4.7 GEOLOGICAL RESOURCES

4.7.1 Introduction

This section discusses existing geological and soil conditions, possible geologic hazards, and geotechnical considerations. Potential impacts and applicant proposed mitigation measures for the project are discussed in Section 5.7.

4.7.2 Methodology

Existing conditions were determined from review of available published and unpublished literature and online sources. Descriptions of geologic units in the project area are based on published geologic quadrangle maps by Thomas Dibblee (1996a, b; 1997a, b, c, d; 2002). Hazard evaluations for landslides and liquefaction derive from published mapping by the Seismic Hazards Mapping Program (SHMP) from the California Geological Survey (CGS, 1998; 1999; 2003a, b; 2004a) and the geologic quadrangle mapping.

Assessment for fault rupture hazard and ground shaking hazard derive from fault mapping and catalogs and interactive maps primarily from CGS (formerly known as California Division of Mines and Geology, CDMG) and U.S. Geological Survey (USGS) sources. The primary sources derive from CGS and include:

- Probabilistic Seismic Hazard Assessment (PSHA) for the State of California (CDOC, Division of Mines and Geology, 1996)
- Earthquake Fault Zones Maps (CDOC, Division of Mines and Geology, 1997)
- Fault Evaluation Reports
- Probabilistic Seismic Hazards Mapping Ground Motion (CGS, 2004b)

Soils information presented here derives from the United States Department of Agriculture (USDA) STATSGO data set (USDA, 1994). Other sources of soil information reviewed include the following soil surveys by the USDA Natural Resource Conservation Service (NRCS) (formerly known as Soil Conservation Service):

- Soil Survey of Antelope Valley, California (USDA, 1967)
- Soil Survey of Kern County, Southeastern Part, California (USDA, 1981)
- Report and General Soil Map, Los Angeles County, California (USDA, 1969)
- Selected Soil Survey Maps, Angeles National Forest

Site-specific geotechnical investigations would be necessary to evaluate subsurface conditions and support appropriate engineering design. Such studies would support the construction, operation, and maintenance of the proposed facilities.

4.7.3 Existing Conditions

4.7.3.1 Physiographic Setting

The project elements traverse two major physiographic provinces, the Transverse Ranges and the Mojave Desert. The Antelope Substation is within the western portion of the Antelope Valley, part of the Mojave Desert physiographic province. The proposed 500 kV T/L route and Alternative 1 extend southwestward across the rift valley associated with the San Andreas fault zone and enter the Sierra Pelona. The Sierra Pelona is a small east-northeasterly trending ridge considered part of the San Gabriel Mountains which in turn are part of the Transverse Ranges.

The proposed and alternate T/L routes extend southwesterly across rugged ridge, canyon, and valley terrain of the San Gabriel Mountains and end at the Pardee Substation. This existing substation is between Valencia and Saugus on the northern margin of the broad Santa Clara River valley. The central portions of these routes are located within the Angeles National Forest.

4.7.3.2 Geologic Setting

The routes traverse diverse geologic conditions associated with the major physiographic provinces discussed above. Table 4.7-1 presents a summary of geologic conditions for the project elements.

The western Antelope Valley is characterized by relatively flatlying topography and valley fill deposits. Near the margins of the Antelope Valley at the flanks of Ritter Ridge and Portal Ridge the routes cross sloping terrain underlain by older alluvial fan deposits shed off of the adjacent ridges.

The ridges are comprised of crystalline rocks of igneous and metamorphic composition. Beyond the ridge the routes cross the San Andreas rift zone in Leona Valley. The rift valley is underlain by Quaternary age surficial deposits and Pliocene and Pleistocene sedimentary deposits.

