C.5 GEOLOGY, SOILS, AND MINERALS

This chapter provides an update on geology, soils, and minerals from that presented in the Final Environmental Impact Statement/Environmental Impact Report (FEIS/EIR) for the California-Oregon Transmission Project and the Los Banos-Gates Transmission Project (TANC/WAPA, 1988). The environmental setting of the Proposed Project area has not significantly changed since the publication of the FEIS/EIR with respect to the geology, soils, mineral and paleontologic resources of the region; however, the general understanding of the processes underlying the observed conditions have advanced and seismic standards have changed. This chapter includes a general description of the geology and associated geologic hazards of the Project area; a revision of the seismic hazard analysis reflecting changes in the governing regulations and an improved understanding of the faulting in the Project area; a description of the soil conditions; and a revised description of the paleontologic resources of the Project area. A revised discussion of potential impacts is presented, as well as five revised mitigation measures for the Proposed Project.

In general, the methodology used for this analysis did not differ substantially from that used in the FEIS/EIR, except for access to recent studies and publications. The impacts identified in this chapter differ from the FEIS/EIR only in the inclusion of a mitigation measure for identification and avoidance of paleontologic resources within the Moreno Formation of the Panoche and Tumey Hills, which has recently been, designated an Area of Critical Environmental Concern. The mitigation measures from the FEIS/EIR have been incorporated into new mitigation measures because those from the previous document were generally vague and lacked enforcement procedures.

The Proposed Project Corridor with the inclusion of Alternative Segment 6A is here designated as the environmentally superior alignment based on the hazards from and impacts to the geology, soils, mineral and paleontologic resources, primarily because this alignment avoids productive agricultural lands and existing petroleum production facilities to the greatest extent feasible.

C.5.1 ENVIRONMENTAL BASELINE

Baseline geologic information was collected from published and unpublished geologic, seismic, and geotechnical literature covering the Proposed Project and the surrounding area. The literature review was supplemented by a limited field reconnaissance of the proposed and alternative corridors. The literature review and field reconnaissance focused on the identification of specific geologic hazards.

C.5.1.1 Regional Overview

C.5.1.1.1 *Physiography and Topography*

The project area is located along the boundary between the San Joaquin Valley on the east and the Diablo Range on the west. The San Joaquin Valley comprises the southern half of California's Central Valley geomorphic province, while the Diablo Range is part of the Coast Ranges geomorphic province.

The Coast Ranges extend along the California coast from the Santa Ynez River in the south to the Klamath Range in the north (Norris and Webb, 1990).

The topography of the project area is varied, with low rolling to moderately steep slopes in the foothills of the Diablo Range and gentle to nearly level slopes on the alluvial fans and the valley floor. Elevations in the project area range from about 175 feet in the valleys to over 1,200 feet along some ridges in the foothills.

The Diablo Range is a series of low ridges reaching elevations of up to 3,000 feet. These mountains form a natural barrier against the coastal winds and fogs, creating a rain shadow on the western side of the valley. Numerous intermittent drainages such as Panoche, Little Panoche, Arroyo Hondo, Cantua, Silver, Domengine, and Los Gatos Creeks drain the eastern slopes of the Diablo Range. These creeks have a variable discharge, with periodic flooding that flushes sediments out of the mountains and foothills and deposits them on alluvial fans at the base of the foothills. Recent alluvial fan deposits may extend up to several miles into the valley, with larger, more extensive fans at the mouths of the larger drainages.

C.5.1.1.2 *Geology*

The San Joaquin Valley is a deep structural basin, which was initially filled by Cretaceous and Tertiary age marine and continental sediments shed from the ancestral Sierra Nevada Range to the east. More recent tectonic forces including regional uplift and the associated folding and faulting of these basin deposits formed the Coast Ranges. The Cretaceous deposits comprise the Franciscan Complex and the Great Valley Sequence. The Tertiary sediments deposited on the Cretaceous sequence are composed predominantly of sandstone and shale with minor conglomerate beds, and typically dip toward the San Joaquin Valley.

Geologic Units

The Cretaceous sequence consists of both marine and non-marine sediments, which were laid down in near horizontal beds and have subsequently been uplifted, tilted, folded, and faulted over a long period of time and now form the rocks of the eastern foothills of the Diablo Range. The rocks of the Great Valley Sequence overlie rocks of the Franciscan Complex, which consist of igneous and sedimentary rocks, which have been folded, faulted, and partially metamorphosed, then uplifted onto the continental margin. Paleocene through Miocene marine sediments and Pliocene through Quaternary marine and non-marine sediments overlie the Cretaceous sequence.

Great Valley Sequence. The Great Valley Sequence is a grouping of sedimentary rocks, which formed in the tectonic setting of a forearc basin, adjacent to a subduction zone. These rocks generally consist of well-indurated graywacke sandstone, siltstone, shale, and conglomerates. In the project area, these rocks have been subdivided into the Panoche Formation and Moreno Shale.

The Panoche Formation primarily consists of mudstone with thin interbeds of sandstone. Dibblee (1971, 1975) subdivided the Panoche Formation into three mapable subunits; a shale unit with minor sandstone interbeds, a sandstone unit with minor shale interbeds, and cobble conglomerate with minor interbeds of sandstone and shale. The overall thickness of the Panoche Formation ranges from about 8,000 feet near Coalinga to as much as 30,000 feet north of Little Panoche Valley. This formation forms a band of continuous exposure nearly 6 miles wide along the western foothills and comprises the majority of mapped bedrock throughout the northern half of the Proposed Project and Alternative Segments 2A and 4A.

The Moreno Shale primarily consists of micaceous claystone with thin interbeds of sandstone and shale. Dibblee (1971, 1975) subdivided the Moreno into seven mapable subunits but only four of these units are found in the Project area: an undivided micaceous claystone, a micaceous sandstone, a siliceous shale, and an organic shale with noted localities of reptilian vertebrate and ammonite fossils.

Paleocene Series. The Paleocene series in the project area consists of the Lodo and Laguna Seca formations. The Lodo Formation is a marine claystone/shale with some mapped areas further subdivided into three members a lower shale member, a middle sandstone member and an upper shale member. The Laguna Seca Formation consists of a light brown to tan weathering, marine, silty to fine-grained sandstone.

Eocene Series. The Eocene series includes the Domengine Sandstone, and the Kreyenhagen Shale. The Domengine Sandstone is a poorly-sorted arkosic sandstone of shallow marine origin, with interbedded claystone and siltstone. The Domengine Formation unconformably overlies the Lodo Formation in areas where the Laguna Seca Formation is absent.

The Kreyenhagen Shale is an organic, diatomaceous shale of late Eocene to Oligocene age. The Kreyenhagen Shale conformably overlies the Domengine Sandstone in the project area. The Kreyenhagen ranges in thickness from about 700 feet in Merced County to as much as 2,000 feet thick north of Cantua Creek, where it consists of a brown sandy shale and white laminated sandstone near the base with about 600 feet of white-weathering diatomite at the top of the formation.

Oligocene Series. The Oligocene Series consists of a small remnant of Tumey Formation exposed between Panoche Creek and Arroyo Hondo. The Tumey Formation consists of a lower arkosic sandstone member with a maximum thickness of 700 feet, and an upper diatomaceous shale member approximately 250 feet thick. Oligocene strata are not found in the remainder of the project area.

Miocene Series. The Miocene Series consists of the Temblor, Big Blue, and Santa Margarita formations. These formations are quite variable in lithology and thickness, but are predominantly marine sandstone and diatomaceous shale.

The Temblor Formation is early Miocene in age and consists of petroliferous sandstone, calcareous sandstone, and diatomaceous and foraminiferal shale, and sandstone, of 550 feet aggregate thickness. The Temblor conformably overlies the Tumey Formation between Panoche Creek and Arroyo Hondo and unconformably overlies Eocene sediments everywhere else.

The Big Blue Serpentinous Member of the Temblor Formation, was mapped as a separate formation by Dibblee (1971, 1975). The Big Blue Formation consists of a serpentinite-rubble conglomerate and claystone composed primarily of serpentinite flakes and fragments derived from the New Idria serpentinite to the west. This unit is found at the top of the Temblor Formation in the area between Anticline Ridge and Cantua Creek, and attains a maximum thickness of 1,000 feet.

The Santa Margarita Formation is late Miocene in age and consists of fine to coarse-grained sandstone with some gravel at the base and top of the formation. It is about 700 feet thick and conformably overlies the Big Blue Formation from Salt Creek to Anticline Ridge.

Pliocene Series. The Pliocene Series consists of the Oro Loma, Jacalitos, Etchegoin, and San Joaquin formations. These deposits unconformably overlie the Santa Margarita and other formations. The Oro Loma Formation consists of terrestrial gray to red gravel, and interbedded gravel, sand, silt beds, with a basal white marly unit. These deposits are late Miocene to early Pliocene in age and are found in a narrow outcrop band at the upper margin of the alluvial fan deposits between about one mile south of Ortigalita Creek and two miles north of Wildcat Canyon.

The Jacalitos Formation consists predominantly of fine-grained, red, green, and gray, silt and sandy silt deposits that are relatively erodable. This unit is found in a band less than a mile wide along the valleys rim in a strip from Anticline Ridge to about one mile north of Arroyo Ciervo, where it forms valleys between more resistant rocks located stratigraphically above and below the Jacalitos Formation.

The Etchegoin Formation consists of coarse to fine, bluish gray, shallow-water marine silty sandstone with beds of pebbly sand, fine gray sand, silt, and clay. The Etchegoin overlies the Jacalitos Formation in a discontinuous band flanking the San Joaquin Valley from Anticline Ridge to about two miles north of Panoche Creek.

The San Joaquin Formation comprises brackish marine silty sandstone, siltstone, and clay deposits, which are younger than the Etchegoin Formation. The San Joaquin Formation is found mainly in the southern portion of the Project area, northeast of Coalinga around Anticline Ridge, in the Guijarral Hills (beneath younger sediments), and further south into the Kettleman Hills. The San Joaquin Formation has a maximum thickness of over 1,800 feet.

Pleistocene to Holocene Deposits. Pleistocene and younger deposits consist of the Pleistocene Tulare Formation, older alluvium and stream terrace deposits, younger alluvial fan and stream terrace deposits, landslide debris, alluvium, and stream gravel and channel deposits. These sediments are everywhere unconformable, and are generally flat-lying to gently dipping toward the valley to the east. They vary widely in thickness, composition, and areal extent as described below.

The Tulare Formation is the youngest of the deformed or tilted strata of the Great Valley deposits. The Tulare Formation is thought to have once formed a continuous blanket of sediments across the present foothill area and extending out into the valley, though the deposits have been extensively eroded. These deposits generally unconformably overlie older deposits and are in contact with most of the older bedrock units. The Tulare Formation consists of sand, silt, and clay in varying amounts with depth and forms the primary groundwater reservoir within the valley proper.

One member of the Tulare Formation of importance is the Corcoran Clay member, which varies in thickness across the San Joaquin Valley, and forms a confining layer for deeper sediments of the Tulare. This confining layer is absent in portions of the western valley margin, and tilted and exposed at the surface along the project alignment in the vicinity of Panoche Creek.

Older Alluvium is mapped as alluvial fan deposits in the inter-fan areas between the larger drainages of Ortigalita, Little Panoche, Panoche and Los Gatos Creeks, and around the nose of Anticline Ridge north and east of Coalinga. These deposits are characterized by poorly sorted, unconsolidated sand, silt, clay and minor gravel, which are moderately well dissected by streams and exhibit strong soil development. Except for their angular unconformity with the Tulare Formation, these deposits are very similar to the Tulare deposits and it is very difficult to distinguish them in surface exposures.

Pleistocene age Terrace Deposits occupy the margins of the larger creek drainages, but are only extensive enough to have been mapped along the margins of Cantua and Panoche Creeks. These terrace deposits are clearly older than present-day floodplain deposits due to their elevation above the floodplain and their extensive soil development. These deposits consist mainly of boulders, gravel, sand, and silt deposits ranging from 2 to 20 feet in thickness.

Alluvial fan and stream floodplain deposits of Holocene age are present in the stream valleys and the uppermost layers of the alluvial fans. In general, these deposits consist of unconsolidated sand, silt, and clay, with minor gravel. Poor soil development and a lack of deeply incised stream channels dissecting the fan surface characterize Younger alluvial deposits. Holocene stream terraces are generally low-lying deposits with only a few feet of separation in elevation from modern floodplain deposits. These deposits exhibit moderate to poor soil development and are difficult to distinguish from more recent deposits of present-day streams. These deposits have only been carefully mapped in the project area in the vicinity of San Luis Reservoir and O'Neill Forebay, where they were used to delineate the age and recency of fault activity through soil dating techniques.

Landslide deposits are generally found at the base of steep slopes and ridges. Extensive landslide hazard mapping has not been performed in the project area due to the sparse population and limited hazard to life and property. Several large landslides have been mapped along the Proposed Project Corridor along Big Blue Ridge (Dibblee, 1971, 1975).

Stream channel deposits are found in the active channels and floodplains of modern streams within the project area. These deposits consist primarily of gravel, sand, and silt, with minor clay, and are typically between 5 and 100 feet thick.

C.5.1.1.3 *Faults and Seismicity*

The faults in the Los Banos-Coalinga area were formed by the interaction between the Pacific and North American tectonic plates. Under the current tectonic regime, the Pacific Plate moves northwestward relative to the North American Plate. The primary right lateral, strike-slip faults of the San Andreas fault system accommodate most of the relative motion of the tectonic plates. In addition, numerous minor faults and folds within the project area accommodate a smaller portion of the crustal strain. The most notable of these faults are the Ortigalita, Quien Sabe, Nunez, and O'Neill fault system, and the blind thrust faults associated with the Coast Range-Central Valley (CRCV) geomorphic boundary (Jennings, 1994; Wakabayashi and Smith, 1994). These faults and folds accommodate the relative motion between the tectonic plates through deformation by strike-slip, reverse and thrust fault movements as well as folding. The effects of this deformation include mountain building, widespread regional uplift, basin development, and the generation of earthquakes.

