5.3 GEOLOGIC HAZARDS AND RESOURCES

This section presents information on the general geology of the region, subsurface conditions at the Solar Two Project (Project) Site, the geologic hazards affecting the Project and associated linear facilities (transmission lines, access road, and water supply pipeline), and the potential effects of the Project on geologic resources. The evaluations of effect significance are based on the type and the proximity of resources to the Project. Recommendations are provided for mitigation of geologic hazards and geotechnical issues at the Project Site.

The primary geologic sources of published information used for this report include the United States Geological Survey (USGS), the California Geological Survey (CGS) (formerly the California Division of Mines and Geology), and Imperial County. Much of the geologic information in this region is based on geologic mapping compiled by Morton (1966) and the Seismic and Public Safety Element of the Imperial County General Plan (Imperial County 1993).

A limited geotechnical and geologic investigation was performed at the Project Site by URS Corporation (URS). The results were presented in a report titled "Preliminary Geotechnical and Geologic Hazards Investigation, Solar Two, Imperial County, California," dated 30 May 2008. This report is provided in Appendix E, Preliminary Geotechnical and Geologic Hazards Evaluation.

Subsurface information is also available from previous projects at and in the vicinity of the Project Site. Two geotechnical studies were previously performed for the existing transmission line that traverses the Project Site. The results of the studies are contained in two reports prepared by URS (formerly Woodward-Clyde Consultants): (1) "Geotechnical Investigation for Jade to Imperial Valley Substation Segment of the Miguel-Imperial Valley 500-kV Transmission Line (Tower Sites 213 through 312, PI 21-28)," dated 12 June 1981, and (2) "Supplemental Geotechnical Investigation for Realigned Towers Along the Miguel-Imperial Valley 500 kV-Transmission Line (Tower Sites 22 through 313)," dated 17 June 1982. Excerpts from these studies are included in Appendix E, Preliminary Geotechnical and Geologic Hazards Evaluation. Another geotechnical report was prepared by Benton Engineering, Inc., titled "Proposed Imperial Valley Substation, Phase III, Site 7A, Imperial Valley, California," dated 14 November 1980, for the substation at the eastern terminus of the proposed transmission line.

5.3.1 Project Description

The Project will encompass approximately 6,500 acres in Imperial County, 14 miles west of El Centro, California. The Project Site is bound by Evan Hewes Highway on the north and Interstate 8 on the south. The majority of the Project components are west of Dunaway Road. Project linears extend to the east and southeast.

The Project will be constructed in two phases: one 300-megawatt phase and a 450-megawatt phase. Power will be supplied by up to 30,000 SunCatchers, which are solar dish structures each supported on a single metal fin pipe foundation that is hydraulically driven into the ground. These foundations are expected to be 13 feet long and 24 inches in diameter, with 12-inch wide fins extending from each side of the pipe pile. Drilled pier-type foundations (also called cast-in-drilled-hole piles) would be used where fin pipe foundations are not practical.

SunCatcher foundations will be installed at a spacing of approximately 112 feet in the east to west direction and 56 feet in the north to south direction. The dish foundations will be lightly loaded, with uplift or overturning forces expected to dominate engineering design considerations.

A Main Services Complex will be constructed near the center of the Project Site and will include three SunCatcher assembly buildings, administrative offices, an operations control room, maintenance facilities, and a water treatment complex. Preliminary details of the structures in the Main Services Complex are as follows:

- an operation and administration building – one story, approximately 200 feet long by 100 feet wide by 14 feet high,
- a maintenance building – approximately 400 feet long by 200 feet wide by 44 feet high,
- three assembly buildings – each 211 feet long by 170 feet wide by 78 feet high,
- a substation building – approximately 100 feet long by 30 feet wide by 14 feet high,
- a water treatment roof cover – approximately 100 feet long by 100 feet wide by 14 feet high, constructed with no walls and a metal roof, and
- storage tanks for fuel and water – supported at-grade on perimeter foundations.

The structures detailed above are expected to be supported on shallow spread and continuous footings or mat-type foundations. A 100-acre area east of Dunaway Road will be used as a construction laydown and truck staging area. Perimeter security fencing and access gates will be constructed at the Project Site, including additional fencing and gates around the main buildings and construction laydown areas.

Linear Project elements include two utility lines, a waterline, and an electrical transmission line. A 6-inch diameter water supply pipeline will be constructed a distance of approximately 7.18 miles from the Imperial Irrigation District Westside Main Canal to the Main Services Complex. The Project will be connected to the power grid through the San Diego Gas & Electric Imperial Valley Substation by a 230-kV transmission line approximately 10.35 miles long. Approximately 85 to 100 double-circuit tower structures will be installed at a spacing of approximately 650 feet to 800 feet, with a dead-end structure in the substation. Transmission towers will generally be steel lattice and/or steel poles. The lattice towers will be supported on four spread footings, one on each corner. The steel poles for the transmission line connection will be supported on cast-in-drilled-hole piles. Where the transmission line crosses under the existing San Diego Gas & Electric Company's 500-kV transmission line, H-frame towers will be used for the 230-kV interconnect transmission line. The foundations for the H-frame towers will consist of two cast-in drilled hole piles.

Paved roadways will be constructed for main travel routes, with unpaved routes used between alternate rows of SunCatchers for construction and maintenance access. In addition, unpaved perimeter roads will be installed to provide security access along the perimeter fence lines. Polymeric stabilizers may be used in lieu of traditional road construction materials for paved roads or to stabilize unpaved roads. Earthwork will be kept to a minimum during Project Site preparation; however, earthwork is required to establish the grade for the building site, substation, and paved arterial roads. Paved roadways will be constructed as close to the existing topography as possible, with limited cut and fill operations to maintain roadways at slopes of less than 10 percent. Blading for unpaved access routes and foundations will occur between

alternating rows of SunCatchers. Minor localized hills or depressions will be removed as needed to provide for proper alignment and operation. Minor cut and fill slopes will be constructed at 2:1 (horizontal:vertical) or flatter. Culverts will be installed in a limited fashion as necessary for crossing of natural washes. Building sites will be developed per Imperial County drainage criteria, with provisions for retention and evaporation basins within the Main Services Complex. In general, cuts and fills on the site will be localized.

5.3.2 Affected Environment

The Project Site is located along the western margin of the Salton Trough near the west side of Imperial County. The Salton Trough is a sedimentary basin that was occupied by Ancient Lake Cahuilla as recently as about 300 years ago. One of the ancient shorelines of Lake Cahuilla is located near the eastern site boundary. The central and western portions of the site are characterized by low and moderate relief alluvial zones and washes. The surficial alluvial materials, created by erosion of the mountains to the west and northwest, are underlain by sandstone and claystone of the Palm Spring Formation. The site is in a highly seismic region of California within the broad limits of the San Andreas fault system.

The following subsections describe the existing geologic and soil conditions, geologic hazards and geologic and mineral resources in the Project area.

5.3.2.1 Geology and Subsurface Conditions

Physiographic Setting

The Project is within the western portion of the Salton Trough, a topographic and structural depression within the Colorado Desert physiographic province. It is bounded by Coachella Valley, by the Gulf of California to the south, and by mountain ranges to the east and west. The Salton Trough is a structural basin filled of marine and poorly clastic fluvial sediments up to 15,000 feet in thickness (Dibblee 1954) overlaying the basement rock. The Salton Trough has filled with sediment due to erosion off the surrounding mountains and Colorado River deposits. It has been inundated by sea level changes and the Colorado River. Ancient Lake Cahuilla formed in the Salton Trough during the last 1,000 years and evaporated completely nearly 300 years ago (Sieh 1986). The Project Site is near the eastern shoreline of the former Lake Cahuilla within the Yuha Desert basin. The lowest portion of the Salton Trough is currently occupied by the Salton Sea, a human-made inland lake with no natural outlet.

The ground surface at the Project Site generally slopes gradually down to the northeast, ranging from about sea level (elevation 0[1]) near the northeastern corner of the site within the construction laydown area, to elevation 345 feet near the southwestern corner of the site development area.

[1] The Project vertical datum is North American Vertical Datum 88.

Regional Stratigraphy

Figure 5.3-1, Stratigraphy in the Salton Trough, presents a generalized depiction of the stratigraphy in the area. The stratigraphic units generally interfinger within the trough, creating asymmetric sedimentary facies. Correlation of stratigraphic units across the basin is particularly difficult both in outcrops and in the subsurface because of abrupt lateral changes, as is characteristic of these types of deposits. The units are discussed in detail below.

The basement of the Salton Trough is composed of Late Cenozoic and older crystalline igneous and metamorphic rocks. Extensive geophysical studies by the USGS in the Imperial County region indicate that the sub-basement, or lower crust, beneath the axis of the Salton Trough is composed of a mafic intrusive complex similar to oceanic middle crust (Fuis and Kohler 1984).

The oldest sedimentary units in the western Imperial County region, mapped by Dibblee (1954) and later compiled and modified by Morton (1966), are the Middle to Late Miocene-age Split Mountain Formation and the Pliocene-age Imperial Formation.

The Split Mountain Formation originally was named by Tarbet and Holman (1944) and later described by Woodard (1974) as having four gradational members. These members include a coarse-grained, locally derived detritus from the surrounding mountains with local interbeds of sandstone and shale. The Split Mountain Formation lies noncomformably on the crystalline basement rocks and the red alluvial sands of the Miocene-age Anza Formation observed in the western margin of the basin (Sylvester and Smith 1976).

The Early Pliocene- to Late Miocene-age Imperial Formation, originally named by Woodring (1932), consists of fine-grained marine-derived strata within the basin. Tarbet (1951) described the Imperial Formation as mostly consisting of interbedded fine sandstone and silty mudstones with biostomal limestone and calcareous arenite. The Imperial Formation grades downward into, and interfingers with, the Fish Creek Gypsum and the Split Mountain Formation. The upper members of these formations record a gradual change to continental deposition as the Colorado River delta developed. The marine waters of the Gulf were cut off intermittently from the Salton Trough by growth of the Colorado River delta and the rise and fall of sea levels, ensuing in the closed basin present today. The deltaic deposits consist of interbedded pebble conglomerates, sands, silts, and clays. The Pliocene-age Canebrake Conglomerate, mapped mostly in the northern parts of the basin, is composed of these coarse basin margin facies.

The younger Pleistocene- to Late Pliocene-age Palm Spring Formation is composed of interbedded finer-grained sandstone and nonmarine and marine mudstone, and grades downward into the Imperial Formation. The sediment source was the rising Peninsular Ranges batholith of Southern California and northern Baja California in the west and the Colorado River to the east (Dibblee 1954). Winker (1987) described the Palm Spring Formation as consisting chiefly of light gray, arkosic sandstone and reddish clay of fluvial and alluvial-fan deposits and minor lacustrine deposits representing interfingering, laterally gradational deltaic and basin-marginal sedimentary facies (Todd 2004). Mudstones of both the Imperial and the Palm Spring formations exhibit an expansive popcorn-like fissile texture (Rockwell et al. 1990; Rockwell and Stinson 1990).

During the Late Pleistocene, the basin was periodically inundated by flood water of the Colorado River to form lakes. The fine-grained silts and clays of lacustrine origin represent the Borrego and Brawley formation, which are exposed in the northern basin region. Continued deposition of

coarser sediments of the Colorado River along the basin margin during the Pleistocene resulted in the Ocotillo Conglomerate Formation. The most recent sediments deposited in the basin, the Holocene Lake Cahuilla Beds, resulted from a series of fresh to brackish water lakes of the Salton Trough. The lake bed deposits consist of tan and gray fossiliferous clay, silt, sand, and some gravel. Young alluvial deposits overlie or interfinger with the Lake Beds around the margins of the ancient lake region that formed the present day expression of the ancient Lake Cahuilla shoreline.

Local Geology

The geologic units in the Project vicinity are presented in Table 5.3-1, Geologic Conditions, and are shown on Figure 5.3-2, Regional Geologic and Mineral Resources Map, and the associated legend on Figure 5.3-3, Legend for Regional Geologic and Mineral Resources Map.

