4.6 GEOLOGY AND SOILS

4.6.1 Introduction

This section discusses the existing geologic and soils setting of the La Entrada Specific Plan (proposed project) site and analyzes the potential impacts associated with project implementation. This section also addresses the potential for structural damage from the local geology underlying the project site, as well as slope stability, ground settlement, soil conditions, grading, and regional seismic conditions. This section is based on the information provided in the following:

- *Preliminary Geotechnical Investigation, Approximately 2200-Acre La Entrada Project* (*Preliminary Geotechnical Investigation*) (Petra Geotechnical, Inc. [Petra], April 15, 2013);
- *Updated Geotechnical Fault Investigation Report for Land Planning Purposes, Approximately 2200-Acre Property (Lomas Del Sol)* (*Updated Geotechnical FI Report*) (Petra, January 15, 2007);
- *Geotechnical Fault Investigation Report for Land Planning Purposes, Approximately 2,200-Acre Property (Lomas Del Sol)* (*Geotechnical FI Report*) (Petra, November 23, 2005); and
- *Response Letter Addressing Comments from the City on the Updated Fault Investigation Report* (*Response Letter*) (March 11, 2007).

These reports are included in Appendix G of this Draft Environmental Impact Report (EIR).

4.6.2 Methodology

Petra conducted a geological investigation that included review of existing published and unpublished data, geologic mapping, fault trenching, aerial photograph analysis, soil profiles, and a field survey. Soils and geologic and seismic hazards, as identified in the *Preliminary Geotechnical Investigation* and *Updated Geotechnical FI Report,* were assessed with respect to significance within the context of Appendix G of the Guidelines for the *California Environmental Quality Act (CEQA) Guidelines*.

4.6.3 Existing Environmental Setting

Project Site. The project site lies between the flat alluvial floor of the Coachella Valley to the west and bedrock highlands of the Little San Bernardino and Orocopia Mountains to the northeast, east, and southeast. The topography of the site ranges in elevation from 50 feet (ft) to approximately 700 ft above mean sea level (amsl). Light desert vegetation is present throughout the project site. In addition, surface drainage on site generally flows toward the southwest.

Regional Geologic Setting. The project site lies within the Salton Trough, which comprises a portion of the Colorado Desert Geomorphic Province. The Salton Trough is characterized by its exposures of the San Andreas fault and related faults that form the margin between the Pacific and North American tectonic plates. Originally the Salton Trough was formed as a result of crustal stretching and sinking from seismic activity during the Miocene period, 5 to 23 million years ago. The Salton Trough has continued to develop during the formation of the northern section of the Gulf of California rift basin for the last 12 to 15 million years. The Salton Sea is located with the Salton Trough.

Sediments in the Salton Trough are approximately 3 miles (mi) thick and originate from the San Jacinto Mountains along the western margins, the San Bernardino Mountains and the Little San Bernardino Mountains to the north and northeast, the Orocopia Mountains to the east, and the Colorado River to the southeast. These sediments are approximately 3–5 million years old and are associated with the Imperial and Palm Spring Formations. These sediment deposits are composed of salt beds, silts and clays, and minor sand and channel gravels. In addition, fine-grained basin deposits are present on site and are generally comprised of sands, gravels, and conglomerates from the Ocotillo and Canebrake Formations.

The major fault located in the Coachella Valley region is the strike-slip San Andreas fault. This fault extends approximately 600 mi from the Gulf of California to Cape Mendocino in northern California. Faulting in the San Gorgonio Pass region (adjacent to the western Coachella Valley) is associated with the San Andreas fault. This 20 mi convergence zone is characterized by strike-slip faults (primarily horizontal motion) and is generally referred to as a tectonic knot. The portion of the San Andreas fault located southeast of the San Bernardino Mountains/San Gorgonio Pass has not experienced a large historic earthquake since the late 1600s. Regional and local faults and fault zones are illustrated in Figures 4.6.1 and 4.6.2 (provided following the last page of text in this section).

Local Geologic Setting. In the northern Coachella Valley, the San Andreas fault system consists of the Garnet Hill, Banning, and Mission Creek branches; the Mission Creek and Banning branches converge at the southern end of the Indio Hills and continue past the project site to Bombay Beach at the Salton Sea, where it is no longer traceable at the surface. Based on a paleoseismic trenching study at Thousand Palms Oasis (Fumal 2002), the most recent surface-rupturing earthquake on the San Andreas fault in the Coachella Valley occurred in the late 1600s. The Fumal study determined that the average repeat time of surface-rupturing earthquakes is approximately 215 years (+/- 25 years), with the last surface-rupturing event occurring approximately 325 years ago.

The project site is located between the Indio Hills and Coachella Fan Fault Zone to the northwest of the site and the Painted Canyon Fault Zone to the southwest in the Mecca Hills. The San Andreas fault runs adjacent and subparallel to the western boundary of the project site. Figure 4.6.1 shows that a portion of the project site is located within a State of California Fault Hazard Zone. In addition, Figure 4.6.1 shows areas where the City of Coachella (General Plan 2008) has delineated Fault Hazard Zones.

As illustrated in Figure 4.6.3, the project site contains faults defined as potentially active or active (areas shaded red), where habitable structures may not be placed, and areas where faulting has been identified but activity has not been determined (areas shaded yellow) (*Preliminary Geotechnical Investigation*). The yellow shaded areas are also areas where habitable structures may not be placed, but if it is desired to place habitable structures in the yellow shaded zone in the future, additional active fault investigations would need to be conducted.

Although numerous faults are present within the Palm Spring Formation and Ocotillo Conglomerate on site, most of these faults were determined to be inactive; however, these faults may still impact the property related to slope stability, groundwater seepage, exposure of geologic unit types across graded pad surfaces, and potential differential settlement.

Subsurface Conditions. The project site is underlain by (youngest to oldest): Artificial fill, Slopewash Fluvial Fan deposits, and mid to late Quaternary sedimentary units consisting of the (youngest to oldest) Ocotillo Conglomerate, Palm Spring Formation, and the Canebrake Formation. The geologic units present on site are described below.

Artificial Fill (Afu). Small amounts of artificial fill are present on the northern portion of the project site near the abandoned portion of the old United States (U.S.) Highway 60. This artificial fill is comprised of local soils and portions of old paved roads.

Quaternary Slopewash Deposits (Qsw). Late Quaternary age slopewash (Qsw) deposits are present along the natural slopes of the incised channels of the older uplifted geologic units and mix with fluvial fan deposits within the current drainages. This unit typically consists of Ocotillo Conglomerate located directly upslope. Quaternary Slopewash Deposits are generally dry, loose, medium brown, and are typically composed of fine to coarse sand and gravels.

Late Quaternary Fluvial Fan Deposits (Qf). Fluvial fan deposits of varying ages are present on site. Fluvial fan deposits consist of reworked Ocotillo conglomerate, Palm Spring Formation, and sediments from the San Bernardino Mountains. These deposits are composed of moderately well sorted, finely to massively bedded, fine to coarse sand with gravels. A fluvial fan deposit is also generally loose in the upper 2–5 ft and is medium dense below 5 ft.

Ocotillo Conglomerate (Late Pleistocene) (Qo). Ocotillo conglomerate is composed of coarse fluvial fan deposits from the Little San Bernardino Mountains. Ocotillo conglomerate consists of massive to fairly well bedded sand and gravels that can range from crumbly to moderately hard. Typically, Ocotillo conglomerate also contains buried soils and thin layers of clays. Ocotillo conglomerate forms the uppermost deposit along ridge tips and erodes to form moderately steep slopes.

Upper Palm Spring Formation (Middle to Late Pleistocene) (Qpu). The upper portion of the Palm Spring Formation generally consists of dense to very dense; dry to moist; and fairly well sorted to well sorted interbedded clays, silts, and sands with occasional local gravels. This formation is characterized by easily eroded, well-sorted, olive brown silt. Coarse-grained members are comprised of well-sorted, medium-grained sand to poorly sorted sand, and rounded gravels. Coarse-grained members are generally crumbly to highly indurated (hard). Fine-grained members typically contain gypsum crystals and calcium carbonate particles.

Canebrake Formation (Middle Pleistocene) (Qc). The Canebrake Formation occurs stratigraphically below the Palm Spring Formation and crops out in the southeastern portion of the project site. Based on geologic mapping, the contact between the upper Palm Spring Formation and the underlying Canebrake Formation is conformable and gradational over a structural distance of 10 to 40 ft. It generally consists of very dense, dry, medium brown, interbedded medium- to coarse-grained fanglomerates; debris flows; and minor fluvial fan deposits. Some dark reddish-brown to olive silty clay members may represent interbedded middle to lower members of the Palm Spring Formation. This unit is distinctive in that it weathers to form vertical cliffs in excess of 50 ft and contains numerous poorly sorted debris flows with angular clasts. Northeast of the property, the Canebrake Formation is deposited in angular unconformity over the lower Palm Spring Formation, which is folded to near vertical and faulted.

Nonseismic Geologic Constraints.

Erosion. The erosion potential of soil is governed by the physical properties of the soil along with environmental factors such as rainfall, wind, topography, and vegetative cover. Erosion typically occurs from concentrated runoff on unprotected slopes or along unlined drainage channels that are underlain by relatively erosion-prone earth materials (e.g., topsoil, soft alluvium, uncemented sandstone). As illustrated on Figure 4.6.4, approximately 50 percent of the project site contains slopes with low gradients (less than 5 degrees), and portions of the project site contain 30 degree slopes (50 ft or higher).

Expansive Soils. Expansive soils contain types of clay minerals that occupy considerably more volume when they are wet or hydrated than when they are dry or dehydrated. Volume changes associated with changes in the moisture content of near-surface expansive soils can cause uplift or heave of the ground when they become wet or, less commonly, cause settlement when they dry out. Based on the findings of the *Preliminary Geotechnical Investigation* and *Updated Geotechnical FI Report*, soils on the project site are generally granular (sandy) in nature and nonexpansive, with the exception of interbedded clayey silt materials of the Palm Spring Formation, which indicate a medium expansion potential.

