities comply with the USEPA's National Pollutant Discharge Elimination System (NPDES) Program. The NPDES program for the Project Site is enforced by the State Water Resources Control Board (SWRCB) through the Central Coast Regional Water Quality Control Board (RWQCB) in San Luis Obispo County. Under the program, a permit must be obtained by complying with and implementing Best Management Practices (BMPs) for erosion control and stormwater management. The General Construction Activities Permit is the basic regulatory instrument of the Clean Water Act.

4.7.2.2 State Policies and Regulations

Alquist Priolo Earthquake Fault Zoning Act (1972)

This act provides for the adoption of zoning laws and regulations for cities and counties to implement in order to prohibit the location of developments and structures for human occupancy across the trace of an active fault. In turn, the state releases a series of maps delineating these zones based on geologic studies and research on fault zones throughout California.

California Building Code (2010)

The California Building Code (CBC) establishes the minimum standards for building and construction design. The CBC is derived from the Uniform Building Code (UBC) but due to the geologic conditions unique to California, the CBC was created as a modified version to account for these conditions such as seismic considerations. The CBC encompasses all phases of

construction including specifications and regulations on design, grading and drainage, and construction safety.

4.7.2.3 Local Policies and Regulations

City of San Luis Obispo General Plan Safety Element (2000; revised 2012)
According to California Government Code Section 65302(g), the adoption of a Safety Element is required in all city and county general plans in order to protect the communities from any unreasonable risks associated with the effects of seismic, geologic, flooding or wild fires hazards. In compliance with section 65302(g), the City of San Luis Obispo has adopted Chapter 5 (Safety) of its 2006 General Plan. The Safety Element focuses on achieving acceptable levels of flood, fire, seismic, geologic, and other risks through decisions on land use and the form of development through planning as well as standards for population density and building intensity. The following City policies are applicable to earthquake and geologic safety considerations.

Policy S 5.5: Avoiding Faults
Development shall not be located atop known faults. Applications for the following types of discretionary approvals within 100 meters (330 feet) of any fault that is previously known or discovered during site evaluation shall be subject to review and recommendation by a state-registered engineering geologist: change to more intensive land-use; subdivision into five or more parcels; development of multifamily, commercial, industrial, or institutional buildings.

Policy S 5.6: Avoiding Slope Instability
Development shall not be located on or immediately below unstable slopes, or contribute to slope instability. Any development proposed in an area or moderate or high landslide potential shall be subject to review and recommendation by a state-registered engineering geologist.

Policy S 5.7: Avoiding Liquefaction Hazards
Development may be located in areas of high liquefaction potential only if a site-specific investigation by a qualified professional determines that the proposed development would not be at risk of damage from liquefaction. The Chief Building Official may waive this requirement upon determining that previous studies in the immediate area provide sufficient information.

Policy S 10.0: Avoiding and Mitigating Hazards
Policy S 10.0 states that development, including access and utility systems, shall be directed away from hazardous areas, which should be designated for appropriate open space or park uses. Where development, including access and utility systems, cannot avoid hazardous areas, the development shall adequately mitigate the hazards. Hazard mitigation measures shall not significantly impact the environment, including wildlife habitats and views. Development shall pay an equitable share of the costs to mitigate area wide hazards. Hazard mitigation measures shall not burden taxpayers with high maintenance costs. Development shall not increase hazards for other properties in area.

Policy S 10.18: Safety of Structures and Facilities
Existing and new structures and facilities should reflect adopted safety standards.

County of San Luis Obispo General Plan Safety Element (1999)
The following County policies are applicable to earthquake and geologic safety considerations.

Policy S-17: Fault Information
Policy S-17 states that the County will enforce the General Plan and applicable building codes that require developments, structures, and public facilities to address geologic and seismic hazards through the preparation and approval of geotechnical and geologic reports. Appointment of a County Geologist will improve implementation of the goals, policies, programs and standards of this Element by assuring more objective review and consistent enforcement of hazard mitigation measures county-wide than is possible under the present system of project review.

Policy S-18: Fault Rupture Hazards
Policy S-18 states that the County will locate new development away from active and potentially active faults to reduce damage from fault rupture. Fault studies may need to include mapping and exploration beyond project limits to provide a relatively accurate assessment of a fault's activity. The County will enforce applicable regulations of the Alquist-Priolo Earthquake Fault Zoning Act pertaining to fault zones to avoid development on active faults.

Policy S-19: Reduce Seismic Hazards
Policy S-19 states that the County will enforce applicable building codes relating to the seismic design of structures to reduce the potential for loss of life and reduce the amount of property damage.