Table 5.3-1
Geologic Conditions

Geologic Map Unit	Unit or Formation Name	Description/Comments
Qal	Young Alluvium	Holocene; unconsolidated gravel, sand, silt and clay; primarily as valley fill and streamwash deposits.
Qc	Colluvium	Holocene; unconsolidated loose clay, silt, sand and gravel of slopewash, grades locally into younger and older alluvium.
Ql	Lake Beds	Holocene; tan and gray fossiliferous clay, silt, sand and gravel; sediments of ancient Lake Cahuilla and playa lakes.
Qoa	Older Alluvium	Late Pleistocene to Holocene; partly dissected largely unconsolidated poorly sorted sand and gravel of alluvial fans, terraces, and valley fill deposits.
QPlps	Palm Springs	Pleistocene and Pliocene; interbedded nonmarine sandstone, siltstone, and claystone locally containing pebble and cobble interbeds.

Source: Geologic unit abbreviations modified from Morton, 1966.

The Project Site is east of Ocotillo, California, approximately 23 miles southwest of the Salton Sea and 100 miles northwest of the Gulf of California. The site is located in the western margin of the Salton Trough within the Yuha Desert geomorphic subprovince. The area within a 2-mile radius of the Project is underlain by marine and nonmarine fine- and coarse-grained deposits of the Yuha Desert. Geomorphic features near the Project are shown on Figure 5.3-2, Regional Geologic and Mineral Resources Map, and include the Yuha Basin, Bullhead Slough to the east, the Coyote Mountains to the northwest, the ancient Lake Cahuilla shoreline to the east, the Peninsular ranges batholith to the west and southwest, and the Laguna Salada basin to the south.

The Yuha Desert region has been uplifted exposing what were once basin sediments. The area lies at a complex intersection of the northwest-trending right-slip Elsinore and Laguna Salada faults, and the Yuha Wells fault zone. The local topography is low to moderate-relief, with significant erosion expressed as badlands. The localized badlands topography consists of the Pliocene- and Pleistocene-age Palm Spring Formation overlying the Miocene-Pliocene-age Imperial Formation (Todd 2004). Deformation along the northeast-striking Yuha Wells fault system has locally sheared the sediments. Many faults and fractures exposed in the badlands contain a distinctive pinkish-brown colored clay gouge (Thomas and Stinson 1990).

Erosion of the mountains to the west and northwest, and within the local badlands, deposited unconsolidated older alluvium of poorly sorted silt and clay, sand and gravel around the surrounding region.

The immediate Project Site is chiefly underlain by the reddish mudstones and yellow well-indurated concretionary sandstones of the Palm Spring Formation, and Holocene- and Late Pleistocene-age alluvial deposits. The younger Holocene-age alluvial deposits and the ancient Lake Cahuilla lacustrine deposits dominate the eastern part of the Project Site, as shown on Figure 5.3-4, Site Geologic Map. Evidence of Lake Cahuilla's last shoreline is still present around Imperial County and can be seen as beach berms near the eastern part of the Project. In general, these lake bed sediments of interbedded fine-grained sand, silts and clays in the Imperial County region are estimated to be generally 100 to 300 feet thick (Kovach et al. 1962) near the center of the former lake.

Subsurface conditions are described in greater detail in Appendix E, Preliminary Geotechnical and Geologic Hazards Evaluation. Based on limited hollow stem borings performed during the recent and previous geotechnical investigations, the near-surface deposits are composed primarily of silty sand (Unified Soil Classification System symbol SM), clayey sand (SC), poorly graded sand with silt (SP-SM), and poorly graded sand with clay (SP-SC). The near-surface alluvium, colluvium, and lake deposits are of similar composition, although shells were found within the lake deposits. The surficial materials range from loose to dense and are typically 2 to 7 feet thick, although they may be up to 15 to 20 feet thick in the deeper alluvial channels. In some areas, a poorly developed crust is present at the ground surface where wind has eroded the finer-grained particles.

The surficial materials are underlain by the Palm Spring Formation, except in limited areas where the formation is exposed at the ground surface. The formational materials were observed to consist of interlayered zones of medium dense to very dense sandstone and very stiff to hard claystone. The sandstone contains varying amounts of silt and clay, and the claystone typically has medium to high plasticity.

The Project Site and the linear facilities are underlain by very similar geologic conditions. The transmission line traverses similar materials to those present on the Project Site and skirts the edge of the lake deposits. The waterline extends several miles into the area mapped as lake deposits. Where the lake deposits are thicker, they may contain zones of clayey lacustrine deposits with the potential for moderate to high expansion potential.

Groundwater levels in the Project area are influenced primarily by recharge at the base of the mountains west of the site, water levels in the Salton Sea to the east, and infiltration throughout Imperial County resulting from irrigation canals. Groundwater pumping wells are also present in the Project vicinity. Groundwater depths may be on the order of 50 to 100 feet below the ground surface in much of the Project vicinity, although it is likely to be deeper in the higher elevation areas of the Project Site (Resource Design Technology 2008). Groundwater levels may be higher locally due to irrigation water. Groundwater was encountered in three of the borings advanced for the URS geotechnical investigation. The static water level at the time of drilling was measured at a depth of about 45 feet below the ground surface along Dunaway Road (approximate elevation 10 feet). Groundwater was also encountered near the U.S. Gypsum

property at a depth of about 50 feet below the ground surface (approximate elevation 90 feet), although it is expected that groundwater in that area may be influenced by infiltration from ponds on that property.

Tectonic Framework

The Salton Trough is a region of transition from the extensional tectonics of the East Pacific Rise in the Gulf of California to the transform tectonic environment controlled by the San Andreas fault system (Elders 1979). The Salton Trough may have first developed as a major half-graben during regional crustal extension of western North America during the Miocene. Crustal attenuation during the Miocene may have helped to preferentially localize the faults of the San Andreas system within narrow zones or blocks of rigid upper crust during the onset of transform faulting (Frost et al. 1997). The left-lateral or dextral relative plate motion between the North American plate and Pacific plate is thought to be transferred mostly to the San Andreas fault near the eastern part of the Salton Sea. The three main fault zones from east to west that comprise the right-lateral San Andreas fault system within the Salton Trough region are the San Andreas, the San Jacinto, and the Elsinore-Laguna Salada fault zones. These three main fault zones form clear tectonic boundaries around the complex oblique pull-apart basin of the Salton Trough. Geophysical studies indicate the presence of a steep gravity gradient across the San Andreas fault along the eastern edge of the Trough (Biehler et al. 1964). This gravity gradient indicates that the northwest-trending San Andreas fault is the principal structural boundary between the Salton Trough and the western edge of the North American plate (Sylvester and Smith 1976).

Two north-south oriented tensional spreading centers have been identified in the Salton Trough based on geophysical surveys and recent volcanic activity (Kerr and Kidwell 1991; Fuis and Kohler 1984). One spreading center is in the southern end of the Trough, approximately 18.5 miles south of the international border of Mexicali Valley of Baja California. The second spreading center is in the northern end of the Trough and extends from the southern part of the Salton Sea to the south under the city of Brawley. Volcanic activity associated with these spreading centers has reached the surface and formed the Cerro Prieto volcano in Mexico and the Salton Buttes near the southeastern shoreline of the Salton Sea. Both are composed of rocks similar in origin to the volcanic rocks of the East Pacific Rise in the Gulf of California (Elders 1979).

The western portion of the Salton Trough formed along the eastern edge of the Pacific plate, which is composed of intermediate composition granitic rocks of the Peninsular Ranges physiographic province. The Salton Trough occupies the structurally weak zone between the strong, rigid edges of the Pacific and North American plates. The Salton Trough region has been offset along multiple strands of the San Andreas system, including the Elsinore, San Jacinto, Superstition Hills, Superstition Mountain, and Imperial faults. A zone of high seismicity connects the San Andreas fault northeast of the Salton Sea and the Imperial fault south of the city of Brawley. Between the San Andreas and Imperial faults, the structurally low area, called the Brawley Seismic Zone, may be the result of a releasing step. Between the San Andreas, San Jacinto, and Elsinore fault zones are sets of left-lateral cross faults.

The northeast-trending, discontinuous, some laterally continuous, sinistral cross faults to the dominant northwest-trending faults of the San Andreas system are common throughout the Salton Trough. These cross faults have an opposite sense of slip to the dominant right-lateral or

dextral transform faults of the San Andreas system. South of the Salton Sea are the Elmore Ranch cross faults associated with the San Andreas and San Jacinto fault zones. In the Yuha Desert region, southeast of Ocotillo, are the Yuha Wells fault and other related cross faults with an average strike of N35E (Thomas and Stinson 1990).

Faults and Seismicity

The Project and associated linear facilities are in one of the most seismically active areas in North America. At least two-thirds of the relative motion between the North American and Pacific plates in California occurs in the San Andreas fault system (Hutton et al. 1991; Sieh and Jahns 1984). In Southern California, deformation on this complex fault system is spread over four major fault zones: the San Andreas fault zone, the Imperial fault zone, the San Jacinto fault zone, and the Elsinore fault zone. Another prominent seismogenic structure in Imperial County is a zone of high seismicity connecting the northwestern end of the Imperial fault and the southeastern end of the San Andreas fault called the Brawley Seismic Zone (Johnson and Hill 1982).

Maps showing the primary seismic sources and earthquake epicenters greater than magnitude 3 are shown on Figure 5.3-5, Regional Active Fault Map, and Figure 5.3-6, Regional Seismicity Map. The following subsection discusses significant faults within a 100-kilometer (62-mile) radius of the Project in order of increasing distance.

Yuha Wells Fault

The Yuha Wells fault consists of a complex zone of anastamosing strands between the northern terminus of the Laguna Salada fault and the southern end of the Elsinore fault (Rockwell and Stinson 1990). The Yuha Wells fault is located within the Project Site and projects to the southwest approximately 8 miles across Highway 98 (Jennings 1994). Little published documentation of the approximate magnitude and recurrence intervals of its seismicity is available. However, geologic researchers from San Diego State University (Rockwell et al. 1990; Thomas and Stinson 1990) have delineated Quaternary scarps and lineaments and possible left lateral separation of Holocene stream channels to the south-southeast of the Project Site near Highway 98. These researchers view the evidence as suggestive of active fault surface rupture. They also note, however, that the geomorphic expression of the Yuha Wells fault decreases to the northeast as it nears the Project Site and that active faulting along this zone does not appear to significantly cut the ancient Lake Cahuilla shoreline. Within the Project Site, the main fault trace appears to either terminate or splay out into a more diffuse zone of minor faults. Evidence of fault displacement was found in two different drainages within the Project area which may represent two splays of the Yuha Wells fault. These faults are shown on Figure 5.3-4, Site Geologic Map. The activity of these faults has not been confirmed, but they are not that well expressed geomorphically and they may not have experienced Holocene fault rupture (last approximately 11,000 years).

Dixieland Fault

Along Evan Hewes Highway to the east of the Project Site, a zone of surface deformation was observed by an Imperial County Sheriff's Deputy in December 1969. The deformation consisted of ground cracks or soil subsidence along a linear zone trending to the northwest and southeast across the highway. It is thought that the ground disturbance may have been caused by a nearby

seismic event 2 years before the observation; however, controversy exists as to whether it represents fault rupture or an associated seismic hazard (Smith 1979). The Dixieland "fault" has been mapped based on the surface deformation noted, but some controversy remains as to the actual nature of the feature and if it represents a significant earthquake fault or if it is a nontectonic structure associated with subsidence. The eastern end of the proposed waterline alignment crosses this feature (see Figure 5.3-2, Regional Geologic and Mineral Resources Map).

Laguna Salada Fault

The Laguna Salada fault trends northwest and is approximately 4 to 5 miles south of the Project near the international border of northern Baja California, Mexico. The fault is approximately 47 miles long and bounds the western margin of the Sierra Cucapa Mountains. The northern Laguna Salada fault may be linked to the Elsinore fault across a complex zone of northeast and northwest-striking faults in the Yuha basin (Mueller and Rockwell 1995).

