5.4 Geologic Hazards and Resources

This section discusses the effect of geologic hazards on the Mariposa Energy Project (MEP) and geologic resources of commercial, recreational, or scientific value at the project site. Section 5.4.1 describes the existing environment that could be affected, including regional and local geology and geologic hazards. Section 5.4.2 identifies potential environmental effects from project development. Section 5.4.3 discusses potential cumulative effects. Section 5.4.4 discusses possible mitigation measures. Section 5.4.5 presents the laws, ordinances, regulations, and standards (LORS) applicable to geologic hazards and resources. Section 5.4.6 provides agency contacts and Section 5.4.7 describes the required permits. Section 5.4.8 provides the references used to develop this section.

5.4.1 Affected Environment

The MEP site is a 10-acre portion of a 158-acre parcel located in northeast Alameda County, California, near the western edge of the San Joaquin Valley and near the border of the Coast Ranges and the Great Valley geomorphic provinces. The Coast Ranges are a series of valleys and mountains along the West Coast of California that extend from Oregon to the Santa Ynez River near Santa Barbara. The Great Valley is a 400-mile-long, northwest-southeast trending structural basin that extends along the center of the state from the Klamath Range in the north to the Tehachapi Mountains in the south. The proposed generating facility site is underlain by Quaternary alluvial and bedrock deposits.

CH2M HILL performed a preliminary design geotechnical investigation at the site in February 2009. The scope of the study included an evaluation of site-specific geotechnical data to identify subsurface conditions with the potential to impact proposed construction and identify preliminary design parameters based on geotechnical constraints. A copy of the geotechnical report is included as Appendix 2C.

5.4.1.1 Regional Geology

The geology of the MEP vicinity is complex, largely a result of the interaction of the strike-slip tectonics of the San Joaquin fault system and the compressional tectonics of the Coast Ranges. The Coast Ranges are composed of several parallel longitudinal ranges that trend northwest. These ranges have resulted from the folding and faulting of intra-basin sediments during Miocene to Pleistocene periods. The Diablo Range, west of the site, is an assemblage of anticlinal folds composed largely of Cretaceous-Jurassic age Franciscan Formation marine sedimentary rocks. Few streams flow easterly from the Diablo Range and drainage tends to be rapid and intermittent. These conditions favor the formation of alluvial fans (Norris and Webb, 1990).

5.4.1.2 Local Geology

The local geology is alluvial fan deposits of Holocene age underlain by semi-consolidated to consolidated deposits of Cretaceous to Pleistocene age. Figure 5.4-1 shows the geology within a 2-mile radius of the MEP site. The structure and stratigraphy of the local area are discussed below.

5.4.1.2.1 Structure and Stratigraphy

The structural geology of the area is dominated by deformation associated with historical tectonic activity, the numerous faults in the region (discussed below), and the more recent (Quaternary) alluvial fan deposition off the Diablo Range immediately to the west of the site.

Some landslides have occurred in the Diablo Range (Dibblee, 1972). These slides are localized, however, and have not been mapped in the vicinity of the MEP site, which is more than 1 mile from the base of the mountains. The site is mapped as not containing historical evidence of landslides (Robertson, et. al., 1997).

The site is immediately underlain by a relatively thin layer of Quaternary alluvial deposit underlain by Cretaceous bedrock deposits of sandstone and shale members of the Great Valley Sequence (U.S. Geological Survey [USGS], 1994 and USGS, 1996) (Figure 5.4-1).

5.4.1.2.2 Seismic Setting

Regional seismicity at the MEP site is primarily influenced by the right-lateral strike-slip of the San Joaquin Fault system and the compressional tectonics of the Coast Ranges/Sierran Block boundary zone. This boundary zone has been designated a “Special Seismic Source” where regional seismicity may be caused from deep-seated slip in which no surface faults exist or faults are concealed by alluvium or complex folding (Stein and Yeats, 1989). In addition to this special seismic source, many faults exist near the vicinity of the site; these faults are discussed in greater detail below.

5.4.1.2.3 Major Faults

Table 5.4-1 lists the significant active (Holocene) and inferred faults that could affect the site. These faults are shown on Figure 5.4-2. For each fault, the Uniform Building Code (UBC) fault class and the maximum magnitude earthquake (Mw) is listed based on data from the California Geologic Survey (CGS) and USGS (CH2M HILL, 2009). The maximum magnitude earthquake potential is based on the Moment Magnitude Scale.