Policy S-20: Liquefaction and Seismic Settlement
Policy S-20 states that the County will require design professionals to evaluate the potential for liquefaction or seismic settlement to impact structures in accordance with the currently adopted Uniform Building Code.

Policy S-21: Slope Instability
Policy S-21 states that the County acknowledges that areas of known landslide activity are generally not suitable for residential development. The County will avoid development in areas of known slope instability or high landslide risk when possible, and continue to encourage that developments on sloping ground use design and construction techniques appropriate for those areas.

Policy S-22: Readiness and Response
Policy S-22 states that fire and law enforcement agencies will maintain and improve their ability to respond to seismic emergencies throughout the County.

County of San Luis Obispo General Plan COSE (2010)
The following County policies are applicable to soils considerations.

Policy SL 1.1 Prevent Loss of Topsoil in All Land Uses
Policy SL 1.1 states that the County will minimize the loss of topsoil by encouraging broad-based cooperation between property owners, agricultural operators, agencies, and organizations that will lead to effective soil conservation practices on all lands, including County-controlled properties.

Policy SL 1.2 Promote Soil Conservation Practices in All Land Uses
Policy SL 1.2 states that the County will require erosion and sediment control practices during development or other soil-disturbing activities on steep slopes and ridgelines. These practices should disperse stormwater so that it infiltrates the soil rather than running off, and protect downslope areas from erosion.

Policy SL 1.3 Minimize Erosion Associated with New Development
Policy SL 1.3 states that the County will avoid development, including roads and driveways, on the steeper portions of a site except when necessary to avoid flood hazards, protect prime soils, and protect sensitive biological and other resources. Avoid grading and site disturbance activities on slopes over 30 percent. Minimize site disturbance and protect existing vegetation as much as possible.

Policy SL 2.1 Protect Watersheds and Aquifer Recharge Areas
Policy SL 2.1 states that the County will give high priority to protecting watersheds, aquifer-recharge areas, and natural drainage systems when reviewing applications for discretionary development.

A preliminary analysis of the project's consistency with applicable geological plans and polices is provided in Appendix E.

4.7.3 Significance Criteria

The CEQA Guidelines delineate that a substantial adverse impact would occur if the Project would expose people or structures to major geologic hazards. In turn, this recognizes any and all unstable geologic and geotechnical conditions as a result of both construction as well as hazards associated with earthquakes, ground shaking, ground movement, fault rupture, groundwater, and other 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.

In accordance with Appendix G to the State CEQA Guidelines, a project could have a potentially significant geology and soils impact if it were to cause one or more of the following conditions:

1. Expose people or structures to potential substantial adverse effects, including the risk of loss, injury, or death involving:
    a. Rupture of a known earthquake fault, as delineated on the most recent Alquist Priolo Earthquake Fault Zoning Map or based on other substantial evidence of a known fault;
    b. Strong seismic ground shaking;
    c. Seismic related ground failure, including liquefaction;
    d. Landslides.
2. Result in substantial soil erosion or loss of topsoil;
3. Be located on a geologic unit or soil that is unstable, or that would become unstable as a result of the project, and potentially result in on- or off-site landslide, lateral spreading, subsidence, liquefaction, or collapse;

4. Be located on expansive soil, as defined in California Building Code (2007), creating substantial risks to life or property;
5. Have soils incapable of adequately supporting the use of septic tanks or alternative waste water disposal systems where sewers are not available for the disposal of wastewater;

In addition, the Project would also result in a significant geotechnical impact if it exceeds the following threshold:

- A project would normally have a significant geologic hazard impact if it would cause or accelerate geologic hazards which would result in substantial damage to structures or infrastructure, or expose people to substantial risk of injury.

The proposed Project's impact is considered potentially significant if it would expose people or structures to major geologic hazards. Therefore, impacts are considered significant if the proposed development would be exposed to a high potential for such seismic hazards as ground shaking, liquefaction, and settlement, and soil hazards such as expansive soils, based on regional or site-specific conditions.

4.7.4 Remediation Project Impacts and Mitigation Measures

The natural drainage patterns of the Project Site have been drastically altered due to historical activity, such as construction of containment berms. The East Fork of San Luis Obispo Creek has been channelized by containment berms along the eastern and southern boundaries of the Project Site. However, the historical ox-bow channel and associated floodplain areas are still evident due to remnant mixed willow scrub habitat. In addition, containment berms constructed around the former oil tanks have created ephemeral wet areas and seasonal wet meadow throughout the Project Site that alter flood flow and contribute to groundwater recharge. Portions of the southwestern and southeastern areas of the Project Site are within the 100-year floodplain. The northwest area also lies within the 100-year floodplain.