Faults are classified as active, potentially active, or inactive by the California Division of Mines and Geology (CDMG) based on the age of most recent activity (Jennings, 1994) as defined below:

- Historic faults have experienced surface rupture during historic time (about the last 200 years) and are associated with either a recorded earthquake with surface rupture, aseismic creep or displaced fault survey lines,
- Holocene age faults have had surface displacement within the past 11,000 years, as demonstrated by young geomorphic evidence, offset young deposits, or radiometrically dated material,
- Late Quaternary age faults show evidence of surface rupture within approximately the last 700,000 years, as demonstrated using the same geomorphic evidence as for Holocene age faults, above,
- Quaternary age faults show evidence of surface rupture younger than about 1.6 million years ago, including faults which displace undifferentiated Plio-Pleistocene age deposits,
- Pre-Quaternary age faults show no evidence of movement within the Quaternary (about the past 1.6 million years) or lack evidence of displacement of younger deposits. Also included in this category are known faults for which detailed studies have not determined fault activity and those faults identified only in preliminary mapping.

The classification of "active" is applied to Historic and Holocene age faults, "potentially active" is applied to Quaternary and late Quaternary age faults, and "inactive" is applied to pre-Quaternary age faults. These classifications were developed to regulate the extent of detailed study required prior to development of projects across known fault traces. This classification is not meant to imply that inactive fault traces will not rupture, only that they have not been shown to have ruptured for some time and the probability of future rupture is low. This classification system also does not address subsurface or "blind" faults, which can rupture and cause significant earthquake damage, without surface rupture.

The blind thrust faults of the CRCV boundary are low to moderately dipping subsurface faults, which do not reach the earth's surface. Movement on this fault system was responsible for the 1983 Coalinga and 1985 Kettleman Hills earthquakes. Wakabayashi and Smith (1994) subdivided the blind thrust fault system along the CRCV boundary into 18 to 25 fault segments, using historic seismicity and changes in surface geomorphology. Each of these fault segments is thought to be capable of producing moderate earthquakes with maximum Richter magnitudes ranging between 5.7 and 6.8 (Wakabayashi and Smith, 1994; Petersen, et al., 1996).

Since the 1994 Northridge earthquake, the California Division of Mines and Geology (CDMG) and the United States Geological Survey (USGS) have taken renewed interest in investigating the potential for large earthquakes taking place on previously unknown "blind thrust faults" and poorly constrained potentially active faults with long recurrence intervals (Campbell, et al., 1995; WG99, 1999). The modeled segments of the CRCV blind thrust fault system beneath the project area extend the entire length of the Proposed Project Corridor and vary in distance from the corridor from 0 to 5.0 miles (Wakabayashi and Smith, 1994).

The New Idria fault, located to the west of the project area, ruptured in October 1982, in a manner similar to the Coalinga earthquake sequence beginning in May 1983. There was no surface rupture evident in the immediate epicenter area, and studies of epicentral locations of aftershocks defined a dipping plane, which is on strike with the fault plane of the Coalinga aftershock pattern. Minor sympathetic fault rupture was observed on another fault outside the study area.

Fault Rupture

Large abrupt differential fault displacements can pose a severe earthquake hazard for electrical substations, but do not pose a significant hazard to overhead transmission lines, unless the rupture occurs directly beneath the support towers. This is because the slack in conductors between towers can usually accommodate relatively large differential movements. Surface fault rupture of known faults is not a potentially severe hazard in the proposed or alternative corridors.

Strong Ground Shaking

The project area has been characterized by low to moderate historic seismicity. Some of the faults within the foothills, such as the Ortigalita Fault, are known to be active, both from surface studies and from instrumentally recorded microseismicity; but the region has a low level of historic seismicity. The low level of reported seismicity may be due to a lack of adequate instrumentation and the sparsely distributed population in the study area (Wong and Ely, 1983).

The project area was severely affected by the Richter magnitude (M_L) 6.5 Coalinga earthquake on May 2, 1983. This earthquake was caused by rupture of a blind thrust fault beneath Anticline Ridge, with an epicenter 10 kilometers northeast of Coalinga. At the Pleasant Valley Pumping Plant, northeast of Coalinga, the mainshock produced strong ground motions, measured as peak ground acceleration (PGA), of 0.54 g (gravity) for a duration of 14.1 seconds at a distance of 11 kilometers from the epicenter (Stover, 1987). The project area was also subjected to strong ground motions from numerous small to moderate aftershocks with 13 aftershocks of $M_L \geq 4.0$ in the first 24 hours after the main shock (Urhammer, et al., 1984). During the 8 months following the main shock, the area was shaken by 49 aftershocks measuring $M_L \geq 4.0$ and 10 aftershocks of $M_L \geq 5.0$.

A M_L 5.3 aftershock on May 8, 1983 produced a measured freefield PGA of 0.56 g (gravity) in both horizontal directions, with a duration of 1.4 seconds. The M_L 6.0 aftershock on July 21, 1983 produced a measured PGA of 1.17 g at the USGS station on Anticline Ridge with a duration of 4.1 seconds. This same aftershock produced measured PGA records at the USGS monitoring stations at Oil

City and Transmitter Hill of 0.85 g with a duration 4.6 seconds and 0.96 g and with duration 4.4 seconds, respectively (Stover, 1987).

Based on the historic seismicity, the project area may be subject to peak ground accelerations of 1.0 g or greater from nearby earthquakes on the San Andreas fault as well as segments 8 through 13 of the Great Valley blind thrust faults (Blake, 2000; Petersen, et al., 1996). The shaking intensity in the project area will be dependent upon the earthquake magnitude, epicentral distance, and the attenuation of seismic energy based on local soil and rock characteristics.

Recent maps published by the CDMG (1994) estimate the peak ground acceleration with a 10 percent probability of exceedance in 50 years would be between 0.4 and 0.5 g for the project area (Petersen et al., 1996). The characteristics of significant local faults that would contribute to the seismic shaking hazard within the Proposed Project area are listed in Table C.5-1, Fault Activity.

C.5.1.1.4 *Soils*

Series Classifications

More than two dozen different soil series and more than one hundred soil types are present in the project area. However, the predominant soil series are the Kettleman, Panoche, and Los Banos series. Since these soil series make up over 90 percent of the project area soils, they were selected for further discussion.

Kettleman Series. Soils of the Kettleman Series have formed in place from the underlying soft sedimentary deposits in the foothills or upland areas. Soils of this series underlie approximately 75 percent of the Proposed Project and Western Corridor Alternative Segments (Cole, 1952; Harradine, 1950).

Most of the soils in this series consist of loam and clay loam, with minor fine sandy loam. They have formed through weathering in an arid climate, with hot summer temperatures and less than 7 inches of annual rainfall. Soil depths average 20 to 30 inches, and they are usually underlain by fine-grained calcareous sandstones or shales. Most soils in the series have good to excessive drainage. The predominant vegetation types are short grasses and scattered low shrubs. These soils are mainly used for sheep and cattle pasture.

Los Banos Series. Soils of the Los Banos Series are primarily developed on terrace deposits derived from weathering and erosion of older sedimentary rocks. These soils formed on lake or stream sediments derived from the upland or mountainous geologic deposits. They have developed under a climate of hot, rainless summers and mild winters with less than 10 inches of annual rainfall. They occur in the northern end of the project area.

The Los Banos soils have a moderately compacted subsoil and well-defined horizontal characteristics. They are closely associated with the soils of the Kettleman Series and often merge with them. Soils of this series have good to excessive surface drainage and good to slightly impeded deep subsoil percolation. Typical vegetation consists of shallow-rooted grasses and low shrubs. These soils are used mainly for sheep and cattle pasture (Cole, 1952; Harradine, 1950).

Table C.5-1 Fault Activity
Known Active and Potentially Active Faults Within 50-mile (80-kilometer) Radius

Fault / Fault Segment Name	Minimum Distance From Project		Potential Rupture Length	Activity	Max. Earthquake Magnitude
	(mi)	(km)	(km)	(Geologic period)	(M_W)
Calaveras--Southern Segment	25.0	40.3	106	Historical (1989)	6.2
Calaveras--All Segments	25.0	40.3	48	Historical (1989)	7.0
Great Valley 7	26.8	43.2	45	Holocene	6.7
Great Valley 8	5.2	8.4	41	Holocene	6.6
Great Valley 9	4.5	7.3	39	Holocene	6.6
Great Valley 10	4.3	7.0	22	Historical (1983)	6.5
Great Valley 11	4.4	7.1	25	Historical (1985)	6.4
Great Valley 12	4.3	7.0	17	Holocene	6.3
Great Valley 13	4.4	7.1	30	Holocene	6.5
Great Valley 14	5.6	9.0	24	Holocene	6.4
Greenville	36.8	59.3	73	Historical (1980)	6.9
Hayward--Southern Segment	50.0	80.0	43	Historical (1868)	6.9
Hayward--Total Length	50.0	80.0	86	Historical (1868)	7.1
Hayward--Southeast Extension	41.4	66.6	26	Holocene	6.7
Monte Vista-Shannon	46.6	74.6	41	Quaternary	6.8
Monterey Bay - Tularcitos	50.0	80.0	84	Holocene	7.1
O'Neill	0.15	0.24	24	Holocene	6.4
Ortigalita	3.9	6.3	66	Holocene	6.9
Quien Sabe	20.6	33.2	23	Holocene	6.4
Rinconada	43.7	70.4	189	Quaternary	7.3
San Andreas--Santa Cruz Mtn Segment	37.8	60.8	37	Historical (1989)	7.0
San Andreas--(1906)	31.1	50.1	438	Historical (1906)	7.9
San Andreas--Pajaro Segment	31.1	50.1	22	Historical (1906)	6.8
San Andreas--Creeping Segment	24.0	38.6	125	Historical (creep)	*
San Andreas--Parkfield Segment	21.1	34.0	37	Historical (1857)	6.7
San Andreas--Cholame Segment	27.9	44.9	62	Historical (1857)	6.9
San Andreas--(1857)	21.1	34.0	345	Historical (1857)	7.8
San Juan	32.6	52.5	68	Quaternary	7.0
Sargent	26.8	43.2	53	Holocene	6.8
Zayante-Vergeles	29.5	47.4	56	Quaternary	6.8

Notes: km = kilometer
M_W = moment magnitude
mi = miles
Source: Blake, 2000; Petersen et al., 1996; Wesnousky, 1986.

Panoche Series. The Panoche Series soils are developed on recently deposited alluvial fan materials. The fan materials were in turn derived from calcareous and gypsiferous sandstones and shales of the Diablo Range and foothills. The series contains a wide range of soil types, varying from sandy loam to silty clay, with loam and clay-loam being the dominant types. They are typically located on the valley side of the Kettleman Series soils. Panoche soils typically do not have distinct horizons, but contain stratified layers of coarse and medium-fine particles. They are formed in semi-arid valleys that have long, hot dry summers and an average rainfall of between 5 and 10 inches. These soils typically have good surface and internal drainage. Short grass and dry adapted shrubs are the predominant vegetation. These soils make excellent agricultural soils for irrigated crops and good sheep pasture (Cole, 1952; Harradine, 1950).

C.5.1.1.5 *Minerals*

Mineral resources found in the project area include petroleum, gypsum, and sand and gravel. These materials have been extracted at several locations.

Petroleum

Economic deposits of oil and natural gas occur in the southern portion of the project area near Coalinga. Exploration for petroleum first started in the 1890's near Oil City, about 10 miles north of Coalinga. Since that time, seven major oil fields have been developed in the project area. However, almost 96 percent of the oil produced in the project area during 1999 came from the Coalinga field.

Production in the Coalinga field was approximately 22,500 barrels per day (bpd) in 1999 (Division of Oil and Gas and Geothermal Resources Annual Report, 2000). This field was switched from primary recovery methods (gravity flow and pumping) to steam enhanced recovery operations during the 1960's and 1970's. By injecting steam and water into the reservoir, the viscous petroleum components are more readily recovered and reservoir pressures may be maintained at higher levels, making recovery more efficient. The production life of the field is expected to extend beyond the year 2010.

The remaining oil fields in the project vicinity are: the Coalinga East Extension, Jacalitos, Guijarral Hills, Pleasant Valley, Kettleman Hills, and Pyramid Hills fields. These fields produced only about 950 bpd or 4 percent of the oil from this area during 1999. These fields are not well suited to enhanced recovery operations and depend on primary recovery methods (PG&E, 1982).

All seven of the existing oil fields in the project area have expanded slightly since publication of the EIS/EIR in 1988, and production from these fields continues to be an important energy resource in the region. In addition to petroleum production near Coalinga, natural gas is produced from two small fields near Cheney Ranch, adjacent to the Eastern Corridor Alternative. Recent discoveries of natural gas have also been made near Tres Picos Farms, in the Cantua Nueva and Turk Anticline gas fields. Discoveries of this nature are encouraging for the prospect of additional fields yet to be discovered.

Oil and gas fields present a siting constraint to the Proposed Project. Well drilling and the normal operations and maintenance required for oil wells (i.e., the use of cranes, towers, drill rigs, etc.) are not compatible with right-of-way (ROW) restrictions for a transmission line. However, directional-drilling techniques can be used to keep new well sites away from the power lines.

Table C.5-2 Productive Oil Fields Crossed by the Project

Segment	Miles Crossed	Oil Field(s)
Proposed Segment 5	1.0	Coalinga
Proposed Segment 6	2.5	Coalinga East and Guijarral Hills
Alternative Segment 6A	1.0	Coalinga
Alternative Segment 6B	2.8 to 4.5	Coalinga East, Pleasant Valley, and Guijarral Hills

Sand and Gravel

Isolated deposits of sand and gravel have been extracted on a limited basis at several small quarry operations within the project area. These operations are generally in the valleys of creeks draining the Diablo Range and are removing recent alluvial deposits from the valley floors. Operations have been identified near Milepost (MP) 7 on Los Banos Creek, MP 23 on Little Panoche Creek, MP 37 on Panoche Creek, MP 58 on Cantua Creek, and at MP 62 and MP 70 on Los Gatos Creek, north of the Coalinga Airport. The only large pit operation in the area is at the Folsom gravel pit on Los Gatos Creek one mile north of Coalinga. This operation is outside of the immediate project area. Most developed and potential sources of aggregate within the project area have difficulty meeting the rigid federal specifications for aggregate materials. Hence, the Folsom deposits, which do meet the standards, were extensively developed.