TABLE 5.4-1
Significant Seismic Sources

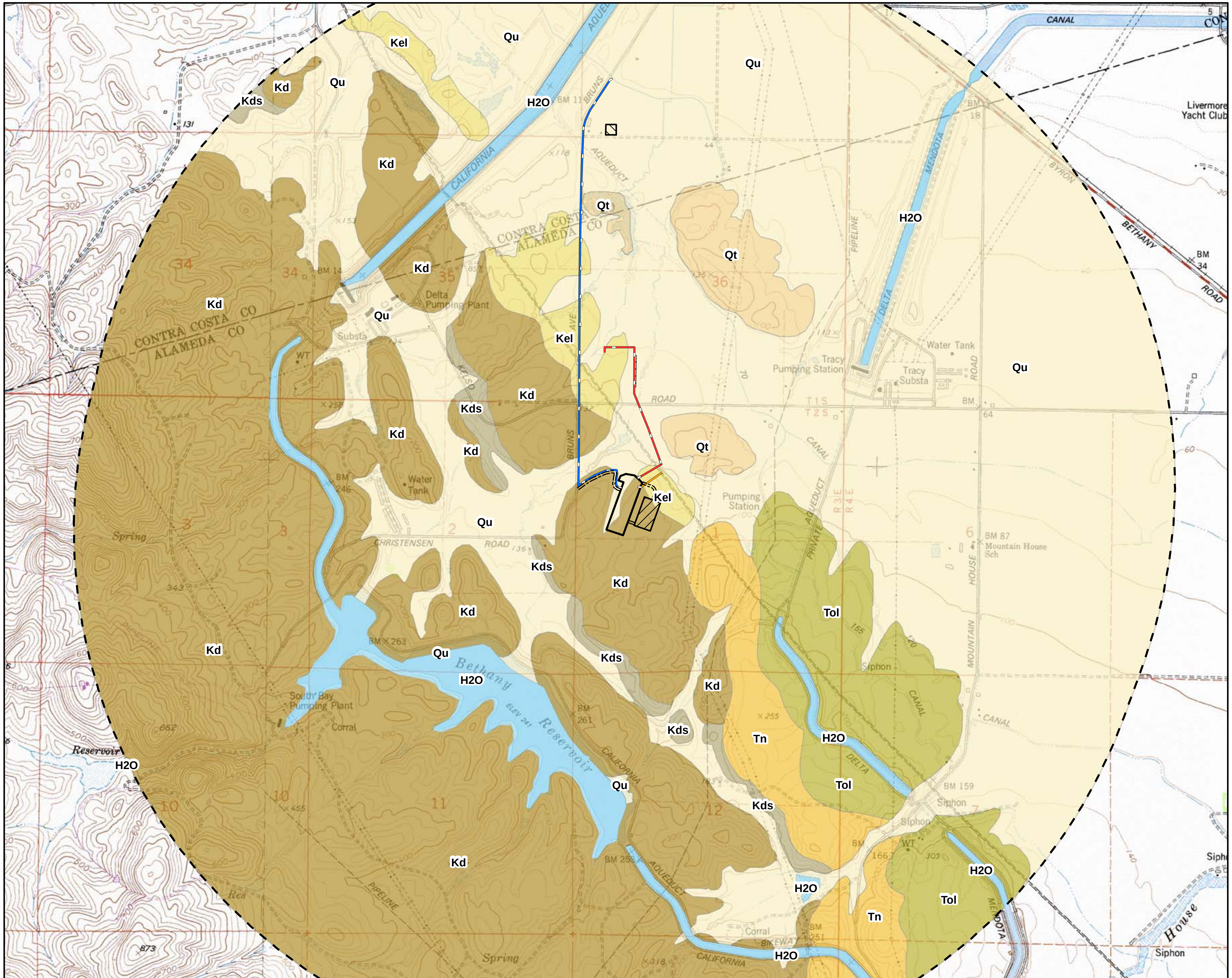
Fault	Fault Type[a]	UBC Fault Class[a]	Slip Rate (millimeters per year) [a]	Maximum Magnitude (Mw[b,c])	Approximate Site-to-Source Distance (miles)[d]
Great Valley Segment 7	Thrust	B	1.5	6.7	6
Greenville (North)	Strike-slip	B	2.0	6.7	7
Mount Diablo	Thrust	B	2.0	6.7	8
Calaveras (North, Central, South)	Strike-slip	B	6.0	6.9	19
Great Valley Segment 5	Thrust	B	1.5	6.5	22
Hayward (Total Length)	Strike-slip	B	9.0	7.3	25
San Andreas Fault (1906)	Strike-slip	A	NA	7.9	44

[a] The fault type and fault class are taken from CGS, 2002.