TABLE 4.7-1
GEOLOGIC CONDITIONS ALONG SEGMENT 1 – ANTELOPE TO PARDEE

Approximate Mile Marker[1]	Geologic Unit/ Structure	Formation Name	Description/Comments
Proposed 500 kV T/L Route			
0.0 -2.3	Qa	Alluvium	Antelope Substation: Alluvial sand and clay
2.3 – 2.8	Qoa	Older Alluvium	Sand and gravel fan deposits
2.8 – 3.0	qm	Quartz monzonite	Granitic rocks, variable weathering profile
3.0 – 3.4	Qa	Alluvium	Identified liquefaction potential
3.2	Fault	San Andreas Fault	Branch fault off San Andreas rift zone; fault rupture hazard
3.4-3.8	ps	Pelona Schist	Identified landslide potential
3.8 -4.3	Qa	Alluvium	Identified liquefaction potential
4.3-4.7	Fault Zone Tas, Tab, Tac, qd	Rift Zone and Anaverde Fm	Rift zone of San Andreas fault with slivers of Anaverde Formation (sandstone, shale, and breccia) and quartz diorite; identified landslide hazard potential; significant fault rupture hazard
4.7-5.2	Qa	Alluvium	Identified liquefaction potential
5.2-9.4	qd	Quartz diorite	Granitic rocks, variable weathering profile, possible landslide hazard potential
9.4	Fault	Clearwater fault	Late Quaternary activity, minor rupture hazard
9.4-10.5	Tsfa, Tsfs	San Francisquito Fm	Lithified, fractured, marine clastic rocks. Argillaceous shales and sandstones; possible landslide hazard potential
	Fault	San Francisquito Fault	Likely inactive, no significant fault rupture hazard
10.5-12.3.3	ps	Pelona Schist	Mica schist, out-of-slope dipping foliation; landslide hazard potential
12.3-12.8	Qls	Landslide	Large feature in foliated metamorphic rock;
12.8-13.1	ps	Pelona Schist	Mica schist, out-of-slope dipping foliation; landslide hazard potential
13.1-13.8	Qls	Landslide	Large feature in foliated metamorphic rock; landslide hazard potential
13.8-17.5	ps	Pelona Schist	Mica schist, out-of-slope dipping foliation; landslide hazard potential
17.5-19.8	Tmc w/Qa	Mint Canyon Fm	Moderately indurated terrestrial fluviatile, predominantly sandstone; identified landslide hazard potential; liquefaction potential in alluvial areas
19.8-20.5	Tc	Castaic Fm	Clastic marine sediments, claystone w/ lesser sandstone; identified landslide hazard potential
20.5-20.6	Qa	Alluvium	Haskell Cyn; identified liquefaction potential
20.6-22.8	QTs	Saugus Fm	Weakly indurated, terrestrial fluviatile conglomerate; identified landslide hazard potential
22.8-22.9	Qa	Alluvium	Dry Canyon, identified liquefaction potential
22.9-23.8	QTs	Saugus Fm	Weakly indurated, terrestrial fluviatile conglomerate; identified landslide hazard potential
23.8-24.1	Qa, Qg	Alluvium	Sand and gravel in San Francisquito Cyn; identified liquefaction pot
24.1-25.1	QTs	Saugus Fm	Weakly indurated, terrestrial fluviatile conglomerate; identified landslide hazard potential

TABLE 4.7-1 (CONTINUED)
GEOLOGIC CONDITIONS ALONG SEGMENT 1 - ANTELOPE TO PARDEE

Approximate Mile Marker[1]	Geologic Unit/ Structure	Formation Name	Description/Comments
25.1	Fault	San Gabriel Fault	Active right slip fault; fault rupture hazard
25.1-25.2	Qa	Alluvium	Reentrant off Santa Clara River Valley, identified liquefaction potential
25.2-25.3	QTs	Saugus Fm	Weakly indurated, terrestrial fluviatile conglomerate; identified landslide hazard potential
25.3-25.6	Qa	Alluvium	Sand and gravel, Santa Clara River Valley; identified liquefaction potential; Pardee Substation at mile 25.6
Alternative 1			
0.0-2.0	Qa	Alluvium	Antelope Substation: Valley alluvial; sand and clay
2.0 –2.5	Qoa	Older Alluvium	Sand and gravel fan deposits
2.5–3.8	Qa	Alluvium	Valley alluvial; sand and clay
3.8-4.2	Qoa	Older Alluvium	Sand and gravel fan deposits
4.2-5.4	qm	Quartz monzonite	Granitic rocks, variable weathering profile
5.4	Fault	San Andreas Fault	Branch fault off San Andreas rift zone; fault rupture hazard
5.4-5.5	Qa	Alluvium	Identified liquefaction potential
5.5-5.7	ps	Pelona Schist	Identified landslide hazard potential
5.7-6.2	Fault Zone Tas, Tab, Tac, qd, Qa	Rift Zone and Anaverde Fm, granitic rock and alluvium	Rift zone of San Andreas fault with slivers of Anaverde Formation (sandstone, shale, and breccia) and quartz diorite; alluvium; identified landslide hazard potential; identified liquefaction potential, significant fault rupture hazard
6.2-6.8	qd	Quartz diorite	Granitic rocks, variable weathering profile, minor zones of identified landslide hazard potential
6.8-7.9	gn	Gneiss	Closely fractured medium-grained, localized areas of identified landslide hazard potential
7.9-9.1	Qoa and qd	Older alluvium and quartz diorite	Older alluvium and granitic rocks with variable weathering profile along margins of San Francisquito Cyn, minor zones of possible landslide hazard potential
9.1-11.9	qd	Quartz diorite	Granitic rocks, variable weathering profile, possible minor zones of landslide hazard potential
11.9-12.3	gn	Gneiss	Closely fractured medium-grained, possible minor zones of landslide hazard potential
12.3	Fault	Clearwater fault	Late Quaternary activity, minor rupture hazard
12.3-14	Tsfa, Tsfs	San Francisquito Fm	Lithified, fractured, marine clastic rocks. Argillaceous shales and sandstones; possible landslide hazard potential
14	Fault	San Francisquito Fault	Likely inactive, no significant fault rupture hazard
14-19.1	ps w/ Qoa	Pelona Schist with minor older alluvium	Mica schist, out-of-slope dipping foliation; landslide hazard potential
19.1-20.5	QTs	Saugus Fm	Weakly indurated, terrestrial fluviatile conglomerate; identified landslide hazard potential