During peak winter rain events, the remediation component of the Project would add approximately 27,000 gallons per day to the flow in the east fork of San Luis Obispo Creek. The discharge of this continuous flow into the creek may potentially increase flow rates and impact flow velocities, which could be detrimental to downstream properties or habitats. These discharges would occur during the winter months and could potentially exacerbate already heavy flows within the nearby creeks and downstream. These geologic characteristics would impact the Project's remediation and are discussed more fully in Section 4.2, Biological Resources, and Section 4.6, Wastewater.

Further, with respect to remediation and the geologic and geotechnical hazards described above in Sections 4.7.1.4 and 4.7.1.5, (e.g., potential for ground rupture and ground shaking, expansive soils, hydroconsolidation, subsidence, dam inundation, etc.), there are no remediation-based Project-related impacts associated with these issues.

Moreover, as part of the remediation component of the Project, the Applicant is proposing to prepare and grade the pads that would be eventually used for the development. However, from a geology perspective the impacts associated with the grading and construction of the building

pads cannot be separated from the building design and construction. Therefore, the impacts associated with building pad development are discussed under the City and County Development Plan impacts sections below.

Impact #	Impact Description	Phase	Residual Impact
GR.1	Remediation activities may cause erosion-induced siltation of nearby waterways as a result of ground-disturbing activities.	Remediation	Class II

Construction remedial measures may cause an increased potential for short-term erosion and sedimentation of local and nearby drainages. Water and wind erosion of the stockpiles and loose dirt could impact surface water run-off. Sedimentation into local creeks would be a potentially significant impact. State and County requirements shall be implemented throughout construction, reducing the potential for off-site sedimentation. The Applicant would be required to prepare a Storm Water Pollution Prevention Plan (SWPPP) by/for the Central Coast Regional Water Control Board. Storm water best management practices (BMPs) would be installed around all soil stockpiles.

Mitigation Measures

GR-1a *Prior to the issuance of the applicable grading permit, the Applicant shall prepare a construction Storm Water Pollution Prevention Plan (SWPPP) for the remediation component of the Project for review and approval by San Luis Obispo County Public Works. The plan shall include features meeting the construction activities best management practices and the applicable provisions of the erosion and sediment control best management practices (ESC-1 through ESC-56) published in the California Storm Water Best Management Practice Handbooks (Construction Activity) and best management practices (CD-4(2)) of the Caltrans Storm Water Quality Handbooks, Construction Contractor's Guide and Specifications, to ensure that every construction site meets the requirements of the regulations during the time of construction.*

GR-1b *Prior to the issuance of the applicable grading permit, the Applicant shall prepare an Erosion Control Plan and Wet Weather Plan for review and approval by San Luis Obispo County Public Works. The plan shall detail the Best Management Practices that will be used on the site to control erosion and sedimentation to be implemented during all remediation activities. The plan shall include at least the following measures unless other erosion control measures are specified in the agency approved SWPPP:*

a. Graded areas shall be stabilized with riprap (i.e., crushed stone) or other ground cover as soon as grading is completed. The surface of slopes shall be roughened during the construction period to retain water, increase infiltration, and facilitate establishing vegetation. Tracked machinery shall be operated up and down (parallel with) slopes to leave horizontal (perpendicular) depressions in the soil, which run across the slope, on the contour.

b. *Slope breaks, such as diversions, benches, or contour furrows shall be constructed to reduce the length of cut- and fill-slopes, thus limiting sheet and rill erosion and preventing gully erosion.*

c. *Sediment barriers shall be used around construction areas to retain soil particles on-site and reduce surface runoff velocities during rainfall events. Sediment barriers could include straw bales, silt fences, and gravel and earth berms. Silt fences shall be placed on slope contours in areas where shallow overland flow is anticipated.*

d. *Temporary and permanent drainages shall be employed, as necessary, to reduce slope erosion and prevent damage to construction areas. Sheet flow across or toward a disturbed area shall be intercepted and conveyed to a low to moderate gradient (1 to 5 percent slope) sediment basin, erosion-resistant drainage channel, or a level, well-vegetated area. Drainages would include swales, diversion dikes, and slope drains.*

e. *Water bars, rolling dips, and out-sloping roads shall be constructed as part of new road construction to disperse runoff and reduce the erosive forces associated with concentrated flows.*

Residual Impacts

Implementation of the above mitigation measures would reduce the impacts due to erosion and sedimentation as *less than significant with mitigation (Class II)*.