Potential aggregate fill and select fines sources have been identified for development in the event of construction of the Los Banos Grandes Reservoir project. If this project were to be approved and built, one of the proposed borrow areas for the Salt Creek Damsite underlies the Proposed Project between MP 8.3 and MP 9.0. It should be noted that both of the existing 500kV transmission lines also cross this potential borrow area and approximately 1.65 miles of these lines would be required to be relocated if this dam is approved according to existing plans (DWR, 1986); however, according to DWR, the project will not be built in the near future.

Gypsum

Quaternary deposits of impure gypsum have been mined near Los Banos and at other isolated locations along the west side of the San Joaquin Valley. These materials are used for agriculture as soil amendments. No known commercially viable gypsum extraction areas are within the project area.

C.5.1.1.6 *Paleontology*

Paleontological study in the project area was initiated in 1937 by the discovery of a nearly complete skeleton of an Elasmosaurid Plesiosaur near Moreno Gulch on the northeastern side of the Panoche Hills.

Personnel from the University of California at Berkeley and the California Institute of Technology conducted intensive paleontological investigations. Activities were concerned primarily with the recovery of vertebrate fossil material and resulted in Camp's (1942) study on Mosasaurs and Wells' (1943) study on Plesiosaurs. These publications documented the distinctiveness of these Mesozoic era reptiles from other known North American forms and identified the Moreno Formation as one of special scientific interest.

The Moreno Formation is a marine deposit formed in California during the last years of the Cretaceous Period and early years of the Tertiary Period, (approximately 63 to 65 million years ago). It was formed in an arm of the sea that covered the Central Valley and the formation's sedimentary material came from erosion of lands to the west. Portions of this deposit are exposed along the Eastern border of the Diablo Range on the western edge of the San Joaquin Valley. These hills form the Diablo Range and extend from the Livermore Area south to the Coalinga region. Both geologists and paleontologists regard the Moreno Formation as one of the most extensive, if not the most extensive, marine deposit in the world that includes the Cretaceous-Tertiary boundary. The abundance and diversity of its paleontological resources make it one of the most significant areas of geological and paleontological investigation.

Three kinds of vertebrates represented by fossil remains are most associated with the scientific significance of the Moreno Formation. They are the Dinosaurs, Plesiosaurs, and Mosasaurs.

Fragmentary remains of seven specimens represent dinosaurs. All are Hadrosaurs, often called Duck-billed Dinosaurs. These were large, plant-eating Dinosaurs, many species that frequented shallow waters of the coastlines to feed on aquatic vegetation. The specimens found in Moreno represent individuals that were washed out to sea after their death. Hadrosaurs were widely distributed, very abundant, and diverse, and they reached their peak of development in late Cretaceous. The hadrosaurs disappeared from the fossil record with the close of the Cretaceous period. Accurate identification of the California specimens cannot be made until more extensive remains of the skulls have been found.

The long-necked Plesiosaurs were abundant throughout the Cretaceous Period and have been found in many marine deposits of the world. Three different kinds of Plesiosaurs have been identified from the Moreno. They are of unusual interest because these kinds have not been found in any other parts of the world; mostly kinds of Plesiosaurs have a wide distribution. Plesiosaurs became scarce in the fossil record before the close of the Cretaceous, and the California specimens are among the latest known. Plesiosaurs also disappeared from the fossil record at the close of the Cretaceous period.

Large marine inhabiting lizards became abundant in the shallow seas of the Late Cretaceous. These reptiles, called Mosasaurs, were the dominant predators of the sea during their relatively short existence, and they also became extinct at the close of the Cretaceous. The Mosasaurs, identified from the Moreno, are unlike the Mosasaurs from other parts of the world. Only those from deposits in Belgium and the Netherlands equal the diversity of the California Mosasaurs. The Moreno Formation is one of the few places in the world where Mosasaur remains and the Cretaceous-Tertiary boundary are in the same deposit.

Other fossil material present in the Moreno includes turtles, sharks, and bony fishes. These are all of considerable scientific interest, because some of the forms became extinct at the close of the Cretaceous while others persisted into the Tertiary. Numerous invertebrate fossils, mostly mollusks, are present. One group, the Ammonites have a long history in the fossil record, and they reached their greatest development in the late Cretaceous but became extinct at its close.

During Miocene time (approximately 10 to 25 million years ago) in the Tertiary Period, shallow seas were present in the San Joaquin Valley and this is when the Temblor Formation was deposited. Fragmentary remains of whales, dolphins, and other early aquatic mammals have been found in the Temblor. Terrestrial vertebrate fossils from the Tertiary include those of camels, horses, antelope, deer, rhinoceros and bear, as well as some Pleistocene mastodon remains.

Outcroppings of the Moreno Formation are known to occur in the west route from the Little Panoche Reservoir south to Capita Canyon, and Temblor Formation outcroppings are known to occur in the west route from Panoche Creek south to the Big Blue Hills. In the Skunk Hollow area is the Etchegoin Formation, which is of Early and Middle Pliocene age (approximately 5 million years ago). That area is rich in marine invertebrate fossils, with clams the most common; numerous plant fossils are also present.

C.5.1.2 Environmental Setting: Proposed Project

This section discusses the geologic setting of each Proposed Project segment.

C.5.1.2.1 *Segment 1*

Segment 1 of the Proposed Project originates at the Los Banos Substation at an elevation of 325 feet, and extends across the gently sloping terrace to the base of the foothills, where it turns generally south and climbs into the foothills, reaching an elevation of approximately 650 feet before dropping back down to about 600 feet at MP 1.9.

From MP 0.0 to 0.5, the corridor crosses both the Tulare Formation and older terrace deposits. Between MP 0.5 and MP 1.2, Segment 1 crosses more Tulare deposits. The corridor crosses into predominantly sandstone beds of the Panoche Formation between about MP 1.2 and MP 1.9, with beds dipping at an angle between 40 and 54 degrees.

Soils of the Los Banos Series overlie both the Tulare Formation and the Older Terrace Deposits, while thin soils of the Kettleman Series are present on the slopes formed by the Panoche Formation. A small landslide is mapped at about MP 1.4, downslope of the corridor. The soils of this area are mostly suited for use as dry pasture.

C.5.1.2.2 *Segment 2*

Segment 2 begins at MP 1.9 at an elevation of about 600 feet, and extends southeast across a small basin between MP 2.3 and MP 3.4. The corridor climbs the other side of the basin and continues to follow along the strike of the ridgeline, traversing gentle to moderately steep slopes, generally between 600 and 660 feet in elevation. The corridor crosses two more small drainages and a ridge before reaching Los Banos Reservoir at MP 6.2, approaching the reservoir down a side canyon.

South of Los Banos Reservoir, the corridor climbs the steep south side of Los Banos Creek valley and traverses a series of steep hills and ridges that range in elevation from 650 to 950 feet near MP 8.0. Between MP 8.0 and MP 10.3, the corridor crosses the Salt Creek stream valley and a series of low rolling hills that range in elevation from 550 feet to 700 feet, before returning to steeper terrain to the south at MP 10.3. This section of the corridor crosses an area of variable slopes, with steeply dipping north- and west-facing slopes and more gently dipping south- and east-facing slopes. This terrain extends across several small drainages, including Ortigalita Creek at about MP 13.6, before reaching a high terrace (at an elevation of about 1000 feet) with low rolling topography at about MP 13.9. The corridor continues across the terrace to the end of Segment 2 at MP 14.6.

For the most part, the corridor extends nearly parallel to the strike of the bedrock, which consists primarily of Panoche sandstone and shale. The Panoche shale is the dominant lithology on the terrace south of Ortigalita Creek. Alluvial deposits of Holocene age are found along the stream drainages, a wide stream terrace deposit is present in the basin between MP 2.4 and MP 3.2. Temblor Formation deposits form the wide rolling topography within the Salt Creek drainage, a small area between Salt and Ortigalita Creeks, and on the high terrace south of Ortigalita Creek, at about MP 14.8.

The soils along this segment of the corridor are predominantly Kettleman Series soils, developed on the Panoche and Temblor formations, and Los Banos Series soils found on the Tulare Formation and terrace deposits.

C.5.1.2.3 *Segment 3*

This segment begins at MP 14.6, northwest of Laguna Seca Ranch, and continues southeast across a high terrace to about MP 16.6. From MP 16.6, the corridor crosses a ridge with a maximum elevation of about 1,240 feet and then extends the length of a small valley along the base of the ridge. The corridor then crosses the valley and climbs up the opposite ridge, and follows a broken ridge to the Merced-Fresno County line at MP 20.4.

The segment begins on Panoche shale beds at MP 14.6 and crosses Tulare Formation deposits on the terrace near Laguna Seca Ranch to MP 16.6. From MP 16.0, the corridor primarily overlies the Panoche shale until it crosses the small valley at MP 18.8, then extends up the eastern ridge, where the bedrock consists of interbedded Panoche sandstone and shale to MP 19.8. The top of the ridge between MP 19.8 and MP 20.4 is blanketed by the Tulare Formation.

The soils along this segment of the corridor are predominantly Kettleman Series soils, formed on the Panoche Formation. The soils formed on Tulare Formation are a mixture of Kettleman Series and Los Banos Series loam and clay loam near Laguna Seca Ranch. Minor amounts of Panoche Series soils are present along the stream courses.

C.5.1.2.4 *Segment 4*

Beginning at MP 20.4, at the Merced-Fresno county line, Segment 4 turns slightly more to the east and crosses over moderately sloping hills to MP 22.9 where it crosses Little Panoche Creek just downstream of Little Panoche Dam. South of Little Panoche Creek, the corridor continues over moderately sloping hills, at elevations of about 800 feet, to about MP 24.2, where the terrain becomes steeper and gradually climbs from about 700 feet to 900 feet at MP 25.7. After crossing a deep, narrow drainage, the corridor continues across steep badlands topography gradually approaching the eastern edge of the foothills to MP 28.9, and maintaining an elevation of about 800 feet.

Segment 4 crosses a small area of Panoche shale between MP 20.4 and MP 20.7, and then primarily traverses Tulare Formation gravel and gravelly sand north of Little Panoche Creek. South of the creek, the corridor crosses Tulare marl and clay to MP 24.2, followed by Tulare gravel and gravelly sand, with minor amounts of Moreno Shale along the eastern edge of the foothills, to the end of the segment at MP 28.9.

Soils along this segment are predominantly gravelly to sandy loams of the Los Banos Series, which are used for dry pasture. Los Banos soils at the valley margin are being extensively farmed for truck crops and planted as vineyards.

C.5.1.2.5 *Segment 5*

Segment 5 begins at MP 28.9 on the valley margin at an elevation of about 780 feet, and follows the edge of the valley, crossing numerous small drainages and maintaining an even elevation to MP 31.4, where it crosses Capita Wash. From MP 31.4, the corridor gradually diverges from the edge of the foothills and crosses the upper margin of the alluvial fan to Panoche Creek at MP 36.6. South of Panoche Creek, the corridor traverses a series of low hills along the valley margin at an elevation of about 850 feet. South of Tumey Gulch (MP 41.2), the corridor climbs higher into the foothills, reaching elevations of 1,400 feet and traversing moderately steep to steep slopes along the base of Monocline Ridge. The corridor crosses Arroyo Hondo at MP 52.5. South of Arroyo Hondo, the corridor traverses low hills about 2 miles east of the Ciervo Hills, crossing Cantua Creek at MP 57.1. The corridor crosses the gently sloping terraces between Cantua and Martinez creeks (MP 61.7), and the moderately steep to very steep lower portion of the Big Blue Hills between Martinez Creek and Skunk Hollow (MP 69.0). The corridor intersects Highway 33 at MP 68.0.

Segment 5 crosses the northern margin of the Coalinga oilfield between about MP 65.9 and MP 67.0, but does not approach any existing oil wells within the oilfield.

Between MP 28.9 and MP 31.7, Segment 5 primarily overlies gravel deposits of the Tulare Formation, with minor alluvium and alluvial fan deposits in the drainages. From MP 31.7 to MP 37.2, the corridor crosses old alluvial fan deposits, with a minor amount of alluvium and gravel mapped in Panoche Creek at MP 36.6. From MP 36.6 to MP 42.4, Segment 5 primarily overlies Tulare gravel with a small amount of alluvium mapped along Tumey Gulch. Between MP 42.4 and MP 46.3, the corridor overlies Pliocene rocks of the Jacalitos and Etchegoin formations, which are predominantly sand, gravel, and clay. From MP 46.3 to MP 46.9, MP 47.7 to MP 48.2, and MP 48.7 to MP 49.0, the alignment overlies sandstone deposits of the Temblor Formation. From MP 46.9 to MP 47.7, and MP 48.2 to MP 48.7, the corridor crosses siliceous shale deposits of the Tumey Formation. Between MP 49.0 and MP 49.8, the corridor overlies serpentinous gravel and clay of the Big Blue Formation. Exposures of Jacalitos Formation are found between MP 49.8 and MP 56.6, with alluvium mapped in the bed of Arroyo Hondo. Unconsolidated and poorly consolidated deposits of Tulare Formation gravels, with minor portions of alluvium, and older terrace alluvium underlie the alignment between MP 56.6 and MP 62.0. Between MP 62.0 and MP 69.0, the corridor crosses sand, gravel, and clay deposits of the Etchegoin and Jacalitos Formations, with minor areas of old alluvium and recent alluvium in the bottom of Skunk Hollow.

Soils found along this segment are highly varied, with Kettleman Series soils predominant in the foothill areas, Los Banos Series soils are found on the terrace deposits of Tulare Formation, and Panoche Series soils have developed on the alluvial fan deposits at the valley margin. Kettleman soils are generally suitable only for use as pasture. Los Banos soils are suitable for pasture and, in some areas, production of winter grains, though yields are poor to marginal. Panoche Series soils are generally very productive and are planted extensively for a variety of crops where irrigation is practiced.

C.5.1.2.6 *Segment 6*

Segment 6 begins at MP 69.0 at an elevation of about 650 feet and extends south along the eastern limb of Anticline Ridge, traversing low, gently sloping hills. At about MP 70.6, the corridor crosses onto the very gentle slopes of the upper alluvial fans along the valley margin following east of and parallel to Anticline Ridge at an elevation of about 550 feet to MP 76.2. From MP 76.2, the corridor traverses Los Gatos Creek Valley, crossing the Southern Pacific Railroad line at MP 76.9 and Los Gatos Creek at MP 77.2. South of Los Gatos Creek, the corridor continues east of the Guijarral Hills to the end of the segment at MP 79.2.