[1] Refer to Figure 3-2 for mile marker locations.

After crossing the rift zone the routes enter the Transverse Ranges and a stretch of granitic rock terrain along the flanks of Jupiter Mountain. As the routes extend southwesterly they transition across Tertiary-age sedimentary rocks between the Clearwater and San Francisquito faults and enter the metamorphic terrain of the Sierra Pelona.

The Sierra Pelona are characterized by an east-west trending anticline underlain by Pelona schist. Both routes cross the anticlinal ridge of the Sierra Pelona and begin dropping in elevation as they extend southwestward toward the Santa Clara River valley. Across this reach the routes transition out of the Pelona schist and into younger sequence of Tertiary-age sedimentary rocks. These Tertiary sediments include marine, nonmarine, and fluviatile deposits. Younger Quaternary age deposits are encountered in the alluvial valleys and landslide deposits are encountered locally throughout the sloping terrain of the Transverse Ranges.

4.7.3.3 Geologic Structure

The proposed project initiates at the Antelope Substation within the Mojave structural block and crosses the San Andreas fault zone, a major tectonic plate boundary characterized by right lateral movement. Across the San Andreas fault the routes enter the Transverse Ranges characterized by compressional tectonics (north-south shortening) that result from the large bend in the San Andreas fault zone. The active compressional environment of the Transverse Ranges has resulted in significant uplift, tilting, folding, and faulting. As a result, much of the route is underlain by moderate to steep terrain and moderate to steeply dipping bedding or foliation in the sedimentary and metamorphic units, respectively.

The active San Gabriel fault is crossed near the end of the proposed 500 kV T/L route and the Northridge thrust fault is present at depth to the southwest of the project area. The San Gabriel fault represents the structural boundary between the largely marine, Tertiary-age deposits of the Ventura basin on the west and the largely terrestrial, Tertiary-age deposits of the Soledad basin.

4.7.3.4 Geologic Units

Geologic units encountered in the project area are presented in Table 4.7-1 and are based on the quadrangle-level geologic maps of Dibblee. The geologic units are described briefly below.

4.7.3.4.1 Surficial Deposits. Quaternary alluvium includes the valley fill deposits of the Antelope Valley and the older alluvial and alluvial fan deposits associated with adjacent mountain fronts. Alluvial deposits are present throughout the Transverse Ranges as deposited in the valley and canyon bottoms throughout the range. Alluvial deposits fill the Santa Clara River valley and underlie the Pardee Substation. Landslides are present locally on the slopes of the Sierra Pelona and the slopes along the northern flanks of the Santa Clara River valley based on mapping by Dibblee.

4.7.3.4.2 Tertiary Sediments. Tertiary-age rock units are found at various points along the T/L routes. Weakly to moderately lithified deposits of the Anaverde Formation are present solely within the San Andreas rift zone. Lithified and fractured sandstones, shales and siltstones of the San Francisquito Formation are present as a faulted wedge between the Clearwater and San Francisquito faults. Weakly indurated marine and nonmarine deposits of the Mint Canyon and Castaic formations are encountered along the southwest flanks of the Sierra Pelona. These deposits are overlain by the Saugus Formation along the northern flanks of the Santa Clara River Valley.