4.7.5 City Development Plan Impacts and Mitigation Measures

Impact #	Impact Description	Phase	Residual Impact
GR.2	Seismically-induced ground shaking could damage proposed structures and infrastructure, potentially resulting in loss of property or risk to human health and safety.	Development	Class III

Peak ground accelerations for the site are estimated to be approximately 0.98 g from the nearby faults, based on the design level ground acceleration. Earthquakes of this magnitude could damage project components and pose risks to human health and safety.

The faults discussed in Section 4.7.1.4 and listed in Table 4.7-1 are not the only faults in the area that could produce earthquakes; however, they are the faults most likely to affect the Project Site according to the latest available data from the State of California. Earthquakes along these faults could produce potentially significant impacts to the proposed structures and improvements that would be built as part of the development phase. Although nothing can ensure that structures do not fail under seismic stress, proper engineering, including the recommended mitigation measures, can minimize the risks to life and property.

In addition to the calculated expected ground accelerations, local site conditions may amplify site ground accelerations. Local building codes and the California Building Code (CBC) do not require any mitigation for possible amplifications resulting from these effects.

The County of San Luis Obispo Safety Element Liquefaction Hazard Map 1999 identifies the site as an area of potential liquefaction. Liquefaction, lateral spreading, seismic settlement, and ground lurching could occur in areas of loose and unconsolidated, low density sediments. The drainage areas that compose the East Fork of San Luis Obispo Creek and Tank Farm Creek may be prone to these hazards. No specific testing and evaluation have been performed in these areas to further assess the hazards.

The Applicant would be required to design and construct all buildings to withstand the expected ground acceleration that may occur at the Project Site based on the California Building Code that is applicable at the time the buildings are permitted. The current California Building Codes requires that the design base ground motion for the site consider the soil type, potential for liquefaction, and the most current and applicable seismic attenuation methods available. The current California Building code requires that surface facilities, buildings, residential structures, and equipment have suitable foundations and anchoring design, surface restraints, and moment-limiting supports to withstand seismically-induced ground shaking. In addition the 2010 California Building Code, and the City of San Luis Obispo building code requires that slopes, roadways, and building pads are properly engineered.

With these building code requirements the impacts associated with seismically-induced ground shaking would be considered less than significant.

Mitigation Measures

No mitigation measures are required since the impact is less than significant.

Residual Impacts

The residual impact associated with seismically-induced ground shaking would be *less than significant (Class III)*.

Impact #	Impact Description	Phase	Residual Impact
GR.3	Existing uncertified fill on-site could be subject to hydroconsolidation, excessive settlement, expansive soil shrink and swell, and differential settlement and expansion, and thus could damage proposed facilities, resulting in loss of property and risks to human health and safety.	Development	Class III

Based on site observations and previous studies, un-engineered fill has been placed across the Project Site at various locations for roads, holding ponds, and other operations. The exact locations and the horizontal and vertical limits of un-engineered fill have not been clearly discerned. Building the proposed structures on un-engineered fill could result in damage to the facilities, which would be a significant impact. The Project would have to meet all of the requirements of the City and the 2010 California Building Code as it relates to all grading activities, including the requirements for compacted engineering fill.

With these building code requirements the impacts associated with uncertified fill would be considered less than significant.

Mitigation Measures

No mitigation measures are required since the impact is less than significant.

Residual Impacts

The residual impact associated with the use of uncertified fill would be *less than significant (Class III)*.

Impact #	Impact Description	Phase	Residual Impact
GR.4	Construction activities and grading may cause erosion-induced siltation of nearby waterways as a result of ground-disturbing activities.	Development	Class II

Grading and building activities associated with the development may cause an increased potential for short-term erosion and sedimentation of local and nearby drainages. Water and wind erosion of the stockpiles and loose dirt could impact surface water run-off. Sedimentation into local creeks would be a potentially significant impact. State and County requirements shall be implemented throughout construction, reducing the potential for off-site sedimentation. The Applicant would be required to prepare a Storm Water Pollution Prevention Plan (SWPPP) by/for the Central Coast Regional Water Control Board.

Mitigation Measures

GR-4a *Prior to the issuance of the applicable building permit, the Applicant shall prepare a construction Storm Water Pollution Prevention Plan (SWPPP) by a Qualified SWPPP Developer (QSD) certified professional for the development component of the Project for review and approval by the City of San Luis Obispo. The plan shall include features meeting the construction activities best management practices and the applicable provisions of the erosion and sediment control best management practices (ESC-1 through ESC-56) published in the California Storm Water Best Management Practice Handbooks (Construction Activity) and best management practices (CD-4(2)) of the Caltrans Storm Water Quality Handbooks, Construction Contractor's Guide and Specifications, to ensure that every construction site meets the requirements of the regulations during the time of construction. Further, the plan shall ensure compliance with and enrollment under the State Water Board General Construction Permit.*