Subsidence. Subsidence is the sinking or settlement of the ground surface relative to the surrounding area, with little or no horizontal movement. Four types of land subsidence are known to occur in California. In descending order of significance, these are (1) subsidence caused by aquifer system compaction related to the lowering of groundwater levels, generally due to groundwater pumping (extraction) activities, (2) subsidence caused by hydrocompaction of soils above the groundwater table (overwetting of moisture deficient deposits), (3) subsidence related to extraction of oil and gas deposits, and (4) subsidence related to seismic activity. The project does not have oil, gas, or water pumping operations on site and has not been used for the extraction of any oil or gas resources.

Corrosive Soils. Corrosive soils contain chemical constituents that may cause damage to construction materials such as concrete and ferrous metals. One such constituent is water-soluble sulfate, which, if high enough in concentration, can react with and damage concrete. Electrical resistivity, chloride content, and percentage of hydrogen (pH) level are indicators of the soil's tendency to corrode ferrous metals. Corrosive elements in soils underlying foundation structures have the potential to degrade cement and concrete. Based on the limited chemical testing performed as part of the *Preliminary Geotechnical Investigation* on selected representative samples of soils at the project site, the soil corrosivity potential for concrete structures and metal structures in fan deposits and Ocotillo Conglomerate are considered negligible and moderate, respectively. Soil corrosivity in the Palm Spring formation is moderate to severe for concrete structures and severe for metal structures.

Groundwater Basin. The Coachella Valley is generally located within the Whitewater hydrological unit. This unit includes the Coachella Valley Groundwater Basin and surrounding subbasins. This basin is bound on the east and west by nonwater-bearing crystalline and metamorphic rocks of the San Bernardino, Little San Bernardino, Santa Rose, and San Jacinto Mountains. Although groundwater flows throughout the entire Coachella Valley Groundwater Basin, fault barriers, basin profile, and areas of low permeability constrict movement, thus resulting in the basin being divided into subbasins and subareas. The project area is located in the Desert Hot Springs subbasin and the Fargo Canyon subarea.

Groundwater. The depths of groundwater in the Coachella Valley region are generally less than 50 ft below the valley floor and greater than 100 ft along the alluvial fan margins of the valley. This depth is highly dependent of faulting because the San Andreas fault forms a barrier to groundwater in this area. In addition, depths of groundwater on the southwest side of the San Andreas fault are generally 10 to 50 ft below the ground surface (bgs), whereas depths of groundwater to the northeast of the San Andreas fault are generally greater than 100 ft bgs. Groundwater on site is estimated to occur at depths greater than 50 ft bgs because it was not encountered in borings at depths up to 51.5 ft bgs.

Refer to Section 4.9, Hydrology and Water Quality, for a more detailed discussion on groundwater conditions on site.

Seismically Induced Hazards.

Ground Shaking and Surface Fault Rupture. The primary seismic effects associated with earthquakes are ground shaking and surface fault rupture. Ground shaking due to seismic events (earthquakes) would typically be considered to be the greatest source of potential damage to structures. Seismic shaking is characterized by the physical movement of the land surface during and subsequent to an earthquake. Seismic shaking has the potential to cause destruction and damage to buildings and property, including damage resulting from damaged or destroyed gas or electrical utility lines; blockage of surface seepage and groundwater flow; changes in groundwater flow; dislocation of street alignments; displacement of drainage channels and drains; and possible loss of life. In addition, ground shaking can induce several kinds of secondary seismic effects, including liquefaction, differential settlement, and landslides, all of which are described below.

The intensity of seismic shaking during an earthquake depends largely on geologic formation conditions of the materials comprising the upper several hundred feet of the earth's surface. The greatest amplitudes and longest durations of ground shaking occur on thick, water-saturated, unconsolidated alluvial sediments. Ground shaking can also cause ground failure or deformation due to lurching and liquefaction.

Surface rupture is the displacement and cracking of the ground surface that occurs along a fault trace. Unlike seismically induced ground shaking, which can affect a wide geographic area, surface rupture is confined to the area very near the fault.

The project area is anticipated to experience strong ground shaking due to its proximity to the San Andreas fault and other known active faults in the region. Primary geotechnical hazards associated with strong ground shaking include near-surface fracturing, lateral spreading, liquefaction, and landslides. Based on probabilistic analysis from the California Geological Survey website, the peak ground acceleration at the project site is estimated to be approximately 0.73 g, based on the probability of 10 percent in 50 years.

The Coachella segment of the San Andreas fault generally parallels the All American Canal, just southwest of the project site. Two City of Coachella fault hazard zones extend into the property, one associated with a possible northwestward extension of the Skeleton Canyon fault in the southern portion of the site, and another associated with the Coachella Fan fault system in the northern portion of the project site. Other faults located within the project site are generally considered inactive, small-scale faults located within bedrock units of the Ocotillo, Palm Spring, and Canebrake formations; most of these faults occurred as a result of lateral spreading within the upper Palm Spring formation during the Pleistocene era. However, based on the findings of trench exploration conducted as part of the *Preliminary Geotechnical Investigation*, some subsidiary faults located on the project site are considered tectonically active or potentially active.

The active San Andreas fault (Coachella–Indio segment) extends adjacent and subparallel to the project site. Several other unnamed active and inactive faults are located east of the San Andreas fault. Co-seismic triggered surface displacements and creep caused by historical regional earthquakes have occurred on the Coachella segment of the San Andreas fault following the April 23, 1992, Joshua Tree; the June 28, 1992, Landers; and the July 8, 1986, North Palm Springs earthquakes.

The most recent surface-rupturing earthquake on the Coachella segment of the San Andreas fault likely occurred in the late 1600s. The average repeat time for surface-rupturing earthquakes on the Coachella–Indio segment of the San Andreas fault is approximately 215 +/-25 years.

Seismically Induced Ground Lurching and Surface Fracturing. Fault exploration trenches revealed near-surface fracturing of unconsolidated granular soils. Trenching data from the *Updated Geotechnical FI Report* indicated that within zones of fracturing, new fractures were typically produced and older fractures abandoned, indicating the random nature of the location of the fractures and the potential for new ones to be produced in the future essentially anywhere across the project site in areas of unconsolidated sediments or even near the tops of bedrock ridges.

Liquefaction and Lateral Spreading. Liquefaction is caused by sudden temporary increases in pore water pressure due to seismic densification or other displacement of submerged granular soils. Intervals of loose sand may, therefore, be subject to liquefaction if these materials are or were to become submerged and are also exposed to strong seismic ground shaking. Seismic ground shaking of relatively loose granular soils that are saturated or submerged can cause the soils to liquefy and temporarily behave as a dense fluid. This loss of support can produce local ground failure such as settlement or lateral spreading that may damage overlying improvements. Groundwater at the site is estimated to be greater than 50 ft bgs. Areas with groundwater less than 10 ft bgs are most susceptible to liquefaction; however, liquefaction can occur in areas with groundwater up to 50 ft bgs. However, due to the absence of shallow groundwater and presence of dense soils, the potential for liquefaction at the site is considered to be low/negligible.

Lateral spreading typically occurs as a form of horizontal displacement of relatively flat-lying alluvial material toward an open or "unconfined" face such as an open body of water, channel, or excavation as a result of seismic ground shaking. In soils, this movement is generally due to failure along a weak plane and may often be associated with liquefaction. Under current conditions, potential for lateral spreading is considered to be low due to the low potential for liquefaction.

Although large-scale lateral spreading has occurred in the bedrock units at the project site in the past (primarily in the Palm Spring Formation), current geologic conditions of the Palm Spring Formation consist of semiconsolidated and dense material. In addition, groundwater is much deeper in the site area due to the dryer Holocene climate and relative uplift of the Coachella Valley margins. Therefore, the potential for lateral spreading at the site is considered to be low.

Slope Instability and Seismically Induced Landslides. The downslope movement of loose rock or soil is a potential secondary seismic effect that can occur during strong ground shaking. As previously discussed, elevations on the project site range from 50 ft to 700 ft amsl. Previous trenching exploration identified a limited landslide in the Palm Spring Formation. Local failures along steepened wash banks were observed.

Seismically Induced Flooding. Seismically induced flooding that might be considered a potential hazard to a site normally includes flooding due to tsunami or seiche (i.e., wave-like oscillation of the surface of water in an enclosed basin that may be initiated by a strong earthquake) or failure of major reservoirs or retention structures upstream of the site. No major reservoir is located near or upstream of the site, so the potential for seiche or inundation is considered negligible. Because of the inland location of the site, flooding due to a tsunami is also considered negligible at the site.

4.6.4 Regulatory Setting

State Policies and Regulations.

Alquist-Priolo Earthquake Fault Zoning Act (1972). Regulations that are applicable to geologic, seismic, and soil hazards include the Alquist-Priolo Earthquake Fault Zoning Act of 1972 and updates (AP, Public Resources Code, Section 2621, et seq.), State-published Seismic Hazards maps, and provisions of the applicable edition of the California Building Code (CBC). The project site is located within an Alquist-Priolo Earthquake Fault Zone; therefore, procedures and regulations recommended by the California Geological Survey (CGS) for investigations conducted in such zones are applicable to the proposed project.

Seismic Hazard Mapping Act (1990). The Seismic Hazard Mapping Act (SHMA) was adopted by the State in 1990 for the purpose of protecting public safety from the effects of (nonsurface fault rupture) earthquake hazards. The CGS prepares and provides local governments with seismic hazard zones maps that identify areas susceptible to amplified shaking, liquefaction, earthquake-induced landslides, and other ground failures. The seismic hazards zones are referred to as “zones of required investigation” because site-specific geological investigations are required for construction projects located within these areas. Before a project can be permitted, a geologic investigation, evaluation, and written report must be prepared by a licensed geologist to demonstrate that proposed buildings will not be constructed across active faults. If an active fault is found, a structure for human occupancy must be set back from the fault (generally 50 ft). In addition, sellers (and their agents) of real property within a mapped Seismic Hazard Zone must disclose that the property lies within such a zone at the time of sale.