4.7.3.4.3 Granitic Rocks. Crystalline rocks of granitic origin are encountered in the northern portion of the alignment within and southwesterly of the San Andreas fault zone. Mapped rock units include quartz diorite, quartz monzonite, and a gneiss-quartz diorite complex.

4.7.3.4.4 Metamorphic Rocks. The Pelona Schist is mapped near the San Andreas fault and underlying the anticlinal Sierra Pelona. These crystalline rocks are extensively folded and faulted with moderately to steeply dipping foliations.

4.7.4 Geologic Hazards

4.7.4.1 Seismicity

The project area is seismically active given the presence of the San Andreas fault system and the active faults of the Transverse Ranges and includes the potential seismicity associated with blind thrust faulting. Notable historic seismic events affecting the project area are presented on Figure 4.7-2. It is likely that the project area would experience minor to moderate earthquakes and potentially a major earthquake (moment magnitude M7, or greater) during its service life. A 1995 estimate by the Working Group on California Earthquake Probabilities gave an 80 to 90 percent probability of an M7 or greater earthquake in southern California before 2024.

4.7.4.1.1 Seismic Parameters. Earthquakes, their causative fault sources, and the resultant ground motions are measured by parameters, including magnitude, intensity, fault length, rupture area, slip rate, recurrence maximum considered earthquake, and peak ground acceleration. These seismic parameters are used to evaluate and compare earthquake events, seismic hazard potential, and ground shaking.

4.7.4.1.2 Magnitude. Magnitude refers to the size of an earthquake. A number of methods are used to measure magnitude, including Richter (M_L), surface wave (Ms), and body wave (M_b). These are instrumental methods, based on the measurement of amplitude of seismic waves recorded on a seismograph, and can yield inconsistent results when considered over wide ranges of magnitudes. A more consistent method of magnitude measurement is provided by the moment magnitude, or M_w. Moment magnitude is based on the energy released across the area of the fault.

4.7.4.1.3 Maximum Considered Earthquake (MCE). Fault parameters are generally used to estimate the maximum considered earthquake (MCE) that can be generated by a given fault or fault segment. In some cases, historic earthquakes are used to characterize the MCE. In general, the MCE is a rational and believable event that can be supported by the seismic and paleoseismic geology of the area.

4.7.4.1.4 Ground Motions. Probabilistic seismic hazard estimates based on the USGS/CGS Probabilistic Seismic Hazards Assessment (PSHA) Model, (2002) and presented on regional maps depict ground motions associated with a 10% probability of exceedance in a 50 year period. The ground motion estimate for both the Antelope and Pardee substations is 0.66 gravity (g) for the peak bedrock ground acceleration. The regional mapping estimates of peak bedrock acceleration for the 10% in 50 year recurrence range from approximately 0.47g to 0.77g along the proposed and alternative T/L routes.

4.7.4.2 Fault Rupture

Active and potentially active faults have been mapped in the project vicinity and documented by a number of government agencies and scientific entities. Numerous published maps and reports have been prepared by the USGS, the CGS, and other State or public agencies (i.e., Caltrans, Southern California Earthquake Center) that present information on fault location and activity. Table 4.7-2 presents a list of active and potentially active faults within the project vicinity and active faults within approximately 60 miles. Fault characteristics listed in Table 4.7-2 are based on published data.

Figure 4.7-1 presents a fault and epicenter map focused on the project area showing the approximate location of the project in the context of seismic sources. The San Andreas fault zone represents the primary component of the transform boundary between the North America and Pacific plates and the dominant seismic source in the project area. As discussed above there is a significant likelihood that there would be large earthquake in area within the