GR-4b *Prior to the issuance of the applicable building permit, the Applicant shall prepare an Erosion Control Plan and Wet Weather Plan for review and approval by the City. The plan shall detail the best management practices that will be used on the site to control erosion and sedimentation to be implemented during all development activities. The plan shall include at least the following measures unless other erosion control measures are specified in the agency approved SWPPP:*

a. Graded areas shall be stabilized with riprap (i.e., crushed stone) or other ground cover as soon as grading is completed. The surface of slopes shall be roughened during the construction period to retain water, increase infiltration, and facilitate

establishing vegetation. Tracked machinery shall be operated up and down (parallel with) slopes to leave horizontal (perpendicular) depressions in the soil, which run across the slope, on the contour.

b. *Slope breaks, such as diversions, benches, or contour furrows shall be constructed to reduce the length of cut- and fill-slopes, thus limiting sheet and rill erosion and preventing gully erosion.*
c. *Sediment barriers shall be used around construction areas to retain soil particles on-site and reduce surface runoff velocities during rainfall events. Sediment barriers could include straw bales, silt fences, and gravel and earth berms. Silt fences shall be installed per specification on slope contours in areas where shallow overland flow is anticipated.*
d. *Temporary and permanent drainages shall be employed, as necessary, to reduce slope erosion and prevent damage to construction areas. Sheet flow across or toward a disturbed area shall be intercepted and conveyed to a low to moderate gradient (1 to 5 percent slope) sediment basin, erosion-resistant drainage channel, or a level, well-vegetated area. Drainages would include swales, diversion dikes, and slope drains.*
e. *Water bars, rolling dips, and out-sloping roads shall be constructed as part of new road construction to disperse runoff and reduce the erosive forces associated with concentrated flows.*

Residual Impacts

Implementation of the above mitigation measures would reduce the impacts erosion and sedimentation as *less than significant with mitigation (Class II)*.

Impact #	Impact Description	Phase	Residual Impact
GR.5	Moderately expansive soils prone to swelling and shrinking from increased or decreased water content could damage proposed structures and infrastructure, resulting in loss of property and risks to human health and safety.	Development	Class II

The on-site soils consist of interlayers of sand, silt and clay. The clay layers present a potential for moderate expansivity, though laboratory soils testing will be necessary during the development phase to determine the magnitude of the expansion potential. Expansive soils can heave foundations and slabs. These adverse effects could damage or cause catastrophic failure to structures and components, which could result in a significant impact. Foundations for structures and slabs constructed on expansive soils require special design considerations to mitigate the hazard.

Mitigation Measures

GR-5a *Expansive soils should be mitigated by the over-excavation and replacement of non-expansive soils for all buildings and structures, as approved by the City of San Luis Obispo. Alternatively, all construction for buildings shall use thickened slabs, extended slab edges, and additional reinforcement to reduce negative impacts from*

any expansive soil movement. Several equivalent remedial measures may be implemented that are standard construction and mitigation measures. In addition, capillary breaks shall be used under slabs to address the potential for moisture transport and pumping that leads to moisture infiltration as a result of heat and moisture gradients where buildings are sensitive to moisture infiltration. All remedial measures, designs, and calculations shall be prepared by a registered civil engineer, and shall be reviewed and approved by the City prior to issuance of the applicable building permits.

GR-5b *The Applicant shall use low- to non-expansive soils for slab, trench backfill, and pavement support to eliminate risk, which can be accommodated by importing select materials. Select grading techniques could utilize the granular soils on-site for subsequent use. Alternatively, an equivalent remedial measure to mitigate expansive soils may be implemented where the appropriate design and calculations prepared by a registered civil engineer, demonstrate a suitable design, and have been reviewed and approved by the City prior to issuance of the applicable building permits.*

GR-5c *Soils shall be properly compacted as specified by a registered civil engineer. The registered civil engineer should also specify the appropriate soil-water content for expansive soil mitigation. The compaction levels and soil-water content shall be approved by the City prior to issuance of the applicable building permit.*

Residual Impacts

Implementing the recommended mitigation measures would reduce the impacts of expansive soils to *less than significant with mitigation (Class II)*.

Impact #	Impact Description	Phase	Residual Impact
GR.6	Construction and improvement in areas lacking suitable factors of safety for existing slopes could result in gross or surficial instability, as well as earthquake-induced landslides, which could damage proposed structures and infrastructure, resulting in loss of property and risks to human health and safety.	Development	Class III

The majority of the Project Site area is relatively flat, with average slope gradients across the site area of less than 1 percent, with the exception of the Project Site's northeast corner. The northeastern corner of the Project Site area consists of an outcropping of moderately sloped Franciscan Assemblege rocks that drops off steeply into a gravel pit ravine just beyond the Project Site boundary. This outcropping, known as the "Flower Mound" will be removed as part of the remediation component of the Project. The Applicant is proposing to use the material from the Flower Mound as engineered fill for some of the development sites.