[b] The maximum earthquake magnitudes and slip rates are taken from the (USGS National Seismic Hazard Maps Fault parameters (2002).

[c] Mw = magnitude as defined in Moment Magnitude Scale

[d] The fault distances were taken from Blake, 2004



LEGEND

- ACCESS ROAD
- NATURAL GAS PIPELINE ROUTE
- TRANSMISSION LINE ROUTE
- WATER SUPPLY PIPELINE ROUTE
- TWO MILE BUFFER
- CONSTRUCTION LAYDOWN/PARKING AREA
- TRANSMISSION LINE LAYDOWN AREA
- WATER SUPPLY PIPELINE LAYDOWN AREA
- PROJECT SITE

GEOLOGY TYPES

- H2O, WATER
- Kd, UNIT D SANDSTONE
- Kds, UNIT D SHALE MEMBER
- Kel, LOWER UNIT D SILTSTONE
- Qt, TERRACE DEPOSTIS
- Qu, UNDIFFERENTIATED
- Tn, NEROLY FM. BLUE SANDSTONE
- Tol, ORO LOMA FORMATION - REDDISH SILT, SAND AND GRAVEL

Notes:

1. Source: USGS OFR 94-622. Preliminary Geologic Map Emphasizing Bedrock Formations in Contra Costa County, California: A Digital Database, 1994. USGS OFR 96-252 Preliminary Geologic Map Emphasizing Bedrock Formations in Alameda County, California: A Digital Database, 1996.

This map was compiled from various scale source data and maps and is intended for use as only an approximate representation of actual locations.

N

0 1,000 2,000
Feet

FIGURE 5.4-1
SURFICIAL GEOLOGY WITHIN TWO MILES OF PROJECT SITE

MARIPOSA ENERGY PROJECT
ALAMEDA COUNTY, CALIFORNIA

CH2MHILL

Source: Unruh & Krug, 2007; USGS 1996a

This map was compiled from various scale source data and maps and is intended for use as only an approximate representation of actual locations.

N

0 5 10
Miles

FIGURE 5.4-2
MAJOR FAULTS
MARIPOSA ENERGY PROJECT
ALAMEDA COUNTY, CALIFORNIA

CH2MHILL

The moment magnitude scale is the preferred method used by seismologists to determine the strength of an earthquake. This scale is an improvement over the Richter magnitude scale that was invented in 1935. In both scales, the stronger the earthquake, the higher the magnitude. The Richter and moment magnitudes are nearly identical for most earthquakes with a magnitude less than 7. However, moment magnitude measures the strongest earthquakes more precisely and accurately than the Richter scale.

This section provides a brief description of the active faults in the site region and the maximum intensity of earthquake that can be expected from the faults. The discussion below provides estimates of the potential force of an earthquake along the identified faults, but the actual impact that could occur at the MEP site would be based on actual distance to the earthquake epicenter, magnitude of the earthquake, and response of the geologic units at the site to the earthquake.

Calaveras Fault

The Calaveras Fault is 75 miles long and is approximately 19 miles west of the MEP site. The Calaveras Fault has been identified as a branch of the San Andreas Fault system. Displacement along the fault has occurred during Holocene time (within last 10,000 years). The Calaveras Fault has a maximum credible earthquake (MCE) estimated to be Mw 6.9 (CH2M HILL, 2009).

Great Valley Fault

This thrust fault is located approximately at the site and extends from near Red Bluff in northern California to Buttonwillow, northwest of Bakersfield in the southern San Joaquin Valley. The Great Valley Fault has been subdivided into various segments. Segments 5 and 7 are in the vicinity of the MEP site and have MCEs of Mw 6.5 and Mw of 6.7, respectively (CH2M HILL, 2009).

Greenville Fault

The Greenville Fault is 45 miles long and is 7 miles northeast of the MEP site at its closest point. The fault extends from Bear Valley to just north of the Livermore Valley. Displacement has occurred during Holocene time (within the last 10,000 years). The MCE for the Greenville Fault is estimated to be Mw 6.7 (CH2M HILL, 2009).

Hayward Fault

The Hayward Fault is 62 miles long and is 25 miles from the MEP site at its closest point. The fault is considered to be the most likely source of the next major earthquake in the San Francisco Bay (Working Group on Northern California Earthquake Potential [WGNCEP], 1996). Although the fault has recently experienced a number of small seismic events, the last major earthquake on the Hayward Fault was a Richter magnitude M_L 6.8 event in October 1868. The MCE for the Hayward Fault is estimated to be Mw 7.3 (CH2M HILL, 2009).