TABLE 4.7-2
SEISMIC SOURCE CHARACTERISTICS

Fault name	Nearest distance to Proposed 500 kV T/L Route Miles[1] (Kilometers)	Nearest distance to Alternative 1 500-220 kV T/L Route Miles[1] (Kilometers)	Type of Faulting[2]	Fault length[2] Miles (Kilometers)	Slip rate Range[2] Inches/Year (Millimeters/Year)	Maximum magnitude earthquake[3] (m_{max})
Clamshell-Sawpit Canyon	36 (58)	36 (58)	Reverse	11.2 (18)	0.02 - 0.04 (0.5 - 1)	6.5
Clearwater	0 (0)	0 (0)	Reverse	19.9 (32)	NA	NA
Cucamonga	49.7 (80)	49.7 (80)	Thrust	18.6 (30)	0.2 - 0.55 (5 - 14)	7.0
Elsinore	49.7 (80)	49.7 (80)	Right-lateral strike-slip	112.0 (180)	0.16 (4)	6.8 - 7.1
Garlock	23.6 (38)	21.1 (34)	Left-lateral strike-slip	155.0 (250)	0.08 - 0.43 (2-11)	7.1 - 7.3
Hollywood	24.9 (40)	24.9 (40)	Left reverse	9.3 (15)	0.01 - 0.03 (0.33 - 0.75)	6.5
Holser	1 (1.6)	1 (1.6)	Reverse	12.4 (20)	0.015 (0.4)	6.5
Malibu Coast	26.7 (43)	26.7 (43)	Reverse	21.1 (34)	0.01 (0.3)	6.7
Newport-Inglewood	29.8 (48)	29.8 (48)	Right-lateral strike-slip	46.6 (75)	0.024 (0.6)	6.9
Oak Ridge	12.4 (20)	12.4 (20)	Thrust	55.9 (90)	0.14 - 0.24 (3.5 - 6)	6.9
Palos Verdes	45.4 (73)	45.4 (73)	Right reverse	49.7 (80)	0.004 - 0.12 (0.1 - 3)	7.1
Pelona	1.1 (1.8)	2.2 (3.6)	Left reverse	4.3 (7)	NA	NA
Pleito Thrust	37.3 (60)	33.5 (54)	Thrust	28 (45)	0.06 (1.4)	6.8
San Andreas	0 (0)	0 (0)	Right-lateral strike-slip	745 (1,200)	0.79 - 1.38 (20-35)	7.9

TABLE 4.7-2 (CONTINUED)
SEISMIC SOURCE CHARACTERISTICS

Fault name	Nearest distance to Proposed 500 kV T/L Route Miles[1] (Kilometers)	Nearest distance to Alternative 1 500-220 kV T/L Route Miles[1] (Kilometers)	Type of Faulting[2]	Fault length[2] Miles (Kilometers)	Slip rate Range[2] Inches/Year (Millimeters/Year)	Maximum magnitude earthquake[3] (m_{max})
San Cayetano	10.6 (17)	10.6 (17)	Thrust	28 (45)	0.05 - 0.35 (1.3 - 9)	6.8
San Fernando	11.8 (19)	11.8 (19)	Thrust	10.56 (17)	0.2 (5)	6.8
San Gabriel	0 (0)	0 (0)	Right-lateral strike-slip	87 (140)	0.04 - 0.2 (1 - 5)	7.0
San Jacinto	56 (90)	56 (90)	Right-lateral strike-slip	130.5 (210)	0.28 - 0.67 (7 - 17)	6.9
Santa Monica	26.1 (42)	26.1 (42)	Left reverse	14.9 (24)	0.01 - 0.015 (0.27 - 0.39)	6.6
Santa Susana	6.8 (11)	6.8 (11)	Thrust	23.6 (38)	0.2 - 0.28 (5 - 7)	6.6
Sierra Madre	18.6 (30)	18.6 (30)	Reverse	46.6 (75)	0.014 - 0.16 (0.36 - 4)	7.0
Simi (Santa Rosa)	15.5 (25)	15.5 (25)	Reverse	24.9 (40)	0.04 (1)	6.7
Whittier	41 (66)	41 (66)	Right-lateral strike-slip	24.9 (40)	0.098 - 0.12 (2.5 - 3)	6.8
White Wolf	41 (66)	39.1 (63)	Left-lateral reverse	37.3 (60)	0.12 - 0.335 (3 - 8.5)	7.2

Sources:

1 Jennings, 1994.

2 SCEC, 1995.

3 ICBO, 1998.

near future. Specifically, the Mojave segment of the San Andreas has a significant potential to rupture with a large magnitude event within the project service life. The San Gabriel is an active fault with surface rupture potential. The proposed 500 kV T/L route crosses the San Gabriel fault at approximately mile 25 as noted in Table 4.7-1.