The most recent large earthquake along the Laguna Salada fault is most likely the earthquake in 1892. The estimated moment magnitude (M_w) for this event, based on ground rupture lengths and measured offsets is 7.1 (Mueller and Rockwell 1995). CGS fault parameters for the Laguna Salada fault indicate a slip rate of 0.14 inch per year, and a maximum M_w of 7.0.

Elsinore Fault Zone

The southern end of the Elsinore fault zone is mapped approximately 10 miles northwest of the Project. The Elsinore fault zone extends northward from this point approximately 140 miles to the Los Angeles basin, where it splays into the Whittier and Chino faults. This fault zone is the major structural boundary between the Peninsular Ranges and the western side of the Salton Trough (Frost et al. 1997).

The Elsinore fault zone is characterized by a moderate amount of seismicity, having experienced several earthquakes in the magnitude range M_w5.0 to 6.0. The only large earthquake to occur on the Elsinore fault in the historic record is the M_w6.0 earthquake along the central section in 1910. CGS fault parameters for the Elsinore fault indicate a slip rate of 0.16 inch per year, and a maximum M_w of 6.8.

San Jacinto Fault Zone

The San Jacinto fault zone is approximately 14 miles northeast of the Project. This zone is a major tectonic and seismic structure, striking northwest for more than 150 miles. The San Jacinto fault zone is part of the San Andreas fault system. The southern segment of the San Jacinto fault zone is composed of the Coyote Creek fault and the Superstition Hills and Superstition Mountain faults. The Coyote Creek strand of the fault zone extends from just north of Borrego Springs to the northeastern end of the Fish Creek Mountains north of Plaster City. The fault is not exposed at the surface to the south, as it is buried by young sediments. The Superstition Hills fault and the Superstition Mountain fault lie along a strike to the southeast of the Coyote Creek fault, and are generally considered to be the southern extension of the San Jacinto fault zone.

The San Jacinto fault zone is seismically the most active structure in Southern California at all magnitude levels below M_w7.0 (Hutton et al. 1991). This fault zone has produced at least ten earthquakes of M_w6.0 to 6.6 since 1890, giving an average recurrence interval of approximately 10 years for a M_w6.0 or larger event (Hutton et al. 1991). The most recent large earthquakes to occur on the San Jacinto fault system were the Arroyo Salada earthquake (M_w6.4) in 1954, the Borrego Mountain earthquake (M_w6.6) in 1968, and the Superstition Hills earthquake (M_w6.6) in 1987. CGS fault parameters for the San Jacinto fault zone include a slip rate range from 0.16 to 0.2 inch per year, and estimated maximum M_w earthquakes of 6.6 to 6.8.

Elmore Ranch Fault Zone

The Elmore Ranch fault zone is approximately 17 miles north-northwest of the Project. The fault zone is composed of six northeast-southwest-trending parallel segments up to 7.5 miles long. These segments are commonly termed the Elmore Ranch fault, the West Elmore Ranch fault, the East Elmore Ranch fault, and the Lone Tree fault. Two smaller faults are in the northeastern portion of the fault zone known as the Kane Spring fault and East Kane Spring fault. These left-lateral faults are conjugate faults, or cross-faults to the adjacent southern segment of the San Jacinto fault zone (the right lateral Superstition Hills fault), and the Brawley Seismic Zone to the east. The 1987 M_w6.2 Elmore Ranch earthquake ruptured these faults and triggered slip on the Superstition Hills fault, which followed with a M_w6.6 event approximately 12 hours later. Aftershocks of the Elmore Ranch earthquake extended into the Brawley Seismic Zone to the east (Magistrale et al. 1989). The nearly simultaneous activation of a conjugate fault pair is unique in the United States. Work by Hudnut et al. (1989) indicates that the fault has ruptured at least once prehistorically, within the past 330 years, possibly as a conjugate pair with the Superstition Hills fault. The earthquake sequence discussed above has generated an important point discussed in the literature, and that is potential cross-fault triggering of the San Andreas fault. As discussed below, the Coachella, or southern, segment of the San Andreas fault has not ruptured historically. According to Hudnut et al. (1989) future slip on other known cross-faults would decrease normal stress across the southern San Andreas fault, potentially triggering an earthquake by a mechanism similar to that observed in the Superstition Hills sequence.

CGS fault parameters for the Elmore Ranch faults indicate a combined slip rate of 0.06 inch per year and a maximum M_w of 6.1.

Imperial/Brawley Fault

The Imperial fault zone is approximately 21 miles east of the Project. This northwest-trending fault is approximately 40 miles long and extends from just southwest of the city of Brawley southeast to the town of Saltillo, Mexico. The Brawley fault is the northeastern branch of the Imperial fault and was generally unrecognized until a series of small earthquakes causing surface rupture occurred in 1975 (Sharp 1976). Both faults ruptured together in the 1979 M_w6.4 event, confirming its presence and relationship to the Imperial fault. The Imperial fault has been modeled as the transform fault between the two northernmost small spreading centers that characterize oblique spreading in the Gulf of California, the Brawley Seismic Zone, and the Cerro Prieto geothermal field in Mexico (Johnson and Hadley 1976).

The Imperial fault is one of the most active faults in the region. In addition to the M_w6.4 earthquake in 1979, the fault also ruptured with a M_w6.9 event in 1940. The 1979 earthquake produced seismic intensities at Niland and Calipatria of V to VI (Reagor et al. 1982), and caused widespread liquefaction. Moderate earthquakes (M_w5.5 to 6.3), which occurred in 1906, 1915, 1917, and 1927, are associated with the Imperial fault (Johnson and Hadley 1976). CGS fault parameters for the Imperial fault indicate a slip rate of 0.8 inch per year and a maximum M_w of 7.0.

Brawley Seismic Zone

The Project Site and linear facilities are located approximately 23 miles west of the Brawley Seismic Zone. This structural depression lies between the San Andreas fault to the northeast and the Imperial fault to the southwest. The Brawley Seismic Zone was first recognized because of the number of earthquake swarms produced from 1973 through 1979 (Johnson and Hill 1982). The swarm sequences and individual event clusters in the 1979 Imperial County earthquake aftershock sequence defined lineations transverse to the strike of the Imperial fault (Johnson and Hill 1982). Two types of earthquake swarms occur in the Brawley Seismic Zone. Swarms that occur in the southern end of the zone near the town of Brawley tend to occur in pairs, nucleating on the Imperial fault to the south and propagating away from it into the Seismic Zone. Swarms occurring in the northern part of the zone nucleate within the zone and do not occur in pairs (Hutton et al. 1991; Johnson and Hill 1982). Analysis of these swarms suggests they are triggered by creep events on the Imperial fault (Johnson and Hill 1982). The blind faulting controlling the geothermal resource geometry does not extend into recent sediments and, therefore is not considered a potential source of ground rupture. Following the 1940 Imperial County earthquake, swarm activity in the Brawley Seismic Zone ceased until the mid-1970s, most likely because of the drop in regional stress after the M_w6.9 event (Hutton et al. 1991).

The Brawley Seismic Zone is characterized by earthquake swarms, generally less than magnitude 3 or 4. CGS fault parameters for the Brawley Seismic Zone indicate a slip rate of 1 inch per year and a maximum M_w of 6.4.

Cerro Prieto Fault

The Cerro Prieto fault is approximately 41 miles southeast of the Project in northern Baja California, Mexico. This northwest-striking fault is over 62 miles long and has been characterized as the southern extension of the San Andreas–Imperial fault system. Like the Imperial fault, the Cerro Prieto fault is adjacent to a structural depression and active spreading center.

The only historic earthquake to occur on the Cerro Prieto fault was in 1934 with an estimated M_w of 6.5 to 7.5. Fault parameters for the Cerro Prieto fault include a slip rate of 0.78 inch per year and a maximum M_w of 7.1.

San Andreas Fault Zone

The Coachella Valley segment of the San Andreas fault is approximately 59 miles long and extends from the town of Indio to Bombay Beach on the northeastern shore of the Salton Sea, approximately 44 miles north-northeast from the site. North of Indio, the fault splays into two active strands, the Banning and Mission Creek faults. The San Andreas fault has not been mapped south of the Salton Sea. Although a linear extension of the fault may exist under the

Salton Sea or in northern Imperial County, no geologic or geophysical evidence supports it (Sharp 1982). It seems reasonable that the Imperial fault and Brawley Seismic Zone, which lie southwest of the San Andreas fault, may be linked together structurally with the San Andreas fault. Seismic activity along the Brawley Seismic Zone suggests that a major portion of the displacement observed on the Imperial fault is being transferred to the San Andreas fault to the northeast (Hutton et al. 1991). Most of the aftershocks following the 1979 earthquake on the Imperial fault occurred within the Brawley Seismic Zone (Sharp 1982). The Imperial fault has a similar strike as the southern segment of the San Andreas fault and has been modeled as a releasing step with the Brawley Seismic Zone occupying the resulting structural depression (Frost et al. 1997). Dillon and Ehlig (1993) hypothesize the San Andreas fault may join the northeastern corner of the Brawley Seismic Zone, and represents the most northerly spreading axis in a system of short spreading axes and interconnected transform faults that form the divergent plate boundary in the Gulf of California.

Although the San Andreas fault has generally produced few moderately sized earthquakes in historic times, no large earthquake (M_w >7.0) has been documented in the historic record for the fault south of San Bernardino (Hutton et al. 1991). This 'locked' southernmost section of the fault also lacks microseismicity and stands in sharp contrast to the northern sections of the fault that have ruptured with the largest historical earthquakes in California.

CGS fault parameters for the Coachella segment of the San Andreas fault indicate a slip rate of 1 inch per year and a maximum M_w of 7.2.

5.3.2.2 Geologic Hazards

The primary geologic hazard at the Project Site and associated linears is strong ground motion from a seismic event centered on one of several nearby active faults. Evaluations of ground surface rupture, seismic shaking, mass wasting and slope stability, liquefaction, volcanic hazards, subsidence, tsunami runup, flooding, and expansion or collapse of soil at the site are discussed below.

Surface Rupture

Major active faults have not been mapped across the Project Site and no Alquist Priolo Earthquake Fault Zones are mapped within the Project area. The nearest major active faults to the site are the Elsinore and Laguna Salada faults, located to the northwest and southwest of the site, respectively. These two faults are generally considered part of an overall fault zone; however, no through-going fault or faults connects them. Both of these faults project towards the western–most portion of the site. Based on current mapping and a preliminary review of aerial photos and satellite imagery, the fault rupture hazard in this area appears to be low.

It appears that the Laguna Salada fault may terminate at the Yuha Wells fault, which is a northeast-trending fault mapped as crossing the site (see Figure 5.3-2, Regional Geologic and Mineral Resources Map, modified after Jennings 1994). This feature is thought to be a cross fault between the dominant northwest-trending Laguna Salada and Elsinore faults to the west and the San Jacinto fault system to the east. The Yuha Wells fault in the Project vicinity is comprised of various strands, two of which (see Figure 5.3-4, Site Geologic Map) have been mapped (URS 2008) on the Project Site. While portions of the Yuha Wells fault south of the Project Site may have ruptured during the Holocene (last approximately 11,000 years) (Rockwell

et al. 1990; Thomas and Stinson 1990), no evidence exists that the strands crossing the site are active. As such, the fault has not been zoned as active on Alquist-Priolo Earthquake Fault Zone maps (Hart and Bryant 1997). The potential for moderate or large displacement rupture of the Yuha Wells fault across the site is judged to be low, based on current understanding. However, additional studies will be performed to demonstrate the activity of the fault within the Project Site.

The Dixieland fault has been mapped across the eastern end of the proposed waterline alignment. As discussed above, the nature and activity of the Dixieland "fault" are poorly understood and it is possible the feature is not a tectonic structure. The potential for seismic activity on the Dixieland fault to produce ground surface displacement capable of damaging the proposed waterline is considered low. Design-level geotechnical studies should address this preliminary conclusion.

Seismic Shaking

The site lies in the Salton Trough, an area of high seismicity and numerous active faults. Moderate to high levels of ground shaking could occur at the site as a result of an earthquake on any of a number of fault in the region, including the San Andreas, Imperial, San Jacinto, Cerro Prieto, Elsinore and Laguna Salada faults. The Project is likely to be affected by an earthquake on one of these faults during its life.