California Building Code (2010). The California Code of Regulations (CCR), Title 24, Part 2, the CBC, provides minimum standards for building design in the State. Local codes are permitted to be more restrictive than Title 24, but not less restrictive. The procedures and limitations for the design of structures are based on site characteristics, occupancy type, configuration, structural system height, and seismic design category. Construction activities are subject to occupational safety standards for excavation, shoring, and trenching as specified in California Occupational Safety and Health Administration (Cal/OSHA) regulations (CCR, Title 8). The latest triennial CBC update was 2010. The next update will be July 2013, but it would not go into effect until January 1, 2014. The CBC is updated every 3 years by the California Standards Board. The most recent version before 2010 was 2007, which went into effect January 1, 2008.

California Health and Safety Code. Sections 17922 and 17951–17958.7 of the California Health and Safety Code require cities and counties to adopt and enforce the current edition of the CBC, including a grading section. The City enforces these provisions (refer to Title 15 of the City’s Municipal Code). Sections of Volume 2 of the CBC specifically apply to select geologic hazards. Chapter 16 of the 2007 CBC addresses requirements for seismic safety. Chapter 18 regulates excavation, foundations, and retaining walls. Chapter 33 contains specific requirements pertaining to site demolition, excavation, and construction.

Unreinforced Masonry Law. In California, unreinforced masonry (URM) buildings are generally brick buildings constructed prior to 1933 and predating modern earthquake-resistant design. In earthquakes, the brick walls (especially parapets) tend to disconnect from the building and fall outward, creating a hazard for people below and sometimes causing the building to collapse. The Unreinforced Masonry Law, enacted by the State in 1986, requires cities and counties within Seismic Zone 4 to identify hazardous URM buildings and to consider local regulations to abate potentially dangerous buildings through retrofitting or demolition, as outlined in the State Office of Planning and Research (OPR) Guidelines. No URM buildings or any other structures are located on site.

Local and Regional Plans and Policies.

Title 15 of the City's Municipal Code. The City adopted, and enforces, Appendix Chapter 1 of the 2008 edition of the CBC, with amendments, as published by the International Code Council. Title 15 and more specifically, Chapter 15.08 of the City's Municipal Code is the City's building code. The intention of the building code is to establish minimum standards to safeguard life or limb, health, property, and public welfare by regulating and controlling the design, construction, quality of materials, use, occupancy, location, and maintenance of all buildings and structures located within the City. Building Code provisions apply to the construction, alteration, moving, demolition, repair, and use of any building or structure within the City.

City of Coachella General Plan Environmental Hazards and Safety Element. The main purpose of the Environmental Hazards and Safety Element (1996) is to reduce and abate natural and man-made hazards that would impact the community's public safety. Examples of hazards this element addresses include, but are not limited to, geologic, hydrogeologic, soil, flood, fire, and hazardous waste hazards. The following policies are applicable to the proposed project:

> **Policy:** The City shall continue to regulate development within Alquist-Priolo and other active or potentially active fault zones. Structures shall be set back 50 ft from each side of a mapped active fault or fault zone unless a geologic report that includes fault trenching recommends reduction of this setback.
>
> **Policy:** Where active or potentially active faults have not been mapped, the City will consult with the Division of Mines and Geology [now the CGS] regarding questions concerning fault alignment. The City shall require evaluation and, if necessary, site specific investigation for development proposed within 500 ft of active or potentially active faults to ensure protection of human life and property.
>
> **Policy:** The City shall discourage land uses that are considered critical from locating in areas subject to geologic hazards. No emergency or critical use facility

such as a hospital, school, fire or police station, utility facility and communication facility shall be located within an active or potentially active earthquake fault zone.

Policy: Erosion control, foundation design, and landscape design plans shall be prepared in accordance with City and County guidelines prior to development activities within the planning area. These plans shall include proper methods to mitigate collapsible soils, expansive soils, and slope protection on newly graded slopes.

Policy: All grading and land for modifications in the Planning Area shall be carried out under guidelines set forth in Chapter 70 of the Uniform Building Code (as a minimum), state of the practice design or construction standards, and/or guidelines established by the City, County, or other responsible regulatory agency as appropriate. These should include slope design that addresses the worst case effects of fluctuating or perched ground water levels.

Policy: The City shall require adequate building setbacks and structural mitigation to provide the most effective strategy of preventing loss of life and property from debris flows and earthquake induced slope failures.

Policy: The City shall require two points of vehicular access for emergency response in hillside areas susceptible to geologic hazards.

4.6.5 Project Design Features

As summarized in Chapter 3.0, Project Description, the proposed Specific Plan includes components that are referred to as Project Design Features. The Project Design Features related to geology and soils are:

- The Specific Plan and associated tract map have been designed to avoid grading the steeper northern/northeastern and southeastern portions of the site; they also incorporate a setback area to ensure that structures are not placed on the identified fault traces within the Alquist-Priolo Earthquake Hazard Zone identified on the project site.
- The Specific Plan has incorporated areas with identified earthquake fault traces into the open space and park components of the plan.
- School sites have been located on the Specific Plan Land Use Plan to ensure adequate separation from existing fault zones.
- The fully developed Specific Plan would result in substantially reduced wind- and runoff-induced erosion.
- Project development would adhere to all of the seismic requirements incorporated into the 2010 California Residential Code and 2010 (or most current) CBC and the requirements and standards contained in the applicable chapters of the City of Coachella Municipal Code.
- Project development would include the implementation and maintenance of BMPs to reduce or avoid soil loss due to wind and water erosion.

- Prior to development of any upstream areas of the site, the on-site drainage facilities would be designed to control debris potentially conveyed from the off-site watershed areas.

4.6.6 Thresholds of Significance

The following thresholds of significance criteria are based on Appendix G of the *CEQA Guidelines*. Based on these thresholds, implementation of the proposed project would have a significant adverse impact related to geology and soils if it would:

Threshold 4.6.1: Expose people or structures to potential substantial adverse effects, including the risk of loss, injury, or death involving:

i) Rupture of a known earthquake fault, as delineated on the most recent Alquist-Priolo Earthquake Zoning Map issued by the State Geologist for the area or based on other substantial evidence of a known fault

ii) Strong seismic ground shaking

iii) Seismic-related ground failure, including liquefaction

iv) Landslides

Threshold 4.6.2: Result in soil erosion or the loss of topsoil;

Threshold 4.6.3: 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 an on- or off-site landslide, lateral spreading, subsidence, liquefaction or collapse;

Threshold 4.6.4: Be located on expansive spoil, as defined in Table 18-1-B of the Uniform California Building Code (1994), creating substantial risk to life or property; or

Threshold 4.6.5: 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 waste water.

4.6.7 Project Impacts

Threshold 4.6.1: Expose people or structures to potential substantial adverse effects, including the risk of loss, injury, or death involving:

i) Rupture of a known earthquake fault, as delineated on the most recent Alquist-Priolo Earthquake Zoning Map issued by the State Geologist for the area or based on other substantial evidence of a known fault

Significant Unavoidable Adverse Impact. According to the State of California Department of Conservation (DOC) Alquist-Priolo Earthquake Fault Zone Map, portions of the project site are located in an area with known and potentially active faults and is located within a designated Alquist-Priolo Earthquake Fault Zone.

As stated previously, the project area is anticipated to experience strong ground shaking due to its proximity to the San Andreas fault and other known active faults in the region. Primary geotechnical hazards associated with strong ground shaking include near-surface fracturing, lateral spreading, liquefaction, and landslides. Other faults located within the project site are generally considered inactive, small-scale faults located within bedrock units of the Ocotillo, Palm Spring, and Canebrake soil formations. Based on the findings of trench exploration conducted as part of the *Updated Geotechnical FI Report*, some subsidiary faults located on the project site are considered tectonically active or potentially active. Figure 4.6.3 shows the locations of faults identified on site.

The *Updated Geotechnical Fault Investigation Report* was conducted to identify the location, age, and style of fault-related deformation across the site. The study resulted in the creation of Preliminary Building Restriction Zones that identify constraints for future development on site.

The Preliminary Building Restriction Zone map (*Preliminary Geotechnical Investigation*) (Figure 4.6.5, Building Zone Restrictions) includes red areas containing identified active fault zones, where no development of structures should occur; white areas delineating areas where no active fault zones were identified, and where development could occur; and yellow zones representing areas that require additional information and further geotechnical studies to either determine whether or not active faults exist or whether or not identified faults are active or inactive. Areas most likely to contain additional active faults are marked as yellow building restriction zones. These red, white, and yellow zones are based on the *Updated Geotechnical FI Report* (page 56 and Plates A and 3).

The land use plan for the proposed La Entrada Specific Plan was developed based on the building restriction zones and the geotechnical fault constraints as determined in the *Geotechnical Fault Investigation* (November 2005). Therefore, the proposed project avoids development in the red and yellow zones. The Specific Plan has been designed to avoid grading the steeper northern/northeastern and southeastern portions of the project site (refer to Figure 4.6.4, Slope Analysis) and also has incorporated a setback area to ensure that habitable structures are not placed on the identified fault traces within the Alquist-Priolo Fault Zone adjacent to the project site. In addition, the Specific Plan has incorporated areas with identified fault traces (refer to Figure 4.6.5, Building Zone Restrictions) into the open space and park components of the plan. School sites are proposed in areas that would ensure adequate separation from existing fault zones per California Government Code (Education Code) Sections 17212 and 17212.5, which specifics that "no school building shall be constructed, reconstructed, or relocated on the trace of a geological fault along which surface rupture can reasonably be expected to occur within the life of the school building." Further, all development associated with the proposed project would be designed to adhere to all of the seismic requirements incorporated into the 2010 California Residential Code and 2010 CBC (or most current building code) and the requirements and standards contained in the applicable chapters of the City of Coachella Municipal Code.