Segment 6 crosses through the East Coalinga Extension oilfield between MP 69.7 and MP 71.7, and passes within 200 feet of two active wells between MP 70.3 and MP 70.4, and within 500 feet of at least 5 other operating oil wells between MP 70.0 and MP 70.6. This segment also crosses the Guijarral Hills oilfield between MP 77.4 and MP 78.2, passing within 200 feet of 7 active oil wells and within 500 feet of at least 7 additional wells, all between MP 77.4 and MP 78.2.

This segment overlies sandstone beds of the Jacalitos Formation between MP 69.0 and MP 69.5. The corridor traverses terrace deposits of sandy gravel of the Tulare Formation from MP 69.5 to MP 71.3 and from MP 74.5 to MP 75.8. The corridor passes over alluvial fan deposits of the upper valley margin between MP 71.3 and MP 74.8, and from MP 75.8 to MP 79.2 where the Alternative segment connects with the Proposed Project.

The Proposed Project predominantly crosses soils of the Los Banos Series north of MP 71.3, which are used for pasture within the oilfields. South of MP 71.3, this corridor crosses Panoche Series soils on the alluvial fan deposits. These soils are used for varied agricultural crops outside of the active oilfields, and for seasonal pasture within developed oilfields. The placement of the transmission line through these agricultural areas will permanently remove small areas of soils from agricultural production, but the area removed will be minimal.

C.5.1.2.7 *Segment 7*

The alignment of the transmission line for Segment 7 follows a straight line along very gently sloping alluvial fan deposits, crossing Interstate 5 at MP 80.7, and extending to MP 82.8 where it turns southeast to the entrance into Gates Substation at MP 83.2. This segment entirely overlies alluvial fan deposits, which have developed Panoche Series soils used for agricultural production. Large portions of the lands traversed by this segment are planted with grapevines.

C.5.1.3 Environmental Setting: Western Corridor Alternative Segments

This section discusses the geologic setting of the Western Alternative segments. Alternative segments are labeled with Alternative Mileposts (AMP) to differentiate them from the corresponding segment of the Proposed Project. The discussion of Alternative segments will use the beginning Milepost (MP) designations for the respective segments they are to replace, beginning with the northern point of departure from the Proposed Project.

C.5.1.3.1 *Segment 2A*

Segment 2A begins at AMP 1.9 at an elevation of about 700 feet, and extends southward along a spur of the ridgeline before crossing a narrow, unnamed drainage and continuing south over moderately steep to steep terrain with elevations varying between about 650 and 1,000 feet. This segment crosses several unnamed drainages at AMP 4.1, and AMP 4.7, as well as several tributary drainages to Los Banos Creek before crossing Los Banos Creek upstream of the reservoir at a narrows in the canyon located at about AMP 6.4.

The alternative alignment then continues in a more southeasterly direction, across some steep, rugged terrain between Los Banos Creek and Salt Creek to AMP 8.7. It then crosses Salt Creek along an elevated ridge at about AMP 9.1, and continues along the ridgeline and then down onto the low, rolling terrace south of Salt Creek between AMP 10.0 and AMP 10.8. South of AMP 10.8, the segment crosses some steep, rugged terrain, between elevations of 600 and 1,100 feet, and follows the northeastern face of a particularly tall ridge to the crossing of Ortigalita Creek at about AMP 13.8. South of Ortigalita Creek, this segment continues across more steep, rugged terrain to a high, rolling terrace at AMP 14.1, and proceeds on to reconnect with the Proposed Project at AMP 14.8.

This alternative alignment generally overlies Panoche Formation sediments throughout its entire length. Beginning at AMP 1.9 the alignment overlies sandstone beds of the Panoche Formation rock. There are several beds of Panoche conglomerate along this alternative alignment, particularly along the ridge north of Los Banos Creek and south of Salt Creek, between about AMP 6.3 and AMP 6.5, and between AMP 8.9 and AMP 9.4. Several beds of Panoche shale are mapped as interbedded with the Panoche conglomerate north of the Los Banos Creek crossing. South of AMP 9.4, the Panoche Formation is predominantly shale, extending to AMP 10.8. Between AMP 10.8 and AMP 11.6, the alignment crosses Panoche sandstone beds, and then extends across Panoche conglomerate beds between AMP 11.6 and AMP 12.9. The Panoche is mapped as interbedded sandstone, shale, and conglomerate beds in the vicinity of the Alternative segment's crossing of Ortigalita Creek (AMP 12.9 to AMP 14.5). Between AMP 14.5 and AMP 14.9, where Alternative Segment 2A rejoins the Proposed Project, the Panoche Formation is mapped as predominantly shale.

Minor amounts of alluvial deposits are crossed by this Alternative where it crosses Los Banos, Salt and Ortigalita creeks. The floor of the small unnamed drainage between about AMP 2.2 and AMP 2.4 is mapped as older terrace deposits.

The soils along this Alternative segment are primarily of the Kettleman Series, but soils are thin to non-existent in many of the steeper portions of this segment. Soils in this area are only suitable for use as dry pasture.

C.5.1.3.2 *Segment 4A*

Beginning at MP 20.4 of the Proposed Project, at the Merced-Fresno county line, Segment 4A turns south along a short ridge, crosses Salt Canyon at about AMP 20.8, and then climbs the western side of the canyon. This segment follows the moderate slope of the ridge approaching Little Panoche Creek at the western margin of the reservoir, before crossing the creek at AMP 23.1.

After climbing the very steep southern margin of Little Panoche Valley, Segment 4A crosses a terrace of gently sloping ridges dissected by steep drainages to AMP 24.0. Between AMP 24.0 and AMP 29.4, where this alternative meets the Proposed Project, the terrain consists of steep to very steep badlands topography ranging from 800 to 1,250 feet in elevation.

Segment 4A begins at AMP 20.4 in Tulare Formation deposits, crosses Panoche shale within Salt Canyon, and crosses Tulare Formation gravel north of Little Panoche Creek, to AMP 22.9. The alternative alignment crosses small amounts of alluvium and stream gravel deposits within Salt Canyon and Little Panoche Valley. South of Little Panoche Valley, the canyon wall consists of Tulare gravels, and the moderately sloping hills are a mixture of Tulare gravel and gravelly sand, and marl and clay. The steep hills exhibiting badlands topography are predominantly Panoche sandstone, between AMP 24.2 and AMP 25.6, with minor amounts of interbedded Panoche shale and small remnants of Tulare clay on several ridgetops. Between AMP 25.6 and AMP 27.8, Segment 4A primarily crosses shale of the Kreyenhagen Formation and from AMP 27.8 to AMP 29.4, it generally overlies Tulare Formation gravels.

Soils underlying this Alternative segment are predominantly soils of the Los Banos Series formed on Tulare Formation materials and soils of the Kettleman Series formed on the Panoche and Moreno formation materials. Most of the Kettleman Series soils along this segment are very thin due to the steep topography.

C.5.1.3.3 *Segment 6A*

Segment 6A diverges from the Proposed Project at MP 69.0 and extends further east. This segment traverses gentle slopes of the terrace east of Anticline Ridge to about AMP 71.0, where it crosses over gently sloping alluvial fan deposits of the valley margin. Segment 6A then continues south, to the west of Interstate 5, crossing the Southern Pacific Railroad line at AMP 76.2, and Los Gatos Creek at AMP 77.0, to AMP 78.3 where it rejoins the Proposed Project east of the Guijarral Hills at AMP 79.3.

This Alternative segment crosses over the East Coalinga Extension oilfield between about AMP 69.5 and AMP 70.6. It is possible to route the transmission line across this oilfield such that it passes no closer than 200 feet from any existing well, while passing within 500 feet of up to 8 existing wells. This segment passes to the east of the Guijarral Hills oilfield avoiding all existing wells in that field.

Between AMP 69.0 and AMP 69.4, Alternative 6A crosses Jacalitos Formation sandstone deposits followed by sandy gravel deposits of the Tulare Formation between AMP 69.4 and AMP 70.9. The segment then traverses alluvial fan deposits along the valley margin from AMP 70.9 to where it reconnects with the Proposed Project at AMP 79.3.

This segment generally traverses Panoche Series soils on the alluvial fans. These soils are largely used for agricultural production. Those lands not within active oilfields are planted with winter grains or used for pasture.

C.5.1.3.4 *Segment 6B*

Segment 6B diverges from the Proposed Project at MP 69.0 and turns south, traversing rolling hills of the terrace at the foot of Anticline Ridge to AMP 71.3. At AMP 71.3 this segment turns southeast and extends along a the gently rolling slopes parallel to Anticline Ridge, to the eastern end of Pleasant Valley at AMP 76.5. Between AMP 76.5 and AMP 77.8 the alignment crosses Pleasant Valley and Los Gatos Creek, before entering the Guijarral Hills. Segment 6B then climbs the short steep northern edge of the Guijarral Hills, and continues down a gently sloping ridge to AMP 78.8, where it turns generally east and extends into the upper alluvial fan of the valley margin. At AMP 80.7, it intercepts the Proposed Project at MP 79.2.

This Alternative segment crosses the East Coalinga Extension oilfield between about AMP 71.9 and AMP 73.5. It crosses the oilfield passing no closer than 200 feet from any existing well, while passing within 500 feet of up to as many as 9 existing wells. It also crosses wastewater treatment ponds related to oil production at AMP 73.0, and passes close to oil storage tanks located at AMP 73.4. Segment 6B also passes through the Pleasant Valley and Guijarral Hills oilfields. It passes within 500 feet of 3 existing oil wells within the Pleasant Valley oilfield between AMP 76.2 and AMP 76.5, and passes within 500 feet of at least 11 existing oil wells within the Guijarral Hills oilfield, between AMP 78.8 and AMP 79.8.

Segment 6B overlies Jacalitos Formation sand deposits between AMP 69.0 and AMP 69.9, and then crosses gravel and sand deposits of the Tulare Formation from AMP 69.9 to AMP 71.9. From AMP

71.9 to AMP 72.2, the alignment overlies alluvium within Shell Creek drainage. South of Shell Creek, it overlies Tulare Formation sand deposits extending the width of the terrace to AMP 76.5 at the edge of Los Gatos Valley. Within Los Gatos Valley, the segment crosses alluvial deposits between AMP 76.5 and AMP 77.8, then traverses predominantly sandy deposits of the Tulare Formation within the Guijarral Hills between AMP 77.8 and AMP 79.8. East of the Guijarral Hills, the segment crosses alluvial fan deposits between AMP 79.8 and AMP 80.7, where it meets the Proposed Project Corridor.

The soils of this Alternative Segment primarily consist of Los Banos Series soils on the sandy terrace deposits of the Tulare Formation. These soils are moderately suited to agricultural production and, where not used for petroleum production, are used for production of winter grain crops or pasture.

C.5.1.4 Environmental Setting: Eastern Corridor Alternative

This section discusses the geologic setting of the Eastern Corridor Alternative.

C.5.1.4.1 *Segment 1*

Segment 1 of the Eastern Corridor Alternative begins at the Los Banos Substation at an elevation of about 320 feet, and extends in a southeast direction across a gently sloping terrace, before crossing existing 230 kV and 115 kV transmission lines at MP 0.3. After crossing these transmission lines, the alignment parallels the lines up a moderately steep ridge, then down the very steep south side of the ridge to MP 2.0.

From MP 0.0 to MP 0.3, this segment crosses sand and gravel beds of the Tulare Formation. From MP 0.3 to MP 2.0, it generally overlies sandstone of the Panoche Formation.

The soils of this segment consist primarily of Kettleman Series sandy loam in the foothills, and Los Banos Series sandy to gravelly loam on the terrace. The Kettleman soils are thin to absent due to the steepness of the slope. The Los Banos soils are moderately deep and suitable for pasture or dry farming of grains.

This segment of the Eastern Corridor Alternative crosses the potentially active O'Neill fault zone in two locations: between MP 0.2 and MP 0.5 and between MP 0.8 and MP 0.9. A third trace of the O'Neill fault zone is found at a distance of between 0.6 and 1.2 miles to the northeast of this segment (Herd, 1979).

C.5.1.4.2 *Segment 2*

Segment 2 of the Eastern Corridor Alternative begins at an elevation of about 400 feet and traverses a series of moderately sloping rounded hills and ridges northeast of and parallel to existing 230 kV and 115 kV transmission lines between MP 2.0 and MP 6.3. South of MP 6.3, it crosses Los Banos Creek downstream of Los Banos Dam, to MP 6.6, and crosses a gently sloping terrace, passing Salt Creek at MP 8.4. The segment ends at MP 9.0 on the eastern margin of the terrace.

Segment 2 generally overlies Panoche Formation shale with interbedded sandstones layers between MP 2.0 and MP 3.8. Shale of the Moreno Formation with interbedded sandstone is found between MP 3.8 and MP 5.6, and MP 6.1 and MP 6.3. Shale of the Moreno Formation forms the south abutment of Los Banos Dam, where this segment crosses the valley. South of Los Banos Creek, this segment crosses predominantly sandy gravel and sandy clay deposits of the Tulare Formation.

The soils of this segment are primarily consist of the Kettleman Series soils formed on the Panoche and Moreno bedrock exposures, with Los Banos Series soils on the Tulare Formation terrace deposits. Soils of the Kettleman Series are generally used for pasture. During the field survey, the Los Banos soils found on the terraces were observed to support production of winter grains in addition to pasture.

This segment of the Eastern Corridor Alternative crosses the potentially active O'Neill fault zone between MP 4.4 and MP 4.5. Two additional traces of the O'Neill fault zone are found at a distance of between 0.3 to 1.0 mile and 0.6 to 1.4 miles southwest of the segment alignment, respectively.

C.5.1.4.3 *Segment 3*

Segment 3 of the Eastern Corridor Alternative begins at MP 9.0 on a gently sloping terrace at an elevation of approximately 300 feet, and then traverses the low hills of the valley margin to about MP 12.5. From MP 12.5 to MP 17.0, it traverses moderately steep hills along the eastern margin of the foothills to the end of the segment.