4.7.4.2.1 **<u>Earthquake Fault Zones</u>.** The Alquist-Priolo Special Studies Zones Act, passed in 1972, requires the establishment of "earthquake fault zones" (formerly known as "special studies zones") along known active faults in California. Strict regulations on development within these zones are enforced to reduce the potential for damage due to fault displacement. However, these restrictions apply only to occupied structures and none of the proposed project facilities would be manned.

In order to be designated as an "earthquake fault zone" a fault must be "sufficiently active and well defined" according to State guidelines. As a result, only faults or portions of faults with relatively high potential for ground rupture are zoned, while other faults that may partially meet the criteria are not zoned. The potential for fault rupture therefore is not limited solely to faults or portions of faults delineated as "earthquake fault zones". Earthquake fault zones within the project area include the San Gabriel and San Andreas faults. Faults crossed by the proposed and alternate routes are listed in Table 4.7-1.

4.7.4.2.2 **<u>Fault Displacement</u>.** There is a significant potential for surface rupture within the project area given the potential for moderate or large earthquakes on the active San Gabriel and San Andreas faults. Estimates of likely surface displacement can be made based on empirical correlations from a catalog of worldwide earthquakes that includes measurements of ground rupture. Mean values of average and maximum displacement can be estimated for the San Andreas and the San Gabriel faults based on correlations to fault magnitude (Wells and Coppersmith, 1994). The mean value of the maximum displacement for an M_w 7.8 earthquake on the central portion of the San Andreas (repeat of 1857 rupture length) is approximately 10 meters (m) and the mean value of the average displacement is approximately 5m. Values for the mean maximum and mean average displacements for an M_w 7 earthquake on the San Gabriel fault are 1.5m and 1m respectively.

These estimates are based on statistical regressions and the computed displacements are mean values. The mean plus one standard deviation displacement is approximately twice the mean value, which indicates the wide range of possible displacements for a given magnitude event. Some comparable worldwide events on strike-slip faults provide additional insight into possible slip scenarios for hazard evaluation. For example, greater than 5m of slip was measured for the 1992 Landers M_w 7.3 earthquake, the 1999 Hector Mine M_w 7.1 event and the 1999 Turkey M_w 7.3 event.

4.7.4.3 Landslides

Landslides, earth flows, and debris flows are relatively common features in the steep ridge, valley, and canyon terrain of the Transverse Ranges. Much of the project area has been mapped by the recent State Seismic Hazards Mapping Program. This program was instituted because "the effects of strong ground shaking, liquefaction, landslides, or other ground failure account for approximately 95 percent of economic losses caused by an earthquake". The portions of the project within the Angeles National Forest (specifically the Warm Springs Mountain, Green Valley, and part of the Sleepy Valley quadrangles) have not been mapped by the program because of the relative absence of development at risk. A review of the quadrangle level hazard mapping for the areas that are mapped, shows a significant amount of potential landslide hazard in the areas of sloping terrain. This is in addition to the regional geologic maps which identify common landslides and extensive areas of out of slope bedding.

4.7.4.4 Liquefaction and Lateral Spreading

Seismically induced soil liquefaction is a phenomenon in which loose to medium dense, saturated, granular materials undergo matrix rearrangement, develop high pore water pressure, and lose shear strengths due to cyclic ground vibrations induced by earthquakes. This rearrangement and strength loss is followed by a reduction in bulk volume. Manifestations of soil liquefaction can include loss of bearing and lateral capacities for foundations, and surface settlements and tilting in level ground. Soil liquefaction can also result in instabilities and lateral deformation in areas of sloping ground. Liquefaction induced failure and lateral movements of slopes or free faces are referred to as lateral spreading.

Liquefaction is a potential hazard at various locations along the T/L routes and at the Pardee Substation based on State seismic hazard mapping. These hazards are not considered significant at the Antelope Substation because of the deep occurrence of groundwater in this area. Lateral spreading is a potential hazard only if structures are placed near slopes or free faces underlain by liquefiable deposits.

4.7.4.5 Expansive and Collapsible Soils

Expansive soils are those that contain significant amounts of clays that expand when wetted and can cause damage to foundations if moisture collects beneath structures. Expansive soils are not anticipated in significant quantities within the hilly terrain or the Santa Clara River valley portions of the project based on a review of soil mapping. Some potential for fine-grained expansive materials may be present in the Antelope Valley.