To provide an estimate of the ground motions expected at the site, a Probabilistic Seismic Hazards Analysis (PSHA) was underway at the time of publication of this document. The probabilistic analysis incorporates the contribution of all known active faults near the site for which published data are available. The analysis attempts to account for uncertainty in rupture size, rupture location, magnitude, and frequency, as well as uncertainty in the attenuation relationship. Preliminary PSHA results are included in Appendix E, Preliminary Geotechnical and Geologic Hazards Evaluation; final results will be presented in a revised version of the report. The preliminary peak ground acceleration (PGA) with a probability of 10 percent exceedance in 50 years (return period of 475 years) is 0.38g (units of gravity) for the site. The preliminary PGA with a probability of 2 percent exceedance in 50 years (return period of 2,475 years) is 0.55g.

Liquefaction

Liquefaction is a process in which saturated soils lose strength because of earthquakes or other sources of ground shaking. The soil deposit temporarily behaves as a viscous fluid; pore pressures rise, and the strength of the deposit is greatly diminished. Liquefaction is often accompanied by sand boils, lateral spreading, and post-liquefaction settlement as the pore pressures dissipate. Liquefiable soils typically consist of saturated, cohesionless sands and silts that are loose to medium dense. Imperial County is an area that is generally susceptible to liquefaction. The 1940 and 1979 earthquakes on the Imperial fault caused widespread liquefaction in areas underlain by alluvium, areas adjacent to canals and drains, and in areas underlain by lake deposits. These liquefiable sites contained predominantly loose sandy soils, or sequences of thick sandy layers within finer-grained soils (Youd and Wieczorck 1982; Holzer et al. 1989).

The potential for liquefaction at the site was evaluated as part of the preliminary geotechnical study for the Project. Loose granular materials were encountered near the ground surface; however, they were underlain at shallow depth by the Palm Spring Formation. Groundwater, where encountered, was significantly below the ground surface, and was within the formational materials, which should not be susceptible to liquefaction. Based on these data, the potential for liquefaction to occur at the site is low.

Subsidence and Collapse

The Project is within a region of active subsidence because of regional faulting. The Salton Trough is filled with up to 20,000 feet of Cenozoic-age sediments. Regional subsidence resulting from a combination of tectonic processes, including faulting and possible reservoir loading by the Salton Sea, may combine to produce roughly 1.6 inches of settlement per year across the entire Salton Trough (Lofgren 1978). Subsidence resulting from tectonic processes generally occurs over large areas. Consequently, the potential for damaging localized differential settlement from regional subsidence is considered low.

Imperial County is also subjected to subsidence from fluid withdrawal (generally associated with geothermal wells). The potential for damaging localized differential settlement from subsidence is considered low, given the sites relative distance (about 5 miles minimum) to the geothermal areas.

Loosely deposited alluvium and colluvium can be subject to collapse due to wetting and/or inundation. The only areas of the site subject to significant saturation are within the washes. These areas have been inundated in the past, and are not likely to experience additional collapse settlement. Natural drainage patterns are not significantly changed as part of the Project and the existing washes are excluded from development areas. Therefore, the Project should not increase the potential for collapse settlement to occur at the site and the potential for collapse settlement to affect the Project is low.

Expansion Potential

Expansive soil and rock shrink and swell with changes in moisture content. While near-surface alluvium, colluvium and lake deposits on the Project Site typically have low expansion potential, portions of the underlying Palm Spring Formation have zones of moderate to high plasticity claystone. Due to the arid environment, the claystone has a low moisture content and could swell with exposure to water. In general, significant increases in moisture are not expected, but could occur as a result of grading operations or an inadvertent release such as a water leak. In most areas where improvements are proposed, the claystone is expected to be sufficiently deep that changes in moisture content should not affect the proposed improvements. If expansive material is encountered during grading for roads, building pads, and/or the waterline, it has the potential to affect the Project if engineering mitigation measures are not followed. Expansive soil and rock within the depths of the foundations for the dish structures and transmission line poles have a low potential to affect the Project, as the subsurface is typically interlayered with sandstone of low expansion potential.

Flooding

The Project is approximately 23 miles southwest of the Salton Sea and approximately 100 miles northwest of the Gulf of California. Rare seismic events could conceivably induce flooding in some areas of Imperial County. These events include tsunamis within the Gulf of California, seiches within the Salton Sea, and flooding from failures along irrigation canal embankments. Given the distance of the Project from these hazards, it is very unlikely that they will affect the Project. Flooding can also occur due to significant rainfall events, although the effect will likely be limited to flows within the washes. These hazards are discussed further below.

Surface Water

The Project is crossed by a series of active alluvial washes. Extensive gullies and channels are present across the Project Site and throughout the general area. Surface water flow across the Project Site is likely to occur during periods of intense rainfall. The majority of the flow should be confined to the existing washes at the site, provided natural drainage patterns are maintained.

The Flood Areas map presented in the Imperial County General Plan (Imperial County 1993) indicates that flooding could occur along the New River, east of the Project Site, and within the low lying area south and west of the site associated with Laguna Salada basin. The map indicates that flooding within these areas is not likely to affect the Project Site. It is assumed that new transmission line poles will not be constructed within flood-prone areas.

Tsunamis

The main Project Site is roughly at sea level near the northeastern corner, suggesting that potential may exist for inundation in case of a tsunami (seismic sea wave) within the Gulf of California. However, the distance of the Project from the Gulf (100 miles) and the higher ground surface elevations to the west of the Project provide some measure of protection from such events, as no records (historic or geologic) indicate that tsunamis have affected Imperial County in the last several hundred years. Therefore, the potential for flooding at the Project as a result of a tsunami is considered to be very low.

Seiches

A wave created by earthquake shaking in an enclosed body of water is called a seiche. The potential for a seiche to occur is related to the natural frequency of vibration of the body of water, as well as the predominate frequencies of vibration in the seismic event. The possibility may exist for a seiche to occur in the Salton Sea. However, no records exist of seiches occurring during recent earthquakes in Imperial County, and the site is located more than 20 miles from, and at a significantly higher elevation than, the Salton Sea. Therefore, the potential for flooding at the site as a result of a seiche is considered to be very low.

Landslides (Mass Wasting and Slope Stability)

Landslides can occur due to the presence of steep slopes, saturated soil or rock, and/or seismic activity. The site is on relatively level or gently sloping ground; therefore, the risk of land sliding is very low. The hills to the west of the site have a low to moderate potential for landslide activity, as shown on the Landslide Activity map in the Imperial County General Plan

(Imperial County 1993); however, due to their distance from the site and proposed improvements, the potential for landslides to affect the Project is low. Further, the Landslide Activity map shows no potential for landslides within the area of the Project Site.

Volcanic Hazards

The Project is about 30 miles southwest of the extrusive rhyolite domes known as Salton Buttes. The USGS includes the "Salton Buttes rhyolite center" among its listed Potential Areas of Volcanic Hazards in California (Miller 1989). The Cerro Prieto volcano is located approximately 40 miles southeast of the Project in Mexico. According to the USGS, the most probable future potential hazards from these sources are explosive and extrusive rhyolitic eruptions, and/or phreatic and phreatomagmatic eruptions (volcanic eruptions or explosions of steam, mud, or other material caused by the heating of groundwater). These hazards could produce ashfall at the Project Site. No recurrence interval has been estimated, and the USGS has not qualified the potential hazard other than to say that it is present. Due to the uncertainty of the hazard, the distance from the Project Site, and the minimal expected effect to the Project, the volcanic hazard potential at the Project Site is considered to be low.

5.3.2.3 Geologic Resources

Based on published information (USGS 2008), five minor mining operations have occurred on the Project Site and several others within 2 miles of the Project limits. These small-scale state and commercial operations, shown on Figure 5.3-2, Regional Geologic and Mineral Resources Map, have primarily consisted of mining sand and gravel from the alluvial materials in the Project vicinity. Graphite has also been mined at one location near the western Project limits. Two clay pits are recorded near the site, one about a mile north of the Project limits and one in the Plaster City area, which borders the northern Project boundary. None of the mining operations on or within 2 miles of the Project Site are known to be active, with the exception of Plaster City, where a large gypsum production plant owned by U.S. Gypsum is in operation. The majority of the raw materials used for production at Plaster City are imported from mines greater than 2 miles from the Project Site. Other mineral resources in the area are located in the mountains 5 to 10 miles northwest of the site and include copper, limestone, and additional sand and gravel sources.

Several known geothermal resource areas (KGRAs) are present in the Project vicinity, including the Salton Sea, Heber and Brawley KGRAs. Approximately 60 percent of the total geothermal resource in the vicinity is present in the Salton Sea KGRA, approximately 20 miles northeast of the site. The smaller Heber KGRA is about 5 miles southeast of the Project Site, and the Brawley KGRA is about 12 miles northeast (Snoeberger and Hill 1978).

Due to the limited presence of geologic resources on the site, and the relative distance of significant resources from the site, the Project does not represent a significant effect to the geologic resources of the region.

5.3.3 Environmental Consequences

Potential effects of the Project on the geologic or mineral resources and potential effects of geologic hazards on the Project can be divided into those related to construction activities and those related to Project operation.

5.3.3.1 Construction-Related Effects

Construction-related effects to the geologic or mineral resources primarily involve grading operations. The proposed improvements include minor excavation and grading for building and equipment pads and foundations, utility trenches, and roads. Site grades will be maintained as close to existing topography as possible; cuts and fills are expected to be minor. Grading operations will be designed to balance cut-and-fill areas such that no significant importation or stockpiling of fill will take place. Minor grading may also be performed within the laydown area. According to Appendix E, Preliminary Geotechnical and Geologic Hazards Evaluation, the Project slopes and temporary construction slopes should be stable.

Potentially significant effects by geologic conditions on the construction are not anticipated. Further, site development is not anticipated to result in significant adverse effects to geologic resources. With implementation of the mitigation measures outlined in Section 5.3.4, Mitigation Measures, effects of construction on the geologic environment will be reduced to less-than-significant levels.

5.3.3.2 Operation-Related Effects

No significant effects to geologic resources have been identified as a result of operation and maintenance. Potential effects of geologic hazards on the operation of the Project and its linears include seismic shaking, fault rupture and potentially expansive soils. With implementation of the measures outlined in Section 5.3.4, Mitigation Measures, effects to Project operations and maintenance from geologic hazards will be reduced to a less than a significant level.

5.3.4 Cumulative Effects

Cumulative effects to the geologic resources at the Project Site are considered to be negligible.

5.3.5 Mitigation Measures

5.3.5.1 Fault Rupture

The potential for surface rupture of strands of the Yuha Wells fault across the Project Site is low; however, few data are available demonstrating the activity of the fault at the site. Additional evaluation of the fault strands will be performed during design-level geotechnical studies to confirm the activity level of on-site faults. To verify that strands of the Yuha Wells fault do not cross the footprints of proposed habitable structures, fault trenching investigations will be performed. With implementation of the following mitigation measure, it is expected that the potential for fault rupture to affect the Project can be reduced to less-than-significant levels.

GEO-1

Conduct fault and geologic hazard studies as part of final design for the Project. Studies will include excavating fault trenches at habitable structures and across identified strands of the Yuha Wells fault. The study will be performed by a State-Certified Engineering Geologist.

The potential for seismic activity or other ground movements on the Dixieland fault to damage the proposed waterline is considered sufficiently low that mitigation measures are not likely to be required. However, to address the uncertainty associated with this structure, the final design geologic hazard studies (GEO-1) will address the possible hazard and provide appropriate mitigation, as necessary. Possible mitigation measures could include one or more of the following: shut off valves, a modified trench configuration, loose backfill and flexible pipe. In addition, to comply with the Imperial County General Plan, it may be required to submit an operation plan for the utility to the County to insure public safety. This need for an operation plan will be confirmed as part of a final geotechnical investigation.

5.3.5.2 Seismic Shaking

The potential exists for strong ground shaking from a variety of nearby sources, including the San Andreas, Imperial, San Jacinto, Elsinore, and Laguna Salada faults. With implementation of the mitigation measures noted below, it is expected that the potential for seismic shaking to affect the Project can be reduced to less-than-significant levels.