Segment 3 primarily overlies terrace deposits of gravelly sand and sandy clay of the Tulare Formation, with minor amounts of alluvium along Ortigalita Creek. Within the foothills, it generally traverses gravel beds of the Oro Loma Formation.

Between MP 9.0 and MP 12.5, the soils of this segment belong mostly to the Los Banos Series formed on Tulare Formation with minor areas of Panoche Series soils on older alluvial fan and stream channel deposits. Soils found between MP 12.5 and MP 17.0 belong to the Kettleman Series and are used for grazing.

C.5.1.4.4 *Segment 4*

Segment 4 of the Eastern Corridor Alternative extends from MP 17.0 to MP 47.0. From MP 17.0 to MP 20.3, this segment traverses low hills with gentle to moderate slopes. The route then traverses gently sloping to nearly level old and young alluvial fan deposits between MP 20.3 and MP 47.0, ranging in elevation from 300 to 500 feet. With the exception of Little Panoche Creek at MP 23.5 and Panoche Creek at MP 40.2, all of the streams draining the foothills in this segment disperse across the alluvial fan surface before reaching the alternative alignment. This segment will cross the existing 115 kV transmission line at MP 42.1 where that line turns east.

This segment overlies Kreyenhagen Shale between MP 17.0 and MP 18.7. The route overlies primarily Tulare Formation gravel deposits between MP 18.7 and MP 20.2, with small amounts of sandstone and shale of the Domengine and Kreyenhagen formations. South of MP 20.0, the route overlies older and younger alluvial fan deposits to the end of the segment at MP 47.0. The deposits of older alluvium between MP 23.1 and 31.2, and the young alluvium between about MP 35.7 and MP 43.5, are mapped as being susceptible to hydrocompaction (Ireland et al., 1984, Bull, 1964).

The soils of this segment of the Eastern Corridor Alternative alignment generally consist of Kettleman Series soils formed on the Kreyenhagen bedrock exposures, Los Banos Series soils on the Tulare Formation gravel deposits, and Panoche Series soils formed on the older and younger alluvial fan deposits. The Panoche soils are extensively developed for agricultural production along this segment of the Eastern Alternative.

C.5.1.4.5 *Segment 5*

Segment 5 extends from MP 47.0 to MP 69.6, the entire length of which traverses gently sloping alluvial fan deposits of the valley margin. The soils beneath Segment 5 of this alignment generally belong to the Panoche Series. These soils are extensively developed for agricultural production along this segment of the Eastern Corridor Alternative.

C.5.1.4.6 *Segment 6*

This Alternative segment begins at MP 69.6 and extends east across gently sloping to nearly level alluvial fan deposits. At MP 75.2, this segment turns south, continuing across similar topography, to MP 84.2 where it turns and enters Gates Substation. This segment crosses near several agricultural water wells, but avoids passing directly over any water wells. Segment 6 crosses the distal margin of the distribution channels of Los Gatos Creek between MP 79.0 and MP 79.5.

The entire length of this segment overlies deposits of young alluvium deposited as alluvial fan materials. The soils developed on these deposits are predominantly Panoche Series clay or silty loam and are used for agricultural production of various field and truck crops.

C.5.2 APPLICABLE REGULATIONS, PLANS, AND STANDARDS

Geologic resources and geotechnical hazards are governed primarily by state and local jurisdictions. The impact assessments were developed based on a geologic, soils and geotechnical engineering evaluation of the Proposed Project and each Alternative. The assumptions and justification for site-specific assessments are explained in the following sections.

C.5.2.1 Federal

No federal regulations apply to geology, soil, or minerals. Federal oversight related to this issue area is limited to approval of plans for Proposed Project facilities located upon lands managed by the Bureau of Land Management.

C.5.2.2 State

In California, the Alquist-Priolo Earthquake Fault Zoning Act of 1972 (formerly the Special Studies Zoning Act) regulates development and construction of buildings intended for human occupancy to avoid the hazard of surface fault rupture. This Act and supplemental amendments group faults into categories of active, potentially active, and inactive. Historic and Holocene age faults are considered active, Late Quaternary and Quaternary age faults are considered potentially active, and pre-Quaternary age faults are considered inactive. These classifications are qualified by the conditions that a fault must be shown to be "sufficiently active" and "well defined" by detailed site-specific geotechnical explorations in order to determine whether building setbacks should be established.

C.5.2.3 Regional and Local

The conservation and seismic safety elements of General Plans for the cities of Coalinga, Huron and Los Banos, and for Fresno and Merced counties contain policies for the protection of unique geologic features and avoidance of geologic hazards. Local grading ordinances establish detailed procedures for excavation and grading required during construction. In addition, building codes in each jurisdiction establish standards for construction of aboveground structures and foundations, generally in accordance with the Uniform Building Code.

C.5.3 ENVIRONMENTAL IMPACTS AND MITIGATION MEASURES FOR THE PROPOSED PROJECT

C.5.3.1 Introduction

Geologic and soils impacts include both the impact on the geologic and soils environment from excavation, trenching, backfilling, and grading activities during construction of the proposed facilities and the impact of geologic hazards on the long term operation and maintenance of the Proposed Project. Some of the geologic hazards may also constitute a hazard to workers during construction of the project facilities. The geologic and soils impacts are found to differing extents along each segment of the Proposed Project and the Alternatives. Therefore, general impacts and mitigation measures are discussed below, followed by a description of the locations of the potential impacts by segment. Section C.5.3.3 explains the differences between the impacts and mitigation measures presented in this SEIR and those in the original EIS/EIR.

C.5.3.2 Definition and Use of Significance Criteria

Geologic and soil conditions were evaluated with respect to the impacts the project may have on the local geology, soils, and mineral resources, as well as the impact specific geologic hazards may have upon the Proposed Project and its related facilities. The standards of significance for these impacts were derived from Appendix G of the CEQA guidelines and appendices, thresholds of significance developed by local agencies, government codes and ordinances, and requirements stipulated by California Alquist-Priolo statutes. Significance criteria and methods of analysis were also based on standards set or expected by state and federal governing agencies for the evaluation of geologic hazards as outlined by the CDMG in Special Publication 117 (1997).

Impacts of the Proposed Project or Alternatives on the geologic environment would be considered significant if:

- Unique geologic features or geologic features of unusual scientific value for study or interpretation would be disturbed or otherwise adversely affected by the transmission line alignment and consequent construction activities
- Known mineral and/or energy resources would be rendered inaccessible by transmission line construction
- Agricultural soils would be converted to non-agricultural uses
- Geologic processes, such as landslides or erosion, could be triggered or accelerated by construction or disturbance of landforms
- Substantial alteration of topography would be required or could occur beyond that which would result from natural erosion and deposition.

Impacts of the following geologic hazards on the Proposed Project or Alternatives would be considered significant if:

- High potential exists for ground rupture due to presence of an active earthquake fault crossing transmission line alignment, with attendant potential for damage to the substations, transmission lines, or other project structures
- High potential exists of earthquake-induced ground shaking, which could cause liquefaction, settlement, lateral spreading, and/or surface cracking along the transmission line alignment, resulting in attendant damage to the transmission line or other project structures
- Potential for failure of construction excavations exists due to the presence of loose saturated sand or soft clay
- Presence of corrosive soils exists which would damage transmission line support structures.
- Potential for settlement or ground subsidence exists due to soft, compressible or collapsible soils.

C.5.3.3 Impacts and Mitigation Measures from 1988 FEIS/EIR

Table C.5-3 presents the geologic impacts identified in the FEIS/EIR, and then compares the impacts to those identified in this SEIR. Impacts and mitigation measures are described in detail in Section C.5.3.4.

Table C.5-4 lists the mitigation measures that were proposed in the FEIS/EIR (TANC/WAPA, 1988) in the area of Earth Resources for the minimization of impacts on and from the Proposed Project, and shows how those measures are addressed in this document. These mitigation measures have been modified because they were generally vague and lacked sufficient enforcement provisions.

Table C.5-3 Summary of Impacts: 1988 FEIS/EIR* and SEIR

Final EIS/EIR Impact	Significance	SEIR Impact	Significance
Soil erosion	Less than significant after mitigation	Impact 5-4, Erosion	Less than significant after mitigation
Soil compaction and horizon mixing	Less than significant after mitigation		Less than significant after mitigation
Slope stability	Less than significant after mitigation	Impact 5-5, Substantial Alteration of Topography Impact 5-10, Slope Instability and Unstable Soil Conditions	Less than significant after mitigation
Soil hydrocompaction	Less than significant after mitigation	Impact 5-8, Expansive, Soft, or Loose Soils Impact 5-9, Ground Subsidence and Settlement	Less than significant after mitigation
Loss of productive agricultural land	Significant	Impact 5-3, Loss of Agricultural Soils	Significant
Disturbance or destruction of cultural resources	Less than significant after mitigation	Impact 5-1, Unique Geologic and Paleontologic Features	Less than significant after mitigation
Mineral and petroleum resources	Less than significant after mitigation	Impact 5-2, Known Mineral and Energy Resources	Less than significant after mitigation
Seismicity, fault rupture	Less than significant	Impact 5-6, Fault Rupture	Less than significant after mitigation
Seismicity, ground shaking	Less than significant	Impact 5-7, Earthquake Induced Ground Shaking	Less than significant

* Impacts from FEIS/EIR are from Table 2-B, Summary of Significant Environmental Impacts, Applicable Mitigation Measures, and Mitigation Effectiveness for Los Banos-Gates

Table C.5-4 Mitigation Measures from 1988 FEIS/EIR

Impact	Text of Mitigation Measure	Disposition in this SEIR
General	Base the tower design on geotechnical evaluation and sound geotechnical engineering practice, including analysis for cut and fill slopes, compaction requirements, and surface or slope drainage.	Replaced by **G-3**, **G-5**
Erosion, Slope Instability, Unstable Soil Conditions	Existing roads will be used for access wherever possible. Minimize number and length of new construction access roads particularly in intensively farmed areas. Use temporary spur roads to towers and remove those roads not required for maintenance. Access roads should be designed to the minimum standards necessary for construction and maintenance vehicle access.	Incorporated into **H-1**
	Design drainage control structures to carry runoff at appropriate velocities. Use properly sized and installed culverts under permanent access road fill sections and discharge runoff to natural drainages that will not be overloaded.	Included in **H-2**
	Minimize steepness and unobstructed length of fill slopes. Protect newly constructed fills from rain splash and surface runoff with slope protection, such as punch straw, tackifier, or jute netting.	Incorporated into **H-1**
	Replant temporarily disturbed areas with a mixture of perennial grasses, forbs, brush, shrubs, and tree species that will provide effective erosion control. Prepare a firm, rough seedbed on fill or cut slopes and apply appropriate types and amounts of fertilizers and seed mixtures. Consider reseeding with native plants only in sensitive areas not subject to grazing.	Incorporated into **H-1**
	Where possible, avoid road construction on very steep slopes to minimize surface erosion and slumping.	Incorporated into **H-1**
	Avoid work on unstable slopes and rock outcrops.	Incorporated into **H-1**
Erosion, Soil Compaction	Avoid causative construction operations during the wet season. Moist soil is generally more susceptible to compaction than dry soil. Minimize the use of heavy equipment on agricultural land to avoid soil compaction.	Included in **H-1**
	Perform contour discharge or ripping operations at the conclusion of construction. This would loosen compacted soil and develop the seedbed for revegetation.	Replaced by **H-1**
	In agricultural areas where sites would be graded, topsoil should be stockpiled. After construction, topsoil should be replaced and the site graded to the original contours. If appropriate, the site should be reseeded in accordance with agency or landowner objectives.	Incorporated into **H-1**
	Add soil amendments to seedbed during revegetation to counteract potential chemical imbalances.	Incorporated into **H-1**
Mineral Resources	Avoid active oil wells and water extraction wells and critical facilities. Cross non-critical facilities if resources cannot be avoided.	Included in **H-9**
Paleontologic Resources	Conduct pre-construction field surveys to locate and record paleontologic resources within the project right-of-way and, in particular, resources that are situated at proposed facilities and roadway locations.	Incorporated into **G-1**
	Avoid sensitive resources by locating construction activities in non-sensitive locations. Consultation with paleontological resource professionals during the siting of the transmission line will facilitate mitigation through avoidance.	Incorporated into **G-1**
Soil Hydro-compaction	Identification of soil parameters that may be used during project design to identify the locations of potential problem areas.	Incorporated into **G-4**
	Site-specific field investigations for the project design that will evaluate susceptible locations.	
	Development of alternative foundation designs for those areas where they are needed, possibly to include pile foundations or pre-wetting and collapse of susceptible soils.	
	Construction of alternative foundations, as appropriate.	

C.5.3.4 General Impacts and Mitigation Measures

This section describes the general types of impacts that occur in the area of the Proposed Project and Alternatives. Subsequent sections explain specifically where each impact occurs, and recommends specific locations for implementation of mitigation measures.

Impact 5-1: Unique Geologic and Paleontologic Features

There are no unique geologic features identified within the Proposed Project area, therefore there is no impact to geologic features. Unique and potentially significant paleontologic features are found along the Proposed Project Corridor, Western Alternative Segment 4A, and the Eastern Corridor Alternative.

The paleontological resources are discussed further in the section for each of those segments. Implementation of Mitigation Measure **G-1** will reduce the impacts of the project upon these resources to a less than significant level (**Class II**).

Mitigation Measure for Impact 5-1, Unique Geologic and Paleontologic Features

G-1 Prior to construction, PG&E shall develop a Paleontological Resources Monitoring Plan (PRMP) for review and approval by the CPUC, which shall address the treatment of paleontological resources discovered during transmission line construction. The PRMP shall be prepared by a qualified paleontologist; it shall include procedures for significance testing and data recovery. The PRMP shall defer to the Cultural Resources Monitoring Plan (see Mitigation Measure C-1) if paleontological resources are found with archaeological resources.

The PRMP shall include a requirement for training of construction workers on why vertebrate fossils are important and what they look like. The training shall explain prohibitions against collecting fossils found during construction.

The PRMP shall identify areas of high paleontological sensitivity along the approved route, and shall define procedures for evaluation of resources found during construction. It shall define procedures for actions to be taken if paleontological resources are found during construction, procedures for fossil recovery, a data recovery program, and a qualified curation facility.