Midway-San Joaquin Fault

The Midway-San Joaquin Fault is 45 miles long and is approximately 1.4 miles west of the MEP site at its closest point. This fault is not officially recognized by the USGS or the CGS as a Quaternary fault (movements within last 1.6 million years). Recent published information suggests that this fault should be considered active and was assigned an Mw of 6.3 (CH2M HILL, 2009).

Mount Diablo Thrust Fault

The Mount Diablo thrust fault is a northeast-dipping structure located beneath the Mount Diablo anticline and is approximately 8 miles west of the MEP site. This blind thrust fault is capable of generating a maximum earthquake of Mw 6.7 (CH2M HILL, 2009).

San Andreas Fault

The San Andreas Fault which is approximately 44 miles west of the site is the largest active fault in California and extends from the Gulf of California to Cape Mendocino in northern California. The San Francisco Mw 7.9 earthquake of 1906 was attributed to this fault. The fault was previously divided into three segments. However, the recommendation of the WGNCEP (1996) was to subdivide the fault into four segments (the section of the fault north of Point Arena is now referred to as the Offshore segment). The primary three segments are located in the San Francisco Bay Area (North Coast, Peninsular, and Southern Santa Cruz Mountains) and have recently been assigned individual MCEs of Mw 7.5, Mw 7.2, and Mw 7.0, respectively, by the WGNCEP (2003). The same working group identified the MCE for all four segments combined, as is thought to be the cause of the 1906 earthquake, to be Mw 7.9. According to the WGNCEP (2003), there is a 21 percent probability of an Mw 6.7-equal or greater earthquake within the next 30 years along this fault.

Historical Seismicity. Recent historical seismicity for the San Francisco Bay region is associated with the San Andreas, Hayward, Calaveras, and Greenville faults. Early settlers wrote the earliest records of earthquakes in this region in the 1800s. The Northern California Earthquake Data Center has compiled data for a total of 7,940 earthquakes. There have been approximately 12 recorded earthquakes of M_L 6.0 or greater in the San Francisco Bay region in recent history. Ground-shaking hazards are significant for earthquakes of this magnitude. The most recent seismic events in the vicinity of the site include the 1979 Coyote Lake earthquake, the 1984 Morgan Hill earthquake, and the 1989 Loma Prieta earthquake.

5.4.1.3 Potential Geologic Hazards

The following subsections discuss the potential geologic hazards that might occur in the project area and are based on a literature search only. Additional information will be available pending review of a site-specific geotechnical report.

5.4.1.3.1 Ground Rupture

Ground rupture is caused when an earthquake event along a fault creates rupture at the surface. No active faults were found to cross either the MEP site or any of the linear facility corridors. Because no known active faults cross the project site, the likelihood of ground rupture is considered low.

5.4.1.3.2 Seismic Shaking

The project area has experienced seismic activity with strong ground motion during past earthquakes, and it is likely that strong earthquakes causing seismic shaking will occur in the future. The significant geologic hazard at the MEP site is strong ground shaking from an earthquake. Ground shaking from a magnitude 6.0 earthquake or greater could occur from earthquakes within a 100-mile radius of the site (Blake, 2004).

A probabilistic site hazard analysis was conducted for the project site based on information obtained from the USGS seismic hazard web site. As presented in the geotechnical report for the site, an analysis was performed for a 2,475-year recurrence interval or 2 percent probability of exceedance in 50 years. The 2 percent probability of exceedance in 50 years is considered the MCE by the California Building Code (CBC) (California Building Standards Commission, 2007). The USGS website indicates that the Peak Bedrock Acceleration (PBA) is 0.60g for a 2,475-year reoccurrence interval. The design basis earthquake (DBE) ground motion is calculated as two-thirds of the MCE or 0.4g, according to the 2007 CBC.

5.4.1.3.3 Liquefaction

During strong ground shaking, loose, saturated, cohesionless soils can experience a temporary loss of shear strength. This phenomenon is known as liquefaction. Liquefaction of soils is dependent on grain size distribution, relative density of the soils, degree of saturation, and intensity and duration of the earthquake. The potential hazard associated with liquefaction is seismically induced settlement.