Additionally, located approximately 1,000 feet north of the Project Site's northeast corner are relatively steep hills composed of Franciscan Assemblege rocks that appear susceptible to landsliding. County of San Luis Obispo Safety Element maps (SLO 1999) indicate that the Franciscan Assemblege rocks have a high potential for landsliding.

Based on the flat topography on-site and distance from suspected landslide areas, the potential for landsliding or the failure of natural slopes to affect the Project Site is low. Therefore, impacts from a landslide would be considered less than significant.

Mitigation Measures

No mitigation measures are required since the impact is less than significant.

Residual Impacts

The residual impact associated with slope failure due to existing landslides would be *less than significant (Class III)*.

Impact #	Impact Description	Phase	Residual Impact
GR.7	Compressible soils that underlie the site are prone to excessive settlement that could adversely affect the proposed development and improvements.	Development	Class II

Consolidation tests performed on the site identified that the site is underlain by normally to low pressure over-consolidated clay layers (Padre 2007). Depending on grading, building location, and other factors, settlements may be on the order of 1 to 4 inches. No time-rates calculations or information to assess was provided in the report to determine waiting periods. This order of settlement poses the potential to damage remediation areas, buildings, pipelines and roadways and render them unusable, resulting in a hazard to public health and safety. Excessive settlement would pose a significant hazard to the Project, therefore mitigation measures are necessary.

Mitigation Measures

GR-7 *Prior to the issuance of the applicable building permit, the Applicant shall have a registered civil engineer prepare a geotechnical report based on the proposed development to the magnitude of total and differential settlements and time rates for waiting during construction. The report shall be submitted to the City for review and approval. The report shall discuss the measures that have been taken to ensure that the primary settlement is within acceptable limits for the proposed development. Acceptable measures could include but are not limited to:*

a. *Surcharging the proposed building sites with fill for a specified time frame. Settlement monuments shall be required to measure the total settlement. The results of the survey shall be presented to the City for review and approval and should include time rate plots to demonstrate that at least 90 percent (t_{90}) of the primary settlement (or as determined necessary) has occurred before any further construction of structures in the area.*

b. *Partial or complete over-excavation of the clay layers and replacement with gravel drain layer and engineered fill. Settlement monuments shall be required to measure the total settlement. The results of the survey shall be presented to the City for review and approval and should include time rate plots to demonstrate that at least 90 percent (t_{90}) of the primary settlement (or as determined necessary) has occurred before any further construction of structures in the area.*

c. *Support structures on deepened foundations that extend thru the soft or unsuitable layers and derive support from suitable materials. Where necessary, the piles shall be required to be designed to withstand negative friction as necessary. Various foundations schemes will require specific design criteria, but are typical to these types of mitigation measures and should follow custom and practice in the industry.*

d. *Perform in-situ remedial measures, such as sand drains, to accelerate and mitigate the anticipated settlements. Various schemes will require specific design criteria, but are typical to these types of mitigation measures and should follow custom and practice in the industry.*

Residual Impacts

Implementation of the above mitigation measures would reduce the impacts excessive compression and resulting settlement as *less than significant with mitigation (Class II)*.

4.7.6 County Development Plan Impacts and Mitigation Measures

All of the impacts and mitigation measures identified for the City Development Plan would apply to the County Development Plan. No additional impacts have been identified for the County Development Plan component of the Project.

4.7.7 Cumulative Analysis

Cumulative impacts related to seismically-related ground shaking, liquefaction, and soil settlement, as well as landslides and other impacts would be similar to the 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.

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.

4.7.8 Mitigation Monitoring Plan

4.7.8.1 Remediation Project Mitigation Monitoring Plan

Mitigation Measure	Plan Requirements and Timing	Compliance Verification		
		Method	Timing	Responsible Party
GR-1a	Prior to the issuance of the applicable grading permit, the Applicant shall prepare a construction Storm Water Pollution Prevention Plan (SWPPP) for the remediation component of the Project for review and approval by San Luis Obispo County Public Works. The plan shall include features meeting the construction activities best management	Review of SWPPP	Prior to issuance of applicable building permits.	San Luis Obispo County Public Works Central Coast Regional Water Quality