Impact 5-2: Known Mineral and Energy Resources

The Proposed Project Corridor traverses the Coalinga, Coalinga East Extension, Pleasant Valley, and Guijarral Hills oilfields in the vicinity of Coalinga. The construction of the transmission line over existing wells would prohibit the operation of cranes and drilling rigs from operating for routine operation and maintenance of these existing oil production wells and related facilities. The land use restrictions imposed by construction of the transmission line would also preclude drilling operations for new wells beneath the alignment. Similar use restrictions would be applicable to existing groundwater extraction wells.

Mitigation Measure **H-9** (in Section C.6, Hydrology and Water Quality) requires that active oil and water extraction wells and critical facilities be avoided whenever possible and to cross over only non-critical facilities where they cannot be avoided. Implementation of this mitigation measure will reduce this impact on existing facilities to a less than significant level (**Class II**). Modern directional drilling techniques allow wells to be drilled from locations not directly over the resource, permitting utilization of mineral and groundwater resources underlying the transmission alignment.

Impact 5-3: Loss of Agricultural Soils

The Proposed Project Corridor crosses agricultural lands in the southern portion. Construction of the transmission line would permanently remove the areas beneath the transmission line support towers from agricultural production. The areas beneath each tower measures about 25 by 70 feet amounting to approximately 0.23 acre per tower. The proposed tower spacing of between 800 and 1,500 feet would average four towers per mile of transmission line amounting to approximately 0.92 acre per mile of transmission line (specific acres lost is presented in the segment analysis in the next section). Conversion of agricultural soils to a non-agricultural use is a significant and unmitigable impact (**Class I**); this impact is also evaluated in Section C.7, Land Use, from the perspective of loss of the use of agricultural land.

Construction of the transmission line would also require the use of pulling sites to be located at approximately 5-mile intervals on level terrain, and each encompassing approximately 0.9 acre. The use of these sites would be temporary, and they would be returned to their original condition after construction was completed. The implementation of Mitigation Measure **H-1** (in Section C.6, Hydrology and Water Quality) will reduce these impacts to a less than significant level (**Class II**).

Impact 5-4: Erosion

The potential for erosion significantly increases as slopes become steeper and less vegetated. Activities such as excavating, pier drilling, road construction, and grading have the potential to cause increased soil erosion because of surface disturbance and vegetation removal. Fine-grained soils can rapidly develop rilling (erosion creating small channels) once vegetation is removed, and this effect can be exacerbated by the application of water for dust control. Implementation of Mitigation Measure **H-1** will reduce this impact to a less than significant level (**Class II**).

Impact 5-5: Substantial Alteration of Topography

The alteration of the local topography caused by the construction of the project is primarily due to construction of all-weather access roads for the construction and maintenance of project facilities. Extensive cut and fill operations will not be required for the Proposed Project. Mitigation Measure **H-1** would ensure that erosion would be prevented and restoration completed (**Class II**).

Impact 5-6: Fault Rupture

Segments 3 and 4 of the Proposed Project and Alternative Segment 4A alignments cross strands of the potentially active O'Neill Fault between Los Banos and Little Panoche Reservoirs (Jennings, 1994; Chin, et al., 1993; Dibblee, 1975). The existing Los Banos Substation may overlie two potentially active traces of the O'Neill Fault (Herd, 1979; Chin et al., 1993). The Eastern Corridor Alternative crosses three strands of the O'Neill Fault and the San Joaquin Fault, both of which are classified as potentially active (Jennings, 1994). The age of most recent fault movement on the O'Neill Fault is unclear; however, with one segment of the fault potentially having ruptured as recently as Holocene time (Herd, 1979). In general, the hazard posed by earthquake surface fault rupture to overhead transmission lines is minor and is only imposed on the support structures, because of the ability of the lines to accommodate the offset.

The implementation of Mitigation Measure **G-2**, requiring a design-level geotechnical investigation and standard engineering practice in placement of tower footings and substation equipment in order to avoid active and potentially active faults, would reduce the impact of this potential hazard to a less than significant level (**Class II**).

Mitigation Measure for Impact 5-6, Fault Rupture

G-2 In areas where the potential for surface fault rupture exists, PG&E shall perform detailed geotechnical surveys at each tower or substation site to accurately determine the fault locations and the seismic potential of each fault, so that facility locations may be adjusted to avoid this hazard. PG&E shall submit these geotechnical reports to the CPUC for review and site approval prior to the start of construction. Incorporation of standard engineering practices as part of the project shall ensure that persons or structures are not exposed to this geological hazard.

Impact 5-7: Earthquake Induced Ground Shaking

The hazard of earthquake induced strong ground shaking from local and regional seismic sources would affect the Proposed Project Corridor and all Alternatives at approximately the same level. The shaking intensity at any given site along the project alignment would be determined by the factors of epicentral distance, earthquake magnitude, and local surface soil conditions. According to the 1986 Draft EIS/EIR, PG&E has committed to following the guidelines for seismic design as presented in IEEE 693, with requirements which are much more stringent than those in the Uniform Building Code. When these guidelines are followed, structures are designed for up to 1.0 g of shear stress from wind loading, and should be capable of withstanding peak ground accelerations approaching that level. While peak ground acceleration in the project area has been measured at slightly higher levels during local seismic events (Stover, 1987), these higher levels have been of very short duration. By following these guidelines and incorporating standard engineering practice in the design and construction of project facilities, impacts from ground shaking would be less than significant (**Class III**).

Impact 5-8: Expansive, Soft, or Loose Soils

Saturated loose sand and soft clay soils may pose difficulties in access for construction and in excavation of foundations for towers or piers. There is a possibility that compaction or differential settlements may occur on the alluvial fans where there are soft or loose deposits or rapid lateral variations in soil strength. Implementation of Mitigation Measure **G-3** would ensure that these impacts are less than significant.

Mitigation Measure for Impact 5-8, Expansive, Soft, or Loose Soils

G-3 PG&E shall perform design-level geotechnical investigations including soil sampling, free-swell tests, density tests, and soil borings or cone penetrometer tests (CPT) to determine the extent of and potential for expansive, soft or loose soils. PG&E shall develop appropriate design features for locations where potential problems are found to exist. Appropriate design features may include excavation of problematic soils and replacement with engineered backfill, ground treatment such as ground densification, and the use of deep foundations such as piers or piles. PG&E shall submit these geotechnical reports to the CPUC for review and site approval prior to the start of construction. Incorporation of standard engineering practices as part of the project shall ensure that persons or structures are not exposed to geological hazards.

Impact 5-9: Ground Subsidence and Settlement

Subsidence is the settling of the ground surface caused by compaction of underlying unconsolidated sediments, often because of the withdrawal of groundwater or hydrocarbons. Ground subsidence can also cause relative elevation changes within an area, increasing the potential for inadequate drainage, localized flooding, or increased erosion. Subsidence can also be caused by strong ground motions, and the presence of soft, loose, or compressible soils not removed during excavation or grading.

Past subsidence from groundwater withdrawal is as much as 20 feet along the proposed corridor in the vicinity of the Gates Substation. Subsidence in the project area had largely stopped by about 1975, due to the decrease in groundwater pumping after completion of the California Aqueduct (Ireland et al., 1984).

Subsidence impacts due to groundwater withdrawal would be less than significant (**Class III**) with implementation of site-specific, design-level review and incorporation of standard engineering practices as part of the project.

Ground subsidence can also occur as a result of collapsible or hydrocompactive soils. The semi-arid climate of the western San Joaquin Valley combined with the occurrence of alluvial fan deposits, primarily composed of mud and debris flow deposits between the larger alluvial drainages have created the hazard of hydrocompactive soils. These soils consist of primarily thinly layered, fine-grained sediments of expansive clay with minor silt and fine sand. These soils have never been completely saturated since deposition, and upon irrigating or applying a load, such as a tower footing, they may collapse. These soils are known to exist along the Eastern Corridor Alternative, in the inter-fan areas between the drainages of Little Panoche, Panoche, and Cantua Creeks. Mitigation Measure **G-4** would reduce these impacts to less than significant levels (**Class II**).

Mitigation Measure for Impact 5-9, Ground Subsidence and Settlement

G-4 PG&E shall evaluate the potential for subsidence or settlement of approved project facilities due to the presence of compressible or hydrocompactive soils during design-level geotechnical investigations. PG&E shall submit these geotechnical reports to the CPUC for review and site approval prior to the start of construction. The results of the investigations will be used to develop appropriate pre-construction ground treatments, and incorporate foundation and structural designs to accommodate expected settlements. PG&E shall remove or rework near surface deposits found to be potentially susceptible to hydrocompaction prior to placing new engineered fill. Incorporation of standard engineering practices as part of the project shall ensure that persons or structures are not exposed to geological hazards.

Impact 5-10: Slope Instability and Unstable Soil Conditions

Destabilization of natural or constructed slopes could occur as a result of construction activities, and from loading of unstable slopes with heavy construction equipment and project facilities. Excavation of access roadways, and grading could alter existing slope profiles and result in the excavation of slope-supporting material, over-steepening of slopes, or increased loading. Construction activities should be suspended during and immediately following periods of heavy or extended precipitation when slopes are more susceptible to failure. Numerous small landslides are located in the vicinity of the Proposed Project Corridor. Implementation of Mitigation Measure **G-5** is recommended for these conditions.

Mitigation Measure for Impact 5-10, Slope Instability and Unstable Soil Conditions

G-5 PG&E shall perform design-level geotechnical surveys to evaluate the potential for unstable slopes, landslides, mudflows, and debris flows along the approved corridors. PG&E shall submit these geotechnical reports to the CPUC for review and site approval prior to the start of construction. Facilities should be located away from steep hillsides, debris flow source areas, the mouths of steep sidehill drainages, and the mouths of canyons that drain steep terrain. Specially designed deep foundations may be used in areas of shallow sliding where unstable slopes cannot be avoided. Incorporation of standard engineering practices as part of the project shall ensure that persons or structures are not exposed to geological hazards.

C.5.3.5 Proposed 500 kV Transmission Line Corridor

The Proposed Project Corridor for the 500 kV transmission line will be subject to the geologic hazard of strong shaking from regional seismicity at approximately the same severity along the entire length of the corridor. The distance from localized blind thrust faults along the range front varies between zero and five miles, and the width of the seismogenic zone precludes eliminating the hazard by modification of the corridor. The following sections explain the specific anticipated impacts by segment.

C.5.3.5.1 *Segment 1*

Portions of Segment 1 cross level to rolling terrain of older alluvium and Tulare Formation deposits which contain moderate to high amounts of clay. The clays derived from local marine sedimentary rocks are predominantly montmorillonite and are subject to expansion with changes in moisture content. The presence of these clays poses a moderate to severe geologic hazard from expansive soils, and soft or loose soils. Mitigation Measure **G-3** is recommended to reduce these impacts to a less than significant level (**Class II**).

Portions of Segment 1 of the Proposed Project traverse steep bedrock terrain of predominantly sandstone. Alterations of these steep slopes by construction of the project and access roads will expose the project facilities to the hazards of increased potential for landslide and slope instability, and the increased potential for erosion. The alignment traverses areas of moderately steep to very steep terrain and is subject to intense rainfall over brief periods, both of which are factors likely to generate mudflows and debris flows. These hazards have not been adequately mapped in the project area.

Implementation of Mitigation Measures **H-1** and **G-3**, including design-level geotechnical investigations, and use of standard engineering and construction practices, does not adequately describe the measures necessary to reduce the impacts from slope instability, landslides, mudslides, and debris flows on project facilities in areas of steep terrain. Mitigation Measure **G-5** is also recommended to further clarify requirements in this segment and reduce these impacts to a less than significant level (**Class II**).

C.5.3.5.2 *Segment 2*

Segment 2 of the Proposed Project traverses predominantly moderate to steeply sloping terrain composed of sandstone, shale, and conglomerate. Alteration of these slopes by construction of the project and access roads will cause increased potential for erosion, landslide, and slope stability hazards. Minimizing roadway construction as required by Mitigation Measures **H-1** and **G-3** would reduce these potential hazards to a less than significant level (**Class II**).

Small portions of Segment 2 overlie low rolling terrain of older alluvium and Tulare Formation deposits which have moderate to high content of expansive clay soils, and soft or loose soils. In areas where these soil conditions exist, Mitigation Measure **G-3** should be implemented to reduce the hazard to a less than significant level (**Class II**).

C.5.3.5.3 *Segment 3*

Segment 3 of the Proposed Project traverses predominantly moderate to steeply sloping terrain composed of shale with minor sandstone beds. Alterations to these slopes by construction of project facilities and construction access roads will cause increased potential for erosion and slope stability hazards. Mitigation Measures **H-1** and **G-3** would reduce these potential hazards to a less than significant level (**Class II**).

A significant portion of Segment 3 overlies gently sloping terrain of Tulare Formation deposits which have a moderate content of expansive clay soils, and soft or loose soils. In areas where these soil conditions exist, implementation of Mitigation Measure **G-3** would reduce the hazard to a less than significant level (**Class II**).

Segment 3 of the Proposed Project crosses several traces of the potentially active O'Neill Fault. The hazard of surface fault rupture to project structures in this area is limited to the locations of the tower structures, as previously discussed in Impact 5-6, Fault Rupture. The implementation of Mitigation Measure **G-2** would reduce the impact of these hazards on project facilities to a less than significant level (**Class II**).

C.5.3.5.4 *Segment 4*

Segment 4 of the Proposed Project predominantly overlies gently to moderately sloping terrain composed of Tulare Formation gravelly sand. Construction of project structures and access roads on these deposits will cause minor increases in erosion and slope stability hazards that are less than significant (**Class III**).

Segment 4 crosses a mapped trace of the potentially active O'Neill Fault at about MP 21.0. Implementation of Mitigation Measure **G-2** is recommended to reduce the hazard of surface fault rupture to a less than significant level (**Class II**).