GEO-2

Project facilities will be designed in accordance with applicable building codes' seismic design criteria. Seismic design criteria in accordance with the 2007 California Building Code (CBC) are provided in Appendix E, Preliminary Geotechnical and Geologic Hazards Evaluation. The dish structures, and possibly other structures at the site, will be designed to resist the seismic loading developed as part of the PSHA.

5.3.5.3 Liquefaction

No liquefaction hazard exists at the Project Site and no mitigations are suggested.

5.3.5.4 Subsidence

The potential for subsidence and/or collapse to affect the Project is low and no mitigations are suggested. One possible exception could be subsidence along the Dixieline fault and possible effect to the waterline. The design-level fault and geologic hazard studies (GEO-1) will evaluate and provide recommendations for mitigation, as appropriate.

5.3.5.5 Expansive Soils

The geotechnical earthwork and foundation design recommendations provided in Appendix E, Preliminary Geotechnical and Geologic Hazards Evaluation, will provide adequate mitigation of any hazard related to expansive soils to less-than-significant levels. Additional recommendations addressing expansive soils will be determined as part of a final geotechnical investigation (GEO-1).

5.3.5.6 Flooding

The larger washes within the Project Site may be subject to significant flow during periods of high rainfall; however, no significant development is planned within these washes. Site development and grading will be performed in a manner that will reduce the effects of drainage and runoff across the Project Site to less-than-significant levels, as discussed in Section 5.3.4.8, Site Grading. The Main Services Complex will be protected from 100-year flooding by berms or channels that will direct the flow around the perimeter of the building site, if required.

5.3.5.7 Landslides

Significant landslide hazards are not present in the Project area.

5.3.5.8 Site Grading

A grading permit is required before commencing site work. Construction activities would also be performed in accordance with the soil erosion/water quality protection measures to be specified in the Construction Storm Water Pollution Prevention Plan (SWPPP) for the Project. The SWPPP is discussed further in Section 5.5, Water Resources. In addition, mitigation measures will be implemented to reduce potentially significant erosion-related effects to the soils resources at the Project Site to insignificant levels. These mitigation measures are discussed in Section 5.4, Soils. With implementation of the soil erosion/water quality protection measures and mitigation measures referenced above, no significant effects are anticipated because of Project construction and operation.

As part of the above-referenced measures, Low Impact Development (LID) will be used to mitigate the potential for water and wind erosion of the soil at the site. LID principles applicable to this Project include:

- maintaining natural drainage and landscape features to slow and filter runoff and maximize groundwater recharge,
- minimizing new impervious ground surfaces, and
- managing runoff close to the source.

Best Management Practices contained in the SWPPP, as discussed Section 5.5, Water Resources, will be implemented to address LID concerns. Further, site grading will be minimized for roads, the Main Services Complex and the substation by constructing as close to the existing topography as possible. Polymeric stabilizers may be used to reduce the amount of imported soil needed for roadway construction and to reduce the need for dust control. Retention basins, infiltration swales, and perforated risers (which act as a desilter) are also planned as part of the Project.

5.3.5.9 Geologic Resources

No significant effects to geologic resources would occur; therefore, no mitigation is recommended.

5.3.6 Compliance with LORS

The Project will be constructed and operated in accordance with all laws, ordinances, regulations, and standards (LORs) applicable to geologic hazards and resources discussed below and summarized in Table 5.3-2, Summary of LORS – Geologic Hazards and Resources.

Table 5.3-2
Summary of LORS – Geologic Hazards and Resources

LORS	Requirements	Conformance Section	Administering Agency	Agency Contact
Federal Jurisdiction				
No federal LORS are applicable				
State Jurisdiction				
Public Resources Code 25523(a), Alquist-Priolo Earthquake Fault Zone	Habitable structures must avoid active fault rupture hazards	Section 5.3.5.2	California Energy Commission	1
Local Jurisdiction				
Imperial County General Plan Seismic/ Geologic Hazards Elements	Utilities that cross active faults are required to prepare an operations plan.	Section 5.3.5.3	Imperial County Planning/ Building Department	2
California Building Code, Chapters 16, 18, and 33	Codes address excavation, grading and earthwork construction, including construction applicable to earthquake safety and seismic activity.	Section 5.3.3 and Appendix E, Preliminary Geotechnical and Geologic Hazards Evaluation	Imperial County Planning/ Building Department	2

Source: URS Corporation, 2008.
Note:
LORS = laws, ordinances, regulations, and standards

5.3.6.1 Federal

No federal LORS exist for geological hazards and resources, or grading and erosion control.

5.3.6.2 State

California Public Resources Code 25523(a): 20 California Code of Regulations Section 1252 (b) and (c)

None of the Project components are located within or cross an Alquist–Priolo earthquake zone. The Project will not be subject to requirements for construction within an earthquake fault zone.

California Building Code

The 2007 edition of the CBC is based on the 2006 edition of the International Building Code, with revisions specifically tailored to geologic hazards in California.

Chapter 16: Structural Design

This chapter requires structural designs to be based on geologic information for seismic parameters, soil characteristics, and site geology.

Chapter 18: Soils and Foundations

This chapter sets requirements for excavations and fills, foundations, and retaining structures with regard to expansive soils, subgrade bearing capacity, seismic parameters, and also addresses waterproofing and damp-proofing foundations. In Seismic Zones 3 and 4, as defined by the CBC, liquefaction potential at the site should be evaluated.

Chapter 33: Site Work, Demolition and Construction, and Appendix Chapter 33

This chapter and appendix establish rules and regulations for construction of cut-and-fill slopes, fill placement for structural support, and slope setbacks for foundations.

California Environmental Quality Act (CEQA)

The California Energy Commission will be the lead agency for rules and regulations to implement CEQA. CEQA Guidelines, Appendix G, Section VI contains the geologic hazards and resources related to the Project.

5.3.6.3 Local

Imperial County General Plan: Seismic and Public Safety Element

The Seismic and Public Safety Element of the Imperial County General Plan provides an implementation program to reduce the threat of seismic and public safety hazards within unincorporated areas of Imperial County.

Utilities that cross an active fault would be required to submit an operation plan to Imperial County describing the probable effects of failures at the fault(s) and the various emergency facilities and procedures that exist to assure that failure does not threaten public safety. Such a plan may be required for the waterline. No active faults would be crossed by the proposed transmission line.

The Project would comply with the Seismic/Geologic Hazards Element of the Imperial County General Plan. The County will review the geologic information and geotechnical recommendations presented in the geotechnical report.

5.3.6.4 Agencies and Agency Contacts

Agencies with jurisdiction to enforce LORS related to geologic hazards and resources, and the appropriate contact person are summarized in Table 5.3-3, Agency Contact List for LORS.

Table 5.3-3
Agency Contact List for LORS

No.	Agency	Contact	Address	Telephone
1	California Energy Commission Facilities Siting Division	Eileen Allen, Energy Facility Licensing Program	1516 Ninth Street, MS-15 Sacramento, CA 95814	916-654-4082
2	Imperial County Planning/ Building Department	Jurg Heuberger	801 Main Street El Centro, CA	760-482- 4238

Source: URS Corporation, 2008.

5.3.6.5 Permits Required and Permitting Schedule

The permits required for this Project are listed in Table 5.3-4, Applicable Permits. A Grading Permit, and possibly an operation plan for the waterline, will be required before construction.

Table 5.3-4
Applicable Permits

Responsible Agency	Permit/Approval	Schedule
Imperial County Planning/Building Department	Grading Permit	Before Construction
Imperial County Planning/Building Department	Operation Plan for Waterline	Before Construction

Source: URS Corporation, 2008.

5.3.7 References

Benton Engineering, Inc. 1980. "Proposed Imperial Valley Substation, Phase III, Site 7A, Imperial Valley, California," prepared for the San Diego Gas & Electric Company, dated November 14.

Biehler, S., R.L. Kovach, and C.R. Allen. 1964. Geophysical framework of the northern end of the Gulf of California structural province. American Association of Petroleum Geologists Memoir 3, p. 126-143.

California Department of Conservation, Division of Mines and Geology. 1977. Geology and Mineral Resources of Imperial County, County Report 7.

California Department of Conservation, Division of Mines and Geology. 1998. Maps of Known Active Fault Near-Source Zones in California and Adjacent Portions of Nevada.

County of Imperial. 1993. "Seismic and Public Safety Element," Imperial County General Plan, Planning/Building Department.

Dibblee, T.W. 1954. Geology of Southern California. *California Division of Mines and Geology Bulletin* 170, p. 21-28.

Dillon, J.T. and P.L. Ehlig. 1993. Displacement on the southern San Andreas fault, in R.E. Powell, R.J. Weldon, and J.C. Matti. eds. The San Andreas fault system: Displacement, palinspastic reconstruction, and geologic evolution: Boulder, Colorado, Geological Society of America Memoir 178, p. 199 -216.

Elders, W.A. 1979. The Geological Background of the Geothermal Fields of the Salton Trough. In Geology and Geothermics of the Salton Trough, Geological Society of America 92nd Annual Meeting, San Diego, p. 1-19.

Frost, E.G., S.C. Suitt, and M.F. Fattahipour. 1997. Emerging Perspectives of the Salton Trough Region With an Emphasis on Extensional Faulting and its Implications for Later San Andreas Deformation. In *Southern San Andreas Fault, Whitewater to Bombay Beach, Salton Trough, California: South Coast Geological Society Annual Field Trip Guide Book No. 25*, p. 57-97.

Fuis, G.S. and W.M. Kohler. 1984. Crustal Structure and Tectonics of the Imperial Valley region, California, In The Imperial Basin – Tectonics, Sedimentation, and Thermal Aspects: Pacific Section, Society of Economic Paleontologists and Mineralogists, Rigsby, C.A., ed. Vol. 40, p. 1-13.

Hart, E.W. and W.A. Bryant. 1997. Fault-Rupture Hazard Zones in California, Alquist-Priolo Earthquake Fault Zoning Act with Index to Earthquake Fault Zones Maps. California Department of Conservation Division of Mines and Geology Special Publication 42, 38 p.

Holzer, T.L., T.L. Youd, and T.C. Hanks. 1989. Dynamics of Liquefaction during the 1987 Superstition Hills, California Earthquake. Science. Vol. 114, pp. 691-697.

Hudnut, K., L. Seeber, T. Rockwell, J. Goodmacher, R. Klinger, S. Lindvall, and R. McElwain. 1989. Surface Ruptures on Cross-Faults in the 24 November 1987 Superstition Hills, California, Earthquake Sequence. Bulletin of the Seismological Society of America, Vol. 79, No. 2, p. 282-296.

Hutton, L.K., L.M. Jones, E. Hauksson, and D.D. Given. 1991. Seismotectonics of Southern California, in Slemmons, D.B., Engdahl, E.R., Zoback, M.D., and Blackwell, D.D., eds. Neotectonics of North America: Boulder, Colorado. Geological Society of America, Decade Map Vol. 1, p. 133-151.

Imperial County. 1993. "Seismic and Public Safety Element," Imperial County General Plan. Planning/Building Department.

Jennings, Charles W. 1994. Fault Activity Map of California and Adjacent Areas with Location and Ages of Recent Volcanic Eruptions. California Geologic Data Map Series, Map No. 6. California Division of Mines and Geology.

Johnson, C.E., and D.M. Hadley. 1975. Tectonic Implications of the Brawley Earthquake Swarm Imperial Valley California. Bulletin of the Seismological Society of America, Vol. 66, No. 2, p. 1133-1144.

Johnson, C.E. and D.P. Hill. 1982. Seismicity of the Imperial Valley, in The Imperial Valley, California, Earthquake of October 15, 1979: United States Geological Survey Professional Paper 1254, p. 15-24.

Kerr, D.R. and S.M. Kidwell. 1991. Late Cenozoic Sedimentation and Tectonics, Western Salton Trough, California. In Geological Excursions in Southern California and Mexico, Walawender, M.J., and Hanan, B.B., eds. Guidebook for the 1991 Annual Meeting, Geological Society of America, San Diego, California, October 21-24, 1991, p. 373-377.