Liquefaction is not anticipated to occur at the site because bedrock is relatively shallow and no groundwater was encountered in soil borings drilled up to 100 feet below ground surface. Additionally, no deposits of loose sand were detected during the investigation (CH2M HILL 2009). Therefore, the potential for direct impact from liquefaction at the site is considered nonexistent.

5.4.1.3.4 Mass Wasting

Mass wasting or slope instability depends on steepness of the slope, underlying geology, surface soil strength, and moisture in the soil. Significant excavating, grading, or fill work during construction might introduce slope stability hazards at either the MEP site or along linear facility routes. A large excavation is planned at the project site during the construction phase. The sides of the excavation will be laid back at a slope of 3:1 to minimize any slope stability concerns. The slopes will be vegetated to reduce erosion and run-off potential.

5.4.1.3.5 Subsidence

Subsidence can be caused by natural phenomena during tectonic movement, consolidation, hydrocompaction, or rapid sedimentation. Subsidence also can result from human activities, such as withdrawal of water or hydrocarbons in the subsurface soils. No known subsidence problems exist in the project area.

5.4.1.3.6 Expansive Soils

Expansive soils shrink and swell with wetting and drying. The shrink-swell capacity of expansive soils can result in differential movement beneath foundations. Expansive shallow clay soils with a high to very high expansive potential were identified at the MEP site.

5.4.1.4 Geologic Resources of Recreational, Commercial, or Scientific Value

There are no known geologic resources that provide a significant scientific or recreational value in the vicinity of the site. According to maps of the California Division of Oil, Gas and Geothermal Resources (2009), geologic resources of commercial value, such as oil and gas, are not present within 2 miles of the project site. There are no oil or gas extraction facilities at or near the project site.

5.4.1.4.1 Sand, Gravel, and Rock Resources

There are no known sand and gravel quarries close to the project site. The closest operating sand and gravel mining operations are approximately 13 to 18 miles west near Fremont and Pleasanton (Alameda County, 1994).

5.4.1.4.2 Clay

Clay mining historically occurred near Corral Hollow located approximately 14 miles south of the MEP site, but is no longer economically feasible (Alameda County, 1994).

5.4.2 Environmental Analysis

The potential environmental effects from construction and operation of MEP on geologic resources and risks to life and property from geologic hazards are presented in the following sections.

5.4.2.1 Significance Criteria

According to Appendix G of the California Environmental Quality Act statues, the project would have a significant environmental impact in terms of geologic hazards and resources if it would do the following:

- Expose people or structures to potential substantial adverse effects, including the risk of loss, injury, or death involving:
  - Rupture of a known earthquake fault (Alquist-Priolo Fault Zone)
  - Strong seismic ground shaking
  - Seismic-related ground failure, including liquefaction
- Be located on a geologic unit or soil that is unstable or that would become unstable as a result of the project, and potentially result in on- or offsite landslide, lateral spreading, subsidence, liquefaction, or collapse
- Result in the loss of availability of a known mineral resource that would be of value to the region and the residents of the state
- Result in the loss of availability of a locally important mineral resource recovery site delineated on a local plan, specific plan, or other land use plan

Potential impacts to the project from site-specific geotechnical conditions, including seismically-induced or building load factor hazards, along with expansive soil hazards, are discussed further in the preliminary geotechnical investigation (Appendix 2C.)

5.4.2.2 Geologic Hazards

There is potential for seismic ground shaking to affect the project site in the event of a large-magnitude earthquake occurring on fault segments located near the project. The project, however, is not located within an Alquist-Priolo Earthquake Fault Zone or within the trace of any known active fault. The project would thus not be likely to cause direct human exposure to ground rupture. Seismic hazards and potential adverse foundation conditions will be minimized by conformance with the recommended seismic design criteria of the CBC seismic requirements. Expansive soils that have been identified at the site can be mitigated by either removal/replacement with non-expansive soil or blending to reduce the expansive potential.

Additionally, the probability of liquefaction, mass wasting, or subsidence occurring at the project site is low to nonexistent.

The project structures, equipment, and the natural gas compressor station will be designed in accordance with CBC seismic requirements. Compliance with the CBC seismic requirements will minimize the exposure of people to the risks associated with large seismic events. Additionally, major structures will be designed to withstand the strong ground motion of a DBE, which is the probabilistic earthquake that is used for evaluating the earthquake resistance of a particular structure.

5.4.2.3 Geologic Resources

There are no known geologic resources of recreational or scientific value at the project site or in the project vicinity. There are no oil and gas extraction facilities at or near the MEP site. Based on the analysis presented, the project would have no effect on oil and gas production or on other geologic resources of commercial value or on the availability of such resources.