Soils that collapse during wetting may be encountered in alluvial deposits when re-wetting causes chemical or physical bonds between soil particles to weaken. This allows the structure of the soil to collapse and the ground surface to subside. In order to collapse, soils must have a weak cementation or cohesive structure that can be modified by the addition of water. Collapsible soils, if present within the project area are most likely to occur in the fine-grained desert soils of Antelope Valley.

4.7.4.6 Subsidence

Land subsidence is a result of fluid withdrawal from compressible sediments. As fluid is withdrawn the effective pressure in the drained sediments increases. Compressible sediments are then compacted because the over-burden pressure is no longer compensated by hydrostatic pressure. This effect is most pronounced in younger, uncompacted sediments. Fluid withdrawal is common in southern California groundwater basins and in the oil and gas extraction fields. The southern end of the project area including the Pardee Substation is in the Santa Clara groundwater basin and is an area of oil and gas withdrawal as well. Subsidence has been documented throughout the southern California area and particularly in the oil producing basins. Dramatic evidence of subsidence has been noted in the oil fields around Torrance, Redondo Beach and Long Beach with rates of about 3 centimeters (cm) year noted at Redondo Beach. Current rates of subsidence in the Santa Clarita Valley are substantially less and largely a result of groundwater withdrawal. Subsidence rates in the project vicinity range from about 2 to 4 millimeters (mm)/year for period between 1971 and 1989.

4.7.5 Soils

Soils result from both the physical and chemical weathering of the geologic deposits exposed at and near the earth's surface. Soil formation is a complex phenomenon and affected by the dynamic interaction of physical, chemical and biological processes. Soil surveys classify soil characteristics based on soil associations, specifically, distinct combinations of soil types (soil series). Soil associations have been mapped by the USDA Natural Resources Conservation Service (NRCS) in the project area.

Soil Associations mapped within the project area are tabulated in Table 4.7-3. The seven map units present in the project area represent soil associations from three distinct groups; Mojave Desert soils, upland soils, and alluvial soils. The Mojave Desert soil group is represented by the Hanford-Ramona-Greenfield soil association and the alluvial soils by the Pico-Anacapa-Salinas soil association. Upland soils include the remaining Cieneba-Caperton-Gaviota, Soboba-Avawatz-Oak Glen, Rock Outcrop-Chilao-Stoneyford, Lodo-Sobrante-Gaviota, and

Cieneba-Exchequer-Sobrante soil associations. Generalized characteristics for these associations are presented in Table 4.7-3.

TABLE 4.7-3
GENERAL CHARACTERISTICS OF SOIL ASSOCIATIONS PRESENT IN THE PROJECT AREA

Soil Association	Segment 1 Location (Mile Marker)[1]	Alt. 1 Location (Mile Marker)[1]	Shrink Swell Potential	Erosion Hazard	Corrosion Concrete	Corrosion Steel
Hanford-Ramona-Greenfield	Antelope Substation 0.0 to 2.6	Antelope Substation 0.0 to 4.1	Low	Slight and Moderate	Low and Moderate	Moderate and High
Cieneba-Caperton-Gaviota	2.6 to 4.5	4.1 to 6.0	Low	Moderate and High	Moderate	Low and Moderate
Soboba-Avawatz-Oak Glen	4.5 to 5.2	6.0 to 6.7	Low	Slight and Moderate	Low and Moderate	Moderate
Cieneba-Caperton-Gaviota	5.2 to 9.4	6.7 to 12.6	Low	Moderate and High	Moderate	Low and Moderate
Rock Outcrop-Chilao-Stoneyford	9.4 to 10.5	12.6 to 14.4	Low and Moderate	Moderate	Low and Moderate	Moderate
Lodo-Sobrante-Gaviota	10.5 to 17.5	14.4 to 19.1	Low and Moderate	Moderate and High	Low and Moderate	Moderate
Cieneba-Exchequer-Sobrante	17.5 to 23.2	19.1 to 22.8	Low	Moderate and Moderate-High	Low and Moderate	Moderate
Pico-Anacapa-Salinas	23.2 to 24.1		Low and Moderate	Slight and moderate	Low	High
Cieneba-Exchequer-Sobrante	24.1 to 25.1		Low	Moderate and Moderate-High	Low and Moderate	Moderate
Pico-Anacapa-Salinas	25.1 to 25.6 Pardee Sub.		Low and Moderate	Slight to moderate	Low	High

[1] Refer to Figure 3-2 for mile marker locations.