Mitigation Measure	Plan Requirements and Timing	Compliance Verification		
		Method	Timing	Responsible Party
	practices and the applicable provisions of the erosion and sediment control best management practices (ESC-1 through ESC-56) published in the California Storm Water Best Management Practice Handbooks (Construction Activity) and best management practices (CD-4(2)) of the Caltrans Storm Water Quality Handbooks, Construction Contractor's Guide and Specifications, to ensure that every construction site meets the requirements of the regulations during the time of construction.			Control Board.
GR-1b	Prior to the issuance of the applicable grading permit, the Applicant shall prepare an Erosion Control Plan and Wet Weather Plan for review and approval by San Luis Obispo County Public Works. The plan shall detail the Best Management Practices that will be used on the site to control erosion and sedimentation to be implemented during all remediation activities. The plan shall include at least the following measures unless other erosion control measures are specified in the agency approved SWPPP: a. Graded areas shall be stabilized with riprap (i.e., crushed stone) or other ground cover as soon as grading is completed. The surface of slopes shall be roughened during the construction period to retain water, increase infiltration, and facilitate establishing vegetation. Tracked machinery shall be operated up and down (parallel with) slopes to leave horizontal (perpendicular) depressions in the soil, which run across the slope, on the contour. b. Slope breaks, such as diversions, benches, or contour furrows shall be constructed to reduce the length of cut- and fill-slopes, thus limiting sheet and rill erosion and preventing gully erosion. c. Sediment barriers shall be used around construction areas to retain soil particles on-site and reduce surface runoff velocities during rainfall events. Sediment barriers could include straw bales, silt fences, and gravel and earth berms. Silt fences shall be placed on slope contours in areas where shallow overland flow is anticipated. d. Temporary and permanent drainages shall be employed, as necessary, to reduce slope erosion and prevent damage to construction areas. Sheet flow across or toward a disturbed area shall be intercepted and conveyed to a low to moderate gradient (1 to 5 percent slope)	Review of Erosion Control Plan	Prior to issuance of applicable building permits.	San Luis Obispo County Public Works Central Coast Regional Water Quality Control Board.

Mitigation Measure	Plan Requirements and Timing	Compliance Verification		
		Method	Timing	Responsible Party
	sediment basin, erosion-resistant drainage channel, or a level, well-vegetated area. Drainages would include swales, diversion dikes, and slope drains. e. Water bars, rolling dips, and out-sloping roads shall be constructed as part of new road construction to disperse runoff and reduce the erosive forces associated with concentrated flows.			

4.7.8.2 City Development Plan Mitigation Monitoring Plan

Mitigation Measure	Plan Requirements and Timing	Compliance Verification		
		Method	Timing	Responsible Party
GR-4a	Prior to the issuance of the applicable grading permit, the Applicant shall prepare a construction Storm Water Pollution Prevention Plan (SWPPP) by a Qualified SWPPP Developer (QSD) certified professional for the development component of the Project for review and approval by the City. The plan shall include features meeting the construction activities best management practices and the applicable provisions of the erosion and sediment control best management practices (ESC-1 through ESC-56) published in the California Storm Water Best Management Practice Handbooks (Construction Activity) and best management practices (CD-4(2)) of the Caltrans Storm Water Quality Handbooks, Construction Contractor's Guide and Specifications, to ensure that every construction site meets the requirements of the regulations during the time of construction. Further, the plan shall ensure compliance with and enrollment under the State Water Board General Construction Permit.	Review of SWPPP	Prior to issuance of applicable building permits.	City of San Luis Obispo Central Coast Regional Water Quality Control Board.
GR-4b	Prior to the issuance of the applicable building permit, the Applicant shall prepare an Erosion Control Plan and Wet Weather Plan for review and approval by the City. The plan shall detail the Best Management Practices that will be used on the site to control erosion and sedimentation to be implemented during all development activities. The plan shall include at least the following measures unless other erosion control measures are specified in the agency approved SWPPP: a. Graded areas shall be stabilized with riprap (i.e., crushed stone) or other ground cover as soon as grading is completed. The surface of	Review of Erosion Control Plan	Prior to issuance of applicable building permits.	City of San Luis Obispo Central Coast Regional Water Quality Control Board.