5.4.3 Cumulative Effects

A cumulative impact refers to a proposed project's incremental effect together with other closely related past, present, and reasonably foreseeable future projects whose impacts may compound or increase the incremental effect of the proposed project (Pub. Resources Code § 21083; California Code of Regulations, title 14, §§ 15064(h), 15065(c), 15130, and 15355).

Cumulative projects are described in detail in Section 5.6, Land Use. Six projects were identified by Alameda County as in development; these projects are from 1 to 5 miles away from the MEP site. As described above, MEP will not cause any adverse impacts on geological resources and will not cause an exposure of people or property to geological hazards. There are no minor impacts that could combine cumulatively with those of other projects.

5.4.4 Mitigation Measures

Mitigation measures proposed for the project are as follows:

- Structures will be designed to meet the seismic requirements of the 2007 CBC. Moreover, the design of plant structures and equipment will be in accordance with CBC seismic requirements to withstand peak ground acceleration of up to 0.6g at the site from a design basis earthquake. Special design considerations will be made for constructed facilities, if warranted, by the findings from the final design geotechnical investigation.
- A geotechnical engineer will be assigned to the project to carry out the duties required by the CBC to assess geologic conditions during construction and approve actual mitigation measures used to protect the facility from geologic hazards.
- Several suitable mitigation measures for the potentially expansive soils beneath improvements were presented in the preliminary design geotechnical report (CH2M HILL, 2009). These measures included placement of select granular fill for the foundation pad; over-excavation of the native clay soils beneath the site equipment pad; installation of sand columns through the clay and preloading the site with additional fill to speed the consolidation process; and construction of the facilities on thick mat foundations to reduce the potential for structural damage related to settlement.

With the implementation of these mitigation measures, the MEP will not result in significant direct, indirect, or cumulative geology-related impacts.

5.4.5 Laws, Ordinances, Regulations, and Standards

The LORS that may apply to geologic resources and hazards are summarized in Table 5.4-2. The local LORS discussed in this section are certain ordinances, plans, or policies of the County of Alameda. The Alameda County Building Department uses the California Building Code (California Building Standards Commission, 2007) as the minimum design standards for construction. Compliance with the California Building Code will achieve compliance with the Alameda County LORS. There are no federal LORS that apply to geologic hazards and resources.

TABLE 5.4-2
Laws, Ordinances, Regulations, and Standards for Geologic Hazards and Resources

LORS	Requirements/ Applicability	Administering Agency	Application for Certification Section Explaining Conformance
State			
CBC 2007, as amended by the County of Alameda	Acceptable design criteria for structures with respect to seismic design and load-bearing capacity	California Building Standards Commission, State of California, and County of Alameda	Section 5.4.2.2
Alquist-Priolo Earthquake Fault Zoning Act (Title 14, Division 2, Chapter 8, Subchapter 1, Article 3, California Code of Regulations)	Identifies areas subject to surface rupture from active faults	California Building Standards Commission, State of California, and County of Alameda	Section 5.4.2.2
The Seismic Hazards Mapping Act (Title 14, Division 2, Chapter 8, Subchapter 1, Article 10, California Code of Regulations.)	Identifies non-surface fault rupture earthquake hazards, including liquefaction and seismically induced landslides	California Building Standards Commission, State of California, and County of Alameda	Section 5.4.2.2
Local			
County of Alameda General Plan (East County Area Plan) (Alameda County, 2000)	Compliance with 2007 CBC, County of Alameda General Plan	County of Alameda	Section 5.4.2.2

5.4.6 Agencies and Agency Contacts

No permits are required for compliance with geologic LORS. Compliance with building standards and building structures are within the exclusive jurisdiction of the CEC.

However, the Alameda County Planning and Building Department is responsible for enforcing compliance with local building standards, including the CBC.

5.4.7 Permits Required and Permit Schedule

Compliance of building construction to CBC standards is covered under engineering and construction permits for the project that are within the exclusive jurisdiction of the California Energy Commission (CEC). There are no other permit requirements that specifically address geologic resources and hazards.

5.4.8 References

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Blake, T.F. 2004. EQSEARCH, *A Computer Program for the Estimation of Peak Acceleration from California Earthquake Catalogs*.

California Building Standards Commission. 2007. *2007 California Building Code*. California Code of Regulations, based on 2006 International Building Code.

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USGS. 1996. Preliminary Geologic Map Emphasizing Bedrock Formations in Alameda County, California: A Digital Database. Open-File Report 96-252.