Kovach, R.L., C.R. Allen, and F. Press. 1962. Geophysical Investigations in the Colorado Delta Region. *Journal of Geophysical Research*, Vol. 67, No. 7, pp. 2845-2871.

Lofgren, B.E. 1978. Measured Crustal Deformation in Imperial Valley, California. United States Geological Survey Open File Report 78-910.

Magistrale, H., L. Jones, and H. Kanamori. 1989. The Superstition Hills, California, Earthquakes of 24 November 1987. Bulletin of the Seismological Society of America, Vol. 79, No. 2, p. 239-251.

Miller, Dan C. 1989. Potential hazards from future volcanic eruptions in California, USGS bulletin 1847.

Morton, K. 1966. Geologic Map of Imperial County, CA. Showing Mines and Mineral Deposits. *California Division of Mines and Geology.*

Mueller, K.J., and T.K. Rockwell. 1995. Late Quaternary Activity of the Laguna Salada fault in Northern Baja California, Mexico. Geological Society of America Bulletin, Vol. 107, p. 8-18.

Reagor, B.G., C.W. Stover, S.T. Algermissen, K.V. Steinbrugge, P. Hubiak, M.G. Hopper, and L.M. Barnhard. 1982. Preliminary Evaluation of the Distribution of Seismic Intensities in The Imperial Valley, California, Earthquake of October 15, 1979: United States Geological Survey Professional Paper 1254, p. 251-264.

Resource Design Technology, Inc. 2008. "United States Gypsum Company Expansion/ Modernization Project, Imperial County, California," Final Environmental Impact Report/Environmental Impact Statement, Volume 1, January 2008, Lead agencies CEQA and NEPA.

Rockwell, Thomas, R. Blom, R. Crippen, R. Klinger, A. Stinson, and A. Thomas. 1990. Recognition, Extension and Significance of Northeast Trending Faults Between the Elsinore and San Jacinto Fault Zones Using Combined Spot and Landsat Imagery. *F.O.P. 1990 Winter Field Trip: Western Salton Trough- Soils and Neotectonics.*

Rockwell, Thomas, A. and A. Stinson. 1990. Northeast Striking Faults of the Yuha Desert southwestern Salton Trough, southern California. *F.O.P. 1990 Winter Field Trip: Western Salton Trough- Soils and Neotectonics.*

Sieh, K. 1986. Slip Rate Across the San Andreas Fault and Prehistoric Earthquakes at Indio, CA: Eos, v.67, no. 44, p.677-691.

Sieh, K.E. and R.H. Jahns. 1984. Holocene Activity of the San Andreas Fault at Wallace Creek, California. Geological Society of America Bulletin, Vol. 95, p. 883-896.

Sharp, R.V. 1972. Tectonic Setting of the Salton Trough, in The Borrego Mountain Earthquake of April 9, 1968: United States Geological Survey Professional Paper 787, p. 3-15.

Sharp, R.V. 1976. Surface faulting in Imperial Valley during the earthquake swarm of January-February 1975. Seismological Society of America Bulletin, Vol. 66, No. 4, p. 1145-1154.

Sharp, R.V. 1982. Tectonic Setting of the Imperial Valley Region, in The Imperial Valley, California, Earthquake of October 15, 1979: United States Geological Survey Professional Paper 1254, p. 5-14.

Smith, Drew P. 1979. Fault Evaluation Report FER-90 (Dixieland fault). California Division of Mines and Geology.

Snoeberger, D.F. and J.H. Hill. 1978. Identification of Environmental Control Technologies for Geothermal Development in the Imperial Valley of California, September 11.

Sylvester, A.G. and R.R. Smith. 1976. Tectonic Transpression and Basement-Controlled Deformation in San Andreas Fault Zone, Salton Trough, California. The American Association of Petroleum Geologists Bulletin, Vol. 60, No. 12, p. 2081-2102.

Tarbet, L.A. 1951. Imperial Valley. American Association of Petroleum Geologists, Bulletin 35:260–263.

Tarbet, L.A. and W.H. Holman. 1944. Stratigraphy and micropaleontology of the west side of the Imperial Valley, California. American Association of Petroleum Geologists, Bulletin (abstract) 28:1781–1782.

Thomas, A. and A. Stinson. 1990. Northeast Striking Faults of the Yuha Desert southwestern Salton Trough, southern California. *in F.O.P. 1990 Winter Field Trip: Western Salton Trough- Soils and Neotectonics.*

Todd, V.R. 2004. Preliminary Geologic Map of the El Cajon 30’ x 60’ Quadrangle, Southern California, Version 1.0. Detailed description of Map Units.

USGS (U.S. Geological Survey). 2004. *Preliminary Geologic Map of the El Cajon 30’ x 60’ Quadrangle, Southern California*. OFR 2004-1361. Compiled by Todd, Victoria R.

USGS (U.S. Geological Survey). 2008. Mineral Resources Data System (MRDS), http://tin.er.usgs.gov/mrds/index.shtml, last modified 22 January 2008.

URS Corporation, 2008. “Preliminary Geotechnical and Geologic Hazards Investigation, Solar Two, Imperial County, California,” dated 30 May 2008.

Winker, C.D. 1987. Neogene stratigraphy of the Fish Creek-Vallecito section, southern California: implications for early history of the northern Gulf of California and Colorado delta. Doctoral Thesis. University of Arizona, Tucson, Arizona, U.S.A.

Woodard, G.D. 1974. Redefinition of Cenozoic stratigraphic column in Split Mountain Gorge, Imperial Valley, California. *American Association of Petroleum Geologists*, Vol. 58, p. 521-539.

Woodring, W.P. 1932. Distribution and age of the marine Tertiary deposits of the Colorado Desert. Carnegie Institute of Washington, Publication 418:1–28.

Woodward-Clyde Consultants. 1981. "Geotechnical Investigation for Jade to Imperial Valley Substation Segment of the Miguel-Imperial Valley 500 kV Transmission Line (Tower Sites 213 through 312, PI 21-28)," prepared for San Diego Gas & Electric Company, dated June 12, 1981.

Woodward-Clyde Consultants. 1982. "Supplemental Geotechnical Investigation for Realigned Towers Along the Miguel-Imperial Valley 500 kV Transmission Line (Tower Sites 22 through 313)," prepared for San Diego Gas & Electric Company, dated June 17, 1982.

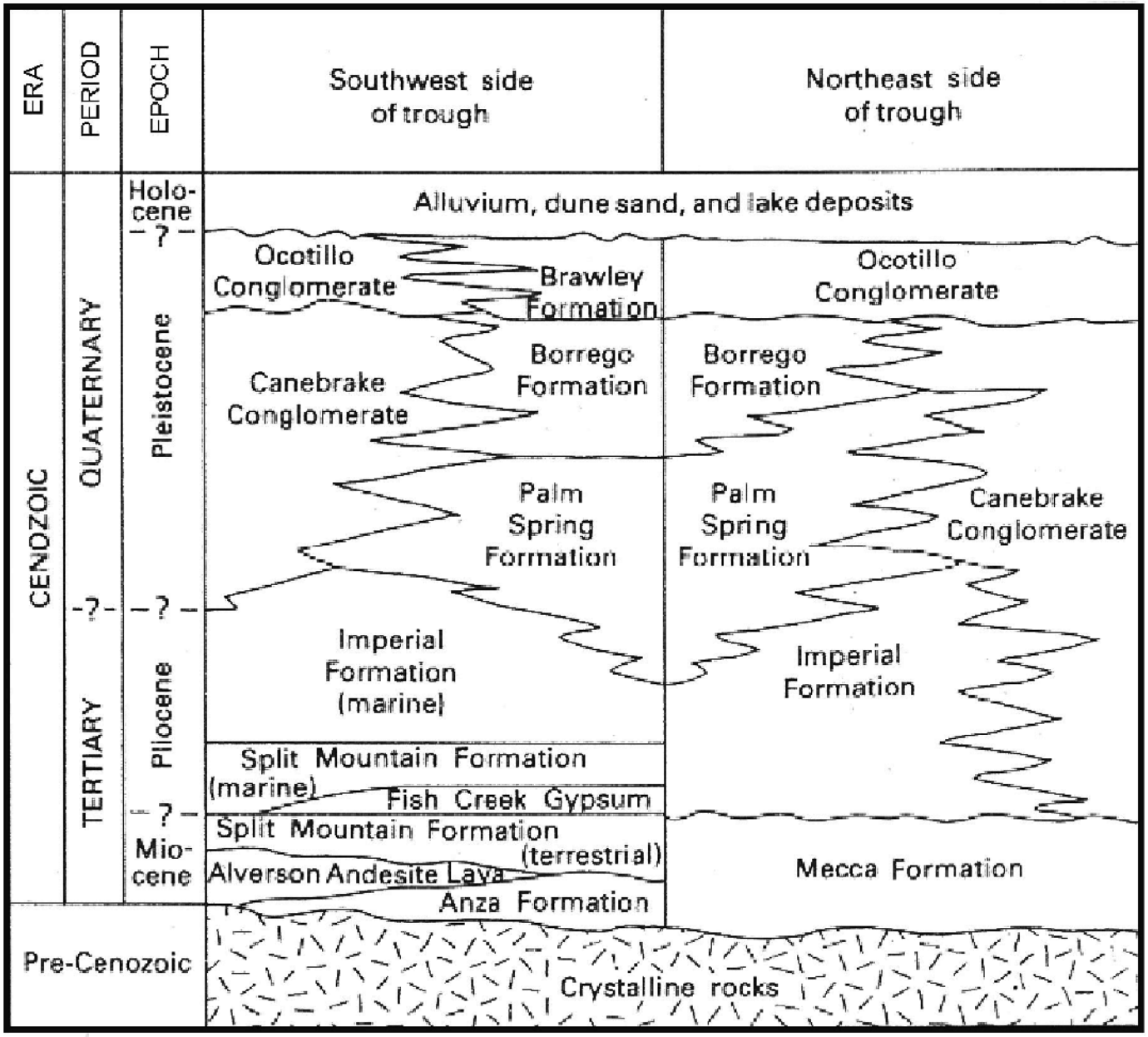
Youd, T.L. and G.F. Wieczorek. 1982. Liquefaction and Secondary Ground Failure, in The Imperial Valley, California, Earthquake of October 15, 1979: United States Geological Survey Professional Paper 1254, p. 223-246.