Although the 2007 geotechnical investigation was sufficient to identify all major active fault zones and most minor active fault zones in the property, the study recommended that a qualified professional geologist evaluate each phase of development at the time that future Tentative Tract Maps are submitted to determine whether or not additional studies are warranted. Although the geotechnical investigation concluded that geotechnical issues associated with faulting can be mitigated with geotechnical engineering practices, additional mapping and supplemental trenching may be necessary depending on the future development proposed, the area of development, and the scale of map utilized. For example, any development or utilities proposed in a yellow or red seismic risk zone (*Preliminary Geotechnical Report*) would require more detailed fault information prior to approval of specific locations for building foundations or inhabited structures. Future geotechnical evaluations would be needed to confirm specific boundaries of the red zone in the vicinity of any proposed residential uses in the Central Village once a specific development footprint has been identified. Mitigation Measure 4.6.1 requires that final geotechnical reports be prepared as each Tentative Tract Map is submitted for development to delineate the exact locations of faults in that specific area of the site, as well as comply with the recommendations in the *Updated Geotechnical Fault Investigation* and the *Preliminary Geotechnical Investigation*. Compliance with Mitigation Measures 4.6.1 and 4.6.2 would ensure that appropriate geotechnical evaluation is conducted prior to development of habitable structures and that recommended geotechnical measures are incorporated into final design plans. Compliance would also ensure that the habitable structures are designed and built in accordance with the seismic regulations as recommended in the CBC, thereby substantially reducing the risks associated with fault rupture to less than significant.

Utilities infrastructure (water, sewer, natural gas, and electricity) and Avenues 50 and 52 would be extended from their current locations to the west of the project site across the San Andreas fault to facilitate the project (refer to Figures 4.14.1 and 4.14.2 in Section 4.14, Public Services and Utilities). There is no feasible way to ensure the fault in this area will not rupture sometime during the life of the proposed project disrupting or severing one of more utilities or severing the roadway(s). Until such time as the I-10/Avenue 50 interchange is constructed, the only way to access the project site will be on Avenues 50 and 52. A disruption or severing of one or both of these roadways could prevent emergency services from reaching the project site. Although the roadways would be constructed per the requirements of a geotechnical and structural engineer, there is no guarantee there would be no fault rupture on the San Andreas fault (Coachella-Indio segment) along the western margin of the project site. Impacts from rupture of a known earthquake fault, as delineated on the most recent Alquist-Priolo Earthquake Zoning Map issued by the State Geologist for the area or based on other substantial evidence of a known fault, cannot be ruled out and is still considered a significant unavoidable adverse impact.

Threshold 4.6.1: Expose people or structures to potential substantial adverse effects, including the risk of loss, injury, or death involving:

ii) Strong seismic ground shaking

Less than Significant Impact With Mitigation Incorporated. The Coachella-Indio segment of the San Andreas fault is located roughly along the All American Canal in the southwest portion of the site. As previously stated, small-scale inactive faults are located within the bedrock units on the project site. These fractures are associated with major earthquakes along the San Andreas fault, which runs along the western boundary of the project site. Evidence from the fault investigation also indicates that fractures have the potential to develop anywhere on site as the result of an earthquake associated with active faults on the project site (*Updated Geotechnical FI Report*, pages 56–57). In addition, the project site contains several faults that are capable of strong ground motion. These faults are associated with the San Andreas and the Painted Canyon fault zones. During an earthquake along these faults, seismically induced ground shaking would occur; however, the severity of the shaking would be influenced by the distance of the site to the seismic source, the soil conditions, and the depth of groundwater. Due to the fact that the project site contains several active faults, the potential for strong seismic ground shaking is considered a potentially significant impact that may affect people and structures affiliated with the proposed project. As a result of the complex fault conditions on site, Petra identified two restricted use zones within the property (Plate A of the 2007 Petra report and EIR Figure 4.6.4, Building Zone Restrictions). The red zones show the location of active and potentially active fault zones on site, although the width of a particular zone may be modified in the future based on a more detailed fault investigation prior to any Tentative Tract Map approvals. Petra also identified yellow zones on site that show the locations of faults whose activity has not been established at this time, but where further investigation is needed if buildings are proposed within these yellow zones. The Specific Plan currently indicates no habitable buildings in the yellow zones (refer to Figure 4.6.4, Building Zone Restrictions).

As discussed above, Mitigation Measure 4.6.1 requires a final geotechnical report to delineate the precise locations of all active faults within each planning area and determine and refine any restricted use zones (as defined above) prior to approval of a Tentative Tract Map by the City. Mitigation Measure 4.6.1 also requires compliance with the recommendations in the *Updated Geotechnical FI Report* and the *Preliminary Geotechnical Investigation*, including recommendations for appropriate development setbacks and building engineering measures to address seismic-related impacts. Further, all development associated with the proposed project would be designed to adhere to all of the seismic requirements incorporated into the 2010 California Residential Code and 2010 CBC (or most current building code) and the requirements and standards contained in the applicable chapters of the City of Coachella Municipal Code. Compliance with Mitigation Measures 4.6.1 and 4.6.2 would ensure that appropriate geotechnical evaluation is conducted prior to development because no Tentative Tract Map would be approved by the City prior to such an investigation, and that recommended geotechnical measures are incorporated into final design plans, thereby reducing the risks associated with strong seismic shaking to less than significant.

Threshold 4.6.1: Expose people or structures to potential substantial adverse effects, including the risk of loss, injury, or death involving:

iii) Seismic-related ground failure, including liquefaction

Less than Significant Impact with Mitigation Incorporated. As previously stated, liquefaction is most likely to occur in areas where noncohesive, saturated soils experience seismically induced ground shaking and where groundwater occurs less than 5 ft bgs. Because groundwater at the project site is anticipated to be more than 50 ft bgs, liquefaction impacts are not anticipated to occur on site. However, the geotechnical investigation determined that if saturated, the Palm Spring Formation is prone to liquefaction and lateral spreading deformation during strong ground shaking.

Development of the site could introduce large volumes of water into the subsoils, which could lead to localized perched water conditions within units that could become susceptible to localized liquefaction during strong ground motion. Water saturation introduced to the project site as a result of project operations (i.e., irrigation of parks and landscape areas) could be addressed through typical civil engineering grading design (such as appropriate surface and subsurface drainage control, etc.) and proper grading recommendations (such as removal and recompaction of near surface soils, foundation design, etc.) from the required future geotechnical studies once specific building locations have been identified. This would be accomplished by removal of the soil conditions that contribute to liquefaction (e.g., recompaction, drainage control), which would be outlined in the future geotechnical studies based on actual building footprints. Therefore, implementation of Mitigation Measure 4.6.1, which requires compliance with the recommendations in the final geotechnical studies, would reduce impacts related to liquefaction to a less than significant level.

Threshold 4.6.1: Expose people or structures to potential substantial adverse effects, including the risk of loss, injury, or death involving:

iv) Landslides

Less than Significant Impact with Mitigation Incorporated. With the exception of lateral spreading type features, few landslides were observed on the property during the geotechnical investigation. An old landslide was observed on site within a trench located in the Palm Spring Formation. The Palm Spring Formation is susceptible to landslides and block failures because of its abundant clay members, localized folding, and preexisting faults. Site grading activities associated with the proposed project would potentially decrease slope stability in some areas. In addition, because the tops of ridges and slopes on site are covered with cobbles and boulders, these could potentially come loose during ground shaking associated with earthquakes on or near the project site. Landsliding and rockfall could be a potentially significant impact, particularly on the southwestern portion of the project site and in hillside areas. Therefore, Mitigation Measure 4.6.3 requires area-specific geotechnical studies to be completed by a qualified professional geologist to identify the potential for landslides and unstable slope conditions within each planning area and provide measures to reduce the potential for landslides. Specific attention shall be made to areas with a slope gradient of 30 percent or greater (refer to Figure 4.6.4, Slope Analysis). Measures that could be required to reduce landslide hazards include the construction of stabilization and/or buttress fill slopes or the placement of underground drainage systems. These and other related measures mitigate for landslides by stabilizing and reinforcing existing slopes so they can support developed uses. Implementation of Mitigation Measures 4.6.3 and 4.6.1, which require incorporation of recommended geotechnical measures into final design plans prior to approval of any Tentative Tract Maps, would reduce impacts associated with landslides to a less than significant level.

Threshold 4.6.2: Result in soil erosion or the loss of topsoil

Less than Significant Impact with Mitigation Incorporated. During construction activities, the project site would be graded and excavated, soil would be exposed to wind and water, and there would be an increased potential for soil erosion compared to existing conditions. During a high wind and/or storm event, there is a potential for soil erosion to occur at an accelerated rate. Adherence to Mitigation Measure 4.6.1 requires a specific final geotechnical study for each specific planning area to be prepared by a qualified professional geologist prior to Tentative Tract Map approval and approved by the City Engineer. The studies would contain measures to reduce the erosion potential of engineered slopes, such as enhanced compaction of fill slope faces, immediate landscaping of slopes at the completion of grading, consideration of jute matting or chemical stabilization if landscaping cannot be established within a reasonable period of time, and use of geotextile fabrics in the construction of oversteepened fill slopes or slopes subject to erosion. Soil erosion from water runoff is discussed in Section 4.9, Hydrology and Water Quality, and requires a Stormwater Pollution

Prevention Plan (SWPPP) that identifies Construction Best Management Practices (BMPs) to be implemented as part of the proposed project to minimize water quality impacts during construction, including those impacts associated with soil erosion. This requirement is set forth in Mitigation Measure 4.9.1; therefore, erosion activities associated with construction activities would be less than significant with incorporation of Mitigation Measures 4.6.1 and 4.9.1 (see Section 4.9).

As previously discussed, approximately half of the project site contains low slope gradients; however, portions of the project site contain approximately 30 percent slopes, 50 ft slopes or greater (refer to Figure 4.6.4, Slope Analysis). The proposed project would consist of large-scale grading and excavation activities that would alter existing slopes and established drainage paths, thus potentially leading to erosion. The proposed project includes channelization of the existing on-site drainages into soft-bottom channels as indicated on Figure 3.10, Conceptual Drainage Plan (refer to Section 3.0, Project Description). It should be noted that the Coachella Valley Water District would review and approve these drainage channels prior to construction as part of the City's development review process. These channels would convey regional and local flows through the project site in a southwesterly direction to the East Side Dike of the Coachella Canal. On-site drainage and erosion are further discussed in Section 4.9, Hydrology and Water Quality. Project design would incorporate erosion control devices, such as street gutters, storm drains, culverts, and detention basins, to control runoff and prevent soil erosion by water to reduce or avoid soil loss due to water erosion. In the ultimate condition, the developed site would result in substantially reduced wind- and runoff-induced erosion. Implementation of Mitigation Measure 4.6.1, which requires compliance with the recommendations in the *Updated Geotechnical FI Report* and the *Preliminary Geotechnical Investigation*, including appropriate erosion control techniques, would reduce erosion impacts to a less than significant level. Such techniques reduce potential erosion by covering native soils with impermeable surfaces or landscaping that are resistant to erosion, or channelizing excess surface runoff before it can cause erosion of native soils.