C.5.3.5.5 *Segment 5*

Segment 5 of the Proposed Project extends across predominantly gently sloping to nearly level terrain comprised of young alluvial fan deposits between Capita Wash and Panoche Creek (MP 31.2 to MP 36.7). These deposits are subject to the geologic hazards of increased erosion, settlement, subsidence, and soft and loose soils. Implementation of Mitigation Measures **H-1** and **G-3** would reduce these hazards to a less than significant level (**Class II**). These deposits are primarily used for agricultural production, and construction of project facilities along this segment would require conversion of these soils to a non-agricultural use (see Section C.7, Land Use).

North of Capita Wash (MP 28.9 to MP 31.2), from Panoche Creek to south of Tumey Gulch (MP 36.7 and MP 42.4), and between Cantua and Martinez creeks (MP 57.5 to MP 62.0), this segment of the Proposed Project overlies gently to moderately sloping terrace deposits of the Tulare Formation. These portions of Segment 5 would be subject to the geologic hazards of increased erosion, expansive, soft or loose soils, slope instability, and mudflows and debris flows. Implementation of Mitigation Measures **G-2** and **G-3** would reduce these hazards to a less than significant level (**Class II**).

This segment traverses moderate to very steep slopes between Tumey Gulch and Cantua Creek (MP 42.4 to MP 57.5) and gentle to moderate slopes from south of Martinez Creek to Skunk Hollow (MP 62.0 to MP 69.0). These portions of Segment 5 would be subject to the geologic hazards of increased erosion, landslide, slope instability, mudslides, and debris flows. Implementation of Mitigation Measures **G-3** and **G-5** would reduce these hazards to a less than significant level (**Class II**).

Known paleontologic resources of significance are found to the west of this segment alignment in the Domengine Formation (Dibblee, 1975). This formation also underlies the Tulare Formation between MP 28.9 and MP 30.0 at shallow depth. There exists the potential for discovery of paleontologic resources of significance in this portion of Segment 5, however, implementation of Mitigation Measure **G-1** during siting surveys and the construction of site facilities shall reduce this impact to a less than significant level (**Class II**).

Segment 5 of the Proposed Project also crosses the northern portion of the Coalinga oilfield between MP 66.0 and MP 67.0. Mitigation Measure **H-9** would reduce this impact to a less than significant level (**Class II**).

C.5.3.5.6 *Segment 6*

Segment 6 extends across low hills with gentle to moderate slopes from Skunk Hollow to Shell Creek (MP 69.0 to MP 71.3) crossing terrace deposits of the Tulare Formation This portion of Segment 6 would be subject to the geologic hazards of subsidence from oil extraction, erosion, and soft or loose soils. Implementation of Mitigation Measure **G-3** would reduce these hazards to a less than significant level (**Class II**).

From Shell Creek to east of the Guijarral Hills (MP 71.3 to MP 79.2), the Proposed Project Corridor crosses gently sloping alluvial fan deposits. This portion of Segment 6 would be subject to subsidence, settlement, erosion, and soft or loose soils. Implementation of Mitigation Measure **G-3** would reduce these hazards to a less than significant level (**Class II**).

Portions of this segment from MP 69.7 to MP 71.7 cross the East Coalinga Extension and the Guijarral Hills oil fields, and approaches within 200 feet of 9 existing wells and within 500 feet of 12 additional existing wells. The implementation of Mitigation Measure **H-9** would reduce this impact to a less than significant level (**Class II**).

Small portions of this segment crossing Los Gatos Creek could overlie potentially liquefiable granular materials in surface or subsurface deposits. The depth to groundwater is generally well below the potentially liquefiable zones, so this impact would be less than significant (**Class III**). While seasonal stream flows may provide temporary saturation in shallow layers, this would not affect towers placed outside of stream zones.

C.5.3.5.7 *Segment 7*

Segment 7 of the Proposed Project extends east from the Guijarral Hills to the existing Gates Substation, crossing predominantly gentle to nearly level terrain, which has been extensively developed for agricultural production. The construction of the project along this segment would permanently remove small portions of these agricultural soils and convert them to a non-agricultural use (see Section C.7, Land Use).

The geologic hazards that would affect this segment are subsidence, settlement, and soft or loose soils. Implementation of Mitigation Measures **G-3** would reduce these hazards to a less than significant level (**Class II**).

Small portions of this segment along Zapato Creek could overlie potentially liquefiable granular materials in surface or subsurface deposits. The depth to groundwater in this semi-arid climate is generally well below the liquefiable zones, so this potential impact is considered to be less than significant (**Class III**).

C.5.3.6 Proposed Substation Modifications

The following sections describe the impacts from geologic hazards that would affect the proposed changes to the substations and other facilities south of the Gates Substation.

C.5.3.6.1 *Los Banos Substation*

The proposed modifications to the Los Banos Substation will require a design-level geotechnical study for evaluating the potential for surface fault rupture through the substation. Of the two traces of the

O'Neill Fault crossed by Segment 1 of the Eastern Corridor Alternative, the eastern trace is mapped as continuous through the northwest corner of the substation, and the western trace is mapped to the edge of the Tulare Formation deposits south of the substation. This western fault trace potentially extends through the center of the existing substation. The proposed modifications within the substation should be subject to Mitigation Measure **G-2** requiring that these fault traces be located and evaluated for their seismic potential. Implementation of site-specific geotechnical evaluations and recommendations from these studies would reduce the potential impact of surface fault rupture to project facilities to a less than significant level (**Class II**).

C.5.3.6.2 *Gates Substation*

The modifications to the Gates Substation will not significantly affect the agricultural lands that surround the facility. The construction of the transformer banks and switches within the facility will be exposed to the potential hazards of expansive, soft or loose soils, and ground subsidence. Implementation of site-specific design-level geotechnical studies and standard engineering practices as required in Mitigation Measure **G-3** would reduce these potential hazards to a less than significant level (**Class II**).

C.5.3.7 Gates Loop

The proposed changes in the area of the Gates Substation include the removal of seven transmission line towers and construction of 6 new replacement towers at another location. These new tower locations would be subject to the geologic hazards of ground subsidence, and soft or loose soils. Implementation of Mitigation Measure **G-3** would reduce these impacts to a less than significant level (**Class II**).

C.5.3.8 Reconductoring South of Gates Substation

Because the reconductoring that may be required on the Gates-Arco-Midway 230 kV transmission line would not require placement of new transmission towers, there would be no impacts to geology, soils, or minerals.

C.5.4 ENVIRONMENTAL IMPACTS AND MITIGATION MEASURES FOR WESTERN CORRIDOR ALTERNATIVE SEGMENTS

The geologic hazard of strong ground shaking from regional seismicity will affect the Western Corridor Alternative Segments with approximately the same severity as the Proposed Project. Minor variations in site-specific soil conditions and the distance to future epicenters will determine the severity of shaking from any future seismic event. Other impacts are described below by segment.

C.5.4.1 Segment 2A

Segment 2A of the Western Corridor traverses predominantly moderate to very steep terrain of sandstone, shale, and conglomerate. Alteration to these slopes by construction of project facilities and construction access roads will cause an increased potential for erosion, landslide, and slope stability hazards. Implementation of Mitigation Measures **G-3** and **G-5** would reduce the hazard to a less than significant level (**Class II**).

Moderate to steep slopes comprised of shale bedrock along this segment may be subject to hazard from expansive soils. The soils found on these slopes contain predominantly expansive clays; however, the limited depth of these soils results in a less than significant (**Class III**) impact.

C.5.4.2 Segment 4A

Segment 4A of the Western Corridor traverses predominantly sandstone and shale beds of the Panoche Formation with minor exposures of the Moreno Shale, and the Domengine and Laguna Seca formations. These bedrock units form moderate to steeply sloping terrain south of Little Panoche Creek and will expose the project segment to increased hazard from landslide, slope instability, and erosion. Implementation of Mitigation Measures **G-2** and **G-3** would reduce these hazards to a less than significant level (**Class II**).

A significant portion of this segment overlies sandy clay and marl deposits of the Tulare Formation, traversing gentle to moderate slopes. The construction of project facilities and access roads on these deposits will increase the hazards of slope instability and erosion. Implementation of Mitigation Measures **G-3** would reduce these hazards to a less than significant level (**Class II**).

Known paleontologic resources of significance are found to the south of the segment alignment in Moreno Shale, and the Laguna Seca and Domengine formations (Dibblee, 1975). These formations also underlie the Tulare Formation between AMP 27.8 and AMP 29.4 at shallow depth. There exists the potential for discovery of paleontologic resources of significance in this portion of Segment 4A, however, implementation of Mitigation Measure **G-1** during siting surveys and construction of site facilities would reduce this impact to a less than significant level (**Class II**).

C.5.4.3 Segment 6A

Alternative Segment 6A crosses gently sloping terrain between AMP 69.0 and AMP 70.9, overlying terrace deposits of Tulare Formation. This segment extends across older and younger alluvial fan deposits from AMP 70.9 to AMP 78.3. These portions of Segment 6A would be subject to the geologic hazards of settlement, subsidence, erosion, and soft or loose soils. Implementation of Mitigation Measure **G-3** would reduce these hazards to a less than significant level (**Class II**).

Portions of this segment cross the East Coalinga Extension (AMP 69.5 to AMP 70.6) oil field, and approaches within 500 feet of 8 existing wells. This segment passes east of Guijarral Hills oil field and avoids all existing facilities there. The implementation of Mitigation Measure **H-9** would reduce this impact to a less than significant level (**Class II**).

Much of this segment has been developed for agricultural production. The construction of the project along this alternative segment would permanently remove small portions of these agricultural soils and convert them to a non-agricultural use (see Section C.7, Land Use).

Small portions of this segment crossing Los Gatos Creek overlie potentially liquefiable granular materials in surface or subsurface deposits. The depth to groundwater is generally well below the potentially liquefiable zones, so this impact is less than significant (**Class III**).

C.5.4.4 Segment 6B

Alternative Segment 6B crosses gently sloping low rolling hills between AMP 69.0 and AMP 76.5, and from AMP 77.8 to AMP 78.8, overlying predominantly terrace deposits of Tulare Formation. These portions of Segment 6B would be subject to the geologic hazards of subsidence, erosion, and soft or loose soils. Implementation of Mitigation Measure **G-3** would reduce these hazards to a less than significant level (**Class II**).

Segment 6B crosses young alluvium within the Los Gatos Creek valley from AMP 76.5 to AMP 77.8 and extends across young alluvial fan deposits from AMP 78.8 to AMP 80.7. This portion of the alignment would be subject to the geologic hazards of settlement, subsidence, erosion, and soft or loose soils. Implementation of Mitigation Measures **G-3** would reduce these hazards to a less than significant level (**Class II**).

Portions of this segment cross the East Coalinga Extension (AMP 71.9 to AMP 73.5), the Pleasant Valley (AMP 76.2 to AMP 76.5), and the Guijarral Hills (AMP 78.8 to AMP 79.8) oil fields, and approaches within 500 feet of 23 existing wells. The implementation of Mitigation Measure **H-9** would reduce this impact to a less than significant level (**Class II**).

Portions of this segment have been developed for agricultural production. The construction of the project along this alternative segment would permanently remove small portions of these agricultural soils and convert them to a non-agricultural use (**Class I**).

The portion of this segment crossing Los Gatos Creek overlies potentially liquefiable granular materials in surface and subsurface deposits. The depth to groundwater is generally well below the potentially liquefiable zones, so this impact would be less than significant (**Class III**).

C.5.5 ENVIRONMENTAL IMPACTS AND MITIGATION MEASURES FOR THE EASTERN CORRIDOR ALTERNATIVE

This section describes the environmental impacts and mitigation measures for the Eastern Corridor Alternative. Many of the Alternative segments are subject to similar hazards as the Proposed Project and these geologic hazards are briefly discussed below. Geologic hazards, which are different from those of the Proposed Project, are discussed in detail within each segment.

C.5.5.1 Segment 1

Segment 1 of the Eastern Corridor Alternative crosses two strands of the potentially active O'Neill Fault. In addition to the hazard of strong ground shaking from regional seismicity, this segment is also susceptible to the hazard of surface fault rupture (Herd, 1979). Implementation of Mitigation Measure **G-2** would reduce the impact of this potential hazard to a less than significant level (**Class II**).

C.5.5.2 Segment 2

Segment 2 of the Eastern Corridor Alternative crosses a third fault trace of the O'Neill fault system, and will be subject to the potential hazard of severe ground shaking from regional earthquakes and surface fault rupture. Implementation of Mitigation Measure **G-2** would reduce this hazard to a less than significant level (**Class II**).

Segment 2 will also be subject to the potential geologic hazards of expansive, soft, or loose soils, settlement, erosion potential, slope instability, and unique or significant paleontologic resources. Implementation of Mitigation Measures **G-3** and **G-5** would reduce the impacts of these hazards to a less than significant level (**Class II**).

Known paleontologic resources exist in the exposures of Moreno Formation sandstones roughly between MP 5.0 and MP 5.4 and in the abutment north of Los Banos Dam contain significant ammonite fossil localities (Dibblee, 1975). These beds also underlie the Tulare Formation deposits at potentially shallow depth between MP 5.6 and MP 6.2. There exists the potential for disturbance of these paleontologic resources along this segment; however, implementation of Mitigation Measure **G-1** during site surveys and construction of project facilities would reduce this impact to a less than significant level (**Class II**).

C.5.5.3 Segment 3

Segment 3 of the Eastern Corridor Alternative will be subject to the potential geologic hazards of expansive, soft or loose soils, ground subsidence or settlement, erosion potential, and slope instability, mudflows or debris flows. Implementation of Mitigation Measures **G-3** and **G-5** would reduce the impacts of these hazards to a less than significant level (**Class II**).

C.5.5.4 Segment 4

Segment 4 of the Eastern Corridor Alternative will be subject to the potential geologic hazards of expansive, soft or loose soils, ground subsidence or settlement, erosion potential, and slope instability, mudflows or debris flows. Implementation of Mitigation Measures **G-3** and **G-5** would reduce the impacts of these hazards to a less than significant level (**Class II**).

Portions of the deposits mapped as older alluvium and young alluvium along Segment 4 of the Eastern Corridor Alternative are known to be subject to hydrocompaction. These types of soils are inter-fan deposits between the drainages of Little Panoche and Panoche creeks, and Panoche and Cantua creeks, rich in expansive clays, such as montmorillonite, which have not been saturated since deposition. These areas are to be further evaluated during site-specific design-level geotechnical studies and appropriate measures, such as pre-compaction, are to be incorporated into the design and construction plan where avoidance is impractical. Implementation of Mitigation Measure **G-4** shall reduce the impacts from soft or compressible soils or from hydrocompactive soils to a less than significant level (**Class II**).