Adequacy Issue:	Adequate		Inadequate		DATA ADEQUACY WORKSHEET	Revision No.	0	Date	
Technical Area:	**Geological Hazards**			Project:	Solar Two Project		Technical Staff:		
Project Manager:				Docket:			Technical Senior:		

SITING REGULATIONS	INFORMATION	AFC SECTION NUMBER	ADEQUATE YES OR NO	INFORMATION REQUIRED TO MAKE AFC CONFORM WITH REGULATIONS
Appendix B (g) (1)	...provide a discussion of the existing site conditions, the expected direct, indirect and cumulative impacts due to the construction, operation and maintenance of the Project, the measures proposed to mitigate adverse environmental impacts of the Project, the effectiveness of the proposed measures, and any monitoring plans proposed to verify the effectiveness of the mitigation.	Section 5.3.1 Section 5.3.2 Section 5.3.3 Section 5.3.4		
Appendix B (g) (17) (A)	A summary of the geology, seismicity, and geologic resources of the Project Site and related facilities, including linear facilities.	Section 5.3.1.1 Section 5.3.1.3		
Appendix B (g) (17) (B)	A map at a scale of 1:24,000 and description of all recognized stratigraphic units, geologic structures, and geomorphic features within two (2) miles of the Project Site and along proposed facilities. Include an analysis of the likelihood of ground rupture, seismic shaking, mass wasting and slope stability, liquefaction, subsidence, tsunami runup, and expansion or collapse of soil structures at the plant site. Describe known geologic hazards along or crossing linear facilities.	Section 5.3.1.2 Figure 5.3-2 Figure 5.3-3* *Note: scale modified to 1:94,000 due to size of Project and extent of linears		
Appendix B (g) (17) (C)	A map and description of geologic resources of recreational, commercial, or scientific value which may be affected by the Project. Include a discussion of the techniques used to identify and evaluate these resources.	Section 5.3.1.3 Figure 5.3-2 Figure 5.3-3		

Adequacy Issue:	Adequate		Inadequate		DATA ADEQUACY WORKSHEET	Revision No.	0	Date	
Technical Area:	**Geological Hazards**			Project:	Solar Two Project		Technical Staff:		
Project Manager:				Docket:			Technical Senior:		

SITING REGULATIONS	INFORMATION	AFC SECTION NUMBER	ADEQUATE YES OR NO	INFORMATION REQUIRED TO MAKE AFC CONFORM WITH REGULATIONS
Appendix B (i) (1) (A)	Tables which identify laws, regulations, ordinances, standards, adopted local, regional, state, and federal land use plans, leases, and permits applicable to the proposed Project, and a discussion of the applicability of, and conformance with each. The table or matrix shall explicitly reference pages in the application wherein conformance, with each law or standard during both construction and operation of the facility is discussed; and	Table 5.3-2		
Appendix B (i) (1) (B)	Tables which identify each agency with jurisdiction to issue applicable permits, leases, and approvals or to enforce identified laws, regulations, standards, and adopted local, regional, state and federal land use plans, and agencies which would have permit approval or enforcement authority, but for the exclusive authority of the commission to certify sites and related facilities.	Table 5.3-2		
Appendix B (i) (2)	The name, title, phone number, address (required), and email address (if known), of an official who was contacted within each agency, and also provide the name of the official who will serve as a contact person for Commission staff.	Table 5.3-3		
Appendix B (i) (3)	A schedule indicating when permits outside the authority of the commission will be obtained and the steps the applicant has taken or plans to take to obtain such permits.	Table 5.3-4		



STRATIGRAPHY IN THE SALTON TROUGH
SOLAR TWO PROJECT

URS	CREATED BY: CPE	DATE: 05-13-08	FIG. NO:
	PM: AL	PROJ. NO: 27657102.00403	5.3-1

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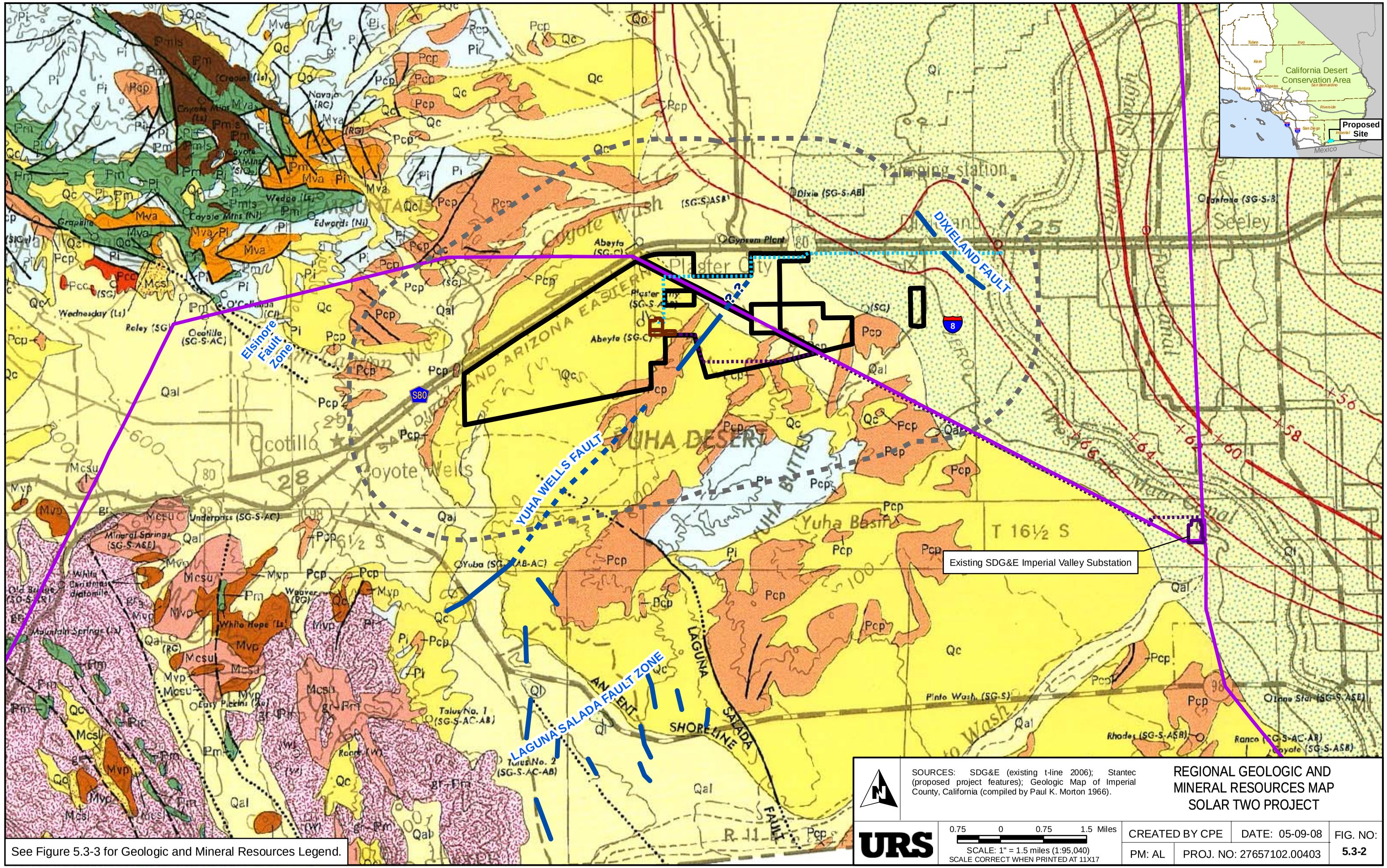

SOURCES: SDG&E (existing t-line 2006); Stantec (proposed project features); Geologic Map of Imperial County, California (compiled by Paul K. Morton 1966).

REGIONAL GEOLOGIC AND MINERAL RESOURCES MAP
SOLAR TWO PROJECT

URS

0.75 0 0.75 1.5 Miles
SCALE: 1" = 1.5 miles (1:95,040)
SCALE CORRECT WHEN PRINTED AT 11X17

CREATED BY CPE	DATE: 05-09-08	FIG. NO:
PM: AL	PROJ. NO: 27657102.00403	5.3-2

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SYMBOLS

Contact
(dashed where approximately located; dotted where concealed; queried where inferred)

Fault
(dashed where approximately located; dotted where concealed; queried where inferred)

Thrust fault
(barb on upper plate)

CO_2 Field

Mill or abandoned mill

Steamwell

Mine or prospect

(AB) —Aggregate base (sand and gravel)
(AC) —Asphalt concrete (sand and gravel)
(Ag) —Silver
(ASB) —Aggregate sub-base (sand and gravel)
(Au) —Gold
(B) —Borrow (sand and gravel)
(Ba) —Barite
(C) —Commercial pit (sand and gravel)
(Cl) —Clay
(CTB) —Cement treated base (sand and gravel)
(Cu) —Copper
(Cy) —County source (sand and gravel)
(Fe) —Iron
(G) —Gemstone locality
(Gyp) —Gypsum
(Ky) —Kyanite
(Ls) —Limestone
(M) —Mica (sericite)
(Mn) —Manganese
(Ni) —Nickel
(Pb) —Lead
(Pc) —Pumice
(Py) —Pyrophyllite
(SiO_2) —Silica
(SG) —Sand and gravel
(RG) —Roof granules
(RQ) —Rock quarry
(S) —State source (sand and gravel)
(Sl) —Salines
(Sr) —Strontium
(St) —Stone
(W) —Tungsten
(U) —Uranium

O118
Temperature wells by U.S.B.R. and others
Numbers (115) are U.S.B.R. designation.

+90
+88

Bouguer gravity contours*
(Contour interval 2 milligals)

Note: 1000 milligals have been added to all readings and the first digit is omitted; thus 84 is actually 984 - 1000 or -16 milligals. (Gravity by Shawn Biehler in Meidav and Rex, 1970)

EXPLANATION

ROCKS OF COUNTY WIDE DISTRIBUTION

Qal

Alluvium
Unconsolidated clay, silt, sand, and gravel occurring primarily as valley fill and streamwash deposits.

Qc

Older alluvium
Partly dissected largely unconsolidated, poorly sorted silt, and gravel of alluvial fans, desert pavement areas, margins of larger canyons, and terraces. Includes Chemihuevis Formation.

CENOZOIC ROCKS OF IMPERIAL VALLEY AND WESTERN IMPERIAL COUNTY

Ql

Lake beds
Sediments of ancient lake Cahuilla and playa lakes. Tan and gray fossiliferous clay, silt, sand and gravel in conjunction with Qal (shown Ql/Qal).

Pcp

Palm Spring Formation
Interbedded nonmarine, light gray, arkosic sandstone and reddish clay; grades into Canebrake Conglomerate towards margins of Salton basin.

Pi

Imperial Formation
Marine sequence of light yellow-gray clay, interbedded arkosic sandstone with oyster-shell reefs, and fossiliferous calcareous sandstone.

Mvp / Mva

Alverson Andesite
Varicolored andesite flows and interbedded tuff, breccia, and nonmarine sediments.
Mvp = Jacumba pyroclastic rocks

Mcsl — Mcs — Mcsu

Split Mountain Formation
Mcsu = Upper member; gray conglomerate and brown arkosic sandstone
Mcsl = Lower member; reddish-brown arkosic sandstone, conglomerate, and sedimentary breccia.

gr

Granitic rocks
Largely Mesozoic in age.
gr_1 = biotite granite
gr_2 = leucogranite
gr_3 = quartz diorite
gr_4 = quartz monzonite

Pmls / Pm

Metamorphic rocks
Predominantly biotite schist, quartzite, gneiss, and marble of Paleozoic(?) age.
Pmls = marble

LEGEND

- Project Boundary (6,176.65 acres)
- 2-Mile Buffer
- Proposed Waterline (7.17 miles)
- Existing Transmission Line
- Proposed 750-MW Transmission Line (10.30 miles)
- Proposed Substation and Main Services Complex
- Faults modified by "Fault Activity Map of California and Adjacent Areas", Division of Mines and Geology, Geologic Data Map No. 6, compiled by Charles W. Jennings (1994). Dashed where inferred, dotted where concealed.