Threshold 4.6.3: 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 an on- or off-site landslide, lateral spreading, subsidence, liquefaction or collapse

The *Preliminary Geotechnical Investigation* concluded that the project site is considered suitable for the proposed development from a soils engineering and geologic engineering point of view. The report further concluded that the building site would be free from landslide, liquefaction, settlement and slippage provided the recommendations in that report were incorporated in the design criteria and project specifications, as required by Mitigation Measure 4.6.1. The recommendations include improvements such as removing unconsolidated soils and recompacting them to proper levels of compaction, stabilizing naturally weak or steep slopes through excavation and regrading at acceptable slope angles and benching, installing subdrainage systems to prevent water buildup or erosion of compacted soils, and overexcavation and deep fill with reinforced foundation designs to prevent lateral spreading or subsidence impacts.

Based on the secondary effects of seismicity discussed in the *Preliminary Geotechnical Investigation,* that report recommended that additional geotechnical investigations be performed as part of future Tentative Tract Map studies to prepare site-specific grading and foundation construction specifications. These are required by Mitigation Measure 4.6.1 to be completed prior to any Tentative Tract Map approval by the City.

4.6.8 Slope Stability

Less than Significant Impact with Mitigation Incorporated. Refer to the impact discussion under 4.6.1.iv. Although little evidence of landsliding was noted during the geotechnical investigations, site grading activities associated with the proposed project would potentially decrease slope stability in some areas. The *Preliminary Geotechnical Investigation* included a stability analysis of selected proposed cut-and-fill slopes. The results indicated that the slope stability would meet or exceed requirements in the City's grading ordinance and the CBC regarding slope stability (pages 28–29 and Appendix C, Petra 2013). However, future site-specific geotechnical studies would be completed pursuant to Mitigation Measures 4.6.1 and 4.6.3 to identify the potential for landslides and unstable slope conditions within each planning area as Tentative Tract Maps are submitted for development. Specific attention shall be given to areas with a slope gradient of 30 percent or greater, which represents approximately 10–20 percent of the site, as shown in Specific Plan Exhibit 1-3 (RBF 2012) (refer to Figure 4.6.4, Slope Analysis). These studies would have to be approved by the City prior to Tentative Tract Map approval, and their recommendations incorporated into all applicable Tentative Tract Map. Implementation of Mitigation Measures 4.6.1 and 4.6.3, which requires incorporation of recommended geotechnical measures into final design plans, would reduce impacts associated with landslides and slope stability to a less than significant level. This would be accomplished by eliminating the natural conditions that contribute to landslides or slope instability and replacing them with manufactured slopes that have been compacted and engineered to safely support project structures. These measures would become conditions of approval as part of the City's development review process.

4.6.9 Lateral Spreading

Less than Significant Impact with Mitigation Incorporated. During the geological field investigation per the *Updated Geotechnical FI Report*, abundant evidence indicating that lateral spreading had previously occurred within the Palm Spring Formation was found on site (*Updated Geotechnical FI Report*, pages 24, 29, and 30). Near-surface fracturing deformation is provided based on data acquired during the fault investigation. The vast majority of the faults across the site were associated with large-scale lateral spreading in the mid- to late-Pleistocene (approximately 12,000 years ago). This lateral spreading was most likely related to liquefaction induced by strong ground shaking. Field observations indicate that, if saturated, the Palm Spring Formation is susceptible to liquefaction and lateral spreading during strong ground shaking. However, current geological conditions are much different, and the Palm Spring Formation material is semiconsolidated and much denser. In addition, groundwater is now located at greater depths below the ground surface (over 50 ft). Therefore, the potential for lateral spreading at the site is considered to be low. However, implementation of Mitigation Measure 4.6.1 requires that a geotechnical study be prepared by a qualified professional geologist and approved by the City Engineer prior to Tentative Tract Map approval that indicates subdrains would be required in areas underlain by the Palm Spring Formation where the depth of fill exceeds 15 ft. The locations of subdrains would be determined by the project geotechnical consultant and would be reviewed and approved by the City Engineer prior to approval of any future Tentative Tract Maps. Proper drainage of irrigation and rain runoff water from the property to avoid saturation of the underlying Palm Spring Formation would minimize the potential for lateral spreading on site. Implementation of Mitigation Measure 4.6.1, which requires incorporation of recommended geotechnical measures into final design plans, would reduce impacts associated with lateral spreading to a less than significant level. These measures would eliminate the natural conditions that contribute to lateral spreading, similar to liquefaction, by removing unconsolidated soils and recompacting them to proper levels of compaction, installing subdrainage systems to prevent water buildup or erosion of compacted soils, and overexcavation of deep fill with reinforced foundation designs to prevent lateral spreading impacts. These measures would become conditions of approval as part of the City's development review process.

4.6.10 Subsidence

Less than Significant Impact with Mitigation Incorporated. Saturation of low-density, granular soils can result in subsidence and settlement under relatively low loads. A rise in the groundwater table or an increase in infiltration can initiate settlement and cause the foundations and walls of buildings or structures to crack. Compressible and collapsible materials are expected to be found in the near-surface portions of the slopewash, landslide deposits, and alluvial deposits. Removal of these upper materials would be required prior to placement of fill, as outlined in the *Preliminary Geotechnical Investigation*. Complete removal of all slopewash and shallow landslide deposits is anticipated, whereas removal of only the upper few feet of loose soils within alluvial units across the site is anticipated.

As stated in the *Preliminary Geotechnical Investigation*, Section 1808.6.2 of the 2010 CBC specifies that slab-on-ground foundations (floor slabs) resting on expansive soils would be designed in accordance with the Wire Reinforcement Institute (WRI) publication "Design of Slab-on Ground Foundation," which was last updated in 1996. The design procedures in the WRI publication are based on the expansion potential and the weighted plasticity index of the different soil layers existing within the upper 15 ft of each building site. Therefore, since the individual lots would be underlain by soil and bedrock materials with variable expansion potentials, final foundation design would contain recommendations provided by the project geotechnical consultant on a lot-by-lot basis and would be based on the actual expansion potentials and weighted plasticity indices of the soil and bedrock materials underlying each individual lot.

Therefore, the potential for collapsible soils at the site would need to be evaluated during subsequent geotechnical investigations as required in Mitigation Measure 4.6.4, prior to Tentative Tract Map approval by the City, and incorporated into the conditions of approval for each site plan. Implementation of Mitigation Measure 4.6.4 and adherence to the recommendations of the geotechnical investigations as required in Mitigation Measure 4.6.1 would reduce potential subsidence impacts to a less than significant level. These measures would remove native soils subject to subsidence and replace them and/or regrade areas of native soil to withstand expected levels of seismic shaking to the degree that habitable structures would not be destroyed by the shaking, and would use reinforced foundation designs to prevent the collapse or subsidence of soils during seismic events. These measures would become conditions of approval as part of the City's development review process.

4.6.11 Liquefaction or Collapse

Less than Significant Impact with Mitigation Incorporated. Refer to the impact discussion under Threshold 4.6.1.iii. Implementation of Mitigation Measure 4.6.1, which requires compliance with the recommendations in the final geotechnical studies, would reduce impacts related to liquefaction to a less than significant level.

Threshold 4.6.4: Be located on expansive soil, as defined in Table 18-1-B of the Uniform California Building Code (1994), creating substantial risk to life or property

Less than Significant Impact with Mitigation Incorporated. As previously discussed, expansive soils (soils with large amounts of clay minerals) are commonly found within the Palm Spring Formation on site. Typically, consequences of development on expansive soils include cracked walls, foundations, decks, sidewalks, garage floors, and driveways. Mitigation Measure 4.6.5 requires soil testing for expansive soils prior to construction and prescribes measures to be incorporated into the project design should expansive soils be found within areas proposed for development. Implementation of Mitigation Measure 4.6.5 would reduce impacts associated with expansive soils to less than significant levels. This measure requires excavation of expansive soils and replacement with nonexpansive compacted fill, additional remedial grading, utilization of steel reinforcing in foundations, nonexpansive building pads, presoaking, and drainage control devices to maintain a constant state of moisture as ways to effectively eliminate potential impacts from expansive soils.

Threshold 4.6.5: 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 waste water

No Impact. The proposed project would connect to the existing City sewer system and is not anticipated to use septic or alternative waste systems. The conceptual project plans include a connection to the City's existing sewer system at an existing lift station located along Polk Avenue and under the Coachella Canal. Therefore, because the proposed project would connect to the City's existing sewer system and because no septic tanks or alternative wastewater disposal systems are proposed as part of the proposed project, the project would result in no impacts related to septic tanks or alternative wastewater disposal systems, and no mitigation is required.

4.6.12 Mitigation Measures

Mitigation Measure 4.6.1 **Compliance with Geotechnical Investigations.** Prior to approval of any future Tentative Tract Maps, a specific final geotechnical study for each specific planning area shall be completed by the project applicant. These studies shall be submitted for review and approval by the City of Coachella (City) Engineer to ensure that each planning area with future development has been evaluated at an appropriate level of detail by a professional geologist. The location and scope of each final geotechnical report shall be tiered off of the two geotechnical reports prepared for the overall site, *Updated*

Geotechnical Fault Investigation Report (Petra Geotechnical, Inc., January 15, 2007) and the *Preliminary Geotechnical Investigation* (Petra Geotechnical, Inc., April 15, 2013).