Mitigation Measure	Plan Requirements and Timing	Compliance Verification		
		Method	Timing	Responsible Party
	slopes shall be roughened during the construction period to retain water, increase infiltration, and facilitate establishing vegetation. Tracked machinery shall be operated up and down (parallel with) slopes to leave horizontal (perpendicular) depressions in the soil, which run across the slope, on the contour. b. Slope breaks, such as diversions, benches, or contour furrows shall be constructed to reduce the length of cut- and fill-slopes, thus limiting sheet and rill erosion and preventing gully erosion. c. Sediment barriers shall be used around construction areas to retain soil particles on-site and reduce surface runoff velocities during rainfall events. Sediment barriers could include straw bales, silt fences, and gravel and earth berms. Silt fences shall be installed per specification on slope contours in areas where shallow overland flow is anticipated. d. Temporary and permanent drainages shall be employed, as necessary, to reduce slope erosion and prevent damage to construction areas. Sheet flow across or toward a disturbed area shall be intercepted and conveyed to a low to moderate gradient (1 to 5 percent slope) sediment basin, erosion-resistant drainage channel, or a level, well-vegetated area. Drainages would include swales, diversion dikes, and slope drains. e. Water bars, rolling dips, and out-sloping roads shall be constructed as part of new road construction to disperse runoff and reduce the erosive forces associated with concentrated flows.			
GR-5a	Expansive soils should be mitigated by the over-excavation and replacement of non-expansive soils for all buildings and structures, as approved by the City. Alternatively, all construction for buildings shall use thickened slabs, extended slab edges, and additional reinforcement to reduce negative impacts from any expansive soil movement. Several equivalent remedial measures may be implemented that are standard construction and mitigation measures. In addition, capillary breaks shall be used under slabs to address the potential for moisture transport and pumping that leads to moisture infiltration as a result of heat and moisture gradients where buildings are sensitive to moisture infiltration. All remedial measures, designs, and	Review of engineering drawings Site Inspection	Prior to issuance of applicable building permits. During construction	City of San Luis Obispo City of San Luis Obispo

Mitigation Measure	Plan Requirements and Timing	Compliance Verification		
		Method	Timing	Responsible Party
	calculations shall be prepared by a registered civil engineer, and shall be reviewed and approved by the City prior to issuance of the applicable building permits.			
GR-5b	The Applicant shall use low- to non-expansive soils for slab, trench backfill, and pavement support to eliminate risk, which can be accommodated by importing select materials. Select grading techniques could utilize the granular soils on-site for subsequent use. Alternatively, an equivalent remedial measure to mitigate expansive soils may be implemented where the appropriate design and calculations prepared by a registered civil engineer, demonstrate a suitable design, and have been reviewed and approved by the City prior to issuance of the applicable building permits.	Review of engineering drawings Site Inspection	Prior to issuance of applicable building permits. During construction	City of San Luis Obispo City of San Luis Obispo
GR-5c	Soils shall be properly compacted as specified by a registered civil engineer. The registered civil engineer should also specify the appropriate soil-water content for expansive soil mitigation. The compaction levels and soil-water content shall be approved by the City prior to issuance of the applicable building permit.	Review of engineering drawings Site Inspection	Prior to issuance of applicable building permits. During construction	City of San Luis Obispo City of San Luis Obispo
GR-7	Prior to the issuance of the applicable building permit, the Applicant shall have a registered civil engineer shall prepare a geotechnical report based on the proposed development to the magnitude of total and differential settlements and time rates for waiting during construction. The report shall be submitted to the City for review and approval. The report shall discuss the measures that have been taken to ensure that the primary settlement is within acceptable limits for the proposed development. Acceptable measures could include but not limited to: a. Surcharging the proposed building sites with fill for a specified time frame. Settlement monuments shall be required to measure the total settlement. The results of the survey shall be presented to the City for review and approval and should include time rate plots to demonstrate that at least 90 percent (t_{90}) of the primary settlement (or as determined necessary) has occurred before any further construction of structures in the area. b. Partial or complete over-excavation of the clay layers and replacement with gravel drain layer and engineered fill. Settlement monuments shall be required to measure the total	Review of the geotechnical report and engineering plans.	Prior to issuance of applicable building permits.	City of San Luis Obispo

Mitigation Measure	Plan Requirements and Timing	Compliance Verification		
		Method	Timing	Responsible Party
	settlement. The results of the survey shall be presented to the City for review and approval and should include time rate plots to demonstrate that at least 90 percent (t_{90}) of the primary settlement (or as determined necessary) has occurred before any further construction of structures in the area. c. Support structures on deepened foundations that extend thru the soft or unsuitable layers and derive support from suitable materials. Where necessary, the piles shall be required to be designed to withstand negative friction as necessary. Various foundations schemes will require specific design criteria, but are typical to these types of mitigation measures and should follow custom and practice in the industry. d. Perform in-situ remedial measures, such as sand drains, to accelerate and mitigate the anticipated settlements. Various schemes will require specific design criteria, but are typical to these types of mitigation measures and should follow custom and practice in the industry.			

4.7.8.3 County Development Plan Mitigation Monitoring Plan

Mitigation Monitoring Plan for the City Development Plan would apply for the County Development Plan.

4.7.9 References

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