LEGEND FOR REGIONAL GEOLOGIC AND MINERAL RESOURCES MAP
SOLAR TWO PROJECT

URS

CREATED BY CPE	DATE: 05-12-08	FIG. NO:
PM: AL	PROJ. NO: 27657102.00403	5.3-3

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LEGEND

Qaf	Artificial fill
Qal	Young alluvium
Ql/QPlps	Thin lake bed deposits overlying Palm Spring Formation
Qal/QPlps	Thin young alluvium overlying Palm Spring Formation
(Qc + Qoa)/QPlps	Thin colluvium and older alluvium overlying Palm Spring Formation
Qoa/QPlps	Thin older alluvium overlying Palm Spring Formation
QPlps	Late Pliocene to early Quaternary - aged deposits of the Palm Spring formation

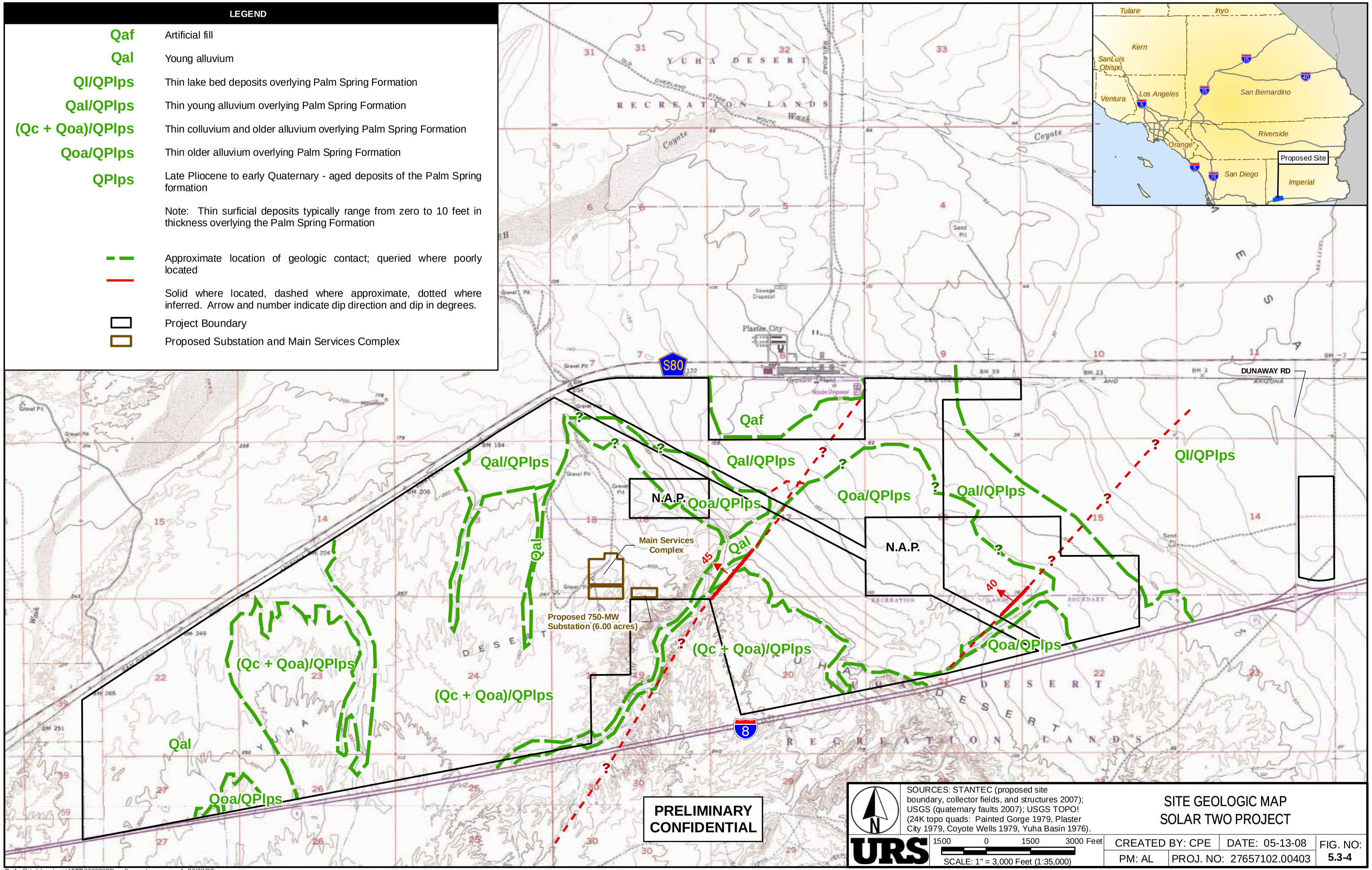
Note: Thin surficial deposits typically range from zero to 10 feet in thickness overlying the Palm Spring Formation

Approximate location of geologic contact; queried where poorly located

Solid where located, dashed where approximate, dotted where inferred. Arrow and number indicate dip direction and dip in degrees.

Project Boundary

Proposed Substation and Main Services Complex



SOURCES: STANTEC (proposed site boundary, collector fields, and structures 2007); USGS (quaternary faults 2007); USGS TOPO! (24K topo quads: Painted Gorge 1979, Plaster City 1979, Coyote Wells 1979, Yuha Basin 1976).

SITE GEOLOGIC MAP
SOLAR TWO PROJECT

URS

1500 0 1500 3000 Feet
SCALE: 1" = 3,000 Feet (1:35,000)

CREATED BY: CPE	DATE: 05-13-08	FIG. NO:
PM: AL	PROJ. NO: 27657102.00403	5.3-4

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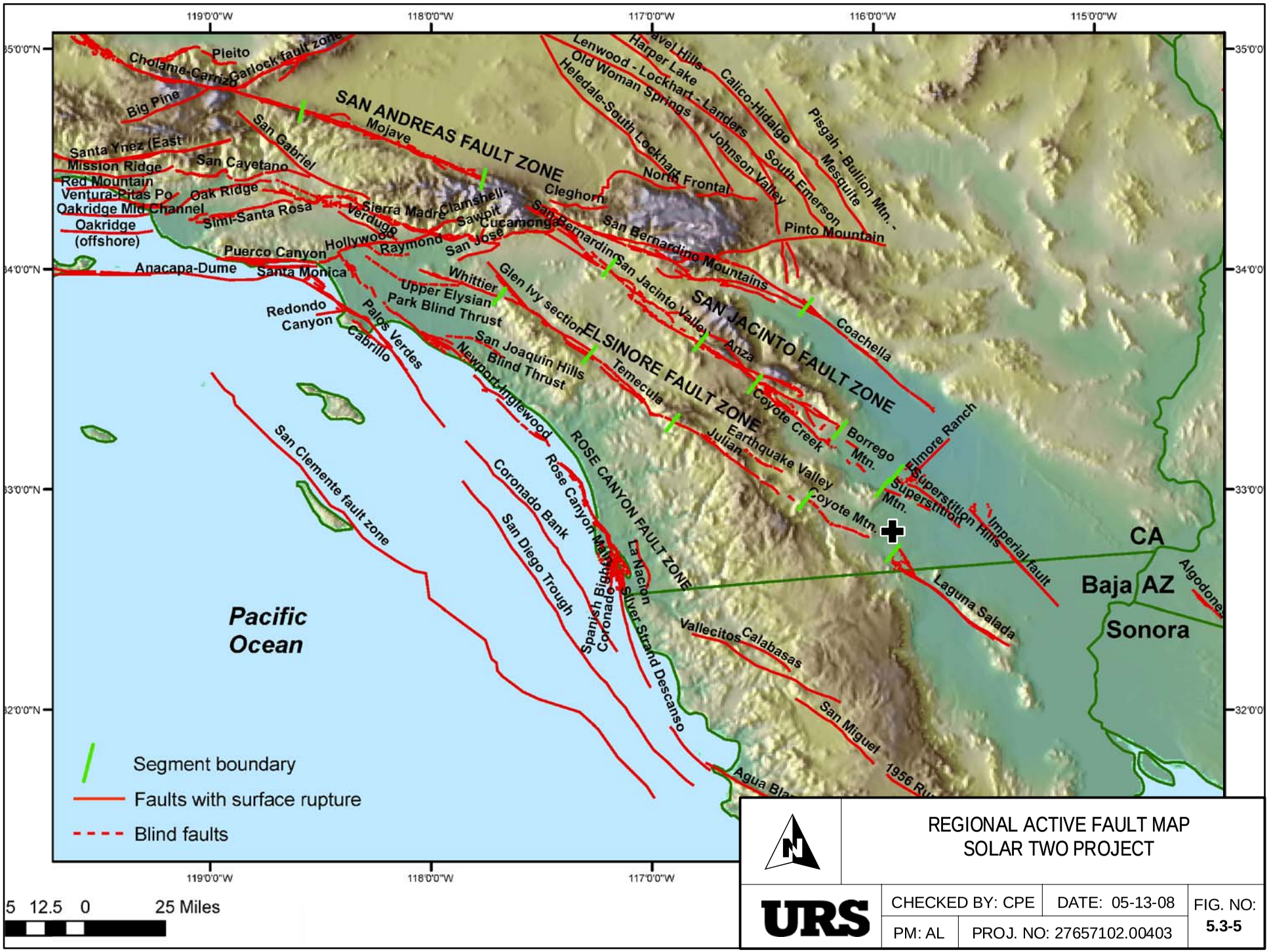
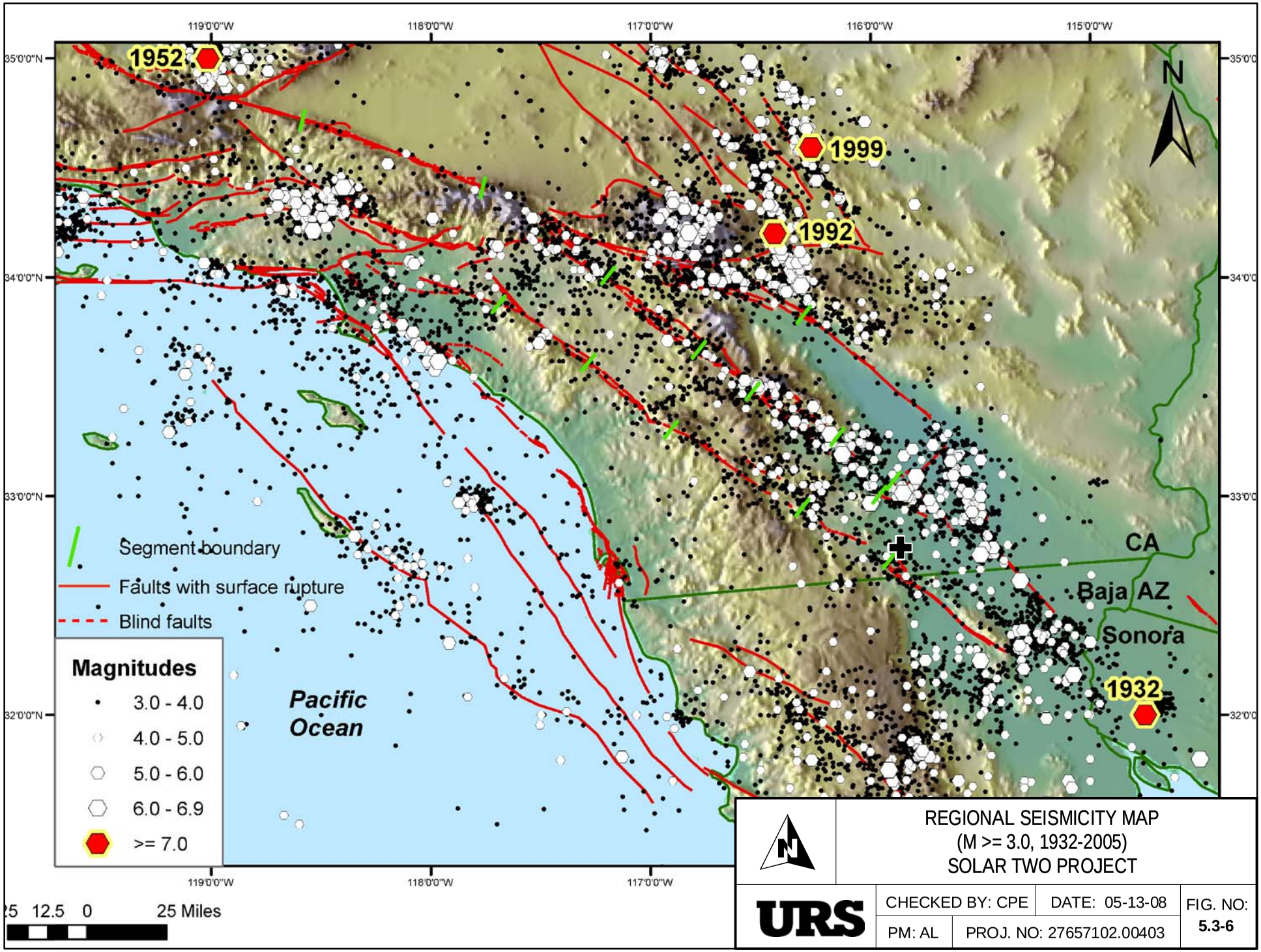


REGIONAL ACTIVE FAULT MAP
SOLAR TWO PROJECT

URS

CHECKED BY: CPE	DATE: 05-13-08	FIG. NO:
PM: AL	PROJ. NO: 27657102.00403	5.3-5



REGIONAL SEISMICITY MAP
(M >= 3.0, 1932-2005)
SOLAR TWO PROJECT

URS

CHECKED BY: CPE	DATE: 05-13-08	FIG. NO:
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