The final geotechnical report for each planning area shall delineate the precise locations of all active faults and shall determine the appropriate building setbacks and restricted use zones within the planning area. Prior to issuance of grading permits, the City Engineer shall confirm that all grading and construction plans incorporate and comply with the recommendations included in the final specific geotechnical report for each planning area. Design, grading, and construction would adhere to all of the seismic requirements incorporated into the 2010 California Residential Code and 2010 California Building Code (CBC) (or most current building code) and the requirements and standards contained in the applicable chapters of the City of Coachella Municipal Code, as well as appropriate local grading regulations, and the specifications of the project geotechnical consultant, including but not limited to those related to seismic safety, as determined in the final area-specific geotechnical studies prepared in association with all future Tentative Tract Map conditions, subject to review by the Director of the City of Coachella Development Services Department, or designee, prior to the issuance of any grading permits.

Specifications in the *Preliminary Geotechnical Investigation* (April 5, 2013) are summarized below.

- **Grading Plan Review.** Finalized grading and development plans at each Tentative Tract Map submittal shall be reviewed by a qualified geotechnical consultant, and recommendations of the qualified professional geologist shall be incorporated in the grading and development plans prior to submittal to the City of Coachella for review and approval.
- **Building Restriction Zones.** The Preliminary Building Restriction Zones identified in the *Updated Geotechnical Fault Investigation Report* (Petra Geotechnical, Inc., January 15, 2007) and the *Preliminary Geotechnical Investigation* (Petra Geotechnical, Inc., April 15, 2013) shall be supplemented with additional mapping and trenching as necessary depending on the developments proposed, area of development, and the scale of maps utilized, particularly in the mapped yellow building restriction zones. Future Tentative Tract Map studies shall be evaluated by a qualified professional geologist to determine whether additional studies are warranted. These subsequent studies shall demonstrate that future development complies with the most current seismic requirements of the CBC and the City of Coachella Municipal Code.

- **Excavation.** On-site materials can be excavated with conventional earthmoving equipment. Some pre-ripping may be required in some areas to facilitate excavation where dense to very dense materials occur, including the Palm Spring and Canebrake Formations.
- **Soils Suitability for Use as Fill and Backfill.** On-site earth materials are generally considered suitable for use as engineered fills in the construction of building pads, roadways, and fill slopes, as long as specifications in the geotechnical report, including specified earthwork adjustments, are incorporated into project design and construction plans.
- **Surface Soils.** Surface soil deposits will require removal from all areas planned to receive fill. The estimated depths of removal range from the upper 1–5 feet, with slopewash areas requiring removal of up to 14 feet, and artificial fill requiring possible removal up to 15 feet.
- **Erosion.** Measures to reduce the erosion potential of engineered slopes shall include enhanced compaction of fill slope faces, immediate landscaping of slopes at the completion of grading, consideration of jute matting or chemical stabilization if landscaping cannot be established within a reasonable period of time, and the use of geotextile fabrics in the construction of oversteepened fill slopes or slopes subject to erosion.
- **Subdrains.** Subdrains will be required in areas underlain by the Palm Spring Formation where the depth of fill exceeds 15 feet. The locations of subdrains shall be determined by the project geotechnical consultant and shall be reviewed and approved by the City Engineer prior to approval of any future Tentative Tract Maps.
- **Geotechnical Specifications.** All geotechnical specifications as identified in the *Preliminary Geotechnical Investigation* (April 15, 2013) shall be adhered to, including:
  - Earthwork Specifications,
  - Slope Specifications,
  - Construction Specifications,
  - Post-Grading Considerations,
  - Preliminary Foundation Design Recommendations,
  - Preliminary Retaining Wall Design Recommendations,
  - Preliminary Masonry Block Wall Recommendations,

- o Preliminary Recommendations for Exterior Concrete Flatwork, and
- o Preliminary Pavement Design Specifications.

- **Corrosive Materials.** Further soil analysis for corrosive materials by a qualified corrosion engineer is warranted for areas where buried metallic building materials such as copper and ductile iron are planned for the project. In the event that sulfates or corrosive materials are found, recommendations to mitigate corrosive soils shall be provided by the qualified corrosion engineer in order to prevent concrete degradation under structures.

Mitigation Measure 4.6.2 **California Building Code Compliance and Seismic Standards.** Structures and retaining walls, if proposed, shall be designed in accordance with the seismic regulations as recommended in the CBC. Prior to issuance of any building permits, the project engineer and the Director of the City of Coachella Development Services, or designee, shall review site plans and building plans to verify that structural design conforms to the CBC.

Mitigation Measure 4.6.3 **Landslides and Slope Stability.** As planning areas are designed and prior to issuance of grading permits, area-specific geotechnical studies shall be completed by a qualified geotechnical engineer and submitted to the City of Coachella for review and approval by the City Engineer to identify the potential for landslides and unstable slope conditions within each planning area. Specific attention shall be made to areas with a slope gradient of 30 percent or greater. Specifications by the geotechnical engineer prior to grading may include the construction of stabilization and/or buttress fill slopes or the placement of underground drainage systems that may require maintenance programs to ensure their effectiveness.

Mitigation Measure 4.6.4 **Subsidence.** Prior to issuance of grading permits for Tentative Tract Maps or planning areas, area-specific geotechnical studies shall be prepared by the applicant's qualified geotechnical engineer and submitted to the City of Coachella for review and approval by the City Engineer. These studies shall include testing for collapsible soils. Laboratory analysis shall be conducted on selected samples to provide a more complete evaluation regarding remediation of potentially compressible and collapsible materials. Where appropriate, these studies shall contain specifications for overexcavation and removal of soil materials susceptible to subsidence, or other measures as appropriate to eliminate potential hazards associated with subsidence.

Per the *Preliminary Geotechnical Investigation* (Petra Geotechnical, Inc., April 15, 2013), Section 1808.6.2 of the 2010 CBC specifies that slab-on-ground foundations (floor slabs) resting on expansive soils should be designed in accordance with the Wire Reinforcement Institute (WRI) publication "Design of Slab-on Ground Foundation" (last updated in 1996). The design procedures outlined in the WRI publication are based on the expansion potential and the weighted plasticity index of the different soil layers existing within the upper 15 feet of each building site. Since the individual lots will be underlain by soil and bedrock materials with variable expansion potentials, final foundation design recommendations shall be provided by the project geotechnical consultant on a lot-by-lot basis and shall be based on the actual expansion potentials and weighted plasticity indices of the soil and bedrock materials underlying each individual lot.

Mitigation Measure 4.6.5

Expansive Soils. As planning areas are designed and prior to issuance of grading permits, area-specific geotechnical studies, including laboratory testing for expansive soils, shall be completed by a qualified geotechnical engineer and submitted to the City of Coachella for review and approval by the City Engineer. If expansive soils are found within the area of proposed foundations, geotechnical testing shall be employed such as excavation of expansive soils and replacement with nonexpansive compacted fill, additional remedial grading, utilization of steel reinforcing in foundations, nonexpansive building pads, presoaking, and drainage control devices to maintain a constant state of moisture. In addition to these practices, homeowners shall be advised about maintaining drainage conditions to direct the flow of water away from structures so that foundation soils do not become saturated.

Section 1808.6.2 of the 2010 CBC specifies that slab-on-ground foundations (floor slabs) resting on expansive soils shall be designed in accordance with WRI publication "Design of Slab-on Ground Foundation (last updated 1996). Individual lots will be underlain by soil and bedrock materials with variable expansion potentials; final foundation design recommendations shall be provided by the project geotechnical consultant on a lot-by-lot basis and shall be based on the actual expansion potentials; and weighted plasticity indices of the soil and bedrock materials underlying each individual lot.

During construction, the project engineer shall verify that expansive soil mitigation measures recommended in the final foundation design recommendations are implemented, and the City Building Official shall conduct site inspections prior to occupancy of any structure to ensure compliance with the approved measures.

4.6.13 Cumulative Impacts

The study area considered for the cumulative impacts related to geology and soils includes the project site and the immediately adjacent areas. In general, only projects occurring adjacent to or very close to the project site have the potential to generate cumulative geologic and soil impacts. There are no proposed projects or existing development other than infrastructure immediately adjacent to the project site. Therefore, the area for cumulative geology and soils area is the project site.

As described in the project-specific analysis above, the project site is located within an Alquist-Priolo Earthquake Fault Hazard Zone and contains several potentially active faults. Additionally, the project site contains areas of potentially expansive soils and is located on a geologic formation that is susceptible to both landslides and lateral spreading. As such, the proposed project would be required to implement Mitigation Measures 4.6.1 through 4.6.5 and comply with applicable State and local requirements, including but not limited to the City of Coachella Building Code and the CBC. Seismic impacts are a regional issue, and all projects must adhere to applicable seismic codes and design standards. The proposed project's individual impacts related to geotechnical constraints are considered significant even after mitigation from fault rupture. Therefore, the project's contribution to regional cumulative impacts regarding fault rupture is considered potentially significant. However, implementation of the recommended project-level mitigation, plus standard mitigation imposed by the City and County on future development in the surrounding area, would result in less than significant cumulative impacts related to geotechnical and soil constraints.

4.6.14 Significant Unavoidable Adverse Impacts

The proposed project would result in significant unavoidable adverse geologic impacts, specifically related to impacts that would result from exposing people or utilities/infrastructure to potential substantial adverse effects, including the risk of loss, injury, or death involving rupture of a known earthquake fault, as delineated on the most recent Alquist-Priolo Earthquake Zoning Map issued by the State Geologist for the area or based on other substantial evidence of a known fault. Due to the presence of the San Andreas fault, even with the incorporation of Mitigation Measures 4.6.1 and 4.6.2, the potential for significant unavoidable adverse impacts from fault rupture may still result with implementation of the proposed project.