Large portions of this segment have been developed for agricultural production. The construction of the project along this alternative segment would permanently remove small portions of these agricultural soils and convert them to a non-agricultural use. This impact is addressed in Section C.7, Land Use.

C.5.5.5 Segment 5

Segment 5 of the Eastern Corridor Alternative overlies agricultural soils along its entire length. This segment will be subject to the potential geologic hazards of expansive, soft, or loose soils, ground subsidence or settlement, and erosion potential. Implementation of Mitigation Measures **G-3** and **G-5** would reduce the impacts of these hazards to a less than significant level (**Class II**).

This segment primarily crosses lands that have been developed for agricultural production. The construction of the project along this alternative segment would permanently remove small portions of these agricultural soils and convert them to a non-agricultural use.

C.5.5.6 Segment 6

Segment 6 of the Eastern Corridor Alternative will be subject to the potential geologic hazards similar to those discussed for Segment 5, above. Implementation of Mitigation Measures **G-3** and **G-5**, described above, would reduce the impacts of these hazards to a less than significant level (**Class II**).

This segment is almost entirely developed for agricultural production. The construction of the project along this alternative segment would permanently remove small portions of these agricultural soils and convert them to a non-agricultural use.

C.5.6 MITIGATION MONITORING, COMPLIANCE, AND REPORTING TABLE

Table C.5-5 on the following page presents the mitigation monitoring criteria for Geology, Soils, and Minerals.

Table C.5-5 Mitigation Monitoring Program

Impact	Mitigation Measure	Location	Monitoring/Reporting Action	Effectiveness Criteria	Responsible Agency	Timing
Proposed Project, Western and Eastern Corridor Alternatives						
Impacts to unique geologic and paleontologic resources (Class II)	**G-1** Conduct pre-construction field surveys and record locations of paleontologic resources. Develop and submit plan for recovery and evaluation of paleontologic resources to agency for review	Panoche Hills - Moreno Formation Area of Critical Concern	Review of siting plans for towers and access roads by agency approved paleontologist. Agency approval of recovery and evaluation plan.	Plan/design avoids disturbing resources to extent feasible.	CPUC, BLM, local planning agencies	Prior to construction
Crossings of active or potentially active faults by project facilities (Class II)	**G-2** Perform detailed geotechnical surveys at each tower or substation site to accurately determine fault locations and seismic potential of each fault. Adjust facility locations to avoid potential fault rupture hazards.	Crossings of potentially active traces of the O'Neill and San Joaquin faults.	Approved engineer to review and approve geotechnical report, site plans, and foundation designs	Identification of fault traces and avoidance of active and potentially active fault traces beneath project structures.	CPUC, CDMG, local planning agencies	Prior to construction
Expansive, soft or loose soils (Class II)	**G-3** Conduct design-level geotechnical investigations in areas classified as having moderate to high potential for expansive, soft, or loose soils. Develop appropriate design features based on results, such as removal or reworking of deposits, ground treatment, or deep foundations.	Areas with moderately to highly expansive soils, soft, or loose soils, or soils subject to compaction or settlement.	Approved engineer to review and approve geotechnical report, grading plans, and foundation designs	Plan/design identifies hazardous soils and presents analysis for soil treatments and foundation designs selected for prevention of settlements to extent feasible	CPUC, BLM, CDWR, local planning agencies	Prior to construction
Ground subsidence and settlement (Class II)	**G-4** Evaluate the potential for subsidence due to the presence of compressible or hydrocomapactive soils during design-level geotechnical investigations. Develop appropriate construction ground treatments and incorporate foundation and structural designs to accommodate expected settlements.	Inter-fan areas between Little Panoche and Panoche Creeks, Panoche and Cantua Creeks, and other known of suspected areas of hydrocompactive soils	Approved engineer to review and approve geotechnical and engineering reports, site plans, and foundation designs	Engineering reports shall identify areas of hydrocompaction susceptibility and present analysis of settlement potential and rationale for ground treatments and foundations selected.	CPUC, BLM, CDWR, local planning agencies	Prior to construction
Slope instability and unstable soil conditions	**G-5** Conduct design-level geotechnical surveys to evaluate and identify unstable slopes, landslides, mudflows and debris flows along approved corridor. Locate project facilities away from steep hillsides, debris flow source areas, and the mouths of steep sidehill drainages and canyons that drain steep terrain. Deep foundations may be used where avoidance is deemed impractical.	Areas of steep terrain, with evidence of prior landslides or other slope instability are present.	Approved engineer to review and approve geotechnical report, site plans, and foundation designs	Plan/design identifies potential slope instabilities and presents analysis for alternative site selection, criteria for non-avoidance, and foundation designs selected for slope instabilities affecting project facilities to extent feasible	CPUC, BLM, CDWR, local planning agencies	Prior to construction

C.5.7 REFERENCES

Abrahamson, N.A. and W. Silva. 1997. *Empirical Attenuation Relations for Shallow Crustal Earthquakes*. Seismological Research Letters, Vol. 68, No. 1, Jan/Feb., pp. 9-23.

Bartow, J.A. 1996. Geologic Map of the West Border of the San Joaquin Valley in the Panoche Creek-Cantua Creek Area, Fresno and San Benito Counties, California. U.S. Geological Survey Miscellaneous Investigations Field Studies Map I-2430.

Bennett, J.H. and R.W. Sherburne, eds. The 1983 Coalinga, California Earthquakes. California Department of Conservation, Division of Mines and Geology (CDMG) Special Publication 66.

Blake, T.F. 2000. EQFAULT: A Computer Program for the Estimation of Peak Horizontal Acceleration from 3-D Fault Sources, Windows 95/98 Version. Thomas F. Blake Computer Services and Software.

Bonilla, M.G. and J.J. Lienkaemper. 1991. Factors Affecting the Recognition of Faults Exposed in Exploratory Trenches. U.S. Geological Survey Bulletin 1947.

Bull, W.B. 1964. Alluvial Fans and Near Surface Subsidence in Western Fresno County, California. U.S. Geologic Survey Professional Paper 437-A.

California Division of Oil, Gas, and Geothermal Resources, 2000. 1999 Annual Report of the State Oil and Gas Supervisor: The Eighty-Fifth Annual Report. California Department of Conservation, Division of Oil, Gas, and Geothermal Resources: http://www.consrv.ca.gov/dog/publications/annualr_b.html

Camp, C.L. 1942. California Mosasaurs. Memoirs of the University of California, University of California Press, v. 13, no. 1.

California Department of Water Resources (CDWR). 1986. Geologic Study on the Feasibility of Los Banos Grandes Project: State Water Project, Future Supply, Los Banos Offstream Storage Unit, Project Geology Branch. California Department of Water Resources.

_____. 1990. Los Banos Grandes Facilities: Draft Environmental Impact Report. Department of Water Resources, Division of Planning.

California Division of Mines and Geology (CDMG). 1997a. Guidelines for Evaluating and Mitigating Seismic Hazards in California. CDMG Special Publication 117.

_____. 1997b. *Fault-Rupture Hazard Zones in California, Alquist-Priolo Special Studies Zones Act of 1972 with Index to Special Studies Zones Maps*. CDMG Special Publication 42, Revised.

Chin, J.L., J.R., Morrow, C.R. Ross, and H.E. Clifton. 1993. Geologic Maps of Upper Cenozoic Deposits in Central California. U.S. Geological Survey Miscellaneous Investigations Series Map I-1943.

Cole, R.C. et al. 1952. Soil Survey of the Los Banos Area, California. U.S. Bureau of Plant Industry, Soils, and Agricultural Engineering; Soil Series 1939, No. 12.

Dibblee, T.W. Jr. 1971. Geologic maps of 17 Quadrangles along the San Andreas Fault in the Vicinity of King City, Coalinga, Panoche Valley, and Paso Robles, California. U.S. Geologic Survey Open-File Report 71-87.

_____. 1975. Geologic Map of the San Benito, Quien Sabe, Tumey Hills, Panoche Valley, Pacheco Pass, Ortigalita Peak, and Hollister Quadrangles, California. U.S. Geologic Survey Open-File Report 75-394.

Hall, C.E. and J.W. Carlson. 1965. *Stabilization of Soils Subject to Hydrocompaction, in* Bulletin of the Association of Engineering Geologists, Vol. 2, No. 2, July, 1965, p. 47-58.

Harradine, F.F. 1950. Soils of Western Fresno County, California. University of California College of Agriculture, Agricultural Experiment Station, Berkeley, California.

_____. 1952. Soil Survey of the Coalinga Area, California. U.S. Department of Agriculture, Series 1944, No. 1.

Herd, D.G. 1979. Geologic Map of O'Neill Forebay, Western Merced County, California. U.S.Geological Survey Open-File Report 79-359.

Idriss, I.M. 1991. *Selection of Earthquake Ground Motions at Rock Sites*. Report prepared for the Structures Division, Building and Fire Research Laboratory, National Institute of Standards and Technology, Department of Civil Engineering, University of California, Davis, California.

Institute of Electrical and Electronics Engineers (IEEE). 1997. Draft Recommended Practices for Seismic Design of Substations. Prepared by the Working Group F1 of the West Coast Substation Subcommittee, Institute of Electrical and Electronics Engineers, IEEE Standards Project P693.

Ireland, R.L., J.F. Poland, and F.S. Riley. 1984. Land Subsidence in the San Joaquin Valley, California as of 1980. U.S. Geological Survey Professional Paper 437-I.

Jennings, C.W. 1994. *Fault Activity Map of California and Adjacent Areas with Locations and Ages of Recent Volcanic Eruptions*. California Division of Mines and Geology, Geologic Data Map No. 6, Scale 1:750,000.

Miller, R.E., J.H. Green, and G.E. Davis. 1971. Geology of the Compacting Deposits in the Los Banos-Kettleman City Subsidence Area, California. U.S. Geological Survey Professional Paper 497-E.

Norris, R.M. and R.W. Webb. 1990. Geology of California, 2nd Edition. John Wiley and Sons, Inc., New York, New York.

Pacific Gas and Electric Company (PG&E), 1986. Los Banos-Gates 500 kV Transmission Project Environmental Report and Technical Appendices.

Pacific Gas and Electric Company, 1982. Coalinga-Gates Growth and Development Study. PG&E Land Department, Land Use Planning Unit.

Petersen, M.D., W.A. Bryant, C.H. Cramer, T. Cao, M.S. Reichle, A.D. Frankel, J.J. Lienkaemper, P.A. McCrory, and D.P. Schwartz. 1996. *Probabilistic Seismic Hazard Assessment for the State* *of California*. California Division of Mines and Geology Open-File Report 96-08/U.S. Geological Survey Open-File Report 96-706.

Rymer, M.J. and W.L. Ellsworth, eds. 1990. The Coalinga, California, Earthquake of May 2, 1983. U.S. Geological Survey Professional Paper 1487.

Sadigh, K., C.Y. Chang, N.A. Abrahamson, S.J. Chiou, and M.S. Power. 1993. Specification of Long-period Ground Motions: Updated Attenuation Relationships for Rock Site Conditions and Adjustment Factors for Near-fault Effects. *Proceedings of ATC-17-1 Seminar on Seismic Isolation, Passive Energy Dissipation, and Active Control*. San Francisco, California. p. 59-70.

Scholl, R.E. and J.L. Stratta. 1984. Coalinga, California, Earthquake of May 2, 1983: Reconnaissance Report. Earthquake Engineering Research Institute Report No. 84-03, Berkeley, California.

Stover, C.W. 1983. United States Earthquakes, 1983. U.S. Geological Survey Bulletin 1698.

Transmission Agency of Northern Californiaand Western Area Power Administration (TANC/WAPA). 1988. Final Environmental Impact Statement/Environmental Impact Report for the California-Oregon Transmission Project and the Los Banos-Gates Transmission Project.

Uhrhammer, R.A., R.B. Darragh, and B.A. Bolt. 1983. *The 1983 Coalinga Earthquake Sequence: May 2 through August 1, in* Bennett, J.H., and R.W. Sherburne, eds., The 1983 Coalinga, California Earthquakes. CDMG Special Publication 66, p. 221-232.

Wakabayashi, J. and D.L. Smith. 1994. *Evaluation of Recurrence Intervals, Characteristic Earthquakes, and Slip Rates Associated with Thrusting along the Coast Range--Central Valley Geomorphic Boundary, California, in* Bulletin of the Seismological Society of America. v. 84, no. 6, p. 1,960-1,970.

Wells, D.W. and K.J. Coppersmith. 1994. *New Empirical Relationships among Magnitude, Rupture Length, Rupture Width, Rupture Area, and Surface Displacement, in* Bulletin of the Seismological Society of America. v. 84, no. 4, p. 974-1,002.

Wesnousky, S.G. 1986. *Earthquakes, Quaternary Faults, and Seismic Hazard in California*. Journal of Geophysical Research, V.91, no. B12, p. 12,587-12,631.

Wong, I.G. and R.W. Ely. 1983. *Historical Seismicity and Tectonics of the Coast Ranges--Sierran Block Boundary: Implications to the 1983 Coalinga, California Earthquakes, in* Bennett, J.H., and R.W. Sherburne, eds., The 1983 Coalinga, California Earthquakes. CDMG Special Publication 66, p. 89-104.

Working Group on California Earthquake Probabilities (WG99). 1999. *Earthquake Probabilities in the San Francisco Bay Region: 2000 to 2030—A Summary of Findings*. U.S. Geological Survey Open-File Report 99-517.

Yeats, R.S., K. Sieh, and C.R. Allen. 1997. *The Geology of Earthquakes*. Oxford University Press.

Youd, T.L. and D.M. Perkins. 1978. Mapping Liquefaction Induced Ground Failure Potential, *Proceedings of the American Society of Civil Engineers, Journal of the Geotechnical Engineering Division*. Vol. 104, No. GT 4.

Ziony, J.I., ed. 1985. Evaluating Earthquake Hazards in the Los Angeles Region – An Earth Science Perspective. U.S. Geological Survey Professional Paper 1360.