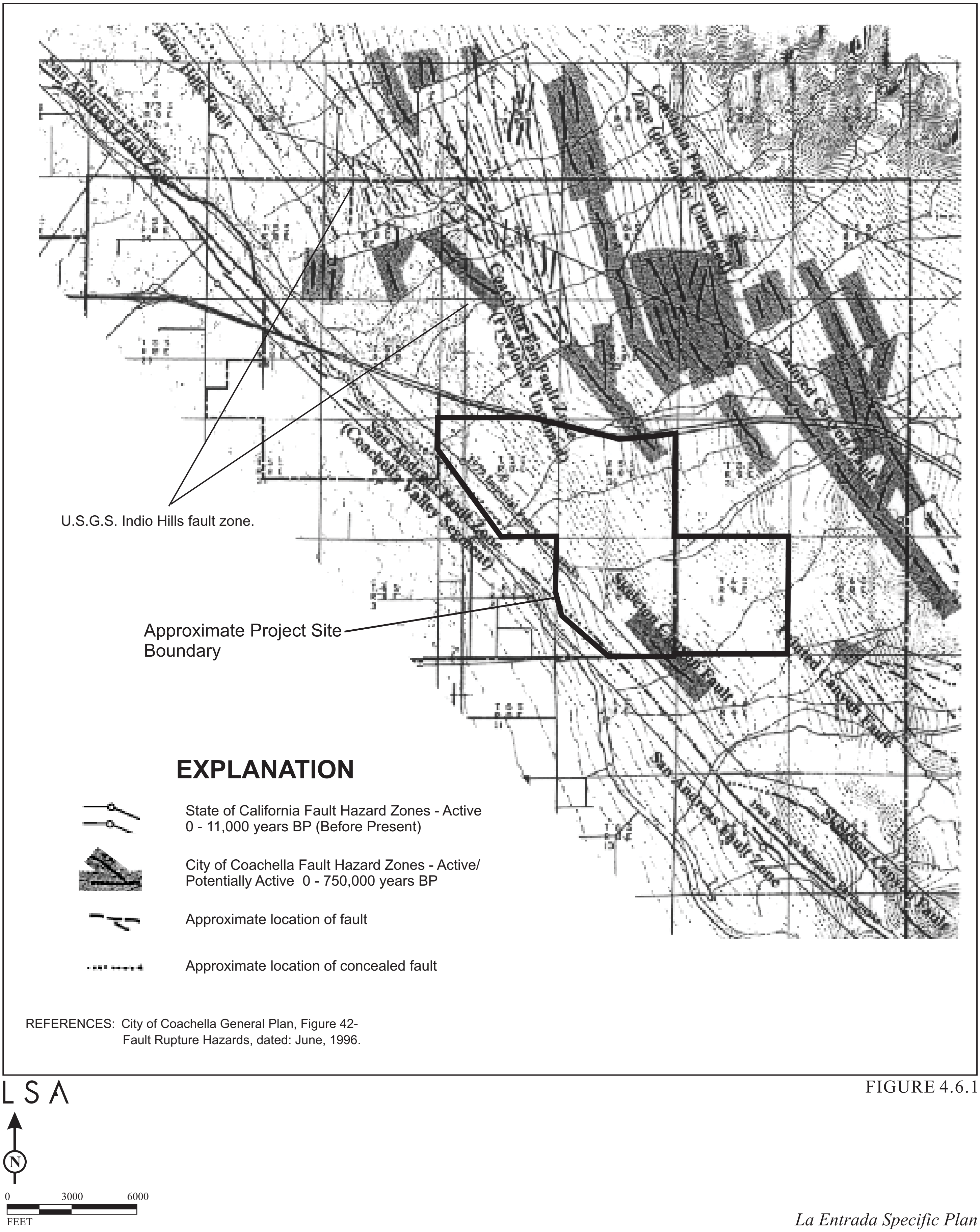

FIGURE 4.6.1

La Entrada Specific Plan

Regional and Local Fault Locations

SOURCE: Petra Geotechnical, Inc. - Updated Geotechnical Fault Investigation Report for Land Planning Purposes, Approximately 2200 Acre Property (Lomas Del Sol), 2007

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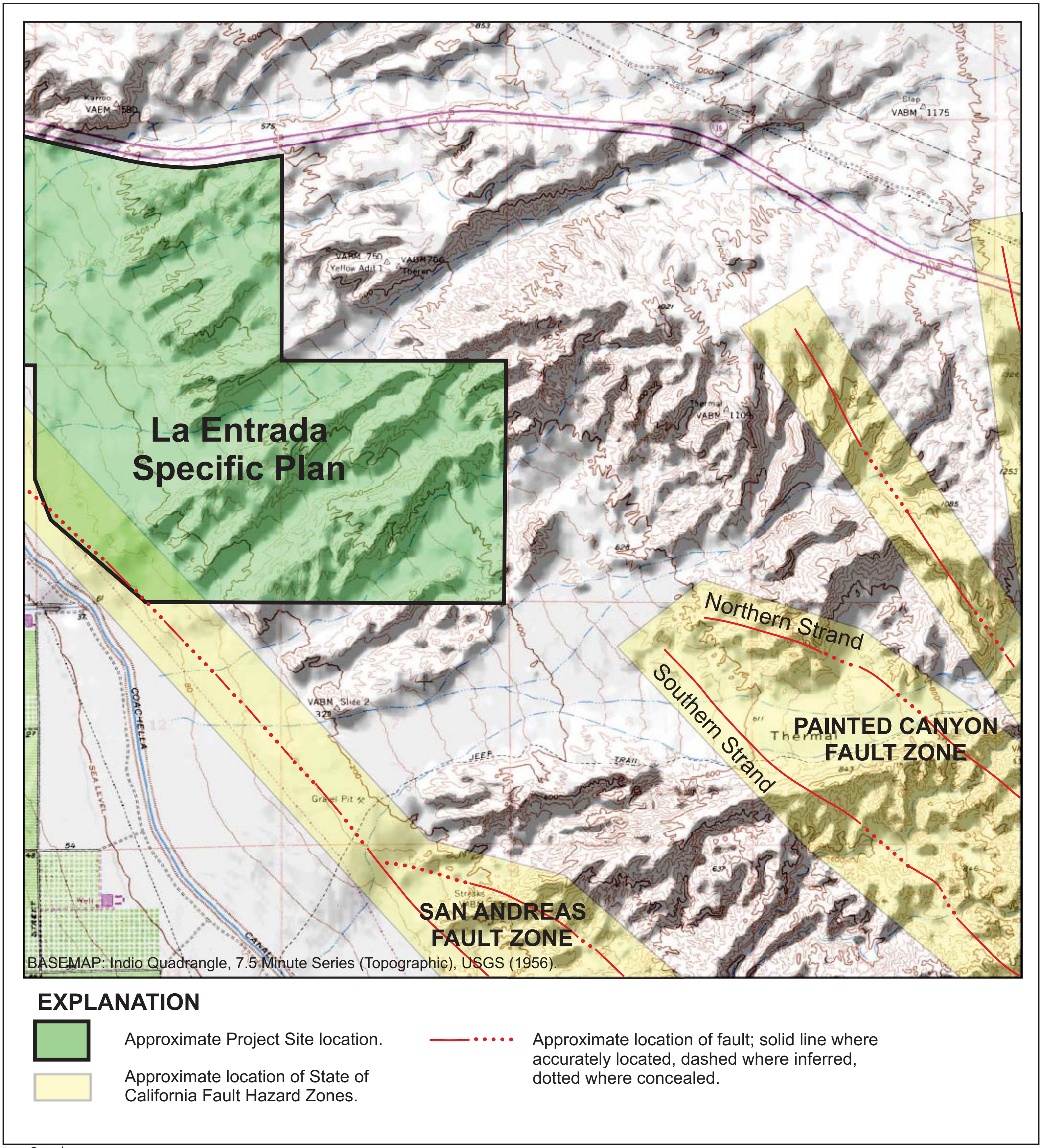

LSA

FIGURE 4.6.2

0 1500 3000
FEET

SOURCE: Petra Geotechnical, Inc. - Updated Geotechnical Fault Investigation Report for Land Planning Purposes, Approximately 2200 Acre Property (Lomas Del Sol), 2007

La Entrada Specific Plan
Fault Hazard Zones

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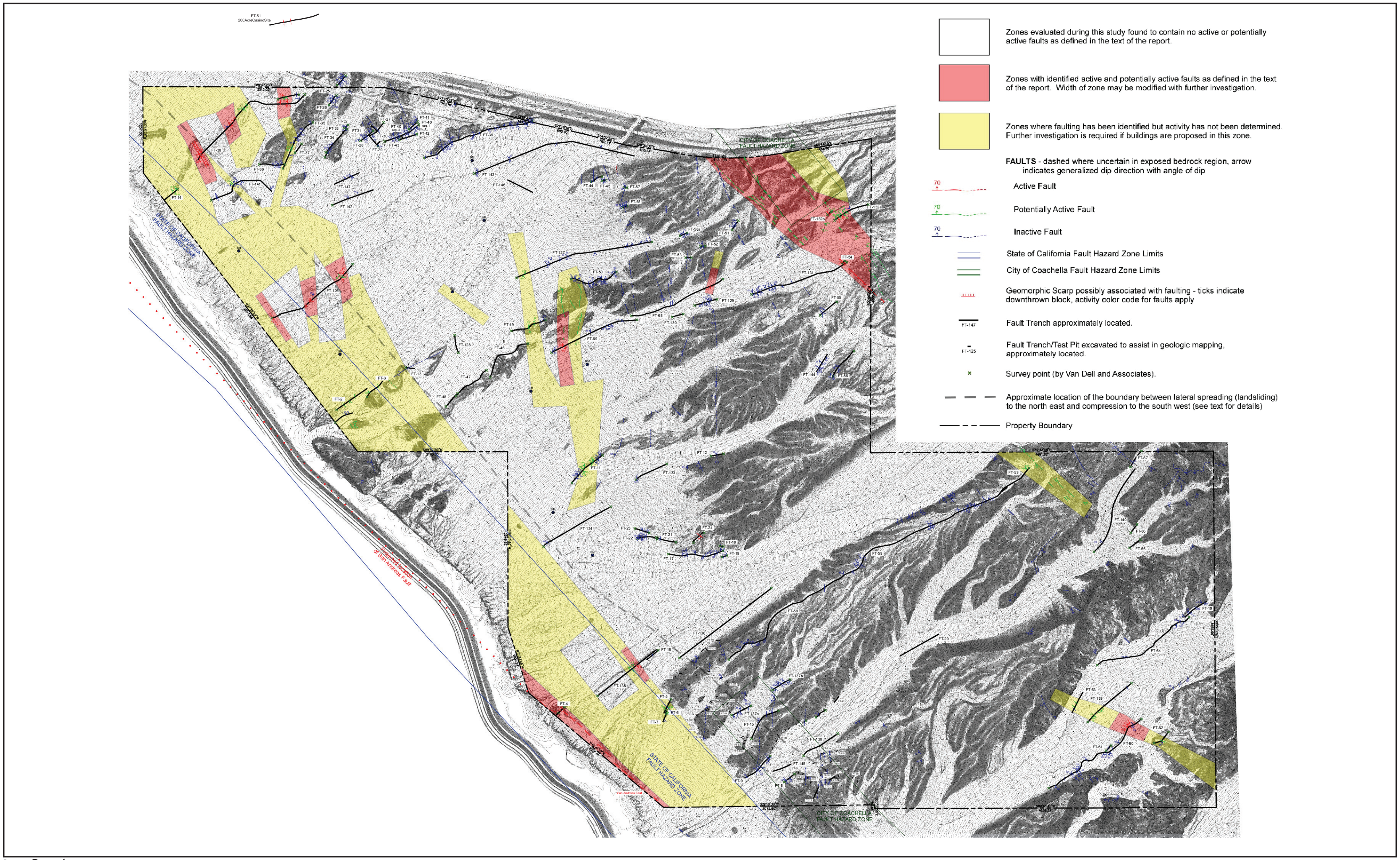

LSA

FIGURE 4.6.3

N

0 1100 2200

FEET

SOURCE: Petra Geotechnical, Inc. (2013)

La Entrada Specific Plan

Fault Locations on the Project Site

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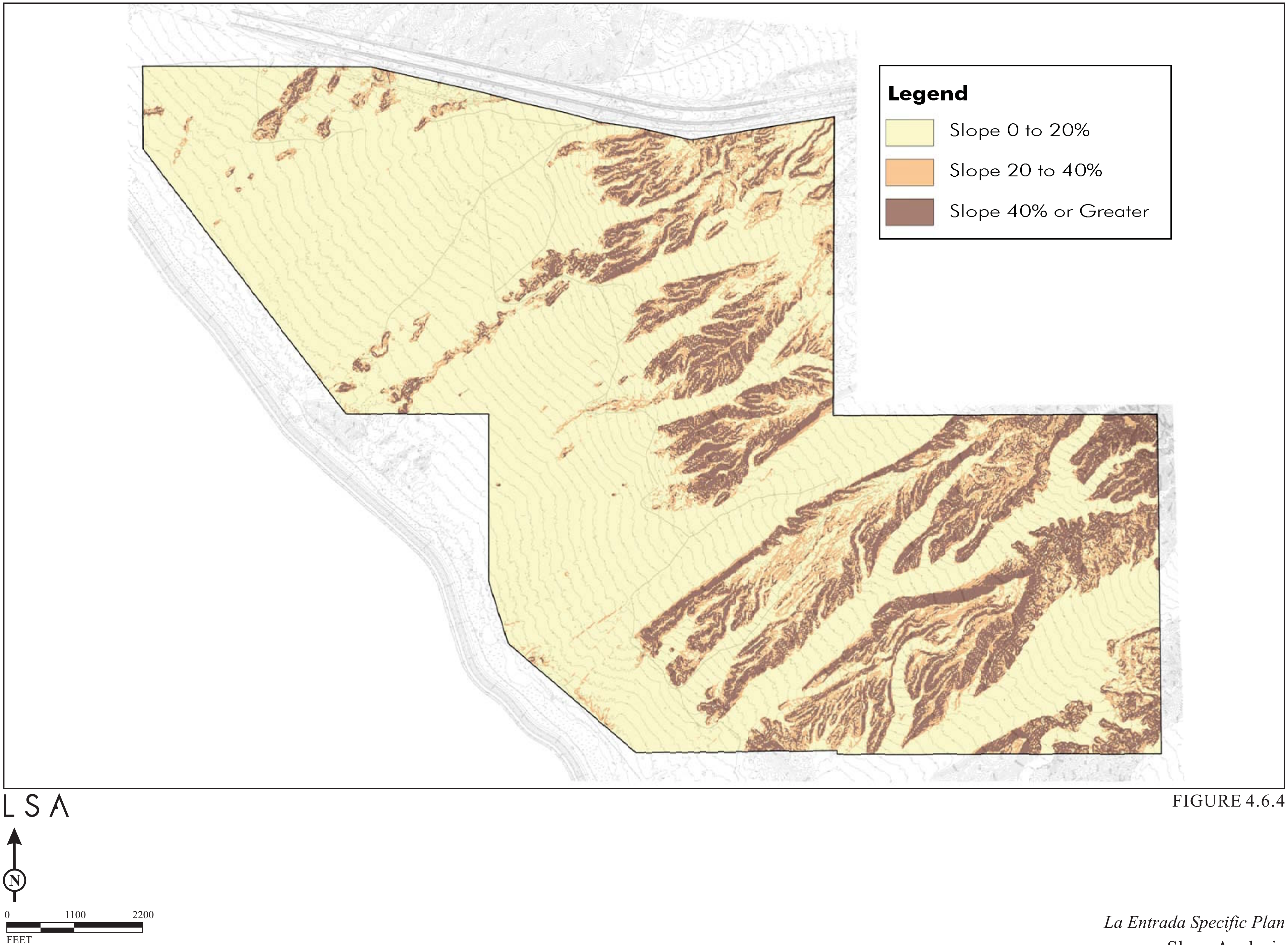

LSA

FIGURE 4.6.4

SOURCE: Draft La Entrada Specific Plan (RBF, April 2013)

La Entrada Specific Plan

Slope Analysis

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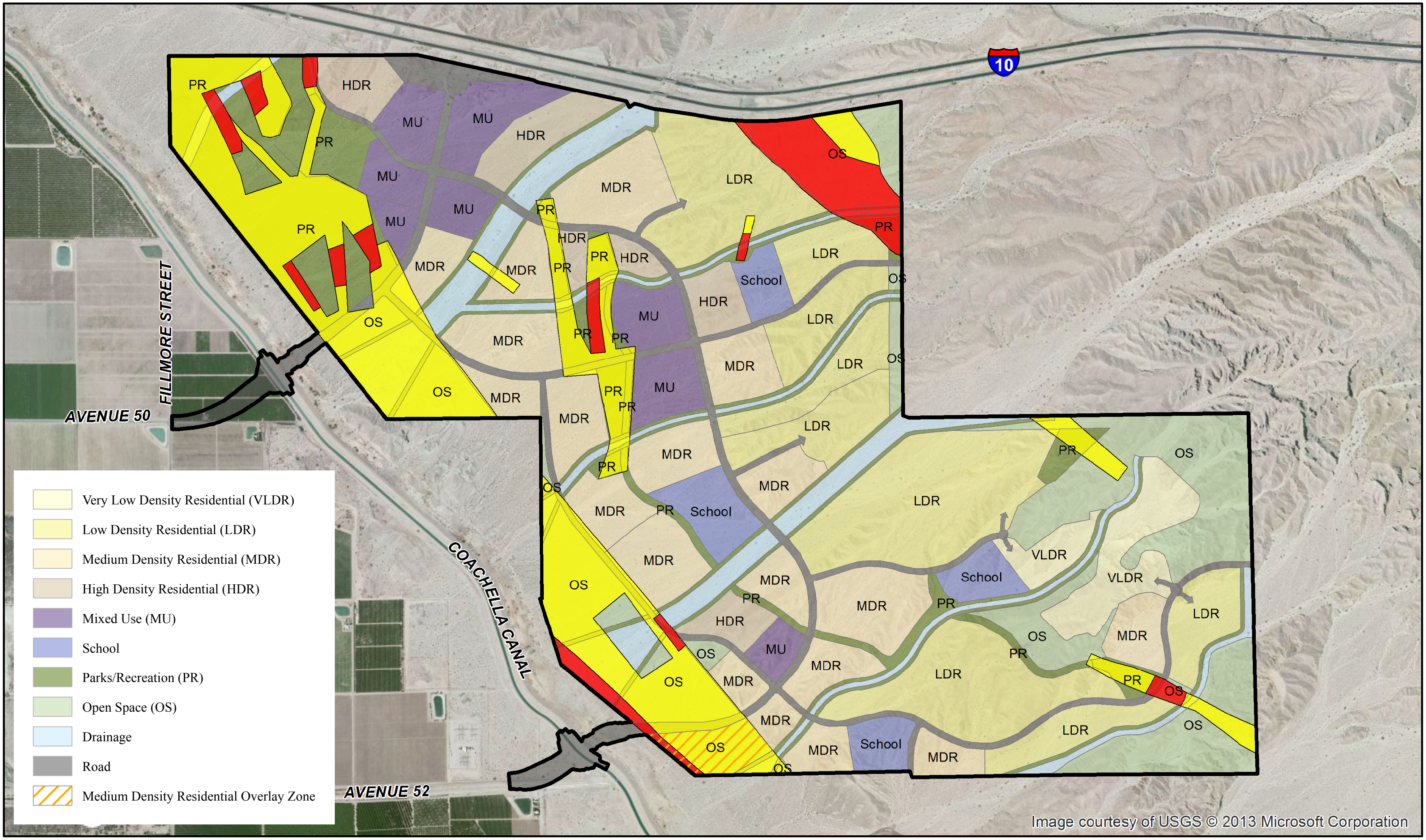

LSA

LEGEND

Project Location

Zones with identified active and potentially active faults

Zones where faulting has been identified but activity has not been determined

0 1000 2000
FEET

FIGURE 4.6.5

La Entrada Specific Plan

Building Zone Restrictions

SOURCE: Bing (c. 2010); La Entrada Specific Plan (RBF, 2013) and Petra Geotechnical Inc. (2013)

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